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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.

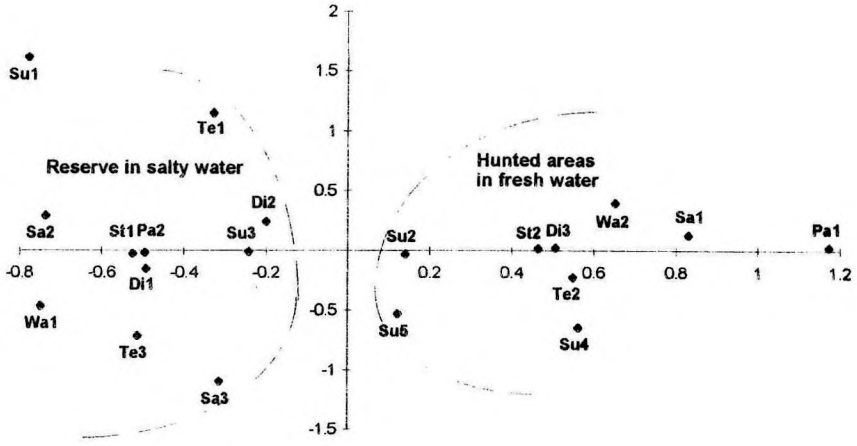

Figure 1: Habitat variables represented by their centre of gravity on F1 x F2 plane. Di: Disturbance, Pa: Parcelling, Sa: Salinity, St: Status, Su: surface, Te: Temporality. Number following the code indicates category (after Dehorter & Tamisier, in submit).

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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