SOPRONI EGYETEM, VADGAZDÁLKODÁSI TANSZÉK, MAGYAR VÍZIVAD KUTATÓ CSOPORT
UNIVERSITY OF SOPRON, DEPARTMENT OF WILDLIFE MANAGEMENT,
HUNGARIAN WATERFOWL RESEARCH GROUP

MAGYAR VÍZIVAD KÖZLEMÉNYEK
Hungarian Waterfowl Publications
No. 3.
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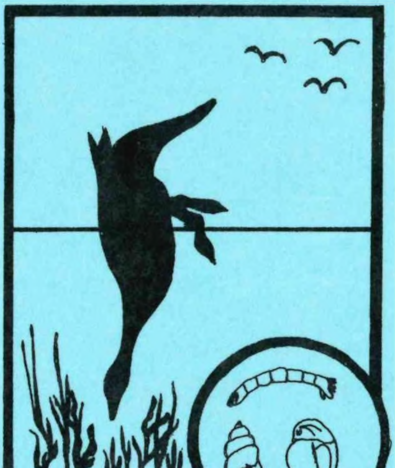
LIMNOLOGY AND WATERFOWL

Monitoring, Modelling and Management

Proceedings of a Symposium on Limnology and Waterfowl
held in Sopron/Sarród, Hungary November 21-23, 1994
Societas Internationalis Limnologiae, Working Group on Aquatic Birds

Editors

SÁNDOR FARAGÓ and JOSEPH J. KEREKES



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Contents

PREFACE

The enthusiasm and momentum generated at the Symposium: "Aquatic Birds in the Trophic Web of Lakes" held in Sackville, New Brunswick, Canada, in August, 1991 (Kerekes and Pollard, 1994), led to the formation of the Working Group on Aquatic Birds of the Societas Internationalis Limnologiae (SIL). The General Assembly of SIL approved the formation of our Working Group on Aquatic Birds during its XXV Congress in Barcelona, Spain on August 26, 1992. One of the primary objectives of the Working Group is to facilitate communication among limnologists interested in waterbirds and ornithologists interested in the aquatic habitat. To achieve this aim the Working Group plans to organize at least one workshop every three years between SIL Congresses.

The first meeting and workshop of SIL Aquatic Bird Working Group "Limnology and Waterfowl (Monitoring, modelling and management)" took place at the headquarters of Fertő-Hanság National Park in Sarród, near Sopron, Hungary on 21-23 November 1994. The second workshop is scheduled in México in November 1997. The Proceedings of the first Workshop are presented in this volume.

The main themes of the workshop were to relate to the management of waterfowl populations and to assist in the development of a scientific basis of waterfowl management plans:

- The limnological basis of waterbird habitat. What is a "good" waterbird habitat, what kind of habitat features and combination of habitat features control waterbird abundance and waterbird distribution.

- Development of a waterfowl monitoring system in relation to habitat (e.g. bird numbers, habitat variables, water renewal, size of waterbody, juxta-position, etc.) waterbirds as bioindicators of habitat quality, and the role of waterbirds in the nutrient dynamics of wetlands.

- Development of a meaningful system to express waterbird abundance in terms of unit surface area which could be used to compare habitats in terms of their basic productivity supporting waterbirds regardless of size.

Several authors, particularly from the former Soviet Union expressed interest in attending the workshop and submitted their abstracts. Unfortunately at the end, they could not attend for financial reasons. We included these entries in the book of abstracts at the time of the Workshop as well in this proceedings. This way a wider audience will become familiar with the work done by these scientists.

From the very beginning, Wetlands International (formerly the International Waterfowl and Wetlands Research Bureau) was very supportive of our working group. They distributed our first announcement with their newsletter world wide and provided significant financial support to the publication of this proceedings. We are particularly indebted to Drs. Mike Moser and Janine van Vessem of Wetlands International for their continuos support. We are grateful also to Dr. R. G. Wetzel of Societas Internationalis Limnologiae for his continuous encouragement and support.

REFERENCE:

Kerekes, J. J. and B. Pollard (eds.). (1994). Symposium Proceedings. Aquatic Birds in the Trophic Web of Lakes. Sackville, New Brunswick, Canada. Aug. 19-22, 1991. (Dev. in Hydrobiol. 96) Hydrobiol. 279/280, 524p.

Dr. Joseph J Kerekes
Coordinator, SIL Aquatic Bird Working Group

GREETINGS TO PARTICIPANTS

Ladies and Gentlemen, Dear Colleagues,

In behalf of the University of Forestry and Wood Sciences of Sopron, I would like to welcome you at the Fertő-Hanság National park here at Sarród in Hungary.

I was very pleased when I first learned that the Working Group of Aquatic Birds of the International Limnological Society proposed the held its first meeting and workshop "Limnological and Waterfowl (Monitoring, modelling and management)" near Sopron in Hungary. The subject of your deliberations is of great interest to us here at the University. Some members of our Wildlife Management Department are intimately engaged in the research of aquatic birds and their habitat. They are facing the task to develop a management plan for the conservation and monitoring of migratory waterbirds in cooperation with the International Wetland Research Bureau (IWRB) here in Hungary. I understand that the main themes of your workshop will relate to the monitoring, managing of waterfowl populations and the development of a scientific basis of waterfowl management plans.

I also understand that the main objective of your working group is to facilitate interdisciplinary cooperation and sommunication among limnologists, both researchers and managers, interested in aquatic birds and ornithologists interested in aquatic habitat. We at the university have a long tradition of interdisciplinary cooperation. We believe and teach here at the university that a good management of the land, forest and wetlands will result in a balanced, sustainable forestry with its wildlife, including aquatic birds.

The area around you here at the Fertő-Hanság National Park will demonstrate to you that here in Hungary we place a great deal of effort and that we believe in the preservation, restoration and protection of wildlife habitat, both terrestrial and aquatic.

From your program and the book abstracts I saw that you have a rich and varied scientific program and two interesting and challenging workshop. I thrust that you will be able to come up with some solid recommendations concerning the long term monitoring of aquatic bird populations and their habitat. During the second day of your program you will be able to see first hand, the Fertő-Hanság National Park and its wildlife.

I hope that your stay here will be both profitable and enjoyable.

I wish you a productive workshop.

Dr. h. c. Dr. András Winkler
rector of the University

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REPORT FROM THE WORKSHOP „BIRD POPULATIONS AND THEIR HABITATS" GUIDELINES FOR LONGTERM MONITORING

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INTRODUCTION

An increase in interest in the role of waterfowl in aquatic ecosystem is evident from the formation of a working group of SIL in 1992, and from the international conferences on „Aquatic Birds in the Trophic Web of Lakes", held in Sackwille, New Brunswick, in 1991 (Kerekes and Pollard, 1994) and on „Limnology and Waterfowl - Monitoring, Management and Research", held in Sopron, Hungary, in 1994. This report incorporates recommendations from a workshop on limnological monitoring and waterfowl, held at the latter conference. The workshop arose partly from fundamental scientific needs, and partly from concerns about the lack of information on how waterfowl may be affected by major changes to aquatic ecosystems resulting from human activity, such as eutrophication, water abstraction and reclamation, acidification, and organic and other pollution.

The objective of the workshop was defined as being to prescribe a minimal set of limnological variables that is desirable to measure in conjunction with waterfowl monitoring programmes, with the ultimate objectives of developing predictive models for the abundance and role in ecosystem function of waterfowl species. Such models might be derived for individual waterbodies, or for individual species or wider taxonomic groupings, over all or part of their geographical ranges. The questions addressed were thus, broadly:

1) What is an appropriate minimum set of limnological variables to monitor in relation to waterfowl populations?

2) How should waterfowl populations be monitored, and in what units should their abundance be expressed for purposes of relating them to limnological variables?

The recommendations are to be regarded as preliminary. There is little reason to believe that the relationship between limnology and waterfowl are simple, and information gathered from continuing or future monitoring programmes may well lead to their revision. It is nevertheless expected that monitoring of these limnological variables will allow a preliminary assessment of whether major long term changes to the waterfowl populations of a particular water body are related to changes within the system, or to causes outside it. Catastrophic effects, such as outbreaks of avian botulism or incidences of other forms of toxic poisoning are not considered, and require specialist study.

Any monitoring programme should have its own, specific, clearly defined objectives, which will ultimately define what is to be measured, and how often. Supplementing these measurements with the limnological measurements listed below is likely to be useful, both for individual monitoring studies, and for future synthesis. The adoption of standard units for expressing waterfowl population densities is essential for any synthesis to become possible.

It is accepted that management of water bodies should not normally be directed primarily to maximisation of waterfowl populations,a s there may often be more important wider ecological considerations. An appropriate general management strategy is therefore to manage for a suitable environment for waterfowl can be considered satisfactory.

LIMNOLOGICAL VARIABLES

Methods

Given the wide range of methods available for many limnological measurements, no specific methods are recommended. The normal scientific criterion of describing methods in sufficient detail for the study to be repeated should be observed.

Frequency of monitoring

The desirable frequency of monitoring is related to the level of precision required, and the temporal and spatial variability of the habitat under investigation. Among the many problems that may be encountered are those relating to the local influence of inflows, the pathiness of surface blooms of algae, short term variations caused by wawe disturbance of the sediment in shallow lakes, and the influence of floods in streams. Specialised texts on chemical and biological monitoring should be consulted before any monitoring programme is begun, and attention should be paid to defining the precision of estimation. A minimal programme of open-water chemical sampling might involve taking duplicate vertically intergrated samples taken with a weighted hose pipe at a single centrally located station at monthly intervals, after preliminary investigation of the variability of the system.

The water body, morphology and climate

Type of the water body* *. Location, with latitude and longitude. Area (ha) and mean depth (m). For some benthivorous species the area of habitat within feeding reach may also be relevant. Range of variation in water level, and seasonal regime. Length of shoreline. Range of surface temperatures. Period of ice cover if relevant. Stream discharge and velocities for lotic studies. Human use of the drainage basin. Human recreational and economic use of the lake (for example for hunting boating, fishing) with reference to potential disturbance of waterfowl. Published sources of limnological information.

Physical and chemical measurements

Surface temperature, pH, Secchi disc transparency (supplementary readings with an all-black disc can be related more directly to inherent optical properties of water). Salinity or conductivity. Total and inorganic suspended solids. Total fixed nitrogen, and the inorganic forms NH_4- and NO_3-N. Total phosphorus and dissolved reactive phosphorus. In addition to these routine measurements, a survey of the nature and organic content of the sediment is recommended.

The International Waterfowl and Wetlands Research Bureau (Address) provides a form „Waterfowl count site form: Western Palearctic" with a classification of habitats that is recommended for use.

Biological measurements

Phytoplankton chlorophyll a. Dominant phytoplankton taxa. Nature of marginal vegetation, nature and extent of emergent vegetation. Distribution, dominant species, height, and depth limit of submerged aquatic vegetation, with biomass estimates if possible. (It was noted that the loss of submerged aquatic macrophytes is a critical stage in the eutrophication of shallow lakes, marked by sharp discontinuities in several major limnological variables, but little is known of its effects on waterfowl.) Survey or monitoring of biomasses of zooplankton, benthic fauna or fish may also be directly relevant for many omnivorous or carnivorous species of aquatic birds.

Waterfowl impacts

The effects on waterfowl on the systems that they inhabit, through feeding, exretion, or other activities, should be expressed in units consistent with those for other limnological measurements. Thus the recommended units are g m^{-2} $time^{-1}$, or g m^{-3} $time^{-1}$.

Waterfowl populations

Species present, abundance, and uses they make of the water body (e.g. roosting, feeding, breeding). It is recommended that the population densities be expressed as No ha^{-1} for the entire water body, and for the area occupied when use is localised. Estimates of the mean weight per bird, either from the literature or by sample measurement, will allow ready conversion to more standard limnological units (for example g m^{-2}).

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TYPOLOGY OF WETLANDS IN THE CAMARGUE (FRANCE): A NECESSARY FRAMEWORK FOR WATERFOWL STUDIES

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ABSTRACT

A new typology of the Camargue is realised with a Multiple Correspondence Analysis according to five variables describing habitat and two supplementary variables describing the human use of habitat. Two major habitats are isolated in the Camargue: freshwater habitats, rich in food resources but hunted, and brackish habitats, protected but poor in food resources. This typology shows the present use of wetlands. Habitat selection of herbivorous waterfowl indicates that birds exploit habitats which respond at the best to their energy requirements. However, security is also an important parameter. Ducks select the protected habitats more than Coots. Since different habitat types have different occurences, the observed typology is a necessary framework to interpret habitat selection. Wigeon and Coot exploit the commonest habitats whilst Gadwall the less frequent ones. This preference indicates a strong habitat selection which can be explained by higher dependence of this species to diurnal feeding.

INTRODUCTION

The loss and degradation of wetlands is increasing in all European countries and especially in the Mediterranean region (Finlayson *et al.*, 1992). Agriculture, urban development or recreation activities are the main causes. The Camargue (France), one of the most important winter quarters in the Mediterranean region for waterfowl species (Monval and Pirot, 1989) suffers from this degradation in spite of many prestigious conservation policies (Tamisier, 1990; Tamisier and Grillas, 1994). Moreover, in this region hunting is a very important activity. Because of kill and disturbance (Dahlgren and Korschgen, 1992) hunting is considered as a major threat for waterfowl wintering in the Camargue (Tamisier and Grillas, 1994). An analysis of wetland typolgy must help understanding the present step of the Camargue and should include as much as possible parameters which deal with human interference on wetland habitats.

The objective of this paper is to present characteristics of the Camargue wetlands according to physical and human variables. This typology will be used as an aid for the interpretation of habitat selection for some waterfowl species.

Habitat selection, a fundamental component of life history traits of animals, relies on two factors, the proper requirements of each species and the available habitats (Kaminsky *et al.*, 1988). Heitmeyer (1988) in the Mississippi delta considers that habitat selection among ducks during winter favours energy storing during the last months of the winter period before leaving towards breeding grounds. So, characteristics of wetlands considered as waterfowl habitat in winter must be analysed precisely. The human variables which can modify the original biological conditions of wetlands and/or control their availability for birds have to be included into the analysis. These characteristics will be helpful for better conservation policies.

STUDY AREA

Camargue is a wide area (145,000 ha) at the mouth of the Rhône river on the Mediterranean coast, with 60,000 ha of wetlands and 25,000 ha of salt marshes. The remaining surface is mostly exploited as farmlands (Tamisier, 1990) which are not used by waterfowl, except for rice fields after harvest for some species. Important changes have occurred during the last century after the building of dikes along the riversides and on the seaside. More recently (i.e. during the last 50 years) the rapid development of human activities including agriculture, hunting and tourism have seriously modified the original characteristics of Camargue wetlands.

METHODS

Since 27 years (from 1964-65 to 1990-91), almost all sites of the Camargue area are annually outlined by seven categorial variables, each variable being characterised by two to five categories (**Table 1**).

Table 1: Description of modalities of the seven environmental variables used. Greyed, the supplementary variables describing the human use (after Dehorter and Tamisier, in submit).

	Categories					
	1	2	3	4	5	6
Temporality (Water)	Temporary	Semi-permanent	Permanent			
Surface (ha)	10-50	50-100	100-250	250-500	500-1000	> 500
Salinity (g/l)	< 5 (Fresh)	5-20 (Brackish)	> 20 (Salty)			
Parcelling	Yes	No				
Water manag.	Weak	Strong				
Disturbance	Null to weak	Medium	Strong			
Status	Reserve	Hunted				

Temporality relates to periodicity of water on marshes along the annual cycle. Temporary marshes dry up annually for more than two or three months whilst semi-permanent marshes dry up irregularly for shorter periods. *Surface* area was measured at full water-level. Three categories of *salinity* characterise the submerged macrophyte community which is dominated by *Myriophyllum spicatum* (< 5 g/l), *Potamogeton pectinatus* (5 to 20 g/l) or *Ruppia cirrhosa* (> 20 g/l) (Dervieux and Tamisier, 1987; Allouche *et al.*, 1989; Grillas, 1990; Tamisier and Pradel, 1992). *Parcelling* concerns some large marshes which are mostly hunted. Beds of *Phragmites australis* isolate several ponds and prevent birds from visual contact from both sides of the beds. *Water management* is considered as strong when an artificial flooding-up occurs in summer, mainly for hunting purposes. *Disturbance* results mostly from waterfowl hunting. The duration of the hunting season ranges from 6.5 to 8.5 months according to year (the shortest duration occurring most recently) and administrative locations (département). Null disturbance refers usually to non hunted areas, medium disturbance refers to rare hunting places where shooting occurs less than 2 days a week, and strong disturbance refers to most other hunting places. *Status* isolates protected vs. hunted sites.

Habitat characteristics are analysed with Multiple Correspondence Analysis (MCA) using BIOMECO software (CEFE/CNRS). MCA provides factorial planes where all categories of variables are distributed according to relative similitude (Dervin, 1988). Coordinates of each category on the factorial plane correspond to its centre of gravity. The amount of information carried by an axis is given by its relative inertia (**Table 2**). Axes of the factorial plane were constructed from the only first five variables which deal with the nature of wetlands. They are called active variables. Two others variables dealing with the use of wetlands by man (Disturbance and Status) were not used for the construction of axes, because they have no direct implication on habitat characteristics; they were considered as supplementary variables. However their location on the factorial plane can be interpreted as for active variables.

Table 2: Eigenvalues, and relative inertia for the three axes retained (after Dehorter and Tamisier, in submit).

	Eigen-values	Relative inertia
Axis 1	0.41	38 %
Axis 2	0.29	20 %
Axis 3	0.27	20 %

The analysis of diurnal habitat selection is made on four species belonging to the herbivorous guild: Gadwall (*Anas strepera*), Wigeon (*A. penelope*), Red-crested Pochard (*Netta rufina*) and Coot (*Fulica atra*). Data come from monthly waterfowl censuses, carried out mostly from the air, by one of us (A.T.) on 70 sites from September to March. The counting method and its reliability are described in Dervieux *et al.* (1980). These sites are considered as carrying the total populations of ducks and Coots wintering in the Camargue (Tamisier and Pradel, 1992). Herbivorous ducks feed a little during daylight hours and mostly at night. Consequently diurnal habitat selection will refer to wetlands which are mostly used for confort activities, and partly for feeding. On the contrary, Coots are diurnal feeders. Hence diurnal habitat selection for Coots directly refer to feeding areas. We predict that habitat selection depends on the specific food preference, e.g. Wigeon prefer *Ruppia sp.*, a brackish water plant while the other three prefer fresh water plants.

The Generalised Linear Model technic (GLM) according a Poisson distribution is used to determine the habitat used by different species with GLIM. Surface is included into the analysis as offset parameter in order to take into account a density effect (Crawley, 1993). The model retained with a forward stepwise procedure excludes all non-significant variables. When the response to a variable, in terms of bird number, is monotonous, we consider this variable as a quantitative one.

RESULTS

The first two axis, out of the 19 available, carry more than half the variance in data set, i.e. 38 % and 20 % respectively (**Table 2**). Some variables have important contributions in the construction of axes. Parcelling, Salinity and Water management explain axis 1; Surface and Temporality illustrate both axes 2 and 3. MCA indicates that wetlands in the Camargue are divided into two main categories (**Figure 1**). On one hand, wetlands are salty and rather temporary (i.e. they dry partly or totally in summer). On the other hand, wetlands are freshwater and rather permanent. Moreover, salty wetlands are associated to protected wetlands (no shooting) whilst fresh water wetlands are associated to hunted sites with high shooting pressure. Axis 2 illustrates a surface gradient from small to larger sites. This two-fold distribution can be used as a framework for classification of the Camargue wetlands.

Whatever the species, three main variables control habitat selection: salinity, temporality and disturbance/status. Differences occur between species at the category level of each variable (**Table 3**). For what salinity is concerned, Gadwall and Coot prefer freshwater sites. Red-crested Pochard uses both fresh and brackish water, whilst Wigeon selects the most salty waters. About temporality, Gadwall and Wigeon take advantage of semi-permanent water whilst Coot exploits rather permanent ones. Red-crested Pochard exploits every type of localities. With parameters describing the human use of wetlands, ducks prefer undisturbed and protected habitat, while coots select hunted and disturbed wetlands.

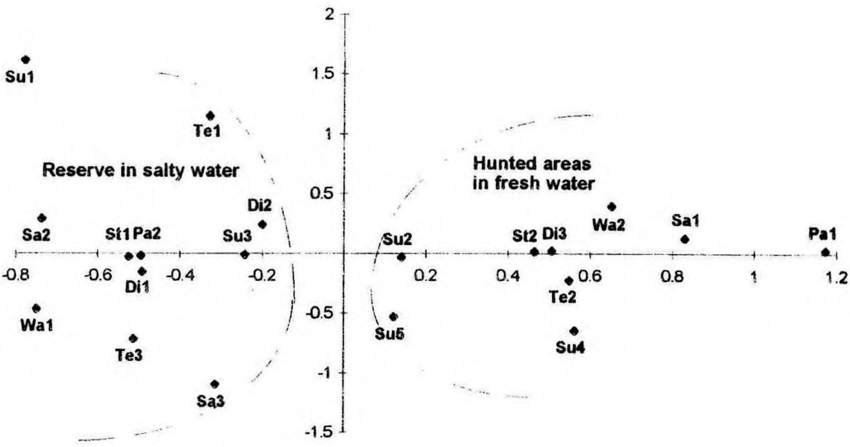

Figure 1: Habitat variables represented by their centre of gravity on F1 x F2 plane. Di: Disturbance, Pa: Parcelling, Sa: Salinity, St: Status, Su: surface, Te: Temporality. Number following the code indicates category (after Dehorter & Tamisier, in submit).

Table 3: Annual mean rank of four important variables for herbivorous guild habitat selection. High rank value indicates high habitat selection.

	Salinity			Temporality			Disturbance			Status		
	1	2	3	1	2	3	1	2	3	1	2	3
Gadwall	3	1.4	1.6	1.7	3	1.3	2.9	1	2.1			
Wigeon	1	3	2	1.7	2.7	2.1	2.5	1.8	1.7	1.6	2.7	1.7
Red-crested Pochard	2.4	2.6	1				3	2	1	3	1	2
Coot	2.6	1.9	1	1	2	3	1.7	1.6	2.7	1.1	2.3	2.6

DISCUSSION

Wetlands of the Camargue are distributed according to a bimodal pattern where hunted freshwater sites are isolated from protected, salt- and brackish-water sites. This segregation reflects the present use of wetlands, either for hunting or for nature conservation respectively. For hunting activities, managers pump freshwater into the marshes, reducing the original constraints of Mediterranean climate (salt level and drying up in summer). The result is an increase of the productivity of aquatic plants, the main food of herbivorous waterfowl species (Tamisier and Grillas, 1994). This water management is not or rarely practised in protected sites. This change in management practices results from the recent socio-economic development where hunting, which brings important financial inputs, plays an important role.

Our results differ from those of Britton and Podlejski (1981) who suggested a continuum from freshwater habitats to saline habitats. Their results refer to data collected in 1976-77, that is to say before the recent change in wetland exploitation by man. The difference between their results (similar to those of Blondel and Isenmann, 1981) and ours illustrate how much rapidly the original diversity of Camargue wetlands has been replaced by a simplified two-fold typology.

Habitat selection occurs on all available habitats. As predicted, herbivorous species, excepted Red-crested Pochard, exploit those habitats where they can fulfil their energy and security requirements. Wigeon and Coot select the commonest habitats of the Camargue whilst Gadwall prefer protected freshwater habitats. Because of the extreme rarity of these sites, the Gadwall preference indicates a strong habitat selection. Moreover ducks, contrarily to Coots, select preferentially protected sites. As a whole, in selecting diurnal habitats, ducks usually balance between productive sites which are disturbed by hunting, and protected sites which are poor in food resources. The preference of Gadwall is rather exceptional and can be interpreted as a higher dependence of this species on diurnal feeding. Therefore Gadwall has a much higher vulnerability to hunting than any other duck species in Camargue (Tamisier and Dehorter, in prep). Coot situation is opposite; this species has to feed during the daylight hours (because of its visual selection of food, Allouche, 1988). Hence it must exploit sites where the maximum food resources are available (the productive hunted sites).

From the point of view of conservation, these two contradictory aspects can also be developed. On one hand, preserving the originality of the Camargue wetlands involves less water management in order to recover more typical temporary brackish habitats. On the other hand, increasing the carrying capacity of the Camargue for wintering waterfowl (which is a common goal of hunters or conservationists) leads to more freshwater management, more productive habitats, but more kill and disturbance in hunted sites and less biodiversity for wetlands.

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THE ROLE OF THE WATER QUALITY MONITORING NETWORK ON THE UPPER STRETCH OF THE DANUBE RIVER IN HUNGARY

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ABSTRACT

After more than 25 years of continuous regular monitoring, it became known that the changes in water quality reflect the natural and geo-economic conditions of the Danube watershed. The scientific understanding of the present complicated relationships among the attributes of the water has been facilitated.

In this paper, the state of water quality in the Hungarian upper stretch of the Danube and its tributary waters is introduced. Special attention is paid to environmental factors influencing the productivity of the waters, such as:

- loading of external and internal organic material
- oxygen supply for the river
- elements of nitrogen and phosphorus contents and
- the quality and quantity characteristics of the primary production of micro vegetation, the basis of the food chain.

INTRODUCTION

The development of the water quality monitoring network

Individual analytical chemical measurements of surface water quality characteristics have been conducted in Hungary for more than 100 years. The first published water quality data related to the Danube is that of Balló (1875). Today, the results of Lajos Winkler's analytical work of water "Determination of Dissolved Oxygen in Water" are used all over the world.

At the turn of the century and in the first half of this century, such measurements were conducted only periodically and unsystematically. The intensive industrialisation - the increase in water demands and of water pollution - also caused a growth in the need for systematic water quality examinations. However, Hungarian water protection could not catch up to the standards which the Western countries had achieved earlier.

The comprehensive, systematic water quality examinations began in Hungary in 1954 in the Water Management Scientific Research Institute, where the first water quality laboratory was developed for physical, chemical and sapro-biological examinations. Later, the organization of the national water quality laboratory network began in the operation of the Water Conservancy Directorate in 1964.

Accordingly, the basic so-called centralized water quality network developed and has operated since 1968 on 113 rivers in the country (including the upper stretch of the Danube). The measurements include 32 physical, chemical, and biological variables with regular annual frequencies of 12, 26, and 52, respectively. The laboratory measurements were conducted according to internationally accepted methods. The measurement results were evaluated primarily from the standpoint of the most important water use.

In 1983, the number of sampling sites were reduced, the sphere of examined parameters were expanded corresponding to the general enviromental expectations and the information requirements necessary for the description of the hydro-ecological system. The scientifically-founded "integrated water quality requirement system," which simultaneously considers the demands for the quality of consumed water and the stability of the hydro-ecological system, was also introduced.

This water quality system was replaced in 1994 with the introduction of the new national norms, the objective of which are the determination of the state of the water quality from the ecological standpoint. At the 150 sampling sites designated for the nation's surface waters, 12 regional Environmental Protection Authority laboratories conduct water examinations for 80 physical, chemical, biological characteristics with an annual frequency of 12, 26 and 52 respectively.

The water quality data developing in the water quality monitoring network since 1968 is now recorded in a microcomputer data base which is accessible to the users and handled as a public data base. It is used to provide the water quality aspects of the monitoring of waterbird populations in the Danube River (Faragó, this volume).

METHODS

The data considered are from the Water Quality Monitoring Network and the data of sampling sites of the branches of Danube. The sampling sites of national water quality examinations are:

- Danube: Rajka, 1848 river kilometer (rkm); Medvei bridge 1806 rkm; Komárom 1766 rkm; Dunaalmás 1751 rkm; Esztergom 1717 rkm.
- Tributaries: Mosoni Duna, Győr-Vének 2,4 rkm; Cuhai Bakonyér, Bőnyrétalap 7,0 rkm; Concó, Ács 2.8 rkm; Kühtreiber stream (Áltaér), Dunaalmás 0,5 rkm; Kenyérmezei stream, Tát-Esztergom bridge 1,4 rkm.

We are presenting data for COD, DO_2, N and P forms and chlorophyll-a. These chemical and biological parameters were measured according to Hungarian water quality standards.

RESULTS AND DISCUSSION

The 2857 km reach of Danube in Hungary is of middle-reach character. The river becomes of middle-reach character approximately 800 km distance from the source, where more and more living organism find favourable conditions not only in the riverbank region, but in the slower flowing main channel as well. In the Danube the plants - primarily the algae in water - form the organic matters of their own bodies form inorganic nutrients dissolved in water with the use of photosynthesis. The quantity of plants are produced as the concentration of the inorganic nutrients and other limiting factors (light, temperature, current, etc.) make it possible.

Organic matter pollution of Danube and its tributaries

The organic matter content of the water of Danube which can be measured by chemical oxygen demand (COD) is formed partly by living organisms of microscopic size, partly by dead organic matter as well as floating matter of dead organisms and dissolved organic matter. The organic matter pollution of the Danube varies between 12,9-15,25 COD mg/l at the upper reach of 140 km, subject to the outer (allochton) and inner (autochton) organic matter loading. Due to the increment of the primary production as well as the direct sewage input at riverside, and the polluting material loading from the tributaries which are polluted at a greater extent than the Danube, significant increase of organic material of 18,5 per cent can be detected. **(Figure 1, Table 1)**.

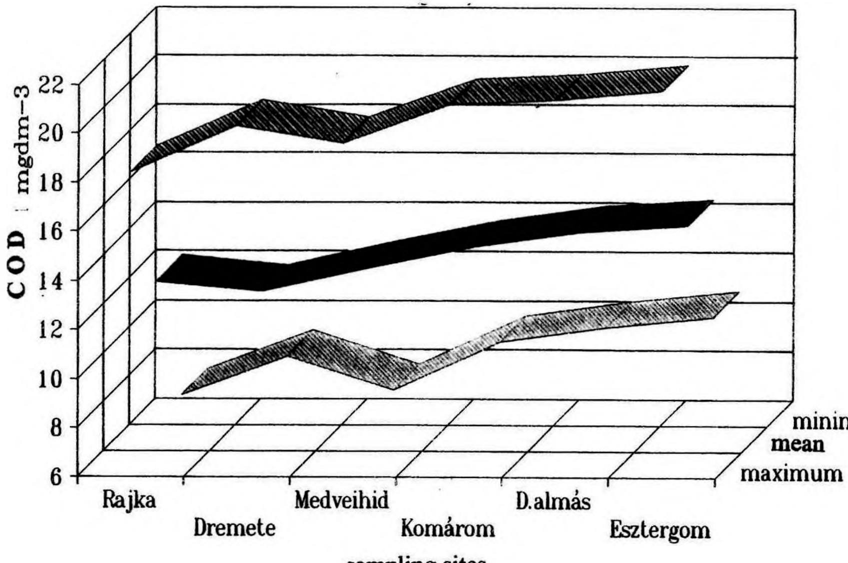

Figure 1: Annual, mean, maximum and minimum values of *chemical oxygen demand* (COD) at six sampling locations in the Danube River in Hungary in 1993.

Table 1: Selected features of water quality at six sampling locations in the Danube in 1993

	river km	1848 Rajka	1825 Duna-remete	1806 Medve	1766 Komárom	1751 Duna-almás	1717 Esztergom
COD mg/l	min.	7,2	8,8	7,4	9,4	10,0	10,4
	mean	12,9	12,55	13,47	14,32	14,95	15,25
	max.	18,4	20,3	19,6	21,2	21,4	21,8
DO2· mg/l	min.	5,84	6,16	4,61	6,25	8,16	5,97
	mean	9,40	9,32	9,36	10,31	10,27	10,45
	max.	12,48	12,72	13,16	13,20	13,60	14,24
Total N mg/l	min.	1,87	1,18	1,57	1,38	1,39	1,56
	mean	3,39	3,03	3,24	3,11	2,90	3,06
	max.	7,57	5,76	5,49	5,21	5,46	5,11
Total P mg/l	min.	0,06	0,09	0,09	0,09	0,09	0,09
	mean	0,16	0,16	0,16	0,16	0,15	0,18
	max	0,42	0,23	0,28	0,24	0,27	0,62
Chlorophyll-a mg.m-3	min.	1,02	1,02	1,36	1,36	2,38	1,70
	mean	25,07	21,03	27,35	31,64	42,49	41,28
	max	115,93	88,29	107,4	101,3	107,99	108,27
n/1993		53	34	54	23	22	22

Among the tributaries Conco Brook which is loaded with agricultural pollutants is the most highly polluted. The water of Kenyérmezei Brook carries the treated sewage of pharmaceutical industry. The change in the organic material content at the mouth section of Általér (Kühtreiber Brook) is affected by the water-discharge of Öregtó in Tata and the treated city sewage. Organic matter content of the water of the Moson Danube is higher than those in the main Danube channel due to the affect of the untreated sewage in Győr (**Table 2**).

The oxygen supply of Danube is satisfactory. The producing and decomposing processes exercise strong influence on the dissolved oxygen content of the water, though the physical affects (temperature, surface diffusion) which are always the primary ones in the Danube. Therefore, the dissolved oxygen content is higher in the winter and lower in the summer. In spring time and early summer supersaturation can be detected more frequently due to the oxygen production of the algal mass. In winter time, oxygen saturation values of less than 75 per cent can be detected due to the oxygen consumption of the decomposing processes. Along the longitudinal section, the maximum and average values of the dissolved oxygen content are increasing, the reason there is the increase of the primary production in the river. The maximum value of dissolved oxygen concentration increased from 12,48 mg/l to

14,28 mg/l (**Figure 2,Table 1**). The degree of oxygen supply of the polluted tributaries flowing into the Danube shows more extreme fluctuation. (**Table 2**.)

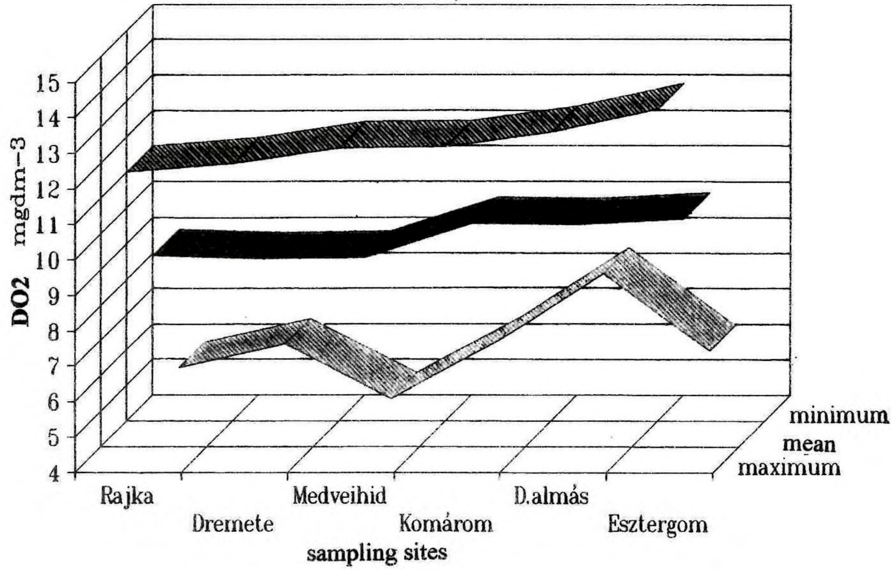

Figure 2: Annual, mean maximum and minimum values of *dissolved oxygen* (DO_2) at six sampling locations in the Danube River in Hungary in 1993.

Aquatic plant nutrients

The nutrients - compounds containing nitrogen and phosphorus - get into the waters through natural and artificial way. Their concentration depends significantly on the biological condition of the water flowing.

Considering the type of forms of nitrogen the Danube, it is featured by nitrate-nitrogen dominance with a contribution of more than 70 per cent. The content of organic nitrogen is about 20 per cent, while the content of ammonium-nitrogen is less than 10 per cent. The nitrite-nitrogen content can be neglected. Such proportion of forms of nitrogen promotes to the formation of alga. At the upper reach of the river the average contents of total nitrogen - 2,90-3,39 N mg/l - deviates from each other only slightly (**Figure 3, Table 1**).

Table 2: Selected features of water quality at five tributaries entering the Danube river in 1993

	river km	2,4 Mosoni Danube	7,0 Cuhai Bakonyér	2,8 Concó	0,5 Általér (Kühtreiber s.)	1,4 Kenyérmezei stream
COD	min.	16,0	16	23	24	45
mg/l	mean	25,3	24	46	50	184
	max.	51,5	66	139	33	478
DO2	min.	1,47	4,49	1,06	1,58	0,22
mg/l	mean	7,60	10,08	7,63	8,52	4,51
	max.	14,10	14,38	12,16	13,88	8,58
Total N	min.	1,25	-	2,68	2,88	17,40
mg/l	mean	3,36	-	10,40	6,13	30,49
	max.	8,32	-	46,80	12,90	48,50
Total P	min.	0,11	0,14	0,19	0,48	1,06
mg/l	mean	0,31	0,57	0,87	3,22	4,43
	max	0,91	1,72	3,55	8,74	9,84
Chlorophyll-a	min.	1,02	1,3	1,70	2,0	0,7
mg.m^{-3}	mean	45,66	8,6	49,0	44,8	3,6
	max	279,89	14,9	330,1	134,5	12,9
n/1993		63	25	25	25	25

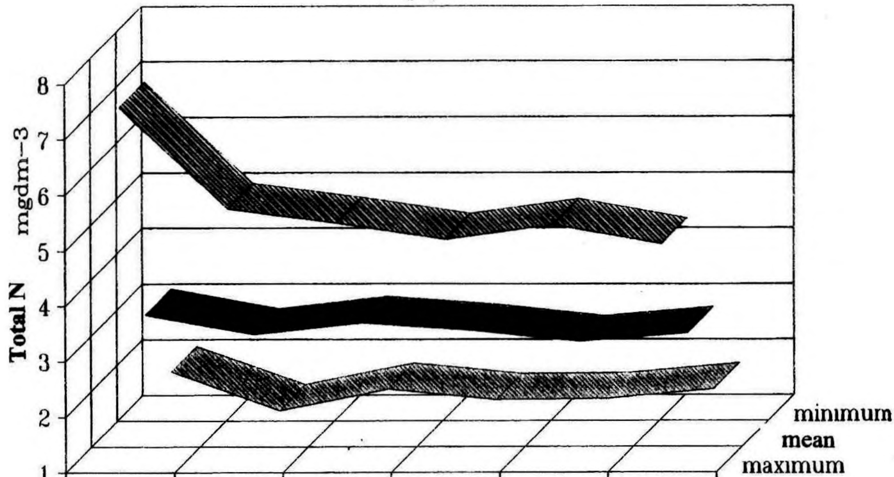

Figure 3: Annual, mean, maximum and minimum values of *total nitrogen* (Total N) at six sampling locations in the Danube River in Hungary in 1993.

The phosphorus the limiting nutrient resource for the water micro-vegetation are nearly identical in the river from the state border to Esztergom. During the past year the phosphorus loading coming from the cathcment area decreased significantly. However due to internal loading the phosphorus concentration in the water (max.: 0,24-0,62 P mg/l) is currently abundantly sufficient for maintaining the highly eutrophic condition of the river (**Figure 4, Table 1**).

The inflows of the tributaries contain sufficient nutrients to maintain high primary productivity of the waters, creating hypertrophic conditions (**Table 2**).

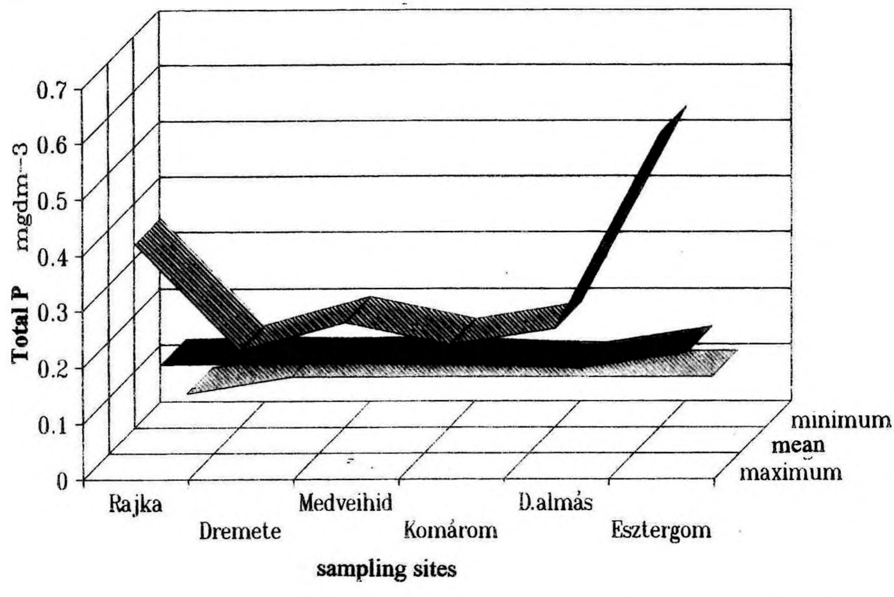

Figure 4: Annual, mean, maximum and minimum values of *total phosphorus* (Total P) at six sampling locations in the Danube River in Hungary in 1993.

Formation of Algae in the Danube and its tributaries

The concentrations of the inorganic nutrients in the Danaube does not limit the extent of algal formation in the river. However, the number of the restrictive factors such as the light conditions and the speed of the current can exert their decreasing effect on algal production.

Due to the natural regulating mechanism of the hydrometeorological factors, in the upper reach of the Danube in Hungary, the vegetative season lasts from the middle of February until early November. The first chlorophyll peak in spring, then in the low waters during summer and in the autumn followed the third maximum. This seasonal change which can be considered as regular, can be modified by water currents relating to the annual hydrometeorological condition (Bartalis, 1987).

The peak algal formation is in the spring, 88 - 115 chlorophyll-a mg.m^{-3}, - indicates hypertrophic condition of the river. The average concentration values of the chlorophyll-a are nearly doubled along the longitudinal section. **(Figure 5, Table 1)**. The trophic state of the right-side tributaries of the Danube exceeds that of the trophic state of the river except in the Cuhai Bakonyér and Kenyérmezei Brook. Their effect can be detected along the rivers bank at a longer-shoulder section located below the inflows of the waters of higher nutrient content **(Table 2)**.

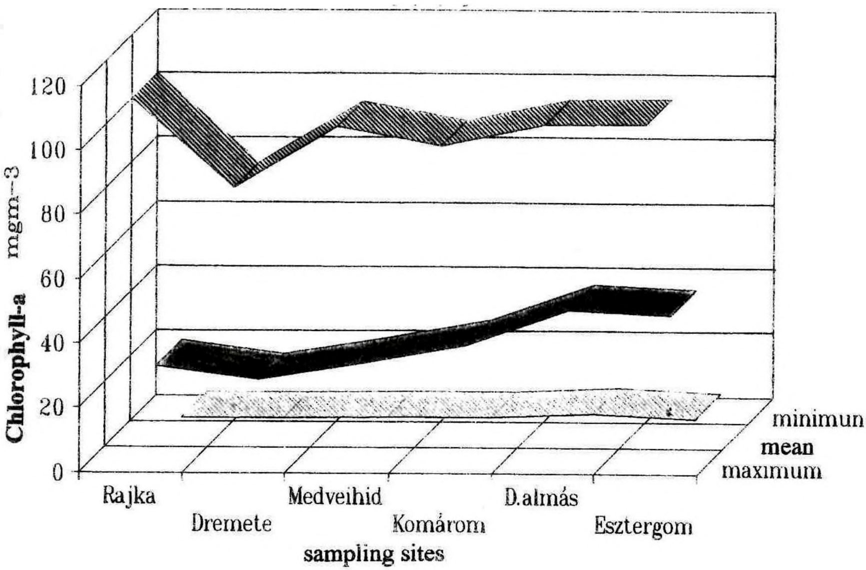

Figure 5: Annual, mean, maximum and minimum values of *chlorophyll-a* at six sampling locations in the Danube River in Hungary in 1993.

The quality of water of the flood-plain branches

The flood-plain branches accompanying the main branch of the Danube create a dense water network of 125 km along the right-side bank of the river at the Szigetköz reach between 1852 and 1806 running km, while the branches between Gönyű and Dömös has been modified to a great extent. Their water supply, the exchange of the water always depend on the running of the water of the main branch. When it is rising, the branches are being filled with fresh Danube-water and the surplus flows back into the main bed. When it is falling, the water remaining in the flood-plain is converting into back-water, certain part of it is running off. When the worst happens, the flood-plain waters changed in quality, flow back to the main branch by a further transfusion.

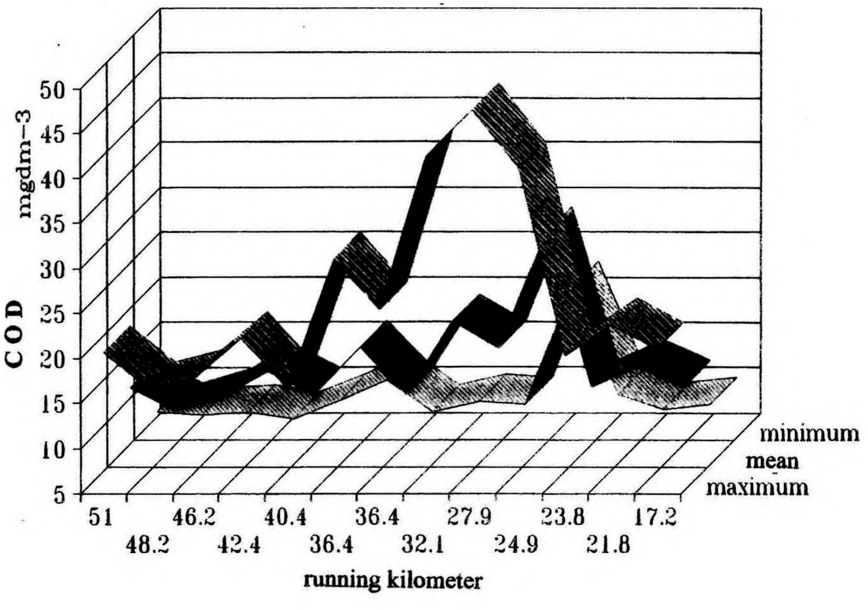

Figure 6: Annual, mean, maximum and minimum values of *chemical oxygen demand (* (COD) at 13 sampling locations in the flood-plain branches of the Danube (1852-1806 river km) in Hungary in 1993.

The inorganic and organic materials carried by the river will be formed through physical, chemical and biological processes as a result of the effects of different hydrological and morphological conditions. Among the nutrients coming with the Danube-water, the nitrate-nitrogen is used to a great extent and the average concentration of phosphate phosphorus is smaller than in the main branch. (Bartalis and Horváth, 1994). The high organic production in the water causes increase in the chemical oxygen demands (**Figure 6**).

CONCLUSIONS

On the 140 km long section of the Danube examined, the load of organic pollutants increases by more than 10 % while the oxygen content of water remained near to saturated level. The nutrient concentration in the river is sufficient to maintain highly eutrophic conditions in water. From the five branches examined of Danube, the Kenyérmezei Brook is the most polluted one, but we couldn't show the impact of the stream on the water quality of Danube. The impact can only be shown locally along the short section on the right bank of the Danube.

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THE METHODOLOGY USED FOR THE LONG TERM MONITORING OF WATERBIRDS IN A LARGE RIVER. THE DANUBE RIVER BETWEEN GÖNYŰ AND SZOB (river kms 1791-1708) IN HUNGARY, A CASE STUDY

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ABSTRACT

The Danube is crossing Middle Europe in a West-East direction, thus is bisects the migration route of a large proportion of the waterfowl. The section under examination has a middle type character with a large diversity of habitat. It's normally open water (in winter) can result a large concentration of waterfowl.

The study is continuing since 1982 with a regular monthly surveys. This paper present a 10 year analysis for the period of 1982-1992.

A long-term monitoring allows a meaningful analysis of species, habitats, communities, river sections and environmental factors as well the clarification of their interconnections.

The results thus obtained may be used:

- in the Hungarian Waterfowl Management Plan
- in the practice of nature conservation
- in the planning and practice of water management.

INTRODUCTION

Few countries in Europe posess less wetlands than Hungary. Since most countries have lenghty sea coasts or lake districts, therefore their rivers that are smaller than the Danube receive very little attention. Outside the countries of the Danube basin in Central Europe, "river oriented" research is also known in Poland. Luniak (1971) published an extensive study of the birds of the middle reach of the Vistula River. Weselowsky *et al.* (1984) considered the limnology of the same area along with the distribution and the size of the breeding populations of waders, gulls and terns. Lewartovsky (1989) studied the waterbirds and the impact of the cultivation of the flood plain on the fall migration in the Warta River. Andres *et al.* (1994) published the results of 15 year observations of the waterbirds on a 185 km reach on the River Rhine in Alsac, France. The average number of 105,000 waterbirds represents 13% of the waterbirds censused in France.

Undoubtedly, large rivers are important habitats for waterbirds and they need to be considered in the census and long term monitoring of waterbirds. Thus there is a need to develop a reliable methodology to monitor waterbirds. To this end an example of the methodology used in such a monitoring in the Danube River is presented. It is hoped this methodology can be adapted and used in other similar studies.

STUDY AREA

The river reach investigated comprises the first 83 river kilometers of the middle course of the Danube (Festetics and Leisler, 1971) which is strongly influenced by human culture, moreover from industry, heavy water traffic and river-bed dredging. The Danube flowing from the West to the East, its direction is perpendicular to that of bird migration going on from the North to the South. Tributaries from the North or South help birds to move to the Danube **(Figures 1 and 2)**.

Meteorological data of the towns Komárom and Esztergom indicate Atlantic-continental character of temperature and precipitation. Annual mean temperature: 10.4 °C, total precipitation: 522-549 mm. Due to mild winters, freezing-over of the Danube did not ensue in the period investigated, and icing occurred only in 2 or 3 winters.

Water-level data for the days of observations are presented according to gauge readings from the towns of Komárom and Esztergom.

Water quality was characterized on the basis of samples taken monthly in the Almásneszmély section (1751.8 km). Analyses were performed in the laboratory of the North

Transdanubian Inspectorate of Environmen Protection. The methodology of monitoring of water quality employed in this study is given by Horváth and Bartalis (this volume).

Figure 1: The Danube from the Black Forest to the Black See

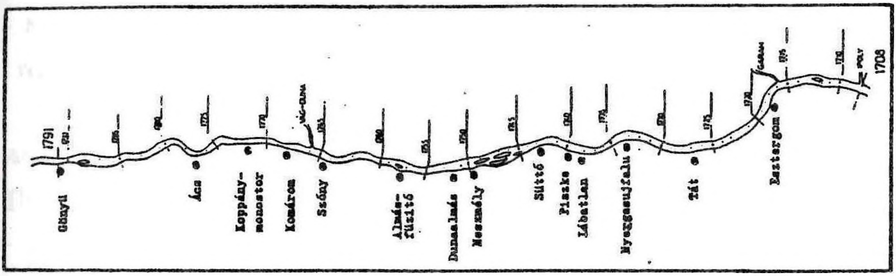

Figure 2: Investigated reach of the Danube between Gönyü and Szob (river km 1791-1708)

MATERIALS AND METHODS

Observations were carried out between October 1982 and April 1992 once per month from the ship "Kitűző VI" of the North Transdanubian Directorate of Water Administration. Observations were not conducted in June, July and August. During the 10 years of study 83 observations were made. The season, August-April was divided into 4 periods:

Early autumn period:	August - September	18 days of observation
Autumn period:	October - November	18 days of observation
Winter period:	December - January - February	27 days of observation
Spring period:	March - April	19 days of observation

Data analyses was performed according to river sections, water birds species and habitats. The data and its analysis are given in detail by Faragó (1996). Thus only the outline of the analysis and the major conclusions are summerized in the followings:

ANALYSIS ACCORDING TO RIVER SECTIONS

General data on water-bird communities:

- summed-up maximum of population numbers
- average maximum of summed-up population matrix
- mean total population numbers for each period
- mean total population numbers for the whole season (August-April)
- species with highest number of individuals in the respective area

Characteristics of water-bird communities in various periods:

- species richness
- total number of birds observed/species
- density of individuals (ind./5 km), and mass density (kg/5 km): D_e and D_t
- individual and mass dominance (%): DO_e and DO_t
- constancy (%): C
- diversity: H
- evenness: J
- community dominance index according to number of individuals and to mass, respectively (Krebs, 1978): KDI_e and KDT_t

The following are presented for the total period (August-April):

- species density rank curve (Moskát, 1988)
- dominance curve (Waliczky, 1992a).

Waterbird communities of each period, and the characteristics of various communities are compared by means of the following methods:

- Jaccard's species similarity index
- Sorensen's similarity index
- Hutcheson's method for comparing diversities.

Methods applied for comparing waterbird communities of various river sections:

- graphic comparison of parameters
- establishing order of rank in the individual periods and in the total season (August-April), respectively. On the basis of orders of rank: calculating rank numbers (so-called cumulative indices)
- defining species similarity by Jaccard's method
- establishing rank order of evenness; calculating rank numbers (cumulative indices)
- cluster analysis
- principal coordinates analysis (= metric multidimensional scaling.)
- Method used for defining connections between community structure parameters: linear regression analysis.

ANALYSIS ACCORDING TO SPECIES

The following factors were analysed and presented in the same way for each species:

- population dynamics (1): on the basis of summed-up results of the 83 kilometers covered by our investigations
- population dynamics (2): maximum, minimum and mean numbers of individuals observed per month
- average flock size in each period and in the total season, respectively
- habitat use (%)
- dispersion: total numbers of birds observed per km; number of observation days
- important Danube section with respect of migration and wintering of the species dealt with

ANALYSIS ACCORDING TO HABITAT

Characteristics applied for describing the main features of habitats:

- total number of individuals
- number of individuals per observation
- individual and mass dominance: DO_e and DO_t
- constancy (for each of the species observed)
- diversity
- evenness

Comparison of waterbird communities present in various habitats:

- graphic method
- method of rank order (cumulative indices)
- comparison of diversities by Hutcheson's method
- cluster analysis
- principal coordinates analysis (=metric multidimensional scaling).

SPECIFIED ANALYSIS OF OBSERVED WATERBIRD SPECIES

In course of the 10-year period of our investigations we observed 58 waterbird species within the Danube reach Gönyü-Szob.

Analysis of common species

Analysis of the 33 species bearing major importance is given according to the following points of view (shown by the example of *Anas platyrhynchos*):

- Population dynamics: referring to the investigated reach of the Danube, for the 10-year period of investigations long-term dynamics (**Figure 3**) and phenology (**Figure 4**) of each species were defined.
- Flock sizes: for each period separately and also for the total season. (**Figure 5**)
- Habitat use: for each period separately and also for the total season. (**Figure 6**)

- Dispersion: analysed on the basis of sightings per river km and on that of observed total numbers of individuals belonging to the respective species (**Figure 7**) as well as by means of the map drawn according to the data mentioned above. (**Figure 8**)
- Definition of status: after summing up the criteria listed above.

Analysis of rare species

For the 25 species appearing more seldom, besides faunistical data (habitat type, data and place of observation) also statements on habitat use and dispersion, furthermore maps showing the appearance of the respective species at the Danube are included in our report.

Evaluation of the avifauna

The zoogeographic evaluation - i.e. by classification according to faunatypes - clearly illustrate the changes of fauna during the course of various periods. Referring to the total season, share of arctic, holarctic and palearctic fauna elements amounted to 74.1 %. Together with old-world and cosmopolitan species their percentage was found to be as high as 93.1 %. The rest of fauna elements appeared only as interesting rarities in the waterbird communities observed.

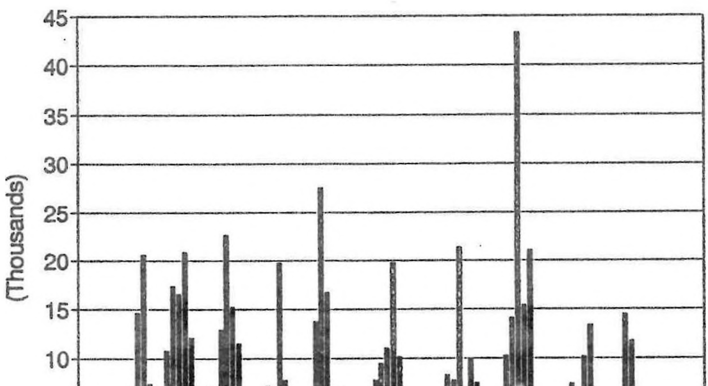

Figure 3: 10-year period of investigations long-term dynamics of *Anas platyrhynchos*

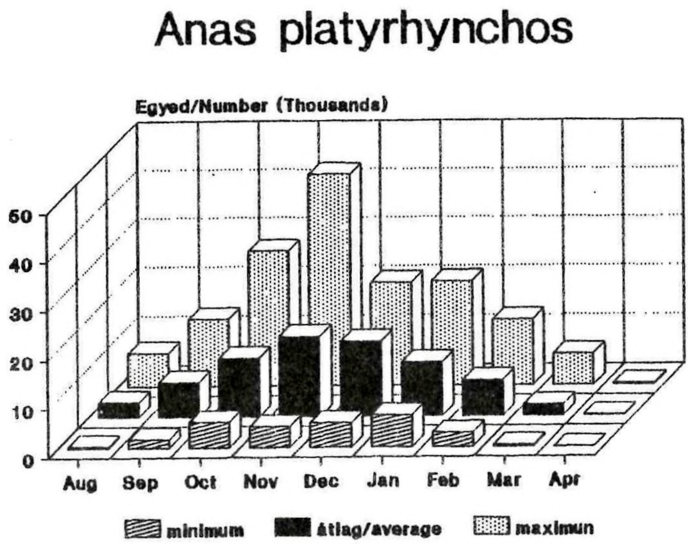

Figure 4: Phenology of *Anas platyrhynchos* on the Danube

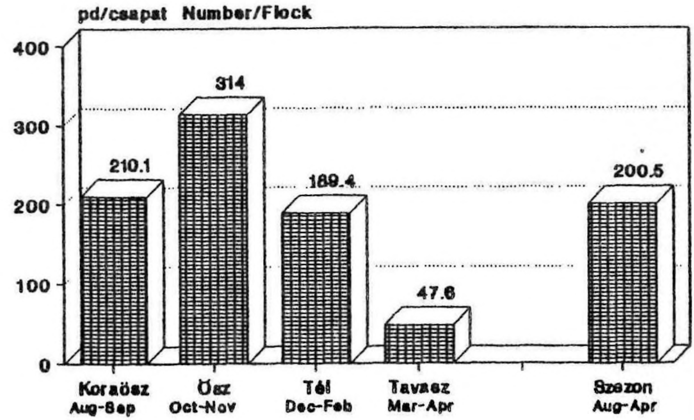

Figure 5: Flock sizes of *Anas platyrhynchos* for each period separately and also for the total season.

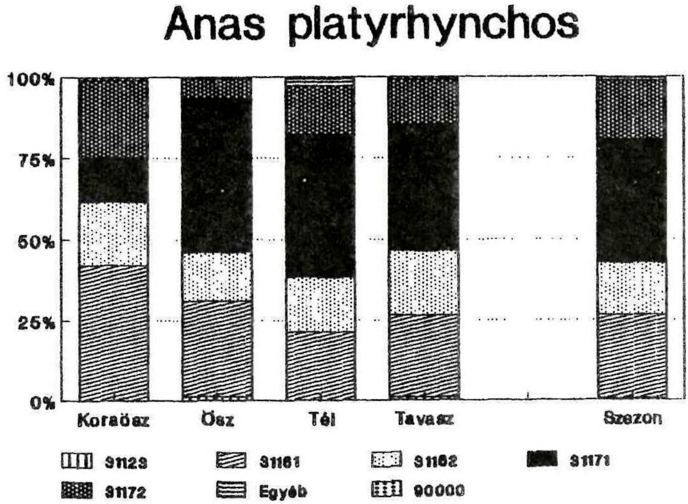

Figure 6: Habitat use of *Anas platyrhynchos* for each period separately and also for the total season.

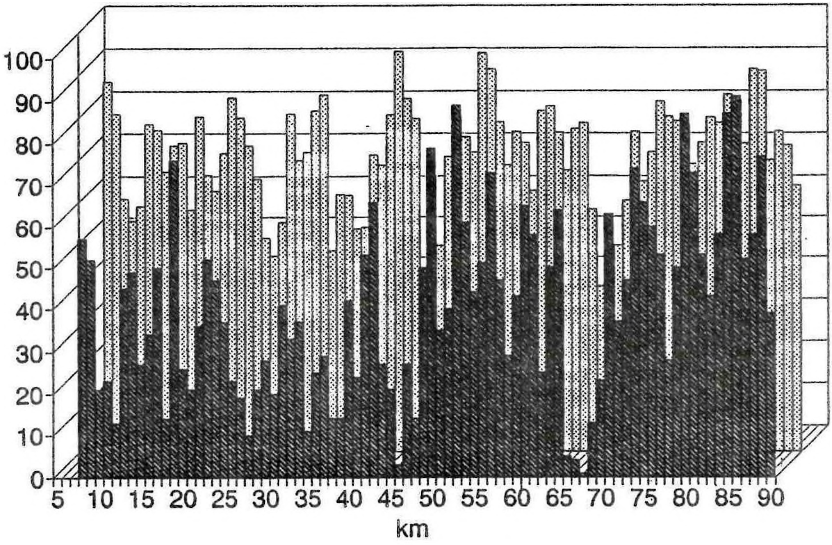

Figure 7: Dispersion of *Anas platyrhynchos* on the Danube analysed on the basis of sightings (number) per river km and on that of observed total numbers (on the figure 20 × ln number) of individuals.

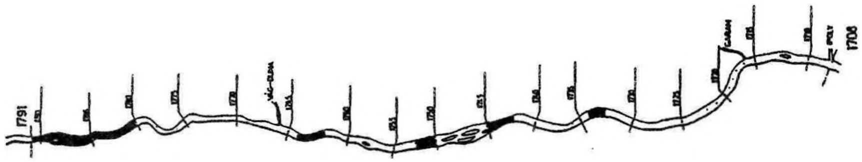

Figure 8: Dispersion of *Anas platyrhynchos* on the Danube.

Role of the examined Danube reach in waterbird migration. Evaluation of its significance

If the examined river sections with length of 5 km each are considered as units, the following can be stated: According to the latest values of the Ramsar criterion 3C (Rose and Scott, 1994), on the basis of great numbers of *Bucephala clangula* and *Mergus merganser* each of the examined sections - with the exception of the section at Komárom and the section Esztergom - must be considered to have international importance.

If the 83-km-long Danube reach that extends from the beginning of the middle course of the river to the clearly separated Danube bend is considered as unit, the results of our investigations prove the following : on the basis of quantitative criteria complied with by 4 species: *Anser fabalis, Anser platyrhynchos, Bucephala clangula* and *Mergus merganser* the Danube reach extending from Gönyü to Szob must be considered as aquatic habitat of international importance.

CONCLUSIONS

The data obtained by long term monitoring can be used for nature conservation and waterfowl managed either at a local or national level.

The monitoring site can be integrated into an existing national monitoring network (in this case the Hungarian Waterfowl Monitoring) as a representative of the region. It represents a given region, it provides migratory data of certain species for the data base. It will make possible to introduce nature conservation and waterfowl management on a regional basis.

The data base of a monitoring site make if possible to practice nature conservation, including restoration or habitat improvement, i. e. "wise use", that would be done based on correct observations.

The long term monitoring replaces the static view with a dynamic view that will dominate both nature conservation and waterfowl management.

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FLUCTUATIONS OF WATERBIRD NUMBERS WINTERING ON LAKE ATTERSEE (AUSTRIA): GLOBAL VERSUS LOCAL EFFECTS

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ABSTRACT

At lake Attersee (Upper Austria) waterbird census data (January) from 27 years were set in relation to local limnological and meteorological conditions and to the middle European trend of waterbird populations. Preliminary results obtained by applying multiple regression analysis show a relationship of local abundance related to global trend numbers at least in the case of the Tufted Duck (*Aythya fuligula*) whereas Pochard (*Aythya ferina*) numbers of lake Attersee show a possible link to local temperature situations. More data about feeding habitats are needed for explaining the fluctuations of wintering waterbird numbers on wintering sites.

INTRODUCTION

Migrating waterbirds are integrated elements of wetland ecosystems using a wide geographical area for their yearly life-cycle. In the non-breeding season and especially at wintering sites the distribution and abundance of waterbirds is mostly explained by size of the site, by availability of food resources, by the diversity of habitat structures and by the influence of human disturbances (Aubrecht 1992, Aubrecht and Winkler 1984, Eichelmann 1994, Eisner 1986, Musil and Salek 1994, Parz-Gollner 1989, Pykal and Janda 1994, Rauer 1989, Reichholf 1994, Suter 1991, Tuite *et al.* 1984).

Therefore wintering waterbird communities which use waterbound food resources are not distributed randomly on a site. Due to specific behavioral and morphological adaptations and to energetic demands they are only able to forage and roost in specific microhabitats which also determine the dominance structure of the waterbird community.

When the numbers of wintering waterbirds on a selected site are analysed, high fluctuations in the abundance of different species can be observed over the years (Aubrecht and Böck 1985). Such year to year differences have been widely explained by changes of site-specific parameters like habitat structure, extent and availability of food resources, local climatic conditions and disturbances but also by non site-specific parameters like breeding success in sometimes far distant regions and continental climatic conditions (Aubrecht *et al.* 1990, Ridgill and Fox 1990).

In the western palearctic region it proved difficult to get accurate numbers about the yearly breeding success of waterbirds. Therefore the census results of wintering birds (organized by IWRB) are commonly used to estimate overall population numbers and trends (Rose and Scott 1994, Rose and Taylor 1993).

This study focuses on an oligotrophic lake in the prealpine part of northern Austria where limnological parameters have been investigated (Moog 1989) and waterbird censuses have been carried out regularly (Aubrecht 1979, Aubrecht and Moog 1981, 1982). The dominant foraging guild of waterbirds in January is represented by diving ducks and coot. According to published and unpublished results the water quality of the lake is increasingly ultra-oligotrophic as indicated, for instance, by high Secchi-depths. Macrophytes (Aubrecht and Steiner 1979, Schröder 1982) and zebra-mussel (*Dreissena polymorpha*) (Aubrecht and Winkler 1984) grow in wide areas of the epilitoral and are harvested by waterbirds according to their diving depths. The observed stable limnological condition of the lake makes a high yearly variation in the abundance of macrophytes and zebra mussels unlikely, however this is not proved. At the study site no disturbances have been observed influencing the abundance of waterbirds in winter.

We hypothesize that at the study site the food resources within available diving depths are not limited. Limitations might occur in relation to the birds' energy demand when diving for food with limited nutrient contents at very cold conditions might become too costly for the birds' metabolic needs.

Furthermore, if the waterbird abundance is not limited by site-specific factors we suggest that an external factor (non site-specific) like the „global" central European population trend might additionally explain the variable population numbers on the study site.

We therefore put the question: Do waterbird numbers of certain species or the whole population at lake Attersee in January fluctuate annually according to local conditions represented by water quality (Secchi depth) and mean air temperature or according to central European waterbird population trends?

STUDY AREA AND METHODS

Lake Attersee is situated at the northern base of the Alps at 469 m and has an area of 4560 ha. More hydrologic and morphometric data of lake Attersee may be obtained from Moog (1989).

The waterbird community includes 23 species (dominant species are Coot, Tufted Duck, Mallard and Pochard) in January with a mean of 4808 individuals; maximum numbers (1990) were 10368 individuals.

Limnological data refer to Moog (1989) and Jagsch (pers. comm.) and meteorological data have been provided by Mahringer (pers. comm.). Distribution of macrophytes has been investigated by Aubrecht and Steiner (1979) and Schröder (1982). The occurrence of zebra-mussles has been discussed by Aubrecht and Winkler (1984). Waterbird census data from lake Attersee refer to Aubrecht (1978), Aubrecht and Moog (1981, 1982) and unpublished results of the International Waterfowl Census. The international trend data derive from analyses of P. Rose (IWRB). Imputed proportions of all middle European census data (Switzerland, South Germany, Czech Republic, Slovakia and Hungary) for trend analysis vary between 80743 (27,9%) and 329080 (33,1 %) individuals for *Aythya fuligula* and between 52058 (40 %) and 178258 (45,7 %) individuals for *Aythya ferina* (1970-1993). Until november 1994 only data for Tufted Duck (*Aythya fuligula*) and Pochard (*Aythya ferina*) were available.

The analysis was based on data from the years 1968 to 1994 and included Secchi depth (yearly minimum, mean, maximum); waterbird census data from January including ducks (Anatidae), grebes (Podicipedidae), divers (Gaviidae), coot (*Fulica atra*) and moorhen

(*Gallinula chloropus*), total sum of individuals, numbers of Pochard (*Aythya ferina*), Tufted Duck (*Aythya fuligula*), Goldeneye (*Bucephala clangula*), Mute Swan (*Cygnus olor*), Coot (*Fulica atra*); guild of fish foragers, guild of diving benthos foragers, guild of dabbling foragers; central European trend numbers for Tufted Duck and Pochard, mean air temperature measured at Weyregg am Attersee from all months, seasons and yearly mean.

Statistical analysis was carried out using standard multiple regression techniques.

RESULTS

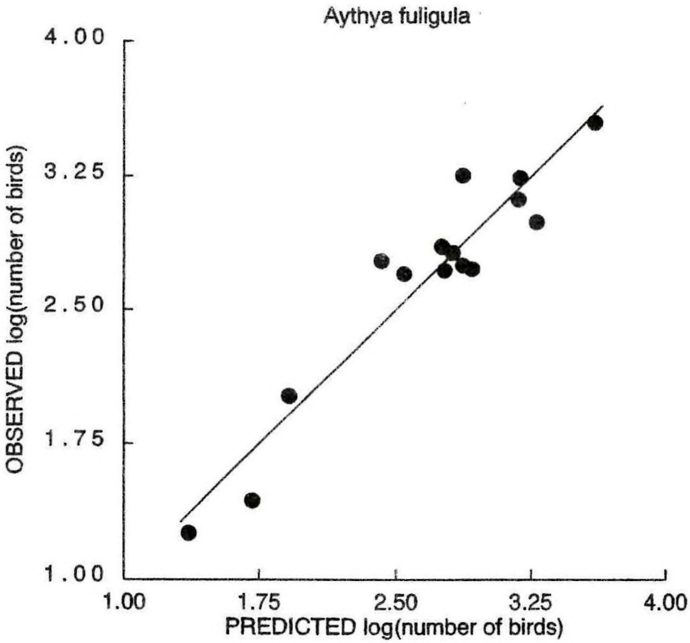

Figure 1: Observed log-numbers of *Aythya fuligula* and predictions derived from multiple regression analysis. Variables included were Central European trend, mean air temperatures in October and September and Secchi-depths. Multiple correlation coefficient is = 0.9 ($p<0.0001$, $F_{(4,10)} = 23.38$).

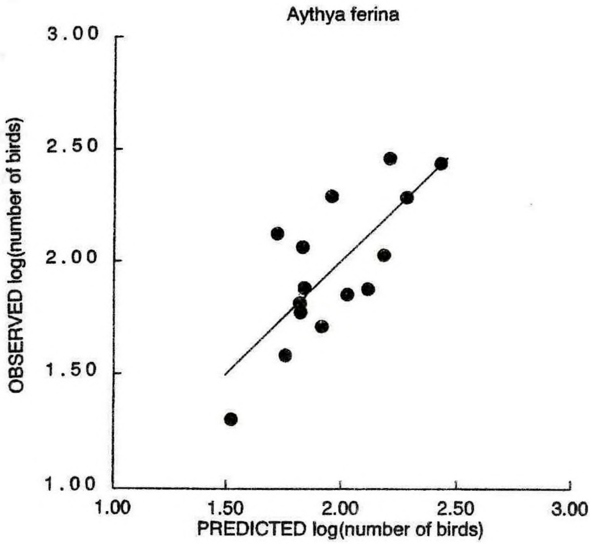

Figure 2: Observed log-numbers of *Aythya ferina* and predictions derived from multiple regression analysis. Variables included were mean air temperatures in August and autumn. Multiple correlation coefficient is 0.62 ($p<0.005$, $F_{(2,12)} = 9.87$).

Multiple Regression Analysis shows that the global (Central Europe) trend alone explains about 64% of the total variance in the count data. When local effects, namely Secchi-depth, and air temperatures in September and October are also included, about 90% of the total variance is explained.

Thus, we conclude that large scale events are mainly responsible for the number of Tufted Ducks (*Aythya fuligula*) observed at lake Attersee.

In Pochards (*Aythya ferina*) only local effects exist. Mean air temperature in August and in the autumn explain together 62% of the total variance.

DISCUSSION

Lake Attersee has been investigated limnologically and ornithologically so that interdisciplinary analysis should be possible. A closer look at available habitat factors shows that we still lack comparable long-term data about litoral habitats which contain the main food resource for wintering waterbirds. So we can only refer to macrophytes according to distribution and density during one year, but not in the term of biomass, nutrient contents or even trends. Concerning the zebra mussel we have only qualitative observations. Therefore we are only able to discuss ecological relationships in testing hypothesis but for modelling ecological relationships we lack important factors.

Even within a close geographical area results of studies about the exploitation of benthic food resources by diving waterbirds vary widely. Reichholf (1994) reports a consumption up to 85 percent of the available benthic fauna when biomass density is high on the Lower Inn reservoirs whereas the studies of Eisner (1989) at the Lower Enns reservoirs show that the food requirements of waterfowl was always under 1 % of the standing crop.

There are studies showing that the influence of disturbance by hunting, fishing or just the presence of man explains a high amount of abundance variability (Eisner 1989, Reichholf 1994, Tuite *et al.* 1984).

The geographical site situation (Aubrecht and Böck 1985), abundance and diversity of food resources and habitat diversity relate to waterbird species numbers and the guild structure and dominance structure of the waterbird community (Aubrecht 1992, Bezzel and Engler 1985, Suter 1991). Shifting of the guild structure can be explained by the change of the above mentioned site-specific factors. But the explanation of the high variability of long-term and year to year changes in the abundance of waterbird populations on specific sites is still a problem (Bezzel and Engler 1985). Large scale weather conditions and the related changes of waterbird numbers across wide geographic areas are very difficult to explain because of the many factors involved (Ridgill and Fox 1990). Therefore the actual „global" trend numbers of waterfowl populations which for discrete geographical areas like central Europe are only available now may represent an important factor for explaining local waterbird abundances when other factors seem not to explain the variability of abundance. Our preliminary results at lake Attersee show a relationship of local abundance related to global trend numbers at least in the case of the Tufted Duck. For the Pochard which uses lake Attersee preferably in the months before January, and the presence of which in January is more variable, such relations could not be found. Results show a possible link to local temperature situations. This indicates that an analysis of the temperatures at other important sites should prove to be interesting. It will be necessary to examine more species and to find a way for regularly monitoring the abundance of benthic organisms in the epilitoral of the lake (Herzig and Pokorny 1994).

By understanding the site-specific and non-site-specific factors regulating waterbird abundances we will be able to use waterbirds as indicators for wetland monitoring and the interpretation of ecological changes in these ecosystems.

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MONITORING OF WATERBIRD HABITATS IN SALINE WETLANDS OF SOUTH-EASTERN SPAIN. GUIDELINES FOR THEIR MANAGEMENT

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ABSTRACT

During a study made in 1987-88 on waterbird use of saline wetlands of SE Spain, it became evident that under current management regimes, much wetland surface and resources were unusable for a large number of species. While it seemed worth preserving large tracts of particular wetland habitats, for those favouring deep or highly hypersaline waters (e.g. Black-necked Grebe, Shelduck, Red-breasted Merganser, Avocet, Flamingo), it also looked essential to maintain particular structural and functional features, favoured by other bird groups -namely waders, and to reproduce these in managed sites. Recently, the environmental office of Murcia Region (Consejería de Medio Ambiente) has started a more detailed ornithological monitoring programme of particular habitats, most of them belonging to protected areas, and some managed directly by it, focusing on both waterbird use and features tied to management opportunities. Many different situations are found, ranging from almost natural functioning of wetlands, to conservation or industrially-oriented artificial management. Among the latter, of special importance are the salinas, submitted to different levels of human use. In the active industrial ones, bird use can be prevented by too high water levels and loss of structural quality. Traditional salinas prone to abandonment, and small unused surfaces inside industrial ones, provide a experimental field for habitat management solutions. All the experience gained during natural and man-made active wetlands' monitoring, can be incorporated in restoration projects of actually abandoned and derelict salinas and other degraded wetlands. The main preliminary results of this monitoring programme are presented and discussed, as a contribution to the adjustment of current management to these findings. Particular attention is

paid to the complementary or alternative role that newly created or restored wetlands can play under unfavourable conditions in natural or industrially managed ones.

INTRODUCTION

Murcia Region's coastal wetlands are located in the semiarid south-eastern corner of the Iberian Peninsula. There, lack of permanent freshwater courses, low rainfall, and high evaporation rates lead to predominantly saline conditions. Many basins have hydrological connections with the sea, through groundwater seepage, surface channels, or both. Surface connections have been modified historically by man to favour salt production or to facilitate the capture of migratory fish (Robledano and Esteve, 1992).

Studies made in 1987-88 (Robledao *et al.*, 1993) revealed that the highest waterbird densities recorded in these wetlands were usually associated with high benthic or planktonic biomass, in habitats receiving fresh or seawater, nutrient rich inflows. It was also evident that physical characteristics rendered unusable large sections of wetlands of high trophic biomass. Only a few species were able to exploit efficiently the extensive open water surface of some saline wetlands, particularly large lagoons and industrial salinas: specialized feeders like Flamingo, generalist, salt tolerant ones like Shelduck, diving species (Red Breasted Merganser, Black-necked Grebe), and large waders like Avocet. In summer these are joined by other waders and seabirds finding suitable nesting habitats in natural and industrial saline wetlands (Britton and Johnson, 1987).

A monitoring programme, started in 1993 and fully implemented in 1994 by the regional environmental authority (Consejería de Medio Ambiente, CMA) tries to evaluate these effects in more detail, by studying waterbird dynamics in response to water level changes and flooding regimes, particularly in man-made wetlands. This programme is co-financed by the European Union through LIFE-Nature funds.

STUDY AREA AND DATA COLLECTION

All the sites studied lie around the Mar Menor lagoon, a large (135 km^2), relatively deep (mean 4 m), slightly hypersaline lagoon. Their main characteristics are summarized in **Table 1**, and their location shown in **Figure 1**. Two types of data were collected:

Bird censuses: Counts of waterbirds were made periodically along pre-established itineraries, covering fixed areas representative of each wetland type. Some counts concerned only waders, a group given special attention since it was thought to be particularly responsive to water level changes, whether natural or man-induced.

Wetland status: The flooding status of each wetland was recorded on each visit, noting both natural trends and unusual changes in water levels. Levels were monitored precisely only in the Interpretation Pond, created by the CMA for endemic fish reintroduction and now devoted to nature interpretation by visitors. Water is supplied continuously by an experimental fish-farm, and levels can be controlled by regulating the outflow. The marsh is a by-product of pond flooding, and has proved to be a valuable nesting area for waders. Monitoring aims at developing a management model for both sites.

Table 1: General characteristics of the wetlands studied. In the columns marked with an asterisk, (*) the figures in brackets show the proportion of area available to at least one species of wader, used in the calculation of bird density. This criteria (<30 cm deep) was not applied to the smaller wetlands, where deepwater habitats do hardly occur.

Site type	Wetland Total area (ha)	Area censused 1987-99*	Area censused 1993-94*	Wetland characteristics
A. Golas (Coastal lagoon opening to sea)	166	130 (34.4)	86 (58)	Mudflats shallows and islands cut by deeper channels
B. San Pedro Del Pinatar (Industrial salina)	463	321 (202)	294 (200)	Large evaporation and precipitation ponds
C. Marchamalo (Small traditional salina)	52.52	52.52	52.52	Small evaporation and precipitation ponds
D. Rasall (Small traditional salina)	17.42	17.42	17.42	Large evaporation and precipitation ponds
E. Interpretation Pond (Restored saltpond)	8.3	-	-	Irregular pond with some islands filled with seawater
F. Interpretation Marsh (Flooded saltmarsh)	1.8	-	-	Saltmarsh flooded by seepage from Interpretation pond

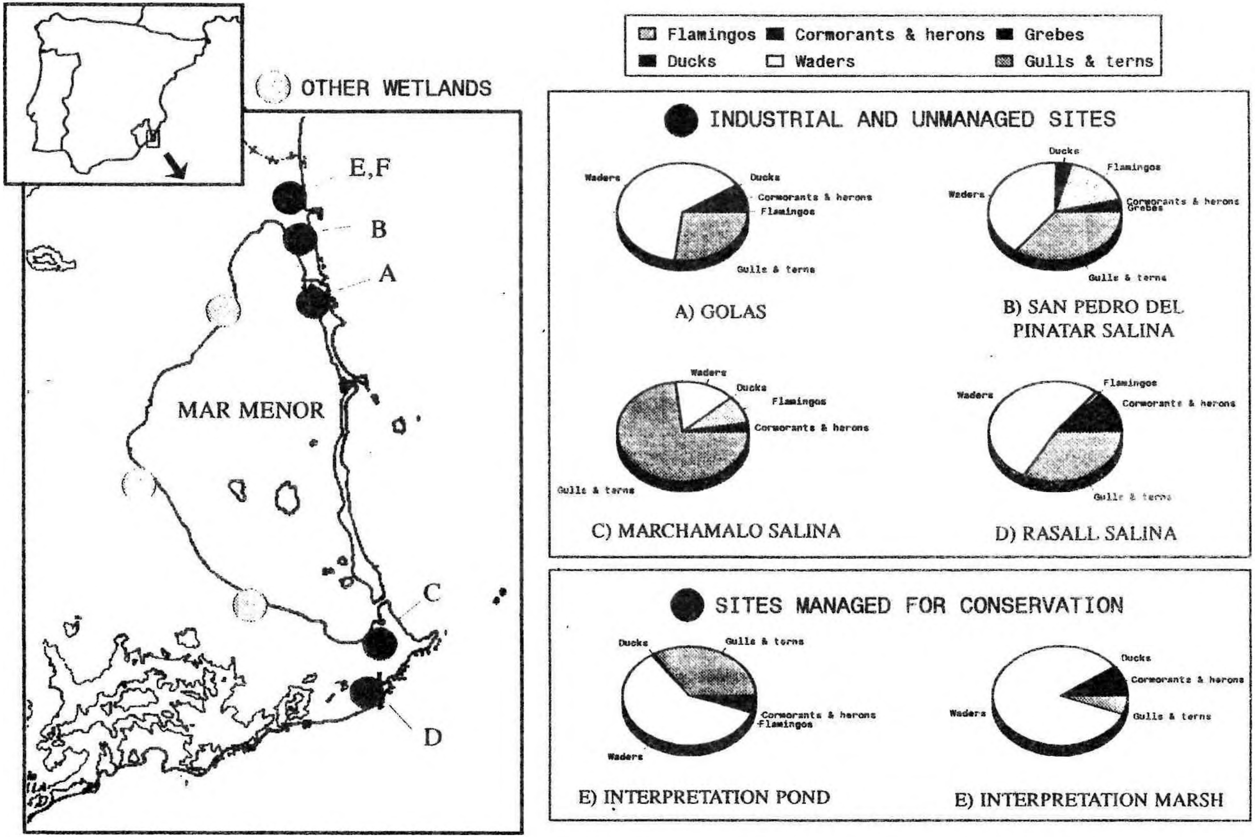

Figure 1. Location of the wetlands studied around the Mar Menor Lagoon. The average composition of their waterbird communities is shown in the pie charts, based on monthly censuses during a year cycle (October 1987-September 1988) in the industrial and managed sites, and on fortnightly censuses made between January 1993-October 1994 in the sites managed for conservation.

At present, the two small traditional salinas undergo irregular level changes as a result of rainfall and intermittent pumping, a consequence of its marginal role in the salt market. In 1994 pumping ceased at all in Marchamalo for some months, being lately re-flooded. In the Golas, water levels -and consequently the area of exposed mudflats- vary in relation to flows between the lagoon and the sea, with a general yearly pattern and unpredictable short-time changes.

RESULTS AND DISCUSSION

Waders were dominant in all sites except in the small Marchamalo Salinas. Only the larger salinas, especially the industrial ones, were used significantly by Flamingos, Ducks and Grebes (**Figure 1**). These groups comprise most of the species previously referred to as typical of coastal saline wetlands.

Golas represent a particularly good habitat for waders -like other Mediterranean coastal areas submitted to aperiodic water fluctuations (e. g. Britton, 1985; Martinez-Vilalta, 1985; Britton and Johnson, 1987), provided that water levels are low, as it occurred in November 1987, January and September 1988 (**Figure 2, a**). Piscivorous birds also favour this fish-migration corridor. The industrial salina of San Pedro del Pinatar has usually lower wader numbers and densities than the adjacent Golas. Wader numbers increase in the salina when high water prevails in the Golas, but it seems that only a fraction of the birds apparently displaced can find suitable conditions in the salina (**Figure 2, a**).

The small Rasall Salina and the Interpretation Marsh are also better habitats for waders in terms of density, compared to the Marchamalo Salina and the Interpretation Pond, as shown by 1993-94 data (**Figure 2, b**). Its physical structure, with abundant shallow zones and high shoreline/area ratio, can explain this fact. In the pond-marsh system, water level was fairly constant in 1993, being lowered in the spring of 1994 (other level changes were incidental) to coincide with one of the peaks of wader migration. This had little influence on wader density in the pond, and it is not clear to what extent it favoured the increase recorded in the marsh in April. It is evident, however, that high water levels due to strong rainfall in early spring and autumn 1994 greatly reduced the use of the pond and marsh with regard to 1993 (**Figure 2, c**).

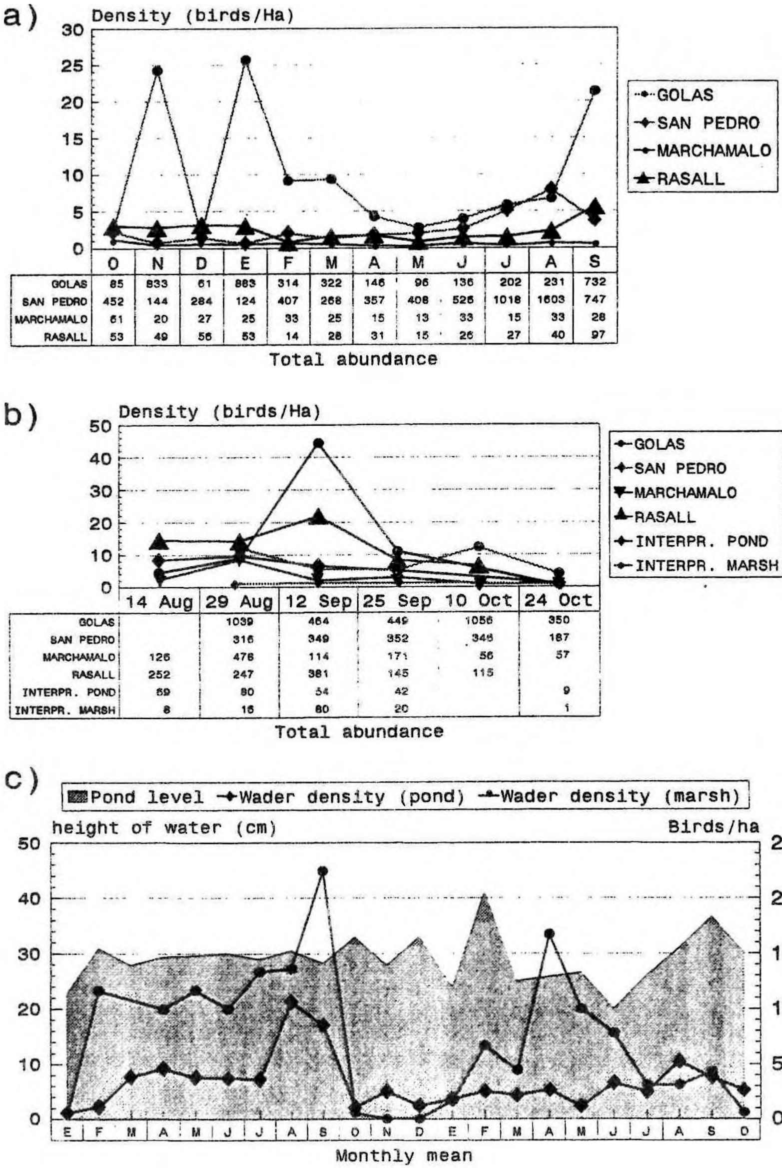

Figure 2: Changes in wader density in different wetland sites during three monitoring schemes: a) the monthly survey of 1987-88; b) a 1993 fortnightly survey of autumn migration; and c) the monitoring of wader density and water level changes in the interpretation pond and marsh since January 1993.

Thus, small wetland surfaces of no economic significance can have an outstanding importance for waders and other waterbird groups, not dealt with here in the same detail. Using 1993 autumn data to compare sites, the industrial salina hosted only 18.7% of the total number of waders counted, despite it contributes a 58% of the theoretically available surface, a feature shared with other large Mediterranean active salinas, where high water levels leave only small usable surfaces (Britton, 1985; Baccetti *et al.*, 1991). If we exclude the Golas, where hydrological management is not feasible, the remaining wetlands, representing only 24% of the available surface (85 ha), were used by a 30.9% of the birds recorded. By properly managing these wetlands, and restoring other drained and degraded sites, the carrying capacity of the whole wetland system could be raised.

In conclusion, while other bird groups seem well adapted to present management regimes, at least in the larger wetlands (industrial salinas and the Mar Menor Lagoon), conditions for waders can be improved by:

- Preserving preferred natural habitats (Golas) against reclamation and disturbance (e.g. by clam-collectors, amateur fishermen, walkers and swimmers)
- Creating or restoring small wetlands, independent of industrial management, where suitable physical conditions can be reproduced and maintained. Small traditional salinas of marginal activity could be managed for this purpose.
- Maintaining a mosaic of different conditions, through the management of these sites, able to maximize bird diversity at the scale of wetland complex, and to provide alternative suitable habitats when conditions deteriorate locally
- Developing management models for newly created or restored wetlands, that maximize prey abundance and its availability to waders (Rehfisch, 1994), while taking into account the needs of other taxa.

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AQUATIC BIRD CENSUSES IN THE PARQUE NATURAL DA RIA FORMOSA

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Situated in the south coast of Portugal, the "Parque Natural da Ria Formosa", is the second most important wintering area for the aquatic birds in country. It is a 60 km long lagoon system, stretching between the peninsulas of Ancao and Cacela. It consists of a barrier of five narrow, sandy islands, lying parallel to the coast and protecting the lagoon from the ocean.

The study area includes channels, salt marshes, salinas, tidal flats, islets, dunes, beaches, grassland, agricultural area and freshwater ponds, a total area of 18.400 ha. Like most wetlands, it is a natural area which is characterized by a high degree of ecological diversity and for this reason it is included in the list of sites recognized under the Ramsar Convention on Wetlands of International Importance.

The study area has been visited since 1991, 10 days a month, during the high tide, by car and by boat, covering approximately 95 % of the whole area. During the survey 67 bird species were recorded. According to the IWRB criteria, the area is of international importance, because it supports more than 1 % of the European total population for 6 species during the breeding season: *Egretta garzetta, Himanopus himantopus, Charadrius alexandrinus, Glareola pratincola, Porphyrio porphyrio* and *Sterna labifrons*.

It is an important wintering area, with particular emphasis to 13 species of birds from northern and central Europe: *Platalea leucorodia, Himantopus himantopus, Recurvirostry avosetta, Charadrius hiaticula, Charadrius alexandrinus, Pluvialis sqatarola, Calidris alpina, Limosa limosa, Limosa lapponica, Tringa erythropus, Tringa totanus, Tringa nebularia, Arenaria interpres* and some species of *Anatidae*. It is also an important resting place for migrants flying from northern Europe to Africa.

If we take the total national data of 1993 January as a reference, the more abundant species are: *Platalea leucorodia* (78 %), *Anas penelope* (55 %), *Anas strepera* (25 %), *Aythya fuligula* (48 %), *Aythya ferina* (33 %), *Fulica atra* (17 %), *Porphyrio porphyrio* (90 %), *Haematopus ostralegus* (62 %), *Himantopus himantopus* (58 %), *Charadrius alexandrinus* (70 %), *Calidris alba* (78 %), *Limosa lapponica* (76 %).

One of the most important part of the Nature park is undoubtedly the Nature Reserve of Ludo, which includes a great diversity of habitats in a small area; forest, agricultural areas, freshwater and salt-water ponds, salinas and salt-marshes, representing an important resting and feeding place for migrant or wintering birds. It also gives shelter to species which rare in Portugal, as *Porphyrio porphyrio*, that has there the only confirmed breeding place in the country. The community of breeding species also includes *Egretta garzetta, Ixobrychus minutus, Ardea purpurea, Ciconia ciconia, Gallinata chloropus, Fulica atra, Porzana pusilla, Tachybaptus ruficollis, Ralus aquaticus, Anas platyrhynchos* and *Anas strepera*.

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MONITORING WATER BIRDS BREEDING POPULATIONS IN CZECH REPUBLIC: AIMS, METHODS AND PERSPECTIVES

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Intensive waterfowl monitoring programmes have been carried out in the Czech Republic (former Czechoslovakia) already for several decades. The oldest programme, i.e. International Waterfowl Census, have been organised during each winter since 1965. The rapid decline in number of many waterfowl species (especially ducks) which was recorded during the first half of the 80s, stimulated the initiation of programmes aimed at the investigation of breeding waterfowl population, such as Monitoring Water Birds Breeding Population by Two-check Method (national programme started in 1988) and Monthly Counts (in some regions, since second half of the 80s). In several regions, exact breeding pairs survey have been pursued annually since 60s, 70s respectively.

Specialised programmes aimed at particular waterbird groups, such as Ciconiforms, Storks, Geese, Mute Swan, Waders also exist in the Czech Republic.

Comparisons of results of particular monitoring programmes show that the widely used census methods (e.g. Two-check Method or Monthly Counts) give only relative data on numbers of particular water bird species. The largest underestimation of species abundance is typical in species which show hidden live habit (e.g. Little Grebe, Rallidae, Passerines). However, no significant differences were found between trends in numbers or/and the community (quild) structure recorded by the Two-check Method and by the direct breeding pairs survey.

Data on population changes obtained by Monitoring Water Birds Breeding Population by Two-check Method in 1988-94 are presented in graphs.

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WATERFOWL IN WETLANDS OF POYANG LAKE OF CHINA AND LANDSCAPE ECOLOGY INFORMATION SYSTEM

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Poyang Lake, the largest freshwater lake in China, situated in the northern part of Jiangxi province and the middle and lower reaches of the Changjiang River, is a typical shallow lake with great seasonal variation in water level. Its mechanism of formation and evolution possesses a unique style with distinct physic-chemical property of lake water, special local aquatic animals and plants and unusual types and distributions of lake sediments. There are 258 species of waterbirds. In winter and spring the surface of the water is being covered with numerous waterbirds. The migratory birds reserve covers an area of 22.400 hectares.

The Landscape Ecology Information System of the migratory bird reserve (PRIS) is a regional geographical information system based on the spatial structure combined with island-like polygon of the dykes, to provide multi-source, multi-level, renewable basic data and applied analysis model for forecasting environment changes and waterfowl protection.

The PRIS consists of a database system and a database update system. The interface between the DBS abd DBUS is responsible for providing the DBS with real-time and dynamic information to maintain the present situation. The interface between the DBS and MBS is responsible for providing the MBS with necessary information and collecting useful data processed by the MBS.

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FEATHER MINERAL CONTENT OF REDHEADS (*Aythya americana*) WINTERING ALONG THE GULF OF MEXICO

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ABSTRACT

To evaluate the potential use of mineral content as a marker for identifying origins of wintering Redhead ducks along the coast of the Gulf of Mexico, we determined concentrations (ppm) of calcium (Ca), copper (Cu), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na), and zinc (Zn) in wing feathers by atomic absorption spectrophotometry (AAS). Samples available for study included pairs of whole wings from Texas saltwater habitat (n = 653 birds), Florida saltwater habitat (n = 287 birds), and South Dakota pond habitat (n = 34 birds), and pairs or single secondary feathers from Louisiana saltwater habitat (n = 287 birds) and Texas pond habitat (n = 2257 birds). We found no differences between secondary feathers from the left and right wings from the same individual, but secondary feathers did differ from primaries from the same individual in Mg and Zn. Concentrations of Ca were higher ($P \leq 0.05$) in flight feathers of juveniles (< 1 yr of age) than in those of adults. Feathers from females had higher ($P \leq 0.05$) Zn than those from males among both adults and juveniles. Concentrations of Ca and Zn in feathers of Texas pond birds were higher ($P \leq 0.05$) than concentrations in feathers from Redheads from other geographic areas sampled. Magnesium from feathers of birds taken in Texas ponds and Louisiana saltwater habitat was higher ($P \leq 0.05$) than in feathers of Redheads from the other three areas. Zinc concentrations in feathers of birds from Texas ponds were higher ($P \leq 0.05$) than those in feathers from Louisiana birds, and Zn in feathers from birds from both of those sites was higher ($P \leq 0.05$) than in feathers from

Redheads from the other three areas. Because of the extremely high variability in mineral concentrations of Redhead feathers as determined by atomic absorption spectrophotometry, use of this technique to identify geographic origins, if based on the elements used in this study, is too uncertain to be reliable.

INTRODUCTION

Knowing the origins of wintering populations of migratory waterfowl facilitates the design of strategies for population management and habitat conservation. Many species of North American waterfowl show relatively broad patterns of movement from extensive breeding areas throughout the prairies or tundra to equally dispersed wintering areas (see Bellrose 1980). Redhead ducks (*Aythya americana*) are unique because approximately 78% of all Redheads in North America winter on the lower Texas and upper Mexican coast and yet come from two strikingly different breeding areas: the prairie pothole region of the northern United States and Canada, and the Great Basin population of Utah and Nevada (Weller, 1964; **Figure 1**). Other smaller populations winter along the Gulf of Mexico in the shallow waters of Chandeleur Sound, Louisiana, and Apalachee Bay, Florida (**Figure 1**), and probably originate in the eastern prairie pothole region (Bellrose, 1980).

A traditional method of tracing waterfowl origins and migration routes is with banding (Nichols and Hines 1987) or the use of alternative methods of marking individuals, such as neckbands or nasal markers. Banding works efficiently, however, only when large numbers of birds from breeding or molting areas can be banded and then recovered in some proportionate manner on migration and wintering areas. Data depend on recovery of bands by hunting, which is virtually nonexistent in some wintering areas (e.g., Chandeleur Sound of Louisiana and the gulf coast of Florida), or which is temporally and spatially biased (Conroy and Blandin, 1984; Nichols *et al.*, 1991). Another method of determining bird origins is to identify populations by morphological differences (e.g., James, 1970; Haberman *et al.*, 1991). Disjunct wintering Redhead populations from Texas and Louisiana showed no significant morphometric differences (M.C. Woodin and T.C. Michot, unpubl. data).

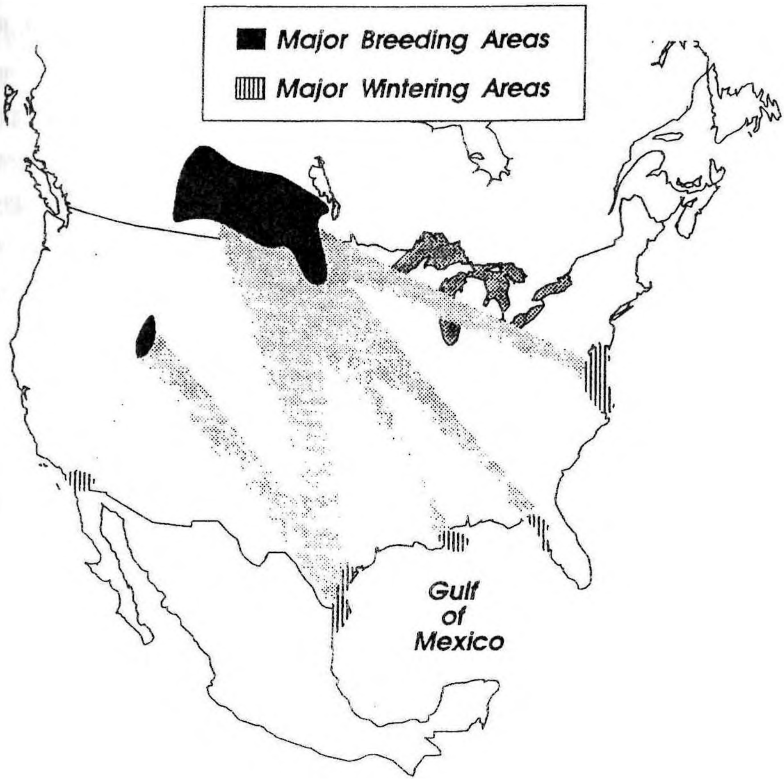

Figure. 1. Map showing general distribution of breeding and wintering areas of the Redhead duck (after Bellrose 1980).

Mineral composition of bird feathers has also been used to determine geographic origins of migratory birds. Hanson and Jones (1968, 1976) used optical emission spectrophotometry of feather minerals to trace origins of Snow Goose (*Chen caerulescens*) populations and subsequently validated the technique by experimental feeding of captive Canada Geese (*Branta canadensis*) (Jones *et al.*, 1987). Kelsall and Burton (1977, 1979), using x-ray emission spectrophotometry, demonstrated sexual differences in feather mineral content and indicated that a sample of at least 40 birds was necessary to represent a population of snow geese and eliminate bias of sex and perhaps age variability.

From 1986 until 1991, during cooperative and overlapping studies of Redheads wintering along the Gulf of Mexico, we had an opportunity to obtain feathers and wings from ducks trapped or collected from the three primary wintering areas along the gulf coast. Despite the possibility that these wintering populations might prove to be mixed pools impossible to identify and classify by origin, a sample of such size and distribution provided a unique opportunity to apply atomic absorption spectrophotometry (AAS) to investigate mineral composition among age, sex, and feather groups and to examine mineral composition patterns related to habitat use.

Objectives of the study were to (1.) Examine differences in feathers or feather groups that might influence accuracy of the AAS technique; (2.) Assess variability in mineral content of feathers of Redheads from different sex and age classes; (3.) Determine if Redheads from three different wintering populations (Texas, Louisiana, and Florida) could be separated based on feather mineral content; and (4.) Compare mineral content of feathers of Redheads according to wetland salinities on their respective ranges.

MATERIALS AND METHODS

Study Areas and Sampling of Populations

Redheads which had been collected for other studies were available from winter ranges in Texas, Louisiana, and Florida, and from within their breeding range in South Dakota. In Texas, Redheads were sampled from two types of wetlands in adjacent study areas (Adair, 1990). Redheads occupying coastal brackish ponds (3-13 ppt) near Corpus Christi were sampled, as were birds from nearby saltwater habitats. All Redheads which used coastal ponds also used saltwater habitats, traveling daily to the ponds after feeding in salt water (Woodin, 1994; Mitchell *et al.*, 1992). Saltwater habitats from which birds were available were the frequently hypersaline (39-48 ppt) Laguna Madre and the normally saline (22-41 ppt) Redfish Bay. Ducks in the ponds were live-trapped, banded, and released (Moore, 1991), and thus only secondary wing feathers could be removed. Birds taken in the Laguna Madre and Redfish Bay were shot for feeding ecology studies, and thus both wings were often available. In Louisiana, sampling likewise occurred in connection with food habits studies in the shallow brackish to saline waters (17-30 ppt) of Chandeleur Sound (Michot and Nault 1993, Michot *et al.* 1994), and secondaries were collected to match studies in Texas. In Florida, all birds were collected for food studies in brackish to saline waters (12-38 ppt, T. C. Michot, unpubl. data) of Apalachee Bay, and one or both wings were available for study. Collection of Redheads from mostly freshwater marshes (< 1-2 ppt) of Day County, South Dakota, was associated with studies by Woodin of other natural tracers; hence, wings were available. Thus, our five study sites comprised a wetland salinity gradient from low to high salinities, which we categorized as follows: (1.) South Dakota pond; (2.) Texas pond; (3.) Louisiana saltwater; (4.) Florida saltwater; and (5.) Texas saltwater habitats. According to Cowardin *et al.* (1979), these sites are classified respectively as (1.) palustrine fresh-mixosaline emergent wetlands; (2.) palustrine mixohaline emergent wetlands; (3.) estuarine polyhaline aquatic bed habitat; (4.) estuarine mixohaline-euhaline aquatic bed habitat; and (5.) estuarine hyperhaline aquatic bed habitat.

Samples available for study included pairs of whole wings from Texas saltwater habitat (n = 653 birds), Florida saltwater habitat (n = 287 birds), and South Dakota pond habitat (n = 34 birds), and pairs of secondary feathers from Louisiana saltwater habitat (n = 287 birds) and Texas pond habitat (n = 2257 birds). Based on plumage (Weller, 1957; Dane and Johnson, 1975) and cloacal characteristics (Kortright, 1943), feathers from ducks collected in fall and winter were classed as juveniles (young-of-the year) or adults, and those taken in spring in breeding areas (South Dakota) were classed as yearlings or adults.

Chemical Analysis

To evaluate the potential use of mineralization as a natural marker for identifying origins of wintering Redhead ducks along the Texas gulf coast, we determined the concentration (limit of detection = 0.01 ppm) of Ca, Cu, Mg, Mn, K, Na, and Zn in feathers of Redheads from Texas (n =40) and Louisiana (n = 40). Minerals chosen for analysis were based on those used successfully in published studies (e.g., Jones *et al.*, 1987), configuration of available AAS equipment, and preliminary testing with feathers. Initial testing of Redhead feathers revealed that Cu and Mn concentrations were too low to be reliably detected;

concentrations of Cu and Mn were <0.01 ppm in all 80 samples tested. We consequently removed Cu and Mn from the list of minerals to be analyzed. Secondary feathers or whole wings were randomly selected from the pool of samples available from each geographical site for the different sex and age classes. Feathers were identified by sample number, primary or secondary, left or right wing, and sex and age. Samples were cut at the shaft into 2- to 3-cm lengths (calamus discarded; see Altmeyer *et al.*, 1991) and placed in an ultrasonic cleaner (Model SF-9, Fisher Scientific, Pittsburgh, PA) designed to hold eight 30-ml beakers. Successive 5-minute washes were used on all feathers as follows: 1:1 acetone:carbon tetrachloride solution, ultrapure water, and acetone.

Mineral concentrations (ppm) were determined in feather samples by flame AAS (Varian, SpectrAA-20, Palo Alto, CA). Samples were prepared for analysis by using a dry-wet-dry ashing procedure (Helrich, 1990). Laundered samples were weighed in dry porcelain crucibles and oven-dried (120^0 C) for 2 hours. Dry matter was determined, and crucibles with dried samples were burned in a muffle furnace (550^0 C) for 2 hours, removed, and allowed to cool. Samples were moistened with ultrapure water, then nitric acid (9 *N*), and gently heated on an electric hotplate to evaporate the liquid until only residual moisture remained. Crucibles were returned to the muffle furnace for an additional 1 hour, removed, and allowed to cool. Ashed samples were solubilized in 6 *N* hydrochloric acid and brought to volume with ultrapure water to obtain a ratio of 1:5 acid:water. Appropriate dilutions were prepared to bring mineral concentrations to reading ranges within AAS standards. We employed quantitative minimum acceptable performance criteria for the AAS based on regression analysis of calibration standards by using least-squares regression analysis ($R^2 > 0.95$) (Sokal and Rohlf, 1981).

Test of Precision

To evaluate the precision of our procedures, we performed three repeated measurements of each of 11 Redhead feather samples. We analyzed samples for concentrations of Ca, K, Mg, and Na on three separate occasions during an 8-hour period, and calculated coefficients of variation (CV) for each element. Only elements with a CV of < 40% were used in subsequent analyses to evaluate differences among Redhead groups.

Test of volume

To determine whether the amount (g) of our sample material was too small (i.e., one secondary feather), we combined 10 secondary feathers from the same wing of adult males to form pooled samples. We then analyzed and compared 20 pooled samples and 20 nonpooled (i.e., one secondary feather) samples from the same location.

Variation in Mineral Concentrations Within and Among Birds

To examine patterns of mineralization in Redhead feathers from the same individual, we compared mineral concentrations between fifth secondary feathers (20 from right and 20 from left wings) of individual birds, and between 20 primary and 20 secondary feathers selected from 20 wings of different birds. We postulated that adults would differ from juvenile birds because adult males generally molt at different geographic locations than juveniles and females (Hochbaum, 1944; Mitchell, 1993). To test this hypothesis, we compared Ca, Mg, and Zn concentrations among sex and age classes of 80 Redheads (20 from each sex and age class) from Texas.

Geographical and Habitat Comparisons

Concentrations of Ca, Mg, and Zn in feathers were compared among 175 adult male Redheads collected from Louisiana, Texas, and Florida saltwater habitats, from Texas pond habitat, and for yearling males from South Dakota pond habitat. Only males were used in the analysis to minimize potential variation produced by sex differences (e.g., Kelsall and Burton 1979, this study).

Statistical Analysis

A two-sample t-test (SAS Institute Inc. 1987) was used to detect differences in mineral concentrations between feathers on right and left wings and differences in mineral concentrations between primary and secondary feathers. Feather mineral concentrations within different sex and age classes were analyzed by using a 2 X 2 factorial design and selected *a priori* contrasts (SAS Institute Inc. 1987). Comparison of mineral concentrations between geographical areas was analyzed by using analysis of variance (ANOVA); separation among means was determined by the Tukey's HSD test (SAS Institute Inc. 1987). Random effect models were used for all ANOVAs.

Validation

To assess the utility of feather mineralization as a natural marker, we conducted a blind-sample test. We used Ca, Mg, and Zn concentrations from adult males collected in Texas saltwater, Texas pond, and Louisiana saltwater habitats to determine the accuracy with which unknown samples could be properly assigned to their respective geographic origin. Ten secondary feather samples from adult males from each geographic area were selected by an assistant and each sample was randomly assigned a number. The number key was placed into an envelope and sealed until all unknown mineral concentrations were assigned to a geographical area based on Z-tests (Sokal and Rohlf, 1981). The z-probabilities were derived by comparing unknown samples with known mineral concentrations of Redhead duck feathers ($n = 29$) from Texas pond habitat and saltwater habitats of Texas and Louisiana. When a sample's P-value from the Z-test fell below 0.05, the hypothesis that the samples came from the same population was rejected.

RESULTS

For the precision test, repeated AAS readings taken from the same samples varied considerably for Na (CV = 59%) and K (CV = 48%), whereas Ca (CV = 29%) and Mg (CV =

8%) were less variable. Because of the high variability in Na and K, we eliminated these minerals from further testing. We did not perform repeated measurements for Zn; the readings among feather groups were very consistent (Note the low SE for Zn in Table 1.). For the volume test, we found that the concentration of Zn was greater (ANOVA; 39 df, $P < 0.001$) in the pooled sample than in the single-feather samples, but Ca and Mg concentrations in the pooled sample did not differ (ANOVA; 39 df, $P > 0.05$) from single-feather concentrations.

Mean concentrations of minerals by wings and feather types are shown in **Table 1**.

Table 1: Mean (±1 SE) concentrations (ppm) of calcium, magnesium, and zinc in flight feathers from different wings and of different types from Redheads wintering along the gulf coast. Means in a column with the same uppercase letter for minerals within wings and within feather types are not significantly different (Analysis of variance; $P > 0.05$).

	Calcium	Magnesium	Zinc
Wing*			
Left	0.39 (0.03) A	0.35 (0.03) A	0.07 (0.03) A
Right	0.39 (0.03) A	0.36 (0.03) A	0.07 (0.03) A
Feather type*			
Primary	0.44 (0.03) A	0.59 (0.03) A	0.10 (0.004) A
Secondary	0.39 (0.03) A	0.36 (0.03) B	0.07 (0.003) A

*Feather samples (n=20) collected from Florida

Concentrations of Ca, Mg, and Zn in the fifth secondary feathers did not differ between left and right wings (t-test, 19 df, $P > 0.05$). Concentrations of Ca, Mg, and Zn, however, did vary between primary and secondary feathers from the same wing. Primary feathers contained significantly (19 df, $P < 0.01$) higher concentrations of Mg and Zn than did secondary feathers. Calcium concentrations were higher in primary feathers than in secondary feathers, although the difference was not statistically significant (19 df, $P>0.25$). Juveniles had higher concentrations of Ca (2 X 2 factorial ANOVA; 39 df, $P<0.05$) in feathers regardless of sex (**Table 2**). Juvenile males possessed greater concentrations of Mg in their feathers than did adult males ($P=0.01$), but adult and juvenile females showed no difference ($P= 0.98$). Adult and juvenile females had higher ($P<0.05$) Zn concentrations than males from the same age class (**Table 2**).

Table 2: Mean (± 1 SE) concentrations (ppm) of calcium, magnesium, and zinc in feathers of different ages and sexes of Redhead ducks from Laguna Madre, Texas, 1988-90. Means within a column with the same letter are not different (ANOVA; P < 0.05).

Age and Sex	n	Calcium		Magnesium		Zinc	
		x	(SE)	x	(SE)	x	(SE)
Ault female	20	0.65	(0.07) A	0.66	(0.07) AB	0.09	(0.004) A
Adult male	20	0.61	(0.06) A	0.55	(0.07) A	0.07	(0.005) B
Juv. female (0.005) C	20	0.90	(0.09) B	0.65	(0.05) AB	0.11	(0.005) C
Jiv. male	20	0.87	(0.06) B	0.81	(0.08) B	0.08	(0.004) A

Feathers of Redhead ducks collected from Texas pond habitat contained higher concentrations of Ca and Zn than feathers from ducks collected from all other areas and contained higher Mg concentrations than all sites except Louisiana (ANOVA, P < 0.05) (**Figure 2**). Feathers from Redheads in Louisiana saltwater habitats differed from those collected in saltwater habitats in Florida and Texas by containing higher (P < 0.05) concentrations of Mg and Zn, although those three sites showed no differences in Ca concentrations. Mineral concentrations in feathers of yearlings from pond habitat in South Dakota were similar to concentrations in Redheads from Florida and Texas saltwater habitats for all minerals, but differed significantly from Louisiana saltwater habitats for Mg and Zn.

For Ca, only 12 of the 29 blind test samples were assigned to their proper origin (**Table 3**). On average, only 30% of the classifications of feathers using Mg concentrations were correct for the three areas. The most successful (66%) classifications were for the Louisiana and Texas saltwater samples using Zn feather concentrations.

Table 3: Number and percent of unknown feather samples (n = 29) from blind-sample test that were correctly classified as to geographical origin using a 2-tailed Z-test probability (P < 0.05).

Collection Site	Calcium		Magnesium		Zinc	
	N. correct	%	N. correct	%	N. correct	%
Texas ponds	10	34	9	31	9	31
Louisiana saltwater	12	41	8	28	19	66
Texas saltwater	10	34	9	31	19	66

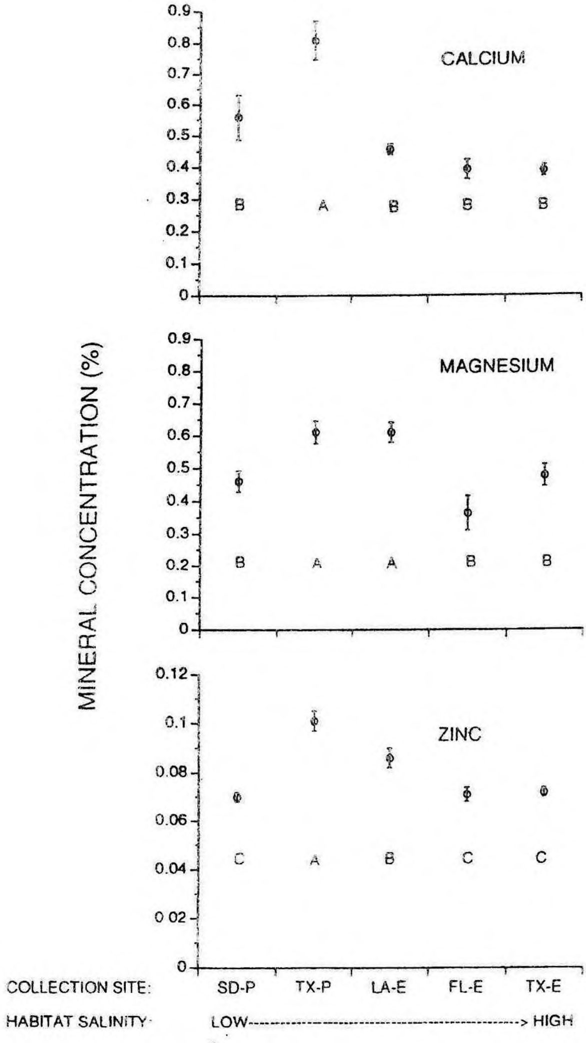

Figure 2: A comparison of the calcium, magnesium, and zinc concentrations in secondary feathers of adult male redhead ducks collected from saltwater habitat of Florida (FL-E; n = 30), Texas (TX-E; n = 40), and Lousiana (LA-E; n = 40) and pond habitat of Texas (TX-P; n = 40), and of yearlings from pon habitat in South Dakota (SD-P; n = 25). Means within a mineral class showing the same letter are not significantly different ($P > 0.05$, Tukey's HSD mean separation test).

DISCUSSION

No differences were found in wings from the same individual, but secondary feathers differed from primaries in Mg, Zn, and possibly Ca; this pattern was also shown for other elements in predaceous birds by Altmeyer *et al.* (1991) and in shorebirds by Goede (1991). Differences were detected between age and sex groups for some elements, a pattern also demonstrated in snow geese by Kelsall and Burton (1977, 1979). Consequently, we recommend that future studies make comparisons only within sex and age groups.

We found that feather mineral content differed by habitat and geographic sites, but there was no clear pattern along a salinity gradient. Habitat differences have been shown to influence feather mineralization during growth (Bortolotti *et al.* 1989), but surface adsorption also seems to be a problem which can, at least in some situations, affect stability of feather mineral profiles (Edwards and Smith, 1984; Cosson *et al.*, 1988a, 1988b). Whatever the cause, mineral concentrations in feathers collected from birds using ponds in southern Texas differed significantly from feathers collected from other sampling areas, including the adjacent Laguna Madre. This is counterintuitive given that at least one third of the Redheads on the Laguna Madre use the ponds every day (Adair, 1990; Moore, 1991).

We cannot recommend use of this technnique to identify geographic origins of birds because of (1.) high variability within samples, and (2.) failure of the unknown-sample test to provide confidence in prediction. Studies using birds from known molting areas are needed to establish baseline mineral concentrations for these areas. Concentrations from feathers of wintering birds could then be compared to the baseline values to ascertain whether birds on the various wintering sites come from separate post-breeding areas.

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ABUNDANCE AND DISTRIBUTION OF FISH-EATING BIRDS IN KEJIMKUJIK NATIONAL PARK, CANADA (1988-1993)

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ABSTRACT

The inventory and baseline characterization of breeding populations of aquatic birds in 40 lakes in Kejimkujik National Park (385 km^2) in 1988 seems to confirm that contrary to previous assumptions these bird populations are of sufficient density to warrant their study with respect to the impact of acid precipitation. The six year breeding population data obtained since 1988 confirmed that the successful breeding of fish-eating bird such Common Loon and the Common Merganser is controlled by the amount of fish available in a lake which is in turn controlled by the nutrient supply (phosporus) in the lake. At least 20 ha of lake surface is required in the Park to provide enough fish to support a territorial pair of loon, 40 ha or more is needed to support the breeding of either if the Common Loon or Common Merganser and 80 ha or more is necessary to support two or more either of these species or their combination.

The six years of breeding data shows that the number of territorial loon pairs remains stable (≈39 pairs) while the number of chick fledged may vary considerably from year to year (average 11.3, range 5 to 18).

A large number of the non-breeding loon population spend their summer in the ocean. The relative closeness to the sea coast (≈40 to 60 km in two directions) ensures that all the suitable loon territory in these lakes is soon filled when they become vacant. This may give an explanation of the low ratio (0.29) of loon chick/territorial pair in Kejimkujik compared to other more continental populations (>0.5) distant from the sea. Some of the year to year fluctuation of breeding success of loons max be the result of changes in water levels during the nesting period, but other unknown factors are at work as well.

The total number of Common Merganser brrods is very stable from year to year (average 13.4, range 12 to 16).

INTRODUCTION

Results of the inventory and baseline characterization of breeding populations of aquatic birds in 40 lakes in Kejimkujik National Park (385 km^2) in 1988 suggest that, contrary to previous assumptions, these bird populations are of sufficient density to warrant their study with respect to the impact of acid precipitation (**Figure 1**). The five year breeding population data obtained since 1988 confirmed that the successful breeding of fish eating birds such as the Common Loon (*Gavia immer*) and the Common Merganser (*Mergus merganser*) is controlled by the amount of fish available in a lake, which in turn is controlled by the nutrient supply (phosphorus) in the lake (Kerekes, 1990; Kerekes *et al.*, 1994). At least 20 hectares of lake surface area is required in the park to provide enough fish to support a territorial pair of loons (**Figure 2**), 40 hectares or more is needed to support the breeding of either of the Common Loon or Common Merganser (**Figure 3-5**), and 80 hectares or more is necessary to support two or more individuals either of these two species or their combinations (**Figure 6, 7**).

The five years of breeding data show that the number of territorial loon pairs remains stable (~39 pairs) while the number of chicks fledged may vary considerably from year to year (average 12.4, range 7 to 18) (**Figure 8, Table 1**).

A large number of non-breeding loons in the population spend their summer in the ocean. The relative closeness to the seacoast (~ 40 to 60 km in two directions) ensures that all suitable loon territory in these lakes is soon filled when they become vacant. This may give at least a partial explanation of the low ratio (0.32) of loon chick/territorial pair in Kejimkujik compared to other more continental populations (>0.5) distant from the sea (**Fig. 8**). Some of the year to year fluctuations of breeding success of loons may be the result of changes in water levels during the nesting period, but other unknown factors, such as Great Black-backed Gull predation and human disturbance are suspected.

The total number of Common Merganser broods is very stable from year to year (average 13.4, range 12 to 16) (**Table 2**).

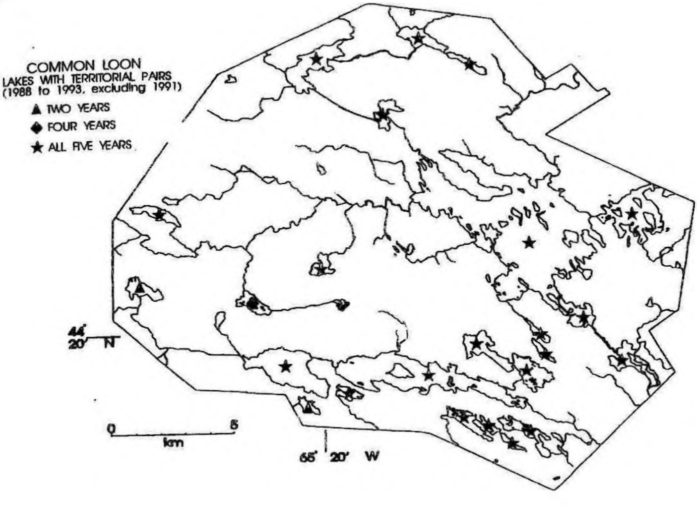

Figure 1: The location of lakes and the presence of Common Loon pairs in Kejimkujik National Park 1988-1993, excluding 1991.

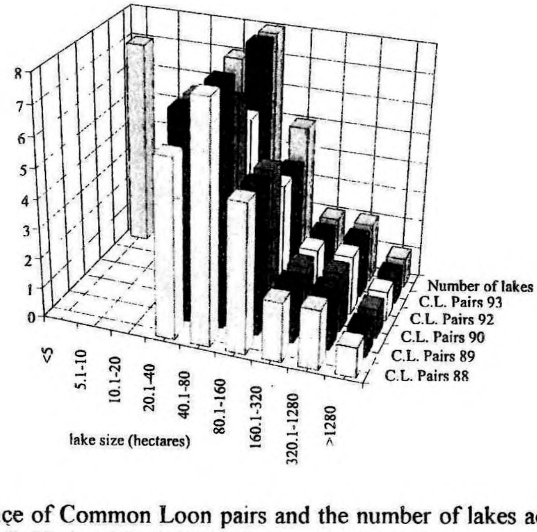

Figure 2: Occurrence of Common Loon pairs and the number of lakes according to lake size in Kejimkujik National Park 1988-1993, excluding 1991.

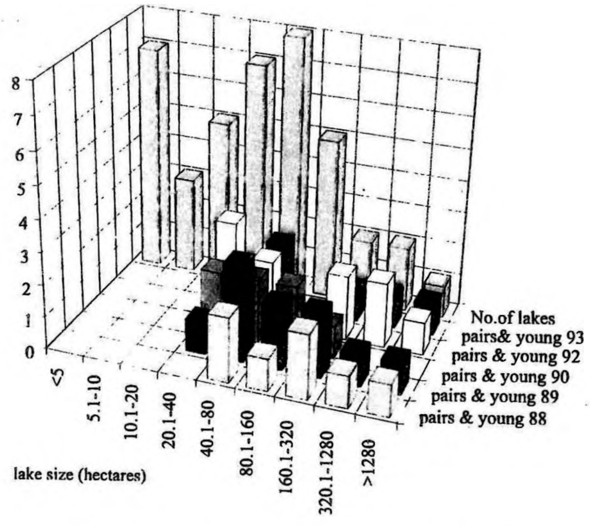

Figure 3: Occurrence of Common Loon pairs and young and the number of lakes according to lake size in Kejimkujik National Park 1988-1993, excluding 1991.

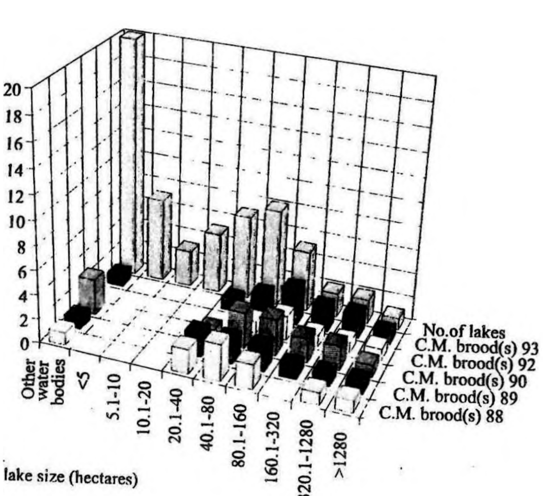

Figure 4: Occurrence of Common Merganser broods and the number of lakes according to lake size in Kejimkujik National Park 1988-1993, excluding 1991.

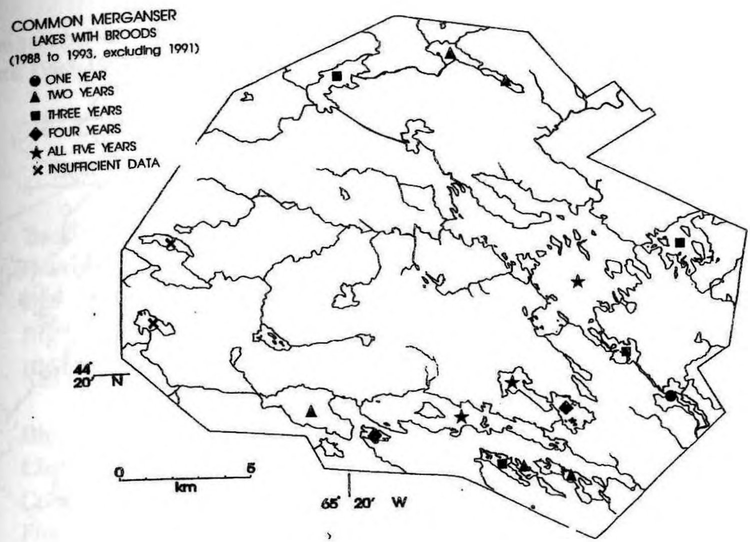

Figure 5: The location of lakes and the presence of Common Merganser broods in Kejimkujik National Park 1988-1993, excluding 1991.

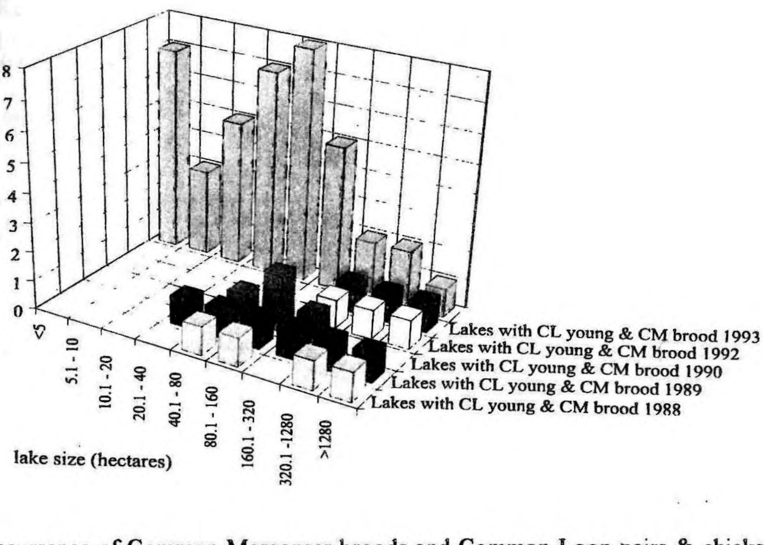

Figure 6: Occurrence of Common Merganser broods and Common Loon pairs & chicks and the number of lakes according to lake size in Kejimkujik National Park 1988-1993, excluding 1991.

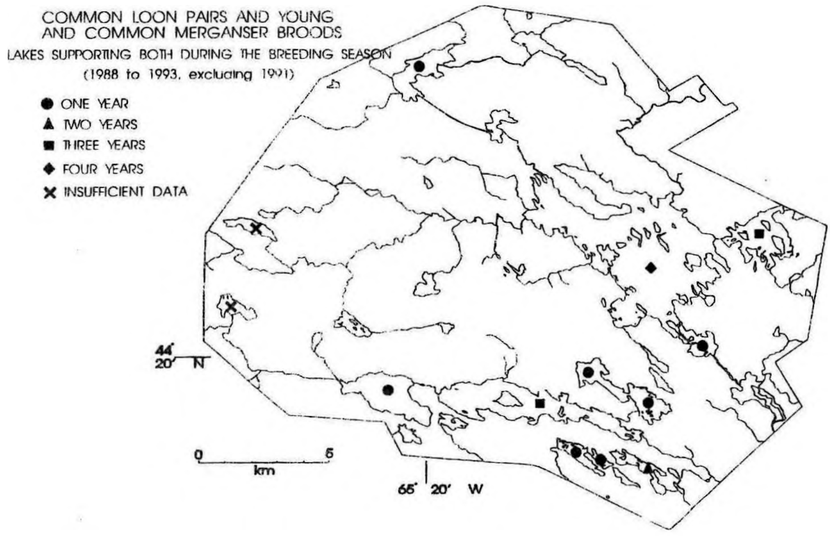

Figure 7: The lakes supporting both Common Loon pairs & chicks and Common Merganser broods in Kejimkujik National Park 1988-1993, excluding 1991.

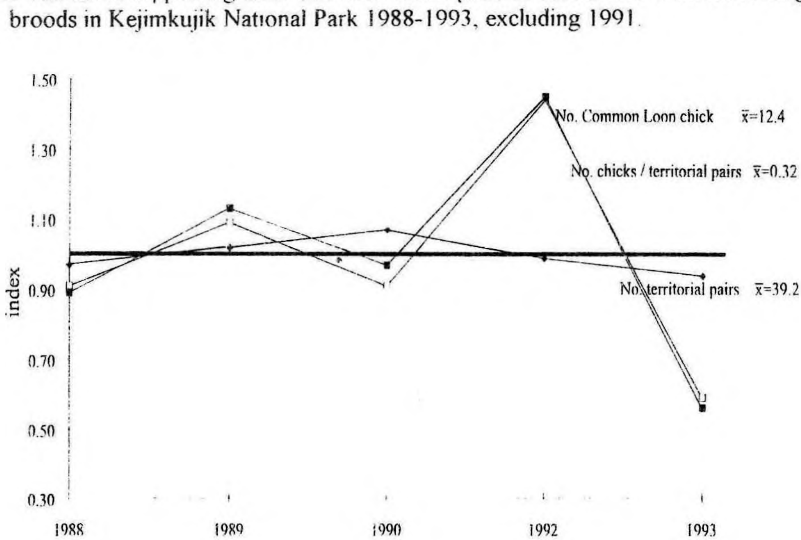

Figure 8: Productivity indices of Common Loon 1988-1993, excluding 1991, in Kejimkujik National Park

Table 1: The number of residential Common loon pairs in 25 lakes (>20 ha) in Kejimkujik Park 1988-1994, excluding 1991. Poplar Lake was not surveyed after 1990.

Lake	1988	1989	1990	1992	1993	5 year mean
Back	1	1	2	1	1	1.2
Beaverskin	1	1	1	1	1	1.0
Ben	1	1	1	1	1	1.0
Big Dam East	1	1	1	1	1	1.0
Big Dam West	1	1	1	1	1	1.0
						0.0
Big Red	1	1	0	1	1	0.8
Channel	1	1	1	1	1	1.0
Cobrielle	2	2	3	2	2	2.2
Frozen Ocean	2	1	1	1	2	1.4
George	1	2	2	1	1	1.4
						0.0
Grafton	4	4	3	4	3	3.6
Hilchemakaar	2	2	2	2	2	2.0
Kejimkujik	4	6	7	7	7	6.2
Liberty	1	1	1	1	1	1.0
Loon	2	2	2	1	1	1.6
						0.0
Lower Silver	1	1	1	1	1	1.0
Luxton	1	1	1	1	1	1.0
Mountain	2	2	2	2	1	1.8
North Cranberry	1	1	1	1	1	1.0
Pebbleloggitch	0	1	1	0	0	0.4
						0.0
Peskawa	2	2	2	3	2	2.2
Peskowesk	3	2	4	3	3	3.0
Poplar	1	1	1	*	*	1**
Puzzle	1	1	1	1	1	1.0
Upper Silver	1	1	1	1	1	1.0
Total	38	40	43	39	37	39.4

*- not surveyed

**- indicates 3 year mean

Table 2: The number of residential Common merganser broods in 25 lakes (>20 ha) in Kejimkujik Park 1988- 1994, excluding 1991. Poplar Lake was not surveyed after 1990

Lake	1988	1989	1990	1992	1993	5 year mean
Back	1	0	1	0	1	0.5
Beaverskin	1	1	1	0	1	0.7
Ben	0	0	0	0	0	0.0
Big Dam East	0	2	1	0	0	0.5
Big Dam West	0	0	0	1	1	0.3
Big Red	0	0	0	*	0	0+
Channel	0	0	0	*	0	0+
Cobrielle	1	0	1	2	1	0.8
Frozen Ocean	0	1	1	0	1	0.5
George	1	1	0	0	1	0.5
Grafton	0	0	1	1	0	0.3
Hilchemakaar	0	1	1	0	0	0.3
Kejimkujik	4	2	5	3	3	2.8
Liberty	0	0	1	*	*	0.2++
Loon	1	0	0	0	0	0.2
Lower Silver	1	1	0	0	0	0.3
Luxton	0	0	0	0	0	0.0
Mountain	1	2	1	2	1	1.2
North Cranberry	0	0	0	0	0	0.0
Pebbleloggitch	0	0	0	0	0	0.0
Peskawa	0	0	1	0	1	0.3
Peskowesk	1	3	1	3	1	1.5
Poplar	0	0	0	**	**	0++
Puzzle	0	0	0	0	0	0.0
Upper Silver	0	0	0	0	0	0.0
Total	12#	14#	16#	12	12	13.2#

* insufficient observations
**not surveyed
#Poplar Lake excluded from totals

\+ indicates a 4 year mean
++ indicates a 3 year mean

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GROUPING DYNAMICS OF COMMON LOON ON GRAFTON LAKE (CECUMCEGA GOWICK[1]), KEJIMKUJIK NATIONAL PARK, CANADA (27 JULY-1 OCTOBER, 1993).

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ABSTRACT

A study of the grouping behaviour of Common Loons (*Gavia immer*) was conducted on Grafton Lake in Kejimkujik National park from 27 July - 1 October 1993. The purposes of the study were to determine the following:

- total number of loons using the lake each day,
- sizes and dynamics of loon groups,
- territories of resident loon pairs and to what degree they were defended.

There were three resident pairs of Common Loons, two territorial pairs and one breeding pair that produced one chick. The most loons sighted on Grafton Lake during a survey was 12 adults and one chick, but there may have been more. The maximum loons sighted per survey' value was limited by the size of the lake and the impossibility to view the entire lake at any one time. The largest single grouping of adults sighted was 11. It is unknown if both adults of the breeding pair were included in this grouping, but is suspected at least one was. The minimum number of loons sighted was one pair, with the chick, on the last days of surveying.

The breeding pair continued to maintain their territory throughout the study. The other two territorial pairs not only allowed other loons to use their territories, but often joined them in a group. The breeding pair was observed joining these groups, but only outside their own territory. Often one adult would stay with the chick, while its mate ventured out into the other

[1] Micmac name of Grafton Lake

territories to feed. Occasionally, and with increasing frequency as the summer progressed, the breeding pair would leave the chick alone while they both went to feed elsewhere. However, at least one was always close enough to nip back intot the territory in the event of an intruder. The chick was sighted on all but four survey days.

Until the last week of the surveying, the resident six adults could usually be sighted during a survey. In addition, other loons would fly in and out of the lake, often forming groups that moved about the lake feeding or just preening and resting. These groups were found to be very dynamic, with loons often joining and separating from gropus, individually and as smaller groups.

INTRODUCTION

The first field season of a three year study of the grouping behaviour of Common Loon (*Gavia immer*) on Grafton Lake (Cecumcega Gowick, 321.5 ha) in Kejimkujik National Park was conducted from 27 July to 1 October 1993. Grafton Lake was chosen as the study site because a draw down of the water level is planned in 1994. A man-made dam which currently maintains the level approximately two meters higher than would naturally occur, is to be removed in the near future. Thus the effects of the reduced surface area and volume of water on the loons using Grafton Lake can be observed. This study is in conjunction with a larger study of Common Loon populations on all lakes in the park that has been on going for the past six years.

The purposes of the first summer of the study were to determine the following:

- total number of loons using the lake each day,
- sizes and dynamics of loon groups,
- territories of resident loon pairs and to what degree they were defended.

METHODOLOGY

From July 27 to October 1, 1993, one observer went out in a canoe each day during the week, paddling one full circuit around Grafton Lake. Notes were made of all Common

Loons sighted as to time of day, numbers and behaviour, as well as marking their locations on a map. Also noted were weather conditions, start and finish times, and water level of the lake (as read from the benchmark on the dam three times a week, starting on 13 August 1993).

The observer would often stop to observe an area for a period of time, especially if loons were sighted. The loons' movements were recorded both on the map and in the notes. Duration of these observations varied, depending on the observers discretion regarding time available and level of activity of the observed loons. The overall time on the lake each day was usually about six hours. On Mondays and Tuesdays, the survey began mid-afternoon and ended at dark; on Wednesdays, the survey covered the middle part of the day; while on Thursdays and Fridays, the surveys began at first light. In this way, all times of daylight were regularly surveyed. From these observations, the number of resident pairs and breeding pairs with chicks was determined, as well as their respective territories. Maximum group size and a minimum total loons on the lake for each day was noted and graphed.

Any flying loons sighted were recorded as to time sighted and directions from and to which they flew. If flying loons were observed taking off from or landing on Grafton Lake, then that location was recorded on the map. All sightings of flying loons were summarized into a table in this report.

RESULTS AND DISCUSSION

The limnological condition of Grafton Lake is described by Kerekes (1975) and selected morphometric features are summarized in **Table 1**.

Table 1: Lake drainage and morphometry for Grafton Lake, Kejimkujik National Park (Kerekes and Schwinghammer 1973).

Latitude - 44° 23'	Longitude - 65° 11'
Elevation - 325 ft. or 100 m	Military grid - 260165
Drainage system area - 53 km^2	Lake surface area - 321.5 ha
Island area - 51.1 ha	Water surface area - 270 ha
Maximum depth - 10.0 m	Mean depth - 2.76 m
Volume of lake - 7440 x 1000 m^3	
Flushing rate - 6.04 times/yr	

There were three resident pairs of Common Loon on Grafton Lake during the summer of 1993; two territorial pairs and one breeding pair that produced one chick. In 1990 and 1992, there were also three resident pairs (Kerekes *et al.* 1994, Kerekes unpubl. data). Two of the pairs in 1990 had a single chick, while in 1992, as in 1993, there was only one pair with a chick. In 1988 and 1989, there had been four resident pairs (Kerekes, 1990; Kerekes *et al.*; 1994; Kerekes unpubl. data). In 1988, one pair had two chicks, one had one chick and another pair were known to have had an unsuccessful nest, while the next year, 1989, only one of the pairs had a chick.

The largest number of loons sighted on Grafton Lake during a survey in 1993 was 12 adults and one chick, but there may have been more (**Figure 1**). The maximum number loons sighted per survey was limited by the size of the lake and the impossibility to view the entire lake all at once. The largest single grouping of adults sighted was 11 (**Figure 1**), which was thought to include at least one of the adults of the breeding pair. The minimum number of loons sighted was one pair, with the chick, on the last day of surveying. The various behaviors observed of loons in a group situation included swimming, drifting, diving, feeding, preening, occasional napping, and simply "hanging out"; the types of behaviour observed did not differ much from that of pairs or single loons.

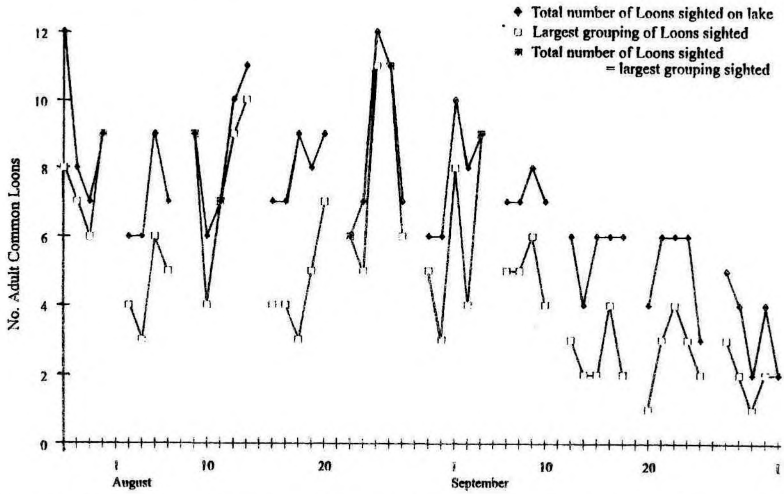

Figure 1: Total numbers and maximum group sizes of Common Loons on Grafton Lake, from July 27 to October 1, 1993

The breeding pair continued to maintain their territory throughout the study **(Figure 2)**, with one exception. On 26 August 1993, two other adult loons flew in and landed in the breeding pair's territory. For about ten minutes they joined the breeding pair diving and feeding, then took off, flying back in the direction from which they came. No hostilities were observed on the part of the breeding pair, but the intrusion only lasted a short time and it appeared to be an isolated incident.

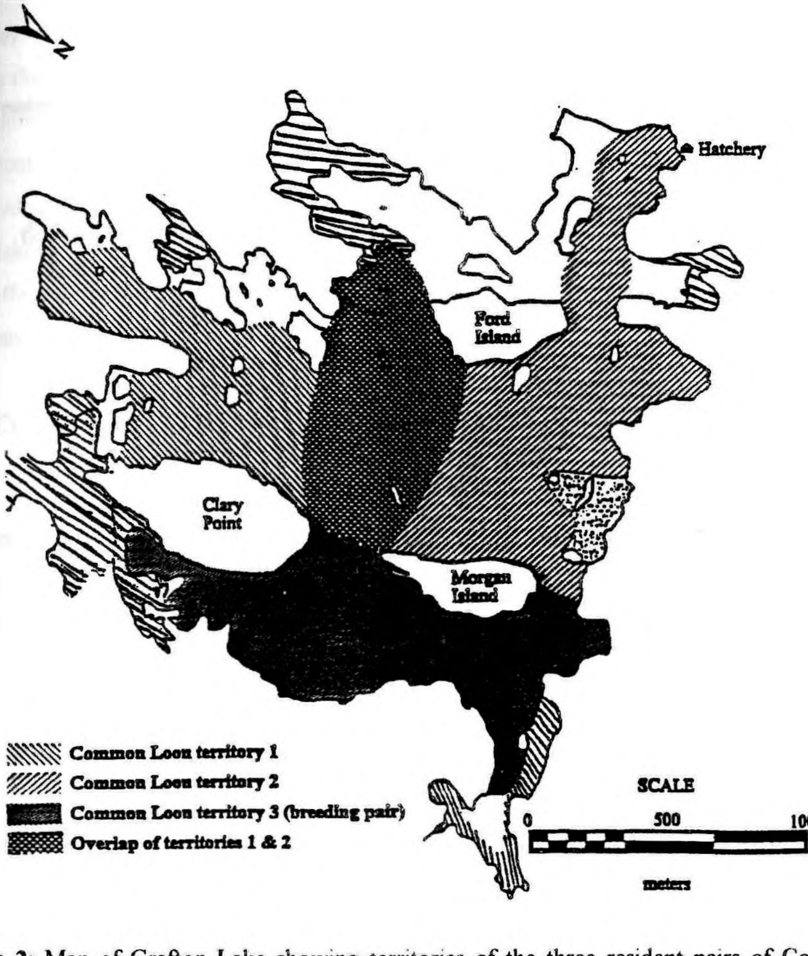

Figure 2: Map of Grafton Lake showing territories of the three resident pairs of Common Loon

The other two territorial pairs not only allowed other loons to use their territories (**Figure 3**), but often joined them in groups. However, there were sections of their respective territories in which other loons were never observed (**Figure 2, 3**). The result was a partial merging (or shared section) of the two territories (**Figure 2**). So in fact, this overlap of territories is really just part of their home range and not truly a "defended area" or "territory".

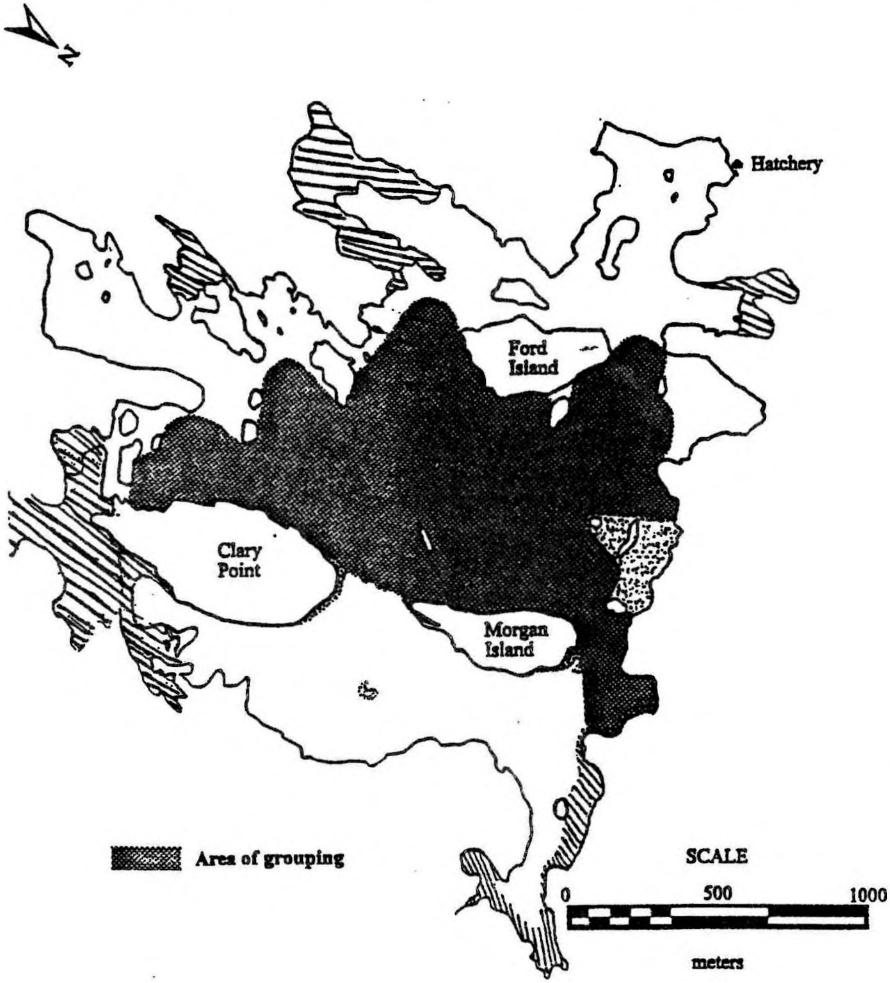

Figure 3: Map showing area of Grafton Lake in which grouping behaviour of Common Loon occurred

The breeding pair was observed joining other loons in groups, but only outside their own territory. Often one adult would stay with the chick, while its mate ventured out into the other "territories" to feed. Occasionally, and with increasing frequency as the summer progressed, the breeding pair would leave the chick alone while they both went to feed elsewhere. However, at least one was always close enough to return to the territory in the event of an intruder. The chick was sighted on all but four survey days.

Until the last week of surveying, the six resident adults could usually be sighted during a survey. In addition, other loons would fly in and out of the lake (**Table 2**), often forming groups that moved about the lake feeding or just preening and resting (**Fig. 3**). These groups were found to be very dynamic, with loons often joining and separating from groups, individually and as smaller groups (**Fig. 4**). It could not be determined if any loons, other than the resident pairs, ever spent the night on Grafton Lake. If visiting loons were residents of other lakes, they may have returned there before nightfall. On the other hand, night may not have affected Common Loon movements at all. Since no nocturnal surveys were conducted, this remains unknown.

CONCLUSIONS

In summary, there were three pairs of resident Common Loons on Grafton Lake in the summer of 1993, one of which had one chick. The two pairs that did not produce chicks, partially merged their territories, sharing them with other loons that also used the lake. The breeding pair, however, defended their territory; although they were observed leaving the chick to join other loons in other parts of the lake. The largest grouping observed on Grafton Lake during the 1993 surveys was 11 adult loons, and the most loons known to be on the lake at any one time was 12 adults and one chick. The groupings of adults were observed to be very dynamic in size and movement. It is unknown if loons other than the resident pairs ever spent the night on Grafton Lake.

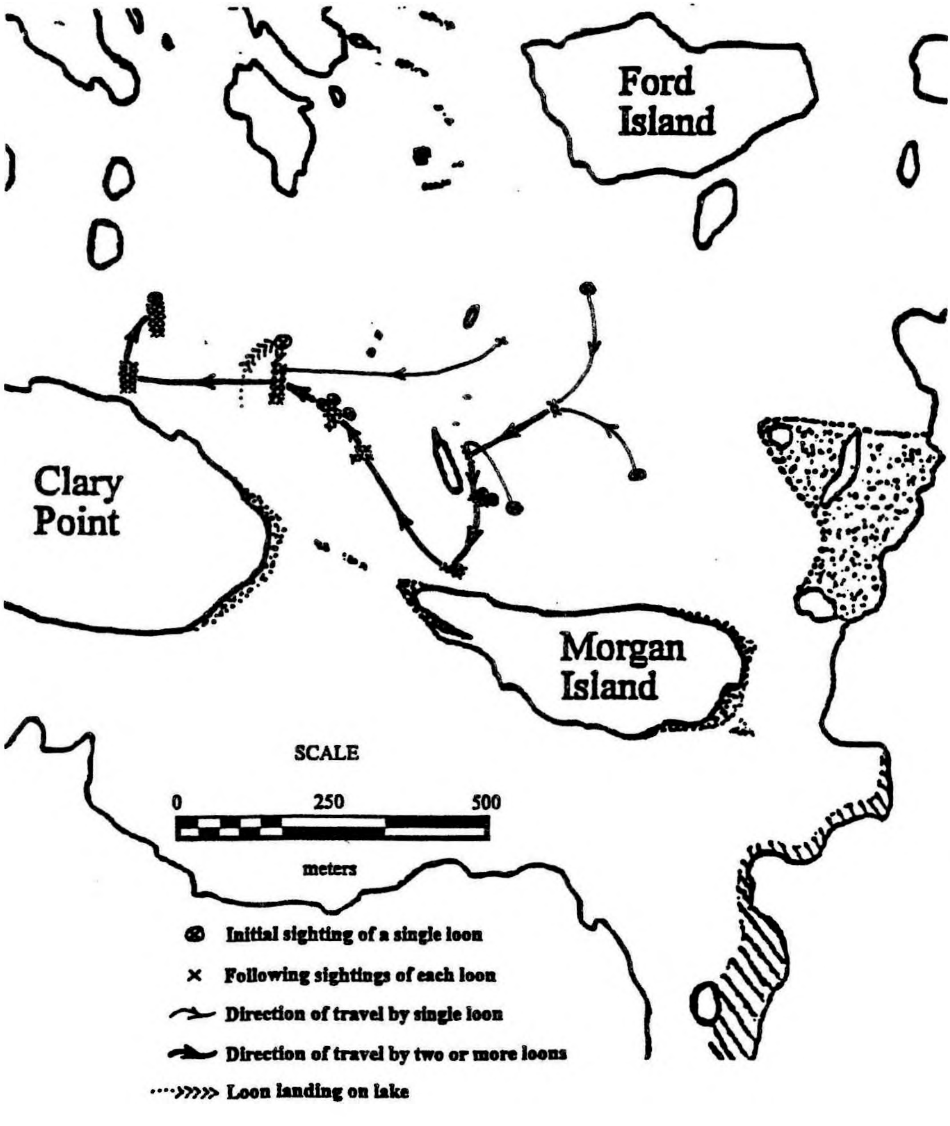

Figure 4: Example of the formation of a group of 11 adult loons, as observed on Grafton Lake, August 26, 1993

Table 2: Sightings of flying Common Loons on Grafton Lake, Kejimkujik National Park from 27 July - 01 October, 1993.

Date	No. of Loons	Flying		Time		
		From	To	Flying over	Take off	Landing
04 Aug	1	E	SE	06:45		
05 Aug	1	SE	E	08:55		
	2	Lake	E/SE		11:00	
	1	Lake	N		11:05	
06 Aug	1	Lake	E/NE		08:15	
	1	Unknown	E/NE	08:20		
	2	Unknown	Lake			08:30
	1	E	Lake			08:30
12 Aug	1	S	Lake			06:40
13 Aug	1	Lake	E/NE		06:55	
	1	SE	Lake			07:00
	1	W	Lake			08:15
	2	Unknown	W	10:00		
	1	Unknown	Lake			11:25
16 Aug	1	SW	Lake			18:25
	1	SE	S	18:45		
17 Aug	1	W/NW	SE	18:35		
19 Aug	2	N	Lake			07:50
	2	SW	NE	08:00		
	2	NE	W	10:10		
20 Aug	1	S	Lake			08:05
	1	NW	Lake			11:35
	1	S	SW	12:35		
23 Aug	1	E	S	18:25		
	1	E	Lake			18:25
	1	Lake	W/NW		20:05	
	2	Lake	Lake		20:15	20:15
	1	Lake	W/NW		20:15	
24 Aug	1	SW	Lake			16:35
25 Aug	1	Lake	S		14:35	
	1	NE	SW	14:50		

continued......

Table 2 ....continued.

Date	No. of Loons	Flying		Time		
		From	To	Flying over	Take off	Landin g
26 Aug	1	Unknown	Lake			07:15
	1	S	Lake			08:05
	2	S	S	08:05		
	2	SW	Lake			08:15
	2	Lake	S		08:25	
	1	Lake	N		08:30	
	2	Lake	NW		09:20	
	1	Unknown	SW	09:25		
01 Sept	1	N/NE	N	12:55		
	2	Lake	Lake		16:45	16:45
02 Sept	2	Lake	W		08:00	
03 Sept	1	W	Unknown	06:25		
	2	Lake	SW		11:15	
	1	Lake	W		11:15	
	1	Lake	E		11:15	
	2	Lake	Lake		11:15	11:40
08 Sept	1	Unknown	SW	11:15		
	1	Lake	W		11:45	
09 Sept	1	Lake	W		10:25	
	2	Lake	W/NW		10:35	
10 Sept	1	SW	W/SW	07:50		
	2	Lake	Lake		07:50	08:00
	1	Lake	W		08:25.	
16 Sept	1	W	E	07:20		
	1	N	SW	11:55		
23 Sept	1	NE	W	11:10		
01 Oct	1	SW	Lake			07:30

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THE OCCURRENCE OF WHITE-TAILED SEA EAGLE (HALIAEETUS ALBICILLA) IN THE DANUBIAN REGION AND ITS PROTECTION UNDER CHANGED ENVIROMENTAL CONDITIONS

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ABSTRACT

This article is focused on the occurrence of the White-tailed Sea Eagle the Danube (river km 1812-1839), to elaborate management of territorial and species protection and to renew the nesting population of this rare species.

The protection management scheme consists of a selection of localities, which favour a high level of protection a special programe of protection has been agreed between competent institutions. During the winter, they were fed with carcasses and artificial nests was built for them.

INTRODUCTION

The section of the Danube between river kms 1812- 1839 still forms at present a relatively well- preserved territory of inpland delta. At present only its small part in the State Natural Reserve "The Island of the Sea Eagle" has been protected (Stollman, 1956). Originally the purpose of the reserve was first of all to protect the nesting sites of the sea eagle, which in the past nested in several localities (Baka, Bodíky, Gabčikovo, Palkovičovo) of the Slovak section of the Danube (Balat 1956). The extinction of the nesting population was due to several synergically operating antropical factors (the growth of economical activities in the forests, building of acceses to formerly inaccesible localities and greater number of visitors).

The aim of study was to evaluate the contemporary condition of the white- tailed sea eagle living on the Danube, to elaborate management of territorial and species protection and to renew the nesting population of this rare species.

METHODS

In the year 1989-1994 observations were made to see if the species existed in the wild, its numbers its habitat and its nutritional habits in the Danube. This branch system was also studied and since the year 1993 also on the Gabčikovo project.

CONCLUSION

Since the last nesting on the year 1964 the sea eagle occurs in the area only in winter months, in numbers of about 8-12, but in the last years their numbers have been growing (Áč, 1977). The most favoured localities were ascertained on the old river Danube and its tributaries. The sea eagle its to be found at the same sites where it nested before.

The protection management scheme consist of a selection of localities, which favour a high level of protection a special program of protection has been agreed between competent institutions .From among the originally selected localities the most perspective appear to be at present the localities at rivers kms 1833, 1823 and 1814. The significance of these localities has been supported by the fact that regular occurrence of the sea- eagle has been observed in them, with its pre-nesting activities.

In nuclear localities artificial nests were built and in case of nesting of the sea-eagle the nesting sites will be guarded and economical activities in the forest will be stopped in the period from December 1st till March 15th, and hunting cut out November 1st till 15th. The artificial nest was built on October 15th, 1994, on a poplar trees in the height of 23 and 20 m. It was built of thicker branches in the size of 1,8x0,8 ms. During the winter, they were fed with carcasses.

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EFFECTS OF SUBMERGED CHANGE ON WINTERING WATERFOWL IN THE COMACCHIO AREA

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INTRODUCTION

The Comacchio area is a major wetland complex for wintering waterbirds (as well as for breeding and migrating ones). Its importance for wintering waterfowl has been emphasized by various national reports for 1975-77 (Boldreghini *et al.*, 1978; Schenk, 1979), 1975-78 (Chelini, 1979) and 1982-85 (Focardi and Spina, 1986).

Information on wintering waterfowl in the coastal wetlands of the Emilia-Romagna Region is given by Boldreghini and Montanari (1978) and recently by Boldreghini (1990). Populations of wintering ducks and *Fulica atra* in the coastal wetlands of the north-western Adriatic Sea over the period 1975-82 have been analysed by Boldreghini and Rallo (1988) and discussed in order to assess the international or national importance of these wetlands. Population trends of wintering waterfowl since 1974 are given by Boldreghini *et al.* (1992).

A strong decrease of wintering waterfowl has been recorded during the early 1980s. The aim of this paper is to discuss the ecological factors likely causing this population change.

STUDY AREA

The Comacchio area is a complex of coastal wetlands covering some 14,000 ha located in the southern part of the Po River Delta. The main wetland (some 11,000 ha) is a system of brackish lagoons (Valli di Comacchio) under controlled connection with the Adriatic Sea and a River Reno, employed since centuries for extensive rearing of euryhaline fish (*Anguilla anguilla, Mugilidae, Atherina boyeri, Dicentrarchus labrax, Sparus aurata*). These are the remnants of wider lagoons (fishing "valli") still extended more than 50,000 ha in the last century, then reclaimed for agriculture. Drainage water is collected into canals in connection with the sea.

Presently the Valli di Comacchio are subdivided into two main basins with high salinity, one basin liable to tide and a number of minor basins, covering more than 1,000 ha and located in the southern part, mainly receiving supply of water from the River Reno. The aquacultural management of the valli is in charge of a public enterprise and a number of private owners.

North-east of the Valli di Comacchio there is a salina (620 ha), no more operative. Between the Valli di Comacchio and the Adriatic Sea a number of interdunal ponds, holding diverse salinity levels and mainly used for extensive fish-culture, are located.

METHODS

The species considered are Ducks (*Anatidae*) and *Fulica atra*, which are jointly called waterfowl. Mid-winter census data from 1974 to 1994 are analyzed. Counts coinciding with cold periods characterized by extensive frost are those of 1979, 1980, 1981 and 1985.

RESULT AND DISCUSSION

The population trend of total waterfowl is shown in Fig. 1; the observed decrease is highly significant (Kendall's = 0.54, $p<0.0009$). The density has varied between 37 and 746 individuals/100 hectares.

Only two species show a population trend strictly correlated with the total waterfowl: *Fulica atra* (Kendall's = 0.78, $p<0.0000$) and *Aythya ferina* (Kendall's = 0.64, $p<0.0000$). Since these species together reach high values of relative importance every year (min. 1982 52,4%; max 1979 98,1%) and show a wide variation of absolute abundance, they can explain most of the variation of total waterfowl (**Figure1**).

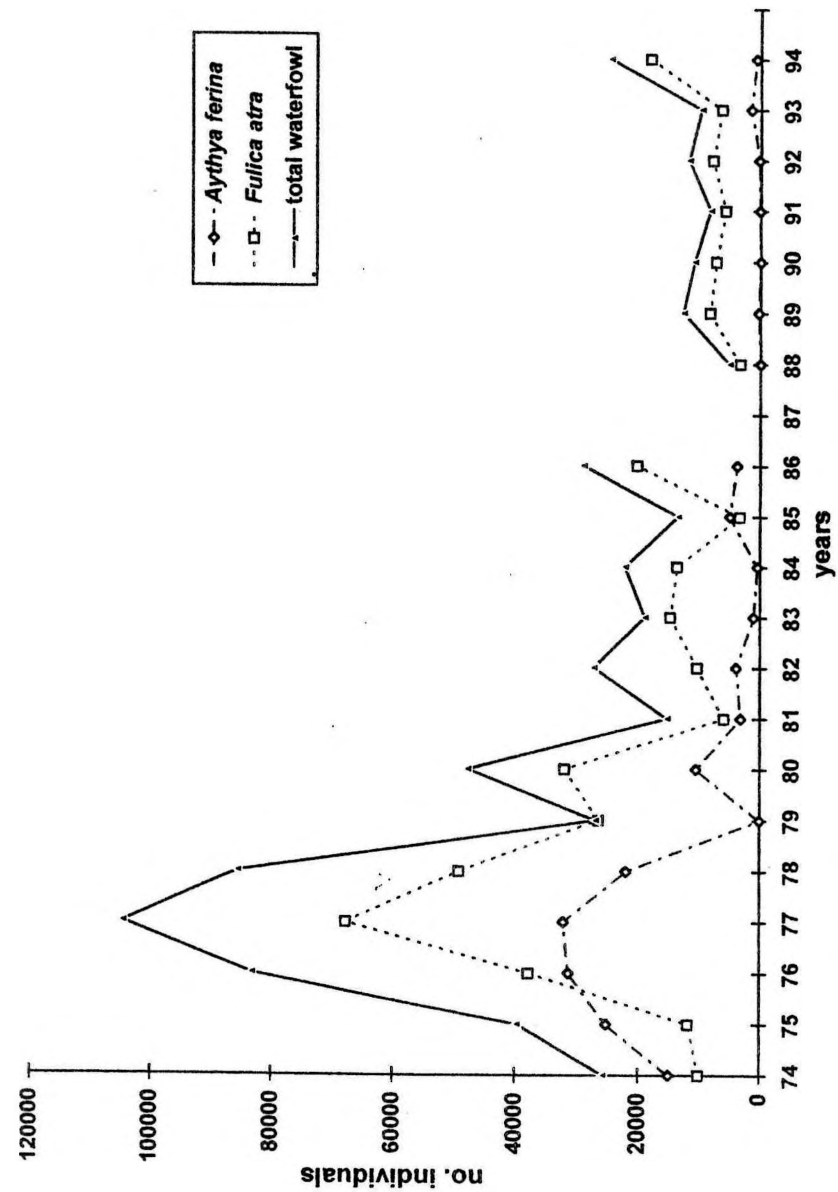

Figure 1: Population trend of total waterfowl and of selected species.

The dramatic fall of waterfowl population occurred in 1979-81: *Aythya ferina* and *Fulica atra* dropped to nearly 1/10 of the peaks previously recorded. During the following years the population level has remained rather low, especially for *Aythya ferina*. In the late 1970s the vegetation of the Comacchio Lagoon changed profoundly. Before the submerged macrophytic vegetation was formed by wide and dense beds *of Lamprothamnium papulosum (Charophyceae)* or *Ruppia spiralis (Angiospermae)* or mixed community (Ferrari *et al.*, 1972). Some species of macrophytic *Chlorophyceae*, such as *Valonia aegagropila*, *Chaetomorpha linum*, *Cladophora battersii* and *Cladophora socialis*, also were widespread and abundant (Giaccone and Piccoli, 1974). The phytoplankton was well diversified and mainly formed by diatoms (Boni, 1971).

Since the early 1980s the macrophytic bottom vegetation almost completely disappeared. During the same period also the phytoplankton changed and in 1988 only one species of unicellular Chlorophyceae, still unidentified, had an extraordinary abundance (Boni 1990); consequently the transparency of the water has strongly decreased. So far the situation is almost the same.

The cause of the shift of the primary productivity from benthic vegetation to phytoplankton is not clear because of lack of appropriate research. We may presume an increase of nutrients in the water, consequently a "bloom" of organisms characterized by a short life-cycle and then the death of bottom plants because of lack of light. Moreover, Cavallini (1980) has found in Valle Campo, one of the embanked basins of the Valli di Comacchio, only a clear increase of the phosphates between 1970-74 and 1978-80. This does not seem to depend on the waste-water drainage from the intensive fish-farm planted in this area. On the contrary, a relation has been found in the years 1977-79 between the increase of phosphates in the lagoon and their doubling in the coastal water of the Adriatic Sea.

Many and diverse environmental factors work in a lagoon ecosystem and the situation of the Valli di Comacchio is complicated by human management not based on deep and integrated knowledge of the functioning of the ecosystem.

The Valli di Comacchio lie in a area, the Po Plain, where surface water however is rich in nutrients, resulting from intensive agriculture, animal rearing and human settlements. In such a situation the occurrence of dystrophic events must not surprise: they are increasingly recorded in many Mediterranean lagoons (Crivelli, 1990; Ximenes and Lieutaud, 1992).

A feasible way to reduce the amount of nutrients entering the Valli di Comacchio should be the creation of water purification systems employing aquatic plant communities.

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THE INFLUENCE OF HABITAT VARIABLES AND INTERSPECIFIC RELATIONS ON WATERBIRD COMMUNITIES OF LOWLAND GLACIAL LAKES IN BELARUS

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INTRODUCTION

The study of waterbird species diversity and number in different habitat types and also the elaboration of general theoretical criteria for estimation of habitat's biological capacity and elucidation of habitat variables determinating this capacity for protected and hunting species are essential for their effective protection and wise use.

Many investigators were devoted to this problem. Habitat variables influence on waterbirds was studied in different directions, including multiple regression analysis (Gibbs *et al.* 1991, Monda *et al.* 1988, Nilson and Nilson, 1978, Sillen and Solbreck, 1977, Utchick, 1980). The classification of lakes as waterbird habitats was elaborated (Kaupinnen, 1993).

MATERIAL AND METHODS

The investigations were carried out in 45 glacial lakes representing different lake types in Belarus (**Table 1**), 272 km^2 of lake surface area (about 20 % of the whole area of Belarussian glacial lakes) were studied.

Waterbird species composition and numbers were estimated using absolute count method with the inspection of all lake surface in kayak (Haldin and Ulfvens, 1987, Kauppinnen *et al.* 1991). Absolute nest census was carried out in 1989-1993. Habitat variable description was made on the ground of aerial photographs interpretation (scale 1:5,000) and large scale maps (scale 1:50,000). The following groups of habitat variables were determined (**Table 2**):

Table 1: Occurrence of waterbirds in glacial lakes (% in the total number of lakes)

Species	Oligo-trophic	Maso-trophic	Slightly eutrophic	Eutro-phic	High eutro-trophic	Hyper-trophic	Dis-trophic	All lakes
	n = 5	n = 2	n = 12	n = 10	n = 2	n = 3	n = 11	n = 45
Gavia arctica	60	-	16,6	-	-	-	-	11
Podiceps cristatus	20	100	33,3	100	100	66,6	-	47
Botaurus stellaris	-	-	-	40	100	33.3	-	15
Cygnus olor	-	100	-	20	50	-	-	11
Anas plathyrhynchos	20	100	33,3	100	100	100	18.2	53
Anas crecca	20	-	25	30	100	-	-	20
Anas strepera	-	-	8,3	-	50	-	-	4
Anas acuta	-	-	-	-	50	-	-	2
Anas querquedula	-	-	-	60	100	-	-	18
Anas clypeata	-	-	-	-	50	-	-	2
Aythya feryna	-	50	-	40	100	-	-	15
Aythya fuligula	-	50	-	30	100	-	-	13
Bucephala clangula	80	100	91,6	30	50	66,6	81,8	71
Mergus serrator	20	50	-	10	-	-	-	4
Mergus merganser	-	-	8,3	-	-	-	-	2
Circus aeruginosus	-	50	-	60	100	66,6	-	24
Fulica atra	-	-	-	30	100	-	-	11
Larus ridibundus	-	50	-	10	100	-	-	9
Larus canus	-	50	-	20	50	-	-	9
Chlidonias niger	-	-	-	40	100	-	-	13
Chlidonias leucopterus	-	-	-	-	50	-	-	2
Sterna hirundo	-	50	-	-	50	-	-	4
The whole number of waterbird species	5	11	7	15	20	5	2	

- percentage of surface area with different types of submerge and surface vegetation;
- percentage of shore types from the whole shore line;
- water basin (percentage of different biotopes from shole basin area on the 5 km distance from lake shore);
- other lake description were taken from reference book on Belarussin lakes (Yakushko *et al.* 1988): mineral matter content, water transparency and colour.

Table 2: Estimated number of waterbirds in glacial lakes

Species	Oligo-trophic	Maso-trophic	Slightly eutrophic	Eutro-phic	High eutro-trophic	Hyper-trophic	Dis-trophic	All lakes
	n = 5	n = 2	n = 12	n = 10	n = 2	n = 3	n = 11	n = 45
Water surface area (ha)	602	7986	1682	8085	7395	1420	127	27297
Gavia arctica	6	-	6	-	-	-	-	12
Podiceps cristatus	22	152	28	372	250	16	-	840
Botaurus stellaris	-	2	-	20	62	8	-	92
Cygnus olor	-	11	-	11	6	-	-	28
Anas plathyrhynchos	14	161	34	682	1900	24	9	2824
Anas crecca	4	-	14	13	92	-	-	123
Anas strepera	-	-	2	-	2	-	-	4
Anas acuta	-	-	-	-	2	-	-	2
Anas querquedula	-	-	-	201	78	-	-	279
Anas clypeata	-	-	-	-	6	-	-	6
Aythya feryna	-	4	-	102	950	-	-	1056
Aythya fuligula	-	74	-	74	310	-	-	458
Bucephala clangula	23	16	80	26	8	12	43	185
Mergus serrator	-	4	-	2	-	-	-	6
Mergus merganser	-	-	2	-	-	-	-	2
Circus aeruginosus	-	2	-	20	62	4	-	88
Fulica atra	-	-	-	94	500	-	-	594
Larus ridibundus	-	800	-	240	3800	-	-	4840
Larus canus	-	40	-	45	50	-	-	135
Chlidonias niger	-	60	-	310	260	-	-	630
Chlidonias leucopterus	-	-	-	-	60	-	-	60
Sterna hirundo	-	6	-	-	20	-	-	26
Whole estimated number	69	1364	168	2188	8498	64	52	12380

Simple correlation coefficients were calculated between habitat variables and waterbird densities. Calculations were made in the Computer Centre of the Mathematical Institute (Belarussian Academy of Sciences).

On the strength of species composition and density of waterbirds in correspondence with mean values of main habitat variables, we have identified seven lake groups mostly coinciding with generally accepted lake classification based on trophic levels **(Table 1, 2)**.

RESULTS AND DISCUSSION

The numbers of bird species nesting in the lakes with different trophic level were different (**Table 3**). The number of bird species increased in the lake series from oligotrophic to distrophic with maximum species number in highly eutrophic lakes (21 species), and than decreased again.

The least number of waterbird species nested in lowly mineralized distrophic lakes situated in peat bogs and also in oligotrophic forest lakes.

Dominant species Mallard (*Anas plathyrhynchos*) and Goldeneye (*Bucephala clangula*) were registered in all types of lakes (**Table 3**). These species were not restricted to only in low mineralized distrophic waterbodies.

Table 3: Environmental variable correlation coefficients with species densities (%)

Environmental variables	CIR AER	POD CRI	BOT STE	BUC CLA	AYT FER	AYT FUL	ANA PLA	ANA CRE	ANA QUE	FUL ATR	LAR RID
Surface area, ha	40	0	18	-24	33	36	2	-4	5	47	63
Submerge vegetation, %	34	20	0	-13	58	57	43	-3	7	50	60
Whole vegetation, %	44	29	26	-22	41	27	21	-11	5	42	42
Mosaic vegetation, %	49	0	62	-17	47	90	17	-1	20	71	51
Unbroken veg. grows, %	34	40	24	-16	17	9	0	-5	5	33	20
Shore line, m	39	0	22	-39	19	32	0	-8	19	33	45
Open shore, %	1	41	20	-17	29	26	40	-13	-3	7	-2
Forest shore, %	-35	-21	-24	15	-30	-23	-20	23	-7	-27	-21
Islands, %	53	-4	19	-13	52	20	0	3	-1	67	80
Water basin: Forest, %	-38	-29	-17	33	-36	-23	-27	0	-8	-24	-26
Marshes, %	27	8	56	-12	42	85	30	-3	6	53	31
Agricultural lands, %	41	41	21	-30	47	21	35	-11	0	30	30
Mineral matter cont., mg/l	49	31	21	-53	25	25	23	-21	34	22	18
Water transparence, m	-28	3	-23	21	0	-15	9	33	-16	-18	-5
Water colour, grad.	24	-7	34	-30	13	46	0	-15	5	32	16
Phytoplankton, g/m^3	54	0	38	-27	23	46	11	-10	14	30	21
Zooplankton, g/m^3	27	-7	74	-25	6	54	-4	-5	24	33	0
Zoobenthos, g/m^2	24	-4	10	0	21	16	2	-2	6	29	34

Large group of species (Eurasian Bittern - *Botaurus stellaris*, Common Teal - *Anas crecca*, Garganey - *Anas querquedula*, Pochard - *Aythya ferina*, Tufted Duck - *Aythya* *fuligula*, Coot - *Fulica atra*, Black Tern - *Chlidonias niger*) occurred only in 6-9 lakes during the nesting period. The others were occurred in 5 and less waterbodies.

Analyses of results from investigations of waterbird numbers in different lake types used to determine dominant species group (Black-headed Gull, Mallard, Pochard, Great Crested Grebe) with their different occurrence. If Mallard and Great Crested Grebe occurred in majority of different lakes, Pochard and Black-headed Gull nested only in some high eutrophic lakes, but with very high density.

Subdominant group consisted of Coot, Tufted Duck and Black Tern. This species group also nested in small number of waterbodies but with high density.

Separate group was formed by Goldeneye, Eurasian Bittern and Marsh Harrier. They occurred in large number of lakes, but with low density. Their low density was attributed to their biological peculiarities and not to the bad environmental conditions.

Common Teal, Garganey, White-winged Black Tern and Common Tern despite of their ordinary occurrence and high abundance in Belarus, were revealed only in few lakes with low density. It was explained by their breeding in river floodplanes.

The rest of species (Black-throated Diver, Northern Pintail, Gadwall, Northern Shoveler, Red-breasted Merganser and Goosander) were rare as in estimated number as in occurrence.

The analysis of different environmental factors influence on ecological capacity of lakes for different waterbird species allowed to distinguish three species groups with similar environmental demands.

The first group consisted of Goldeneye and Black-throated Diver. They preferred to breed in small unproductive lakes situated in forest tracts or in peat bogs. Low content of mineral matter, high water transparency and sparse surface vegetation are distinguishing features of such lakes.

The second group of species with the same environmental demands consisted of Pochard, Tufted Duck, Eurasian Bittern, Black-headed Gull and Marsh Harrier. Their densities positively correlated with majority of variables connected with highly eutrophic lakes. Different vegetation communities, the presence of vegetation-floe and islands formed high environmental mosaicity, so large quantity of species utilized such areas with high density.

Positive correlations between densities of such species showed not only the same environmental demands of them, but also the absence of interspecific competition. Low interspecific competition were explained by as well as ecological niches interference, as also food abundance and good protective properties, that also lowered the competition.

The third group consisted of Mallard and Great Crested Grebe. They occurred in majority of lakes with rather high density. The absence of high positive correlations with analysed environemntal factors was expalined by the high plasticity of these species. They can use for nesting the lakes with different surface area and trophic level. The same reasons led to the lack of close relationships with densities of other species.

Interspecific correlation indices between densities were also indicated the presence of three species group with high interspecific positive correlation within group and correlation lack between species from different groups.

Analysis of species distribution and estimated number allowed us to conclude that populations of species nesting with high density in small number of high productive lakes were in the most unstable conditions. We can attribute to such species group Pochard, Tufted Duck, Coot, Eurasian Bittern, Marsh Harrier. Instability of their populations can be explained by first of all with small quantity of natural lakes with high productivity (there are only ten such lakes in Belarus now) and secondly - rapid decreasing of lake productivity because of anthropogenic eutrophication.

Mallard and Great Crested Grebe were in best conditions because of their ability to populate different types of waterbodies. The estimated number of Goldeneye was also rather stable because of stability of lake ecosystems in early and late stages of development.

We can conclude that increase in the hunting of waterbirds and the conservation of rare species will be impossible if only a few lakes will be protected. It is necessary to develop guidelines (or rules) for all Belarussian natural waterbodies for wise use and protection. It will not only improve conservation of natural lakes, but also increase the ecological capacities of natural waterbodies.

Other, more effective way of protection is the development of waterbird reproduction centre network in artificial waterbodies.

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AUTUMN DUCK PAIRING AND WINTERING STRATEGIES: AN ADAPTIVE RESPONSE TO ENVIRONMENTAL WINTER CONDITIONS

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ABSTRACT

Recent papers demonstrated a strong correlation between body conditions of ducks at the end of the winter season and breeding success. From data (feeding duration per day and body mass) collected in the Camargue, south France, on three duck species, we already suggested that birds adopt a sets of behavioural and ecological mechanisms, so called a wintering strategy, from which body conditions at the beginning of the winter season predict body conditions at the end of the season (Tamisier *et al.* 1996). Within this strategy which has an adaptive value, autumn pairing seems to have a key position since paired birds are hierarchically dominant for food access at the end of the winter when food shortage occurs. Hence early pairing would be an advantage, not only for females, as most often thought, but also for males. The cost of early pairing would be recuperated later on in terms of breeding success.

INTRODUCTION

Until the beginning of the 80's, breeding performance was supposed to be controlled by variables associated to breeding environment, and no functional link was supposed to exist between winter season and breeding season (Anderson and Batt, 1982). Following the Puxico Symposium in Missouri (Anderson and Batt, 1982) and the Conference at Galveston, Texas (Weller, 1988), an increasing number of papers revealed the existence of strong correlations between body condition of birds (mostly waterfowl and more recently waders) at the end of the winter season, and breeding performance (see Ankney *et al.*, 1991 for a review). Birds which are able to store enough energetic reserves (mostly lipids, but also proteins in some circumstances) while they still are on their winter quarters, are those which have the highest breeding success several months later, at several thousands km further north. Conversely birds which fail storing reserves at the end of the winter or at intermediate stopping areas will produce less or no juveniles. Thus two points occurring in winter are of prime importance in the breeding success of waterbirds: 1) food resources that exist at the wintering grounds and/or at the stopping areas and 2) the capability of birds to have access to these resources.

In the Camargue, one of the major wintering grounds for western paleartic duck species in the Mediterranean basin, we developed the model of wintering strategies (Tamisier *et al., in press*), first proposed by Heitmeyer (1985) and Allouche (1988), for 3 duck species according to observed changes in energy demand and body mass. Autumn pairing is part of the wintering strategy. The aim of this paper is to propose that pairing in autumn, so far considered as an advantage only for females who benefit of their mate's attention to store reserves more easily (Rohwer and Anderson, 1988), has a decisive function for both partners in terms of breeding success. And if it can be associated to the availability of food resources once ducks arrive at the Camargue, then the environmental conditions that prevail during the fall months in these south-western winter quarters would actively participate in controlling breeding performance of the following season in reproductive areas.

STUDY AREA AND METHODS

The Camargue, delta of the Rhône river in the Mediterranean sea, is a wide area of 145,000 ha where wetlands cover less than 40 % of the surface. Out of them, 19,000 ha are included in strictly protected areas (Reserves, mostly state owned). Other parts are affected to agricultural, industrial and urban use. In spite of several prestigious conservation policies, the trend is a decrease of wetlands because of the extension of human activities; after a rapid decrease between 1942 and 1984 (40,000 ha of wetland loss) the present trend is less but still at a rate of 0.5 % per year (Tamisier, 1990; ARPE, 1992; Tamisier, 1994). Furthermore, qualitative modification occurs on non protected wetlands; in effect those wetlands, privately owned, are used mostly for hunting (and more recently for tourism for some of them) which leads to a mean kill of 150,000 ducks per year, to a high shooting disturbance during the 7.5 month hunting season. Hunting also implies water management; natural summer drying up of the marshes is replaced by permanent or semi-permanent flooding, salt or brackish water are replaced by fresh water pumped from the Rhône river. As a consequence, losses of heterogeneity and biological diversity of Mediterranean-type marshes are observed while monospecific continental-type communities become the most frequent on these private wetlands. They also are more predictable and more productive in terms of aquatic plant biomass than natural wetlands. Nevertheless they could not favour any increase of the size of the waterfowl populations since these populations are likely to be limited by hunting (Tamisier and Grillas, 1994). For a more detailed description of the Camargue wetlands, see Dehorter and Tamisier in this volume).

Climate is mediterranean-type in Camargue, with heavy rains in autumn and winter, mild temperatures till November and coldest temperatures from December to February (Heurteaux, 1976). Cold spells cause freezing of most or all marshes and lakes for periods which last usually 3-8 days, up to 3 weeks. For the last 30 years, freezing occurred 11 times, mostly in January. Water level increases regularly from September (usually low waterlevel in most marshes, many being even dry in Reserves) to February-March (all wetlands usually are inundated).

Camargue is the most important wintering area for ducks and Coots (*Fulica atra*) in France with a mean maximum population of about 125,000 ducks and 30,000 coots for the last 30 years. These numbers are those that can be counted at a given time, they do not take into account the number of birds which transit over the Camargue (probably around 500,000 birds). We selected three species which represent ca. 40% of the total wintering duck population: European Teal *Anas c. crecca*, European Wigeon *A. penelope* and Gadwall *A. strepera*. We used two sets of data, time budgets and body mass. Time budgets provided feeding durations per 24 hour cycle (Tamisier, 1974; Campredon, 1982; Allouche, 1988). Body mass were those of hunted ducks in the Camargue. Specific mass were standardised in order to allow interspecific comparisons through ANOVA. Details are provided in Tamisier *et al.* (1995).

DISCUSSION AND CONCLUSIONS

The wintering strategy

From these Camargue data, the winter season can be divided in three successive periods, each period lasting 2-3 months according to species:

1) *Restoring period.* Birds arrive in the Camargue, they must gain energy to recuperate the energy lost during the migration flight. Furthermore juveniles must gain some more energy to reach adult weight. As a consequence, all birds feed actively, feeding duration per 24 hour cycle is very long (12 to 16 hours according to species), and the 24 hours of the day are fully occupied by feeding (which brings energy) and sleeping (which limits at a minimum the energetic losses). Only a few hours in Teal are devoted to preening, a necessary activity related to moult of body-feathers.
2) *Pairing period.* Bird weights are maximum, climatic conditions are still comfortable. This is the only period in the winter season when ducks have extra time and they take advantage of that situation for swimming, courtship and pair formation.
3) *Fattening period.* From January onwards, environmental conditions become worst, food is scarcer and birds must store energy for spring migration and breeding. Sleeping is long again and feeding durations become longer than ever. Interspecific competition is probably at its highest and paired birds are hierarchically dominant for food access.

These three phases of the winter season are not only successive phases, they interact effectively in that only paired birds have a sure access to food at the end of the season (when food is less abundant); and paired birds are those which could perform courtship at mid-winter, that is to say those which had previously stored enough energy during the first period of the winter season. The three phases have functional links and support the model of a wintering strategy; we can hypothesise that body conditions of birds when they arrive in the Camargue have a predictive value for the conditions of birds 6 months later, when they leave to the breeding grounds (Tamisier *et al.*, 1995). In this context, pairing is a full component of the wintering strategy (**Figure 1**).

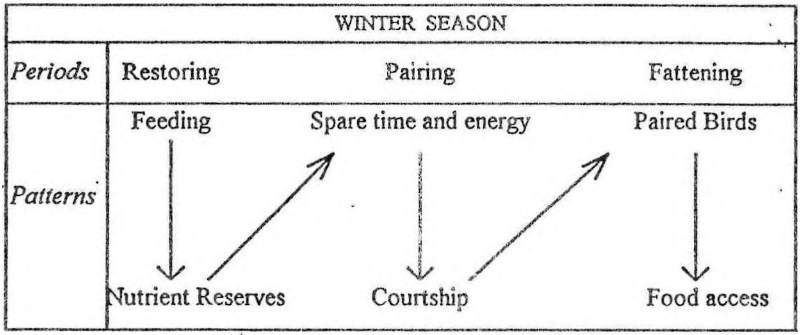

Figure 1: The Camargue model of wintering strategies (after Tamisier et al., 1995).

Autumn pairing

According to this strategy, it is a selective advantage for an individual to be paired before the end of the winter, so that it can store sufficient reserves, from a qualitative (lipids and proteins) and quantitative point of view, for spring migration and breeding. Hence it can have a better fitness in terms of breeding success. Pairing in autumn probably is the key point of the wintering strategy. As a matter of fact, those birds which failed to pair at that period will have no time to do it after, since they can hardly both store energy and pair at the end of the winter; and they won't have a good breeding success. As a consequence, autumn pairing and wintering strategy are fully integrated into the annual cycle. The cost of pairing so early is recuperated several month later at the breeding grounds. So a trade-off can be suggested between early pairing and breeding success (**Figure 2**).

Pairing in autumn is a very unusual timing characteristic for most waterfowl species as compared to other bird species and families in the northern hemisphere (Anderson *et al.* 1988). So far, pairing early in winter was considered as the result of a strong male competition because of a shortage of females (Spurr and Milne, 1976). Pairing early can be an advantage since, later on, no more females were available. However this advantage for males is counterbalanced by a risk for the paired male not to have enough reserves either for maintaining pair bond (and be replaced by a male in a better condition) or even for its own energy consumption during spring migration (Afton and Sayler, 1982). Finally most authors considered that pairing early in the winter season was mostly an advantage for females to store nutrients during the last period of the winter while being defended by their mate against courting males (Ashcroft, 1976; Rohwer and Anderson, 1988). Social dominance at feeding sites is also at the advantage of paired females (Paulus, 1980). From our observations, we can add that it is also an advantage for males, since as paired birds, they have a priority access to food at a time when feeding is the most problematic (food shortage).

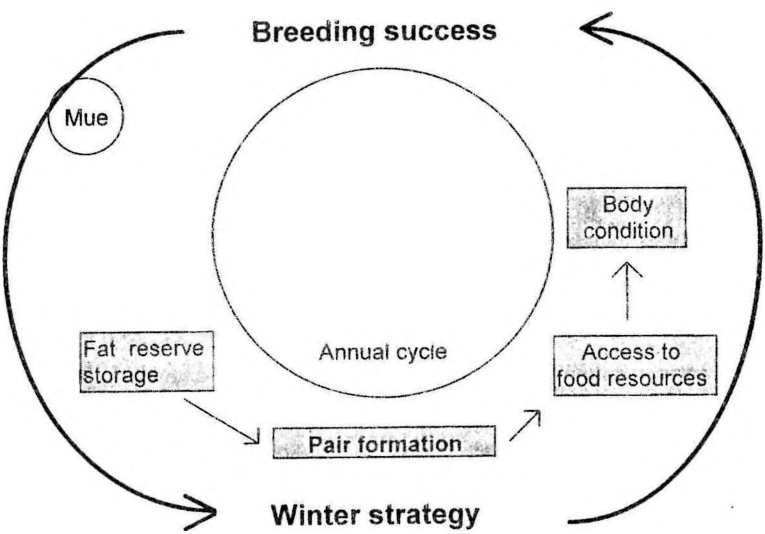

Figure 2: Pair formation, a key point in the wintering strategies, and a suggested trade-off with breeding success

Are this wintering strategy and the key position of pairing in the strategy characteristic of a single wintering area (the Camargue from where field data come), or do they have a more general significance ? In spite of detailed analysis from this point of view, we can suspect that ducks which winter in more northern wetlands like Sweden (cf. Nilsson, 1972) or Alaska (Conant *et al.*, 1988), as well as those wintering in tropical areas like Senegal (Roux *et al.*, 1978), behave differently and hence, have different wintering strategies. But we wish to emphasise that, since birds must have good body conditions at the end of the winter season for a good breeding success, specific mechanisms should allow them to reach that point wherever they winter. The wintering strategy is supposed to be this adaptive set of mechanisms and we can suggest that it has a regional specificity. Now since autumn pairing is a very general life-history trait for most ducks of the northern hemisphere, and considering the cost of pairing, we can suspect that it keeps a central position whatever the wintering strategy. Wintering in tropical zones is probably an exception since palearctic ducks are not known to pair there (Roux *et al.*, 1978). More studies should be done in similar zones, especially in tropical winter quarters of central and south America.

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SREBARNA CASE STUDY: HABITAT CHANGES AS REFLECTED BY WATERFOWL

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ABSTRACT

The long-term observations on the waterfowl and the complex limnological situation of the lake allowed us to conclude:

1. The case of Srebarna gave an excellent example of the statement that the abundance and distribution of birds (and especially of waterfowl) depends on many different and sometimes even contradicting factors. That is why it is impossible to detect the early stages of changes in wetland habitats only by changes in bird population and colonies.

2. The waterfowl and especially the pelicans are more or less conservative element of limnological systems and their reactions to changes in the habitat quality sometimes is not so immediate. Taking in mind the nest-conservative behaviour and genetic breeding memory it is necessary to stress that the feeding activity of waterfowl (especially of fish-eating ones) is much more important indicator than their nesting.

3. According to our observations in the case of Srebarna the glossy ibises were much more sensitive to habitat changes than the other waterfowl birds. The colonies of *Plegadis falcinellus* were the first that left the lake territory. Thus, it is possible to propose that this species could provide sufficient indicative information on wetland habitat quality.

INTRODUCTION

Lake Srebarna in Bulgaria was declared as Ramsar site (1975), UNESCO biosphere reserve (1977), Monument of World Cultural and Natural Heritage (1983) and Important Bird Area (1990). The reason behind this recognition was its extremely rich ornithofauna and particularly the breeding of globally threatened species *Pelecanus crispus* and *Phalacrocorax pygmeus*. During the last years the lake ecosystem underwent significant changes toward strong eutrophication and anthropogenically speeded-up succession. The main reasons were the interrupted connection with the Danube river (because of a dyke built in 1948) together with the pumping of the underground waters, as well as the agricultural changes and activities in the watershed basin.

The case of Srebarna could be regarded as an example of the birds response to habitat changes. The problems of use the waterfowl as indicators of the wetland habitat quality are discussed.

STUDY AREA

Lake Srebarna is situated in North-Eastern Bulgaria on the right bank of the River Danuba (44° 05' n.l. and 27° 07' e.l). It is located in a karst depletion and is surrounded by three hills. Between the lake and the Danube there was a strip of arable land up to 1994. Recently Srebarna is a shallow (0.8-0.2 m depth) hypereutrophic (**Table 1**) polymiktic basin. The total reserve territory is 902.1 ha. The lake surface is about 2.4 km^2, including the open water area and the surrounding reed-belt and the volume is $0.37 \cdot 10^6$ m^{-3}. The climate in the region is continental with a temperature varying between -2.5 °C (in January) and 39 °C (in July). Annual precipitation average is 159 mm. The average ionic concentration is high (1135 mg l^{-1}) with a sulphate character, corresponding to the average conductivity of 570.0 S cm^{-1} and 6.5-7.5 pH (Michev *et al.*, 1993; Radev *et al.*, 1993). The karst sediment nowadays are covered by a 7 m thick layer of sapropel.

Table 1: Selected water quality features of the Srebarna lake

	1960	1985	1993
SO_4 (mg l^{-1})	48.1	38.1	487.3
Cl (mg l^{-1})	146.4	41.0	150.5
PO_4 (mg l^{-1})	0.02	0.20	1.14
NH_4 (mg l^{-1})	0	0.07	0.40
NO_3 (mg l^{-1})	-	1.42	2.53
EJ (mg l^{-1})	663.3	496.3	1178.3
HCO_2 (mg l^{-1})	321.9	293.6	178.3
Cond (µS cm^{-1})	-	-	570.0

LAKE ECOSYSTEM UP TO 1948

During the last two centuries a regular annual intrusioof Danube waters in the lake occurred. According to the descriptions of foreign naturalist in 19th centruy the Lake of Srebarna was full of life and was called "waterfowl Eldorado". Scientific investigations have started at the end of 19th and beginning of 20th century. Data on the lower flora of the lake could be found only in the monograph by Petkoff (1911), who mentioned 15 species. The lake higher flora (47 species) and vegetation were studied in a pilot way by Petkoff (1911), Bonchev (1929) and Jordanov (1946-47). Hydrobiological and hydrochemical investigations had not been carried out in the lake. The data on the invertebrate fauna are scarce. The most thoroughly studied component of the lake ecosystem was its ornithofauna and mainly the waterfowl (Hodek, 1882; Christovich, 1890; Reiser, 1894 and Petrov, 1947). The last author mentioned especially the presence of big heron colonies (of *Egretta alba*, *Egretta garzetta*, *Ardea purpurea*, *A. cinerea*, *Ardeolla ralloides*, *Nycticorax nycticorax*), *Plegadis falcinellus* and *Platalea leucorodia*. According to him the pelican colony (50-60 breeding pairs) inhabited the pool "Babushko blato" and several floating reed inlets.

CHANGES IN ECOSYSTEM AFTER THE DYKE-BUILDING IN 1949 (WITH SPECIAL RERERENCE TO WATERFOWL)

In 1948-49, in spite of the severe protests by scientists from Bulgarian Academy of Sciences (BASc), a dyke between the lake and the Danube river was built. Thus the previously existing connection between the lake and the Danube was interrupted. The first result was the decrease of lake surface from 5 km^2 with an open water area of 3.35 km^2, to 2.5 km^2 with an open water area of 0.6 km^2 (Modev, 1994). The water volume also decreased and the bottom rose up and the depth changed from 3.5 m to 1 m. The last even was caused mainly by the prohibited harvesting of the reed *Phragmites australis* (in 1975). This lead to the increase of the reed-bed in the lake. The previously floating *Phragmites*-inlets became anchored. They increased both in numbers and in surface area. All the events mentioned above changed the habitat features in a way that it became a wintering place for *Anser albifrons* and *Anser anser*. The first census of these geese in 1977 showed that about 10,000 individuals overwinter there. This number did not change significantly in the following years. According to our previous count-speculations it could be proposed that minimum about 1,000 kg excrements per day (about 60,000 kg per season) are involved in the nutrient cycling in the lake. The increase of dead reed material and bird excrements together with the agricultural policy to use artificial fertilizers seems to be the reason for the detected increase of SO_4, PO_4 and N (NH_4 and NH_3) in the lake waters (**Table 1**).

During the same period a decrease in the species composition of fish stocks was detected; from 19 species reported by Bulgurkov (1958), only 6 remained in the period of 1954-80 (Michev, 1968, 1981). Reptiles and amphibians were represented by 11 species (Paspaleva-Antonova, 1961; Michev - unpubl.).

There were different trends in the development of the ornithofauna during this long period (1949-1983). On one hand, at first a kind of enrichment was observed. This enrichment was due to the returning of big heron colonies to the reserve territory. The special cause for this event was not connected with the habitat changes.

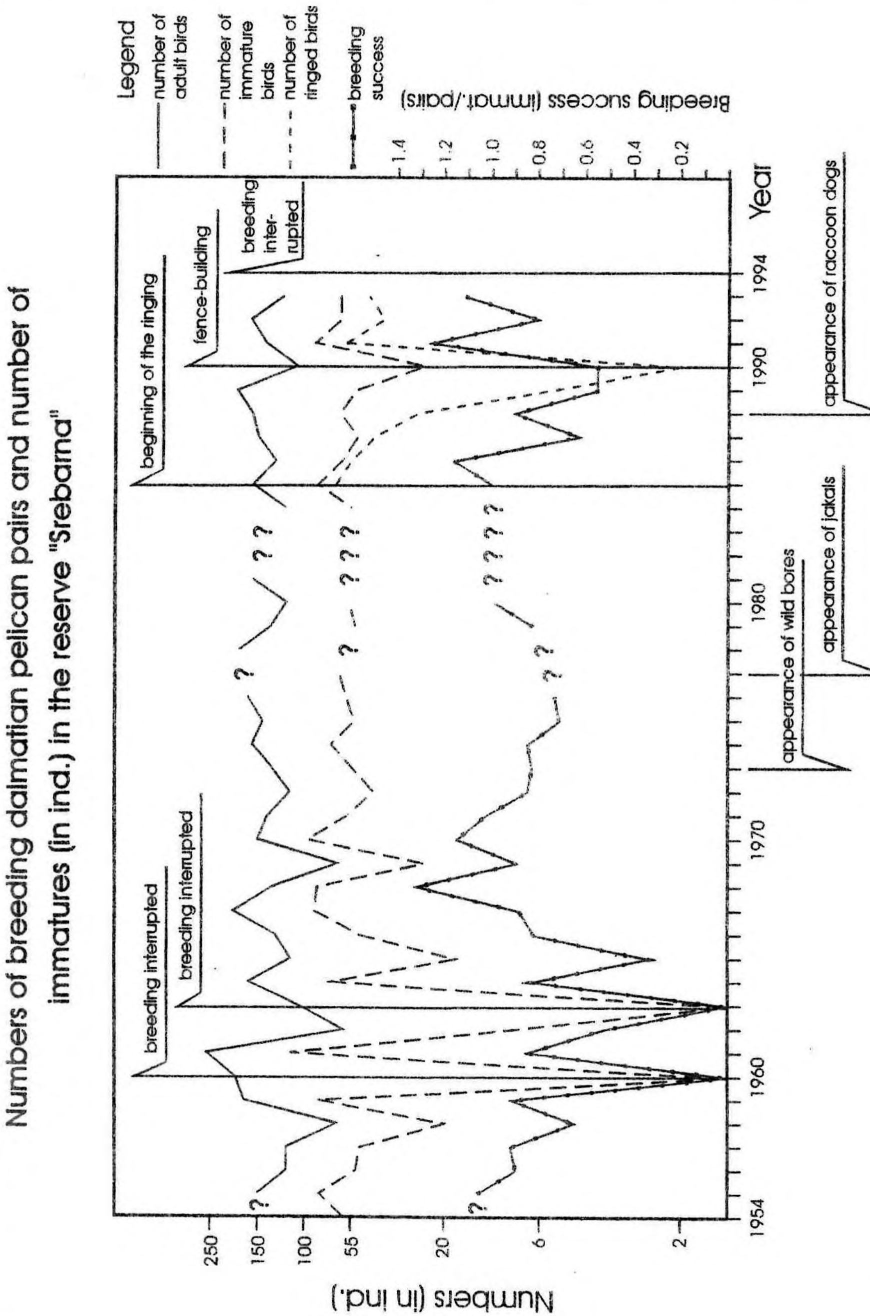

Figure 1: Numbers of breeding dalmatian pelican pairs and number of immatures (in ind.) in the reserve "Srebarna"

Such a cause was the lack of harassment of the herons after the imposed restrictions on their persecution in Bulgaria in the period 1944-1958. But afterwards, the number of species and abundance of waterfowl decreased. Paspaleva-Antonova (1961) in her list of species breeding in Srebarna (totally 33) did not include *Plegadis falcinellus* (compare with the text above). During the period 1966-67 the reserve became more important as a migration point for the waterfowl, than as a breeding place because of its changed habitat features and increased anthropogenical influence (Paspaleva, Michev, 1971). It is noteworthy to mention that the numbers of Dalmatian Pelicans varied during the period 1954-80 (Michev, 1981). He detected the interruption of their breeding in 1960 and in 1963 and increase in numbers after 1975 **(Figure 1)**, when the direct anthropogenic influence was forbidden by law.

In our opinion the enrichment of species list, mainly during the period 1961-1975, could be explained with much more intensive ornithological studies carried on the reserve. I.e. Paspaleva-Antonova (1961) reported 144 psecies, whereas in the paper of Michev (1968) this number increased to 152. According to the unpublished data of the latter author the total number of bird species recorded in the reserve is 178.

The cladoceran character of the zooplankton by Naidenov (1965) was shown. The data on the lower flora of the lake from this period (Vodenicharov, 1962; Vodenicharov et al., 1971) are scarce and incomparable with the previous publication of Petkoff (1911). But it must be noted that algal blooms had not been reported. The investigations of the higher flora and vegetation (i.e. Ganchev, 1957; Vihodcevski - in Paspaleva- Antonova, 1961; Kochev, Jordanov, 1981) showed the dominance of *Phragmites australis* and existence of 67 plant species. Among them 13 were representatives of the Bulgarian Red Data Book (1984). The *Populus* plantations around the lake with their high transpiration activity have negative influence on the water regime of Srebarna since they were created.

CHANGES IN THE ECOSYSTEM AFTER DYKE REMOVAL IN 1983

The above mentioned changes in the ecological situation in the lake were the reason for the further activities of the scientists from BASc against the dyke. A lenght of 500 m was removed in 1983. During the first three years the Danube waters entered the lake and a considerable increase of the water volume was observed and for a short period the maximum depth became again 3.5 m. This resulted in an overflow of many of the floating reed-inlets and afterward in the re-elevation of the particularly decayed dead inlets. In the same time many previously anchored inlets (including the big islet with colony of *Pelecanus crispus*) became free again and their movement and distribution in the lake followed the changes in the water level and wind direction. In this way the position of many channels in the lake were changed and the open water surfaces increased. We have to mention especially that the increase of the open water surfaces increased. Also noteworthy is that the increase of water level restored the open water surface strip between the bank and the reed-belt. Thus the nutritional basis (mainly small fish and invertebrates) for many waterfowl representatives was recovered and was available again. A re-enrichment of species composition of the birds was detected (Michev, unpubl. data) and we can only speculate that the number of bird species in this period were more or less the same as in 19th century. In the same time high concentrations of DDT in the pelican eggs were detected (Michev, Dilchev, 1985). The species composition and numbers of fish fauna increased to 9 species with large populations (Michev *et al.*, 1993). The algological investigations during this period (1982-1985) showed the specific character of the pools among the reed-belt (Stoyneva, 1991; Stoyneva and Draganov, in press). Totally 411 algal taxa (except diatoms) were recognized so far in the lake (Stoyneva and Draganov, 1994).

Danube waters did not enter the lake any more after 1988. Together with the pumping-out of the ground waters this lead to drastic changes in the total lake ecosystem. First of all the water level was diminished and a shallowing was detected. (The depth of the water column decreased to 15 cm in 1993 - Michev *et al*, 1993; Stoyneva, 1994). Again, the surface and the thickness of the floating reed-inlets increased and the nesting habitats of many waterfowl species became available for jackals, foxes, raccon dogs (a new species in the mammal fauna of the lake) and wild boars. They destroyed the nests and eggs of many species. The counts from these period showed the drastic decrease in species numbers and abundance of the birds. Only pelicans (with nutritional basis in Romania) and several trivial species (*Acrocephalus scirpaceus, A. arundinaceus, Gallinula chloropus, Fulica atra, Anas platyrhynchos, Pica pica*) remained in the lake. The numbers of pelican birds and of breeding pairs increased after 1990 because of the especially built Danube island wich recently (1994) is included in the reserve territory. Another, additional reason for the decrease of species composition and abundance of the birds was the elimination of many vineyards and orchards in the western part of tha lake in 1983. This became very damaging because of the heavy rains and storms in this part of Bulgaria. Large amounts of soil masses were carried into the lake and on the background of the diminished water quantity this became one of the most important reasons for the strong eutophication and speeded-up succession of Srebarna. The eutrophication was detected by chemical analyses (Michev *et al.*, 1993 and Radev *et al.*, 1993, Table 1) and changes in zooplankton and zoobenthos communities towards decrease in species composition and abundance (Kraeva, 1992; Radev *et al.*, 1993) as well as by a shift in algal communities and appearance of blue-green algal blooms (Stoyneva, 1994). A strong pyrrhophyte bloom was detected also in 1993 (Michev *et al.*, 1993 - manuscript). Changes appeared in the species composition and abundance of higher flora and vegetation of Srebarna: the number of species decreased (from 157 in 1975-1989 to 136) and some of the rare and threatened species disappeared (i.e. *Aldrovanda vesiculosa*, *Stratioites alloides*, *Carex disticha*, *Nuphar lutea*) or diminished their populations (i.e. *Nymphaea alba*), whereas for other trivial species (mainly *Phragmites australis* and *Typha angustifolia*) an "offensive" was detected (Baeva, 1992). *Phr. australis* showed pronounced morphometrical changes (diminished sizes) in the last years (Baeva, 1994). Many animal species disappeared from the reserve territory. The globally threatened *Astacus astacus*, *Hirudo medicinalis* and *Lutra lutra* among them.

CHANGES IN THE ECOSYSTEM AFTER THE BUILDING OF A NEW CANAL BETWEEN THE LAKE AND THE DANUBE RIVER IN 1994

All the events mentioned above were the reason to alarm the Ramsar Bureau and with its help and with the financial support of the World Bank a new canal between the lake and the Danube was built in May 1994. The most important change observed was the increase of water volume (depth of 1 m) and observed appearance of zoobenthos and of some representatives of the charophycean algae in the phytobenthos of the lake. A complex monitoring program started (October 1994) and it is possible to predict that hte regular entrance of Danube waters would stop the enforced succession of the lake. In this way we expect the returning of the colonies of the waterfowl representatives which recently breed on the neighbour Danube islands.

CONCLUSIONS

The long-term observations of the waterbirds and the complex limnological situation of the lake allowed us to conclude:

1) The case of Srebarna gave an excellent example of the statement that the abundance and distribution of birds (and especially of waterbirds) depends on many different and sometimes even contradicting factors. That is why it is impossible to detect the early stages of changes in wetland habitats only by changes in bird populations and colonies.

2) The waterbirds and especially the pelicans are more or less conservative element of limnological systems and their reaction to changes in the habitat quality sometimes is not so immediate. Taking into consideration the nest-conservative behaviour and genetic breeding memory it is necessary to stress that the feeding activity of waterbirds (especially of fish-eating ones) is much more important indicator than that of their nesting.

3) According to our observations in the case of Srebarna the Glossy Ibises were much more sensitive to habitat changes than the other waterfowl birds. The colonies *of Plegadis falcinellus* were the first that left the lake territory. Thus, it is possible to propose that this species could provide sufficient indicative information on wetland habitat quality.

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LIMNOLOGICAL CHARACTERISTIC OF THE GLACIAL LAKES OF THE NORTH OF THE KOMI REPUBLIC (RUSSIA) AS A WATERFOWL HABITAT

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INTRODUCTION

Limnological study of lakes situated in latitude 66,5 North in the Komi Republic, where a lot of waterfowl species are nesting and also concentrating during the season passage, is very important for conservation of waterfowl habitat limnological base. We wanted to determine parameters of some qualitative and quantitative ecosystem characteristics of the four lakes: Pysey-ti, Vozey-ti, Evsya-ti, Siatey-ti. Mentioned lakes belong to the Kolva Basin and they are situated at a distance is 7 up to 80 km from each other. These are residual reservoirs of the big lake-land glacial reservoirs (Kolvinskoe lake) existed in the late-quartenery period. They are situated in the interpilly hollow of of postglacial ridge (Kvasov, 1975).

MATERIALS AND METHODS

Water sample selection for hydrochemical analysis was held from the 5 of September to the 5 of October according to the general method: one station is in the middle of the lake, two station on the coast, the samples were taken additionally in different lake points from the surface for determination of pesticidae, bichromatic acidification, coloration. Water samples were taken by Ruthner's bathometer. The hydrochemical material consisted of 60 samples. The hydrobiological material was collected during the period of time from July 5 to the October 5, 1990. Zooplankton was gathered by Jady's quantitiative net, kapron sieve N62 was used for the net cone. Zoobenthos was gathered with the help of Peterson's bottom-scoop 1/40 m. Benthos samples were washed through the washer made of kapron net N40. In each lake 13 zooplankton and zoobentos sampler were gathered according to the general scheme: 3 stations in different plots - 3 samples in each one and one station - 4 samples in the middle of the lake. Each sample was processed separately. Mean arithmetical index is introduced in the article. Hydrobiont determination was conducted up to the species, excluding some systematic groups. Zooplankton biomass calculation was made with use of individual balance tables (Mordulhai-Boltovskoy, 1954; Yukhneva, Koynova, 1973). Collection, processing and calculation of the hydrobiological material was committed according to the generally accepted method. That is why the determination of the quantitative and qualitative lake ecosystem characteristics is of great interest. Peaceful and raptorial species production was calculated from the mean seasonal populational biomass and P/B during the season for the given species (Zaica, 1972; Slepukhina, 1977). Seasonal specific production index is taken from the literature about the lakes of the similar latitunde zone (Karelia, Siberia) (Alimov, Pohinogenova, 1975; Kuzmenko, 1976; Sadyrin, 1984). Ration of raptorial invertebrate animals was calculated proceeding from the quantities of the daily rations in % from the body weight (Sadyrin, 1978; Sokolova, 1980) according to equation

$$Cr = Cr - B\ t,$$

using quantities of the daily rations in accordance to the species or groups. Pure zooplankton and zoobenthos production was calculated according to the following equation

$$Ppure = Pr + Pp - Cr,$$

where Pr - raptorial's, Pp - production of peacefuls, Cr - raptorial's ration (Shushkina, 1966). Truthhel difference of the selective means was determined (Rokitsky, 1967). During discussion of the results of morphoedaphic index was used:

$$MEI = \frac{S_i}{H}$$

where S_i - general mineralization, H - mean lake depth (Kitaev, 1984).

RESULTS

The territory of the Kolvinskaya lowland where the lakes are situated, serves a nesting place for some duck species. Number of the nesting ducks consist of 70-300 individuals/100 km (Mineyev, 1987). Number of the mass nesting species on the given territory consists %: *Clangula hyemalis L.* - 45-67 %, *Melanitta nigra* L. - 9,3-15 %, *Aythya marila* L. - 6-12,3 %, *Anas penelope L.* - 5,6-8,3 %. Anser fabalis Lat. concentrates during the autumn passage. The reservoirs belong to the most biggest glacial continental lakes on the north of the Komi Republic (**Table 1**).

Table 1: Morphometrical data and hydrochemical classification of lakes

Lake	Area (ha)		Depth (m)		Water	Classification of waters
	Total	Overgrowned (%)	Mean	Maximum	volume mln. m^3	in accordance to Alekhin, 1953.
Siattey-ti	170	0,85 (0,5)	4,2	9.0	4,25	$C_1^{Ca}0,34$ 0,03
Evsya-ti	180	3,50 (2,0)	5,6	26,7	13,32	$C_1^{Ca}0,29$ 0,03
Pysea-ti	266	7,98 (3.0)	8,4	23,8	11,97	$C_1^{Ca}0,30$ 0,028
Vozey-ti	610	18,30 (3,0)	13,0	47,0	62,70	$C_1^{Ca}0,34$ 0,031

The distinctive feature of studied lakes is a poor overgrowness by the high water plants. Waters of all studies lakes (**Table 1**) belong to hydrocarbonateclass of calcium group, the type of small mineralization between lakes is not great. Therte are no distinctive differences of biogenic element concentration in the water, for example: concentration of general nitrogen varies in the interval of 0,1 to 0,34 mg/l.; mineral phosphor from 0,002 up to 0,006 mg/l. According to the summed nitrogen the most eutophic lakes are Evsya-ti and Pysey-ti, according to the sum of biogenic elements the first place is takeb by the Evsya-ti lake, the most oligitrophic lake is Vozey-ti. In spite of the general genesis, there are distinct differences between lakes in some biogenic elements: in accordance of summed iron index lake Siattey excels all the others in 3-13 times, in the waters of lake Evsya-ti flint concentration is 1,4 mg/l, that excuds concentration in other lakes in 3-4 times. There is low concentration of seenimed iron in lake Vozey-ti from 0,001 up to 0,04 mgr/l. Such index fluctuations in abiotic environmental factors should influence on the development of organic life in the lakes, that exactly what we saw while analysing zooplankton and zoobenthos communities **(Table 2)**.

Table 2: Indices of the mean number and lake zooplankton biomass (July-September, 1990)

Lake	Coast line		Pelagial		Level of significance (P) of the head of selective means	
	sp/m^3	g/m^3	sp/m^3	g/m^3	according to numbers	according to biomass
Siattey-ti	5850	1,30	3100	0,83	0,05	0,05
Evsya-ti	138630	5,31	103149	3,20	0,05	0,05
Pysea-ti	6998	0,19	4998	0,13	0,10	doubtful
Vozey-ti	6251	0,50	4809	0,17	0,10	0,05

Analysis of the material showed that the coastal zooplankton; a little bit richer than the plankton of pelagial. The difference is statistically proved in most cases **(Table 2)**. All the lakes during investigation had the common complex of dominants in numbers and in biomass of zooplankton species.

Among *Rotatoria Asplanchna priodonta Cosse, Conochilus unicornis Rous* were dominating; among *Calanoidae- Mesocyclops leuckarti Claus + M. oithonoides Sars, Rosmina obtusirostris Sars* were dominating.

The richest species diversity of zooplankton was found in lake Pysey-ti (19 species), in other lakes species diversity is smaller (8-13 species). In the coast of lakes species diversity is bigger than in pelagial. Differences in composition of benthos is much more considerable, than in zooplankton. In different lakes the first is taken by the different groups of invertebrates. According to biomass the dominating invertebrate in Lake Evsey-ti - *Oligochaeta*, in Lake Pysey-ti - larva of *Ephemeroptera*, in Lake Vozey-ti - *Oligochaete*, in Lake Siatey-ti - *Mollusca*. The dominating group mollusks from the Siattey lake is represented by the following species: *Euglesa rosea Schol., Sphaerium corneum L., Planorbarius corneus L., Lymnaea ovata Dr.* In Lake Pysey-ti the dominating larvas of *Ephemeroptera* in their biomass are *Baetis sp., Chironomidae - Stiotochironomus pictulus (Mg.), Potthastia gaedi (Meig.), Trichoptera - Molanna angustata Curt.*

Numbers and biomass of benthos is considerably higher in the coast line, benthos is much more richer in Lake Siattey-ti biomass in twice less (approximately) in Lake Pysey-ti (**Table 3**).

Table 3: Indices of numbers and lake biomass zoobenthos (July-September 1990)

Lake	Coast line		Pelagial		Level of significance (P) of the head of selective means	
	sp/m^2	g/m^2	sp/m^2	g/m^2	according to numbers	according to biomass
Siattey-ti	20800	3,12	10500	0,87	0,05	0,01
Evsya-ti	7920	18,61	160	0,78	0,01	0,01
Pysea-ti	7400	5,06	2840	0,18	0,01	0,01
Vozey-ti	5680	35,00	305	1,60	0,01	0,01

In the productivity of lakes there are considerable differences. According to the production indices Lake Siattey-ti is separated. This is the only one among the studied lakes, where benthos production in the litoral zone and in the whole reservoir is much bigger then zooplankton production. According to the productive indices of zooplankton and zoobenthos Lake Pysey-ti is regarded as the most productive one, it corresponds in a good way with its hydrochemical characteristic and morphometry.

The most productive Lake Vozey-ti is a highly eutrophic reservoir. Taking into consideration the calculations pure zooplankton and zoobenthos production during the season consists according to lakes: Pysesy-ti - 4,64; Evsya-ti - 1,08; Siattey-ti - 0,45; Vozey-ti - 0,39 t/ha. Contribution of the litoral zone into the total production of forage reserve-compiled (%): Pysey-ti - 19,6; Evsya-ti - 5,5; Siattey-ti - 70,8; Vozey-ti - 14,5.

According to morphoedaphic index (Ryder, 1965) expected quantity of zooplankton and zoobenthos biomass is lower than real (**Table 4**).

Table 4: Zooplankton and zoobenthos biomass and M_{EI} correlation

Lake	H	Si H	Prognosed biomass		Real biomass	
			zooplankton g/m^3	zoobenthos g/m^2	zooplankton g/m^3	zoobenthos g/m^2
Siattey-ti	4,2	7,1	1,07	3,57	0,34	18,30
Evsya-ti	5,6	4,2	0,82	3,98	6,90	1,99
Pysea-ti	8,4	3,2	0,90	4,00	4,26	9,69
Vozey-ti	13,0	2,3	0,70	3,50	0,16	2,62

DISCUSSION

Estimating lake investigation accodring to one of the indices for waterfowl habitats quantitative and qualitative composition of forage reserve, it is possible to come to the certain prognostic estimates. For this is not enough to make comparison of forage reserve of the lakes with the feeding spectrum of the waterfowl species living there. Lake Siattey-ti is optimal as a habitat for *Melanitta nigra*, *Aythya marila*. Feeding spectrum consist of mollusk from 25 % - 50 % according to the general feeding clot. Lake Pÿsey-ti is a good habitat for *Clangula hyemalis*, *Anas penelope* and also for *Anas crecca*. Feeding larvas of *Trichoptera*, *Chironomidae*, *Ephemeroptera* compiling from 36 up to 73 % from the total feeding clot, and also vegetative pacts of plants (Mineyev, 1987). Availability of the organisms used as fodder for waterfowl is high in Lake Siattey-ti, Lake Pysey-ti, where there is a wide litoral zone, and as a results of it, production of the litoral zone compiles from 20 u to 70 % from the total lake zooplankton and zoobenthos production. The lakes obtain considerable potential resources for increasing the species of the birds.

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WATERFOWL NUMBERS ON SOUTH BOHEMIAN FISHPONDS IN RELATION TO FISHPOND MANAGEMENT

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ABSTRACT

In the period 1990 - 1994 point counts of waterfowl were conducted on 88 fishponds of different size (1 - 394 ha) in monthly intervals. Data on the numbers of waterfowl were compared with the data on management of the fishponds counted (total fish biomass, age class of the fishes). Highest densities of waterfowl in the breeding season (*Aythya fuligula, Aythya ferina, Anas strepera, Anas platyrhynchos*) were observed on the fishponds with the lowest fish stock (mainly fry fishponds). The competition for protein-rich food between fishes and waterfowl is supposed to be responsible for this pattern. In opposite, the highest densities of waterfowl in autumn (mainly *Anas platyrhynchos and Anser anser*) were observed on big ponds, irrespectively of the fish biomass. However, Mallards and Grey Lag Geese are feeding outside of the fishponds at this time. Main factor affecting distribution of waterfowl in the autumn seems to be safety from hunting and other disturbance.

INTRODUCTION

In the second half of 1970's and in the beginning of 1980's sharp decline of the waterfowl numbers was observed on South Bohemian fishponds (Czech Republic). Various species of ducks - Mallard, Tufted Duck, Pochard - and Coot were most affected (Hudec *et al.*, 1994; Musil and Fuchs, 1994). Several factors were proposed to be responsible for this decline - eutrophication of fishponds connected with botulism and liquidation of littoral vegetation by heavy machinery were quoted most often (Hudec *et al.*, l.c., Musil, 1987)

Because the period of the decline of waterfowl occurred at the same time as the period of greatest intensification of fishery on these fishponds, I examined possible influence of fishpond management (mainly mass of fish stock) on the waterfowl numbers.

STUDY AREA AND METHODS

South Bohemian fishponds are shallow artificial water bodies of different size (from 1 to ca 500 ha), constructed mainly in the 15th and 16th centuries for the purposes of fishery (mainly carp rearing). Number of the fishponds in South Bohemian region is ca 6000, total area approximately 25.000 ha. Most of the fishponds are eutrophic or hypertrophic currently, due to intensification of fishery in the 20th century (mean total N ca 2-3 mg per liter, mean total P ca 300-500 mg/l, mean chlorophyll-a 100-150 mg/l). Average production of fish was ca 50 kg per hectare in 1950's (after the Second Word War), however at present average fish production is more than 500 kg per hectare (Korinek *et al.*, 1987).

The fish stock of the ponds is formed mainly by carp (ca 90%), additional fish species are tench, grass carp, pike, common whitefish etc. The carps are artificially fed in the ponds mainly by grain and pellets. Natural food is responsible for ca 30% of fish production, artificial food for remaining ca 70% of production. Separate age classes of carp are kept in fishponds separately, i.e. - fry fishponds, ponds with 1 year old carp (referred to as K1, ponds with 2 or 3 year old carp - K2, K3. In the autumn fishes are taken from the ponds and sold or put to anther pond. Fertilizers are also used to increase production (organic - manure, synthetic - nitrates, phosphates).

In the period 1990 - 1994 I made regular counts of aquatic birds on a set of 88 fishponds of different size (total area ca 2700 ha). Each fishpond was controlled in a monthly intervals by point count method (largest ponds were counted from 2 or 3 points) and all visible waterbirds were counted. Data on the fishpond management were gathered from the fishery enterprises (i.e. data on a mass of fish stock in a given pond in a given year, data on species and age class of fishes in the pond etc.).

I calculated average seasonal mass of fish stock for a given pond and given year as an average value of fish mass put to the pond in the spring and fish mass taken from the pond in the autumn respectively. Average seasonal mass of fish stock was used as a measure of feeding pressure exerted by fish stock in the pond.

RESULTS

Data on seasonal dynamics of average densities of most common waterfowl species on the fishponds with different age classes of carp are shown on **Figure 1**. Average seasonal mass of fish stock was lowest on fry fishponds (183 kg per ha) and highest on fishponds with the oldest carp K3 (1100 kg per ha), intermediate on K1 (374 kg per ha) and K2 (618 kg per ha). Densities of waterfowl in the breeding season were highest on fry fishponds and lowest on K3 fishponds. [Note that fry fishponds are in the spring (March April) usually without water, therefore average densities of waterfowl are very low there in that period].

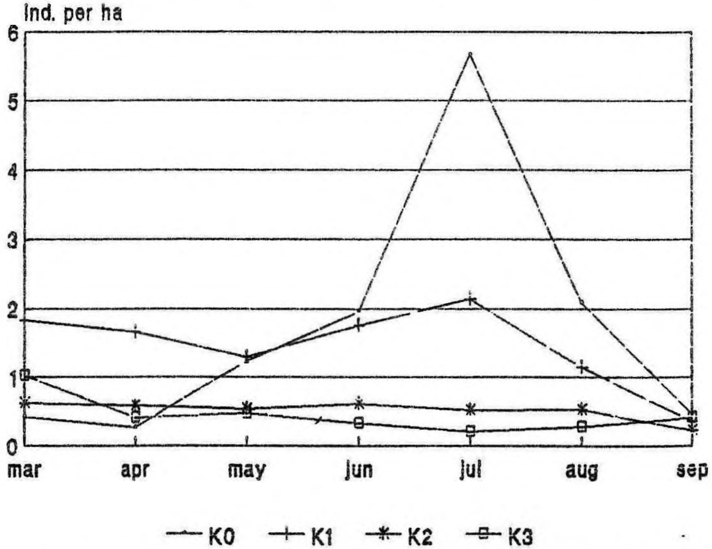

Figure 1: Seasonal dynamics of average densities of most common waterfowl species (Tufted Duck, Pochard, Mallard, Gadwall, Teal amd Coot) on the fishponds with different age classes of carp. K0 - fry fishpond, K1 - one-year-old carp, K2 - two-year-old carp K3 - three-year -old carp

Same trend is obvious if diving ducks (Pochard and Tufted Duck) are treated separately (**Figure 2**). On the contrary, fish stock in the ponds was not an important factor for waterfowl numbers since September onwards, when Mallard and Grey Lag Goose were prevailing species. Both these species are feeding mainly outside the fishponds in the fields (geese) and in oak woods and alleys (Mallards), just roosting on the fishponds. At this time of the year they therefore choose largest fishponds (K2 and K3), where they are relatively safe from hunting and predation. This situation is illustrated by seasonal dynamics of Mallard shown on **Figure 3**.

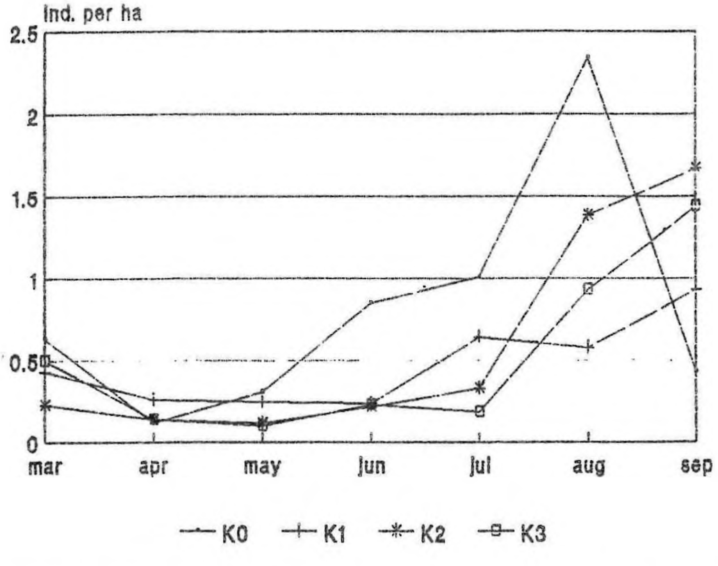

Figure 2: Seasonal dynamics of average densities of diving ducks (Tufted Duck, Pochard) on the fishponds with different age classes of carp. For other explanations see Fig. 1.

Relation between mass of fish stock per hectare (irrespective of age class of fish) and density of aquatic birds in July, i.e. at the end of breeding season, is shown on **Figure 4**. It can be seen clear negative relation between these two variables. Higher densities of aquatic birds were observed only on the ponds with average mass of fish stock less than 400-500 kg per hectare. Densities of birds on fishponds with average fish stock higher than ca 1000 kg per hectare are always low. Same trend is apparent if diving ducks (Pochard and Tufted Duck) are treated separately (**Figure 5**). Therefore diving ducks, that are easily observable on fishponds, can be used as a suitable model species.

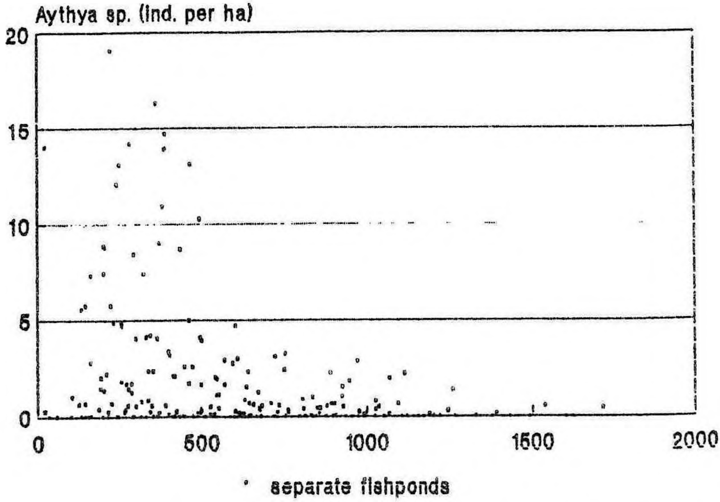

Figure 3: Seasonal dynamics of average densities of Mallard on the fishponds with different age classes of carp. For other explanation see Fig. 1.

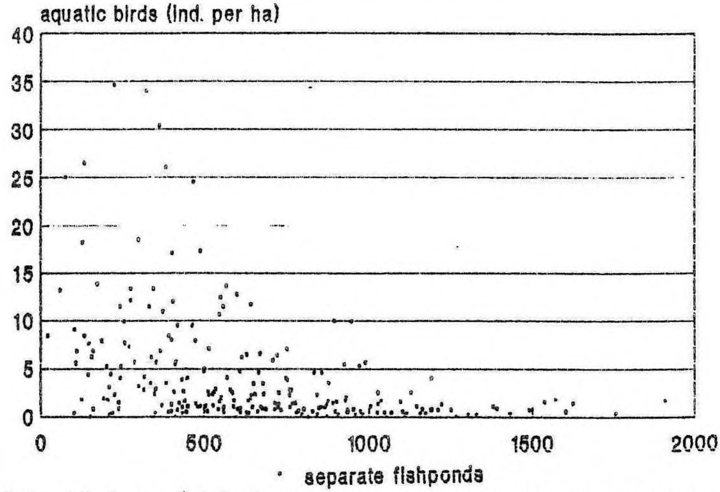

Figure 4: Relationship between July density of aquatic birds (except Black-headed Gulls) and mean fish biomass (kg per ha).

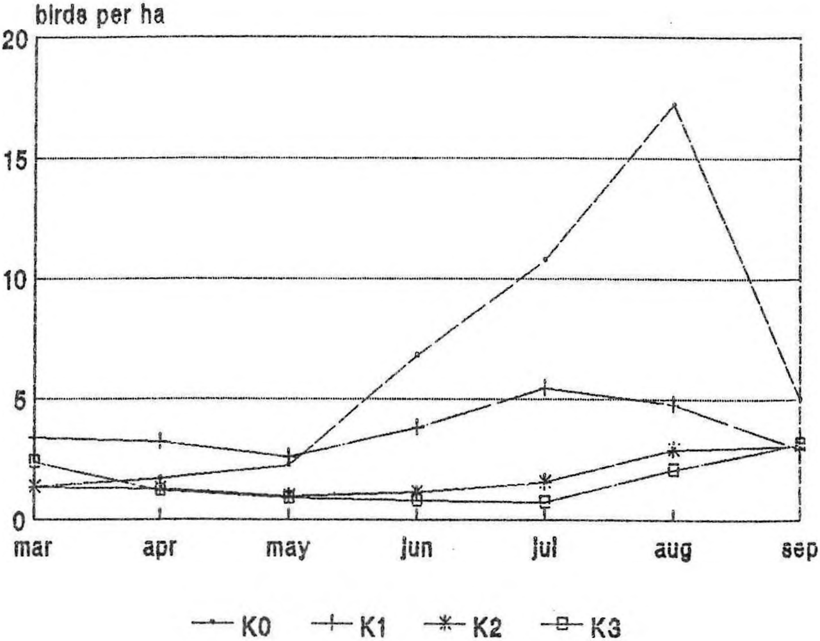

Figure 5: Relationship between July density of diving ducks (Pochard, Tufted Duck) and mean fish biomass (kg per ha).

DISCUSSION

I propose a hypothesis, based on presented data, that competition for food between waterfowl and fishes exists in these fishponds, mainly in the breeding season, when juveniles of most species of waterfowl (even primarily phytophagous species like Gadwall or Coot) are dependent on protein-rich invertebrate food (large zooplankton, zoobenthos, littoral fauna, necton). High densities (or masses) of fish consume almost all available invertebrate food in the pond or lower substantially amount of this food and cause their shortage for waterfowl.

This hypothesis agrees well with results of limnological observations on South Bohemian fishponds. Faina (1983) ascertained ten years ago large zooplankton (2,5-5 mm) prevailing on fishponds with low fish stock (lower than 500 kg per hectare), and, on the contrary, clear prevalence of small zooplankton (lesser than 1,5 mm) on fishponds with high fish stock of carp (higher than 800 kg per hectare). The amount of large zooplankton (mainly large cladocerans) is a representative parameter for the amount of natural food in the pond (Pokorny *et al.*, 1994).

An obvious influence of absence of fishes in the water body on numbers of waterfowl was reported by Giles (1991, 1994), which experimentally removed fishes from gravel pit in England. After the removal of fish biomass invertebrates and submerged vegetation increased substantially and number of breeding Tufted Ducks increased many times, as well. Similar results reported McNicol and Wayland (1992), that studied ducks numbers on Canadian lakes. Highest densities of ducks were observed on acidified lakes, where the fishes were absent because of low pH, their feeding pressure was eliminated and subsequently the density of invertebrates was highest. Similarly, Mallory *et al.* (1994) showed that presence or absence of fishes in the water body is the best predictor of macroinvertebrate abundance.

South Bohemian fishponds have considerable experimental advantage, ensued from the fact that it is possible to get exact information on fish stock (biomass, age composition, species composition) in any pond every year, because ponds are managed in one or two year cycle. Fishpond management creates in this way some kind of semi - natural experimental conditions.

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EFFECTS OF A POWER GENERATING STATION ON THE OCCURRENCE AND DISTRIBUTION OF WINTERING WATERBIRDS (MaB - ÖKOSYSTEMSTUDIE ALTENWÖRTH, AUSTRIA)

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ABSTRACT

Data of regular waterbird counts on the river Danube were used to compare the habitat situation for communities of wintering waterbirds prior and after the building of the hydroelectric power plant station Altenwörth. Counts were carried out along a 20 km long river section. Due to the dam construction the following effects could be observed: a significant increase in the total number of wintering waterbirds, a change in the species composition and abundance of various species, and changes in the distribution of waterbirds within the impoundment area.

INTRODUCTION

Besides the dammed parts of the Inn river and the Rhine delta at Lake Constance, the stream system of the river Danube serves as an important resting area for migrating and wintering waterbirds in Austria. An average of 30% of all waterbirds registered during mid-winter counts were recorded on the Danube during the last years (Aubrecht and Böck, 1985). As a result of the industrial development many large rivers have been dramatically changed by stream regulations for power generation. Waterbird communities react very quickly to such new environmental habitat situations and are good indicators for the evaluation of the ecological situation of a freshwater eco-system (Reichholf and Reichholf-Riehm 1982; Rüger *et al.* 1987). The objective of the interdisciplinary Man and Biosphere (MaB) research project "Ecosystem Study Altenwörth" was to investigate the impacts of a big hydro-power plant station located at the river Danube on the environment, taking into account biological factors as well as social and economical aspects. Eight research groups were involved in this programme: limnology, hydrology, fish biology, climatology, zoology, botany, forestry and socio-economics (Hary and Nachtnebel, 1989). One part of the zoological research team investigated to which extent numbers and communities of waterbirds were and are influenced by the construction and the operation of the power plant station.

METHODS

Regular waterbird counts were carried out along the 20 km long impoundment area between stream km 1980 (location of the power plant barrage) upstream to km 2000 (city of Krems) during the winter season (months September until April) in the years 1984/85 - 1987/88 (**Figure 1**). Following data were noted: day, time, species, numbers, male-female ratio, position of the birds on the river (stream-km, north / south bank, middle of the river), activity of the birds and possible human impacts like traffic on the river and on the roads on the dams. All observations were made from the riverbank. The frequency of complete counts varied between 4 to 6 counts per month, depending on the seasonal occurrence of the species and the actual climatic conditions. Additional observations were made occasionally in the remaining part of the original old river, below the barrage downstream and along several water bodies in the adjacent riverine forests. Data of waterbird counts for the same river section before the building of the power plant station were available to compare the former and actual situation.

RESULTS AND DISCUSSION

The data material obtained was analyzed in different levels ranging from coarse to fine grained resolution. Analyses with coarse resolution were used for the comparison of waterbird counts prior to and after the building of the dam, to discuss the development of waterbird

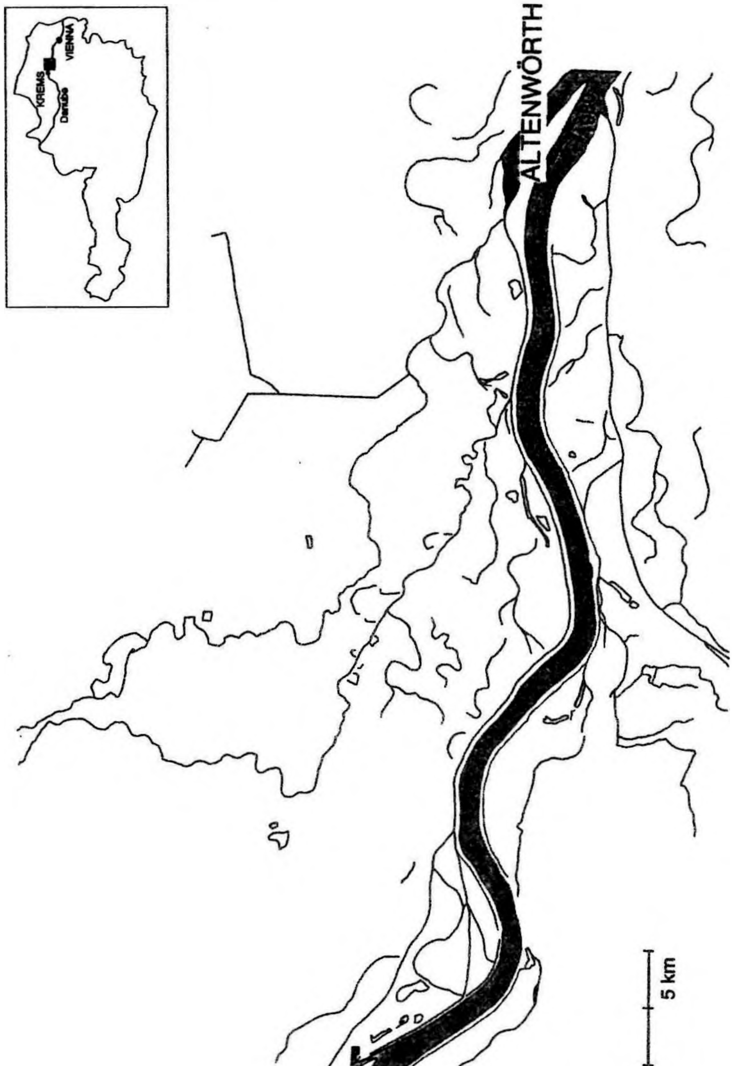

Figure 1: Backwater area Altenwörth between stream-km 1980-2000, tributaries and the network of surface waters in the riverine forests

numbers over the years, the seasonal occurrence of different species and the actual spatial allocation of various species to river areas. More detailed analyses on a fine grained resolution could be used to demonstrate the species and sex-specific differences in the utilization of the dammed river section as a feeding or resting area and the effects of single or regular human disturbances (Parz-Gollner, 1989a).

Due to the dam construction the following general effects were observed:

- a significant increase in the total number of migratory waterbirds
- a change in the species composition
- changes in the occurrence and the distribution of various species within the impoundment area.

Numbers and species composition

During the study period 22 waterbird species were observed regularly in very different quantities, 12 additional species visited the backwater area only occasionally in very low numbers, only one to five individuals during one observation day **(Table 1)**. An average of 7000 - 8000 birds were the daily maximum registered in December or January during the years 1984/85 - 1987/88 **(Figure 2)**. Comparing the available data for the years 1965 to 1988 the average number of waterbirds per count increased from 1332 birds to 4813 birds in January. Because of the reduced flow velocity, the danger of a total icing in the impoundment area in cold winters has increased. A solid ice cover in the dammed section of the river, reaching over 20 km for several weeks, was observed in January 1985 and in January 1987. Such events may cause a sudden loss of already limited habitat suited as a resting and feeding area for wintering waterbirds under severe winter conditions within a few hours. Diving duck species were leaving the area completely, their numbers in the following spring time were much lower than during moderate winter periods. During winters with icing periods a conspicuous migration peak of several species like the Smew or the Goosander could be registered in March, when these birds were flying back to their northern breeding grounds.

Table 1: Migrating waterbirds registered on the stream and the Danube riverbanks between stream-km 1980 and km 2000 in the months September until April in the years 1984-1988.

Regular migrants	Rare migrants (all years N =< 40)
Great Crested Gereb (*Podiceps cristatus*)	Black-throated Diver (*Gavia arctica*)
Little Grebe (*Tachybaptus ruficollis*)	Red-throated Diver (*Gavia stellata*)
Cormorant (*Phalacrocorax carbo*)	Red-necked Grebe (*Podiceps grisegena*)
Heron (*Ardea cinerea*)	Slavonian Gereb (*Podiceps auritus*)
Mute Swan (*Cygnus olor*)	Black-necked Grebe (*Podiceps nigricollis*)
Bean Goose (*Anser fabalis*)	Great White Egret (*Casmerodius albus*)
Mallard (*Anas platyrhynchos*)	Grey-lag Goose (*Anser anser*)
Teal (*Anas crecca*)	Pintail (*Anas acuta*)
Garganey (*Anas querqudula*)	Shoveler (*Anas clypeata*)
Gadwall (*Anas strepera*)	White-eyed Pochard (*Aythya nyroca*)
Widgeon (*Anas penelope*)	Common Scoter (*Melanitta nigra*)
Red-crested Pochard (*Netta rufina*)	Eider (*Somateria mollissima*)
Scaup (*Aythya marila*)	
Tufted Duck (*Aythya fuligula*)	
Pochard (*Aythya ferina*)	
Goldeneye (*Bucephala clangula*)	
Long-tailed Duck (*Clangula hyemalis*)	
Velvet Scoter (*Melanitta fusca*)	
Smew (*Mergus albellus*)	
Red-brested Merganser (*Mergus serrator*)	
Goosander (*Mergus merganser*)	
Coot (*Fulica atra*)	

Reviewing the actual species composition in the backwater area with the former free flowing river, one had to take into account, that during the study period much more counts were made and also better trained research teams were involved. As a result, also usually rare waterbird species were registered more frequently. So in a first step only January mid-winter counts were taken as a basis for comparison.

In the years prior to the building of the power plant station the dominant species in the waterbird community were Mallards (76%), Goldeneye (13%), Teal (5,1%) and Goosander (4,2%). The recent situation in the impoundment area now favours the occurrence of large concentrations of mainly four waterbird species: Mallards (57%), Coots (9,1%), Pochard (15,4%) and Tufted Duck (9,3%). More than 90% of all waterbirds belonged to this group. Other species, such as the Goosander or the Goldeneye, which require higher flow velocities decreased in their abundance (**Figure 3**).

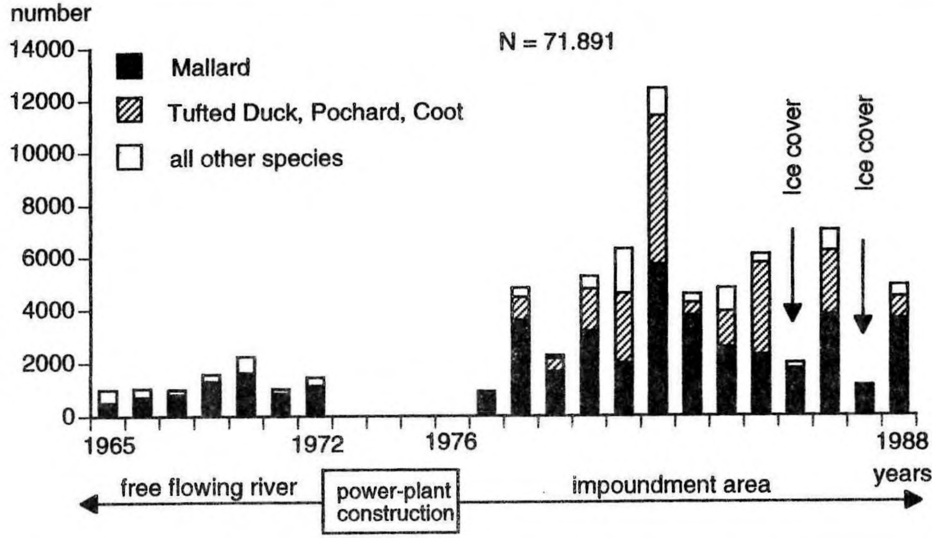

Figure 2: Number of all waterbirds counted on the river and in the corresponding impoundment area on one day in January between stream-km 1980 - 2000 before and after the building of the power plant station (mid-winter counting dates).

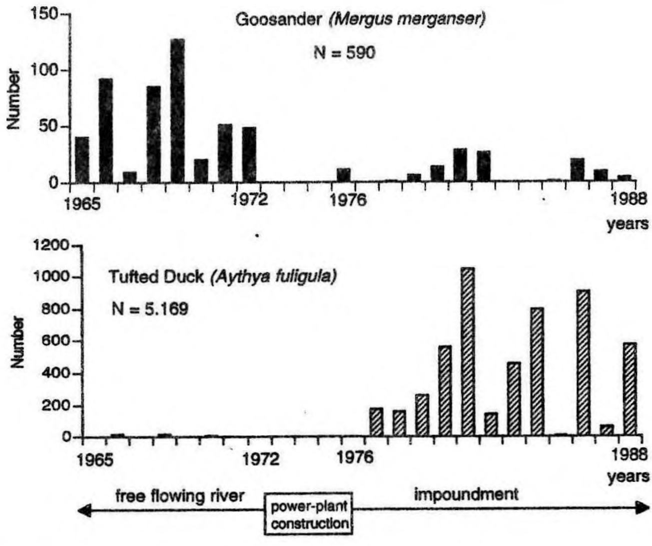

Figure 3: Numbers of Goosanders and Tufted Ducks counted on the river - respectively the corresponding impoundment area - between stream-km 1980 - 2000 before and after the building of the power plant station (January mid-winter counts).

Decreasing tendency was further noticed for the Red-breasted Merganser and the Little Grebe. More often and in slightly increasing numbers the following species were recorded: Gadwall, Smew, Velvet Scoter, Long-tailed Duck, Divers and other Grebes. No clear tendency in the development of their occurrence showed Widgeon, Pintail and Garganey. Great fluctuations in the numbers of some species - e.g. the Goldeneye - could be noticed in consecutive years. Beside the environmental habitat changes the local situation of migrating waterbirds is highly depending on the actual climatic condition in middle Europe.

Distribution of waterbirds within the impoundment area

The distribution of the most abundant species within the impoundment area was analyzed and if possible compared with the former situation in the free flowing river (Parz-Gollner, 1989b). It seems obvious, that environmental factors like water depth, current velocity, structure of the river banks, sedimentation, location, type and amount of food as well as human disturbances are responsible for the distribution of the species along the riverbanks and within the impoundment area. The utilization of the new man-made habitat as a resting or feeding area depends on the morphological and physiological capacity of each species and determines the quantitative and qualitative changes of the waterbird community.

An example for the distribution of diving ducks and a fish-eating species within the backwater area is shown in **Figure 4**. The great majority of Tufted Ducks and Porchards are concentrating in the lower section closer to the barrage with slower water movement and high sedimentation. They are resting and also diving for food close to the slopes of the river banks in this part of the dammed river. In the contrary "rheophilic" species - e.g. the Smew - preferred the remaining "free-flowing" section in the uppermost part of the impoundment area.

Most of the dabbling duck species, especially Mallards, but also Gadwalls, Teals or Garganeys are using the river now mainly as a resting area. These duck species may appear in high numbers. Due to the damming the water surface area increased, the width of the water body guaranties a secure resting place for these ducks during daytime. Because of steeper banks and the depth of the water, dabbling ducks are not able to feed in this environment. There are no gravel banks or zones of shallow water in the main stream, only temporary small macrophyte belts grow along the shoreline between a monotonous rockfall. The adjacent riverine forests with tributaries and a network of surface waters therefore serve as an important retreat area for feeding and during spring and summer time also for breeding waterbirds.

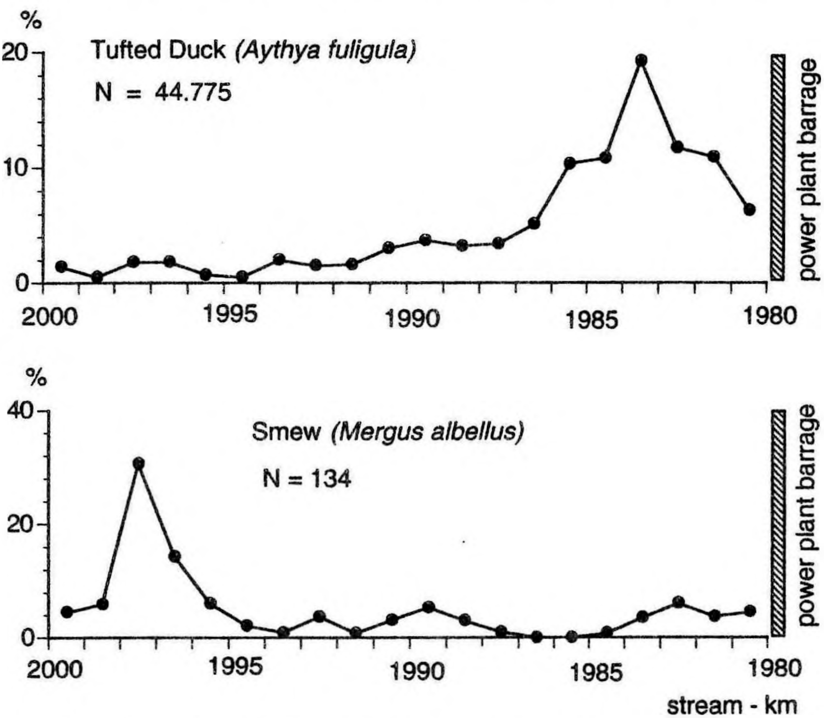

Figure 4: Distribution of Tufted Duck and Smew within the impoundment area between stream-km 1980 -2000; November, 1984 - February, 1988, 66 counts.

CONCLUSION

Due to the hydro-power plant construction the eco-system of the river in general changed from a former "rheophilic" habitat to a "limnophilic" water body. Velocity, water depth, structure of the river banks, food supply (invertebrates) - depending on grain size, location and extent of sedimentation in the river - changed basically. Rare waterbird species, characteristic for faster flowing rivers, can still be observed as migrants but in very low numbers and in places with higher current velocity. New diving duck species, typically for standing water bodies, appear in great numbers in the new, man-made habitat. More than 90% of the observed birds belong to only four species, a result which is emphasizing the uniformity of the impoundment area. With regard to the actual climatic conditions and the differences in the migration pattern of various species, waterbirds should be registered over the whole winter season (migration period) to evaluate the local situation.

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HABITAT SELECTION BY WATERFOWL BROODS ON INTENSIVELY MANAGED FISHPONDS IN SOUTH BOHEMIA (CZECH REPUBLIC)

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ABSTRACT

The number of occurring waterfowl broods on fishponds in the Třeboň region (South Bohemia, Czech Republic) occurring was recorded in 1992-94. Among 1165 broods of 13 species, Gadwall was the most common. Preference of fishponds with higher water transparency was found in diving ducks which were negatively associated with the age of dominant fish cohort. On the contrary, a positive dependence on age of stocked fish was recorded in Great Crested Grebe broods. The occurrence of Mallard broods was dependent on water surface area and Coot broods prefer relatively isolated fishponds with well developed littoral vegetation.

INTRODUCTION

The breeding numbers of the most abundant duck species and some other waterfowl, which showed increasing trend for several decades, began to decline abruptly in many fishpond regions in the Czech Republic in the early 1980s (see e.g. Musil and Fuchs, 1994, Musil and Šálek, 1994). An increase in fish stock size during the 1970s and early 1980s (Pokorný *et. al.*, 1992) was also considered as a possible hypothesis explaining this phenomenon (Pykal and Janda, 1994).

The negative effect of high fish stocks on waterfowl abundance as well as on their reproduction output was described by Giles (1991, 1994) and Phillips and Wright (1993). The abundance and survival of ducklings seems to be more affected by trophic status of a water body, rather than that of adult ducks, esp. due to specific food requirements and lower moving ability of the former (Cramp, 1980, Owen and Black, 1990). Intensively managed fishponds provide a suitable model for investigation of fish-waterfowl relationships as well as for general investigations of waterfowl-habitat relationships, which could be used for finding key factors affecting water bird abundance. Therefore we started investigation of habitat selection by waterfowl brood on various types of fishponds in the Třeboň region differing in numerous parametres, including management practices.

STUDY AREA

Fishponds currently existing in the Třeboň region as well as in other parts of Bohemia and Moravia have been created in suitable places since the Middle Ages.

Table 1. Summary characteristics of fishponds under study

fishpond characteristic	range		average	±	st.dev.
water surface area (ha)	0.33 -	149.00	17.72	±	24.31
littoral stands area (ha)	0.11 -	31.28	3.40	±	4.14
littoral stands proportion (%) 1)	1.91 -	63.60	20.22	±	12.96
length of shoreline (km)	0.23 -	7.57	17.36	±	13.11
shoreline development ratio 2)	1.02 -	1.98	1.30	±	0.24
mean water depth (m)	0.20 -	2.50	0.72	±	0.29
proportion open landscape (%)	0.00 -	95.00	15.11	±	23.03
pond isolation index (m) 3)	42.00 -	750.00	247.55	±	189.13
water transparency (m)	0.04 -	1.50	0.40	±	0.30
small zooplankton: length < 0.5 mm (%)	0.00 -	100.00	59.25	±	27.61
middle zooplankton: length 0.5 - 2.0 mm (%)	1.00 -	93.00	31.28	±	20.92
large zooplankton: length > 2.0 mm (%)	0.00 -	95.00	9.64	±	16.60
mean zooplankton length (mm)	0.25 -	2.81	0.64	±	0.40
age of dominant fish cohort (year)	0 -	3	1.45	±	0.94
fish stock abundance (1000)	0.10 -	5787.23	268.29	±	718.96
mean fish body weight (kg)	0.01 -	1.75	0.38	±	0.42
fish stock density (kg/ha)	0.91 -	23607.00	1908.11	±	3106.71

1) littoral stands proportion ... ratio littoral stands area to total area of fishponds

2) Shoreline development ratio ... ratio of the length of the shoreline to the length of the circumference of a circle with water surface equal to that of the lake

3) Pond isolation index ...mean distance from the four nearest neighbouring fishponds

Recently, investigated fishponds represent shallow eutrophic or hypertrophic water bodies with well developed littoral vegetation (see **Table 1** for summary characteristics). Fishponds are surrounded by the mosaic of woods, fields, meadows and villages (Husák and Hejný, 1978, Pokorný *et. al.*, 1994).

METHODS

In total, 314 checks of 64 studied fishponds were carried out in the Třeboň region in 1992 (4 checks of 10 ponds), 1993 (2 checks of 41 ponds) and 1994 (3 checks of 64 ponds). Broods were counted in early morning and late evening. Water transparency (Secchi depth) was measured at each count.

Data were analyzed using Canonical Correspondence Analysis (CCA, program Canoco 3.1, Ter Braak, 1988). The set of variables that explained the species data as sufficiently as the full set was chosen using forward variable selection.

RESULTS

In total, 1165 broods of 13 species were recorded in the study area. Only 1127 broods of 8 most common waterfowl species (i.e. Little Grebe *Tachybaptus ruficollis*, Great Crested Grebe *Podiceps cristatus*, Mallard *Anas platyrhynchos*, Gadwall *Anas strepera*, Pochard *Aythya ferina*, Tufted Duck *Aythya fuligula*, Goldeneye *Bucephala clangula*, Coot *Fulica atra*) were included in further analysis. The highest number of occurring broods as well as the highest brood size were found in Gadwall (**Table 2**).

Seven variables (water surface area, littoral stands proportion, proportion open landscape in the fishpond surroundings, pond isolation index, water transparency, age of the dominant fish cohort, fish stock abundance) were found as the set of variables that best explain the species data. The first ordination axis ($lambda_1$=0.121) was positively correlated with fish stock abundance (r=0.357) and water transparency (r=0.31) and negatively with dominant fish cohort stocked in fishpond (r=-0.304). The second ordination axis ($lambda_2$=0.077) was positively correlated with the proportion of open landscape in the pond surroundings (r=0.35) and negatively with water surface area (r=-0.284). The first axis accounted for 42.4% of variance in data set was highly significant (Monte Carlo test, $P < 0.01$). Cumulative percentage variance accounted for by the first two axes of species-environmental biplot was 69.5 %.

Table 2. Number of broods and mean brood size of investigated species

Species	Total number of broods	broods per pond mean ± st.dev.	(n)	brood size mean ± st.dev. (n)
Tachybaptus ruficollis	13	0.03 ± 0.19	(8)	2.50 ± 1.35
Podiceps cristatus	79	0.25 ± 0.96	(30)	1.95 ± 1.32
Anas platyrhynchos	.109	0.32 ± 0.85	(62)	6.67 ± 4.13
Anas strepera	242	0.70 ± 2.07	(81)	7.30 ± 3.26
Aythya ferina	202	0.62 ± 2.89	(61)	4.92 ± 2.50
Aythya fuligula	150	0.45 ± 1.68	(56)	5.51 ± 3.20
Bucephala clangula	32	0.09 ± 0.51	(15)	4.31 ± 2.60
Fulica atra	300	0.82 ± 2.20	(86)	3.26 ± 1.71

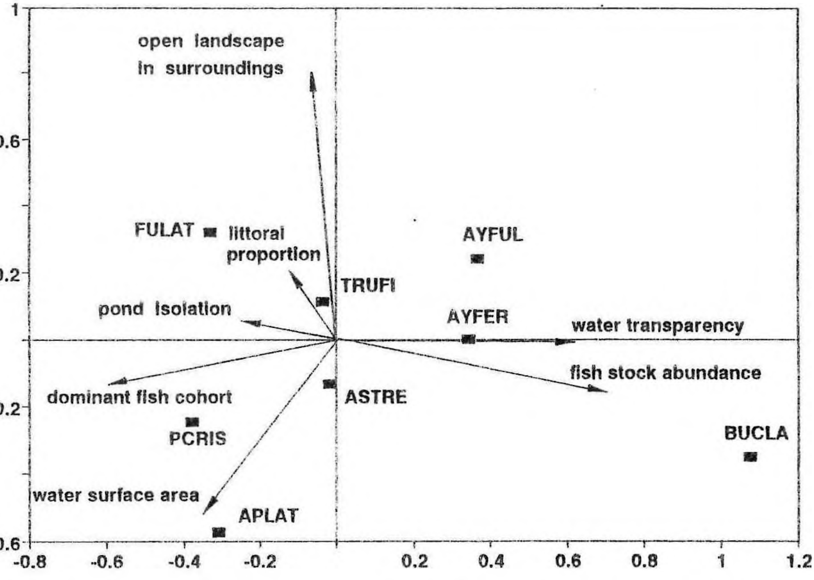

Figure 1: Ordination diagram (CCA) referring to the analysis species-environmental relationships. Species codes: APLAT - *Anas platyrhynchos*, ASTRE - *Anas strepera*, AYFER - *Aythya ferina*, AYFUL - *Aythya fuligula*, BUCLA - *Bucephala clangula*, FULAT - *Fulica atra*, PCRIS - *Podiceps cristatus*, TRUFI - *Tachybaptus ruficollis*.

The number of diving duck broods (Goldeneye, Tufted Duck and Pochard) broods was associated with water transparency. On the other hand, dabbling duck broods do not prefer fishponds with higher water transparency and seem to be more dependent on topical characteristics of fishponds (water surface area - esp. Mallard). Coot broods prefer relatively isolated fishponds with well developed littoral vegetation. Broods of Great Crested Grebe, the only piscevorous species under study, was positively associated with the age of dominant fish cohort. The occurrence of broods of remaining two species (Gadwall and Little Grebe) was not remarkable dependent on any of the investigated environmental variables (see **Figure 1**).

DISCUSSION

The strong positive correlation between the occurrence of diving duck (Goldeneye, Tufted Duck and Pochard) broods and water transparency and fish stock abundance is a consequence of specific trophic conditions of intensively managed fishponds in the Třeboň region. Water transparency can be used as an indicator of the trophic level of water body as well as a physical parameter describing the food availability. Food availability (Gardarsson and Einarsson, 1994) and fish stock (Giles 1991, 1994) appear to be important factors affecting the occurrence and survival of young diving ducks. In Southbohemian fishponds (i.e. hypertrophic water bodies), the competition between fish and waterfowl was recorded only in adult ducks during postbreeding period (Pykal and Janda, 1994, Pykal, this issue).

The results presented in this paper show that the relationship between trophic condition and ducklings occurrence is closer in diving ducks (Goldeneye, Tufted Duck and Pochard) than in dabbling ducks (Gadwall, Mallard). These differences in habitat selection of two duck groups could be causes of different trends in breeding population numbers in Třeboň region. Numbers of diving ducks have been decreasing since the end of the 1970s (e.g. Musil and Fuchs, 1994), whereas the numbers of both dabbling ducks seem to be stable or increasing after 1985. Nevertheless, the negative effect of adult fish density on occurrence of broods also reported by in Mallard from gravel pit lakes in England (Phillips and Wright, 1993). Occurrence of broods of Great Crested Grebe (*Podiceps cristatus*) depends mostly on prey (i.e. fish) availability as well as on water body surface area. These relationships correspond also with studies from another part of the breeding range

(Ulenaers *et. al.*, 1992) and with the study on habitat selection of other piscevorous species on fishponds in investigated area (Musil *et. al.*, 1995).

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CHANGES IN THE SPATIAL RELATIONSHIPS OF SELECTED BIRDS IN THE DANUBIAN AREA INFLUENCED BY THE GABCIKOVO DAM

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ABSTRACT

The aim of the study is to analyse the spatial relationship of selected bird species in the Danubian region (the inundation area of the Danube and the channel of Gabčikovo's dam) influenced by the Gabčikovo dam operation.

Data was obtained by the line method on the transects along an artifical channel of the dam, the main flow of the Danube and in the branch system.

Data was used which has been obtained in the same way every year from 1985 to 1993 for comparison with the year 1994 (the year after the start of the dam operation).

The occurrence and spatial relationships of water birds in the inundation area directly depends on the water regime and its dynamics. Changes in the regime since the start of the dam operation have manifested themselves in the presence of some bird species and their preference of habitats (respective sites). Significant differences were noted in the preference of sites during seasonal cycles. In the sites with increased human contact some species reacted by limiting their flight distances.

INTRODUCTION

During the past, the river Danube has created by its sediments a dynamic system of branches, continually changing itself under the influence of the water flow. There existed in the area a mosaic of aquatic, terrestrial and semiterrestrial habitats. Their diversity and carrying capacity manifested themselves in the species diversity occuring in this ecosystem, which also served as an important corridor and gathering place of migrant species. Because of its unique and particular surviving functions this area is recorded as a site of Important Bird Areas of the Slovak Republic, and since 1993 has been in the list of important wetlands of the Ramsar Convention as well. Through historical times, there have been changes in the ecosystem of the investigated area, which have been proportionate with the rising technical possibilities of man. Flood control, the adaptation of the river for shipping and later, excessive dredging of gravel led to changes in the river's character and a significant loss of branch system dynamics. Forestry gradually replaced the majority of the natural flood plain forests by managed forests with a different structure. Lastly, and may be the most important human impact was the construction and operation of the Gabcikovo Barrage System (GBS). Data about the biota status existed before the start of construction, creating the opportunity to compare the new status with the past. Birds of aquatic habitats were selected as indicators for the evaluation of changes. We investigated their spatial relationships and habitat preferences.

CHARACTERIZATION OF SITES AND METHODS

Sites were selected as being representative of the landscape as it was known before the start of the GBS construction and its operation (the main river Danube and the branch system) and the diversion channel of the GBS.

The main river Danube

Constant water flow is characteristic of this site. Along the full length of the river, the banks are almost completely made up of large quarry stone, with the occassional shallow gravel bank. After the main river was dammed near the village of Gabcikovo, the current declined to approx. 1/7 - 1/5 of the primary. The water level proportionately declined and the river narrowed itself. Gravel banks were revealed along the majority of the affected river section. Some of these revealed areas that were more than one hundred meter wide.

The branch system

During the 20th century the branches were isolated from the main river, primarily the inflow mouths. As the river bed eroded, the water flow through the branches gradually dwindled so that in the years immediately preceeding the start - up of the GBS, the water in the branches was mostly stagnant. Seasonal floods and minimal water level dynamics existed because of the river natural regime. The seasonal cycles of the spatial relationships of the biota also adapted themselves. Branch banks are forested by shrubs and trees of willow (*Salix sp.*), poplars (*Populus sp.*), and in certain areas, a growing reed (*Phragmites communis*). Submerged macrophytes were rare in the past because of the dynamic water regime. Shallow gravel or mud banks were exposed during times of low water levels.

The diversion channel of the GBS

The channel is an artificially constructed water route flowing at a higher level than the surrounding landscape. It serves for shipping and water leading to a hydro - electric power plant. Banks have been created by asphalted gravel dams. Along the top of these dams is an asphalt road.

Data was obtained by the line method from January to August 1994. Data was used which had been obtained in the same way every year from 1985 to 1993 for comparison purpose with the year 1994 (the year after the start of the dam operation). The investigated section of main Danube river was delineated by river marking from 1821 - 1835 kilometers in a total lenght of 14 km. Within the branch system transects led through newly constructed small dams. The total lenght of the transect was 5 km. In the diversion channel we obtained data from the top of its dam, the full channel lenght is 17 km.

RESULTS

During the investigation we recorded 52 bird species of aquatic habitats (**Table 1**). From this number we selected 8 easily identifyable regularly occuring species. Their minimal and maximal relative numbers in the investigated sites are tabulated (**Table 2**). In comparing the spatial relationships of the selected species to the natural landscape sites and the artificial channel, it was found that the *Phalacrocorax carbo*, *Egretta alba* and *Haliäeetus albicilla* species were most closely dependendent upon the main river and branch system of the Danube.

Table 1: List of observed bird species in investigated sites

Species	GBS	D	Species	GBS	D
Gavia stellata (Pontopp.)	+	-	*Mergus merganser L.*	-	+
Podiceps nigricollis Brehm	+	-	*Somateria molissima (L.)*	+	-
Podiceps cristatus (L.)	+	+	*Circus aeruginosus (L.)*	-	+
Podiceps ruficollis (Pall.)	+	+	*Milvus migrans (Bodd.)*	+	+
Phalacrocorax carbo (L.)	-	+	*Haliäeetus albicilla (L.)*	-	+
Ardea cinerea L.	+	+	*Pandion haliaetus (L.)*	-	+
Ardea purpurea L.	-	+	*Fulica atra L.*	+	+
Egretta alba (L.)	-	+	*Gallinula chloropus (L.)*	-	+
Egretta garzetta (L.)	-	+	*Charadrius dubius Scop.*	-	+
Nycticorax nycticorax (L.)	-	+	*Numenius arquata (L.)*	-	+
Ixobrychus minutus (L.)	-	+	*Actitis hypoleucos (L.)*	-	+
Platalea leucorodia (L.)	-	+	*Tringa ochropus L.*	-	+
Ciconia ciconia (L.)	-	+	*Tringa nebularia (Gunn.)*	-	+
C. nigra (L.)	-	+	*Tringa totanus (L.)*	-	+
Cygnus olor (Gm.)	+	+	*Philomachus pugnax (L.)*	-	+
Anser sp. Briss.	-	+	*Vanellus vanellus (L.)*	-	+
Anas platyrhynchos L.	+	+	*Recurvirostra avosetta L.*	-	+
Anas penelope L.	-	+	*Larus canus L.*	+	+
Anas stepera L.	-	+	*Larus argentatus Pontopp.*	+	+
Anas acuta L.	-	+	*Larus ridibundus L.*	+	+
Anas querquedula L.	+	+	*Larus minutus Pall.*	-	+
Anas crecca L.	+	+	*Sterna hirundo L.*	-	+
Aythya ferina (L.)	+	+	*Chlidonias nigra (L.)*	-	+
Aythya nyroca (Ghld.)	-	+	*Alcedo atthis (L.)*	-	+
Aythya fuligula (L.)	+	+	*Bucephala clangula (L.)*	+	+
Clangula hyemalis (L.)	+	-	*Mergus albellus L.* -	-	+

D - main river and branch system of the Danube; GBS - the Gabcikovo Barrage System

+ presence ; - absence

Table 2: Occurence of selected bird species in investigated sites

Species		Jan.	Feb.	March	Apr.	May	June	July	Aug.
Phalacrocorax carbo L.	D	0.2-1.1	0.3-18.3	1.1-3.7	3.6-9.2	3.9-9.7	0.3-26.3	0.6-1.9	6.3-26.8
	GBS	0	0	0	0	0	0	0	0
Ardea cinerea L.	D	0.2-1.2	0.1-0.5	0.1-0.5	0.8-1.5	0.1-1.3	0.1-1.3	0.2-1.6	0.9-3.9
	GBS	0.3	0	0	0.1	0.1-0.9	0	0	0.1-0.4
Egretta alba L.	D	0.8-2.2	1.2-1.9	0.8-1.3	1.1-2.5	0.3-0.6	0.1	0.1-0.2	2.2-7.5
	GBS	0	0	0	0	0	0	0	0
Anas platyrhynchos	D	12.4-39.5	11.5-21	4.2-15.8	0.3-6.4	0.8-5.3	0.4-1.3	0.8-4.5	10.3-15.6
	GBS	56-289.1	1.8-88.2	3.2-4.5	0.2-1.3	0.2-0.7	2.1-12.9	0.7-2.5	7.1-13.5
Cygnus olor Gm.	D	0.1-0.5	0.1-1.5	1.2-2.9	1.3-2.9	0.3-0.5	0.1-0.3	0.1-0.2	0.1-0.3
	GBS	0.8	0	0.4-0.9	0.4	0	0	0	0
Larus ridibundus L.	D	0.3-1.4	1.8	0.2-0.3	0.2-0.5	0.6-1.9	0.6-6.4	0.6-2.1	1-4.3
	GBS	0.4-5.6	0.3	0.8-5.4	1-1.2	0.2-0.5	0.5-0.5	0.1-0.7	0.7-5.6
Fulica atra L.	D	1.7	0.3-4.2	0.3-2.6	0.3	0.1	0	0.1-0.3	0.6-0.9
	GBS	0.4-10.2	0.4	0.9-3.5	0.2	0	0	0.1-0.2	0
Haliäeetus albicilla L.	D	0.1-0.4	0.1-0.4	0.1-0.2	0.1	0.1	0	0	0.1
	GBS	0	0	0	0	0	0	0	0

D - main river and branch system of the Danube; GBS - the Gabcikovo Barrage System

During the winter of 1994, the species of genus *Anas* and *Fulica atra* prefered the open water and asphalt banks of the artifitial derivation channel. During the breeding season these species migrated and lived in the branch system until the juvenils became independent. The diversion channel of the GBS attracted birds mostly during the winter, it does not have conditions for breeding.

DISCUSSION

Through the comparison of the present results with our own data and published data from the period preceeding GBS function we have noted several significant changes. In contrast to the past (Bohus, unpubl. data) we have noted an increase of the *Fulica atra*, *Gallinula chloropus* (*L.*) and *Podiceps ruficollis* (*Pall.*) breeding populations within the branch system. This phenomenon could be attributed to population trends, but is more likely connected with the stabilized water level which is enabling successful breeding, as well as with phytocenological changes (submerged macrophytes developing). Again, in contrast to the past (Bohus, unpubl. data) during the summer of

1994 and 1993 more adults of *Ardea purpurea L.* were recorded in the branch system. An abundance of this species rose to approximately 20 specimens after the juvenals became independent. Not long ago (Balát, 1963; Balis, 1952; Matousek, 1961 and Kux, Randik 1961 in Hudec *et al.*, 1972) this species nested on the Slovak side of the Danube, but as a result of destruction and the changed character of the breeding sites, nesting now takes place only on the Hungarian side of the river. During the investigated period this species utilized the area only as a trophic base. According to our records from recent period, shallowed branches during low water levels were an important trophic base mostly during post breeding translocations and migration of *Ciconia nigra, Ardea cinerea* and *Egretta alba*. In 1993, this important function did not occur due to the stabilized water regime which was accomplished through water supplied to the branches by the GBS. As a result, the above mentioned species did not group themselves in common gatherings but occured only singly. During the summer of 1994 abnormal reduction in the branch system water supply caused partial to absolute emptyig of the lower branch system section, in which 142 *Egretta alba*, 70 *Ardea cinerea* and 68 *Ciconia nigra* gathered during August 1994. Notable changes in the spatial relationships of *Phalacrocorax carbo* were recorded. After the damming of Danube and emptying of its branch system during the winter of 1992/93, species were concentrated in the reduced main river Danube (Bohus, unpubl. data). Following the rise in the fish population in the storage lake of the GBS, this lake is now the prefered feeding area of the species. A certain area of Slovak section of the branch system has re-evolved as a night resting place for this species after a ten year hiatus. In the case of the *Haliäeetus albicilla* we recorded a significant preference for the least frequented sites of the branch system and the main river of the Danube, where, at this time, there were no finished reinforced roads unlike the majority of the area. During our investigated period we recorded an unusual rise in the abundance of *Cygnus olor*. During the fifties, this species was not considered as an avifauna member of the area (Balát, 1963; Balis, 1952). The phenomenon is most probably connected with species population trends. Part of this population has probably been artificially translocated from old gravel pits in the city of Bratislava. Some of the records that we investigated should be compared with the status of Danubian inundation area of the Hungarian section. There are strong indications, that the changes noted by us are connected with alternations in the water regime in the Hungarian Danube area, but we have not had the opportunity to judge or follow their impact in this area.

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THESIS FOR A TRADE-OFF WITH BREEDING SUCCESS

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According to the most recent studies, breeding success in several waterfowl species (geese, ducks, coots, shorebirds) has been correlated with nutrient reserves (mostly lipids, but also proteins) stored at the end of the winter season whilst birds are still on their winter quarters. Wintering strategies suggest that body condition of birds at the end of the winter season is controlled by body condition at the beginning of the winter season. Wintering strategies analysed on several duck species in Camargue, south France on the mediterranean shore, allow birds to optimize daily allocation of time and energy. Considered as a model to be realised at the individual level, they rely on ecological links between three successive periods. 1) Restoring period. When birds arrive at the winter quarter, they must refuel after migration till optimum weights are reached. Daily feeding times are long and the period lasts 2-3 months. 2) Pairing period. Birds have enough stored energy to reduce daily feeding and sleeping duration. This is the only period in the winter season when they have some extra time and they take advantage it for courtship and pairing. 3) Fattening period. From January onwards, environmental conditions become worst, food is scarce and birds must store energy for spring migration and breeding. During this period, daily feeding durations are the longest and a strong intraspecific competition for food occurs where paired birds are hierarchically dominant.

According to this hypothesis, it is a selective advantage for a duck to be paired before the end of the season in order to have a priority access to food during the last months of the winter season, hence to have a better body condition before leaving for spring migration and a better fitness in terms of feeding success. Autumn pairing, an unusual timing characteristic of most waterfowl species as compared to other bird species and families, appears as a full component of wintering strategies for these species in Camargue. We suspect the existence of a trade-off between early pairing as a part of a wintering strategy, and breeding success. The cost (or one of the costs) of this early pairing is to maintain pair bonds for a longer time than if birds were paired just before laying. The benefits are 1) to increase the ability of paired females to store nutrients during the late winter fattening period , but also 2) to increase fitness because pair formation is very time consuming and pairing later (that is during the fattening period) would be hindered by lack of available time and energy. From this point of view, pairing does not only concern females, but both males and females.

This wintering strategy hypothesis is a model based on observational data from species which winter in mild temperate zone. It is supposed to differ from one population, species and winter quarter to another, respectively. It has to be tested at the individual level to be validated.

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POLLEN IN LUNGS AND AIR SACS.A SPATIO-TEMPORAL MARKER FOR LONG DISTANCE MIGRANTS

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Pollens are microscopic species-specific cells which resist on the long term to strong physical and chemical constraints. The pollenic composition of the atmosphere varies with space and time and pollenic calendars are available for most regions (1). Living animals inhale pollens of the biogeographic area where they are and they can store it in their respiratory system. This storage capacity was first demonstrated in man where pollen can stay several month in lungs (2). We first verified that birds can also store pollens in their lungs, air sacs and syrinx (3). Similar mean densities were found in birds as in man (1-5 pollen/g of lung) and higher values in air sacs and syrinx. These differences in densitiy between the several parts of the bird respiratory system are likely to be related to the relative importance of the air volume which transits through each of them. Then we tested the hypothesis that pollen stored in respiratory system of birds can indicate migration routes and periods, and can be used to isolate populations.

Preliminary results on Coots *Fulica atra* showed differences between mediterranean type (i.e. olive tree *Olea europea*) and continental-type (i.e. birch tree *Betula spp.*) pollens, which could be associated with sedentary and migrating birds respectively. Strict seasonality of most pollens should allow more precise interpretation, for instance about the arrival or departure date of birds at/from a given area. This point could be used to evaluate the respective size of successive groups of transient birds and the duration of their stop-over. Other conclusive results are expected from birds wintering in tropical wetlands (Garganey *Anas querquedula* and Pintail *A. acuta*) where botanic taxons are quite different.

The advantages of this new technic to isolate populations are several: cheap and very rapid as compared to classical ringing procedures, restricted sampling (few birds to analyze). The inconveniences are several also: precise knowledge of the pollenic calendars for the analyzed region, collaboration with a competent laboratory of palynology, availability of dead birds, difficulty in eliminating any form of pollenic pollution. Moreover, it has to be proved that, during non-stop long-distance flights (trans-mediterranean + trans-sahara routes for instance) where pulmonary activity is exceptionally strong, pollen still remains in lungs. Many more studies should be made on that topic which can be of prime importance and lead to many diverse applications.

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SPATIAL DISTRIBUTION OF BREEDING RED-NECKED GREBE (*PODICEPS GRISEGENA*) IN THE LITTORAL ZONE OF LAKE TAKERN, SWEDEN

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The Red-necked Grebe is known to feed on small aquatic animals in the breeding season. These food items are also an important food source for many fish species. Lake Takern in southern Sweden is well known as an eutrophic lake with a dense fish population. Ornithologists have regularly counted the breeding birds in this lake for several decades. The Red-necked Grebe began to breed in the lake at the end of the '70s and has since then become well established with almost 100 pairs in some years. This is at variance with other recent studies in southern Sweden, where Red-necked Grebe was found not to breed in ponds with a dense fish population.

In 1991-1992, the distribution of Red-necked grebes, macroinvertebrates, fish, vegetation and water depth were investigated in Lake Takern. The littoral zone of the lake consists of dense stands of the reed *Phragmites australis*, with areas of sparse reed stands and open water. The nests were situated in areas of sparse reed beds, and the average water depth was 0,44 m, compared to the open littoral zone with an average depth of 0,93 m. The fish (tench *Tinca tinca*, rudd *Scardinius erythophthalmus*, perch *Perca fluviatilis*, roach *Rutilus rutilus*) were absent or very rare in the reed beds but abundant in the open littoral. The results indicate that there exist a habitat division between breeding Red-necked Grebe and fish in Lake Takern and that this may have to do with the distribution of food sources.

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LIMAN LAKE AS A WINTERING GROUND OF WATERFOWL IN THE NORTHEASTERN PART OF UKRAINE

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Liman Lake (area 9.15 km^2) lies in Zmiiv district, Kharkiv region and is the residue of the ancient bed of Seversky Donets river on the third terrace of its valley. Since 1961 the lake is a cooling reservoir of Zmiiv State Regional Power Station, therefore its surface is free of ice in winter, that has allowed to form the large flocks of wintering of waterfowl.

Unfortunately, data concerning the initial stages of the process of wintering accumulation of waterfowl are not available.

Since January 1991 we are carrying out the absolute census of wintering waterfowl by foot along the shores, of several times in the season - from the end of October until the middle of March.

For the period of investigation 24 species of waterfowl were censused, of which Slavonian Grebe (*Podi ps auritus*), Scaup (*Aythya marila*), Lond-tailed Duck (*Clangula hyemalis*) and Little G (*Larus minutus*) can be considered as a late autumnal or early sp ng migrants. The numbe remaining species varied within (minimal-maximal) limits:

Little Grebe	(*Tachybaptus ruficollis*)	3-10
Great Crested Gre	(*Podiceps cristatus*)	3-20
Black-necked Gr	(*Podiceps nigricollis*)	2-12
Bittern	(*Botaurus stellaris*)	1
Mute Swan	(*Cygnus olor*)	3-20
Whopper Swar	(*Cygnus cygnus*)	1-4
Mallard	(*Anas platyrhynchos*)	1950-3750 (average 2550)
Red-crested hard	(*Netta rufina*)	5
Pochard	(*Aythya ferina*)	1-10
Tufted Du	(*Aythya fuligula*)	90-100

Velvet Scoter	(*Melanitta fusca*)	1
Goldeneye	(*Bucaphala clangula*)	118-414 (average 194)
Smew	(*Mergus albellus*)	2-44
Red-breasted Merganser	(*Mergus serrator*)	3-10
Goosander	(*Mergus merganser*)	40-51 (average 47)
White--tailed Eagle	(*Haliaeetus albicilla*)	1-3
Moorhen	(*Gallina chloropus*)	2-16
Coot	(*Fulica atra*)	130-150
Black-headed Gull	(*Larus ridibundus*)	2-24
Common Gull	(*Larus canus*)	1-16

Fourteen species which were observed in each of four winter seasons form the "core" of wintering. Such species as Red-breasted Pochard (perhaps, the early spring migratory bird) and Velvet Scoter were observed only once (in 1992/93). For two seasons Black-necked Grebe (in 1991/92, 1993/94) and Smew (in 1992/93, 1993/94) were registered, and Whooper Swan was observed for three seasons except the season of 1990/91.

For four years the presence of Mute Swan's and Goldeneye's number increased. The number of Mallard and Goosander is left as relatively constant. The number of remaining species are subjected to year-to-year fluctuations.

The appearance of White-tailed Eagle as a wintering species in Liman Lake in the season of 1993/94 is of interest: until now it was observed as a migratory bird only.

The formation of wintering accumulations begins from middle of November and it is completed to the end of December with Goosander appearance, and its dispersal takes place in the first half of March.

The different waterfowl species are distributed on the lake's surface in different ways, being either restricted for the same site like the Coot, or to be distributed relatively uniformly on the whole area such as the Goldeneye, as an extreme case. The remaining species demonstrate the intermediate types of distribution: from those which have several permanent sites of concentration (Moorhen, Little Grebe, Mute Swan) to those which form the periodically moving accumulations (Goosander, Mallard) that can be connected with foraging peculiarities of these species and weather conditions.

The wintering ground of waterfowl in Liman Lake is the largest in region, and high level of birds species richness and abundance allows us to consider this place as Important Birds Area in the continental part of Ukraine, especially in winter period.

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SMALL STORAGES OF THE WESTERN UKRAINE: HYDROBIOLOGICAL CHARACTERISTICS AND PECULIARITIES OF THE WATERFOWL (ORNITHOFAUNA)

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Modern urbanization level affects greatly water ecosystems, causes the changes of their hydrobiological features, affects the living conditions of waterbirds. Considering of structural and functional characteristics of hydrobiocenoses and their correlation with waterbirds, it is a necessary element in creating an optimal strategy of human influence on reservoirs.

Zooplankton of ponds was examined during vegetative season in 1980-1985 and irregularly in 1986-1992. Data were processed by using the general methods. 153 species was found , such as: 81 species of *Rotatoria*, 46 species of *Cladocera* and 26 species of *Copedopa*. The ponds were separated by their economic use in the following categories: ponds of biocleaning, fishing ponds, recreation ponds, ponds of filtration fields. The base for formation of zooplankton cenoses was the rate of organic pollution of reservoirs and trophic correlations between components of groups.

During the last 100 years the most significant changes in waterbirds of Western Ukraine were observed in fishing ponds ornitho-complexes. 69 species nested there for the first time in the region in ponds, the followings began to nest: *Cygnus olor, Aythya fuligula, Bucaphala clangula, Mergus merganser, Larus cachinans, Chlidonias hibrida. Phalocrocorax carbo* and *Anser anser* have begun to nest again. Fishing ponds have the greatest importance for migrating birds.

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THE DNIEPER'S RESERVOIRS AS THE PLACES OF CONCENTRATION OF WATERFOWL

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Many years of studying the conditions of life of waterfowl on reservoirs (Kiev, Kanev, Kremenchug, Dnieprodzer innsk, Kakhovka) allow to establish the following: at present these water basins have unlimited food supply for adult birds of the most species without any food for nestlings. This fact explains concentration of adult birds during the period of after-nest migration and autumn-spring migration with low density of nesting. In August-September the following species dominate: *Anas platyrhynchos, Fulica atra, Anas querquedula, Aythya ferina, Anas clypeata*; in October-November - *Anas platyrhynchos, Anas crecca, Anas penelope, Anas acuta, Bucephala clangula, Aythya fuligula, Gavia arctica.*

Waterfowl make the nests in the shallows of all the reservoirs where *Anas platyrhynchos, Fulica atra, Anas querquedula* predominate with low density of the nests; in some places - *Aythya ferina, Podiceps cristatus, Podiceps nigricollis, Gallimula chloropus. Anas acuta, Anas crecca, Anas clypeata, Anser anser* make the nests less than above mentioned. Grouping of *Anas platyrhynchos*, making the nests within the city limits of Kiev, Dniepropetrovsk, Zaporo ye, are stable in time. Usual species (*Anas platyrhynchos, Fulica atra, Anas querquedula, Podiceps cristatus*) are not noticed on the Kiev reservoir (zone of radioactive contamination; according to the data of 1993). Beginning with 1988 strong depression of all species of waterfowl was noticed, which is possible to explain by negative influence of ionic radiation (during this period biological productivity of this water basin has two or three times increased).

In winter, waterfowl is concentrated on the non-frozen area of low and higher rims of the reservoirs and on the warm water of thermal power-stations. *Anas platyrhynchos* predominates, *Bucephala clangula, Aythya fuligula, Mergus albellus, Podiceps cristatus, Aythya ferina, mergus merganser* are not so numerous and may not be present in all winter concentrations.

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AQUATIC BIRDS AND FISH HABITAT DEGRADATION IN KŐRÖS RIVER VALLEY ECOTONES OF THE GREAT HUNGARIAN PLAIN

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The River Kőrös draining 27,537 km^2 is the second largest watershed of the River Tisza which once harboured fish and aquatic bird habitat as it was meandering through the Hungarian Lowland. During the three to four months of floods, the main river channel became a large floodplain which then subdivided with the drop in water level and frequently translocated. These changes were maintaining a diversity of aquatic ecosystems which in turn maintained a high species diversity. The riverine landscape was rich in wetlands which existed aside of the main water channel in river branches, permanent and temporal standing open waters. There were marshes, meadows and soft-wood gallery forests full of wildlife. Every kilometre of the River Tisza had an average of 20.7 km^2 of such a floodplain.

In the second half of the 19th century, due to the need of agricultural land, the largest river regulation in Europe decreased this specific floodplain area to less than 1 km^2. The river valley completely changed, being converted into a canal surrounded by wheat and corn fields. The river has lost most of its diverse habitats and much of its rich wildlife. The industrialization of the Hungarian agriculture started during the sixties of the century further deteriorated most of the spawning, breeding, nursing and feeding habitats for both the aquatic bird and fish species.

Computing and analyzing national statistics we have quantified the structure of the industrial agriculture buildup in Hungary from 1950 to 1993. Industrialized cereal production, animal husbandry together with the nitrogen-rain producing coal-gas-oil consumption have developed a deadly impact on these fragile habitats highly reducing their diversity and disparity. The present environmental state of thirteen lowland river deadarm ecosystems was surveyed for geomorphology, sedimentation, nutrient supersaturation, heavy metal contamination, bacterial, redox and metabolic gas condition in their sediments. Deadarm littoral ecotone of 75,500 m has been monitored and quantified for aquatic bird and fish habitats along eupotamon, parapotamon, semipaleopotamon and paleopotamon deadarms.

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THE NUTRITION OF GREYLAG GOOSE AND ITS EFFECT ON THE EUTROPHICATION OF KISBALATON (HUNGARY)

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ABSTRACT

During a year we estimated the number of Greylag Geese in the area of Kisbalaton, we observed their living habits. In laboratorial studies, we measured the daily consumption, the daily feces and urine output of Greylag Geese feeding on different plant material. We calculated the food consumed by the population of Greylag Geese in the area of Kisbalaton, and the part of the produced feces and urine which enters into the water. From these data we were looking for the answer what role the Greylag Goose plays in water eutrophication of Kisbalaton

INTRODUCTION

More and more studies show that animals, especially waterfowl can influence water quality by their metabolic products. The important role of the birds can be explained by their large number at the same place and by their rapid metabolism. As a consequence they cause high turnover of substances and energy in communities.

We started this study to evaluate the importance of some common waterfowl associated with different food webs in effecting water quality. First, we studied fish-eating Cormorants (*Phalacrocorax carbo*) (Gere and Andrikovics 1986, 1992a, 1992b), then the omnivorous Mallard (*Anas* *platyrhynchos*) (Gere and Andrikovics 1994). Now we are considering the mainly herbivorous Greylag Geese (*Anser anser*).

The aim of our study was not only to find out the importance of these birds in the turnover of substaces and energy, but to study the special hydrobiological situation in a wetland of European significance, the Kisbalaton.

There was a huge territory of marsh land in this area, which was drained to its small fractions by human activity. Therefore the self purification of River Zala running through this marsh decreased to a minimal level. It had an disadvantageous effect on Lake Balaton as well, because pollutants and the substances causing eutrophication got directly into Keszthely Bay without filtering (**Table 1**). The river that carries most of the inorganic materials in Lake Balaton, which cause eutrophication, is the River Zala. This river brings 10-15000 tonnes of floating substances, 1500 tonnes of N and 100 tonnes of P into the lake in a year. According to the OECD Classification (Vollenwerder and Kerekes 1981, *in* Szilágyi *et al.* 1990) Lake Balaton belongs to mesotrophie and hypertrophie categories. Keszthely area, which is the closest bay to the inflow of River Zala, is hypertrophic (**Table 1**).

A large-scale program was started to protect Lake Balaton in 1985, when the first reservoir called Lake Hídvégi was constructed. An area of 18 km^2 was flooded with River Zala. The average depth of the lake is 1.14 m, and the reservoir stores 20 million m^3 of water. The conditions of the late 18th century were practically reconstructed by this technical project at the lower part of Zala valley. The original ecosystem started to recolonisate in the first reservoir.The second part of the reservoir system is under construction now (1995).

The nitrogen and the phosphorus removals have been evaluated every year since the construction of Lake Hídvégi. We can state that the nutrient load on River Zala decreased. The reservoir removed the 26 % of total nitrogen and the 49 % of total phosphorus carried by River Zala (Pomogyi and Süle 1988). So there is an urgent need of construction of the second reservoir but it would be necessary to study the internal load of nitrogen and phosphorus coming from the reservoir itself.

There have already been positive effects of the first reservoir on the waterfowl by now. The lake offers excellent, large habitat for aquatic birds including the Greylag Goose. The chief uncertainty is the possibility that wild bird populations around the new reservoir may cause an increased trophic level of Kisbalaton and Lake Balaton by their metabolic products, which has already been pointed out in studies with other goose species (Manny *et al.* 1975, Sterbetz 1992, Manny *et al.* 1994). But in our studies we observed, that this effect does not work only in one way, and we hope that it could be insignificant in the case of Greylag Goose, which is protected in Hungary.

METHODS AND MATERIALS

We combined laboratory analysis and field observations. In our laboratory experiments Greylag Geese's eggs were hatched and the youngs were brought up in semi-wild conditions. Time by time we put some of the young of different age in a closed box to collect data about their metabolism. The young were put in cage of 1 m^2, adults were put in a cage of 3 m^2 area. The bottom of the cages was made of net, the its holes were 2 by 2 cm mesh size. Plastic sheets were put 10 cm under the cage, on which the feces and urine were accumulated. The birds were fed with measured amount of food. Daily consumption was estimated from the amount of the food which was given in and the amount of the left over food after 24 hours.

During our laboratory study period the birds were given concentrated chicken feed, which is a mixture of both plant and animal materials. This food is said to contain all the nutrients that a growing bird needs. At an other time they were fed with wheat, corn or the root and the stalk of Jerusalem artichoke. At last they were fed with the mixture of green grasses like lucerne (*Medicago sativa*), barley grass (*Hordeum murinum*) and chickweed (*Anagalis arvensis*). Since the birds are usually picking about this kind of food in nature, the grasses were cut into small pieces to help their feeding. Hereon, this mixture will be simply called as grass. We collected and measured their daily excrements and weighed each bird in the beginning and in the end of the 24-hour-periods. According to these data we calculated production-biological parameters. 4 young and 2 adult birds were involved.

In our field study we found the following data on the living habits of Greylag Goose in the area of Kisbalaton. Disregarding the fluctuation of the population, year by year, there was an average of 70 pairs nesting around the reservoir and 100 pairs around the original territory of Kisbalaton in the previous years (1993-1994). There were 1500-3000 of Greylag Geese around the reservoir in winter. These migrating birds obviously arrived from other neighbouring marshes. This number takes up 22-42 % of the whole Hungarian population,which is about 7500 individuals (Faragó, 1991 *in* Roomen and Madsen (eds.) 1991).

Pairs are formed in March. Birds that did not form pairs stay together in groups and migrate with Bean Geese (*Anser fabalis*). Goslings (4-5 in each pair) start hatching out in the beginning of April. The young birds that are unable to fly and their parents spend more time on water than on land between April and June. Between July and November most geese are feeding in groups on the nearby stubble-fields from 4 to 10 o'clock am. Between 10 and 12 a.m. they are usually drinking on the water, then they are again on the stubbles between 12 and 6 pm. They spend the night on water or on the bank from 6 o'clock pm to 4 o'clock am. In winter they feed on the stubbles or they stay on the water or the ice-floe. Their excrements may accumulate on the ice-floes, but some parts of these are consumed by wild ducks.

RESULT AND DISCUSSION

The production-biological parameters of young geese on different foods are shown in **Tables 1-3**. The parameters of adults are shown in **Tables 4-6**. If we consider that these data were obtained from relatively small number of individuals and days, then we should take this study only as a pilot investigation.

Table 1: Production-biological parameters of young Greylag Geese fed on concentrated chicken food (average of 4 birds)

Date	Initial	Late	Growth	C*100	P*100	FU*100	R*100
	Living mass (g)		(g)	G	C	C	C
7-8/05	354.5	431.0	76.5	30.9	18.2	18.3	63.5
16-17	759.0	839.5	8.5	22.2	12.4	18.0	69.6
17-18	839.5	918.5	79.0	26.5	9.2	9.7	81.1
23-24	966.0	1065.5	99.5	17.5	15.3	17.8	66.9
24-25	1065.5	1166.0	100.5	22.2	11.0	17.0	72.0
6-7/06	1658.7	1813.0	154.3	16.5	14.7	16.5	68.8

Table 2: Production-biological parameters of young Greylag Geese fed on different types of food like wheat, corn and Jerusalem artichoke (average of 4 birds)

Date Food type	Initial	Late	Growth	C*100	P*100	FU*100	R*100
	Living mass (g)		(g)	G	C	C	C
5-6/05 wheat	353.5	324.5	- 29.0	4.8	- 22.2	69.5	52.7
6-7 wheat	324.5	354.5	30.0	20.7	11.6	16.8	71.6
30-31 corn + J. artichoke	1099.0	1228.0	129.0	13.3	22.9	15.8	61.2
31-1/05-06 corn + J. artichoke	1228.0	1296.0	68.0	11.8	12.1	19.5	68.4

Table 3: Production-biological parameters of young Greylag Geese fed on grass (average of 4 birds)

Date	Initial	Late	Growth	C*100	P*100	FU*100	R*100
	Living mass (g)		(g)	G	C	C	C
7-8/06	1813.0	1768.5	- 44.5	2.7	- 25.7	56,9	68.8
13-14	1802.5	1690.0	- 112.5	2.7	- 59.6	91.2	67.9
14-15	1690.0	1642.0	- 48	2.1	- 34.6	66.0	68.6
20-21	1647.0	1601.5	- 45.5	0.7	-	-	-
21-22	1601.5	1674.0	45.5	5.9	18.8	46.1	35.1
14-15/09	1986.0	1900.5	- 85.5	4.4	- 25.3	98.2	27.1
15-16	1900.5	1945.0	44.5	5.8	10.4	43.3	46.3
20-21	2006.0	2009.0	3.0	3.3	25.8	68.6	5.6

Table 4: Production-biological parameters of adult Greylag Geese fed on concentrated chicken food (average of 2 birds)

Date	Initial	Late	Growth	C*100	P*100	FU*100	R*100
	Living mass (g)		(g)	G	C	C	C
7-8/06	3345	3258	- 87	4.5	- 17.8	11.7	106.1
16-17	3611	3284	- 327	1.4	- 196.2	67.8	228.4
17-18	3284	3241	- 43	1.1	- 34.9	17.5	117.4
23-24	3111	3213	102	7.2	25.5	14.3	60.2
24-25	3213	3219	6	13.7	0.6	13.2	86.2

Table 5: Production-biological parameters of adult Greylag Geese fed on different types of food like wheat, corn, concentrated chicken food and Jerusalem artichoke (average of 2 birds)

Date	Initial	Late	Growth	C*100	P*100	FU*100	R*100
Food type	Living mass (g)		(g)	G	C	C	C
5-6/05 wheat	3500	3500	0.0	4.8	0.0	20.8	79.2
6-7/05 wheat	3500	3345	- 155	1.7	- 80.2	19.6	160.6
6-7/06 wheat + chicken food	3193	3227	34	3.4	9.4	12.0	78.6
30-31/05 corn + J. artichoke	3276	3244	- 32	5.4	- 5.4	. 20.5	84.9
31-1/05-06 wheat + corn + J. artichoke	3244	3254	10	4.1	2.4	17.2	80.4

Table 6: Production-biological parameters of adult Greylag Geese fed on grass (average of 2 birds)

Date	Initial	Late	Growth	C*100	P*100	FU*100	R*100
	Living mass (g)		(g)	G	C	C	C
7-8/06	3227	3183	- 44	1.3	- 31.1	56.2	74.9
13-14/06	3201	3081	- 120	0.8	- 210.4	14.1	296.3
14-15/06	3081	3064	- 17	0.4	- 45.1	34.3	110.8

It is well known that geese, especially the young ones, need mixed, protein-rich food. Concentrated chicken feed is the most suitable for this purpose from the nutrients which we have used. They ate this food the most intensively. They used it up at the highest degree, the lowest amount of the excrement was found in these cases (**Tables 1, 4**). Geese are known as grazing animals, so it was surprising that they did not want to eat the grass we had given them and they couldn't use it up. This study shows that `grazing' alone is insufficient, it is only a supplementary way of feeding, geese need protein-rich food as well. It can't be a question that protein-rich food is especially important for growing animals.

We have to know several data to estimate the effect of geese on eutrophication. These are the followings:

1. the quantity and the quality of the food they consume
2. the quality of their utilization of food
3. the number of the geese staying at the area and its daily and seasonal fluctuation.

If we want to answer the first point, according to the data of Sterbetz (1992) we could say that adult geese consume daily as much food calculated in dry weight as about the 5.6 % of their body weight. Young birds' demands of food were calculated in three periods, the average of them was 10.4 %.

The excrements (dry weight) of young birds were 23.3 % of their consumed food and 21.5 % at the adults (the data which were obtained from the birds fed on grass were not included). These results look reasonable and we would like to mention that similar data were obtained from young and adult Cormorants, which were 31.5 % and 21.1 % (Gere and Andrikovics, 1986, 1992a,b).

We can estimate the quantity of the food the adults consume from the data shown in **Tables 4** and **5**. The average of Cx100/G was 5.6 % and 3.9 %. If we consider the higher mobility of birds in nature, we should use 6 % of live weight as Cx100/G to calculate the basic consumption (in dry weight) of the adult population. We calculated the consumption of the goslings in three of 30-day-periods according to their age. The average of daily consumption is 100 g between the age of 1 and 30 days, 200 g between the age of 31 and 60 days and 300 g between the age of 61 and 90 days. The consumption of adult birds is about 200 g of dry weight a day. (This data was used in our calculations.)

We based our estimates for four period of the year that were winter, nesting time, growing time of the young and summer-autumn period.

In winter, from December to February, which is altogether 90 days, at Kisbalaton 2000 Greylag Geese spend 4.32 million goosehours. (Goosehour = number of geese x the hours spent by one goose at the pointed area.) According to our field studies the half of it, 2.16 million of goosehours are spent on water. The consumption of an adult goose during a goosehour is 8.39 g, the total consumption is 35,986 kg in dry weight.

The nesting period is 31 days in March. If we calculate with all the 340 adult Greylag Geese, it makes 2.52 million of goosehours. An adult goose spend only two hours a day on water, so the number of goosehours spent on water is 2.108 million, which is only 8.3 % of the total goosehours. The total consumption during the nesting period is only 2107 kg.

The growing time of the young lasts from April to June, which is 91 days. There are 340 adult geese and 850 young geese at the area. There are about 5 goslings in each pair in this period, but we will calculate with 4 in the next period because of their mortality. The total number of geese is 1190 in this period, which makes 2.59896 million goosehours. The geese spend 16 hours a day on water, which is 66.6 % of the total goosehours. Considering that the average of the consumption of the young birds is the same as the the adults, we do not have to differentiate the different ages of young birds. The consumption during the total goosehours is 2.165 kg.

In the summer and autumn period from July to November, which is 153 days, geese (340 adults and 170x4 youngs) spend 3.74544 million goosehours at the area. They spend the 6.25 % of this on water and they are on the stubbles or on the bank or on the islands of the reservoir at the rest of the time.The consumption of this period is 31200 kg of dry weight.

According to the data showed above here is the summary of the parameters of Greylag Geese living at the area of Kisbalaton:

Period	consumption in a year (kg)	feces and urine in a year (kg)
winter	35986	8960
nesting	2107	524
growing of youngs		
adults	6235	1552
youngs	15415	2497
summer-autumn	31200	7769
Total	90943	21302

The next step is to calculate the distribution of feces and urine (FU) between water and land.

In the winter period (December-Febrruary) the half of the produced FU gets into the water and half of it gets on the land.

In the nesting period (March) 91.67 % of the FU remains on the land, only 8.33 % of it gets into the water.

In the growing period (April-June) we can calculate the 90-day-FU of young geese if we substract their growing in dry weigh from the 90-day-FU of the adults. The Cx100/G at this time is 17 %. According to other studies a young bird contains 74% water and their dry weight is 26 % (Austin 1971). The N content of the birds is 11.6 % and the P content is 2 % of their living weight (Kear 1963). A goose grows about 1940 g living weight in three months, this is 504,4 g in dry weight. The N content of it is 58.5 g (calculating with 11.6 %) and the P content of it is 10.09 g (calculating with 2 %). 49.7 kg of N and 8.5 kg of P are built in all growing birds (850) a year. We found that the proportion of consumption (C) and FU is 16.2 % in the youngs and 24.9 % in the adults fed on concentrated chicken food. The total amount of FU is 21302 kg a year and 2.2 % of it is the gross N, which is 468.6 kg of N. If we substract the N built in the body of the youngs (49.7 kg) from the gross N that will make 418.9 kg, so feces and urine contain altogether 418.9 kg of N. The total amount of FU is 21302 kg a year and 0.41 % of it is the gross P, which is 87.3 kg, from which we have to substract the P buildt in the body of the youngs (8.5 kg), so feces and urine contain altogether 78.8 kg of P.

In the summer and autumn period (July-Nov) 93.5 % of the FU remain on the land, only 6.25 % of it get into the water.

If we compare the goosehours spent on water to the total goosehours in the different periods, we will get the following summary:

Period	goosehours total	percent on water	goosehours on water
winter	4320000	50.00 %	2160000
nesting	252960	8.30 %	21071
growing of the youngs	2598900	66.60 %	1732640
summer-autumn	3745400	6.25 %	234090
Total	10917360		4147801

Greylag Geese spend 38 % of the total goosehours on water and 62 % on land. If we consider N and P causing eutrophication, we find that the inner load is only the 38 % of the total N of excrements(418.9 kg), which is 159.2 kg N, and 38 % of the total P of excrements(78.8 kg), which is 30.0 kg, these amount of nutrients get into the water of Kisbalaton a year. This amount of nitrogen and phosphorus produced by the population of Greylag Goose is insignificant for the inner load of Kisbalaton and Lake Balaton.

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FLAMINGO FOOTSTEPS ENHANCE NUTRIENT RELEASE FROM THE SEDIMENT TO THE WATER COLUMN

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ABSTRACT

A two phases experiment was carried out in a shallow coastal lagoon in the Ebro Delta (NE Spain) in order to know the potential effect of flamingo footsteps on nutrient release from the sediment to the water column. The experiments consisted of artificial simulation of repeated footsteps in microcosms located in the lagoon.

The amounts of particulate matter and nutrients (nitrate, ammonium, total nitrogen, soluble reactive phosphorus, total phosphorus and soluble reactive silica) in the water column of the disturbed microcosms were much higher than in the water column of the undisturbed (no footsteps) microcoms and than in the water column of the lagoon (neither enclosure nor footsteps).

The amounts of particulate matter and nutrients are significantly higher in sediment with a higher proportion of fine particles than in sediment with a lower proportion of fine particles. The amounts of particulate matter and nutrients in the water column of disturbed sediments were directly related to the number of footsteps and inversely related to the time passed after the footsteps.

INTRODUCTION

Flamingos and other long-legged birds in aquatic ecosystems include continuous disturbance of the sediment by the birds' feet, which could enhance nutrient exchange between the sediment and the water column. Indirect evidence for this and other effects (increasing water turbidity and decreasing dissolved oxygen concentration, abundance of macrophyte and macroinvertebrate populations and community diversity) of flamingos walking in shallow aquatic ecosystems have been presented by various authors (Hutchinson, 1951; Vareschi, 1978; Hurlbert, 1983; Johnson, 1992; Montes and Bernués, 1991). Direct demonstrations of the effects of flamingo populations on the limnological characteristics of shallow ecosystems are not easy because of the mobility of the birds. The aim of the experiments described in this paper was to determine whether nutrient concentrations in the water column increase as a consequence of the disturbance of the sediment by flamingo footsteps.

When the flamingo walks on the sediment, it sometimes paddles and stirs up the sediment with its feet (Cramp and Simmons, 1977; Johnson, 1992). However, the most frequent movement is just sinking the foot a few cm into the sediment. The very high density of flamingos observed during many hours of the day suggests that footsteps may affect the limnology of the shallow water masses of the world where they live.

In order to demonstrate the potential effect of flamingo footsteps on the nutrient exchange between the sediment and the water column in shallow ecosystems, an experiment simulating footsteps with a flamingo's leg was carried out in a coastal lagoon.

MATERIAL AND METHODS

Two experiments were performed in Tancada, a typical 1.8 km^2 coastal lagoon located in the Delta of the Ebro River (NE Spain). The experiments were carried out in the south zone of the lagoon, 50 m far away from the shore. The bottom of the lagoon was very flat and the average depth was 37 cm (Comín, 1984). A flamingo (*Phoenicopterus ruber roseus*) population of 40-1,000 birds was present in this lagoon throughout all the year.

In both experiments, a leg from a male adult flamingo, provided by the Natural Park of the Ebro Delta, was used to simulate flamingo footsteps. The experiments were conducted during calm days, in order to avoid the effects of sediment and water disturbance by the wind. A plastic tube - 20 cm diameter - was softly sunk ten cm into the sediment of the lagoon, isolating a microcosms. The top of the tube was always above the water surface, in such a way that no water from the lagoon could enter the water column isolated inside the tubes. Sediment was disturbed following a delay of one minute after the tube had been sunk into the ground. The flamingo footsteps were simulated sinking the flamingo's leg softly through the water column isolated within the tubes and down there between 2 and 5 cm into the sediment and taking the leg out from the sediment and through the water column out of the tube softly in a continuous movement.

Water samples were collected from the mid depth of the water column with a long, thin plastic tube connected to a syringe. The samples were preserved at 4 °C, and analyzed in the laboratory the next day after sampling.

The first experiment was carried out in spring 1992, to assess whether flamingo's footsteps resuspend sediment and increase nutrient concentrations in the water column in the short term. In some way, it was performed to have a qualitative confirmation of our hypothesis. After setting up the tubes, after a delay of one minute, the first sample of water was collected. Immediately after that, 15 footsteps were simulated with the flamingo's leg in one minute. Three water samples from the tubes were collected, immediately after the simulation, after 15 minutes and after 30 minutes. Control samples were also collected from a water column within a plastic tube with no disturbance, and from the lagoon water column in the vicinity of the experimental area. All the treatments were performed in triplicate.

The second experiment was carried out in spring 1993 to determine the effects of different intensity of flamingo footsteps in two areas of the lagoon with different sediment at a longer term. After setting up the tubes in the sediment and waiting 1 minute, the first water sample was collected from the tubes, before the disturbances. Then, in different tubes, 1, 3, 5, 10 and 15 footsteps were simulated in one minute. These are usual number of flamingo footsteps at the walking rate frequently observed while they eat in the study area. Water samples from the tubes were collected 5, 15, 30, 60 and 120 minutes after the disturbances. The experiment was conducted simultaneously in two close zones of the lagoon with a slight difference in texture. All the treatments were performed in triplicate.

Water analysis included suspended sediments (dry weight of suspended material retained in 0.45 mm glass fiber filter), dissolved inorganic nitrogen (ammonium, nitrate and nitrite), soluble reactive phosphorus, total nitrogen and phosphorus and soluble reactive silica.

Methods used for the analysis followed Grashoff *et al.* (1983). Sediment texture was determined as percentages of the total dry weight corresponding to different size particle fractions. Water content and organic matter content were determined from loss of weight at, respectively, 100 °C and 400 °C. The sediments of the two areas where the second experiment was performed had a slight difference in their textural composition (**Table 1**). The first experiment was carried out in the area with the coarser sediment (A in **Table 1**).

Table 1: Percentages of the particles sizes (sand, clay and silt), and water and organic matter contents of the sediments from the two experimental areas where the experiments were performed.

Site	Size % particles	% Water	Loss on ignition mg/g
A	69.18-30.80-0.01	31±1	17.5±6.9
L	59.60-40.35-0.03	31.5±4.6	18.5±5.6

RESULTS AND DISCUSSION

Short term effects

Particulate matter in the water column of the microcosms where the sediment was disturbed by footsteps is much higher than in non disturbed microcosms and in open water of the lagoon (**Figure 1**). The effect of disturbing the sediment was a resuspension of particulate matter 10 times higher than the concentration in the open water. It reached 0.2 g/l at its maximum, 15 minutes after disturbing the sediment. This was the net effect because in this figure it is included the decrease in particulate matter produced by enclosing a zone of the water column in the microcosm (difference between open water and non disturbed in **Figure 1**). These results are particularly reliable because no significant changes were observed in the particulate matter suspended in the open water column during the experiment. From this figure, it is also clear that the operation of locating the experimental tubes in the sediment did not produce a resuspension of particulate matter. On the contrary, a slight decrease in suspended particulate matter takes place within the tubes because of particles sinking in a more stable water column originated by isolating a portion of the lagoon within the tube.

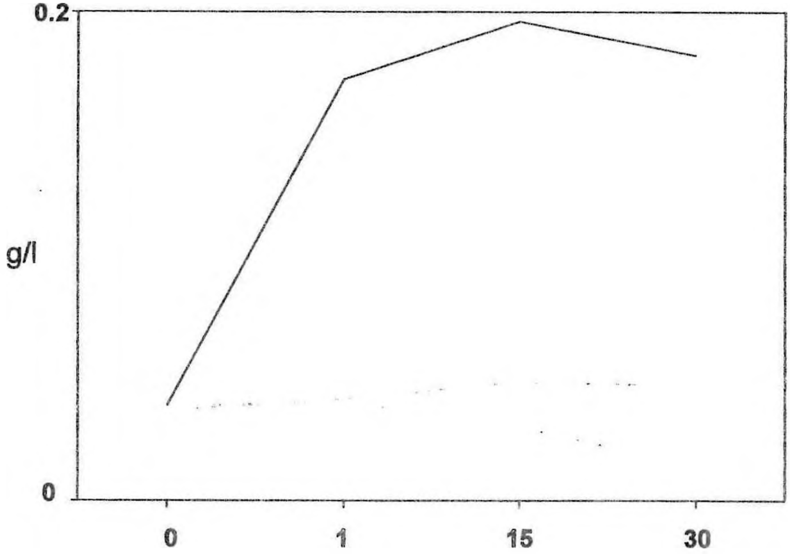

Figure 1: Suspended matter (g/l) in the water column in disturbed -with footsteps- (continuous line), non disturbed microcosms (discontinuous line), and in open water (points). The horizontal axis indicates the time of samplings: before footsteps simulation (time 0) and 1, 15 and 30 minutes after the disturbance.

Nutrient concentrations also increased in the short term (**Figure 2**) as a consequence of sediment disturbance by flamingo footsteps. In the non-disturbed microcosms a slight and short increase of most of the nutrients forms was observed after locating the tubes in the sediment. The concentrations rapidly returned to similar values as in open water. In the disturbed microcosms, the pattern of concentration changes observed was quite common for most of the nutrients: after a slight change (T_0) with respect to the concentrations in the open water (Control), a relatively rapid increase took place in 15 minutes, from T_1 to T_2. The concentrations reached in the disturbed microcosms are 2-3 times higher than those in the initial conditions for all the nutrients. A final phase of decreasing concentrations was observed for most of the nutrients during the second quarter of this 30 minutes experiment. This was not observed for nitrate and SRP.

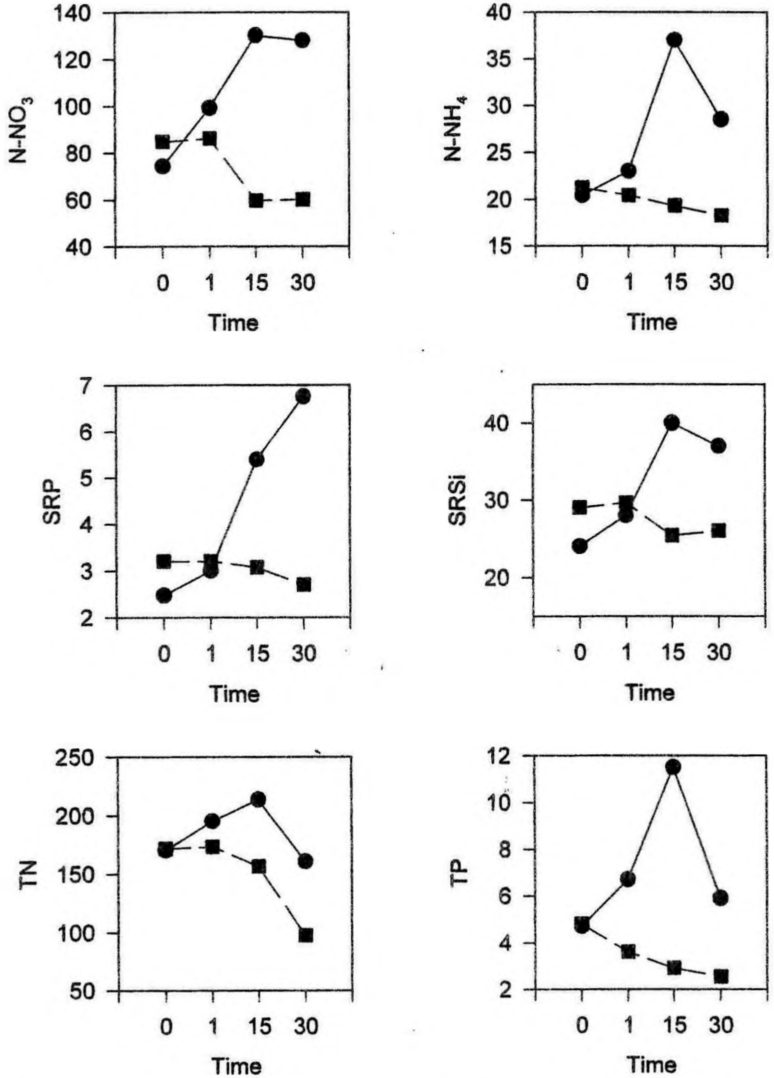

Figure 2: Nutrient concentrations (μM) in disturbed (circles) and non disturbed (quadrats) microcosms Horizontal axis as in **Figure 1**.

It can be concluded from this experiment that disturbance by flamingo footsteps produces nutrient release from the sediment to the water column in a short period of time, 15 minutes.

Long term effects

The amounts of particulate matter resuspended by the effects of footsteps disturbance were higher in the area where the sediment contained a higher proportion of finer grains (L in **Table 1**) than in the area where the sediment contained a higher proportion of coarser grains (A in **Table 1**) (**Figure 3**). This was also observed for most of the nutrient forms analyzed (TN, NO_3, NH_4, and SRP), their concentrations were double in the finer sediment respect the coarser sediment, but not for TP and SRSi (**Figures 4-9**).

The kinetics of particulate matter resuspension can be described as: a rapid increased in 5 minutes, in both types of sediments, and a slow decrease for between 2 hours, in the finer sediment and highest disturbance, and 15 minutes, in the case of coarser sediment and lowest disturbance. The same type of kinetics is observed for all the nutrient forms. However, in general, there is a delay in the nutrient concentration increase with respect to the particle resuspension.

If nutrient concentration increase is due to desorption from the resuspended particles and/or exchange between the sediment and the water column, it takes a time for these processes to be reflected in the water column. The time for most of the nutrients to reach the maximum concentration in the water column was about half an hour, while maximum particle resuspension was observed in the 5 minutes sampling.

In general, the maximum nutrient concentration is observed half an hour after the disturbances. At this time, the amount of particulate matter resuspended had began to sink in most of the treatments. For most of the cases in our experiment, adsorption of nutrients to sinking particles is not an important process sequestering nutrients from the water column to the sediment, at least in a short period of time, because nutrient concentrations were still high compared to the initial conditions after most of the particles resuspended had sunk again. So, in addition to desorption and adsorption linked to the particles some other mechanisms must play an important role controlling the nutrient concentrations.

Among others, solubilization from the disturbed sediment and from the resuspended or previously floating organic particles should be considered (Kennish, 1986). Further evidence for this consideration is the fact that all nutrient concentrations were increasing between 15 and 30 minutes, while resuspended particle matter was clearly sinking.

The concentration of most of the nutrients decreased after the maximum at a slower rate per time than they increase, except for SRP in the finer sediment and SRSi in the coarser sediment, which decreased rapidly (at the same rate as it increased, in half an hour).

In these two cases, it is likely that adsorption into particles is taking place because it is well known that this process is very effective for removing phosphorus and silica from the water column (Kennish, 1986). However, it is not clear from our results to what extent it is occurring because of the lack of correspondence between the decreases of nutrient and particulate matter concentrations in the water column. Other processes must also be involved in controlling the nutrient concentrations in the water column. A combination of a rapid nutrient release from the interstitial water to the water column, slower desorption from the resuspended particles to the water, and later adsorption onto the particles can take place for these two nutrients, because these processes occur at different scales of time (Anderson, 1976; Carrit and Goodgal, 1954).

There is a direct relationship between the number of footsteps and the amount of particulate matter resuspended in both types of sediment. However, this type of relationship is not found between the number of footsteps and the maximum nutrient concentration reached in the water for most of the nutrients. Particle resuspension is directly related to the physical disturbance created by the footsteps. The energy associated with the disturbance intensity produced in our experiments is probably at the limit of the energy required to resuspend the types of sediment in our study area because very similar results of particulate matter resuspended were obtained with 10 and 15 footsteps. However, the concentrations of the nutrients in the water column are the result of different biogeochemical processes after the mechanical disturbance. These processes may take place with different intensities and rates and may have opposite effects on the final nutrient concentrations .

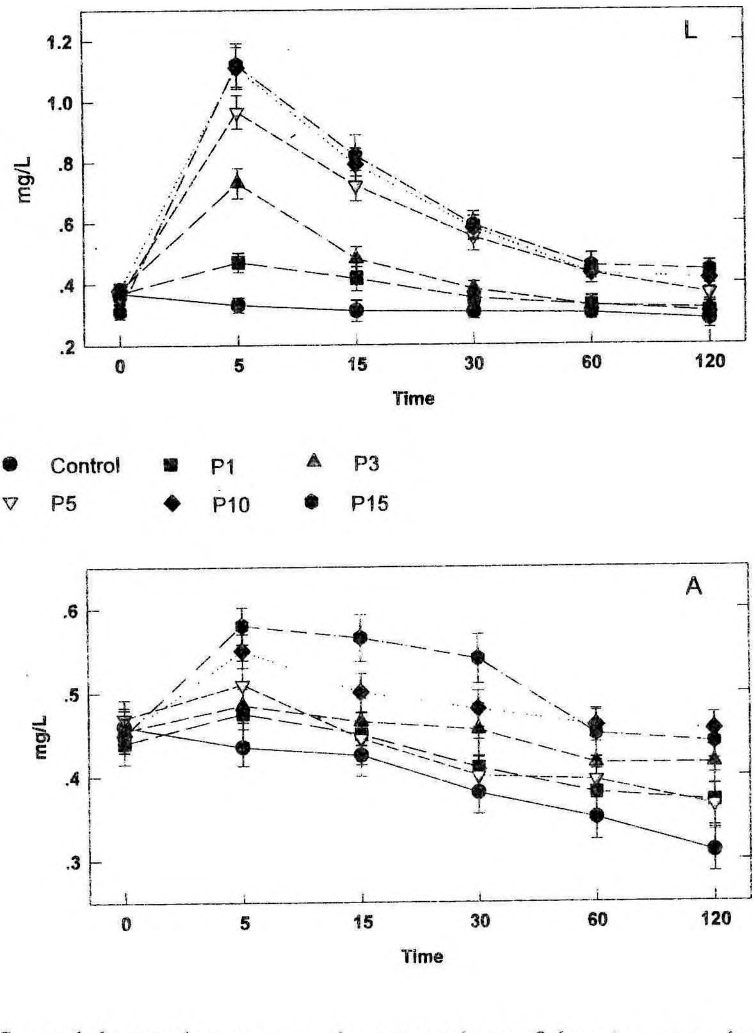

Figure 3: Suspended particulate matter in the water column of the microcosms during the second experiment. Above: microcosms in the finer sediment zone (L in **Table 1**); below: microcosms in the coarser sediment zone (A in **Table 1**). Horizontal axis indicates time of sampling (0 is sampling before footsteps were performed). The different number of footsteps performed in the different treatments are indicated by the number besides the symbols in the figure (Control corresponds to the treatments without footsteps). (See the text for further explanations).

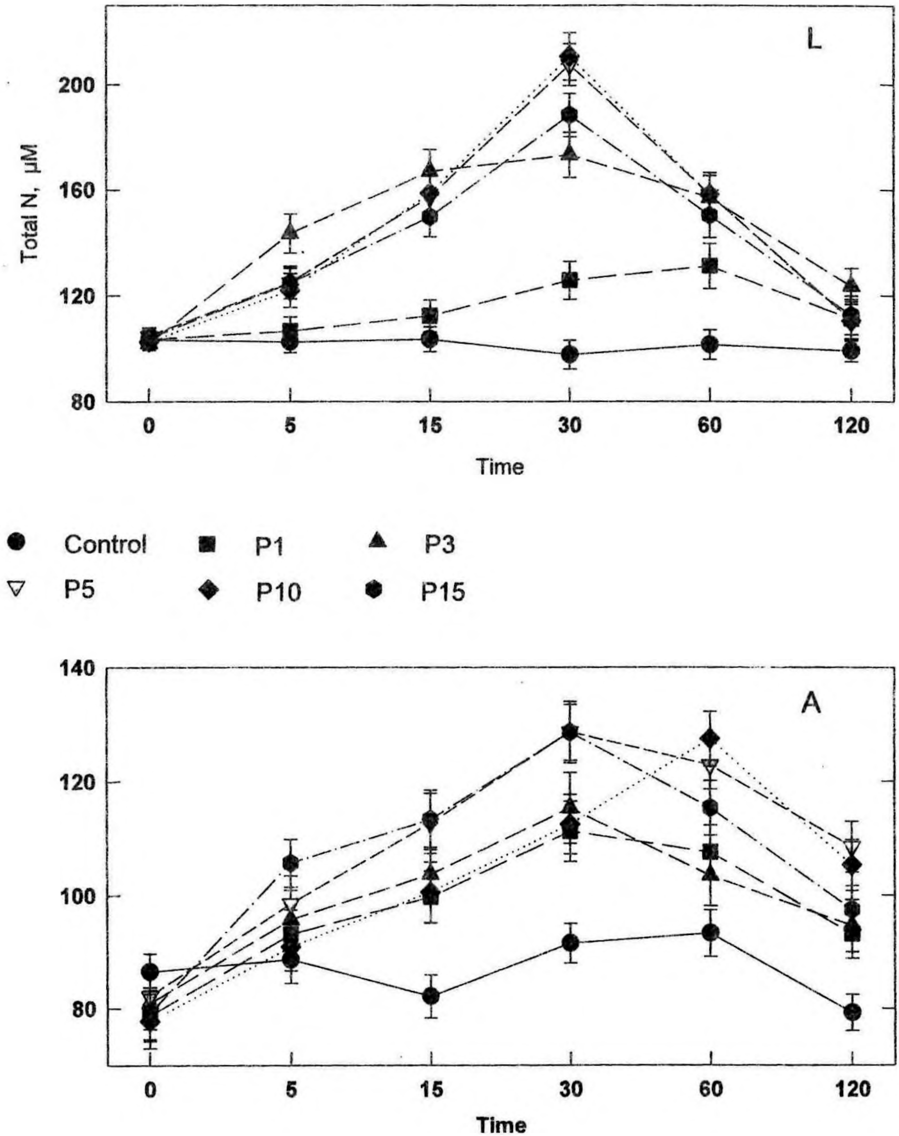

Figure 4: As Figure 3 but for total nitrogen.

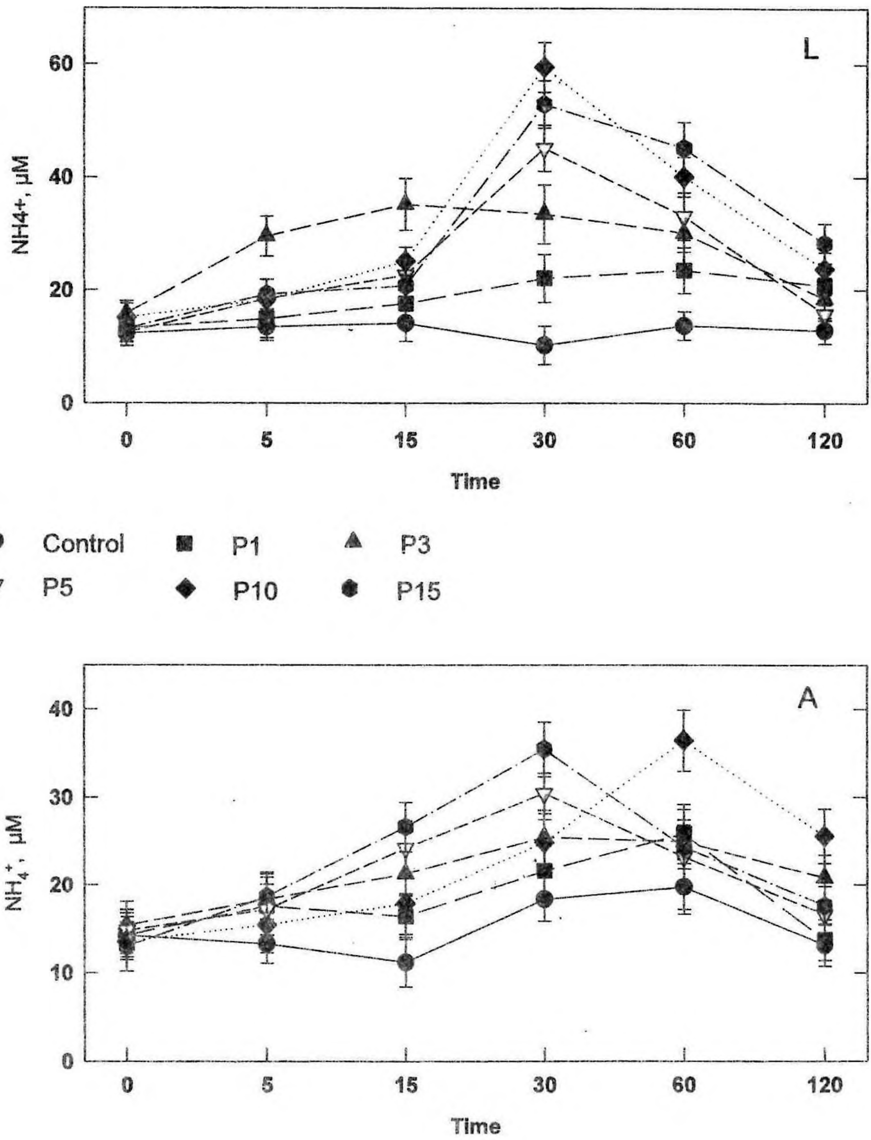

Figure 5: As Figure 3 but for dissolved inorganic nitrogen in the form of ammonium.

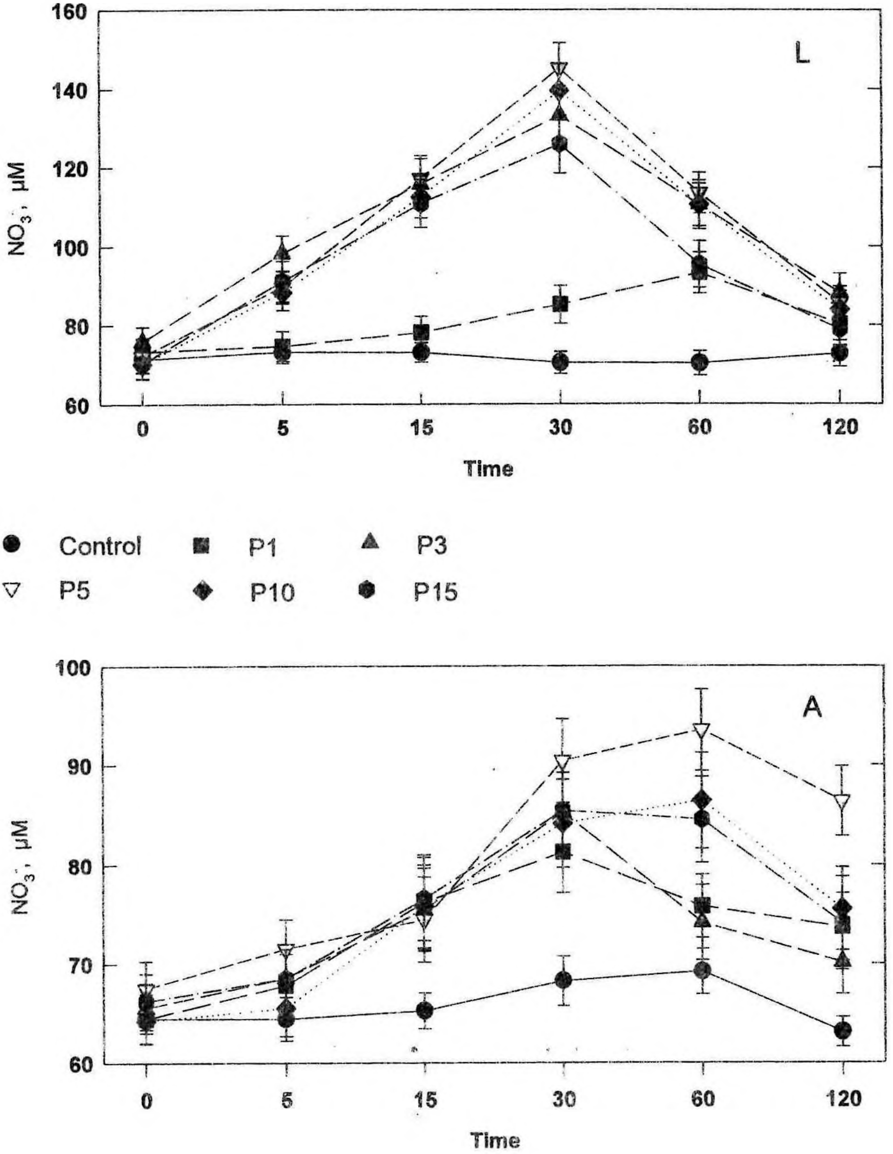

Figure 6: As Figure 3 but for dissolved inorganic nitrogen as nitrate.

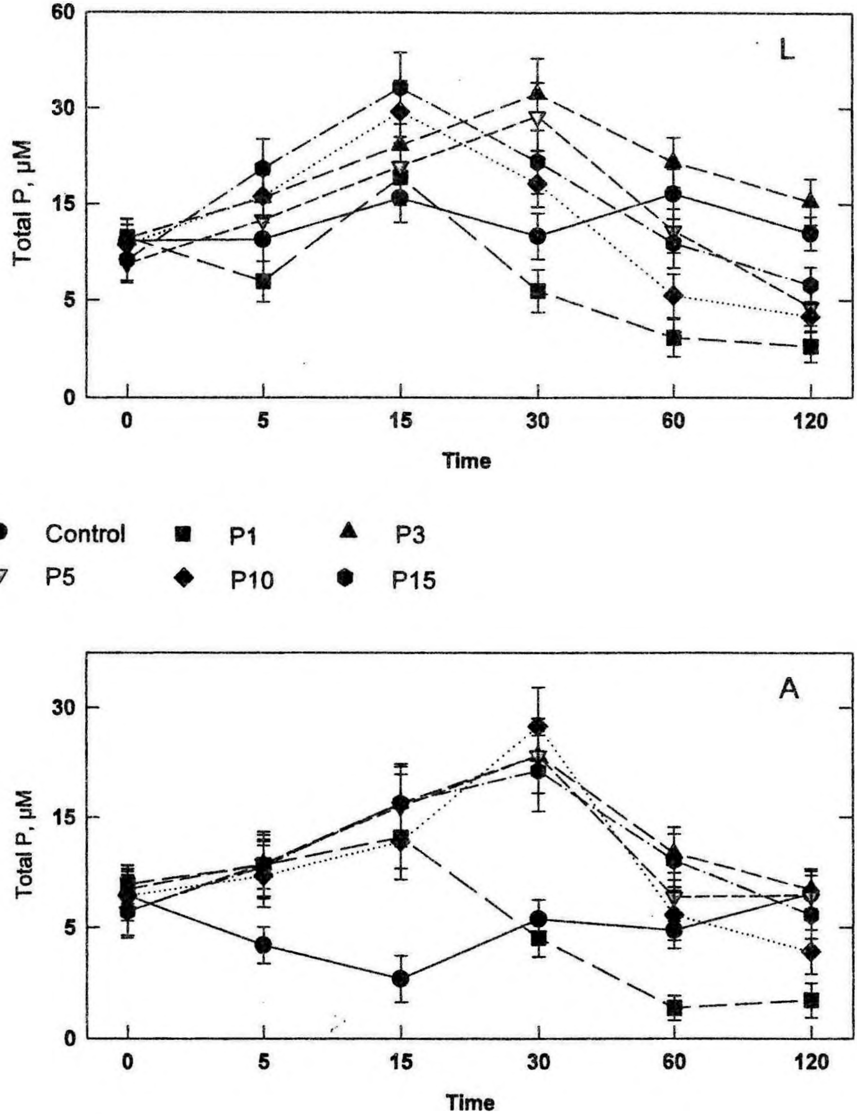

Figure 7: As Figure 3 but for total phosphorus.

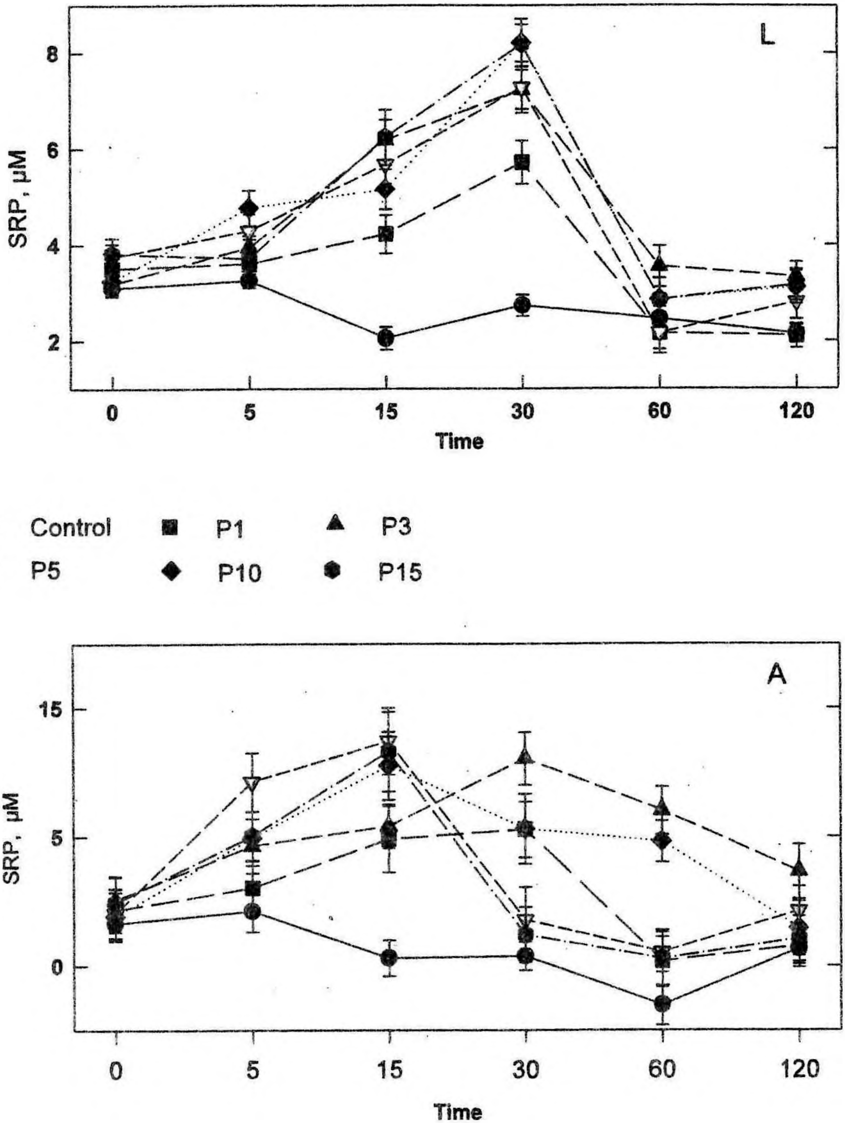

Figure 8: As Figure 3 but for soluble reactive phosphorus.

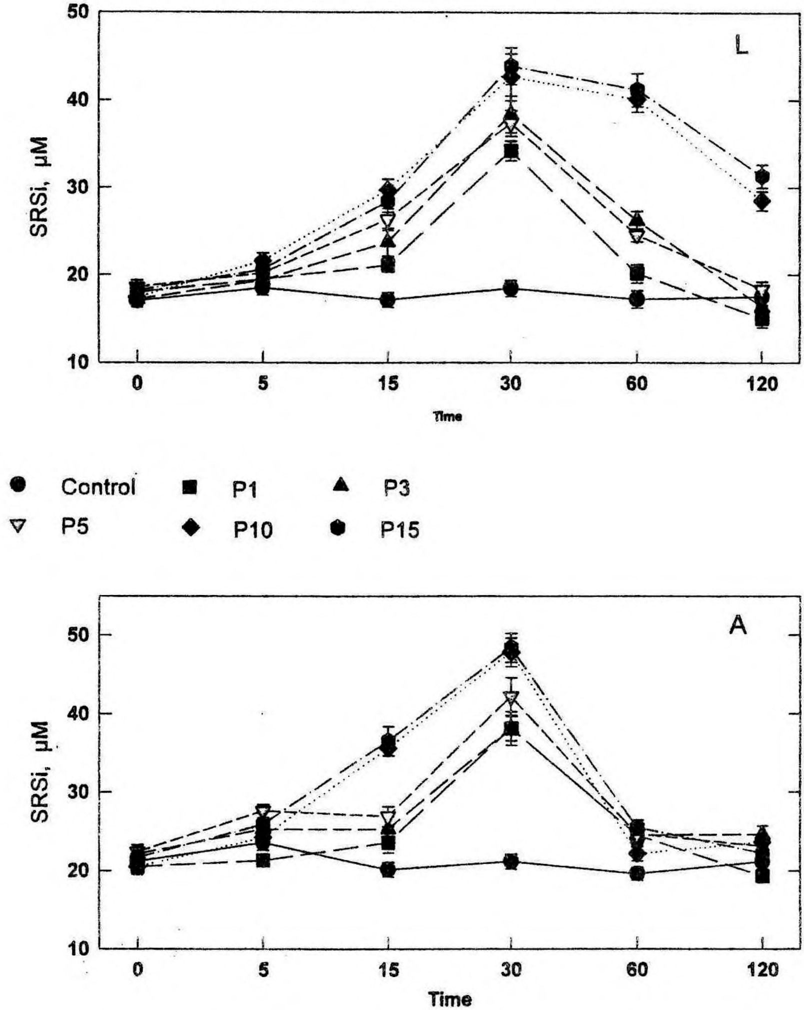

Figure 9: As Figure 3 but for soluble reactive silica.

CONCLUSIONS

Flamingo footsteps at the walking rate frequently observed while the birds eat in the study area -between 3 and 15 footsteps per minute- cause sediment resuspension and nutrient release from the sediment to the water column in the short term, the two-hour period of our longer experiment. In the experimental conditions, increased suspended particulate matter and nutrient concentrations in the water column lasted for 2 hours, which may not be enough to decrease water transparency or to stimulate phytoplankton growth. In natural conditions, a continuous effect of flamingo footsteps can take place in a defined area if different individuals walk on the same place or the same individuals remain active in the same area. Then the effects described here can last for longer. However, flamingos usually sleep and stay without movements during night hours. Further experimental evidences are required in order to check the role of flamingos in the nutrient cycles and other aspects of the limnology of shallow aquatic ecosystems.

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THE DIPPER (*CINCLUS CINCLUS*) AS THE INDICATOR OF WATER QUALITY IN CREEKS OF HUNGARY

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ABSTRACT

In the last century the Dipper was still very frequent in the foothills of the Carpathians. Nowadays the number of Dippers has become very rare. The aim of this paper is to explore the causes of the decrease in the number of Dipper and to examine the relationship between the Dipper's presence and the creeks' water quality.

We studied the macrofauna and water quality along three model creeks (Jósva-, Apátkút-, Eger-creek) in relation to with the Dipper's decennial presence.

The Dipper is an excellent indicator of water quality, as its fedding habits show.

INTRODUCTION

Several researchers considered with the Dipper's Carpathian basin habitat (Creutz 1986, Hudetz 1983, Horváth 1992 etc.). The recent scientific literature examins its food (Horváth-Andrikovics, 1991). At the beginning of this century it was common in the Alps and in the Carpathians, where it still lives, but the actual numbers are unknown. In the Hungarian mountains there have always lived only peripherial populations. Their numbers have never been large. According to surveys done in the North of Hungary, several pairs nested in the creeks of Bükk, Pilis, Mátra, Aggteleki Karszt, Tokaj, Börzsöny and Medves mountains (Horváth, 1993). Their numbers decreased in all known habitats in the following mountains: Bükk (the Szinva-creek), Pilis (the Apárkút-creek), Aggteleki Karszt (the Jósva-creek) and Börzsöny (the Kemece-creek) (Horváth, 1988). Morphometric and food biological examinations were done on the existing stock (Horváth-Andrikovics 1991, Rékási 1984). The aim of these was to study the "health" of the endangered Hungarian population on the basis of food supply.

We compared the Central Europen Dipper's food content with that of the Northern European Dipper population. We observed and measured the most important features of water quality and of bed formation in creeks where the Dipper no longer lives and also where some pairs found good nesting places. On the basis of the results, we try to answer the following questions: What are the causes of the decrease in the number of Dippers in Hungary? What change in water quality is associated with the decrease?

MATERIALS AND METHODS

We studied the Eger-creek in the Bükk Mountains, the Apátkúr-creek in the Pilis-Visegrád Mountains and the Jósva-creek in the Aggteleki Karszt. We studied the changes of bed formation during regular visit to the creeks and we measured the water quality in the field and in the laboratory. We have made regular invertebrate macrofauna surveys in all three creeks for years and the results have been published (Andrikovics-Hadnagy 1994, Andrikovics 1989, Uherkovics-Nógrádi-Andrikovics 1992). These results provide an accurate picture of the invertebrates along the creeks and give an account of larva examinations and the results of light traps.

The **Tables 2-3**. concerning the Eger-creek and the Aggteleki Karszt show the details of our macrofauna investigations done in 1994.

We applied two methods to estimate the food eaten by the Dipper. We can examine the undigested chitin remains in the Dipper's pellet or animal remains in its excreta.

First we examined a Dipper pair in the Aggtelek National park (Horváth-Andrikovics, 1991). We repeated these examinations at the end of 1994 and we measured the quantity of food eaten by the Dipper. Food items can be identified easily from the pellets. Determination of food items from the excreta remained unsuccesful.

RESULTS AND DISCUSSION

The most important water quality parameters of the three creeks are compiled in **Table 1**. Those three creeks where the Dipper nested had excellent water quality from the point of view of total salt content, nutrients agents or decomposing. On the other hand the Eger-creek is seriously polluted according to several indices.

Table 1: The most important water quality parameters of the three creeks

	Eger-creek	Jósva-creek	Apátkút-creek
Conductivity µS/cm	1177	748,0	
pH	7,78	7,8	7,2
Dissolved O_2 (mg/l)	12,2	8,6	20,0
Total hardness nk	19,32	18,9	10,0
Calcium (mg/l)		125,8	
Magnesium (mg/l)		8,6	
Hydrocarbonate (mg/l)		445,0	
Sulphate (mg/l)	159,0	33,0	
Chloride (mg/l)		5,2	
Nitrate (mg/l)	13,8	10,5	
Nitrite (mg/l)	0,4	0,02	
Chemical ogygen (COC)	15,0	3,0	
BOD-load	8,0	3,0	

The chemical analyses were made in the Dipper's habitat. An examination of each creek's full length reveals useful information. The Eger-creek begins above Balaton (a village) and after 60 kilometres it flows into the river Tisza. There is a short, relatively clean section above Eger. The creek receives households sewage at its upper reaches and industrial sewage downstream. The source of the creek is about 320 metres above sea level (**Figure 1**). The control of the bed does not often go with the region.

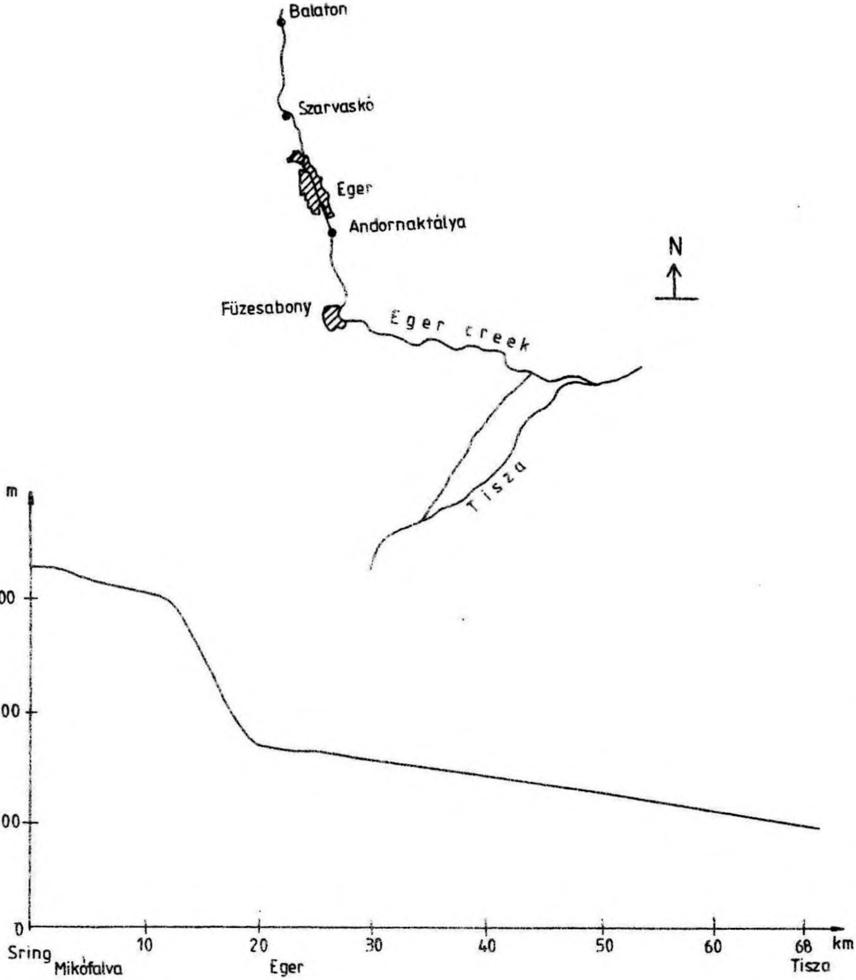

Figure 1: The Eger-creek's topography, slope graph and the nesting places of the Dipper. The bird does not nest in this region anymore

The Jósva-creek originates at Jósvafő, and after 13 kilometres it flows into the Bódva. Its upper reaches were channeled in 1938. Lake Tengerszem, above which the Dipper's nest can be found (**Figure 2**). The water is fast-flowing along the creek. The creek receives a great deal of pollution (artificial fertilizer) at Szinpetri (a village) which is about 6 km from the spring. In spite of the artificial conditions the Dipper nest is quite stable here. On the other hand the considerable tourist traffic endangers the stock.

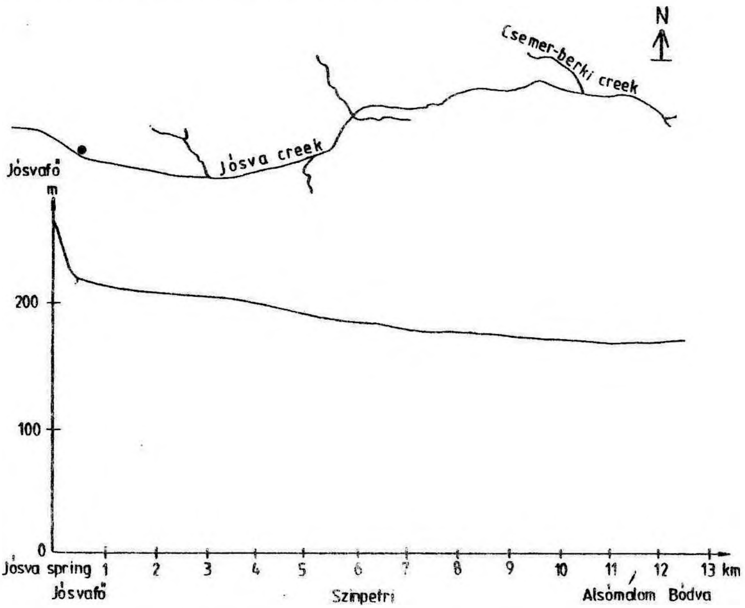

Figure 2: The Jósva-creek's topography, slope graph and the nesting places of the Dipper

The Apárkút-creek originates at Pilisszentlászló where it immediately receives of a considerable quantity of water. After ten kilometres in paved bed it flows into the Danube (**Figure 3**). It receives a little sewage again at Visegrád. The Dipper's nest was at Magda spring far away from Pilisszentlászló. **Figure 3** shows the changes in water speed and dissolved oxygen content which are favorable. The **Tables 2-3** show the results of surveys of invertebrate macrofauna elements in the Eger, Jósva, and Apátkút creeks.

According to a survey done in 1994, 35 invertebrate macrofauna taxa were found in the Eger creek. **Table 2** shows that on the very long section of the creek there are only Chironomida, Tubifex larvae which are not suitable food for the Dipper. Mayflies, stoneflies and caddis flies occure only on the upper reaches of the creek. There are Amphipods on the upper part but suitable nesting places cannot be found even here.

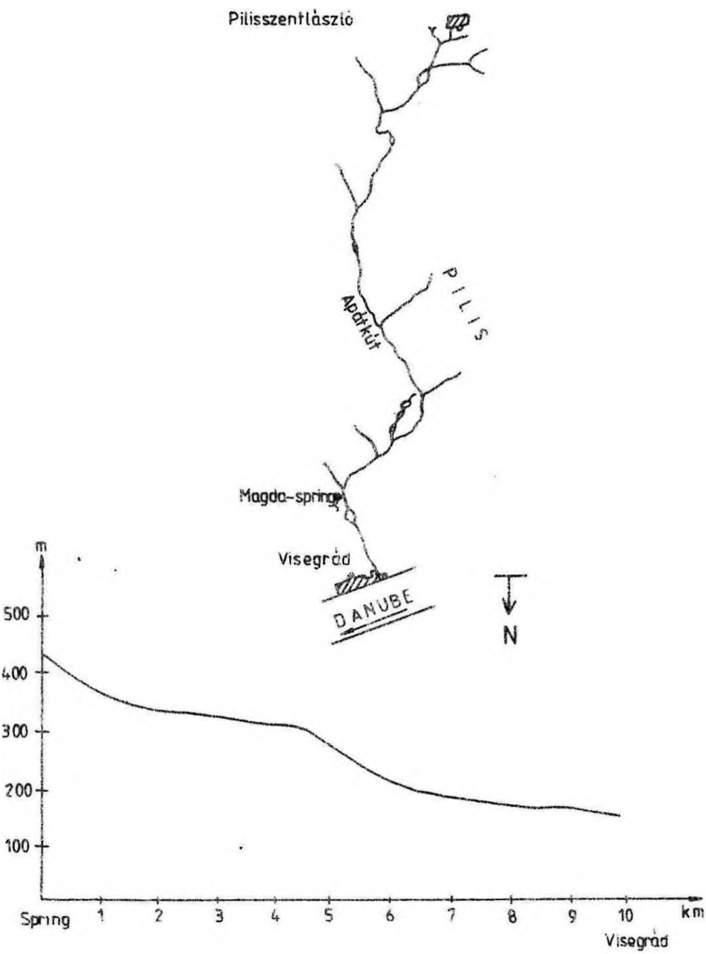

Figure 3: The Apátkút-creek's topography, slope graph and the nesting places of the Dipper

In the Jósva-creek there were many Amphipodas and Trichopteras. In contrast with our expectations there are few mayflies and stoneflies. Large numbers of *Sadleriana pannonica* (Mollusca) cover the creek-bottom in many places. **Table 3** summarizes the macrofauna elements in the area. The table does not contain the Amphipods and snails. The Trichopteras were collected by light trap.

Table 2: Imported food taxons along the Eger-creek

Turbellaria	*Dendrocolum lacteum*
	Policelis nigra
Hirudinoidea	*Dina lineata*
Oligochaeta	*Tubifex sp.*
Gastropoda	*Bithynia tentaculata*
Amphipoda	*Gammarus rhoeseli*
	Chaetogammarus tenellus
Isopoda	*Asellus aquaticus*
Ephemeroptera	*Baetis rhodani*
	Baetis vernus
	Baetis sp. juv.
	Cloeon simile
	Electrogena lateralis
	Electrogena sp. (juv.)
Plecoptera	*Nemoura cf. cambrica*
	Nemoura cf. cinerea
	Nemoura sp.
Coleoptera	*Helodes hausmani*
	Noterus crassicornis
Trichoptera	*12 spp.*
Diptera	*Silulium larvae*
	Simulium numph.
	Chironomidae

Table 3: Imported food taxons along the Jósva-creek

Ephemeroptera	*Cloeon dipterum*
	Caenis horaria
	Caenis robusta
	Ephemerella ignita
	Baetis rhodani
	Baetis fuscatus
	Baetis sp. (juv.)
	Electrogena lateralis
	Ecdyonurus submontanus
	Epeorus sylvicola
Odonata	*Agrion splendens*
	Aeschna cyanea
Plecoptera	*Nemoura flexuosa*
	Protonemoura aestiva
Trichoptera	47 *spp.*

Table 4: Important food taxons along the Apátkút-creek

Decapoda	*Astacus torrentium*
Amphipoda	*Gammarus rhoeseli*
	Gammarus fossarum
Ephemeroptera	*Ephemera danica*
	Baetis rhodani
	Cloeon dipterum
	Procloeon bifidum
	Centroptilum luteolum
	Procloeon sylvicola
	Rhitrogena semicolorata
	Electrogena lateralis group
	Ecdyonurus starmachi
	Ecdyonurus sp.
	Ephemerella ignita
	Habroleptoides modesta
	Caenis robusta
	Caenis horaria
Trichoptera	*32 spp.*
Plecoptera	*Capnia bifrons*
	Leuctra pseudosignifera
	Leuctra digitata
	Leuctra hippopus
	Protoneomura intricata
	Nemoura flexuosa
	Nemoura scriums
	Nemoura cambria
	Nemuella pictetti
	Isoperla tripartita
	Isoperla grammatica
	Chloroperla tripunctata
	Perla burmeisteriana
Coleoptera	*Elmidae*
Megaloptera	*Sialis fulinginosa*
Diptera	*Empidiae*
	Simuliidae
	Tabanidae

The invertebrate macrofauna in the Apátkút-creek is rich and varied. Here the main elements are also the Amphipods and the Trichopteras, but the number of Molluscs is insignificant. Apart from polluted zones, the mayfly and the stonefly fauna is richer than average both in number of species and in number of individuals (**Table 4**). The number of aquatic invertebrates can reach 250 ind/m² (**Figure 4**). The Amphipods had the largest percentage in the Dippers' food. Next in abundance were the Hydropsyche and Rhyachophila species from the caseless caddis fly. *Silo pallides* and the different Lmnephilidae species from the case bearing caddis files, were also present.

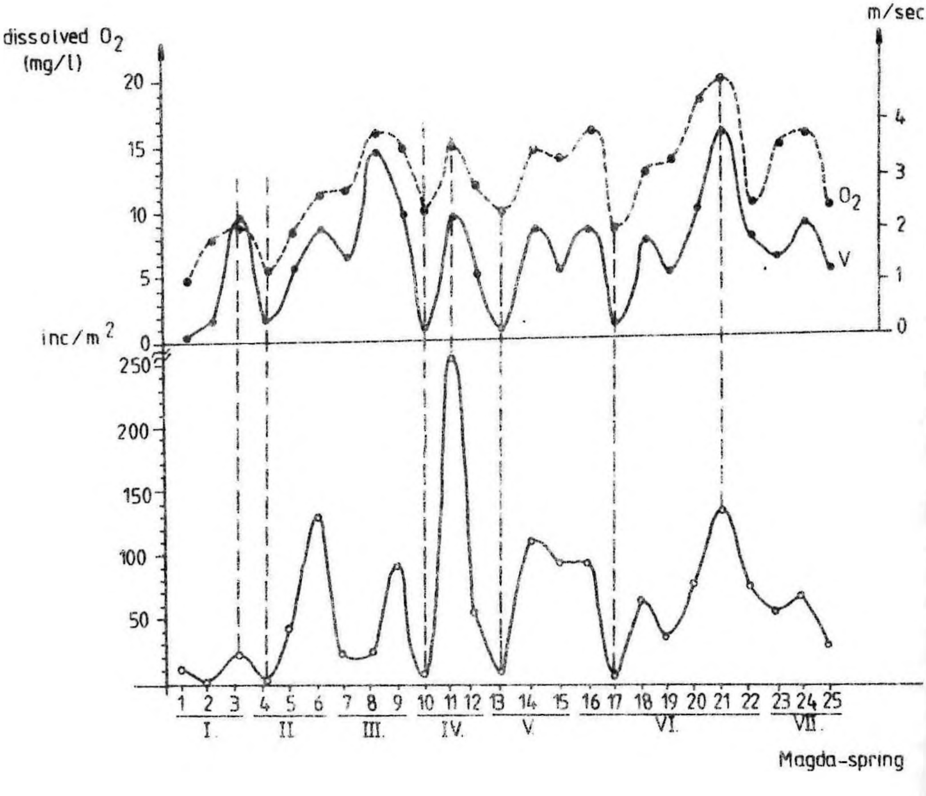

Figure 4: The changes of water speed (V), dissolved oxygen (O_2) and the number of aquatic invertebrates along the Apátkút-creek

According to real number of individuals the Dipper eats *Sadleriana pannonica*, too. There were water beetles and diptera larvae only in small in the analysis of the spittles. The Amphipoda-Trichoptera dominance found in the diet of Hungarian Dippers differs considerably from Western Europeans results. For example Dippers living in England eat mainly Ephemeroptera, Plecoptera and Trichoptera larvae (Ormerod, 1985).

We can state thet the Dipper's disappearance is associated with the water quality which is going from bad to worse, but other factors, like stream bed-control, continuous water shortage and the disturbance caused by tourists also can have an important effect as our sketch shows (**Figure 5**).

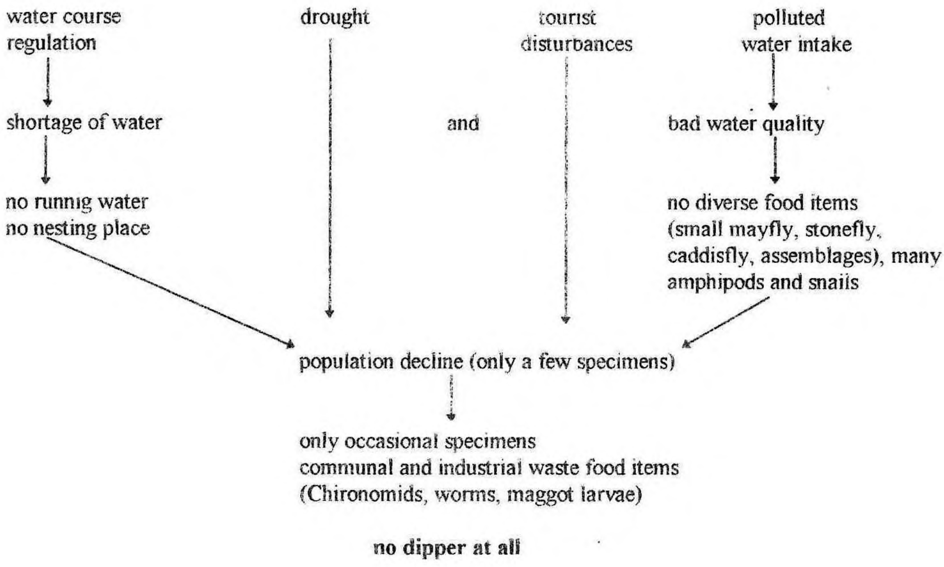

Figure 5: The simplified process diagram of ecological factors causing the disappearance of the Dipper

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MICROCRUSTACEAN ZOOPLANKTON AS POTENTIAL FOOD OF *RECURVIROSTRA AVOSETTA* IN SODIC WATERS OF THE HUNGARIAN PLAIN

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ABSTRACT

The distribution of Avocet was observed between March and June in 1992 and 1993 at several sodic waters and at the same time quantitative zooplankton samples were collected. High positive correlations were found between zooplankton density (Cladocera and Copepoda combined) and bird numbers and even stronger correlation was shown between density of Copepoda and Avocet distribution. These correlations were changing in time, highest correlations were found in April, but in spite of high zooplankton densities in May the correlation was less strong between zooplankton and Avocet. These results very likely indicate that in spring the distribution of Avocet has been influenced by the zooplankton abundance while in the nesting period zooplankton abundance seems a less important factor in determining the distribution of Avocet in the Hungarian Plain.

INTRODUCTION

The Avocet is a characteristic sodic bird nesting at sodic waters in the Hungarian Plain. Previous Hungarian studies dealt with various aspects of the biology and ecology of the species, i. e. with the habitat requirements, breeding biology, behaviour etc. In spite of this, however, little attention was paid to the feeding ecology, although the connection between the habitat selection and the food resources was investigated with more emphasis in several European countries. In this paper an attempt is made to correlate results form two, seemingly remote disciplines, such as ornithology and hydrobiology. These results are of informatory nature and we hope to provide impetus for further researches in this field.

The species composition of the bird communities of the sodic waters in Hungary is well known. As an indicator species the Avocet has also been studied, some connections between habitat features, such as vegetation, water depth etc. and habitat choice of the Avocet were clearly described (Molnár, 1986; Boros 1993a). Already in these investigations emerged the question if there is any relation between the feeding behaviour of the species and the microcrustacean fauna of sodic waters (Bankovics, 1984), thus e. g. *Arctodiaptomus spinosus*, the most characteristic copepod of the sodic waters in the Carpathian basin, was considered as an important food organism, however, no attempt was made to quantify the presumed relationship. The traditional and previously preferred method of studying food selection in birds is the analysis of stomach content, nowadays it is questionable in the case of strictly protected species as the Avocet. Few data on stomach content can be found in the Hungarian literature, for the Avocet only two records are available (Sterbetz, 1988). More data are given by Glutz *et al.* (1977) and Cramp (1983) for the food selection of this species based on stomach content analyses. Mostly speciemens from coastal biotopes were investigated, where Polychaeta (e. g. *Nereis diversicolor*) and arthropods dominated in the stomach content. Within the Arthropoda two main groups, crustaceans (e. g. *Cladocera*, *Copepoda*, *Artemia* sp., *Corophium* sp., *Palamonetes* sp.) and insects (e. g. *Coleoptera* and *Diptera*) were recorded. There were seasonal differences in the proportions of the food items, insects were preferred in the nesting period when the birds are residing on dry shelves or waste land.

More recently Moreira (1992) found, that in saline coastal lagunes there is a positive correlation between the distribution of the Avocet in the area and the available food. These literature data gave us the idea to carry out simultaneous investigations on the abundance of microcrustacean zooplankton of sodic waters and to find out if they are correlated. In the first year, 1992, studies were made at two sodic waters in the Kiskunság National Park. The first results indicated strong correlation between the abundance of the formerly mentioned calanoid copepod (*A. spinosus*) and the site selection of the Avocet (Boros and Mocskonyi, 1993). Based on these results a more extensive study was carried out in 1993.

MATERIALS AND METHODS

In 1993 various water bodies were included in the investigations, taking into aconsideration the fact, that in the last years the number of natural sodic waters sharply decreased and the Avocet started expanding to artificial aquatic habitats as reflected by the bird counts (Boros, 1993b; Borosd and Szimuly, 1993). Large numbers of breeding and migrating Avocets regularly occur in most cases at large fishponds (e. g. Szeged, Fehér-tó), which were built on former sodic lakes or marshes. In addition, mainly in the nesting period are important some small, shallow ponds now used for goose breeding. For these reasons zooplankton sampling and bird counting were carried out at the following localities (see also **Figure 1**):

Sodic waters: Fülöpszállás: Kelemen-szék, Fehér-szék, Sátánhalom; Szabadszállás: Zab-szék; Kardoskút: Fehér-tó; Soltszentimre: Állam-puszta; Dunatetétlen: Sósér;
Fishponds: Szeged: Fertő; Tömörkény: Csaj-tó; Dunatetétlen: Sóséri-halastó;
"Goose pond": Békéssámson.

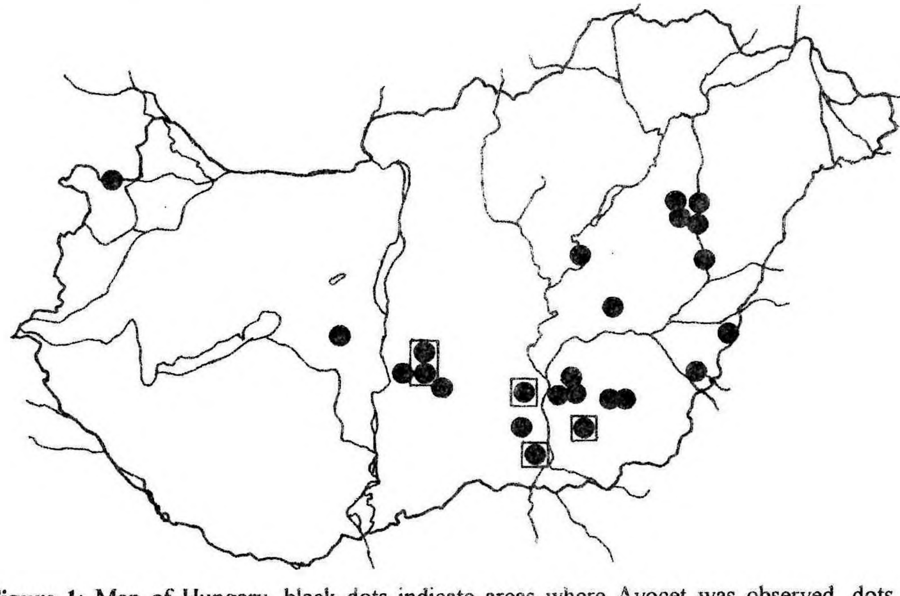

Figure 1: Map of Hungary, black dots indicate areas where Avocet was observed, dots in squares are collecting localities of the present study

This study was planned for the whole year but because of the dry weather the small waters dried up by mid-summer, thus data could be obtained only between March and June. The artificial fishponds were still filled after the nesting period, we could not establish sites where the Avocets assemble before migration.

Zooplankton samples were collected by wading into the waters (depth mostly less than 50 cm), 30 liters, taken from several points, 1 liter aliquots were filtered through a planktonnet of 100 μ mesh size. The samples were preserved in the field with formol. The abundance is given in individuals/liter. At the same time all Avocets at the given water body were counted, without considering their feeding or other behaviour. These two variables were used in the correlation analyses, where the microcrustacean abundance was the independent and the number of avocets was the dependent variable.

RESULTS

1. Composition of the microcrustacean fauna

In 1992, between May and July, eleven samples were collected from Kelemen-szék and Zab-szék, before they were drying out. Six species (4 Cladoxera and 2 Copepoda) were found in Kelemen-szék, while in Zab-szék only three species occurred. In both waters the *Moina brachiata - Arctodiaptomus spinosus* communities dominated, the other species were not percentual composition of microcrustacean zooplankton in Kelemen-szék as shown in Figure 2. The abundance has greatly increased from May onwards to the desiccation, changing from the first value of 145 ind./l to almost 7000 ind./l. Three samples were collected from Zab-szék, the abundance increased here from 814 to 7192 ind./l, until the desiccation of the pond.

Nine water bodies were investigated in 1993, 24 species (16 Cladocera and 8 Copepoda) were found (**Table 1**). The most frequently occurring species were *Daphnia magna, Moina brachiata, Macrothrix hirsuticornis, Arctodiaptomus spinosus, A. bacillifer* and *Megacyclops viridis*. *Daphnia*-species (*D. magna* and *D. atkinsoni*) dominated in April with two *Arctodiaptomus*-species, thereafter in May *Moina brachiata* was the dominant cladoceran taxon. Within copepods the *Arctodiaptomus-Cyclops* ratio was variable, in the more sodic, smaller ponds (such as Zab-szék) species of the first genus dominated, frequently no *Cyclops* at all was found.

Table 1: List of species collected in 1993 (Numbers refer to the following localities: 1 = Fülöpszállás, Kelemenszék, 2 = Szabadszállás, Zabszek, 3 = Fülöpszállás, Fehér-szék, 4 = Fülöpszállás, Sátánhalom, 5 = Soltszentimre, Állampuszta, 6 = Dunatetétlen, Sós-éri halastó, 7 = Dunatetétlen, Sós-ér, 8 = Tömörkény, Csaj-tó, 9 = Szeged, Fertő)

Cladocera			**Copepoda**		
1.	*Daphnia magna*	1,3,4,5,6,7,9	17.	*Arctodiaptomus bacillifer*	1,5,6,7,9
2.	*Daphnia atkinsoni*	1,2,5	18.	*Arctodiaptomus spinosus*	1,2,3,5
3.	*Daphnia pulex*	2,3,4	19.	*Eucyclops serrulatus*	3,5
4.	*Ceriodaphnia reticulata*	3	20.	*Cyclops strenuus*	4,5
5.	*Simocephalus vetulus*	3,4	21.	*Cyclops vicinus*	8,9
6.	*Scapholeberis ramneri*	5	22.	*Acanthocyclops robustus*	5,9
7.	*Megafenestra aurita*	4	23.	*Megacyclops viridis*	1,2,4,5,9
8.	*Bosmina longirostris*	8	24.	*Metacyclops planus*	5
9.	*Moina micrura*	8			
10.	*Moina brachiata*	1,2,3,4,5,6,7,9			
11.	*Macrothrix rosea*	1,2,5			
12.	*Macrothrix hirsuticornix*	1,4,9			
13.	*Ilyocryptus agilis*	9			
14.	*Alona rectangula*	1,6			
15.	*Pleuroxus aduncus*	3			
16.	*Chydorus sphaericus*	1,3,4,5			

In the less sodic lakes mostly one or two *Cyclops* species were dominant. Also, in Csaj-tó, which was used as a fishpond for a long time, only these species occurred. Changes of abundance in Kelemen-szék are shown in **Figure 2**. The abundance was much lower in this year, than in the previous one, even the last sample before desiccation contained relatively few specimens. Very few individuals were found in April, in the first sample. Maximum abundance, 1252 ind./l occurred early May, most of the animals belonged to *Moina brachiata*.

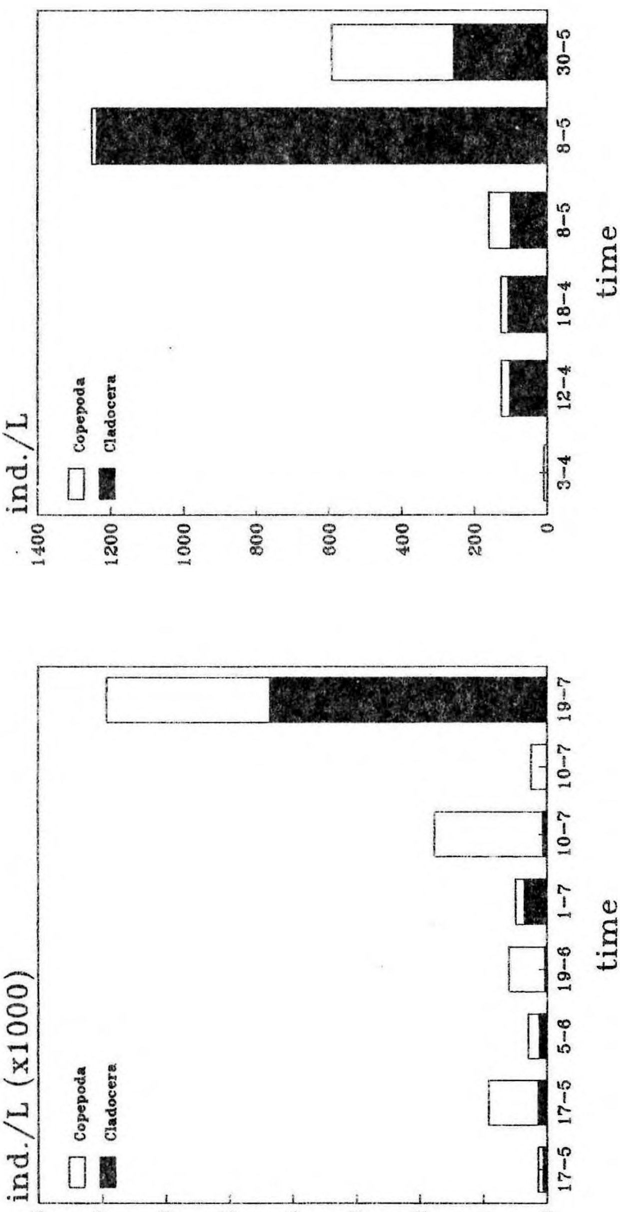

Figure 2: Microcrustacean abundance in Kelemen-szék, 1992 and 1993

There are less regular data from the other lakes. The abundance in Zab-szék was also lower in 1993, maximum value was more than 6000 ind./l, all specimens belonged to *A. spinosus*. In the other waters a few hundred ind./l was the maximum abundance. Extremely high was the density in April in Csaj-tó (885 ind./l), over 50 % of it was composed of nauplius larvae.

2. Correlations between the abundance of microcrustaceans and Avocets

The correlation analyses were made only with the data from April and May 1993 because sufficient data were available only from this period. Analyses were done on the total data set and several separate data sets were analysed, for the two months separately and also for the dominant orders and genera. The results are shown in **Table 2**, where the values of the correlation coefficients above 0.7 are in bold. **Figure 3** provides graphical presentations of the data used in the analyses.

Considering the abundance of total microcrustaceans relatively strong correlations were found, the strongest one occurred in April (**Table 2**). Using the data of the two orders separately, the number of Avocets showed very slight correlation with the abundance of cladocerans, while with copepods strong correlations were detected for total and separated data sets, as well.

Table 2: Results of the correlation analyses between the number of Avocets and density of microcrustaceans

	Cladocera and Copepoda	Cladocera	Copepoda	Cyclops	Arcto-diaptomus
April-May	**0.715**	0.019	**0.865**	**0.872**	0.007
April	**0.933**	- 0.199	**0.939**	**0.929**	- 0.258
May	**0.906**	0.599	**0.926**	- 0.110	**0.924**

The correlation between the number of Avocet and zooplankton abundance was less strong in May. Cladocera showed again less strong relation, while copepods were strongly related, however this month the abundance of *Arctodiapromus* showed very strong relation.

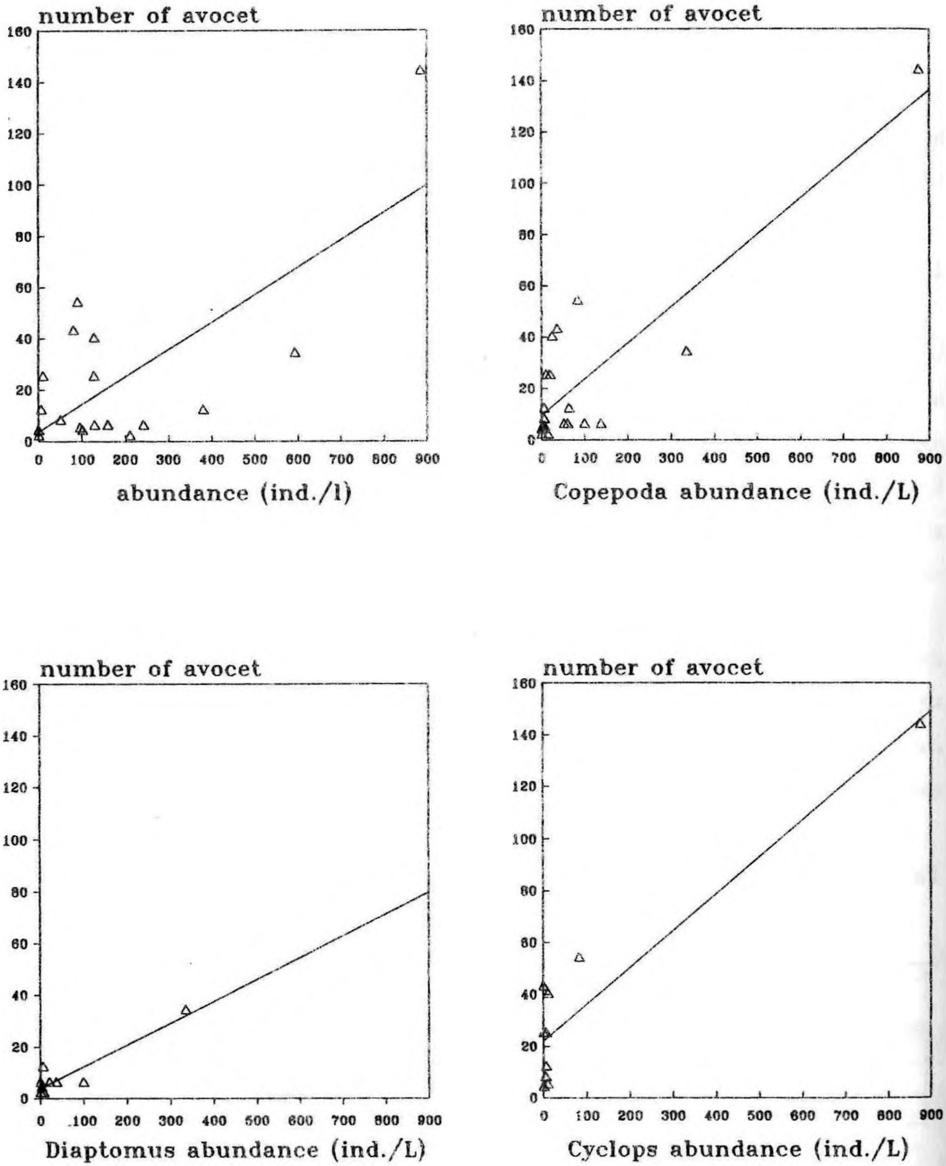

Figure 3: Relationships between the number of Avocets and the abundance of different microcrustacean taxa, based on data from 1993

DISCUSSION

The Avocet is distributed in coastal areas and at continental saline waters in Europe. Festetics (1971) considered it, together with *Charadrinus alexandrinus*, as halophilius species. In the Camargue Avocet is one of the three bird species that show the wildest salinity areas (Britton and Johnson, 1987). In the Carpathian Basin its distribution was limited to the so-called white sodic lakes, which are more saline than the black ones. This species is regularly occurring in this area, it was recorded also in recent years in the eastern part of Austria (in Seewinkel, at the eastern side of Neusiedler See) (Festetics and Leisler, 1970; Festetics, 1971; Kohler and Rauer, 1990) and in Hungary (Bankovics, 1983, 1984; Kárpáti, 1991; Hadarics et al., 1992; Boros, 1993a, 1993b). Boros and Szimuiy (1993) reported its occurrence at less saline waters as well, which might be due to the decreasing number of sodic waters.

In the Hungarian literature the Avocet was reported to feed by scything, moving the head and bill from side to side, from the water or soft mud (Beretzk, 1938, 1950; Bankovics, 1984). According to Keve (1958) the food is made up by insects and other invertebrates, while Bankovics (1984) mentioned microcrustaceans, aquatic insects and their larvae as main food items. In the Seewinkel (Austria) Seitz (1942) found that Avocets occurred in greater numbers as those lakes where the anostracan *Branchinecta orientalis* was abundant. Festetics and Leisler (1970) accepted Seitz's opinion, however, they considered water bugs also as important food. They also stated that the Avocet is an extreme specialist in feeding because while scything it can cath bigger food items only. Goutner (1985) and Britton and Johnson (1987) also found that in brackish areas the Avocet was feeding on larger crustaceans, on Gammarus in the Evros delta and on Artemia in the Camargue. Moreira (1995a, b) observed winter feeding of Avocet on intertidal areas, here the ingested prey was bigger than a minimum treshold dimension of around 1.5 mm. These results are based on analyses of droppings.

In the present study we found that the microcrustacean zooplankton was very abundant in the sodic lakes, similar results were published for this region by Megyeri (1980) and Nógrády (1956). Cladocerans and copepods occurred in large numbers and biomass, while now *Branchinecta* was not found at all in these waters. Boros (unpublished) took mud samples, which contained very few chironomid larvae only. Ferencz (1980) studied the zoobenthos of three waters, including Kelemen-szék and Zab-szék. In Zab-szék she collecte 16 specimens (mean 2 specimens/sample). In Kelemn-szék 44 specimens were found (mea. 5.5 specimens/sample). The animals were oligochaets and insects.

We collected droppings in July near the nests at the Kelemen-szék, very few remains could be identified. Some remains were chironomids and a few ephippia of cladocerans also were found. The ephippia are strongly chitinized cases of cladoceran resting eggs, most likely only these parts of the microcrustacean remained recognizeable after digestion, thus it is at least a positive indication that the Avocet is fedding on small crustaceans.

Comparing the abundance of microcrustacean zooplankton and numbers of Avocet at some localities we could show highly positive correlation between them. Since fairly shrimps were not found at this time and the benthic abundance was low it can be presumed that microcrustaceans were the most abundant potential food for Avocet. This is a migrating bird, it usually arrives early March in the Carpathian Basin, nesting period begins in May. As the correlation was stronger in April than in May, it can be concluded that in the nesting period the zooplankton abundance is less important in determining the distribution of Avocet. The ephippia found in droppings collected in July certainly indicate that the Avocet fed also later in the season on microcrustaceans.

In conclusion we think these results show that in the case of the sodic waters the microcrustaceans are important food organism of the Avocet, particularly before the nesting period, though they can be smaller than 1.5 mm, the minimum treshold food size pointed out by Moreira (1995b). Further research is needed to provide a better quantification of the relationship between Avocet and its food resources.

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WATERFOWL AND MACROZOOBENTHOS OF THE STANING RESERVOIR (RIVER ENNS, AUSTRIA)

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ABSTRACT

The waterfowl population of the Reservoir Staning (River Enns, Austria) was counted monthly from 1984 - 1990. The daily food demand of the diving waterfowl (Tufted Duck, Goldeneye, Pochard and Coot) was compared to the standing crop of macroinvertebrates. The benthos assemblage was sampled at three sites in water depths of 1m, 2m and 3m in 1984 and 1985. Average biomass ranged between 8-36 g/m5 dry weight. The biomass was calculated for the total bottom area beneath less than 3 metres of water. Assuming that diving waterfowl feed mainly in this area the calculated food-demand of the diving waterfowl was always lower than 0.5% of the average standing crop.

INTRODUCTION

In many cases reservoirs have become important areas for waterfowl. Sufficient food supply may be a decisive reason. In many studies the availability and amount of prey has been assumed to be the main factor determining the distribution and density of waterfowl (Galhoff, 1987; Hargeby *et al.*, 1994; Staicer *et al.*, 1994; Suter, 1994). Some authors discuss good correlations between the densities of waterfowl and macrozoobenthos but the published data concerning the degree of utilizations vary from a few percent to nearly 100 percent (**Table 1**). We have tried to investigate the question of wether the amount of available food in an impoundment seems to have any effect on the abundance and species composition of diving waterfowl and if there is a measurable effect of feeding pressure on the macrozoobenthos as some authors state (Szijj, 1965; Nilsson, 1969; Willi, 1970; Newton, 1972; Thompson, 1973; Reichholf and Reichholf-Riehm, 1982; Ponyi, 1994).

Table 1: Published consumption rate on Zoobenthos by waterfowl in percent

%	Author	Study site
10 - 15	Unterer Inn - Reservoir	Reichholf & Reichholf-Riehm 1982
> 90	Klingnauer - Reservoir	Willi 1970
100*	Lake Bodensee	Szijj 1965
70	Coastal Waters	Nilsson 1969
50	Loch Leven	Allison and Newton 1972
25	Mississippi	Thompson 1973
1.1 - 7.1	Kemnaden	Galhoff 1987

*Concerning Zebra mussels (*Dreissena polymorpha*)

Generally, zoobenthos is known to be very abundant in reservoirs (Flak, 1978; Polzer, 1985; Russev, 1985; Krzyzamek and Kasza, 1986; Kohmann, 1982). The probable cause of these rich zoobenthic communities may be the low velocity of the waterflow, resulting in high sedimentation rates and the deposition of organic matter (Herzig, 1987).

METHODS

Our data are based on monthly counts of waterfowl, from 1984 to 1990 and 1993 on the reservoir near Staning on the River Enns. The common diving depth of waterfowl extends up to three metres or more. In 1984 and 1985 macro-invertebrates (larger than 0,5 mm) were sampled at three sites at different depths (1 m, 2 m, and 3 m) using an Ekman grab. Five samples were taken per site and date and sieved with a net (500 Fm opening). Samples were preserved with formalin and examined in the labratory. Geometric mean, upper- and lower 95% confidence limits of numbers were calculated after a log (x+1) transformation and the dry weight of the zoobenthos was determined (24 hours, 90EC).

The amount of food available for diving waterfowl (Tufted Duck, Goldeneye, Pochard and Coot) was estimated in kJ using the energy contents of the invertebrates given in the literature (**Table 2**). Extrapolations are based on mean values of the average benthos biomass for the depth zone 0 to 3 m (0.6 km^2). The consumption rate was calculated using the daily energy demand of the diving waterfowl (**Table 3**). In cases where the conversion factors varied in the literature an average value was adopted. The mean energy demand of diving waterfowl was calculated and corresponds to 45.5 g invertebrate biomass in dry weight per day.

Table 2: Energy contents of the most common groups of invertebrates

	kJ/g	Author
Chironomids	18.3	Galhoff 1987
Oligochaetes	20.9	Galhoff 1987
Pisidia	20.5	Suter 1982

Table 3: Daily energy demand (kJ/24) of diving waterfowl

	kJ/24h	Authors	Used
Aythya fuligula	911.2 796.3	Nilsson 1969 Suter 1982	854
Aythya ferina	1003.2 836.4 883.4	Nilsson 1969 Galhoff 1987 Suter 1982	908
Bucephala clangula	961.4	Nilsson 1969	961
Fulica atra	690.7	Hurter 1970	691
Diving Waterfowl			853

STUDY AREA

The study site is an impoundment on the River Enns (48°47'N 14°28'E), upstream of its confluence with the Danube River (**Table 4**). The reservoir has a length of 10 km behind a dam which was constructed in 1946. The hydrological regime of the River Enns is affectet by a cascade of 15 reservoirs but the study site follows a section of 6 km which is not impounded and is free flowing. The catchment is dominated by limestone. The upstream end of the impoundment, a small section with higher velocities and islands is followed by a larger open surface area with two small islands and a water depth mostly less than 3 metres. Further downstream follows a less wide section with a larger island, snag wood and a large expanse of shallow water followed again by large open water areas, steep banks and deep water. The last part of the reservoir is in a narrow ravine with a stretch of deep water.

Table 4: Enns Reservoir Staning

Hydrological and morphological data		
Above Sea Level	m	283
Volume	m3	13*106
Length	km	10
Depth max	m	16
average	m	5.8
Area	km^2	2
Area Water depth 0-3 m	km^2	0.6
Area of islands	ha	12
Discharge		
MQ (1966-81)	m^3	202
NQ (1970)	m^3	26.3
HQ (1975)	m^3	2560
Theoretical renewal rate		
MQ	hours	17.9
HQ	hours	1.4

The monthly average discharge ranges between 100 and 400 m^3/s. The main discharge occurs between April and June, the time of snowmelt. The biological oxygen demand (BOD_5) and total phosphorus concentrations (PTot.) are in the range of mesothrophic systems (BOD_5 1983-1993: 0.4-3.3 mg/l; PTot. 1983.1993: 50-340 ppb).

RESULTS

Waterfowl

Of the most frequently observed species (**Table 5**), Mallard, Coot, Tufted Duck, Mute Swan and Black-headed Gull are abundant throughout the year, Pochard, Great Crested Grebe, Little Grebe and Teal are all fairly frequent and Heron and Moorhen are sometimes abundant whereas Goldeneye occurs only during winter. Common Gull, Cormorant and Goosander are highly variable in their occurrence.

Table 5: Frequency of occurence (FO) of the observed species on the Staning Reservoir in % (FO > 5%, 1984-1990 and 1993); monthly counts (n=91)

Species	FO
Mallard, *Anas plathrhynchos*	100%
Coot, *Fulica atra*	98.9%
Tufted Duck, *Aythya fuligula*	98.9%
Mute Swan, *Cygnus olor*	97.8%
Black headed Gull, *Larus ridibundus*	96.7%
Pochard, *Aythya ferina*	86.8%
Great Crested Grebe, *Podiceps cristatus*	81.3%
Little Grebe, *Tachybaptus ruficollis*	70.3%
Teal, *Anas crecca*	59.3%
Heron, *Ardea cinerea*	48.4%
Goldeneye, *Bucephala clangula*	47.3%
Moorhen, *Gallinula chloropus*	39.6%
Common Gull, *Larus canus*	23.1%
Cormorant, *Phalacrocorax carbo*	20.9%
Goosander, *Mergus merganser*	15.4%
Black throated Diver, *Gavia arctica*	12.1%
Garganey, *Anas querquedula*	9.9%
Gadwall, *Anas strepera*	9.9%
Eider, *Somateria mollissima*	7.7%
Black Tern, *Chlidonias niger*	6.6%
Herring Gull, *Larus cachinans*	6.6%
Smew, *Mergus albellus*	6.6%
Red crested Pochard, *Netta rufina*	5.5%
Wigeon, *Anas penelope*	5.5%

Birds gather in groups of 300 to more than 3000, equivalent to 150 to 1500 ind/km5. The highest numbers are observed in autumn and winter, the lowest in summer. Seasonality differs among the most common species: Coot, Great Crested Greb, Mallard and Little Grebe peak in autumn, Black-headed Gull, Tufted Duck, Goldeney, Pochard and Cormorant in winter. The Mute Swan is the only species with a peak of abundance in summer.

The waterfowl population is dominated by diving ducks throughout the entire year (**Figure 1**) while dabbling ducks and Coot are sub-dominant.

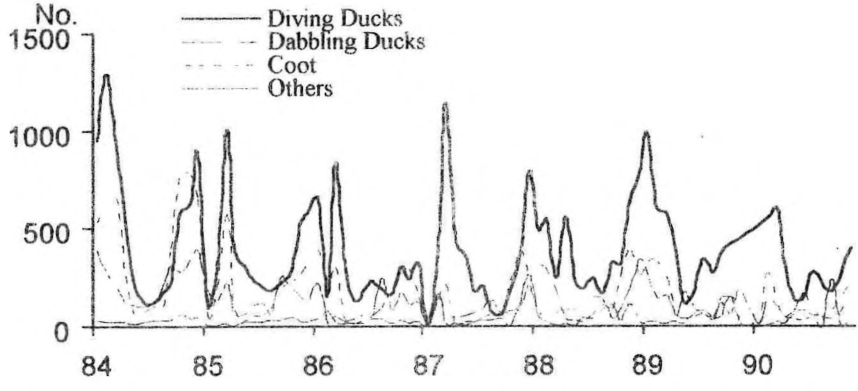

Figure 1: Number of diving ducks, dabbling ducks, coot and other species on the Staning Reservoir in 1984 -1990 (monthly counts, n = 83).

Zoobenthos

The macrozoobenthos community of the reservoir is dominated by *oligochaetes* (50 - 95% of numbers) and *chironomids* (10 - 25% of numbers). These groups constitute more than 90% of the community at each sample site and date. Rather common small mussels such as the *Pisidia* occur in most samples but always in low numbers. They are most abundant at around 2 m depth of water.

The highest densities of total benthos were found in August with more than 200,000 ind/m^2 and lowest in winter with 8,000 - 10,000 ind/m^2. Biomasses are higher in February in areas with water depths around 1 m because of the occurence of very large *Oligochaetes*. The sampling sites with water depths of 2 and 3 m had higher biomasses during spring and autumn.

In areas with a water depth of up to 3 metres (about 40% of the impoundment) mean benthic biomass was in the range of 8 - 36 g/m^2 dry weight (1m: 4 - 39 g/m^2; 2m: 15 - 64 g/m^2; 3m: 3 - 29 g/m^2). 3 to 80 kg DW of benthic biomass is needed to satisfy the daily energy demand of diving waterfowl.

Table 6: Daily Food demand (DEM, kg) of diving waterfowl (WF, monthly count), standing crop (SC, kg) of the area less than 3 metres (0.6 km^2) and theoretical feeding pressure (FP, % of SC)

	WF	DEM	SC	FP
1984 08	417	19.0	19440	0.1
09	829	37.7	19800	0.2
10	1343	61.1	21000	0.3
11	1721	78.3	21480	0.4
12	1615	73.5	17460	0.4
1985 01	55	2.5	4860	0.05
02	1412	64.2	12240	0.5
03	1446	65.8	16020	0.4
04	576	26.2	13860	0.2
05	340	15.5	14700	0.1
06	242	11.0	13800	0.08
07	308	14.0	16440	0.08
08	282	12.9	14640	0.09
09	519	23.6	9600	0.2
10	493	22.4	10080	0.2

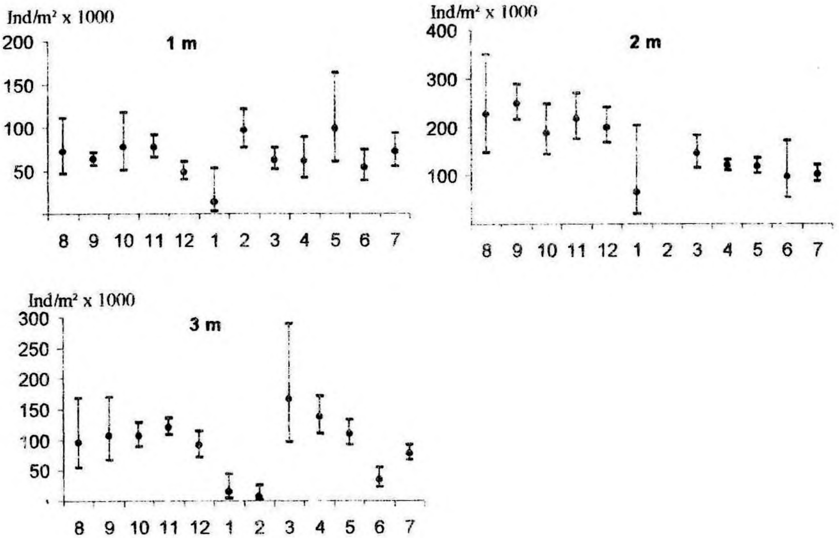

Figure 2: Density of macroinvertebrates below water depths of 1 m, 2 m and 3 m on the Staning Reservoir; August 1984 - July 1995, geometric means, lower- and upper 95% confidence limits

The feeding pressure of diving waterfowl on the benthos is thus surprisingly low when the whole of the bottom area below less than 3 metres of water is taken into acount (**Table 6**). The daily pressure is less than 0.5 percent of the total benthic biomass.

DISCUSSION

The proportion of the benthos removed by waterfowl is actually even smaller, than calculated above, since benthic production is not taken into acount in comparing the standing crop and the daily food demand of the diving waterfowl. It can therfore be concluded that there is no food limitation for the waterfowl. On the other hand, the majority of the zoobenthic population may be flushed away in flood conditions. Abnormal high floods in summer reduce the densities of diving ducks in autumn and winter (**Figure 3**), although zoobenthic standing crops in autumn are not significantly different before and after floods in summer.

Zoobenthos is not a limiting parameter as a food source for waterfowl on this reservoir.

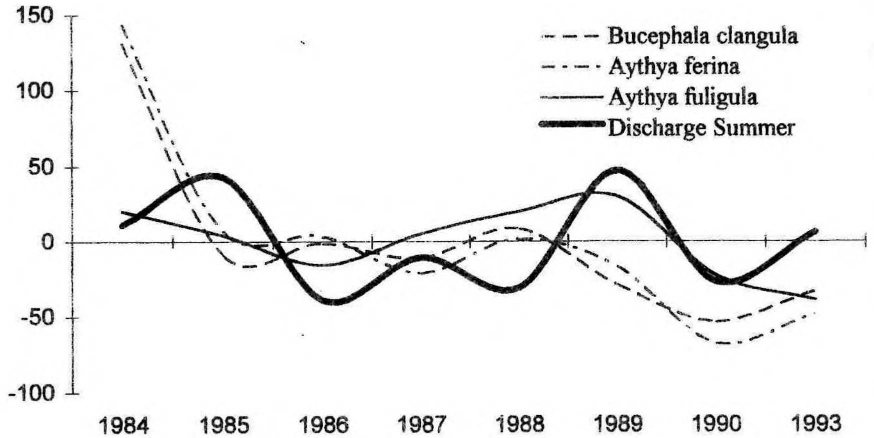

Figure 3: Deviation of summer discharge (June - August) and the yearly totals of diving ducks (October-March) from the long term mean (in percent).

This is contrary to the conclusions of other authors (Szijj, 1965; Willi, 1970; Reichholf and Reichholf-Riehm, 1982; Ponyi, 1994). However, the standing crop may only approximately reflect the available food. The sampling method used (Ekmann-grab) collects the benthic assemblage up to a depth of 10 cm within the sediment. Diving waterfowl feed mainly on the surface of the sediment. Additionally, selective feeding can also reduce the range of potential food. Tufted Duck feed mainly on molluscs (Mlikovsky and Buric, 1983) while Pochard and Goldeneye are less selective in feeding (Blömel and Krause, 1990; Bauer and Glutz von Blotzheim, 1980). Furthermore, it is the productivity of the macrozoobenthos (the biomass produced per unit time) which actually determines the availible resources. Another important factor might be the possible competition for benthic food resources between waterfowl and fish species. Fish appear to exploit the aquatic invertebrate food supply more efficiently than waterfowl (Giles, 1994).

The results of this investigation thus only permit the conclusion that a whole year the daily food demand of the diving waterfowl was less than 0.5 % of the standing crop of benthos. While the rich faunal community of the reservoir may be attractive to waterfowl, the density and distribution of birds are most probably influenced by other variables, such as impoundment morphometry, shoreline structures or human disturbance.

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RELATIONSHIPS BETWEEN THE POPULATION AND FEEDING ECOLOGIES OF THE DIVING DUCKS AND FISH OF LOUGH NEAGH, NORTHERN IRELAND: A SYNTHESIS

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ABSTRACT

Lough Neagh is a large (surface area 387 km^2), eutrophic (long-term annual mean total phosphorus 107 mg l^{-1}) lake in Northern Ireland, U.K., which supports large overwintering populations of the diving ducks Common Pochard (*Aythya ferina*), Tufted Duck (*Aythya fuligula*), Greater Scaup (*Aythya marila*) and Common Goldeneye (*Bucephala clangula*) (approximate densities of up to 100, 90, 6 and 26 individuals km^{-2}, respectively). An examination of long-term population trends between 1965 and 1988 revealed that the abundance of Common Pochard and scaup had been relatively stable and Goldeneye had shown a recent increase. In contrast, the numbers of overwintering Tufted Duck had declined markedly during the early 1980s, but recovered to former levels in the winter of 1987/1988. These latter changes were subsequently found to mirror those in the abundance of roach (*Rutilus rutilus*), a cyprinid fish which was first recorded in the Lough Neagh system in 1970. After its introduction, the roach rapidly increased in abundance before declining in the late 1980s, probably due to heavy infestation by the cestode tapeworm *Ligula intestinalis*.

Studies carried out in the late 1980s, when the roach population was in a state of relative decline, showed that the diets of the above diving ducks and the major fish of the lough (i.e. roach, perch *Perca fluviatilis*, pollan *Coregonus autumnalis* (Pallas) and eel *Anguilla anguilla*) showed relatively high overlaps due to the common consumption of chironomid larvae. However, three major groupings were apparent. Common Pochard, Greater Scaup, Common Goldeneye and eel formed a group with diets dominated by chironomid larvae, while perch and pollan formed a smaller group in which the crustacean *Mysis relicta* Loven was an important dietary component. Tufted Duck and roach formed a third and distinct group in which molluscs, particularly *Valvata piscinalis* (Muller), were important in the diet.

It is suggested that the feeding ecology of Tufted Duck and roach in Lough Neagh forms an example of distant competition which may be responsible for the observed fluctuations in the numbers of overwintering Tufted Duck. Consistent with this hypothesis, during the early to mid 1990s the roach population has remained low in abundance and the numbers of Tufted Duck have remained high. The strengths and weaknesses of this interpretation, and those likely to be met in any study of competition between ducks and fish, are discussed.

INTRODUCTION

Limnology has always involved a multi-disciplinary approach to the study of fresh waters, with even its earliest studies involving physics, chemistry and biology (see Persson *et al.*, 1988). However, it was not until the 1960s, following the pioneering studies of Hrbacek *et al.* (1961) and Brooks and Dodson (1965), that limnological investigations truly expanded to include vertebrate animals in the form of teleost fishes. By the 1980s and early 1990s, expansion had continued to include the remaining major group of temperate zone aquatic vertebrates, the waterfowl. While such investigations of birds in freshwater ecosystems are still in their infancy, they have already contributed greatly to our understanding of their role in the trophic webs of lakes, with implications for both fundamental and applied ecology (see collected papers in Kerekes and Pollard, 1994).

Although studies of fish and waterfowl in a limnological context have only a short history, investigations in a fisheries context have a much longer standing. However, such studies, which may be traced back to Beach (1937) and earlier, have been concerned largely with the predatory impact of piscivorous waterfowl on fish populations of commercial importance (see review by Suter, 1991). In contrast, few studies have considered possible competitive interactions between these two major groups of aquatic vertebrates. Notable exceptions have been a study by Hurlbert *et al.* (1986) of competition for zooplankton by Chilean flamingos (*Phoenicopterus chilensis*) and cyprinodont fish (*Orestias* spp.), and work by several European authors including Eriksson (1979), Pehrsson (1984), Hill *et al.* (1987) and Giles (1994) addressing competition between young dabbling (e.g. *Anas* sp.) or diving (e.g. *Bucephala* sp.) ducks and fish (e.g. *Perca* sp., *Rutilus* sp., *Abramis* sp.) for macroinvertebrates, particularly emerging chironomid larvae.

The present paper provides a synthesis of our work (Winfield *et al.*, 1989; Winfield, 1991; Winfield *et al.*, 1992; Winfield *et al.*, 1993; Winfield and Winfield, 1994a; Winfield and Winfield, 1994b) on the waterfowl and fish populations of Lough Neagh, Northern Ireland, where competition for macroinvertebrate prey appears to be an important factor in determining the overwintering population dynamics of at least one species of diving duck. The study is unique among investigations of competition between waterfowl and fish because it incorporates both long-term population data and information on resource (i.e. food) utilisation and availability. Moreover, the system has been subject to major perturbations which, while not being purposefully designed or controlled, have been particularly illuminating.

THE STUDY SITE

With a surface area of approximately 387 km^2, Lough Neagh is the largest expanse of fresh water in the British Isles, even though its mean depth is only *c.* 9 m. This eutrophic (long-term annual mean total phosphorus 107 mg l^{-1}, R. H. Foy, Department of Agriculture for Northern Ireland, unpublished data) lough has been extensively studied over the last three decades and an authoritative review is provided by Wood and Smith (1993). Macrophytes are limited to a few sheltered bays, but the offshore benthos is abundant and dominated by oligochaetes and chironomid larvae. Molluscs are also present, although not the zebra mussel (*Dreissena polymorpha* (Pallas)) which is an important component of the diets of some waterfowl in mainland Europe (Cramp and Simmons, 1977).

The fish community of Lough Neagh contains significant populations of perch (*Perca fluviatilis*), pollan (*Coregonus autumnalis*) and eel (*Anguilla anguilla*), all of which are exploited by commercial fisheries (see Winfield *et al.*, 1993). In addition, following an introduction in 1970 (see below), the lough now also supports a fluctuating population of roach (*Rutilus rutilus*), a cyprinid fish which although not fished commercially became a major target of recreational angling on the lough's larger tributaries.

Within the lough's waterfowl community (see Winfield *et al.*, 1989), numbers of the overwintering diving ducks Common Pochard (*Aythya ferina*), Tufted Duck (*Aythya fuligula*), Greater Scaup (*Aythya marila*) and Common Goldeneye (*Bucephala clangula*) are all of international importance, and approximate densities of up to 100, 90, 6 and 26 individuals km^{-2}, respectively, have been recorded over the last three decades.

DIVING DUCK POPULATION TRENDS, 1965-1988

Our study began with an analysis of long-term trends in the numbers of waterfowl overwintering on Lough Neagh between 1965 and 1988 (Winfield *et al.*, 1989). **Figure 1** presents the trends observed in the four most abundant species of diving ducks, i.e. Common Pochard, Tufted Duck, Greater Scaup and Common Goldeneye.

The numbers of Common Pochard showed considerable short-term variation which made it difficult to discern any long-term changes, while Greater Scaup remained relatively stable although with occasional very large peaks. Common Goldeneye numbers also showed little long-term change up to the last two winters of the dataset, which saw considerable increases.

The long-term trend which generated most interest and concern among conservationists, however, was that displayed by Tufted Duck. A dramatic decline occurred during the early 1980s following a period of stability through the 1960s and probably the 1970s (note that counting was intermittent during the latter decade), although it was apparently reversed in the last winter of the dataset with a peak of over 19,000 birds in January 1988. Moreover, the facts that the Tufted Duck overwintering on Lough Neagh originate from a number of discrete European breeding grounds (see ringing returns given in Winfield, 1991) and European overwintering numbers have been consistently increasing (Owen *et al.*, 1986) suggest that local trends in numbers are the result of local rather than distant environmental conditions.

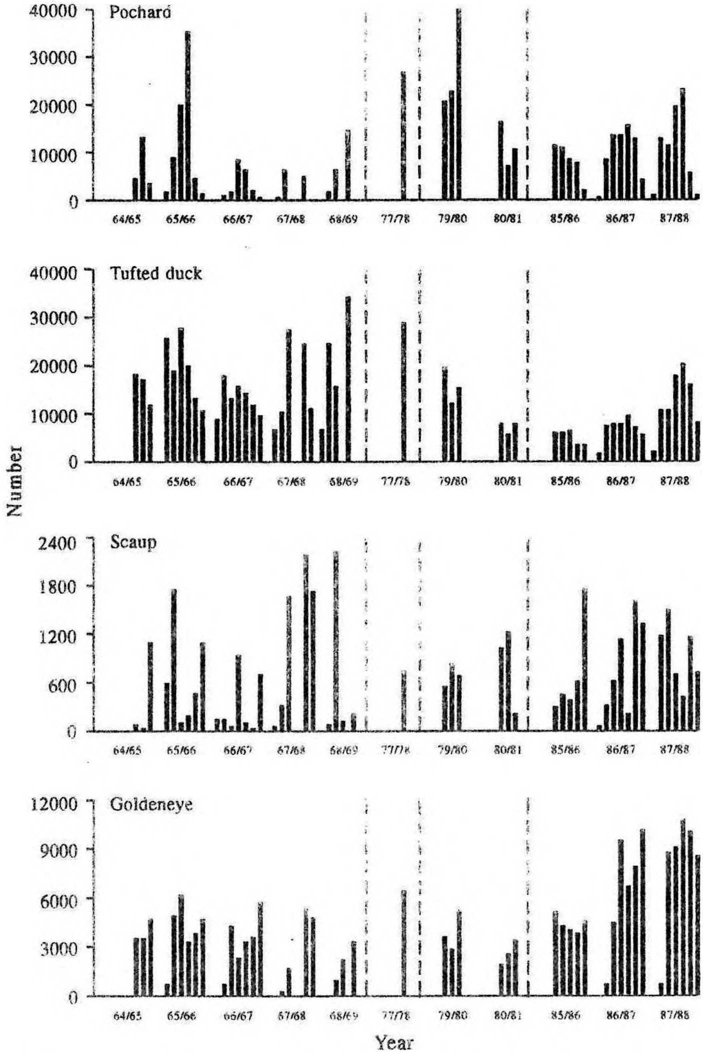

Figure 1: Trends in the numbers of Common Pochard, Tufted Duck, Greater Scaup and Common Goldeneye overwintering on Lough Neagh between 1965 and 1988. The horizontal axis plots all of the seasons for which data are available with one division for each month (seven per winter) and one division space between each year. The broken lines indicate breaks in the count coverage of one year or greater. Redrawn from Winfield *et al.* (1989) with permission from the Irish Wildbird Conservancy.

The population increase of Tufted Duck in Europe as a whole has been attributed to an increase in suitable man-made habitat and the continental spread of the zebra mussel, a preferred food item, (Owen *et al.*, 1986), but neither of these factors are applicable to the Lough Neagh situation. Furthermore, while Lough Neagh has been subject to changes in both lake levels and eutrophication, neither have occurred with a magnitude or timescale likely to have been responsible for the observed changes in the numbers of Tufted Duck (for a fuller argument see Winfield *et al.*, 1989).

By a process of elimination, interactions with the fish community were left as a possible agency of the fluctuations in the numbers of Tufted Duck overwintering on Lough Neagh. In particular, given the earlier findings of workers such as Pehrsson (1984) and Hill *et al.* (1987), competition for macroinvertebrate prey appeared to be a plausible hypothesis. However, in contrast to the situations studied by the above authors, such interactions on Lough Neagh would have to be occurring between fish and adult, rather than duckling, waterfowl. Furthermore, for the hypothesis to be correct, significant changes would have had to have occurred in the Lough Neagh fish community during the time period of the observed changes in the abundance of Tufted Duck.

THE FISH COMMUNITY AND INTRODUCTION OF THE ROACH

Like the fish communities of many lakes in Ireland, that of Lough Neagh is relatively species-poor when compared with similar lakes elsewhere in Europe, even though the native fauna has been augmented by anthropogenic introductions of new species over historical time. A brief description of the mid 1980s fish community of Lough Neagh is given by Winfield *et al.* (1993), who recorded bream (*Abramis brama*), eel, gudgeon (*Gobio gobio*), perch, pike (*Esox lucius*), pollan, river lamprey (*Lampetra fluviatilis*), roach, rudd (*Scardinius erythrophthalmus*), salmon (*Salmo salar*), stone loach (*Barbatula barbatula*), tench (*Tinca tinca*), three-spined stickleback (*Gasterosteus aculeatus*), and trout (*Salmo trutta*).

Even though complex patterns of spatial distributions (see upper part of **Figure 2**) and sampling biases make the calculation of an overall numerical composition of the Lough Neagh fish community a difficult and arguably misleading exercise, it is beyond doubt that eel, perch, pollan and roach are the four most abundant species and dominate the community in terms of both numbers and biomass. Moreover, during the mid 1980s the roach was the dominant fish in the inshore region of the lough during the summer, and was also important in the deepwater community during the cooler parts of the year when shallow habitats had been vacated (see lower part of **Figure 2**).

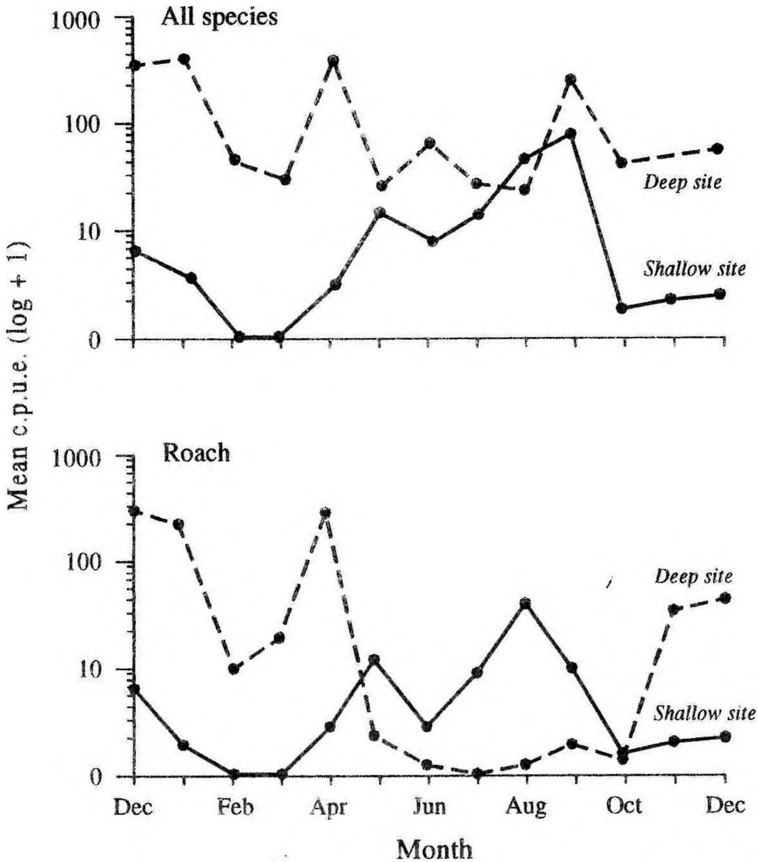

Figure 2: Seasonal changes in the abundance of all fish species and roach alone at shallow (Ballyronan Bay) and deep (Toome Bay) sites in Lough Neagh sampled by scientific trawling from December 1985 to December 1986. Redrawn from Winfield *et al.* (1993) with permission from Kluwer Academic Publishers.

This importance of roach in the Lough Neagh fish community was particularly remarkable because the species was only first recorded in a backwater of the catchment in 1970, presumably as a result of introduction by anglers (Cragg-Hine, 1973). While anecdotal evidence suggested a rapid subsequent increase in abundance and distribution during the 1970s (Cragg-Hine, *op. cit.*; Winfield *et al.*, 1993), quantitative data on the population dynamics of the roach in Lough Neagh are only available for the mid to late 1980s. Nevertheless, the introduction and establishment of the roach has undoubtedly been the major feature of the recent ecology of the Lough Neagh fish community.

DIVING DUCK AND FISH POPULATION CHANGES, 1985-1989

Although roach had become established as the dominant inshore fish of Lough Neagh by 1985, it subsequently underwent a dramatic decline in abundance as recorded by catch-per-unit-effort (c.p.u.e.) of scientific trawling (see insert of **Figure 3**) and the bycatch of the commercial fisheries (I.J.W., personal observations). Between 1985 and 1988, the declining roach population showed significant changes in individual size (main body of **Figure 3**) and age distributions. In 1985 the population was dominated by fish of approximately 90 mm in length and 2 years of age. This year class continued to dominate through to 1988, and thus the modal size class of the population reflected the growth of these fish. As a result, in 1988 the much reduced roach population was composed largely of fish approximately 150 mm in length and 5 years of age. There was very little recruitment of young roach until 1989 when a new strong year class appeared and the now declined population became dominated by fish approximately 40 mm in length and 1 year of age. The mechanism of the decrease in roach is difficult to determine, although a heavy infestation by the tapeworm *Ligula intestinalis* was recorded at the time (Tobin, 1986) and the observed repeated recruitment failure is a typical effect of this parasite

It was notable that the increase in abundance of roach during the late 1970s and early 1980s coincided with the decrease in Tufted Duck presented in Fig. 1. Furthermore, the decline of roach during the mid to late 1980s occurred over a time period similar to that in which the overwintering Tufted Duck population recovered to its former levels of the 1960s. As a result, the c.p.u.e. of roach in a given summer was significantly negatively correlated with the average number of Tufted

Duck present during the following winter (Spearman's Rank Correlation r_s = -8.86, N = 9, p < 0.01). Thus, when roach were abundant, Tufted Duck were present in lower numbers (**Figure 4**).

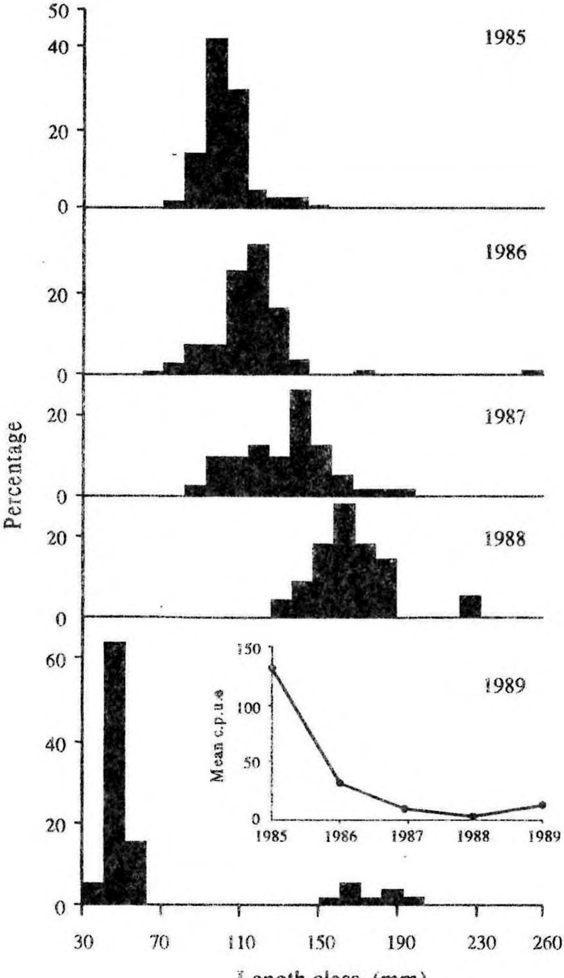

Figure 3: Changes in the size structure of the roach population during the period 1985 to 1989, with the corresponding trend in mean catch-per-unit-effort shown as an insert. Redrawn from Winfield *et al.* (1992) with permission from Kluwer Academic Publishers.

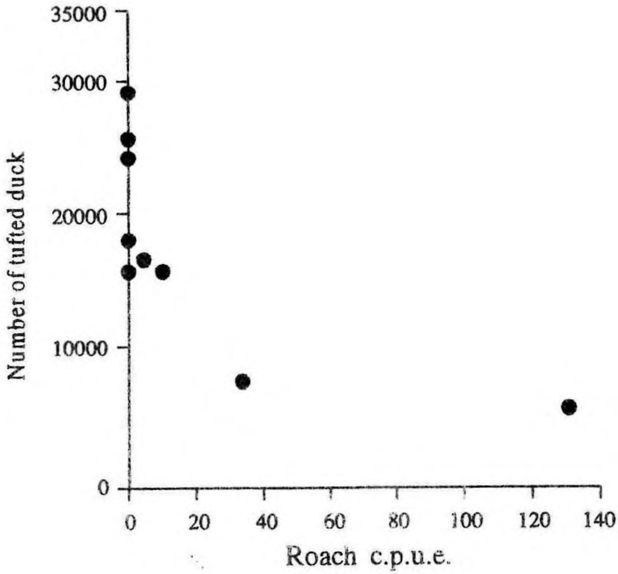

Figure 4: The relationship between the mean catch-per-unit-effort of roach from scientific trawling in a given summer and the mean number of Tufted Duck present during the following winter from 1965 to 1989. Points from the pre-1973 period assume that the catch-per-unit-effort of roach was zero. Redrawn from Winfield *et al.* (1992) with permission from Kluwer Academic Publishers.

When considering the possible mechanisms behind this apparent negative effect of roach on overwintering Tufted Duck, the agency of direct predation can be confidently discarded because even though the diet of the roach has been studied extensively (e.g. see review by Lammens and Hoogenboezem, 1991), predation on ducks or any other large vertebrates has never been recorded. On a more subtle level, Andersson (1981) has suggested three ways in which cyprinids such as roach may influence duck populations, i.e. by an indirect reduction of macrophytes, by an increase in eutrophication resulting from cascading effects through the zooplankton, or by direct competition for invertebrate food supplies. As macrophytes have been rare and the level of eutrophication has been relatively steady over the period of the observed interactions, only the latter mechanism can be operative on Lough Neagh. Further exploration of a competition hypothesis requires information on the feeding ecology of the waterfowl and fish of Lough Neagh.

DIVING DUCK AND FISH DIETS

Figure 5 shows the diet compositions of Common Pochard, Tufted Duck, Greater Scaup and Common Goldeneye, based on birds taken by shooting or accidental capture in gill nets between 1988 and 1990 (for further details see Winfield and Winfield, 1994b), in terms of both prey frequency of occurrence and composition by weight. The diets of Common Pochard, Greater Scaup and Common Goldeneye were dominated by chironomid larvae (100, 100 and 91 % by frequency of occurrence, respectively), although that of Common Goldeneye included a greater range of less important prey types. In contrast, the main prey of Tufted Duck was molluscs (71 %), with *Lymnaea peregra* (Muller) and *Valvata piscinalis* (Muller) being particularly important, and chironomid larvae being the second most frequently taken prey type (50 %).

The diet compositions of roach, perch, pollan and eel, based on fish over 70 mm in fork length collected by monthly trawling between 1989 and 1990 (for further details see Winfield and Winfield, 1994a) are given in **Figure 6**, although only data on prey frequency of occurrence could be consistently presented because of extensive prey mastication by the pharyngeal teeth of roach (diet descriptions for perch, pollan and eel based on prey weight may be found in Winfield and Winfield, *op. cit.*). Chironomid larvae were important in the diets of all four fish species, and dominated those of roach, pollan and eel (57, 65 and 96 % by frequency of occurrence, respectively). However, with the exception of eel, other prey types were also of considerable importance in the diets. For perch and pollan, the malacostracan *Mysis relicta* Loven was particularly important (83 and 50 %, respectively). Most notably, however, the second most frequently taken prey type of roach was molluscs (46 %), particularly *Valvata piscinalis*. Moreover, data presented in detail in Winfield and Winfield (*op. cit.*) showed that molluscs were only a major dietary component of roach greater than 160 mm in length.

A summary of overlaps among the above waterfowl and fish diets is presented as a dendrogram in **Figure 7** (for full methodological details see Winfield and Winfield, 1994b). Three distinct groupings were apparent. Common Pochard, Greater Scaup and eel formed a close group with diets overwhelmingly dominated by chironomid larvae, with which Common Goldeneye was also associated. Tufted Duck and roach formed a second group in which molluscs were also important in the diet. Finally, pollan and perch constituted a third and very isolated group in which *Mysis relicta* was an important dietary component.

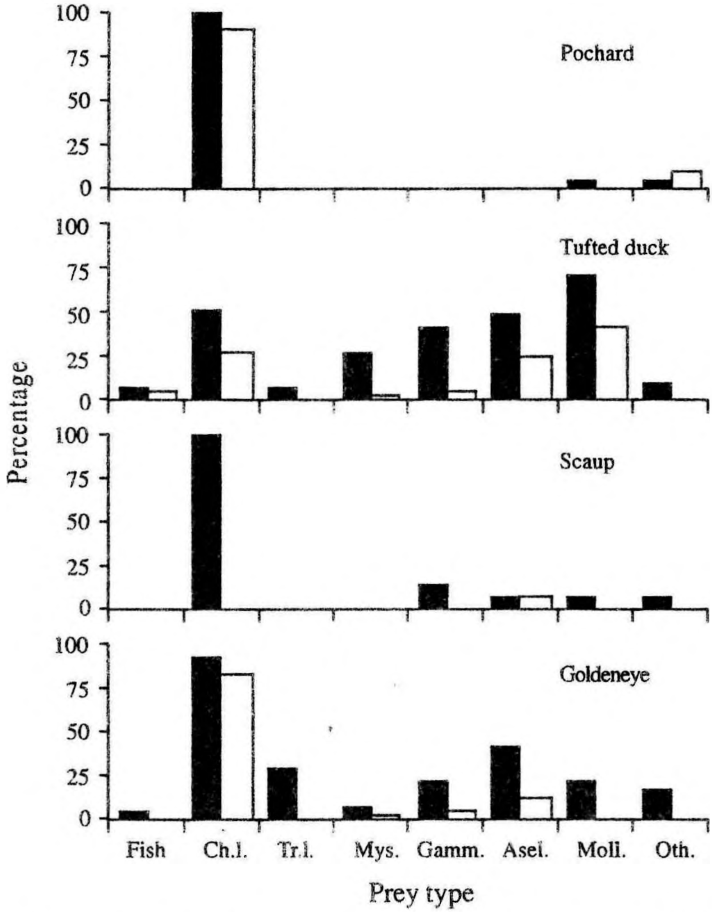

Figure 5: The diet compositions of 25 Pochard, 14 Tufted Duck, 14 scaup and 23 Common Goldeneye presented as prey frequency of occurrence (closed bars) and percentage by weight (open bars) during 1988 to 1990. Abbreviations are as follows; Ch. l., chironomid larvae. Tr. l., Trichoptera larvae. Mys., *Mysis relicta*. Gam., *Gammarus* sp. Asel., *Asellus* sp. Moll., molluscs. Oth., other. Redrawn from Winfield and Winfield (1994b) with permission from Blackwell Scientific Ltd.

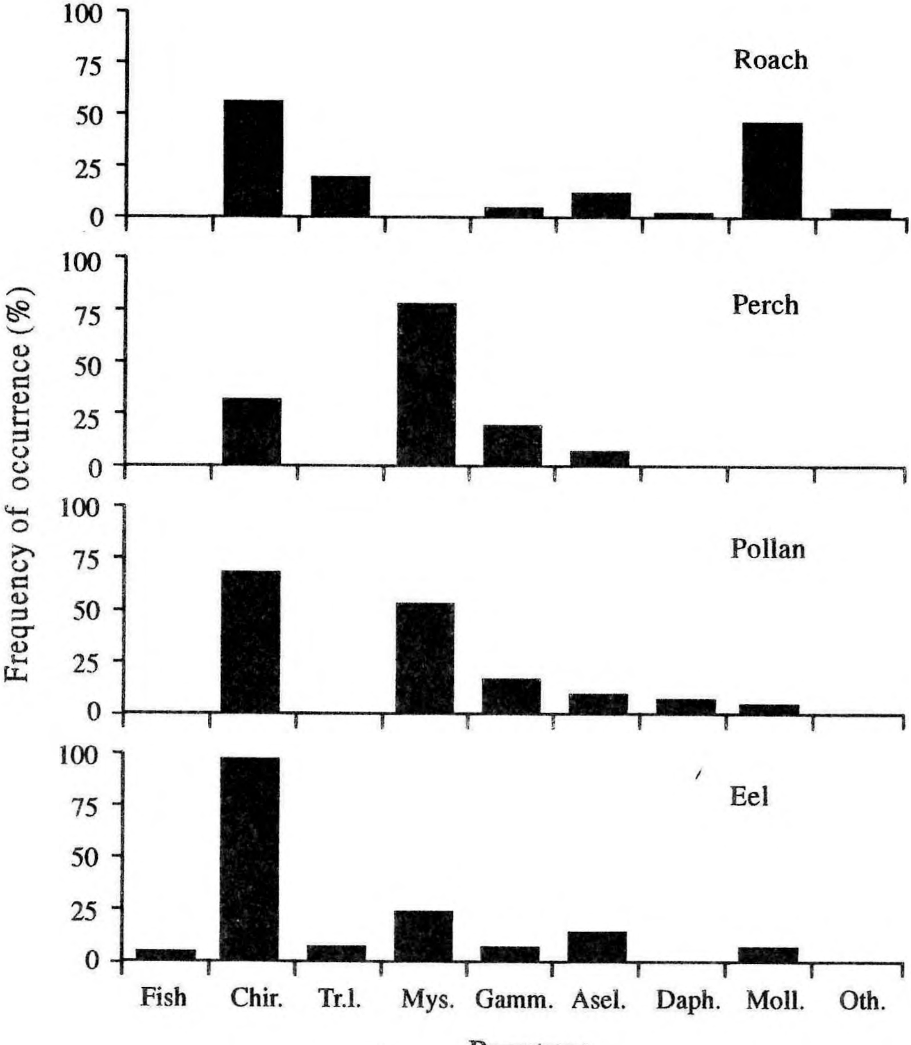

Figure 6: The diet compositions of 69 roach, 87 perch, 155 pollan and 25 eel greater than 70 mm in fork length as assessed by prey frequency of occurrence during 1989 and 1990. Abbreviations are as follows; Chir., chironomid larvae, pupae and adults. Tr. l., Trichoptera larvae. Mys., *Mysis relicta*. Gam., *Gammarus* sp. Asel., *Asellus* sp. Daph., *Daphnia* sp. Moll., molluscs. Oth., other. Redrawn from Winfield and Winfield (1994a) with permission from Kluwer Academic Publishers.

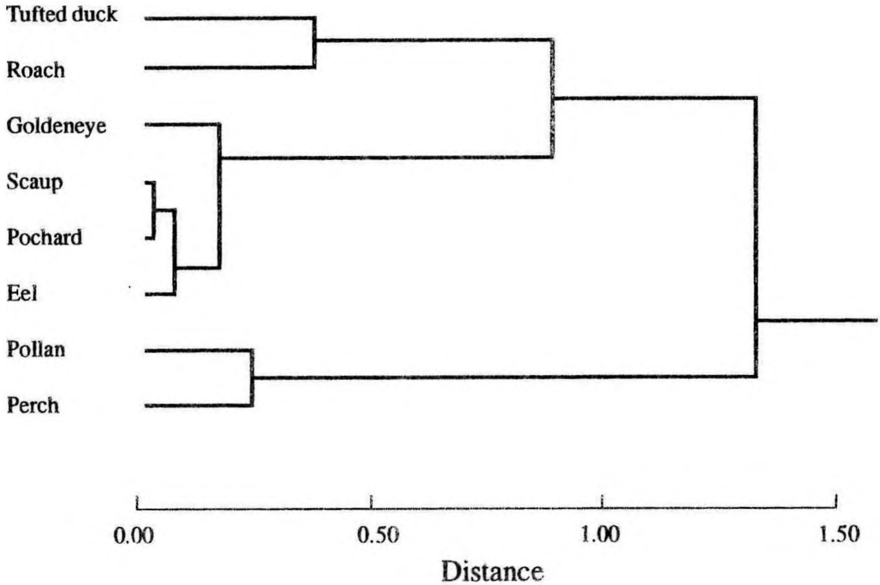

Figure 7: Dendrogram showing the diet similarities based on prey frequency of occurrence among the major diving duck and fish populations of Lough Neagh. Redrawn from Winfield and Winfield (1994b) with permission from Blackwell Scientific Ltd.

Although the above analyses revealed a high dietary overlap between Tufted Duck and roach consistent with a competition hypothesis, they do not in themselves show that competition is actually occurring. In order to demonstrate such an interaction unequivocally, the commonly-exploited food resources must also be shown to be limiting and, ideally, the system should be manipulated experimentally. While information on the abundance and distribution of the Lough Neagh benthos was obtained during 1989 to 1990 (for details see Winfield and Winfield, 1994b), it was not possible to determine if the absolute densities observed were effectively limiting in the context of the foraging requirements of Tufted Duck s and roach. Nevertheless, it did appear that the inshore areas of the lough offered poor feeding conditions for diving ducks because chironomid larvae and molluscs were of small individual body size or low abundance. This led to Tufted Duck s foraging at least in part at depths greater than those usually exploited, which in turn may have made them more likely to be outcompeted by a truly aquatic benthivore such as roach.

Unfortunately, the experimental manipulation of a system involving a very large lake, tens of thousands of waterfowl and probably hundreds of thousands of fish is clearly impossible. However, given the 'natural experiments' produced by the introduction of the roach in the 1970s and its subsequent demise in the 1980s, it is possible that a third natural experiment may occur in the 1990s in the form of a recovery of the roach population. In such circumstances, the continued monitoring of the overwintering Tufted Duck population and a repetition of the diet and benthos studies described above would produce information pertinent to the competition hypothesis.

THE SITUATION IN THE 1990s

While the consistent scientific monitoring of the roach population described above has been discontinued in the 1990s, other scientific sampling (R. C. Kirkwood, University of Ulster Freshwater Laboratory, unpublished data) and anecdotal information from the commercial fisheries of Lough Neagh have shown that, unfortunately in the context of this study, the roach population has not yet shown any signs of recovery. This situation is also indicated by the trend between 1985 and 1994 in the winning weight of angling matches held on the Upper Bann, one of the lough's major tributaries to which fish freely migrate (see Winfield *et al.*, 1993) and where roach formed a major component of the catch at the beginning of this period (**Figure 8**). Winning weights usually exceeded 50 kg in the mid 1980s, but since 1990 they have not exceeded 20 kg and other species such as bream are now of more importance.

Although the lack of a roach recovery is frustrating in that it does not allow further 'experimental' testing of the competition hypothesis, it is relevant to note that following the recovery of Tufted Duck in the late 1980s, the numbers of overwintering birds in the 1990s have remained remarkably stable (**Figure 8**), as would be predicted by the competition hypothesis.

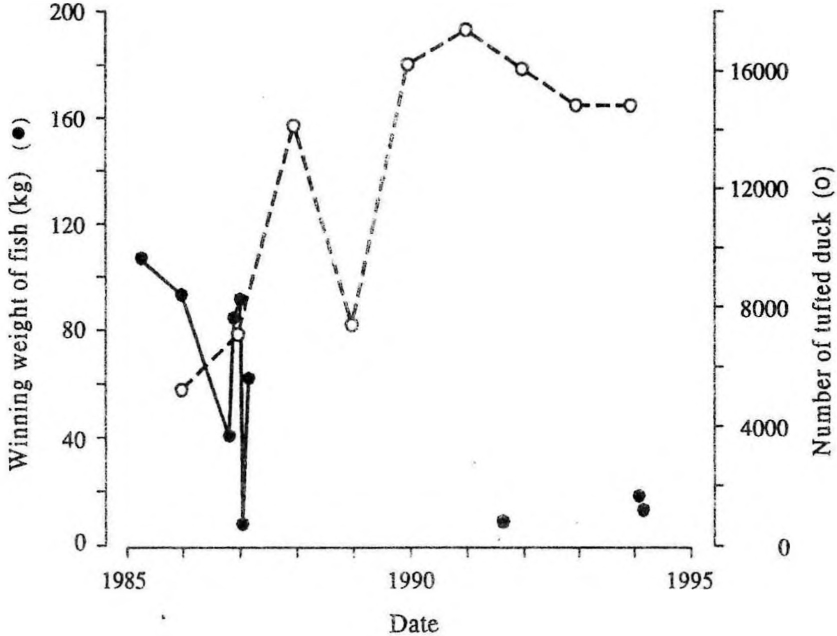

Figure 8: Trends between 1985 and 1994 in the winning weight of angling competitions (closed circles) held on the Upper Bann, a major tributary of Lough Neagh, and the mean numbers of overwintering Tufted Duck (open circles).

CLOSING REMARKS

The present synthesis of our study of the overwintering waterfowl and fish of Lough Neagh is presented not as a completed investigation, but as the story so far in a project which by its very nature must be both long-term and broad. The study contains both strengths and weaknesses, some of which are likely to be found in any investigation of interactions between waterfowl and fish, which will be briefly considered in this closing section.

Firstly, while waterfowl, fish and limnology are still sometimes investigated by workers residing in discrete research bodies, arguably the greatest strength of our study is that it has combined the expertise of workers from these three areas and as a consequence has allowed the combination of long-term population data with detailed information on feeding ecology. However, this collaboration only arose through largely fortuitous circumstances. Although communication and collaboration between relevant disciplines are improving through workshops such as that reported in the present volume and that of Kerekes and Pollard (1994), much remains to be done to bring researchers into full contact with each other. Expertise transfer and increased accessibility should remain a fundamental goal of the research community.

Studies of competition between any organisms can be conducted either by simple correlative analyses, which may reveal apparent manifestations of competition but are in themselves inconclusive and indicate nothing of the responsible mechanisms, or by experimental manipulations of varying scale, which are more robust. Examples of waterfowl-fish correlation analyses in space and time are provided by Eriksson (1979) and Andersson (1981), respectively, while Pehrson (1984), Hill *et al.* (1987) and Giles (1994) described experimental studies of increasing scale and complexity. In particular, the study of Giles (*op. cit.*) involved an entire-lake manipulation in which the abundance of a cyprinid-dominated fish community of a medium-sized flooded gravel pit was greatly reduced. Such an ambitious approach is to be applauded and highly recommended for future research projects, although in practice the difficulties inherent in such work are likely to remain a major restriction on the common use of this powerful technique. Moreover, fish removal is usually impossible on larger or natural water bodies such as Lough Neagh, where researchers are likely to have to continue to wait patiently for 'natural experiments' such as those described in this review.

Another difficulty in any study of competition lies in translating prey abundance as measured by the researcher into prey abundance as perceived or assessed by a foraging animal, e.g. what densities of molluscs expressed as a number of individuals per square metre of substratum may be foraged profitably (in energetics terms) by a diving duck? Studies on other predators suggest that what may appear to be a relatively high absolute abundance may in fact be too low for the predator to exploit. For example, young roach switch from feeding on planktonic cladocerans to taking benthic species when the density of the former falls to *c.* 40 individuals per litre (Townsend *et al.*, 1986), which would otherwise probably be interpreted as still a relatively high density. For diving predators such as many waterfowl, additional factors including water depth will also be critical in the energetics of benthivory. A full understanding of this aspect of the feeding ecology of adult Tufted Duck would require laboratory-based experimental observations similar to those carried out by Giles

(1990) for Tufted Ducklings. As with the technique of entire-lake manipulation, such an approach is certainly to be recommended but is unlikely to become commonplace.

Finally, and perhaps most importantly, some comment must be made on the role of long-term investigations in the study of interactions between waterfowl and fish. Most members of both of these animal groups are relatively long-lived and so a long-term component is essential in any programme of research into their population dynamics. Fortunately, the long-standing popularity of birdwatching as a recreation has resulted in the accumulation of decades of waterfowl population data which are now available for many lakes in Europe and elsewhere. Unfortunately, the rarity of such studies on other components of lake biota, including fish (see Elliott, 1990), means that most of these counts cannot be exploited in the study of interactions between waterfowl communities and other aspects of lake ecosystems. In the frequent absence of long-term fish data, the study of competitive and other interactions between these two major groups of freshwater vertebrates will be regrettably slow, but their importance is such that their investigation must not fall into neglect.

ACKNOWLEDGEMENTS

Many people and organisations too numerous to mention here, but already acknowledged in our earlier publications, made invaluable contributions to our work. However, we would like to record again our particular thanks to the many who have counted the waterfowl of Lough Neagh over the last 30 years, to the staff and students of the University of Ulster's Freshwater Laboratory, and to Bob Foy for the total phosphorus data. Robert Buick of the Ulster Coarse Fishing Federation kindly made available the match angling records, while the figures were ably and swiftly produced by Trevor Furnass.

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ARE NORTHERN BREEDING DABBLING DUCKS RESOURCE LIMITED?

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ABSTRACT

We describe patterns relating breeding waterfowl to habitat structure as well as to abundance and diversity of aquatic food invertebrates in 60 lakes in six regions in Sweden and Finland. Based on these patterns we studied the possible role of resource limitation and competition by a field experiment in which wing-clipped mallards were released to augment wild dabbling duck populations in 16 lakes in each of two years. Preliminary results of the experiments indicate no competition at the time of nest-building (pair counts), but that intra- as well as interspecific effects are possible later on in the breeding season (brood counts).

INTRODUCTION

Regulation of species richness and relative abundance in animal communities has been a central topic in ecology for a long time (cf. MacArthur, 1972; Cody, 1975). In this respect waterfowl have been fairly extensively studied in North America as well as in Europe (e.g. Nudds, 1992). Birds are problematic as well as challenging study objects, though, because patterns observed may depend on processes occurring in breeding, staging or wintering areas, as well as on different spatial scales (e.g. Wiens, 1989). Hence, there is still controversy as to when, where and what regulates waterfowl populations and communities (Nudds and Wickett, 1994). We here report on extensive field studies describing relationships between communities of breeding waterfowl and habitat variables, and the devising of an experiment testing for resource limitation among dabbling ducks on their breeding grounds in boreal Europe.

METHODS

In 1990 and 1991 we studied breeding waterfowl in six regions in Sweden and Finland along a gradient from broadleaved deciduous forest to northern coniferous forest (see map in Elmberg *et al.* 1993). In each region we selected 10 lakes to represent its gradient from oligotrophic to eutrophic conditions. Waterfowl were censused by two pair counts in spring and two brood counts in early summer. Abundance and diversity of benthic, nectonic and emerging invertebrate prey in the lakes were measured by activity and emergence traps (Elmberg *et al.* 1992, 1993). At the end of the breeding season the floating and the emergent vegetation in each lake were identified, mapped and measured. Subsequently, prey data were pooled to different composite measures, and the 18 variables of vegetation type, height and width were combined in a principal component analysis, in which the first axis explains 25.7% of the variation. Each lake's score on the axis is termed "habitat structural diversity". Details about the methods used are found in Elmberg *et al.* 1992, 1993, 1994.

RESULTS AND DISCUSSION

Our study concerns all waterfowl (i.e. the orders *Gaviiformes*, *Podicipediformes* and *Anseriformes*, and the Coot *Fulica atra*), but we here deal mainly with the dabbling ducks (*Anas*) and some functional groups of possible competitors. Species richness and pair density (relative abundance) of dabbling ducks varied among regions, but showed no consistent latitudinal or longitudinal trend (Elmberg *et al.* 1993, **Table 2**). In pairwise correlation analysis, species richness as well as relative abundance of dabbling ducks increased with overall abundance of activity trap invertebrates and emerging *Diptera*, with habitat structural diversity, and with the percentage of *Equisetum*-dominated shoreline (**Table 1**). Species richness also correlated positively with mean size class of activity trap invertebrates and with lake area. However, stepwise multiple regression analysis showed that the best set of predicting variables for species richness was habitat structural diversity, abundance of emerging *Diptera*, and the abundance of activity trap invertebrates. For the relative abundance of dabbling ducks the same type of analysis show that the percentage of *Equisetum* shore type, habitat structural diversity, and the abundance of emerging *Diptera* constituted the best set of predictors.

Table 1: Pairwise Pearson correlation coefficients between environmental variables and aspects of dabbling duck communities in 60 lakes in Sweden and Finland. Only statistically significant correlations are given.

Food resurce variables	**Species richness of dabbling ducks**	**Relative abundance of dabbling ducks**
Abundance of activity trap invertebrates	r = 0.453, P<0.01	r = 0.348, P<0.01
Mean size class of activity trap invertebrates	r = 0.328, P<0.01	
Abundance of emerging *Diptera*	r = 0.274, P<0.05	r = 0.324, P<0.01
Habitat variables		
Lake area	r = 0.267, P<0.05	
Habitat structural diversity	r = 0.528, P<0.001	r = 0.398, P<0.01
Shore with *Equisetum* (%)	r = 0.409, P<0.001	r = 0.432, P<0.001

In a biogeographical analysis of all waterfowl, the observed species richness pattern did not fit the random placement null model, suggesting that factors other than lake area per se were also important in affecting species number (Elmberg *et al.* 1994). We related species richness of different functional groups of waterfowl to environmental variables. In pairwise correlations, overall species richness, species richness of one-lake species (species not moving broods between lakes) and 'intermediate species' (those sometimes moving broods) were positively related to lake area. Overall species richness and species richness of non-piscivore birds and species which move the brood between lakes correlated positively with habitat structural diversity, whereas species richness of one-lake species and intermediate species did not. Except for in one-lake species, species richness also correlated positively with the number of prey taxa. Stepwise multiple regression revealed clearer differences between the functional groups. Overall species richness was best explained by the number of prey taxa and lake area, and that of non-piscivores by the number of prey taxa alone. Lake area was the best single predictor of species richness in both one-lake-species and intermediate species, whereas the number of prey taxa and habitat structural diversity was the best predictor set for species richness of lake changing species.

Our results thus indicate that species richness as well as abundance of breeding waterfowl communities are affected by a set of environmental factors. At least food resources, habitat diversity and lake area are important. However, the importance of these factors varies between different functional groups of waterfowl.

Thus far we have only described patterns, which in turn seem complex and not always very consistent. One reason for this being the case could be that the communities studied are not resource limited, i.e. that the patterns observed is a mesh of overlaid species-specific responses to different environmental variables. To approach the processes behind the patterns we thus devised a field experiment to test for resource limitation.

We selected 32 lakes in Västerbotten and Ångermanland, North Sweden, in which Mallard *Anas platyrhynchos* and Teal *Anas crecca* were the only dabbling ducks known to have bred regularly in the previous years. Lakes were generally smaller than 10 hectares, and they were poor to intermediate with respect to the local oligotrophic-eutrophic gradient. Six Mallards were introduced to each of 16 of the lakes in 1993, utilization by mallard and teal was recorded, and the intra- and interspecfic relations were compared with the situation in the remaining 16 lakes to which no birds were added. In 1994 the experiment was reversed, i.e. reference lakes became experimental lakes and vice versa.

The idea behind the experiment is simple. If there is resource limitation in the breeding lakes our introducing six mallards will be a test of intra- and interspecific competition. Assuming resource limitation the predicted outcome of intraspecific competition is that conspecifics (mallards) will utilize the lake less and/or have a lower reproductive success than mallards in control lakes, and the outcome of interspecific competition is that teal will utilize the lake less or have lower reproductive success.

Interestingly, occurrence of neither species differed markedly between experimental and control lakes in the early phase of breeding (**Table 2**; pair counts). However, inter- as well as intraspecific utilization was lower in experimental lakes than in reference lakes during the brood-rearing period, thus indicating resource limitation at this stage.

Table 2: Accumulated utilization of breeding lakes by wild ducks from two censuses in each census period. Sixteen lakes were experiment lakes in 1993, and reference lakes the next year. The remaining sixteen received the reversed treatment. m=male, f=female, p=pair, d=duckling

Census period	Experiment Mallard	Experiment Teal	Reference Mallard	Reference Teal
Pair count	49p	19p	43p	18p
Brood count	1m 9f 55d	3m 17f 40d	1m 14f 72d	1m 23f 76d

One interpretation is that adult birds respond less to the observable abundance of food or scarcity of nest sites, and commence nesting regardless of the situation encountered. By the time broods hatch and forage actively they have incurred higher mortality, or they have been moved by the female to a better foraging site.

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TIME AND ENERGY CONSTRAINTS IN TUFTED DUCKS (*AYTHYA FULIGULA*) FEEDING ON ZEBRA MUSSELS (DREISSENA POLYMORPHA)

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Diving ducks, like Tufted Duck (*Aythya fuligula*) and Scaup (*A. marila*) are well-known for wintering in large numbers (over 300.000 birds) in freshwater lakes in western Europe while feeding mainly in Zebra Mussels (Dreissena polymorpha). The feeding behaviour and energetic costs were studied in mussel feeding ducks diving under semi-natural conditions. Diving ducks swallow whole mussels, thereby ingesting large amounts of shell and water ('bulk-feeding'). Consequently, the daily mussel consumption was about 3 times the body mass of the birds to meet their daily energy demands. Crushing the shells in the muscular gizzard and probably recovering from heat loss after diving and ingesting cold food masses constrained food intake rates. Typically, the ducks were resting (i.e. not diving) for 15 minutes between foraging bouts of ca. 10 dives to process the ingested food mass. The energetic expenditure of ducks diving for mussels, as measured by the technique of doubly labeled water turnover, was 4 to 5 times their basal metabolic rate (BMR), as opposed to a level of 2 times BMR when resting on the water surface. In conclusion, feeding on Zebra Mussels is extremely time and energy consuming.

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THE ROLE OF CONDITION AND DENSITY OF ZEBRA MUSSELS (*DREISSENA POLYMORPHA*) AS SELECTION CRITERIA FOR PREDATION BY DIVING DUCKS (*AYTHYA* SP.)

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Diving ducks, like Tufted Duck (*Aythya fuligula*) and Scaup (*A. marila*), overwinter in large numbers (up to 300.000 birds, over 50 % of the population in northwestern Europe) in the freshwater lake IJsselmeer, the Netherlands. These ducks mainly feed on Zebra Mussels (*Dreissena polymorpha*). Each bird has to consume 1.5 to 3 kg mussels (fresh mass) per day, i.e. 600 tons in a winter's night for all birds in the lake, to meet its daily energy demand. Diving ducks prefer the shallow parts (2-3 m deep) of the lake, although mussel densities are 10-50 times lower than in deeper parts of the lake. However, the condition of mussels (flesh mass relative to shell mass) decreases with water depth. In experiments with captive birds, which have been trained to dive for freshwater mussels, we measured food selection, the energetic costs of diving, and food intake rates in relation to mussel density. The results show the diving ducks are able to distinguish between mussels with high flesh content and low flesh content and that feeding on low densities is less efficient, thereby increasing the costs of foraging. Moreover, there is evidence that feeding on mussels may be constrained by the time available for foraging and the amount of energy expended on foraging. We conclude that diving ducks have to balance the costs of foraging (related to density of mussels) and the relative benefits (related to the condition on mussels) within a narrow range of the energy and time budget in winter. This study suggest that the exploitation on benthic mollusc populations by diving ducks is strongly limited and that large areas in the lake are not available for diving ducks.

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EFFECT OF FOOD AVAILABILITY ON WATERFOWL ABUNDANCE IN CONDITIONS OF SOUTH BOHEMIAN FISHPONDS (CZECH REPUBLIC)

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A remarkable decrease in breeding population size was recorded in many waterfowl groups (esp. in ducks) in most of the fishpond regions in the Czech Republic. This phenomenon has been the main stimuls for the initiation of many investigations of waterfowl ecology. The assessment of factors affecting habitat preference of particular waterfowl species seems to be very important for understanding the population dynamics of respective species.

We studied habitat preferences of waterfowl species on 74 fishponds in Třeboň Basin (South Bohemia, Czech Republic) in 1992-1994. Our study was aimed to:

- comparison og habitat preference of adult and young waterfowl
- investigation of changes in habitat preference of adult waterfowl during breeding season
- studying of sexual variation in habitat preference
- circadial investigation of feeding behaviour of particular duck species

On each fishponds, the census of waterfowl as well as limnological investigation (water transparency, zooplankton composition) were carried out. In total, we recorded more than 3000 adult and more than 1000 broods of about 20 waterfowl species. Habitat of particular fishponds studied was characterised by water surface area, littoral stands area, shore development, water depth, surrounding habitats and pond isolation index. Majority of the fishponds were under a high pressure of enormous fish stock.

More detailed analysis of habitat preference was carried out for the most common waterfowl species (*Podiceps cristatus*, *Anas platyrhynchos*, *Anas strepera*, *Aythya ferina*, *Aythya fuligula*, *Fulica atra*). Preliminary results show that:

- Waterfowl broods prefer ponds with higher transparency (i.e. with larger food supply and availability)
- Adult ducks prefer ponds with higher transparency only at the beginning of the breeding period
- Only Gadwall (*Anas strepera*) occurs more frequently on ponds with lower water transparency. This species is the only duck species whose abundance is slowly increasing.

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REED REDUCTION AND GOOSE GRAZING IN SOUTH SWEDISH LAKES

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The lakes in Scania (the southernmost province of Sweden) are generally shallow, eutrophic and surrounded by reed belts. During the 1980's increasing damage was observed at the lakeward edge of many reed belts. Aerial photographs document that reed area in some lakes has declined substantially during the last ten years.

This reduction has occurred simultaneously with a large increase in the population of the Greylag Goose (*Anser anser*) in Sweden. It is believed that the decline is caused mainly by grazing Greylag Geese, staying in the Scanian lakes during breeding (April-May), molting (June) and autumnal migration (July-September). In August-September large areas of *Phragmites australis* are affected by geese grazing. However, the largest impact is thought to occur during the early breeding season, when nutritious shoots (submerged) of *Phragmites* are important food items.

Food preference among common reéd-forming macrophytes follows the sequence *Phragmites-Scirpus-Tyoha*. In some areas with heavy grazing pressure *Phragmites* has disappeared from the edge, facing open water and now occurs inside protecting stands of *Typha*.

The reduction of the reeds is in some lakes seen as an environmental deterioration, because the heterogeneity of the littoral zone is reduced. Particularly, observed reduction in some of the south Swedish waterfowl lakes is detrimental to several waterfowl species. The Greylag Geese are themselves destroying habitats they utilize for foraging and breeding.

Grazing effect on macrophytes have also been observed in lakes where the Canada Goose (*Branta canadensis*) has increased during recent years. The species was introduced into Sweden in the early 1930's and the population is now approximately 50.000 individuals. The

Canada Geese breed in more oligotrophic lakes and feed partly on macrophytes during the breeding and molting season. Food preference seems to follow the sequence *Equisetum* - *Scirpus* -*Phragmizes*.

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WATERFOWL ON THE POLLUTED LANDSCAPE IN THE UKRAINIAN POLESJE

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The basic results of the accident on the Chernobyl Atomic Power Station one of the highest levels of pollution by radionuclides and heavy metals of landscape in Ukrainian Polesje. They are mainly concentrated in the water ecosystems. As a result the increasing level of radionuclides and heavy metals found in all components of those ecosystems.

The high level of radioactive pollution of the landscape stopped traditional human activities and changed the complex of factors, which influenced the ecosystem. All elements of this system are changing.

In population of the waterfowl we can observe:

- decreasing amount of nesting population of birds more than 200 times;
- decreasing of functional level of birds, disbalance of fat-carbon energy exchange with increasing level of basal metabolism more than 3-5 times;
- decreasing of the level of reproduction of populations of all waterfowl up to 0-3 percent;
- re-distribution of nesting populations of *Larus ridibundus*, *Sterna hirundo* on the territory with low level of pollution (1 Ku/sq.km, Sr-90, - 5 Ku/sq.km Cs-134-37);
- concentration in zone of the high level of pollution non-breeding birds.

These processes take place simultaneously with increasing of food capacity of ecosystem and change for the worse of the parasitology situation. Depression of nesting populations is the results of decreasing of reproduction level of population, decreasing of functional level of adult birds and change for the worsening of parasitology situation.

Concentration of non-breeding birds results in increasing of food capacity of the ecosystem and full-protection regimen of territory.

The response of the waterfowl to the radioactive pollution of the landscape and change of influence factors is the most powerful in comparison with another elements of ecosystems. It will give the opportunity to use one for estimation of ecotoxycology effect of pollution for the water ecosystems

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EGGSHELLS OF GEESE'S EGGS AS AN INDICATOR OF WATER POLLUTION

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To wildlife irreplaceable damage is caused by such agricultural chemicals as pesticides, herbicides, fungicides, etc., and the most dangerous one DDT and its analogue DDE. They are particularly dangerous for birds which cause of their mobility and feeding from soil and water are victims of pollution. According to Fisinin *et al.* (1990) DDE available in foods (75 ppm) decreases thickness of laid eggs by 20 %. These data are confirmed by Kiff (1991) reviewed the investigations in different areas. Thus, nature and level of soil and water pollution can be estimated by measuring thickness and weight of eggshells of birds inhabiting this territory. When measuring eggs they should be intact.

Geese's eggs may be a good indicators of water pollution. To determine the characteristics of their shell the correlation in morphological parameters of geese's eggs was studied. According to previous research (Narushin, unpublished) the eggs of the wild geese and domestic ones were not different in their morphological structure. To find the correlation in morphology 170 eggs of domestic geese of different strains such as Italian White, Gorky, Kuban and Obroshinsky breeds were used. It was found that eggshell thickness T and weight Ws are in close correlation with the egg weight W, length L and maximum breadth B:

$$T = 0.5L + B - 0.25(L + 2B)^2 - 0.575W^{0.0038}L^{0.6809}B^{0.3618\ 0.5}$$

$$Ws = 1.0767W^{3.08}L^{-2.268}B^{-4.536}$$

The formulae obtained allow to calculate the mean shell thickness and weight of goose egg, to compare their meanings with the average ones and to determine the level of water pollution effect on fauna of a given region.

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AUTUMN FEEDING AND LEAD POISONING OF GAME DUCKS IN DNIEPER RESERVOIRS, UKRAINE

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There are six reservoirs in the Dnieper region. 16 species of game ducks use the areas of wetlands in the basins during autumn migration. In autumn the vegetable food prevail in nutrition of dabbling and diving ducks. Such food as duckweeds (*Lemna minor, L. trisulca, Sridodela polyrrhysa*), winter buds of frogbit (*Hydrocharis morsus-ranae*), axilliary shoots of soldier (*Stratiotes aloides*) and vegetative parts of other higher aquatic plants are the most energy rich value for game waterfowl birds in this season. Mollusks, insects and small crustaceans, which are the inhabitants of these plants, are also consumed.

There are species differences in using food resources by ducks. For instance, Mallards (*Anas platyrhynchos*) prefer to ingest the soft parts of aquatic plants. 92 % of food samples studied contained the water plants seeds with hard cover, namely the following: *Potamogeton sp., Sparganium erectum, Schoenoplectus lacustris*. In ducks' gizzards these seeds are grinded up slowly and help to break down the food.

In 2,8 % of food samples of Mallards and 23 % - Red-head Duck (*Aythya ferina*) - lead shot was observed (from 1 to 9 shots). The lead was present in gizzards of other game duck species.

The lead is easily oxidized by organic acids and is transferred through the food chains. Thus, the lead is found in mollusks tissues (*Limnea stagnalis, Viviparus viviparus*), in liver of such fishes as *Perca fluviatilis, Scardinius erythrophtalmus*, in liver of Mallards, red-headed Ducks, Coots (*Fulica atra*).

The shot made from other metals hasn't been used in Ukraine for the present. It is obvious, that is necessary to prohibit the using of lead shot cartridges all over the Ukrainian wetlands and in Dnieper reservoirs in particular.

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CONTROL OF BOTULISM IN WATERFOWL IN THE SALT PANS EAST OF NEUSIEDLER SEE

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ABSTRACT

The results of field experiments with chicken carcasses underline an important role of the maggots of *Lucilia caesar* in multiplication, dispersal and transfer of the toxin to birds during an outbreak of botulism. The time of exposure of a fresh carcass necessary for the development of maggots sharply decreased during summer, thus especially in August, dead and sick birds should be removed from the area at least on every 4th day.

INTRODUCTION

Between 1982 and 1992, in the shallow salt pans of the Seewinkel east of Neusiedler See, four serious outbreaks of botulism were recorded, with a total number of 5,365 dead or sick birds collected. From 1984 to 1986, the ecological causes of these outbreaks were the subject of an interdisciplinary study including ornithology, limnology and microbiology. The methods and results of this project have been published in detail in Grüll *et al.* (1987). In this paper we concentrate on the role of dung-flies in multiplication, dispersal and transfer of the toxin to waterfowl and summarize the conclusions of our study for the control of botulism.

The role of dung-flies

Since the beginning of this century it is known, that the maggots of some species of dung-flies feeding in the decomposing carcasses of botulism-victims may store the toxin in their bodies in high concentrations. If they are consumed by waterfowl they cause further dyings. To gain more detailed information on this subject, important for controlling botulism, in a series of field experiments with chicken carcasses, we monitored the development and behaviour of the maggots as well as the significance of the maggots as a food resource for waterfowl. The results of these experiments can be summarized as follows (Grüll *et al.* 1987):

(1) The mass of dung-fly maggots feeding in carcasses in the salt pans of the Seewinkel is *Lucilia caesar*.

(2) Adult dung-flies can transfer the bacterium to carcasses not jet infected with *Clostridium botulinum* ; they so may accelerate the spreading of an outbreak or even transfer botulism to other waterbodies.

(3) The maggots feeding in infected carcasses may be a toxic food resource at least for gulls, and in the phase of dispersal before pupation probably also for waders. Drowned maggots are floating on the water surface for about five days, and during this time they are a dangerous source of toxin for different species of surface-feeding waterfowl (e.g. dabbling ducks, terns).

(4) The time the maggots leave the carcass varied not only with air temperature, but also with the season (**Figure 1**): While the time from exposure of a fresh carcass to dispersal lasts more than two weeks at the beginning of June, the maggots start their migration already after a few days at the end of August.

CONCLUSIONS

As a consequence of these results and in accordance with many other studies we recommend the quick removal of sick and dead waterfowl as the most efficient and careful measure in controlling an outbreak of botulism. To discover the first carcasses as early as possible, regular controls of all open shores and margins of reedbelts from June until September are necessary. Considering the time pattern of larval development in *Lucilia caesar* the intervals between the controlling respectively collecting actions especially in late summer should not be longer than 4 days (for details see Grüll *et al.* 1987, Westphal 1991).

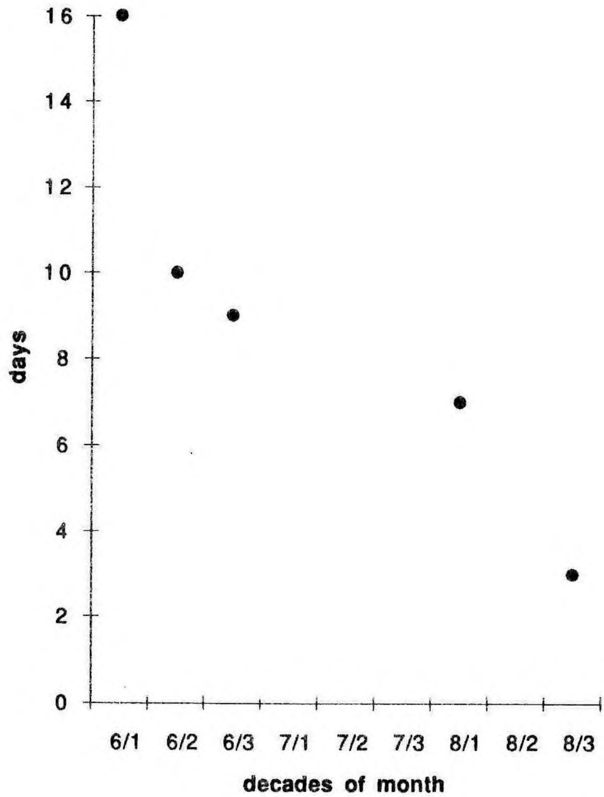

Figure 1: Duration larval development in the dung-fly Lucilia caesar (days) between exposure of a fresh carcass and dispersal of the maggots in the decades of June and August (from Grüll *et al.*, 1987)

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HELMINTHS OF WATERBIRDS FROM THE RESERVOIR OF LAKE SEVAN, ARMENIA

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Lake Sevan is the unique largest Alpine water reservoir of Armenia (1916 m above sea level with 1416 km^2 surface). The ornithofauna of the reservoir numbers 210 bird species comprising 91 waterbirds that belong to the following 7 orders: *Charadriiformes* - 41 species, *Anseriformes* - 20 species, *Ciconiiformes* - 11 species, *Gruiformes* - 10 species, *Podicipitiformes* - 4 species, *Pelecaniformes* - 3 species, *Gaviiformes* - 2 species. Here, 16 species are settling birds, 28 - nesting transmigrated, and 47 - transmigrated ones. From the mentioned orders of birds 500 specimens referred to 47 species are subjected to helminthological investigation (by dissection). As a result, 313 specimens or 62.6 % are found infected with helminths comprising 23.3 % of trematodes, 81 % of cestodes, 7.9 % of nematodes, and 17 % of acanthocephala. Seventy-two helminth species referred to 50 genera and 22 families are revealed in birds, of which 33 species are trematodes, 22 species - cestodes, 10 species - nematodes, and 7 species - acanthocephala.

The following 22 families present the structure of helminthofauna:

Trematoda (10 families): *Echinostomatidae, Diplostomatidae, Strigeidae, Cyclocoeliidae, Notocotylidae, Echinochasmidae, Plagiorchidae, Cyathocotylodae, Bilharziellidae, Dicrocoeliidae*

Cestoda (4 families): *Ligulidae, Hymenolepididae, Choanotaeniidae, Dilepididae*

Nematoda (5 families): *Anisakidae, Capillariidae, Amidostomatidae, Acuariidae, Streptocaridae*

Acanthocephala (3 families): *Polymorphidae, Plagiorhynchidae, Filicollidae.*

It has been proved that the principal role in the forming of helminthofauna and circulation of helminths of waterbirds from Lake Sevan play the most frequently occurring species - *Larus argentatus, Anas platyrhynchos, Fulica atra*.

Various species of invertebrates take part of natural infection of invertebrates with helminths' larvae has been revealed by us. Mollusks of *Lymnaea stagnalis* have been infected with the larvae of trematodes by 90.6 %, *L. auricularia* - by 80.4 %, *L. lagotis* - by 64.4 %, *Planorbis planorbis* - by 72.2 %. *Cestoda cysicercoids* have been revealed in single specimens of *Cyclops strenuus, Arctodiaptomus bacilifer* and *Daphnia pulex*, and *acanthelia* of *acanthocephala* - in *Gammarus locustis*. Not high percent of infection of crustacea is, likely, explained by the fact that in natural conditions to reveal the very infected one among the numerous specimens, is highly problematic. Besides, the temperature limit of the lake being 18-22 °C during 2-2.5 months (from June 15 to August 15), and considerably low in other seasons, is also an inhibiting factor for the development of the larval forms of helminths in the organism of invertebrates before the infection stage. Unlike mollusks, that are in great number enough in off-shore grass-plots of the lake, where the water temperature is considerably high, and therefore, the larvae of trematodes develop successfully, crustacea occur mostly in the very lake with the limited low temperature that leads to their infection with the larvae of helminths.

The other component of Lake Sevan is the fish of the following 2 families: *Salmonidae* and *Cyprinidae*. The species *Salmo ischan* with its four races (Winter Bakhtak, Summer bakhtak, Gegharkhuni and Bojak) and, subspecies Sevan Sig - *Coregonas lavaretus sevanicum*, are characteristic for the first family; *Varicorhinus capoeta* - "lamy" and *Barbus goktschaicus* - year - for the second one. Considerably, water invertebrates and fish are considerable in the food ration of a number of species of waterfowls. As is known, among the mentioned animals are species, that participate in the life cycles of helminths as invertebrate hosts.

Thus, as a result of forming of helminthofauna of the region waterbirds, fish and invertebrates, mostly fresh-water mollusks and a single species of *Crustacea*, play a decisive role.

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RESTORATION OF WETLANDS IN NORTHEASTERN HUNGARY

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ABSTRACT

Nowadays is evidently proved that the maintenance of state of protected or potential protected wetlands can only be provided through the restoration activities based on the results of well founded research.

There are many different types of wetlands, each of which provides a different range of benefits to human society.

The term wetlands groups together a wide range of inland, coastal and marine habitats which share a number of common features, but on the decision of the Ramsar Convention defining wetlands as: "Areas of marsh, fen, peatland or water, whether artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters."

Wetlands are an ecotone, the transitional zone between land and water, and they combine characteristics of both environments. The wetland habitat consist of permanent or seasonal shallow water dominated by large aquatic plants and broken into diverse microhabitats (Horne and Goldman, 1994).

Despite the importance of wetlands, vast areas have been degraded or lost as the results of human impacts. In order to reduce the rate of wetlands loss and enhance the contribution that these ecosystems can make to sustainable socio-economic development, a range of actions needs to be taken to improve restoration (Dugan, 1990). Only recently has recognition of their value as wildlife feeding and breeding are led to protection and restoration.

INTRODUCTION

In this century it is evidently proved, that the maintenance of the condition of protected or potentially protected wetlands can only be provided through management activities that are based on the results of well founded research.

There are many different types of wetlands, each of which provides a different range of benefits to human society (Mitsch and Gosselink 1993). Wetlands are an ecotone, the transitional zone between land and water, and they combine characteristics of both environments. The wetland habitat consists of permanent or seasonal shallow water dominated by large aquatic plants and broken into diverse microhabitats (Horne and Goldman, 1994).

Wetlands are threatened all over the world and those which are located in Central-Eastern Europe are of no exception. Wetlands well reflect the natural character and condition of the environment, therefore the priority of their restoration is well documented (Mitsch *et al.* 1994). This attitude is supported by several other factors since microorganisms, plant and animal communities have the highest biodiversity in wetlands, especially in the case of the temperate zone. Their heterogeneity and the role they play which are directly or indirectly advantageous for mankind can be easily damaged or even destroyed (Maltby 1994). In order to reduce the rate of wetlands loss and enhance the contribution that these ecosystems can make to sustainable socioeconomic development, a range of actions needs to be taken to improve their restoration (Dugan 1990). Only recently has the recognition of their value as wildlife feeding and breeding area led to their protection and restoration.

This paper presents the results of studies on hydrobiological conditions and different water supplies in the existing protected or potentially protected wetlands in the Northeastern part of Great Hungarian Plain.

MATERIALS AND METHODS

The 31 wetlands studied are located in North-eastern part of Hungary (Nyírség, Szabolcs, Hajduság and Bihar areas) and the borderland (Bereg county) in the Ukraine. In the field temperature, pH, redox and conductivity were measured. In the laboratory the major anions and cations were analyzed to establish the status of water quality.

The oxygen contents were measured and oxygen saturation was estimated. To establish the trophic state of wetlands the concentrations of ortho-phosphate and total phosphorus were measured besides ammonium, nitrite, nitrate, Kjeldall nitrogen, total inorganic, -organic nitrogen forms, and total nitrogen (TN) was estimated.

The chemical oxygen demand (COD) and total organic carbon (TOC) were also measured to establish the saprobity of water quality.

Chlorophyll-α content of water samples were measured and the taxonomic composition of phyto- and zooplankton were studied. Floristic and cenological studies were carried out and we applied Simon's nature conservation ranks of the vascular flora analysis (Simon 1988).

On the basis of our results we summarized our suggestions for restoration from the point of view of the possible solution of water supply and the state of water quality. The preservation of nature values were given a high priority.

RESULTS AND DISCUSSION

Study of the water supply

With respect to the degree of solution of the problem of water supply (de Mars and Wassen 1993), the studied wetlands can be grouped and the results are presented in **Table 1**. We can state on the basis of this list, that the water supply at most of the protected wetlands have not been solved. The loss of water from precious wetlands, resulted in a degradation over and above the allochtonic organic pollution, that causes significant threat to these resources. This situation is characterized by the ancient Ér-bed at Pocsaj. Unfortunately the Nyirábrányi-bog and Kállósemjéni

Mohos can be placed into the nonsolved water supply group, although potential factors of the assuring of their water-demands are given, but both protected areas have almost totally dried up. With the disappearance of water, the spread of weeds is excessive, especially in the case of Mohos where an intervention for nature restoration is urgently need.

Table 1: The groups of wetlands studied with respect of the solved and nonsolved water supply in the norteastern part of Great Hungarian Plain.

solved	nonsolved	no problem
Bátorliget-bog	Nyirábrány-bog	Fényi-forest-bog
Fehérszik-marsh	Mohos-bog	Bihari-pasture
Haláp-reservoir	Hajdubagos	Hencida-marsh
Konyár sodic marsh	Pocsaj Ér-bed	Gáborján-marsh
Vajai reservoir	Bojt meadow	Kereki-marsh
Vámospércs-bog	Daru-bog	Bakonszeg reservoir
Beregi pond	Tiszadob oxbow	Dédai reservoir
Dédai pond	Borzsa oxbow	Nagyberegi channel
	Tisza dead-arm	Csizaji pond
	Szernye swamp	Szernye channel
	Csaronda	
	Mérce	
	Kráter pond	
	Vérke	

Biological water quality of studied wetlands

On the basis of the results of our chemical and biological water investigations we compiled the cation and anion types, trophic state and saprobity degrees of wetlands and their channels. Concerning the three indicators of the biological water quality it can be stated that the water of the channels is suitable for providing the appropriate level of supply. The degrees of the trophic state and saprobity are more favorable in the supplying channels, which may be attributed to the significant internal loading by nitrogen and phosphorus and organic matter.

During the floristic investigations 106 vascular plant species were identified which live in different types of wetlands. High plant species number and diverse community were characterized Bátorliget ancient-bog, Tiszadob oxbow system and Halápi-reservoir in Hungary, while natural or near-natural conditions were observed in case of Borzsa oxbow system, Mérce creek and Kráter-pond in Ukraine. Cenological studies were carried out in Bátorliget-, Nyirábrányi-bog and Mohos-bog at Kállósemjén and the findings were compared to the previous data (Lakatos, 1990). Heavy negative impact of water supply shortage could be established, mainly in case of Mohos-bog.

On the basis of the water quality and the plant species, wetland communities can be classified into four groups, namely, sodic (alkaline) marshes, bogs, transition-state wetlands and degraded wetlands (**Table 2**).

Table 2: Classification of wetlands on the basis of the water quality and the plant species communities in the norteastern part of Great Hungarian Plain

bogs	sodic marshes	transition-state wetlands	degraded wetlands
Bátorliget-bog	Fehérszik-marsh	Haláp-reservoir	Pocsaj Ér-bed
Fényi-forest-bog	Bihari-pasture	Hajdubagos	Mohos-bog
Nyirábrány-bog	Konyár sodic marsh	Bojt meadow	Tisza dead-arm
Daru-bog	Fehérszik-marsh	Borzsa oxbow	Szernye channel
Vajai reservoir	Hencida marsh	Kráter pond	Vérke
Tiszadob oxbow	Gáborján marsh	Beregi pond	
Szernye swamp	Nagyberegi canel	Dédai pond	
Mérce	Csaronda	Dédai reservoir	
		Csizaji pond	

The preservation, the conservation, the reconstruction, the rehabilitation, the management and the maintenance of biodiversity, where it is needed, are the main tasks of the nature restoration activities not only in our country but in many regions of the Earth. The experts in the nature protection and the ecologists can meet the expectations only if they act in cooperation.

The solution of water supply in Tiszadob oxbow system and the implementation of nature conservation treatment of valuable marsh-fern "floating-bog" are significant tasks. The case of

Mohos-bog at Kállósemjén may serve as a good example for illustrating the overall and harmonized research required to the proper way of the reconstruction. Firstly, it is necessary to search for well-water of the appropriate quality and quantity in the vicinity of the bog. Secondly, regular water chemical and ecological investigations should be performed in order to control the water quality of the supplying channel and canal for the sake of the suitable flooding. The third task is the hydrobiological research of the bog with a special attention given to the plant ecological and zooecological studies for revealing the effects of the changes after the nature reconstruction treatment. Finally, we have to analyze the efficiency of the reconstruction and the replantation, for the redesign of the reconstruction or treatment model in each case, as it is needed.

Wetlands in the Northeastern Great Hungarian Plain represent an internationally recognized as unique natural values. However, in addition to the general pollution problem they are in danger of drying up. As a consequence of the significant decreases of water quantity, all wetlands are in an extreme peril (Lakatos, 1995). Properly identifying them and especially saving the representatives of the internationally unique wetlands, should play a central role in the future nature restoration activity.

CONCLUSIONS

The wetlands belong to the most threatened waters and those are of no exception which are located in Central Eastern Europe. In order to reduce the rate of wetlands loss a range of action needs to be taken to improve restoration. Recently the recognition of their value as wildlife feeding and breeding area led to their protection and restoration.

The studied 31 wetlands are located in Northeastern part of Great Hungarian Plain. On the basis of our results restoration suggestions were summarized from the point of view of the possible solution of water supply and the state of water quality.

On the basis of the water quality and the plant species, communities wetlands can be classified into four groups, namely, sodic marshes, bogs, transition-state wetlands and degraded wetlands.

The preservation, the conservation and the reconstruction, the rehabilitation are the main tasks of the nature restoration activities in many regions of the world. Searching wetlands and saving them should play a central role in the future nature restoration activity.

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ORNITHOLOGICAL CHANGES FOLLOWING WETLAND RESTORATIONS

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ABSTRACT

In the course of the habitat restorations it was shown, that the already existing mosaic structure of the vegetation had basic importance for the rapid stabilization of the avifauna. During the first period of the restorations, an over-population of the site was observed, which is characterised by the relatively low number of species and high number of individuals. During the stabilization of the birdlife, this process is replaced by the decline of individuals and the increase of species. The effectiveness of the restoration is influenced by existing mosaic structure of the vegetation, the connections of the restored sites with the habitats nearby and the migratioty corridors.

INTRODUCTION

Our study is based on the data of the changes following the flooding of two sites of the Egyek-Pusztakócs Marshes covering an area of 4070 hectares in the Hortobágy region (East Hungary). The restoration work began in 1982 on the Fekete-rét marsh and at the same time a long-lasting research process was initiated, focusing on the recolonization process of the area (Aradi 1984, 1990). Valuable new data were obtained for improving the methods of nature conservation management and the conservation - biological approach of this issue. Based on these experiences there has begun the reconstruction of the Kis-Jusztus marsh in 1992, as well as a plan with the scope to ensure an adequate water supply to the whole marsh system. The implementation of this plan will be the next step of the restoration process.

In the course of our investigations, the principles of the restoration were drawn up, which were to be followed during our further experiments. These are the following:

- Only the most necessary work should be implemented, leaving the largest part to nature.
- Only habitats proven to have existed before should be restored.
- Changes that have taken place in the meantime must be considered and the valuable habitats that developed secondarily should be preserved.
- Attention has to be paid to the connections (corridors) between both near and distant refuges, gene-centers, those places which assure the natural recolonization of the restored site.
- Part of the reconstruction work is to restore the natural migration corridors, the typical "ecological network" of the region.
- Prior to the beginning of the reconstruction, the basic causes for the transformation of the area have to be known. The work can only be started when the causes of the previous destruction are stopped.
- During the first two years of the reconstruction - in the so called stabilization period - the artificial reintroduction of species which have became extinct should be avoided. The development of the "ecological framework" of the habitat should be left to nature.
- It is very important to choose the adequate size for reconstruction (e.g. it is not worth it to try to restore small remains of marshes inserted in ploughfields).

STUDY AREA

Once the Egyek-Pusztakócs marsh system occupied an area of 10.000 ha on the western edge of the Hortobágy. Originally the area was dominated by a vegetation which combined the characteristics of the backwaters, oxbows along the Tisza river, and the typical astatic and semistatic waters of the Hortobágy (Bulla, 1962). The difference between the water depth was significant and could reach 2 metres. The remains of these marshes did not extend to more than 4000 ha due to the regulation of the riverways done in the last century which resulted in many separate water bodies. The degradation was accelerated by the drainage and the cultivation of the levees covered by rich soil. The adverse weather conditions (for 10 years, an extremely dry period is being recorded) together with the agricultural drainage speeded up the drying of the area. To prevent the changes mentioned, reconstruction work has been started on the Fekete-rét. This site was in the best condition- with the capability to assure adequate water supply for the site. The favourable changes following this work have raised the possibility and necessity to continue the restoration.

The Fekete-rét is originated from an ancient permanent marsh and was transformed into a habitat which could hardly be called a temporary marsh. Mostly the spring rainfall and the snow melting supplied the site with water. The largest part of the site remained dry and the meadow zone developed (Aradi, 1988). Nowdays the habitat is an oligotrophic marsh with rich macrophyte vegetation.

The Kis-Jusztus marsh kept its alkaline marsh character only in patches of some m^2's. A relatively small area was covered by meadow vegetation and the different types of the alkaline grassland dominated to the greatest extent. In the restored status this habitat represents the alkaline temporary marsh type. The other wetland types we were working with are a typical astatic marsh (the Polturás marsh), a large fish pond system (Hortobágy Fish Pond, created after the WW I), and an example of the original semistatic marshes of the region (Kunkápolnás Marsh). The size of the sites is given in the **Table 1**.

Table 1. Comparative ornithological investigation of water bodies in the Hortobágy Study sites are listed at the end of the **Table 2**.

Species	1	2	3	4	5	6	7	8
Podiceps ruficollis	0	1	1	1	1	1	1	1
Podiceps nigricollis	0	1	1	1	1	1	1	0
Podiceps cristatus	0	1	1	1	1	1	1	0
Podiceps griseigena	0	1	1	1	1	1	0	1
Ardea cinerea	0	0	0	0	1	0	0	0
Ardea purpurea	0	0	1	1	1	1	0	1
Egretta alba	0	0	1	1	1	1	0	1
Ixobrychus minutus	1	1	1	1	1	1	·0	1
Botaurus stellaris	1	1	1	1	1	1	0	1
Platalea leucorodia	0	0	0	1	1	0	0	0
Plegadis falcinellus	0	0	0	0	1	0	0	0
Anser anser	1	1	1	1	1	1	1	1
Anas platyrhynchos	1	1	1	1	1	1	1	1
Anas querquedula	0	1	1	1	1	1	1	1

Table continues...

Species	1	2	3	4	5	6	7	8
Anas acuta	0	0	1	0	0	1	1	0
Anas clypeata	0	0	1	1	0	1	1	1
Anas crecca	0	0	0	0	0	1	0	0
Anas strepera	0	0	0	0	0	1	0	0
Aythya ferina	0	0	0	1	1	1	0	0
Aythya nyroca	0	0	1	1	1	1	1	1
Circus pygargus	0	0	1	0	0	0	0	0
Circus aeruginosus	1	1	1	1	1	1	1	1
Rallus aquaticus	0	1	1	1	1	1	1	1
Crex crex	0	0	1	0	0	0	1	0
Porzana parva	0	0	0	1	1	1	0	0
Porzana porzana	0	0	1	1	1	1	1	1
Porzana pusilla	0	0	0	0	0	1	0	0
Gallinula chloropus	0	1	1	1	1	1	0	1
Fulica atra	1	1	1	1	1	1	0	1
Vanellus vanellus	1	1	1	1	0	0	0	1
Charadrius dubius	0	1	1	0	0	0	0	0
Charadrius alexandrinus	0	0	1	0	0	0	0	0
Limosa limosa	1	1	1	1	0	0	1	1
Tringa totanus	1	1	1	1	0	0	1	1
Gallinago gallinago	0	1	1	1	0	0	1	1
Recurvirostra avocetta	0	1	1	1	1	0	0	0
Larus melanocephalus	0	1	1	1	0	0	0	0
Larus ridibundus	0	1	1	1	1	1	0	1
Chlidonias hybrida	0	1	1	1	1	1	0	1
Chlidonias leucopterus	0	1	0	0	0	1	1	0
Chlidonias niger	0	1	1	1	1	1	0	1
Sterna hyrundo	0	0	0	1	0	0	0	0
Cuculus canorus	1	1	1	1	1	1	0	1
Asio flammeus	0	0	0	0	0	1	0	0
Pica pica	0	0	0	0	1	0	0	1
Panurus biarmicus	0	1	1	1	1	1	0	0
Remiz pendulinus	0	0	0	0	1	0	0	0
Oenanthe oenanthe	0	1	1	1	0	0	0	0
Luscinia svecica	0	0	0	0	1	1	0	0
Locustella luscinioides	0	0	1	1	1	1	0	0
Lusciniola melanopogon	0	0	0	1	1	1	0	0
Acrocephalus arundinaceus	1	1	1	1	1	1	0	1
Acrocephalus scirpaceus	1	1	1	1	1	1	0	1
Acrocephalus schoebaenus	1	1	1	1	1	1	1	1

Table continues...

Species	1	2	3	4	5	6	7	8
Motacilla alba	0	0	1	1	1	1	0	1
Motacilla flava	0	1	1	1	1	1	1	1
Emberiza calandra	1	1	1	1	0	0	0	0
Emberiza schoeniclus	1	1	1	1	1	1	1	1
Number of species :	15	33	43	43	39	40	20	30
Number of species occuring exclusively in the given sample:	0	0	2	1	3	2	0	0

METHODS

Sampling: during the nesting period (beginning of March - middle of July) without taking into account the quantitative data. On the Fekete-rét 5 sampling points were chosen (5-5 hectares) : homogenous reed stands, open water surface and hairweeds, meadow zone of the marsh, mosaic communities (open water, *Phragmites, Typha, Schoenoplectus), Bolboschoenus maritimus* stands.

Table 2: Sampling sites

1. Fekete-rét 1th year	460 ha
2. Fekete-rét 2nd year	
3. Fekete-rét 3rd year	
4. Fekete-rét 4th year	
5. Hortobágy Fish Pond	1350 ha
6. Kunkápolnás marsh	1500 ha
7. Polturás marsh	130 ha
8. Kis-Jusztus marsh	76 ha

During the period of the investigation on the Fekete-rét, we compared the trend of the changes in the number of the nesting species to the other characteristic wetland types of the region. Data were analysed using Jaccard Principal Coordinate Analysis and Rogers-Tanimoto Nonmetric Multidimensional Scaling (Legendre and Legendre 1983, Tóthmérész 1993).

Of course the question can be put if these habitats are comparable or does the comparison have any reason. Although we understand that it is difficult to compare a fish pond with an astatic marsh, nevertheless this work can be considered necessary, as we are considering the most important waterbird habitats of the Hortobágy.

RESULTS

The species list of the investigated habitats is shown in **Table 1** (Aradi, 1990; Göri 1993). The evaluation of the first 4 years and a comparative study of some water bodies in the Hortobágy is shown on the figures based on the data of **Table 1**. Our research have been focused on the following of the recolonization process of the area:

1. In the first year of the restored status, the immediate reaction of the waterfowl was the most remarkable. The mass of birds present in the area was far beyond the amount, which had been registered before and was the multiple of the usual amount of birds present in the other habitats in the Hortobágy with similar ecological character (Aradi, 1990; Kovács, 1982 and 1984), although, to a lesser degree, this phenomenon was observed when the drained fish ponds were filled up (Kovács, 1984). Since the second year, this invasion began to decrease. This phenomenon can be similar to the "flocking to the place" reaction described by ethologists.
2. The first period was characterized by a low number of species and high number of individuals. The area supported large flocks of bird species nesting in the Hortobágy, but without any obvious reason, the breeding did not take place. This occurrence was observed in the case of all restoration work, usually for the species which have a very active exploration movement on large areas, such as the Black-headed Gull and Terns (Whiskered T., Black-winged Whiskered T.) (Aradi, 1990). That the breeding did not occur can be explained by the continuous and rapid transformation of the area, which is due to the man-made interventions.
3. Since the second period, the number of species began to slightly increase while that of individuals fell. Very soon, already by the fourth year, a peculiar species composition developed, remaining typical of the site after ten years as well. This immediate stabilization can be explained probably by the effect of the surrounding areas (marshes, fish ponds)

(Kovács, 1984). This does not mean that any structural or functional stabilization had happened (see point 6).

In a four year period following the reconstruction, the numbers of the nesting species were 16, 27, 37, 37. Behind the apparent similarity of the 3rd and 4th years, some smaller changes can be found: three atypical species disappeared (Pintail, Mediterranean Gull, Common Tern) and replaced by three typical marsh species (Pochard, Little Cracke, Moustached Warbler) (Aradi 1972). Another important change was that the huge Black-headed Gull colony (2500-3000 pairs) after the first year began to decline and in the 6th year completely disappeared.

4. The stabilization was accompanied by the appearance, brooding and disappearance of some atypical species of this type of marshes (Avocet, Little Ringed Plover, Kentish Plover), nesting on the bare sites created by the earthwork (Aradi 1990, Horváth and Szabó 1981) .
5. Starting with a very rapid translocation, the botanical change of the habitat is still going on after thirteen years, although at a much slower rate. This slow change is not connected with the modification of the species composition or of the amount of waterbirds anymore, rather with a very fine restructuring of them.
6. The birdlife of the habitats dominated by mosaic-like vegetation structure already by the time of the reconstruction became stable, in a much shorter time inside the marsh, than in the homogenous stands. These patches played a significant role in the summarized data to suggest a stabilization already by the fourth year.

DISCUSSION

The territorial distribution of the waterbirds can be investigated in connection with the transformation of the mosaic structure of the vegetation and the characteristic points of the recolonization process (Aradi, 1990; Sasvári, 1986). Between the two phenomenon, the principles of the succesional processes can be compared. The research on the Fekete-rét showed, that, due to the rapid ecological change, special and stable bird communities don't belong to a certain part of the marsh. The changes in time in a fix direction is accompanied by a continuos translocation in space. The direction of the changes can be evaluated by **Figures 1** and **2**.

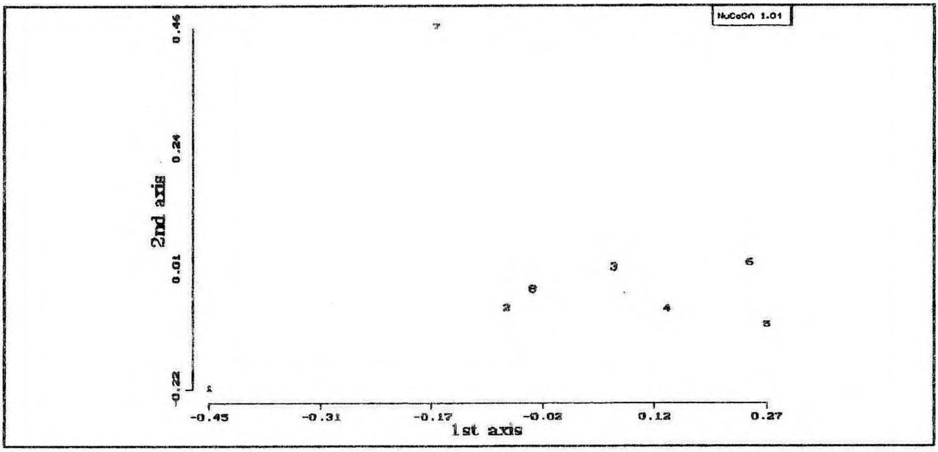

Figure 1: Jaccard Principal Coordinate Analyses

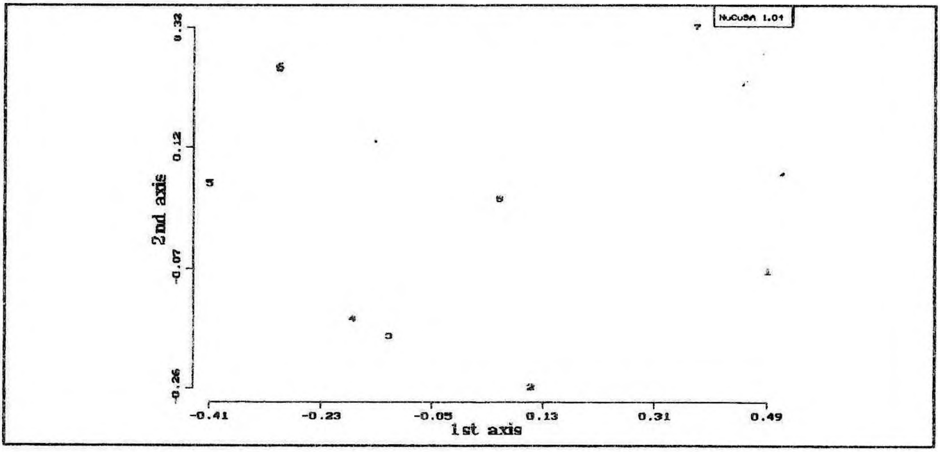

Figure 2: Rogers-Tanimoto Nonmetric Multidimensional Scaling

The Fekete-rét was functioning before the reconstruction as an astatic marsh, supplied with water only by the autumn - spring precipitation and by the confluence of the melt waters.

Therefore, the nature of the wildlife of the site has turned from the permanent marsh type into the direction to become a temporary, astatic marsh type from the time of the regulation of the Tisza River until the restoration had been started. Before the reconstruction, it already showed the temporary type; after the first year of the restoration, the astatic character was still dominant. This can be the explanation for the closeness of points 1-7 on the figures.

The downward trend of the distance between the points of the series 1-2-3-4 indicates growing similarity and the slowing down of the change respectively. While the similarity between the points 1 and 2 is low, between 3 and 4 is rather high.

The transformation of the Fekete-rét has slowed down by the 4th year, pointing towards a development of an avifauna similar to the Kunkápolnás Marsh and the Fish Pond (points 5, 6) (Kovács, 1980).

Remarkable is the situation of the Kis-Jusztus marsh (8). This water body differs from almost all the other Hortobágy types in the same degree. It can be explained by its localization (closeness of the Fekete-rét) or the starting position of the stabilization process.

The high similarity of the Kunkápolnás Marsh (5) and the Fish Pond (6) can be explained by the large size of these sites or the permanent water coverage (Kovács, 1984). The disadvantage of the Fish Pond arising from its artificial being is balanced by its extra food resources.

CONCLUSIONS

The investigation of the birdlife and the recolonization process of these marshes leads to the conclusion that the communities with mosaic-like structure show prominent diversity due to a phenomenon called "internal edge effect" (Göri 1993). Investigated separately from the whole marsh, we find that their stabilization happens in a much shorter time compared to the homogenous communities. The mosaic communities responded the most favourably to the rapid changes following the reconstruction (Aradi, 1990; Dévai, 1991). Further studies need to be carried out in order to determine how to use the water level fluctuation as a major tool in the management to maintain the mosaic-like structure, since it would imitate the ancient water-movement of the region. It is very important from a conservation point of view to repress the environmental conditions which are causing homogenization of the habitat.

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DEVELOPMENT OF WINTERING WATERFOWL COMMUNITIES DURING THE AGEING OF MAN-MADE LAKES

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ABSTRACT

In the Donaumoos near Ingolstadt, Bavaria, a large number of gravel-pit lakes have been created during the last decades. Since the beginning of the 1980s they are under investigation with respect to the species succession of wintering waterfowl, with the increasing age of the lakes and regarding the maximum bird numbers in relation to biological and morphometric parameters of the lakes.

Though even on lakes smaller than 4 ha, great numbers of birds could be seen in some cases, however as a rule lakes had to be larger than 5 ha to be attractive for waterfowl.

Based on the investigation of 37 lakes an equation was found, which describes the correlation between the size of a lake and the maximum bird number found. Yet this equation is valid for mesotrophic lakes only, because apart from the size of the waterbody bird numbers are influenced by the trophic state of the lake and its structure and shape.

INTRODUCTION

The Donaumoos, where the investigations take place, is a flat terrain with high groundwater level in Germany's pre-alpine region south of the River Danube close to Ingolstadt (**Figure 1**). The fluviatile sediments found there consist of high-quality gravel, which makes the area interesting for mining companies. Up to the sixties of this century, the size of the gravel-pits ranked between a few hundred square metres and about 10 ha. Since 1970, due to new techniques and changes in the legislative background, the size of the pits rose rapidly. At the moment, the largest area being under excavation covers almost 400 ha, but there no uniform waterbody is being created, the lake is subdivided by dikes for reasons that will be discussed later on.

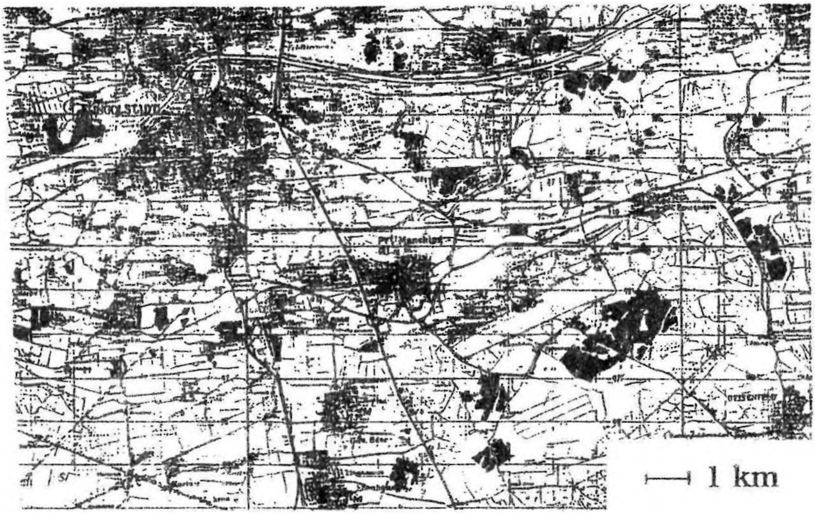

Figure 1: The Donaumoos near Ingolstadt, Bavaria. Black: gravel-pit lakes

The investigations that started in 1981 are being carried out, because there are two airfields in the Donaumoos, and the occurrence of waterfowl causes a risk to flight safety. The goal was to find out in which cases the lakes are most attractive to waterfowl and what can be done to reduce the attractiveness.

During the period of breeding and raising their young, ducks and most other waterbirds live hidden in the reedbelts and show little flight activity only. Therefore they normally do not cause problems to air traffic. (There are no breeding colonies of Laridae in the Donaumoos, for details about bird species see Schmager 1986.)

Of much greater importance with respect to potential hazards for flight safety are the migrating and wintering birds. That is because the risk of severe collisions between birds and aircraft increases with the number of birds, their flight activity, and their weight. For this reason, special attention was paid to the development of the numbers of wintering birds on the lakes. The fact that the lakes meanwhile reached a magnitude that from a bird's-eye view the mere optical impression makes them very attractive already let the Donaumoos become an important area for wintering waterfowl.

RESULTS

Species succession

As an example the changes of the bird-population on the lakes in the Feilenmoos, the part closest to the Manching airfield, are presented in the following. Since changes take place slowly and step by step, on the figures for a better understanding only the conditions in 1981 and those ten years later are presented. In order to register the maximum numbers of wintering birds - because they cause greatest risk to flight-safety - the investigations were made at the end of November or the beginning of December, just before the lakes freeze over.

The largest one of the lakes (in the south-western part of the area) was created between 1970 and 1984 with minor changes till 1989. The size is about 50 ha, the maximum depth 6.5 meters, but even in the centre of the lake, there are shallow parts and islands.

In 1981, only Mallards (*Anas platyrhynchos*) were found (**Figure 2**), a bird species searching for food on the banks or in shallow water up to a depth of 48 cm. The lacking of diving birds was due to the turbidity of the water caused by inorganic particles (Secchi-depth 60 - 80 cm), because this prevented a colonization of the benthic regions by submerged plants, so there was no adequate food supply.

Five years later Mallards were still the most frequent species, yet the number of species was much larger already. The Pochard (*Aythya ferina*) was the first diving duck found there; its food consists of benthic macrophytes and animals. Two of the three fish-eating bird species (Crested Grebe - *Podiceps cristatus* and Cormorant - *Phalacrocorax carbo*) are divers, they profit from the increasing transparency of the water (Secchi-depth now: 2.1 m). Grey-lag Geese (*Anser anser*), though taking up their food on the surrounding agricultural land, use the lake as a roosting place because of its favourable structure (islands and great distance of the centre from the shore).

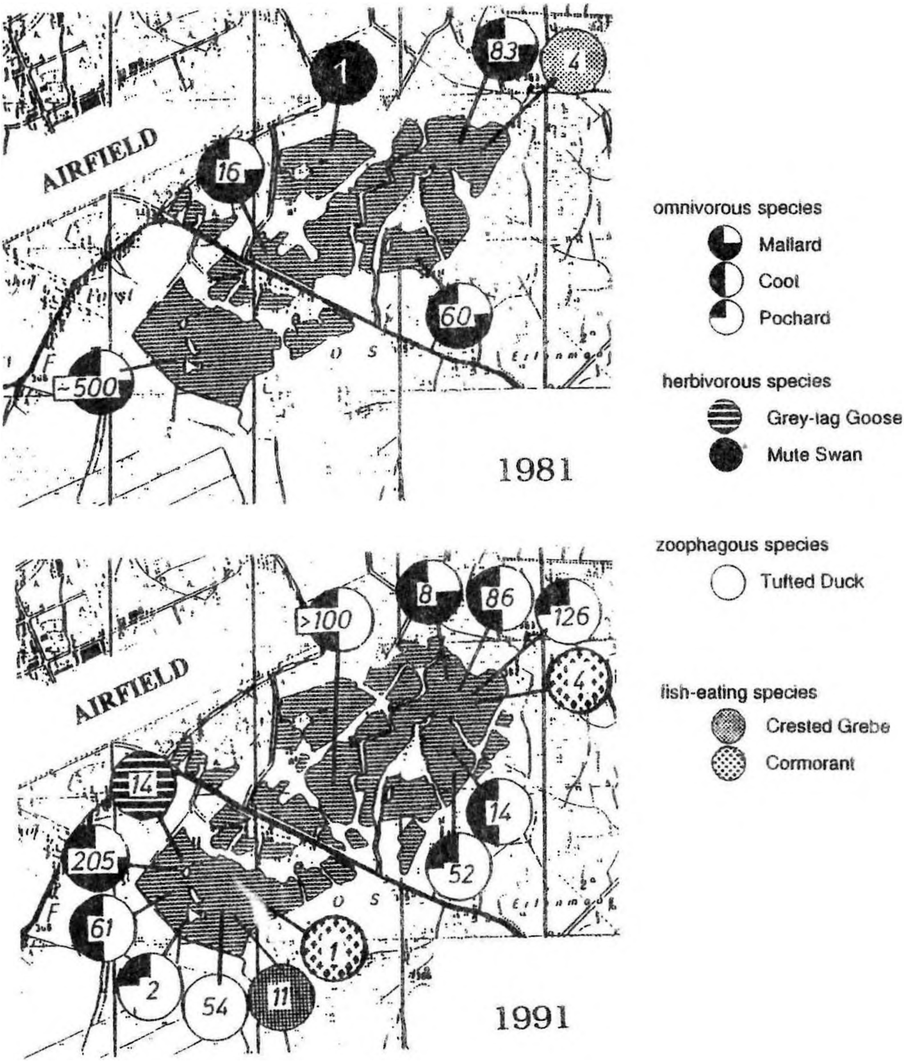

Figure 2, 3: Changes in species composition of wintering waterfowl during the ageing of gravel-pit lakes

Until 1991 (**Figure 3**) the number of species and individuals of diving birds had increased further because of the immense increase in benthic organisms that always results from accelerated eutrophication of lakes. By this time, the zebra-mussel (*Dreissena polymorpha*) had been imported into the lake. This mollusc is the main food-source for the Tufted Duck (*Aythya fuligula*) and therefore the reason for the occurrence of this bird species.

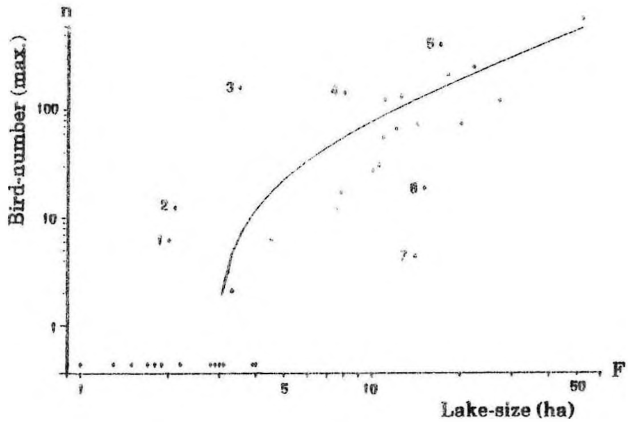

Figure 4: Correlation between lake size (F) and maximum bird number (n) on mesotrophic gravel-pit lakes: **n = 10.16F-29**

The north-eastern parts of the area had been excavated mainly between 1970 and 1980. Yet in some gravel-pits the works are still going on, besides new excavations partial refilling of lakes or their subdivision by dikes takes place. Until the end of the eighties, the water was turbid in most of the lakes. This hampered or even completely prevented the development of submerged macrophytes. Because of this, during that time only few birds visited these lakes, the Mallard being the dominant species (**Figure 2**). During the further development of the lakes, the transparency of the water increased and meanwhile the bottom of the older lakes was completely covered with macrophytes up to a depth of about 4.5 metres. In that vegetation great numbers of aquatic insect-larvae and mollusks were found, with the consequence of an increasing attractiveness of the lakes for diving birds (Coots, Pochards; **Figure 3**, in 1993 even Tufted Ducks).

The main reason for that unusually fast ongoing eutrophication and by that the development of a food-chain with aquatic birds at the end is the use of the lakes as fishing-grounds with the release of an inadequate amount of fish. To have the fishes grow the fishermen either feed them or fertilize the water, both resulting in an increase of the trophic state of the water.

Bird numbers

Besides the lakes mentioned above, several other ones were investigated in the Donaumoos (37 altogether). On this basis, an attempt was made to correlate numbers of wintering birds with the size of the lakes, in a similar way as Reichholf (1990) did for man-made lakes in the Erdinger Moos and the region west of Munich.

Figure 4 shows the dependence between the maximum bird number (n) and the lakes' surface area (F). The correlation can be described by the formula **n=10.16F-29**. (That means up to a size of about 3 ha, there is little chance only that birds consider a lake to be interesting enough to search for food or rest on it).

If the numbers are by far higher than on "average" lakes (see. no. 1 to 5 on **Figure 4**) this, as a rule, is the result of an extraordinary good food-supply. Lake no. 2 served as a receiving water for the sewage treatment plant of a small village for decades. Therefore the bottom is densely populated by chironomids and *Tubifex*. In lake no. 4, the bottom is completely covered with *Ceratophyllum* with up to 1700 water snails living there per m^2. Because of the low depth (4.2-4.5 metres) this enormously rich food source can easily be reached by diving birds. Lake no. 5 is situated right on the outskirts of a larger town and therefore despite of its size, it has the character of a pond in a park with the birds being fed there by people. Prevailing species on that lake were those accustomed to the presence of man: Mallard, Coot and Mute Swan (*Cygnus olor*).

Yet in some cases the reasons for high bird densities remain unknown (Lake no. 1 and 3) if among a homogeneous group of lakes some are visited by flocks of birds while on the others there are no birds at all.

Below average bird numbers were observed in pits still under excavation and therefore with intensive disturbances, and if either the water is made turbid by inorganic matter (lake no. 6) or if the shape of the lake is unfavourable, as it is the case with lake no. 7 in an extreme way. The latter lake is long and narrow, so the distance of no part of the surface is greater than

100 m from the closest bank. This obviously is adverse to the birds' need for safety and so they avoid landing there.

DISCUSSION

The investigations about the succession of waterfowl on man-made lakes reveal, that single birds visit the lakes already a short time after their completion, in the case of larger lakes even while they are under construction. Yet not earlier than about five years after the end of an excavation the colonisation of the lake by submerged vegetation is that dense that it - together with the inhabiting lower animals - can be the food source for a bird population rich in species and individuals.

The first species visiting a lake in search for food are dabbling ducks (food-uptake in the littoral zone). They are followed by diving species with a decreasing percentage of phytogenic food. The last species appearing are those that feed exclusively on benthic animals, which in turn are the organisms that do not colonize the lake's bottom in sufficient numbers unless the lake has reached at least a mesotrophic state.

First appearance and numbers of fish-eating bird species however are no indicators for a certain stage of succession in a lake, since development, species composition and density of fish in almost all cases is the result of artificial measures.

As soon as the size of lakes exceeds the "threshold value" of about 4 ha, the number of birds increases quite steadily with increasing lake-size. But apart from the size, the structure and the trophic state influence bird numbers, to a certain extent the latter is the most important factor, because the available amount of food depends on it.

Structural parameters that influence bird numbers and thus cause deviations from the expected value for mesotrophic lakes given by the regression, are

- **water depth**. It has a positive effect, if it is that low, that the benthic region lies within the euphotic zone completely or at least to a major part. In this case macrophytes can grow there and the bottom can easily be reached by diving waterfowl.

- the **shape**. It has a negative influence, if the distance between the centre of a lake and its banks is shorter than the flight distance of the birds, that means if the lakes are narrow.

On the other hand lakes that have a too low trophic state or are too deep to serve as feeding grounds, can be attractive roosting places if the surface is large enough to satisfy the birds' need for safety. (In this case periodic flights take place between such a lake and the feeding grounds).

These results are the basis for management measures to keep bird numbers low, if it is not possible to prevent an excavation in the vicinity of an airfield. The water-depth of excavations is given by the thickness of the gravel layer and the ground-water level, so with this respect our influence is limited. Therefore large excavation areas are subdivided by dikes to create smaller and thus less attractive water bodies. Furthermore structures that are favourable for waterfowl have to be avoided: there must be no islands and the banks must be steep and straight to reduce the area that can be used for food-uptake by non-diving bird species. Yet all those measures are of little value only, if the trophic level of the lake rises; rich food supply causes high bird numbers even if the structure is not very favourable.

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PREFERENTIAL HABITAT OF AQUATIC BIRDS IN RESTORED WETLAND

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ABSTRACT

Aquatic birds were counted in different experimental wetlands located in the Ebro Delta (NE Spain) every two hours for one day, every month from May to September in order to identify preferential habitats of waterfowl in wetlands restored from ricefields. Emergent, floating and submerged vegetation and macroinvertebrates were monitored together nutrient content in the sediments as characteristics defining the habitat status for bird utilization

The number of individuals of the different species observed (*Anas platyrhynchos*, *Gallinula chloropus*, *Fulica atra*, *Ixobrychus minutus*, *Himantopus himantopus*, *Bubulcus ibis*, *Ardea purpurea*) was, in general, higher during the early and late hours of the day than at midday.

A higher number of birds of the various species was observed in the wetlands on which *Typha* plants were the dominant vegetation compared to those where *Phragmites* were dominant. The number of birds was lower in the wetlands with short emergent vegetation (including ricefields) than in the wetlands with tall emergent vegetation.

Protection by tall emergent vegetation, open areas in the vegetation and relatively deep water are the major factors favouring the presence of waterbirds in the experimental wetlands.

INTRODUCTION

Habitat restoration is one of the main reasons for restoring wetlands (Mitsch and Gosselink, 1993). Different communities can be established in restored wetlands depending on the level of restoration achieved. Aquatic birds prefer a wetland based on their requirements for food and/or environmental protection, and these two characteristics can change in a wetland during the process of restoration.

In those areas where most of the wetlands was lost, restoring wetlands can also be a way to restore the biological community. This is the case of many lakes and lagoons where the vegetated belt was reduced, usually because of agricultural and urban developments. Restoring the wetland belt would contribute to the restoration of the habitat used by many aquatic birds. Identifying the habitat preferences of the bird community may help us to understand the community structure and the value of the restored wetland as habitat for birds.

An experimental programme of wetland restoration for the enhancement of habitat and water quality has been developed in the belts of the Ebro Delta coastal lagoons for several years. This offers the opportunity to compare the ecological characteristics of wetlands at different stages of restoration. Among other objectives, the preferential habitat of aquatic birds was studied by comparing the use of restored wetland of different ages in the reed belt of a coastal lagoon, which is reported in this paper.

MATERIALS AND METHODS

The study area consists of five wetlands located in the vegetation belt of a coastal lagoon in the Delta of the Ebro River. The five wetlands are contiguous and have the same general climate. The wetlands are abandoned ricefields (cultivated for at least thirty years, until recently) which were allowed to evolve under the same hydrologic regime for several years. They are similar in area and in their morphometric characteristics (**Figure 1**). The time since the paddy fields were abandoned for rice cultivation and became natural wetlands until 1994 - the year of this study- is indicated in **Figure 1**, and will be called here the wetland age. They all receive freshwater from a common irrigation channel from mid April to the end of September. During the rest of the year there is no water inflow. The study was performed during the plant growing season of 1994. The water column was in all the cases between 5 and 20 cm depth, except in wetland 3b, where depth was between 20 and 40 cm because it had been excavated just after the last season as a ricefield.

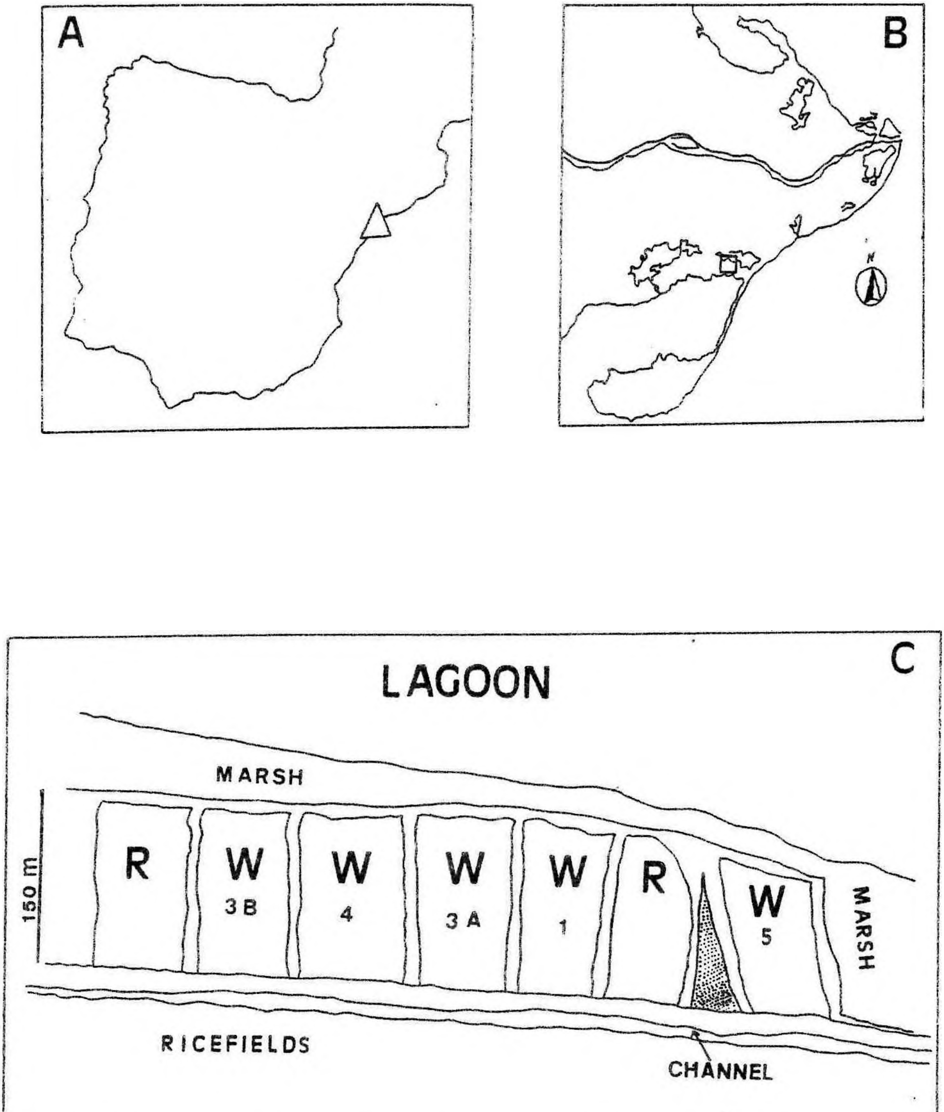


Figure 1: Study area. A) Location in NE. Spain. B) Location in the Delta of the Ebro River. C) Distribution of the wetlands. The numbers in the different areas indicate the number of years since they were abandoned as ricefields.

Aquatic birds in the different wetlands were counted monthly by walking carefully around every area and counting the birds identified by sight or sound. The count was repeated every two hours in every area during the light hours of the day. The maximum number of birds observed at any time during the day, which corresponded in most cases to the last and to the early hours of the day, is used as an estimate of the abundance of birds in the wetlands. As all the wetlands have similar areas, the numbers of birds per wetland can be used to compare bird abundance between wetlands. Observations in the different areas were recorded following a spatial sequence and taking care not to disturb the birds. The number of birds per wetland observed were lower than in other areas where colonial birds accumulate. However, these abundance are similar to those observed in other studies for birds living is similar environments (Acuna *et al.*, 1994, Lillie and Evrard, 1994).

The number of species (species richness) and the diversity index S-1/N (where S is the number of species and N the number of individuals) were used as indicators of the structure of the bird community. This index is appropriate in this context because of the low number of species and individuals in our data (Magurran, 1988). The minimum value of the index (minimum diversity) is 0 and the maximum value (maximum diversity) is 1.

Monthly samples of submerged invertebrates and macrophytes were collected with a plastic tube (ten cm diameter) from random places in the study areas. Macrophytes were collected from the space limited by the tube located in the wetland area. The invertebrate samples consisted of the animals collected within a closed plastic tube after it was towed for two meters submerged in the water. Several replicates in every wetland were obtained from random sites.

Monthly samples of emergent macrophytes were obtained from sampling quadrates (50 cm per 50 cm) placed at random in every wetland. Dry weight of plant material was determined after drying until constant weight at 70 °C.

Total biomass and necromass (decaying non photosynthetic plant material) abundance are expressed as dry weight per area unit. Density of plants, number of emergent individuals per area unit, and stem height are also used to define the wetland vegetation. Abundance of other organisms is indicated as number of individuals.

The sediment of the wetlands was sampled with a plastic tube (5 cm diameter) from three different sites at random to analyze the carbon and nitrogen content by Automatic Analyzer and phosphorus by a colorimetric method (Grasshoff *et al.*, 1983) after digestion.

RESULTS

The highest number of birds was observed in wetland 3b, followed by wetlands 3a and 4. A decreasing trend in the number of birds in the different wetlands is observed during the plant growing season (**Figure 2**). After September either a very low number or an increasing trend is observed in the different wetlands.

In wetland 3b, 3a and 4 a higher number of species was also observed than in the other wetlands. These species were: *Gallinula chloropus, Ixobrychus minutus, Anas platyrhynchos, Ardea purpurea, Fulica atra, Bubulcus ibis, Tachybaptus ruficollis, Himantopus himantopus, Chlidonias hybrida, Larus rudibundus.*

The number of species observed in the wetlands and the diversity decrease over time during the period of study. Wetland 3b is also the area with the highest number of species and diversity observed during the period of the study. The lowest values of these two parameters corresponded to wetlands 5 and 1. A general trend of decreasing number of species and diversity was observed during the period of study

A general pattern of hourly variation of the abundance of birds in the wetlands was observed (**Figure 3**). These figures represent the monthly average (and the standard deviations) of the number of birds observed at the time of the day indicated on the horizontal axis. In spite of the high dispersion of data, it is clear from this figure that the birds showed a pattern of using the wetlands mostly in the early and late hours of the day. Very few birds were observed in the wetlands during the central hours of the day. Again, a higher number of birds were observed in wetlands 3b, 3a and 4 than in the other wetlands.

None of the different biological groups studied showed any pattern of variation of their abundance's related to that of the birds (**Figure 4**). Emergent macrophytes (mostly *Phragmites australis, Typha angustifolia, Scirpus maritimus*) showed a typical pattern of increasing their biomes as the growth season proceeded (**Figure 5**)

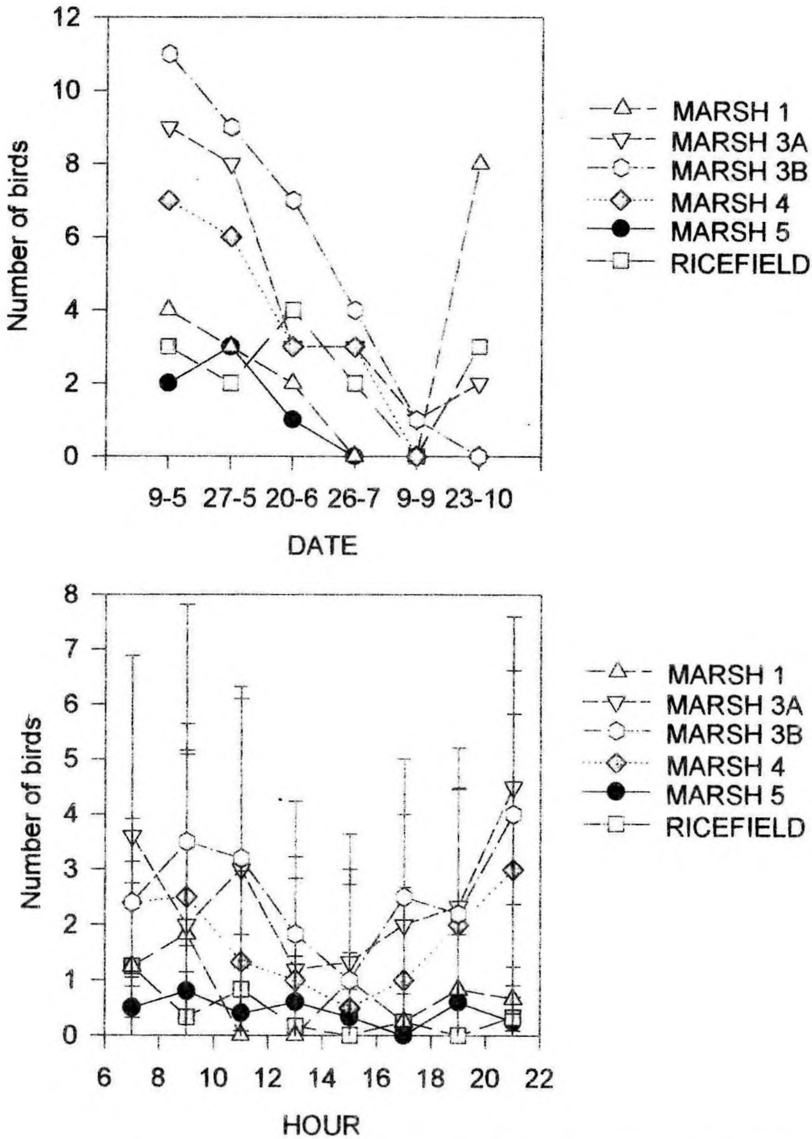


Figure 2: Above: Changes of the maximum number of aquatic birds per wetland counted during the daily observations carried out monthly during the plant growing season in the wetlands studied. Below: Average and standard deviation of the number of birds counted monthly at a given hour of the day of observation (horizontal axis).

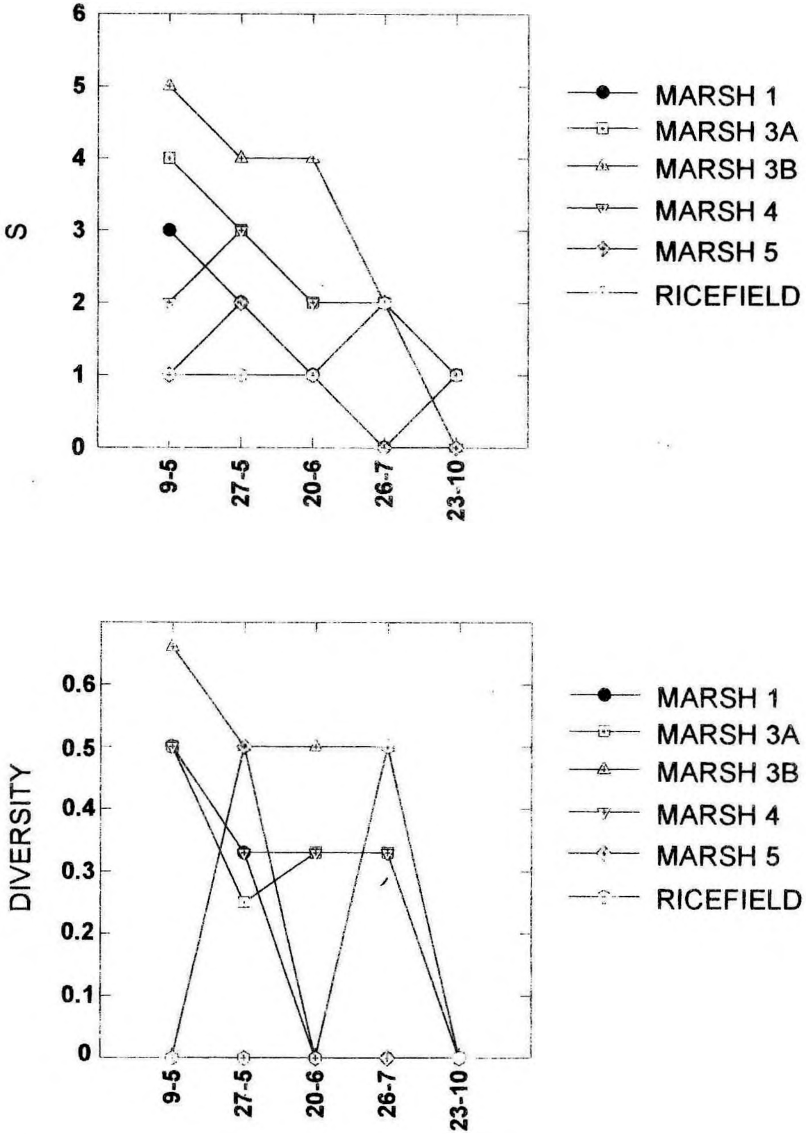


Figure 3: Number of species (above) and diversity (S-1/N, see explanation in the text) (below) in the different wetlands during the period of study.

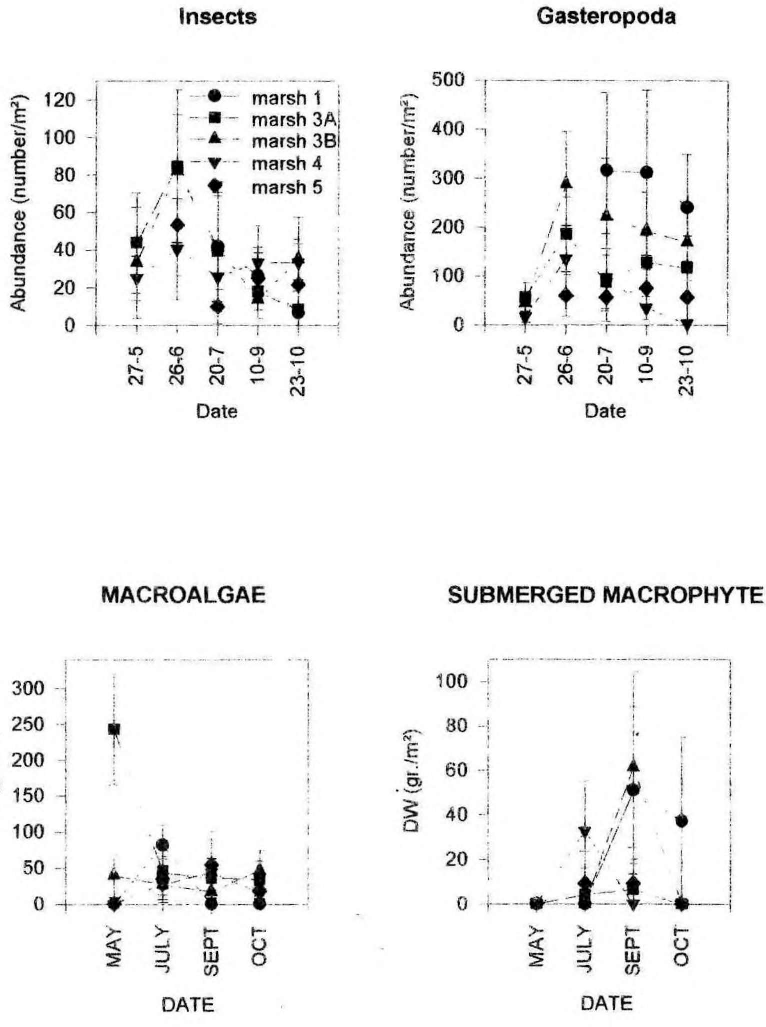


Figure 4: Changes of the abundance of different biological groups in the wetlands during the period of study.

Differences between wetlands are attributed to the age and species composition of the vegetation. In wetland 1, the emergent vegetation was dominated by *Echinochloa crus-galli* and short *Typha angustifolia*. The maximum height of the plants in this wetland was 40 cm at the end of the growing season. Wetland 3 is dominated by *Scirpus maritimus* and *Typha angustifolia*. Wetland 4 is dominated by *Scirpus maritimus and Phragmites australis. Wetland 5 is almost exclusively occupied by P. australis.* In general, the older the wetland the higher the biomass reached during the growing season. This is also the case for the dry weight of decaying emergent macrophytes accumulated in the wetlands (**Figure 5**).

Differences between wetlands are also observed on the basis of the structure of the emergent vegetation. The highest biomass observed in the oldest wetland is due to a higher density and height of the stems than in the other wetlands (**Figure 6**).

The sediment characteristics of the wetlands showed a higher nutrient content, particularly clear for carbon and nitrogen content, as the wetlands' age increases (**Figure 7**).

DISCUSSION

All the results from this study indicate that wetland 3b (a 3-year-old wetland with a 20-40 cm water column) contained the highest number of birds and the highest structure of the bird community compared to the other wetlands during the growing season of the vegetation. Wetland 3a (a 3-year-old wetland with a 5-20 cm water column) follows wetland 3b in bird abundance and community structure and it is also outstanding compared to the other wetlands. Wetland 4 occupies an intermediate position between wetlands 3 and wetlands 5 and 1 with respect to the presence of birds. Clearly, wetlands 5 and 1 contained the lowest number of birds and their bird community structures were the lowest, as indicated by the species richness and diversity indexes.

Wetland 3b appeared to be more attractive to birds. In this wetland, the water was deeper, the plants were less dense and taller than in the other wetlands. These characteristics are related to the possibility of living in a protected environment and, at the same time, allow birds to hide and move more freely than in the other wetlands. These characteristics favor the preferential selection of this wetland by the birds. Wetlands with very dense vegetation - e.g., wetland 5 - present difficulties for birds to move within the wetland. On the other hand, wetlands with low plants - e.g., wetland 1 - do not offer as much protection for the birds as wetlands with taller plants.

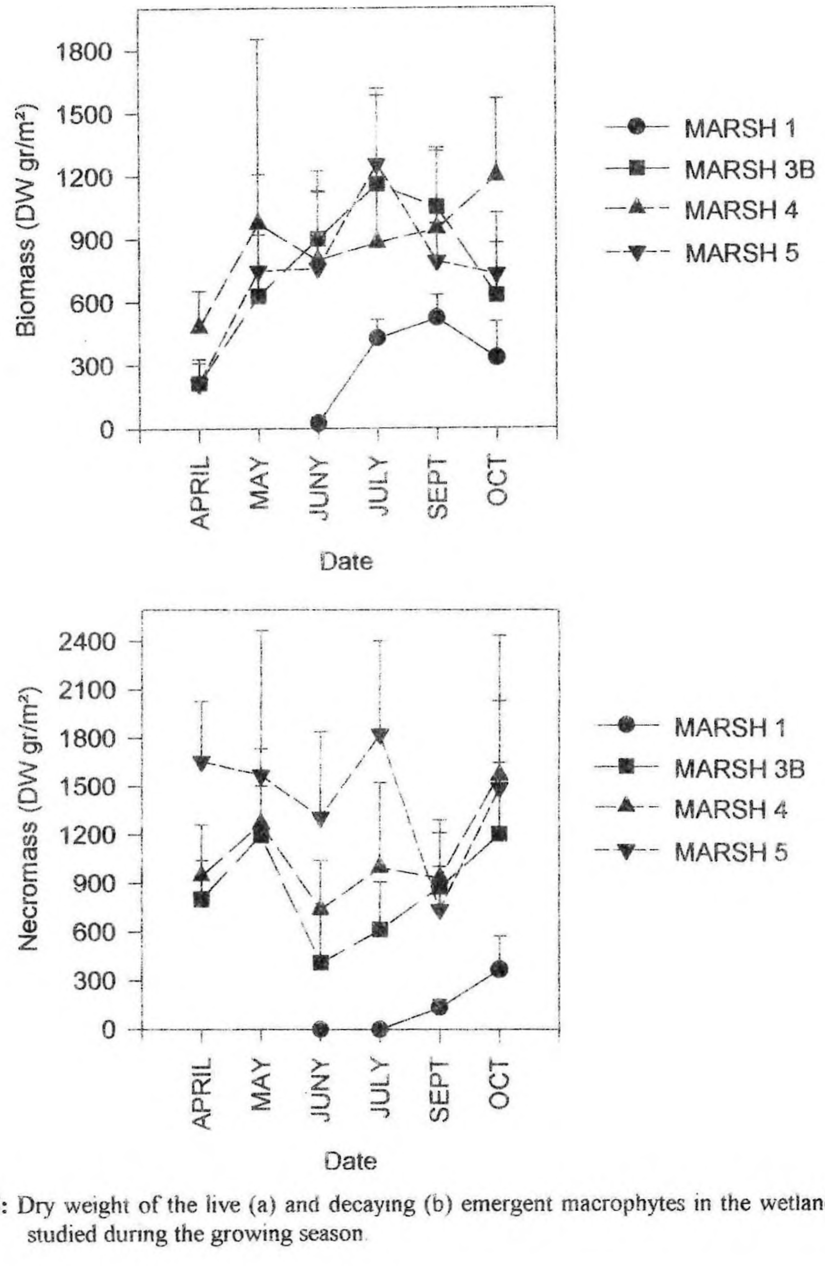


Figure 5: Dry weight of the live (a) and decaying (b) emergent macrophytes in the wetlands studied during the growing season.

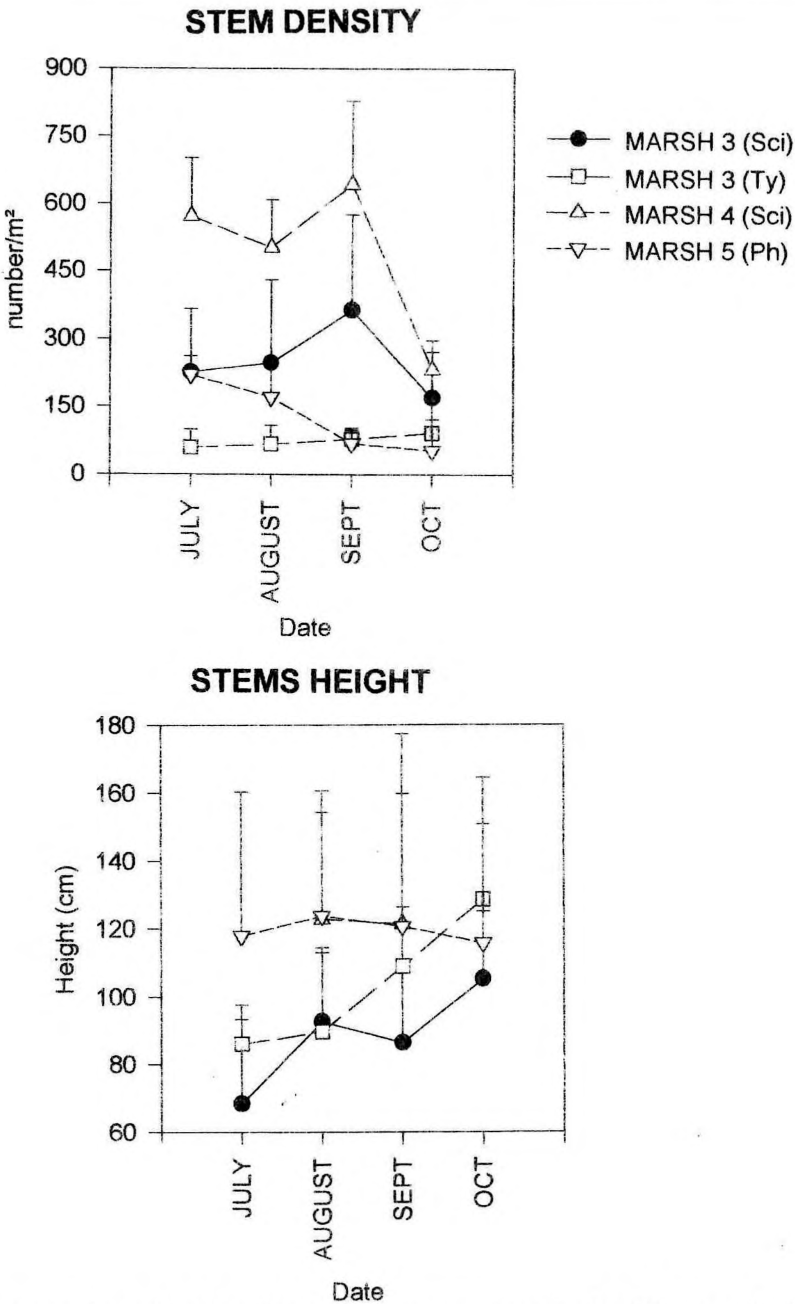
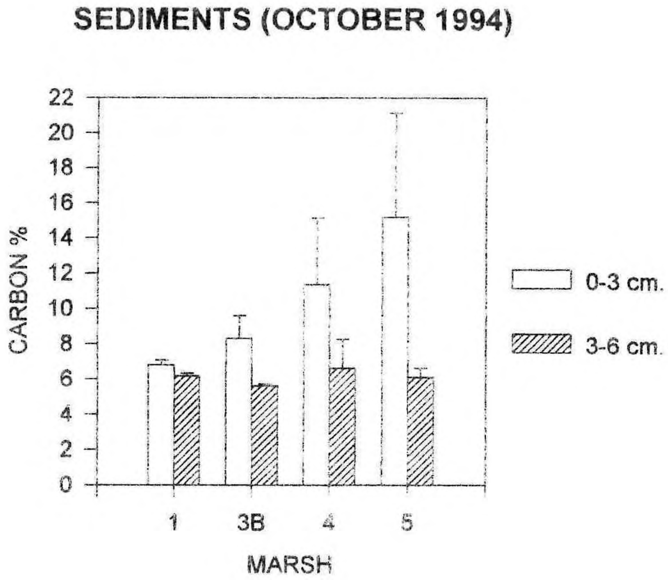


Figure 6: Stem density and height of the emergent macrophytes in the different wetlands during the growing season.



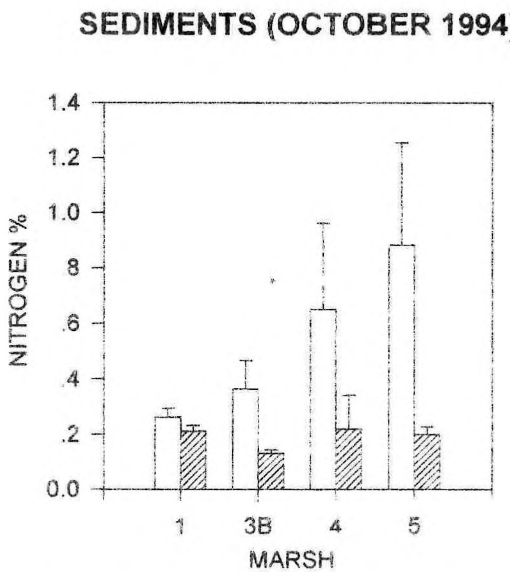


Figure 7: Some characteristics of the sediment in the wetlands at the time indicated in tl figure.

The facts that the number of birds varies during the day, with a trend to stay in the wetlands at night, and the lack of apparent relationship of the number of birds to the abundance of other biological groups, which could be potential food for the birds, indicates that these birds used these wetlands mostly as a refuge during the early and late hours of the day and to rest at night. For this reason, a wetland with relatively tall and not excessively dense emergent plant population is attractive for a bird because it provides more quietness, security and it is more comfortable than a wetland with very low or too dense plants. One additional aspect is the fact that wetlands 3 are dominated by tall *Typha* and, because of this, a relatively high amount of decaying plants which, while accumulating in the wetland, form small mounts of soft material, which is used by the birds to rest and to form nesting areas. This is not possible either in wetlands dominated by *Scirpus* or *Phragmites* - wetlands 4 and 5 - because of the morphology of their leaves or in wetlands dominated by short *Typha*, because of the size of their leaves.

It is interesting to note that the data obtained for the ricefield give to it a close position to wetlands 5 and 1 in the preference of the birds. Ricefields, after the plants emerge from the water- have intermediate characteristics from the points of view considered here - water column depth, height and density of the emergent plants - in comparison with the range of wetlands considered, but closer to wetland 1 than to wetlands 3. As ricefields have been claimed to play an important role as alternative habitats for birds in the surroundings of natural areas (Fasola and Ruiz, *in press*), it is interesting to note that this is a forced alternative. Our results show that birds prefer natural habitats to rest in. The use of ricefields may be linked to the greater accessibility of food compared to other environments, as has been mentioned elsewhere (Ferrer and Martinez, 1987).

If a 2-year-old wetland had been available during this study the gradient of bird preferences shown here might have been shown complete. That is to say, the characteristics of the plant populations in wetland 2 would be intermediate between those of wetlands 1 and 3 and, consequently, the bird community characteristics in wetland 2 would be intermediate between those of wetlands 5 and 1 and those of wetlands 4 and 3. From the results presented here, a general conclusion can be proposed: wetland restoration plans for this particular area should aim to maintain zones of vegetation on the lakeshore at an intermediate successional stage, if the major objective is to favour waterbird populations in some way. The heterogeneous environment (from the point of view of vegetation structure) created in natural conditions on the shores of many coastal lagoons may provide areas of the characteristics mentioned here as preferential habitat for the birds observed in our study.

ACKNOWLEDGMENTS

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CONSTRUCTED WETLANDS FOR TERTIARY TREATMENT OF DOMESTIC WASTEWATER AND CREATION OF WILDLIFE HABITAT

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ABSTRACT

Hundreds of constructed wetlands for the treatment of wastewater have been built in Europe and the United States. The benefits and function of these wetlands as wastewater treatment systems have been documented in numerous books, and symposia, as well as hundreds of peer-reviewed scientific papers. A new, value-added approach is to design constructed wetlands to optimize their wastewater treatment efficiency and value as wildlife habitat.

Construction of two wetlands at River Hebert River, Nova Scotia, Canada was completed in October, 1994. The purpose of these wetlands is to create wildlife habitat and treat domestic wastewater that is currently being discharged from a primary/secondary aerated lagoon system. Segment 1 is a 1.9 ha highly engineered wetland that has two internal berms to maximize retention time. The bottom of this wetland has been cleared of all vegetation and graded level. Segment 2 is a 6.5 ha wetland that has a morphology similar to natural wetlands. There is slight variation in the elevation of the wetland, with deeper areas created during the excavation of materials to build the external dikes and nesting islands.

The objectives of this study is to evaluate the cost-effectiveness of the two wetland designs in treating wastewater and providing wildlife habitat. It is planned for water chemistry, primary productivity, and wildlife use of the constructed wetlands to be monitored over the next 10 years.

INTRODUCTION

The use of free-surface-water constructed wetlands has gained much attention during the last decade because of their ability to offer a low-cost alternative to traditional sewage treatment systems (Hammer, 1989; Moshiri 1993). Many wetlands in Atlantic Canada are oligotrophic and this lack of available nutrients results in low levels of primary and secondary productivity as well as waterfowl use (Kerekes *et al.* 1986, Underwood *et al.* 1986, Bateman *et al.* 1994). Wetlands that receive anthropogenic nutrients are known to have increased primary productivity and wildlife use (Melanson and Payne 1988). In fact, some of the highest waterfowl densities observed in Atlantic Canada have been on sewage lagoons or wetlands receiving effluent discharged from sewage systems (Stacier *et al.* 1994). The basis for this project is the philosophy that domestic sewage is an under-utilized resource containing valuable nutrients and where possible we should construct wetlands instead of sewage lagoons.

Atlantic Canada is characterized by many small towns (<5,000 people), widely dispersed along the coast or inland water systems. Because of the small tax base and easy disposal of effluent, many communities have no sewage treatment facilities or facilities that do not provide adequate levels of sewage treatment. With population growth and an increased understanding of how sewage effluent affects water quality and the environment, there is growing pressure for the development of sewage treatment facilities. The harvesting of shellfish such as soft-shelled clams (*Mya arenaria*), and blue mussels (*Mytilus edilus*) are an economically important industry, but increasingly, shellfish areas are being closed due to bacterial contamination. Moreover, the discharge of effluent with high nutrient levels and biological oxygen demand creates conditions unfavourable to salmonids. Angling for brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*) is an important recreational activity and a key component of the tourism and guiding industries. Thus, there is an economic as well as environmental benefit of sewage treatment.

The majority of existing sewage treatment facilities in Atlantic Canada consist of aerated primary and secondary lagoon systems. These facilities are relatively efficient at reducing suspended solids and biological oxygen demand but the effluent can still remain high in nutrients. These high levels of nutrients can be responsible for eutrophication and subsequent undesirable algal blooms in the receiving waters.

Constructed wetlands and natural wetlands have the same nutrient cycles, mechanisms and rates (see Moshiri, 1993). Wetlands develop unique floral and faunal communities in response to high levels of nutrient availability. The majority of existing constructed wetlands have been designed to maximize their sewage treatment efficiency and minimize their size (Knight *et al.* 1993). This maximization of efficiency per unit area of wetland results in highly engineered wetlands with high construction costs. Wetlands were constructed at River Hebert River to optimize their efficiency of wastewater treatment and optimize their suitability as wetland habitat. The objectives of this study are to evaluate the cost-effectiveness of constructed wetland designs in treating wastewater and providing wildlife habitat. This evaluation includes determining the relative merits of a highly engineered internal berm constructed wetland compared to a constructed wetland with a natural morphology. It is planned for water chemistry, primary productivity, and wildlife use of the constructed wetlands to be monitored over the next 10 years.

METHODS

Study Site

River Hebert River, Nova Scotia, Canada (45° 41' 45"N, 64° 22'45" W) was chosen as the site for construction of wetlands. Existing sewage treatment facilities consist of primary and secondary aerated lagoons with no chlorination. The sewage treatment facilities are built on land reclaimed from tidal river, and the underlying Acadian Soils are of marine silt origin and water impermeable. The sewage system at River Hebert River treats 250 m^3 of water per day. The sewage system services 1100 people and is primarily domestic wastewater, with no stormwater or industrial wastewater going into the system. Constructed wetlands clean wastewater by transferring material into the sediments, atmosphere, or biota. Therefore the use of constructed wetlands for wastewater treatment and creation of wildlife habitat should only be promoted when the sewage does not contain heavy metals, PAHs, OCs, or other deleterious substances. As part of this program, a public awareness campaign was initiated to make residents more aware of the environmental consequences of improper disposal of hazardous household materials.

Wetland Design

Two wetlands were constructed at River Hebert River to treat wastewater (**Figure 1**).

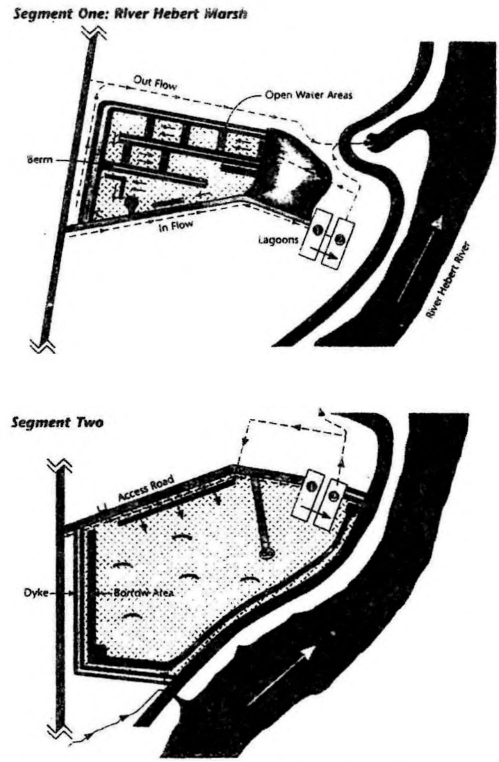

Figure 1: Constructed wetlands at River Hebert River consist of two segments. After being treated in a primary/secondary aerated lagoon, wastewater can be treated in either Segment 1 or Segment 2. Internal berms and deep water areas were constructed in Segment 1, while Segment 2 had crescent shaped nesting islands, a loafing bar and an internal perimeter ditch constructed.

The size of the constructed wetlands were determined by the availability of land and construction techniques. Data collected on flow rates, precipitation, and evapotranspiration were used to determine hydraulic loading rates and retention time in these wetlands. Hydraulic loading rates and data collected on effluent quality were used in models which predict removal performance (e.g. Knight *et al.* 1993). These models predicted that very good removal efficiencies would be obtained in both wetlands. The primary design objective of the constructed wetland is that it meets water quality discharge guidelines. After this objective has been met, then the fact that larger wetlands create more wildlife habitat, and other wildlife habitat considerations should be incorporated into the design. Designing a wetland that is larger than required to meet current loading rates also gives improved water quality and the ability to maintain discharge quality even if loading rates increase in the future.

Segment 1 is 1.9 ha in size and highly engineered. Internal berms in the wetland ensure that the effluent must travel the entire area of the wetland and thus retention time is maximized. Deep water zones were created by digging ditches 0.6 m deep, 10 m wide, perpendicular to water flow, approximately 37 m apart. Alternate areas of shallow water (0.6 m) and deep open water (1.2 m deep), decreases channelization and increases retention time. Nitrogen removal is increased because the marsh contains both deep water 'anaerobic zones in addition to the aerobic shallow water conditions that exist throughout the marsh. All vegetation was removed from Segment 1 and the bottom of the marsh graded to within 3 cm of design specifications. Cattail (*Typha latifolia*) and wildrice (*Zizania aquatica*) seeds were sowed, and water from a nearby freshwater marsh was added to expedite the colonization of submergents. There are two water control structures in this wetland, giving the capability to discharge water into the River Hebert River River or into Segment 2. All water control structures are fabricated off-site, and are constructed of concrete with steel I-beams as guides for planks which act as the dam. By varying the number and dimensions of the planks, the water levels in the wetland can be manipulated or the marsh completely drained.

Segment 2 is a 6.5 ha wetland designed to minimize construction costs while maximizing the amount of wetland habitat created. Dikes were constructed around the wetland with material obtained from the excavation of internal borrow pits. A shallow header ditch 0.6 m deep was excavated along the western side of the wetland originating at the sewage inflow point. This ditch gradually broadens from 1.3 m wide to 4 m wide at its terminus. The header ditch is designed to evenly distribute the sewage influent throughout the marsh and thereby increase retention time. Crescent shaped nesting islands, aligned to provide a lee against prevailing winds were constructed, and Tree-swallow (*Tachycineta bicolor*) and Wood Duck (*Aix sponsa*) nest boxes erected.

A determination of the relative merits of the two wetland designs will incorporate a cost analysis. Construction of internal berms in Segment 1 added substantially to construction costs ($62,000) when compared to the larger Segment 2 ($32,000). Land costs were minimal with Segment 1 costing $3,000 and Segment 2 costing $8,000.

Sampling Protocol

i) Hydrology

The volume of wastewater entering the system is determined using data obtained at the lift station located at the base of the access road. Sewage is pumped from the collection well to the primary lagoon. Having determined the volume of sewage pumped per unit time, the amount of sewage entering the system will be determined based on the amount of time the pump has been in operation. Evapotranspiration, precipitation and other climactic data will be obtained from an Environment Canada weather station located 10 km away, which is also situated adjacent to a tidal river. Water discharge from the constructed wetlands will be monitored by measuring the water level of the marsh. Discharge curves will be calculated based on the volume of water being discharged from the water control structure in relation to water levels.

ii) Water Chemistry

Water samples have been collected weekly at the outflow of the secondary lagoon to determine the level of treatment of the existing lagoon system as well as temporal variability. Water samples were analyzed for: ionic constituents (specific conductance, alkalinity, pH, dissolved sodium, dissolved magnesium, silicate, sulphate, chloride, dissolved potassium, dissolved calcium); nutrients (nitrate, total nitrogen, inorganic phosphorous, soluble reactive phosphorous, total phosphorous, dissolved organic carbon); metals (aluminum, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, magnesium, manganese, nickel, lead, strontium, vanadium, and zinc); common wastewater parameters (suspended solids, biological oxygen demand, faecal coliform bacteria, total coliform bacteria); and toxics (PAHs, PCBs, Ocs) Once the constructed wetland begins treating wastewater in the summer of 1996, water samples will be collected at the inflow and outflow. Water samples will be analyzed for the water chemistry parameters already listed as well as phytoplankton abundance (chlorophyll-a concentrations). On site measurements of dissolved oxygen, conductivity, and pH will also be taken.

(iii) Sediments

Sediments were collected from the constructed wetlands in October 1994 and analyzed for toxics (PAHs, PCBs, and Ocs), metals (aluminum, arsenic, barium, beryllium, cadmium, cobalt, chromium, copper, iron, magnesium, manganese, nickel, lead, strontium, vanadium, and zinc); nutrients (total nitrogen, total phosphorous, potassium, calcium), conductivity, pH, cation exchange capacity, and soil particle size. Sediments will be again sampled in 1997. Redox potential of the sediments will also be measured in the field beginning in 1996.

Wildlife

Waterbird use of the wetlands will be measured by conducting hour long bird counts from elevated viewing platforms. Muskrat use of the wetland will be estimated based on the number of lodges observed. Muskrat carcasses were obtained through a local trapper from the lagoons and ditches that carried effluent from the lagoon to River Hebert River. River muskrats were also collected from wetlands in the area not exposed to sewage effluent. General nescropsies were performed and tissues will be analyzed for metal and toxin levels. Muskrats and fish will also be collected in the future to determine risk to wildlife from exposure to sewage effluent.

RESULTS AND DISCUSSION

Evaluating the treatment efficiency and wildlife use of the constructed wetlands will begin during the summer of 1996.

The use of constructed wetlands for the treatment of wastewater gained public attention and acceptance because it is a cost-effective alternative to traditional wastewater treatment facilities. Constructed wetlands are land intensive and rely on natural wetland organisms and processes to treat wastewater. Conventional systems are resource ($$) intensive, because they are constructed of steel and cement and require electricity and chemicals to operate. It is of paramount importance that the system adequately treat the wastewater and meet legislated standards of treatment. Constructed wetlands can not make heavy metals or toxic chemicals disappear, rather they are buried in the sediment or incorporated into the food chain. Therefore the use of constructed wetlands should be promoted for domestic sewage only, i.e. wastewater that is high in faecal matter and low in solvents, heavy metals, or other toxic chemicals. Constructed wetlands will operate more efficiently and have lower maintenance costs if they are associated with a primary lagoon system.

Although this project has only recently been established, considerable interest has been expressed by wildlife agencies, municipalities, and environmental agencies. Because of the benefits to many sectors, cost-sharing relationships can offer financial impetus towards the construction of wetlands for treatment of sewage and creation of wildlife habitat. We encourage other groups to promote the multi-resource benefits of using constructed wetlands to treat domestic wastewater and create wildlife habitat.

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CAN WE RESTORE WATERFOWL POPULATIONS BY RESTORING AQUATIC MACROPHYTES? EXPERIMENTS IN A NEW ZEALAND LAKE

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The black swan population of Hawksbury Lagoon, a very shallow (z = 40 cm) eutrophic coastal New Zealand lake, collapsed in April 1993. After being stable for more than 3 years at a mean of 250 birds (10 ha^{-1}) it declined to below 10 in a 2 week period with the advent of an algal bloom, higher water levels, increased turbidity of the water, and loss of aquatic macrophytes. In August (Southern spring) an attempt was made to restore the population by lowering the water level to allow more light to reach the lake bottom, and reestablish the benthic flora on which the swans feed. This attempt enjoyed a spectacular success initially, with a progressive increase in the biomass of benthic algae to 30 gm^{-2} by February, and a tightly coupled increase in the swan population to 25 ha^{-1}, the highest ever recorded for the lake. This success was, alas, short-lived. The benthic light climate deteriorated again in association with high phytoplankton biomasses and sediment resuspension by wind, the benthic flora again collapsed, and the swans departed. Swan grazing did not contribute significantly to this loss of vegetation. A model for sediment resuspension suggests that the benthic algal biomass almost reached the threshold necessary to suppress wave resuspension of sediment, and the experiment will be repeated in 1994, in an effort to switch the ecosystem to a state in which benthic plants are dominant and the swan population is high.

This and earlier studies indicate that there are discontinuities in the swans' numerical response at both high and low macrophyte biomasses. Biomasses as low as 3 gm^{-2} support good populations, but below 2 gm^{-2} the birds are effectively absent. Conversely, studies of faecal distribution indicated that when the biomass of filamentous algae became very high, swans were largely excluded from the areas of the lake in which patches of algae grew close to the surface, and the total population declined. Calculations based on grazing consumption and algal growth rates in spring- autumn indicate that benthic algae need to attain a biomass of only 6 gm^{-2} to ensure escape from complete suppression by swan grazing. Once this threshold biomass is exceeded, their potential for regulation of the algae is slight. Swan faeces similarly contribute little to the nutrient pools or nutrient dynamics of the lake.

The very close correlation between swan population density and benthic plant biomass (r^2= 0.95) during the present study, indicates that a management strategy which is effective in restoring the benthic vegetation will be beneficial to the swan population of this lake. In earlier studies we have also shown that winter populations of black swans are significantly correlated with plant biomass for lakes spanning a wide range of size and trophic status.

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