Selection of Foraging Micro-Habitat in the

LITTLE EGRET (Egretta garzetta L)

in the Reserve Tour du Valat Camargue, southern France

by Johan Timmer

Modifierraneates

Sea

Étange de Vaccare

Tour du Vala

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INTRODUCTION

The study related in this report was conducted in may through october 1984 in the Camargue, the delta of the river Rhone, on the french Mediterranean coast. It is an alluvial plain, bounded to the North by young tectonic hills, to the East by the main branch of the Rhone and to the South and West by the Mediterranean Sea. A concise overview of the region's geological development and subsequent modification by man is given by Blondel and Isenmann (1981). Insight into the Camargue's importance for the european avifauna is afforded by the same source.

work was done at the biological station Tour du Valat, A11 which is part of the private reserve of the same name, founded in 1954 by Dr. Lukas Hoffmann. Following the terminology used by Blondel and Isenmann (1981), the reserve is situated in the "fluvio-lacustrine Camargue", a landscape formed by recent fluvial action and transgressions. The station's main effort is directed towards wunderstanding of the ecological functioning of wetland systems, especially those factors limiting the distribution and abundance of Ciconiiform wading birds. One of the remarkable achievements made, which is of great importance to this study, is the successfull attempt to establish a colony of tree-breeding Ardeidae on the grounds of the reserve (Hafner, 1982). The numerically dominant species of Ardeid in the colony, as in the whole of the Camarque, is the Little egret (Egretta garzetta L.). It is certainly the one bird species studied in most detail at Tour du Valat. Detailed descriptions of the bird's feeding ecology and behavior are to be found in Hafner (1977) ,Hafner, Boy and Gory (1982) and Hafner and Britton (1983).

The study subject originally aimed at was a continuation of the work done by Harro Reeders (1983) on the prey available to E. garzetta in the marshes of Ligagneau, on the East bank of the Rhone. This, however, proved not to be feasible because in 1984 no birds bred in the colony there and the marshes themselves were largely dry.

The aim of the study eventually conducted is the achievement of a general insight in the factors influencing E. garzetta's choice of foraging habitat on a micro-patch scale and the interrelationship between these factors.

The relevance of such a study is to gain knowledge meeded for management of wetlands with regards to E. garzetta's requirements. For that reason, much of the effort was concentrated on the artificial marshes next to the station, which are very close to the Tour du Valat heron colony and therefor of great potential value to the colony at times of high food demand. Moreover, being former ricefields, they allow more precise manipulation of micro-habitat than do the natural marshes, thus allowing an experimental approach in the longer run.

The improvised nature and limited timespan are not ideally suited to the complexity and novelty of the matter at issue. However, an effort was made to analyze the data available in such a way as to indicate the possibilities of a similar study if conducted on a longer term. The work was done as a project in the biology "Doctoraal" programme at the Rijksuniversiteit Groningen, The Netherlands. Supervisors were Prof. Dr. Rudolf Drent, Department of Zoology at the said university, and Dr. Robert Britton and Dr. Heinz Hafner, both of the Station Biologique de la Tour du Valat, Le Sambuc, Camargue, France.

Johan Timmer





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Description o	1 V
Table 1 :	

Areas of natural marshes not given because of strong fluctuation during the study period. Map of recent land use experimental fields : App. 2

			ATT TRATAT	148 ; App. 2.		
Natural marshes	Area	Dried up	Grazing or	ວ ນ ວ ນ >	астоп	Short characteristic
	ha	in 1984	treatment	Submerged + floating	Emergent	
Relongues de la Tour du Valat		early July	horses	Dom: Chara spp. Zanichellia pedunculata Add: Ranunculus ba ć tii	Dom: Scirpus maritimus Tamarix sp. Tvpha spp.	Uniform, short-grazed, emergent cover<5% ; aquatic vegetation variable, mostly/10 and<60%.
				Potamogeton pusillus Callitriche spp.	Add: Scirpus lacustris Juncus spp. locally along shores.	Strongly influenced by trampling Tamarix nearly continuous along both banks, some bushes in marsh.
Marais de St Seren		Mid-July	cattle, mown after	Dom: Chara spp.	Dom: Scirpus lacustris	Emergents concentrated in clumps.
			drying up.		Add: Typha spp. Scirpus maritimus Juncus spp. almost cont. along shores.	Aquatic plant cover mostly 20-70%, rarely none. Tamarisk along fringes and on small islands.
Etang de Redon		Mid-July	cattle, mown after drying up.	Dom: Chara spp. Zanichellia pedunculata	Dom.high: Typha spp. Scirpus littoralis low : " maritimus	Emergents: pattern of patches. Short-grazed (S.maritimus) and tall (Typha) with a few deeper
				Add: Ranunculus spp.	Add: Phragmites australis Juncus spp.	parts devoid of emergents. Aquatic: uniform, mostly 20-50% cover. Tamarix almost and Juncus completely restricted to frinnes
Bonborinette		mid-June	cattle.	Dom: Chara spp.	Dom: Juncus spp.	Emergents : wide Fringe of Juncus:
	-			Add: Ranunculus spp.	Typha sp. in centre Scirpus maritimus in N. part. Atriplex hastata var.	dense; centre sparse, high Typha. Aquatic : mostly 20-60% cover, densest in deeper parts
Experimental fiel	ds				salina.	
C 2 C 3a	1.82) 0.55)		Roues-cages (tractor)	Dom: Naīas flexilis	Dom: Scripus micronatus. Polynographics	Emergents : untreated parts,
င ၁ ၁ ၁ ၁ ၃ ၁ ၁	0.63) 1.06)	October		Add. Chara spp. Ranunculus spp.	Alisma plantago-aquatica	cover IU-3U%, height 40-70 cm. treated parts lower, but little [less dense.
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.84)				Add: Scirpus maritimus	Aquatic: untreated parts sparse, (<10%), treated parts more, yet still<10%. Very shallow.
6 10	1.41		hardly at all used hy horses	Dom. Naīas flexilis	✓ ^C ² , ^C ³ , ^C ⁴ etc	✓ C 2 etc Very low water table, some use by horses for resting after drying up completely.
C 11	2.25	late Sept.	lightly grazed bv	Dom. Naīas flexilis	Dom. Scirpus micronatus	Emergents : 0-20%, oriented in
			horses since 1984 (?)	Add: Chara spp. Ranunculus spp. Alisma plantago- aquatica in roubines.	Add: Scirpus maritimus Alisma plantago-aquatica Paspalum digitatum	rows上road (previously tractor- treated). Aquatic: O-60%, highest in rows with sparse emergents. Nb: depth differences rows. Vegetation very variable,
C 12	2.71	dry all season				more species than in any other field
C 13 b c	0.53 0.52	early Octo.	horses (lightly) since 1984	Dom. Filamentous algae (very !) Naīas flexilis	Dom : Juncus Eleocharis palustris	Emergents: 0-10% uneven. Aquatic: 0-100%, very dependent on
				Add: Ranunculus spp. Chara spp.	Add. Paspalum digitatum Phragmites australis Iris pseudacorus.	local concentration of Fil. algae. Rather deep (20-40 cm) ; fringed by shrubs and trees on all sides.
C 13 a	1.24	early Octo.	horses since 1982	Dom: Naīas flexilis	Dom. Paspalum digitatum	Emergents : even 0-20%. Aquatic : 10-60%.
		-				

Rather deep (15-30 cm).	Emergents: Paspalum evenly distributed. O-10%,Iris in tussocks.	Aquatic : cover 10-20%, distribu- tion greatly influenced by tramp- ling.	Depths 10-30 cm, mostly < 20 cm. Emergents: even, 0-10%.	Aquatic: even, 10-60% distribution greatly influenced by trampling. Depth 5-15 cm, mostly<10 cm. Nb : Water input via D 6.	Similar D 7.	Nb. water table communicating, input into D 8.	
Add: Scirpus maritimus Alisma plantago-aquatica	Dom: Paspalum digitatum Iris pseudacorus	Add: Scirpus micronatus	Dom. Paspalum digitatum	Add: Alisma plantago-aquatica	Dom: Paspalum digitatum	Auu: Allsma plantago-aquatica	
Ranunculus spp.	Dom. Naīas flexilis	Add: Chara spp. Ranunculus spp.	Dom: Naias flexilis	Add: Chara spp. Ranunculus spp.	Dom: Naīas flexilis Add: Chara son		
	horses; heavily since 1982		horses; heavily	since 1982	horses; heavily	since 1982	
	1.03		1.08	n attantisetter data sing asper	0.76		

0 0

D 7

6 0



Photo 1: The Etang de Redon in late may: deep water, high emergent vegetation, whose visual aspect is dominated by Scirpus lacustris and Typha spp.



Photo 2: The Marais de Saint Seren shortly before drying up completely in mid-july. Note the dense clumps of grazed Scirpus lacustris and the near-total absence of emergent plants outside these clumps.



Photo 3: Horses grazing in experimental fields D8 and D9. Note the shallow depth and the short-grazed emergent vegetation, dominated by Paspalum digitatum.



Photo 4: Experimental fields D6 (foreground) and D7. Note the high tussocks of Iris pseudacorus. The low, intensively grazed emergent vegetation exists mainly of Paspalum digitatum.



Photo 5: The ungrazed experimental field C5 during treatment with "roues cages" (cage wheels). The high and very dense emergent vegetation is dominated by Scirpus micronatus, Polypogon montspeliensis and Alisma plantago-aquatica.



Photo 6: The 1m² frame used for sampling, held in place by two short canes. The knots along the diagonal strings indicate the points where depth to vegetation and depth to sediment were measured.

P A R T I : ANALYSIS OF FEEDING SITE CHARACTERISTICS

I-1-A: AIMS : 1-To describe in detail the micro-habitat =========== characteristics of foraging sites chosen by Little egrets

- 2-By comparison with a number of randomly chosen points, to determine whether birds were selective in their choice of foraging site
- 3-To attempt an analysis of some of the factors emerging as crucial in any selectivity encountered
- 4-To function as a pilot project for more extensive habitat studies in the longer run

I-1-B: METHODS

From ideas (basically Bob Britton's, worked out and supplemented by the author), study of literature and try-out in the field, a data sheet was developed which contained entries for a wide range of data on vegetation and physical variables (App. 1).

Initially, two sets of data were intended to be gathered:

- Descriptions of sites where egrets had been observed to take a peck (bird points) and
- Descriptions of sites established by random coordinates obtained from the computer, plotted in a grid superimposed on airphoto-interpretations of the marshes. The latter were traced on transparencies on black and white panchromatic photography, original scale 1:25 000, enlarged to approximately 1:5 000. The method described above for establishing the random points, however, proved unsatisfactory due to the irregular shape of the marshes. It was replaced by the "closed eye and pencil"-approach and, in one case (Marais de St. Seren), points taken at random distances apart along a transect defined by a random compass bearing.

For two of the experimental fields (artificial marshes), systematic descriptions were conducted, taking points along diagonals.

At each point, a 1 m2 sampling frame (Fig I-1) was placed and micro-habitat variables were described for this area, using the above- mentioned sampling form.

1-2: SPECIFICATION OF VARIABLES AND THEIR DESCRIPTION OR MEASUREMENT

General and physical variables

Sample number: Each natural marsh worked in was given a oneletter code: R = Relongues de la Tour du Valat S = Marais de Saint Seren E = Etang de Redon B = Bonborinette Each experimental field was given a code corcorresponding to its number on the map (App.

2). Per marsh, each sample was given a code existing of one letter to indicate the type (0 = bird points, R = random points, S =

(0 = bird points, R = random points, S = systematic points) and a number.

- Coordinates: As described above, random points were initially selected using random coordinates. The entry for topographic coordinates to allow a numerical description of the site's location was not used.
- Weather variables: Temperatures were measured with an aquarium thermometer. All measurements were taken avoiding direct exposure of the thermometer to the sun, the air temperature was taken as well as possible out of the wind as well.
 - Wind direction was measured with a precision of 10 degrees, using a Silva 15-TD-CL orienteering compass.
 - Wind velocity was measured in meters per second with a hand-held anemometer manufactured by Jules Richard, Paris, type no. 7253.
 - Cloud cover of the sky was estimated in eighths.

Hydrographic and sediment variables:

- At each site, two water samples were taken. One was used to measure water density rather than the salinity mentioned one the data sheet. The other one was used to me asure turbidity and apparent colour in a Hach DR-EL/2 portable spectrophotometer. Readings were taken with a precision of 10 units (Hach 1975).
 - Percentage of quadrat out of water was estimated and described using the scale described in App. 3.
 - Height of waves was estimated and described using the scale described in App. 4.
 - Descriptions of the sediment were given using color and consistency, but not included in the analysis and are therefor left undiscussed.

Distance to nearest: - Shoreline: not considered if more than 25 metres away.

 Colony: for the the marshes studied, this was always the Tour du Valat colony.

- Artefact: not considered if more than 25 m away and not deemed of influence. All man-made contraptions were included, except in the experimental fields, where the dikes enclosing the fields were not mentioned.
- Depth distribution: Depth to submerged vegetation and to sediment were measured in cm. with a ruler at the center of the quadrat and at 16 fixed points along the diagonals.

Wading depth: Registered for bird points only, while observing the bird. Following Hafner (unpublished data), the following scale was used: 1 Up to halfway the tarsus 2 Up to the tarsus-tibia joint 3 Up to halfway the tibia 4 Over halfway the tibia

Vegetation variables

- Number of emergent stems along diagonal: This was used as an index, the total number in the quadrat often being too great to count. In order to avoid bias in choice of the diagonal along which the stems were counted, a standard diagonal was always taken.
- Cover data: Cover was estimated visually, using a decimal scale, specified in App. 3. To indicate whether the matter constituting was Evenly or Unevenly distributed, a U or an E, respectively, were added
- Definition of categories distinguished: - Submerged: all plants or parts of plants not attaining the water surface.
 - Floating attached: all plants or parts of plants attaining the water surface and constituting a cover at the surface, which are attached under water.
 - Floating free: all plants and parts of plants attaining the water surface and constituting a cover at the surface, which have no attachment under water.
 - Emergent low: less than 50 cm high, measured from the sediment.
 - Emergent high: more than 50 cm high, measured from the sediment.
- Total real cover: Defined here as the total cover of the substrate constituted by living vegetation and litter.
- Litter: Dead organic material, still retaining its original structure.
- Bare: Only bare spots of 5 by 5 centimeters' size or bigger were considered. A visual estimate was made of their total cover.

Cover estimates per species: For each species, the cover it constituted per vegetation stratum, as well as its total cover were estimated.

Strata: Cover estimates were given for the following strata: - Submerged

- Submerged + floating attached + floating free (first "total" column)
- Emergent low + emergent high (second "total" column)
- Shrubs/trees (third "total" column)
- Height distribution emergents: Per quadrat, in principle 35 heights of emergent stems were measured, all from the substrate to the top of the stem. If less than 35 stems were present, all were measured. If 35 or more were present, those along the diagonals were measured, the number 35 being filled with others if needed. Species was recorded for each stem measured.

I-3: PRACTICAL PROBLEMS

- Evasive behaviour of birds:

During the period of development of methods, birds were not at all shy and kept feeding within easily observable distances during sampling. After those first weeks, however, they became much more shy and evasive, which result ed in greater problems than foreseen in observing.

Precision of establishment of bird points: The validity of the method used stands or falls with the observer's ability to locate the bird points precisely. The above-mentioned evasiveness on the egrets' part made this even more difficult.

- Problems due to vegetation type:

The more uniform vegetation types sometimes presented problems in recognition of bird points. In marshes with a continuous vegetation of high emergent plants, it was impossible to approach the birds closely enough to establish bird points with the precision required without disturbing them. This accounts for the extremely low number of samples in the Etang de Redon.

- Drying-out of marshes:
 Due to the late start of the field work, marshes started to dry up soon after the beginning. This accounts for the fact that only one bird point was sampled in the Bonborinette.
- Observation pressure on marshes:
 - Certainly in the beginning of the study, the marshes in which there were any birds were, for much of the time, inaccessible due to "occupation" by other observers. By the time they became acessible, they were invariably already in a late stage of drying up.

I-4: RESULTS AND DISCUSSION

In the analysis presented im this section, data from the experimental fields C4 and C11 were excluded, because of their great difference from the other marshes and the lack of bird points in them. The data from the Marais de St. Seren were included in the total, and also treated separately for some of the variables.

Depth measurements

The measured depths were divided into classes of 5 cm width and the percentages of individuals in each class were calculated (Fig. I-1). A Chi-squared contingency table test was done on the heterogeneity between the distributions of the 0 and the R+S points. Both depth to vegetation and depth to sediment appeared to differ significantly at confidence level 0.001.

E. garzetta tends to avoid sites with more than 5 cm of free water over the vegetation, as well as sites with none at all. With regards to depth to sediment, sites with depths of less than 15 cm were preferred by the birds. Sites without water were shunned, which is not amazing for a wading bird. Equally, depths greater than 20 cm were almost completely absent from the bird points. This corresponds with the limits imposed upon the birds by the length of their legs.

However, in the experimental fields birds were repeatedly seen feeding in the ditches around the field, which are too deep to wade in, whilst wading along them in shallower water.

Percentage out of water

The only trend clearly visible in the histogram (Fig. I-2) is the birds' avoidance of sites which are largely or entirely out of the water. This was already shown above.

It is interesting to note that the only bird which was seen feeding on completely dry ground was doing so around the edge of a remnant puddle in a drying-out marsh. It was hunting for prey animals which the dropping water level had left stranded in the thick mat of filamentous algae, and which tried to regain the water.

Vegetation strata

Three strata were distinguished: - submerged

- submerged + floating free + floating attached

- emergent (high + low)

Per stratum, the density and distribution of the vegetation in each stratum were expressed as percentages of occurrence in the classes specified in App. 4 (Fig. I-3).

Chi-squared contingency table tests were done on differences within and between the O and R+S data sets. The results are summarized in Table I-1.

The St. Seren data separately were too few to allow use of the test for any but the cover data of 0 versus R+S for the strata "submerged" and "submerged + floating". Neither showed a significant difference.





(b) to sediment



Fig. I-2: Percentage out of water





between 0 and	R+S points.		
n.s. = not sig (p > 0.05) U = µnevenly c	gnificant; distributed; d	= test not a (no sufficien E = evenly di	pplicable t data) stributed
	submerged	submerged + floating	emergent
U v. E : within O	រា.ទ.	n.s.	
within R+S	< 0.05	< 0.05	
0 v. R+S : U	n.s.	n.s.	
E	< 0.01	n.s.	
totals U v. E	n.s.	n.s.	
0 v. R+S, U and E combined	< 0.01	< 0.001	< 0.01

Table I-1: Results of Chi-squared contingency table tests

Submerged:

The one trend that emerges most clearly is E. garzetta shuns both sites with very low submerged plant cover and those with a very high cover in this stratum (Fig. I-3a). Cover densities in the classes 4-6 (35-65 %) appear to be preferred. Another visible tendency is the preference by birds for uneven rather than even vegetation cover in this stratum. Although the difference between 0 and R+S in distribution of unevenly covered sites was not significant, that of the distribution of evenly covered sites was. Also, the frequency of even cover among the high cover classes of the R+S points was significantly higher in the R+S points than in the O points (Figure I-3a Table I-1). This means that E. garzetta tends to avoid even, dense cover of submerged vegetation. The data from St. Seren confirm E. garzetta's shunning of little or no submerged cover (Fig. I-4a), although the difference was not significant. The histograms seem to contra-

dict the preference for uneven submerged plant cover. However, it has to be borne in mind that in any but the low cover classes, uneven submerged plant cover hardly occurs in the samples from this marsh.

The relatively high frequency of uneven submerged cover in the R+S points can be attributed to the sites which have an emergent cover as well, and which were systematically avoided by birds (Fig. I-4c, discussion below).

Submerged + floating:

The trends which emerge are the same as for submerged vegetation (Fig. I-3b). The preference for higher cover classes than was found for the latter stratum may be attributed to the fact that in fact, it is the same stratum with an addition.

The St. Seren data follow the same trends (Fig. I-4b).

Emergent:

From the full data set, it becomes clear that E. garzetta avoids both absence and relatively high densities of emergent plants (Fig. I-3c). The test confirmed the significance of the difference (Table I-1).

In St. Seren, however, any presence of emergents was shunned (Fig. I-4c, Table I-1). This was the only marsh where a clear choice for presence or absence of emergents could be made, as the emergents present occurred in discrete, dense clumps.

Heights of emergents

Classes of 5 cm width were defined and percentages per class calculated. Fig. I-5 shows the results obtained using the whole data set. Two differences between the histograms for 0 and R+S are visible:

- The absence of emergents higher than 60 cm in the 0 points and their presence in the R+S points.
- The "concentration" in the 10-15 and 15-20 cm classes, which is more pronounced in the 0 points than in the R+S points.

Both were tested using the Chi-squared contingency table test and found to be significant (p < 0.001). The "concentration" effect was found to be significant (p < 0.001) even in a second test, where all heights greater than 50 cm were excluded.

A third test was then done on the classes 0-5 and 5-10 cm only, which proved to be significantly more highly represented in bird points than in the R+S points (p < 0.01). The data from St. Seren (Fig. I-6) are an interesting addition to the image thus obtained, although they do not permit statistical testing. As seen above (Strata, section Emergent), emergent vegetation was totally avoided. A fact which is the more interesting because of the fairly high frequencies in the higher height classes found in this marsh.

The image obtained is that E.garzetta shuns emergent vegetation when possible. If no "emergent-free" sites are available, birds show a preference for the height classes 10-15 and 15-20 cm. Emergent vegetation higher than 50 cm appears to be systematically avoided.

Number of emergent stems along the diagonal

No significant difference between the 0 and the R+S points was found here. Yet, in the principal components analysis a strong correlation was found between this variable and emergent cover (Chapter I-S), which does show a highly significant difference. Apparently the distribution of emergent plants within the quadrats was too irregular for their number along a diagonal to be a reliable measure for their density.

Percentage bare

In the histograms (Fig. I-7), three features are clearly visible:

- Sites without bare spots were more frequent in the R+S points than in the O points.
- In the lower cover classes, the frequency of unevenly distributed bare spots is far higher in the R+S points than in the O points. This difference was tested using a Chi-







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I



squared contingency table test and found to be significant (p < 0.05).

- The higher cover classes occur at lower frequencies in the O points than in the R+S points.

The first of these three differences can be interpreted as the birds' avoidance of sites with dense, closed vegetation, in which prey would not be visible.

The second feature constitutes preference for fewer, slightly bigger rather than more numerous smaller bare spots: too small bare spots do not sufficiently enhance visibility and allow too much chance for the prey to hide or escape. This matches well into the image obtained above, in the discussion of the data on vegetation strata.

The third feature again matches the trends seen earlier: big open spots are avoided, probably because prey animals do not venture into them. Another possible cause is that wading in places with little or no vegetation stirs up the sediment and very quickly reduces visibility in the water to almost zero.

Birds apparently tend to go for mosaics of fairly dense vegetation (Fig. I-3) with bare patches in it of a size which has a lower as well as an upper limit. Such vegetation offers shelter to prey animals, which are nonetheless well accessible to the birds, either by movement on their own accord, or by their being "chased up" (foot-stirring, Hafner, Boy & Gory, 1982).

Total real cover

The histogram (Fig. I-10) shows a tendency towards a higher frequency in higher cover classes for the 0 points than for the R+S points. The Chi-squared contigency table test, however, showed the differences to be non-significant. Probabably there are too many variables included in the total real cover to make it a distinctive characteristic.

Height of waves

The distributions of the heights of the waves over the classes distinguished (App. 4) did not differ significantly between the 0 points and the R+S points (Fig. I-9). This is probably due to insufficient variation in the data set.

Turbidity

The values measured were grouped according to the 10 units classes of the readings. Fig I-10 shows their distributions for the 0 and for the R+S points.

The only important difference between the two distributions is the higher presence of high turbidities in the R+S points, but no statistically significant difference could be shown. It is worth noting that extremely high turbidities (800 and 1600) were found both at bird points (both values once) and at random points (both values twice). These occurred in a final pool of the Relongues when it was almost totally dry. It seems that birds avoid water with a high turbidity. However, "free" water depth (i.e. to sediment or, where present, to submerged vegetation) is likely to play a role here: the deeper the water, the greater the visual restrictions imposed by the turbidity. The fact that birds are nonetheless fishing in water with a high turbidity, which is also rather deep and







Fig. I-10: Turbidity (FTU) devoid of vegetation (final pools Relongues and Etang de Redon) may be interpreted as their being able to afford such handicaps because of the high concentration of prey animals.

Other variables

The rest of the variables listed on the sample sheet were found not to distinguish between O points and R+S points.

I-5: PRINCIPAL COMPONENTS ANALYSIS

A Principal Components Analysis was performed using 15 of the variables, which were standardized using a centering routine. These were: 1-Turbidity 2-Colour 3-Height of waves 4-Percentage out of water 5-Depth of soft sediment 6-Depth to vegetation 7-Depth to sediment 8-Number of emergents along the diagonal 9-Total real cover 10-Percentage bare 11-Submerged vegetation cover 12-Submerged + floating vegetation cover 13-Emergent cover 14-Mean of heights of emergents 15-Variance of heights of emergents Their correlation matrix is included as Appendix 7. High positive correlations (0.5 or more) were found between: - turbidity and colour (1 and 2) - depth to vegetation and depth to sediment (6 and 7) - depth to sediment and submerged vegetation cover (7 and 11) - number of emergents along diagonal and emergent cover (8 and 13) - total real cover and submerged + floating vegetation cover (9 and 12) - submerged vegetation cover and submerged + floating vegetation cover (11 and 12) - emergent cover and mean emergent height (13 and 14) - mean and variance of emergent height (14 and 15) High negative correlations (-0.5 or more) were found between: total real cover and percentage bare (9 and 10) - percentage bare and submerged + floating vegetation cover (10 and 12)

Å plot of both sites and variables on axes 1 and 2 is given in Fig. I-11.

×









INTERPRETATION OF AXES

Axis 1:

Separates the sites with much vegetation and low turbidity from those with little vegetation and high turbidity.

The points in the top right hand corner of the first quadrant of the plot (Fig. I-11) are all from the experimental field C4 before treatment in august: shallow and clear, with dense emergent cover. Those in the far left end of the fourth quadrant are from the final pool in the Relongues: deep, extremely turbid, almost devoid of vegetation and with deep soft sediment.

Axis 2:

Distinguishes deep sites with dense submerged vegetation, which cluster at the lower end of this axis from shallow sites with much emergent vegetation. In Figure 2, the sites found high on axis 2 are shallow: sites in the experimental field D7 and in the Marais de St. Seren and the Relongues in late stages of drying up.

It is worth noting that, throughout the data set, shallow sites and sites with a high percentage out of water tend to have a high percentage bare and a high emergent plant cover.

Bird points are concentrated near the origin on these two axes (Fig. I11), the only exeptions being the above-mention ed final pool sites from the Relongues. Random and systematic points, however, show a wide scatter. This indicates that birds were highly selective in their choice of foraging sites and used only a small part of the available range of microhabitats.

The outlying bird points can be attributed to exeptional situations, e.g. marshes in late stages of drying up.

Axis 3:

The plot of this axis versus axis 1 was dominated by one site which combined great depth (mean of 43.8, a random point from the Relongues) with low turbidity. It was separated from the deep, turbid final pool sites with deep soft sediment previously commented upon.

Axis 4:

Was highly similar to axis 3. The one thing it singled out specifically was high percentage out of water.

Axis 5:

Very difficult to interpret, almost identical to axis 4. It appeared to single out the few points where turbidity and colour were not correlated.

*

Groups of points were distinguished in Fig. I-11 according to spatial and temporal criteria. These point clouds were indicated on two overlays: one for the natural marshes and one for the experimental fields.

For the natural marshes, the within-marsh differences tend to be greater than for the experimental fields. This is due to two factors:

- The experimental fields, which are former agricultural fields, are more homogeneous in nature and far smaller in size.
- There is a temporal effect in the scatter of the points from the natural marshes, caused by their drying up during summer. In the same period, the water level in the experimental fields is kept stable by irrigation.

Natural marshes:

The points from the Relongues de la Tour du Valat are remarkably separated into groups (Fig. I-11, overlay). This can be explained by the fact that this is the only marsh in which samples have been taken from early june, all through the process of drying up, until the final stages in mid-july. This entails a spatial separation as well as a temporal one: sites in the same part of the marsh show a temporal effect, whereas the sites sampled in early/mid-july are essentially the deeper ones, part of which were too deep to be accessible to egrets earlier on. The box in the top left-hand corner of Fig. I-11 characterises these points in the final pools: deep, almost devoid of macrophytes and extremely turbid due to a high concentration of phytoplankton.

Egrets made heavy use of the pools, in spite of the depth and turbidity of the water. Apparently the concentration of prey made this worth while, as has been documented before (Hafner 1977, Kushlan 1976 and others). The same phenomenon was seen, though not documented, in the final pool of the Etang de Redon.

The box on the left hand side along Axis 2 and the one along the upper half of Axis 1 contain sites which are partly similar; they are mainly distinguished by their depths (mostly a temporal effect) and the thickness of their submerged and floating vegetation. Those in the box along Axis 1 are further united by the relative abundance and height of the emergent plants in them. The two points above this box represent a very low water level (and thus a high % out of water) and a high abundance of emergent plants.

The sites in the bottom left hand part of Fig. 1-11, from the Etang de Redon, represent an early stage. The water is deep, the aquatic vegetation is principally submerged with a low cover of submerged and floating vegetation. The depth to the vegetation being relatively great, these sites allow waves to develop to a greater height than elsewhere. The site to the right hand side of the box is less deep, thus causing more of the aquatic vegetation to surface and increasing its % cover and restraining the development of waves.

The points around the origin are the "grey mass" of sites, which have no extreme characteristics. As mentioned above, most bird points are concentrated in this area of the plot.

Experimental fields

One of the striking features is the effect of the "roues cages" treatment on C4: the emergent vegetation, which is a dominant trait before the treatment and the differences in which cause a wide scatter of the points, is destroyed. The field is visibly more uniform after treatment than before (Fig. I-11).

D7 is much shallower than most of the other grazed fields sampled. The "ribbon" of points in the upper half of the plot corres-ponds to a few days in early july when insufficient irrigation water was put in and part of the field came dry.

The small concentrations of points in the bottom right-hand quadrant, from D6 and C13c, correspond to deeper sites. In C13c, moreover, the total real cover was enhanced by dense accumulations of floating plants (Lemna spp. and filamentous algae). It will be noted that the most "extreme" of these (deepest and most covered) are not bird points.

The two points from C11 which overlap with sites from C4 before treatment are points from the longitudinal rows of dense Scirpus micronatus, one of the great dominants in the ungrazed fields.

The outlying point from D6, in the C4 point cloud, is the one site in this marsh which included part of a tussock of Iris pseudacorus, whence the great average height of emergents.

1-6: CONFIDENCE REGIONS

A 95% confidence regions (CR) plot (Sokal and Rohlf, 1969) was made, using the same variables used for the Principal Components Analysis (PCA). The plot is shown in Fig. I-12.

The CR plot (Fig. I-12) does not give the detailed information found in the PCA (section I-5, Fig. I-11). However, it has the merit of simplification, which allows overall tendencies to be evaluated more easily.

Because in this method, the ellipses are centered around the average values, the points are more concentrated. This explains the small overlap between the natural marshes and the experimental fields in Fig. I-12.

The bird points appear to overlap more with the natural marshes than with the experimental fieldss. However, it must be borne in mind that 44 bird points were sampled in the natural marshes against only 21 in the experimental fields. Also, the main "harvest" of bird points was in the Relongues and the Marais de St. Seren, in shallow parts of both marshes.

Once again, it becomes clear that the bird points comprise the "moderate" part of both the natural marshes and the experimental fields. Extreme depth and extremely dense vegetation, especially emergent, are avoided by egrets, which is in compliance with what was previously found.





95% confidence regions plotted using the same variables as in the Principal Components Analysis (Fig. I-11)



Fig. I-12:

95% confidence regions plotted using the same variables as in the Principal Components Analysis (Fig. I-11)

overlay Fig. 1-12

P A R T II : USE OF THE EXPERIMENTAL FIELDS BY EGRETTA GARZETTA IN RELATION TO HABITAT MANAGEMENT AND PREY DENSITY

- I-1 AIMS : 1-To describe the foraging habitat used by E. garzetta in the experimental fields in relation to some management factors.
 - 2-To establish the number and species composition of prey for E. garzetta present in different marshes at different moments.
 - 3-To monitor the temporal fluctuations in use of the fields by E. garżetta in relation to some management factors.
 - 4-To evaluate the predictive value of the conclusions arrived at in part I by comparing these with the trends found in the experimental fields.

Descriptions of the experimental fields are to be found in the Description of study marshes, land use in recent years is given in App. 2.

Management of the fields in 1984 makes them fall apart into two main categories: grazed by horses and ungrazed. Of the grazed fields, C12 was the only one which was dry during the study period. The ungrazed fields were all treated with a tractor with "roues cages", uprooting the vegetation and aerating the sediment (Photo 5). Treatment took place in august-september, but two guarter sections of C4 had been previously treated in april.

II-2: METHODS

II-2-A: HABITAT DESCRIPTIONS

Per field, the bird points and the random and systematic sampling points together were used to describe the foraging habitat in the field in histograms, using the characteristics and classes defined in section I-2.

Because of the small number of sampling points, only the following variables could be used:

- Depth to vegetation

- Depth to sediment
- Height of emergent stems

II-2-B: PREY SAMPLES

Sampling was done by the Tour du Valat Heron Team and by Gordon Copp (Copp, 1984). The Heron Team took samples with the Kushlan throw trap (Kushlan, 1981, Reeders, 1983, Hafner and Britton, 1983) of 1 m2 each and aimed at a comparison between marshes. Copp's sam-ples were 0.25 m2 in size and afford an evaluation of differences both between marshes and within marshes.

Heron Team sampling data were available for the fields C4, D6 and C13a, Copp's data comprise C2, C3, C4 C1D and C11.

For use in this study, 8 groups of species were distinguished:

1-Frog tadpoles

2-Fish

3-Big Coleoptera larvae: genera Hydrous, Dytiscus and Cybesterinii and specimens longer than 15 mm if unidentified

4-Small Coleoptera larvae: subfamilies Hydraticini, Cobelatini and

Hydrophylidae and specimens shorter than 15 mm if unidentified

5-Notonecta (various instars)

6-Libellulidae larvae

7-Miscellaneous big: > 15 mm

8-Miscellaneous small: < 15 mm

II-2-C: BIRD COUNTS

From april to early august, counts of numbers of E. garzetta present in each of the experimental fields were conducted by the Heron Team at intervals of approximately 9 days. At each day, a morning count, a mid-day count or an evening count or any combination of these was done.

Starting in early august, the author conducted a count programme which consisted of a morning, a mid-day and an evening count each day. This was continued until october 28. inclusive. The sheet designed and used for these counts is included as App. 5.

From these data, the index of preference (Ip, described in App. 6) was calculated for each field.

Practical problems

- The data on some of the counts done by the Heron Team vanished from the file before the author got hold of it. - The count programme conducted in august through october proved rather assiduous for a single person, causing some minor gaps in the data set.

II-2-D: MONITORING OF WATER LEVEL AND PERCENTAGE INUNDATED

In the fields C11, C13a, C13b, C13c, D6 and D7, which received no more irrigation water from september 18 onward, the water level and the percentage of the field that was inundated were monitored daily from that date until their drying up. The same was done in D8 and D9, which continued to receive some surplus water from the ungrazed fields until early october.

The water level measurements were done at the deepest point encountered in each field, usually in the ditch(es) along fields, using a marker pole.

The percentage inundated was estimated visually in the following empirically defined classes:

10: >95%

7: 50-95%

3: 10-50%

1: 5-10%

0: <5%

These classes reflect the measure of precision with which the estimates could be made.

II-3: RESULTS AND DISCUSSION

II-3-A: HEIGHTS OF EMERGENT STEMS

Fig. II-1 gives the histograms of the frequency distributions of emergent vegetation heights per field. The differences between distributions were submitted to a Chi-squared contingency table test. Frequencies were found to be significant (p(0.05)) between all distributions except between C4-III+IV and D7.

In grazed marshes, the height of emergent stems (measured from the sediment to the tops of the stems) is partly a function of water depth: horses tend to snip off the emergents at a fairly constant height above the water. Due to the small variation in water depth both between fields and within fields, great differences due to this factor were rare. On the other hand, Iris pseudacoris, which occurred only in D6, was not eaten by the horses and thus attained much greater heights (see Photo 4).

The data set was too small to test the significance of any correlation between emergent heights and the preference index Ip. However, Fig. II-4 makes it clear that the egrets prefer D6 and D7 to the other fields. Both fields are heavily grazed and have few high emergents. The pronounced difference between D7 and C4-III+IV can not be explained by a difference of emergent heights, as these were not significantly difference between these two fields.

Save for this one case, the differences in preference between fields comply with what was found in Part I: high and dense emergent vegetation is shunned by E. garzetta.

The within-field differences in the frequency distribution of emergent vegetation heights in C4 are both temporal and spatial. One will not be surprised to find that in the part of the field treated in april, the emergent plants were significantly lower (p<0.05) before the august treatment than in the part which had hitherto not been treated. Yet, there was no significant difference in bird preference between treated and untreated parts.

C10 may, for all practical purposes, be counted as an ungrazed field; it is far from the horses' entrance to the experimental fields and was used by them only as a resting site once it dried out during summer. It had a dense, high emergent vegetation and was not treated with "roues cages"

II-3-B: "ROUES CAGES" TREATMENT

The ungrazed fields are all treated with a tractor with "roues cages" (cage wheels, see photo 5), uprooting the vegetation and aerating the sediment in order to prevent the marshes from filling up completely in a few years' time (as has C10; see above).

This treatment has a tremendous effect on the vegetation in the fields (Fig. II-1). The only ungrazed field in-cluded in the analysis was C4. The part of this field which was not treated in april (C4-II; see Fig. II-1) reflects the situation in the other ungrazed fields, none of which was treated before august in 1984.

Fig. II-2 shows the effect of the treatment on the egrets' use of the field. Peaks in preference are visible on the day





Fig. II-2:

Effect of "roues cages" treatment on use of the experimental fields by E. garzetta, expressed in the Preference Index Ip of the treatment and/or the days immediately after in C2, C4 and C5. In C3b this effect is slightly retarded and in C3a, C6 and C7 it is absent.

Feeding observations done by Ruedi Nayer on the days of treatment and immediately after in C4 and C5 seem to indicate that wounded frogs and tadpoles are important prey animals at those moments. However, no persistent increase in use of the fields was observed for any other field than C2, which became quite popular. It must be noted, however, that this was the first field to be treated, the largest one and the one closest to Tour du Valat heron colony. It was used quite frequently in the evening for pre-roost gathering, which distorts the index of bird preference for this field.

II-3-C: DEPTH TO AQUATIC VEGETATION

In section I-4, it was concluded that E. garzetta tends to avoid sites with more than 5 cm. of free water over the vegetation, as well as sites with none at all. This was true for the experimental fields (Fig. II-3a). The differences in frequency distributions between fields of depth to aquatic vegetation were all found to be significant (p<0.005) in Chisquared contingency table tests. Among the differences within C4, only those between C4-III+IV and C4-I and C4-II, respectively, were significant

In D7, the percentage of aquatic vegetation which attains the water surface is relatively low (Fig. II-3-a), in spite of the fact that the field is quite shallow (Fig. II-3-b). Perhaps the temporary drop in water level mentioned in section I-5 has stunted the growth of the aquatic vegetation. Although the limited data set did not permit statistical evaluation of the differences in density of submerged and floating vegetation between fields, the impression was obtained that this vegetation was thinner in D7 than in the other heavily grazed fields.

In C13c, the accumulations of filamentous algae rendered visibility at these sites almost nil, and of course this would prove a mechanical problem for wading birds as well. The impression was obtained that on days when this caused only the deeper parts of the field (too deep for egrets to wade in) to be free of filamentous algae, C13c was systematically shunned. Both C13c and C11 had local accumulations of Lemna spp., as stated before (section I-5), which causes visibility through the water surface to be virually nil as well. Both these effects are related to the direction and strength of the wind, which could not be included in the analysis.

II-3-D: DEPTH TO SEDIMENT

Water deeper than 20 cm., which is the upper limit of wading depth for E. garzetta, is almost absent in the experimental fields (Fig. II-3-b).

The differences in depth distribution between the fields were significant (p<0.005) in a Chi-squared contingency table test, except those between C11 and D7 and between D7 and C4-III+IV. Tests on the differences between C11 and C13c and between C4-I+II and C13c proved not to be feasible due to the lack of overlapping cells in the contingency tables.

Given the fact that depths in the experimental fields vary little and hardly surpass 20 cm., I do not think that many conclusions can be drawn from Fig. II-3b as for the birds'



preference of any specific field. C13c, however, has a high proportion of sites in the 15-20 cm. class and a considerable proportion in the 50-55 cm. class and was not much used by E. garzetta until its drying up in september. Fig. I-1 showed extremely shallow sites to be little used as well, but in the experimental fields studied, extreme shallowness coincided with high densities of emergent vegetation, so that this factor can not be evaluated.

II-3-E: PREY SAMPLES

The data obtained from prey samples and bird counts were combined into Figures II-4 ,II-5 and II-6 for june, july and august, respectively. Linear regressions were calculated between Ip (average per month) and the mean density of the various categories of prey for each field. The only two significant correlations obtained (p<0.001 in both cases) were those for frog tadpoles and the the total of prey per field. The two regressions were very similar, so that only the plot of total prey versus Ip is given here: Fig. II-7.

Data on the egrets' selectivity in use of the prey present could not be incorporated here. Hafner (pers. comm.) said that tadpoles do not constitute a major part of their diet, which seems contradictory to what was found here. An explanation might be that insect larvae and frog tadpoles develop in the same period and metamorphose into insects and frogs in the same brief timespan. Both insects and frogs leaving the marshes (the numerically dominant frog tadpole species is Hyla meridionalis, the tree frog) at roughly the same moment, this could cause the similarity in temporal density changes found here. The correlation between the egrets' preference for the marshes and the density of frog tadpoles might thus be a mere co-incidence.

The high seasonal average of Ip for D7, as found in Fig.s II-1 and II-2, is not reflected in Fig.s II-4, II-5 and II-6. This field became more intensively used only in late august through october.

Discussion per month

June:

In june (Fig. II-4), the egrets' attention appears to be almost equally divided over all fields. The emergent vegetation in the ungrazed fields is not being fully developed yet, this is no obstacle to the birds. The differeves in total prey numbers per m2 are not very different either, but for a low in C10 and a high in D6, which latter field is, accordingly, the one most used.

July:

In july (Fig. II-5), the emergent vegetation in the ungrazed fields is fully developed, forming an almost impenetrable jungle with Scirpus micronatus, Alisma plantago-aquatica and Polypogon monspeliensis, almost as hing as an egret's head. As remarked before (section II-3-A), C10 can be counted as an ungrazed field or all practical purposes. Thus, in spite of the numbers of prey present, rather higher than in june, egrets did not use these fields. C11 and C13a, both grazed, have lower prey densities, but are used! It will be noted in Fig. II-7 that the points for july are in the part of the plot which shows most scatter.









Fig. II-7:

Correlation between the density of prey available to E. garzetta in some of the experimental fields and the Preference Index for these fields in june, july and august. The regression of least squares was significant (p < 0.01) The most used field is again D6, which offers both a favorable foraging habitat structure (see above) and ample prey.

August:

In august(Fig. II-6), the ungrazed fields are subjected to the roues cages treatment. C10, although quite as densely vegetated, is not. As seen in Fig. II-2, the response by egrets to the treatment is not very clear-cut in all cases. The fact that C2 does become more used can be at least partly explained by the high prey densities there. Both the count data and the prey sampling data used in Fig.s II-6 and II-7 are from early august (sampling was done only in early august), so that the increased use of C2 later in the same month (Fig.s II-2 and II-7) are not incorporated here. However, Fig.s II-6 and II-7 give a reasonable idea of egret use of C2 during the whole month.

D6, in spite of its still considerable prey densities, is used much less, the egrets' attention has shifted to D8 and D9. The latter are both quite similar to D7 in habitat structure. One common trait is their smaller depth, which may cause prey, though present in lower densities, to be more easily acessible than in D6, which is deeper. Once prey densities in D6 and the the other fields gets below a certain "critical value", the shallower fields may thus afford more efficient foraging.

II-3-F: WATER LEVEL AND PERCENTAGE OF FIELD INUNDATED

The results of the measurements and estimates were combined with the Ip values for individual fields (Fig. II-8). A sign test was carried out to establish whether the falling water levels in autumn affected bird preference for the fields as measured by Ip.

As egrets may respond to changes around a certain "critical value" for both water level and percentage inundated and the measures and estimates were fairly crude, inreases or single peaks in Ip may occur either just before or just after a change in either of these two factors was registered. Therefor, Ip-peaks or increases were considered both the day before and the day after a change in one of the two factors monitored. A peak in Ip was considered to occur when Ip for a day was higher than that for the day before and the day after. A "plus" was scored when there was an increase or peak in Ip on the day of a drop in water level or % inundated or on the day before or he day after. A "minus" was scored when there was no increase or peak in Ip on the day of a drop in either or on the day before or after and when a rise in either was associated in the same way with an increase or peak in Ip.

Both variables appeared to be significantly correlated (p < 0.05) with peaks in Ip. It may thus be concluded that egrets respond to drops in water level and/or % inundated in a certain field by making more intensive use of that field.

The data would seem to indicate that indeed a certain "critical water level" is involved. A small drop in water level on sept. 26 in D6 yields a peak in Ip, which vanishes immediately when the water table rises sightly on sept. 27.

D7, D8 and D9 show the peaks in use by egrets associated with the final stages of drying up, which has been encountered in the natural marshes as well.

Clac is a rather peculiar case. The field itself dried up



completely around sept. 25., but in the ditch along, the water was still too deep for egrets to wade in. From oct. 3. onwards, culminating in the peak on oct. 6., birds started to feed in the remnant pools in the ditch.

The minor peaks in Ip in D8, C11 and D6 may be explained by the fact that this caused the average depth of the free water layer above the aquatic vegetation, which had fallen to almost nil due to drying up, to rise a little. As seen before (sections I-4 and II-3-C), this depth to aquatic vegetation appears to be an important factor in E. garzetta's choice of foraging micro-habitat.

C11 was the first and fastest to dry up. It is sited highest, upstream with respect to the others along the irrigation ditch, and has a "leak" in its bottom: a strip of sandy sediment outcropping through the clay.

II-3-G: THE OVERALL VIEW OF PREFERENCE IN AUGUST-OCTOBER

The preference index Ip was calculated per period of five days during the period of the intensive counting programme in august, september and october. Fig. II-9 shows the outcome. Taking the average of Ip per block of five days has the merit of "ironing out" incidental peaks. An example is the occurrence of a 200-bird pre-roost gathering of E. garzetta in C2 on sept. 22., which would otherwise have distorted the image of its use as a feeding marsh.

Until october, the only ungrazed marsh used consyantly and in quantity by E. garzetta is C2. The grazed fields dried up in september-october (Fig. II-8), the ungrazed ones thus being the only inundated fields left. It is striking that among the lightly grazed fields, C13a, which is most used by horses, is also the one most used by egrets.

It has been demonstrated that there is a relationship between the vegetation structure in the experimental fields and E. garzetta's preference for individual fields. One of the variables which could not be tested was the distribution of aquatic vegetation. It was shown in section I-4 that birds tend to go for mosaics of fairly dense aquatic vegetation with bare patches in it. Although I have no proof for it, I believe that horses or cattle wading through a marsh create that type of mosaic by trampling the aquatic vegetation. Add the fact that they keep the emergent vegetation short and big herbivores emerge as a positive influence upon E. garzetta's foraging micro-habitat.

An indirect influence of grazing is that the water table has to be kept sufficiently high, so as not to give vigorous colonisers like Alisma plantago-aquatica a chance. The result in D6, D7, D8 and D9 is a "wet meadow" of neatly trimmed (highly appreciated by the horses) Paspalum digitatum with a fairly dense, patchy vegetation of submerged and floating plants, dominated by Naias flexilis, which proves to be quite attractive to E. garzetta.

Another factor influencing use of the fields by egrets, but which has not been analyzed, is the disturbance of birds in the various fields. Except for C10, C11, C2 and C3, all fields are screened from the road by a dense "hedge" of high reed (Arundo donax). The lack of this may be one of the factors which makes C11 less attractive; the traffic along the road is not intensive, but every passing vehicle caused any egrets in the field to retreat to the far end.



Fig. II-9: The Preference Index Ip for the experimental fields in august-october.

PART III: CONCLUSIONS AND EVALUATION

Part I describes an attempt to quantify the selectivity of foraging micro-habitat by E. garzetta. Part II tests the practical value of some of the conclusions arrived at by this method and applies it to a specific case: the experimental fields. The conclusions to be drawn fall into three categories:

- those concerning the methodology
- those concerning E. garzetta's behaviour in selecting fo-raging sites
- those concerning practical implications for the management ment of the experimental fields and, by extrapolation, other marshes

METHODOLOGY

The method used to gather data is extremely laborious and is limitEd in its applicability to areas almost or wholly devoid of high emergent vegetation. This and the little time available resulted in problems of analysis due to a lack of sufficient quantity of data, especially the number of data per marsh. However, sufficient data were obtained to allow some conclusions to be drawn on egret selectivity of foraging micro-habitat.

The principal components analysis yielded insights into the nature of the data set which could not have been gained from histograms. Yet, it can not be a single method in this type of study, because, though it be extremely useful to get an overall image of tendencies snd the relationships between variables, it does not yield quantitative relationships between bird use of habitat and habitat variables.

In order to increase the efficacy of this type of study, the data acquisition would have to be tackled in such a manner as to circumvent the problems discussed in section I-3. The improvised nature is a matter of organisation; had I known beforehand that I was to find myself doing this work, I could have done far more preliminary study of literature and have started fieldwork earlier and with a better idea of what to do. The problems caused by high vegetation in marshes could be solved by observing egrets from an elevated observation post and pinpointing the feeding sites to be sampled on large scale (at least 1:2000) aerial photography, which would have to be recent. In order to increase the precision of site location under these circumstances, the work would have to be done by two people, one of whom could direct the other from the observation post.

Using airphotos would permit a parallel mapping approach as well. Bird points and random points, with stratified sampling points where needed, could be used as samples for a microhabitat classification procedure and the definition of mapping units.

This, in its turn, would make it possible to integrate the description of micro-habitat in terms of vegetation and physical factors with a (stratified) prey sampling scheme. It has become abundantly clear in this study that neither prey

alone nor habitat alone can explain E. garzetta's choice of foraging habitat. The two together, combined with feeding rate observations, could yield a fairly complete insight into the matter. An integration with feeding rate observations was intended in this study, but had to be dropped due to lack of time.

The preference index Ip proved a very useful tool in the comparison of egrets' preference for individual marshes relative to the other ones in the analysis. Van Horne (1983) quite rightly points out that indices based on density may be misleading in the assessment of habitat quality, the restriction to foraging habitat, as in this study, makes the problems which Van Horne (1983) discusses less accute already. The system of three counts a day is only one of many possible ones, though it was the most reliable one feasible in this study.

E. GARZETTA'S CHOICE OF FORAGING SITES

As stated above, habitat structure alone can not explain this, nor can prey density alone. The picture obtained in this study can be briefly summarized as follows:

No matter how close to the "ideal" the habitat is, no egret will forage in it unless prey densities are sufficiently high to make foraging there profitable. On the other hand, physical (e.g. depth) or vegetation (e.g. dense, high emergents) factor may render an otherwise good prey stock inaccessible to wading birds. Some factors, such as turbidity, may be taken into the bargain when prey densities are sufficiently high to ensure a sufficient foraging success notwithstanding.

An approach integrating feeding rate observations, prey density assessment and (micro-)habitat classification, might prove the only way to assess the ecological va-lues of foraging site selection strategies employed by wading birds.

PRACTICAL IMPLICATIONS

In Part I, egret foraging habitat was described in terms of optimum values for various variables. The conclusions from this which could be applied in Part II proved to hold true. Some general conclusions about management of the experimental fields and some specific recommendations can be arrived at.

Grazing has proven to be positively associated with E. garzetta's preference for individual marshes. Heavily grazed fields were prefered to lightly grazed ones. Among the lightly grazed fields, the one most used by horses, C13a, was also the one most used by egrets. A field which was hardly used by the horses, C10, quickly became overgrown by emergent vegetation and was subsequently not used any more by egrets.

A water depth of 15 cm. maximum appears to be prefered by E. garzetta, with a minimum od about 5 cm. This may correspond to the horses' preference as well. The depth data in Fig. II-3b would seem to indicate that the O-5 cm. class of depth to sediment is associated with the dense emergent "jungles" in

the ungrazed fields. Keeping depths between 5 and 15 cm., combined with the trampling involved in grazing, might counteract this and stimulate a development towards the situation in D6, D7, D8 and D9.

Disturbance may play a role in the use of individual fields by egrets. A screen of dense, high reed along the road could reduce this. Traffic along the road to the Northeast side of the ungrazed fields may add to their being little used and should thus be reduced or "screened".

This screening also provides good cover for observers. Small platforms placed over the irrigation ditches, with reed matting screens to hide the observer, would be a great help in conducting counts.

The category notably lacking from the prey species samples in the experimental fields is fish. Creating a stable fish population in one or more of the fields might considerably enhance the attractiveness of the complex to egrets. Especially C2 and C11, both large and close to the colony, could be considered for this.

ACKNOWLEDGEMENTS

This study has been very important to my formation. It has led to my finally formulating my main interest, integrating the wide range of landscape ecological items incorporated in my studies programme: habitat studies. Accordingly, I am very grateful to all those who were involved in its coming about.

Without Dr. Hoffman, Tour du Valat would not exist in its present shape. It was he, too, who approved my coming to the station to do something completely different and, when this sprung a leak, approved my tackling this study.

Rudi Drent has been the one to suggest my coming to Tour du Valat and my supervisor at Groningen University. His comments at various stages of the work have been of great value.

When, after I drove 1400 km. to come to Tour du Valat, the project which I had come for proved not to be feasible, Heinz Hafner, Bob Britton and Patrick Dugan gathered around the table with me to discuss what I could do. Bob came up with the idea for this study and Heinz and he have been guiding my activities during my stay here. Both supplied valuable suggestions for the analyses and ripped the first version of my manuscript quite rightly apart.

The mind boggles at what would happen at Tour du Valat should Vincent Boy be unexpectedly taken ill for some time. The biometrical part of my work would certainly not have withstood the shock. His expertise in handling this side of the matter and, above all, his patience (of which I haven't seen the end) with my bungling were guite remarkable.

Furthermore, there were those who helped me by helping to gather data or lending data. Sylvie Liarcou, Milagros Moneva, Catherine Davenport and Gittan Mattson have helped me in my habitat descriptions and kept me on my linguistic toes by having to work in french and spanish as well as english. Earthwatch Team VII did the prey sampling in C4 in august on my request, led by Heinz. It was Heinz, too who gave me the other Heron Team prey sample data. Ruedi Nayer did the bird counts during my absence in late august and the feeding rate onservations which regrettably had to remain unused in this study. More prey sampling data on the experimental fields were borrowed from Gordon Copp. Sylvie Liarcou drew the cover and Map 1.

Josiane Xuereb typed Table 1. Chantal Heurteaux assisted in the final editing of the text. Patrick Duncan supplied mental suuport and practical suggestions at various stages of the work.

Without Joseph Chessari, the station's mechanic, my car might not have seen the end of the field work. He is but an example of the entire technical, household and administritive staff of Tour du Valat, to all of whom I am quite indebted and of whom I retain fond memories.

The same goes for all who made their contributions to social life at Tour du Valat during my stay. Some were more prominent or permanent than others, but the only effect of mentioning names would be to omit others, as a complete listing would be out of the question. Last but certainly not least, my parents have been the ones to foot the major part of the bill for my studies as a whole and equally for this project. I left for Tour du Valatin may 1984 for a two months' stay, they came to visit me here in late august and I finally shoved my feet under the parental table again in february 1985. Their patience has been monumental end their involvement both tantamount and paramount.

Johan Timmer

EPILOGUE

Now, almost a year and a half after my arrival at Tour du Valat and fully eight months after my departure, I am again behind the terminal which has been my sparring partner for many days and, above all, nights, to finally type these last words.

Not only my professional interest has found its direction at last, I am also, since nearly half a year, married to Sylvie Liarcou, in my meeting whom at Tour du Valat Stuart Gregory was instrumental.

Much has occurred in the meantime, internal as well external factors have delayed my finishing this report. I can but hope that it will be as useful to Tour du Valat. But that would be imagining much.

I will continue woring on habitat studies, be it on burly wild boar rather than on slim, white egrets, in the Pyrenees rather than in the plains of the Camargue. The basis has been laid here.

In august, the University of Groningen has issued me my diploma, so that officially I am now a Doctorandus in Biology and no longer a student. Yet, I hope I will be able to remain one for the rest of my life.

Tour du Valat, november 13, 1985, 05.37 h.,

oho Jimmer

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Land use in the experimental fields in recent years

Experimental fields, Tour du Valat

Sketch map



Appendix 3

Scale of cover estimates: cover code > 95 % : 10 .-. : 9 85 ~ : 8 • 75 .-. : 7 65 \sim : 6 55 .-. : 5 45 0 : 4 35 \sim : 3 25 •*• : 2 15 : 1 5 < 5 % : number of individuals: M : > 8 A : 5-8 P: 3-4 R : 1-2 5 % cover followed by one of:4 : ^ **3 % cover** 2 : ^ 1 % cover 1 : < 1 % cover To indicate Evenly or Unevenly distributed vegetation, respectively: E or U. Examples: 9U, 8E, M1U, R2U Appendix 4: ______ code Scale of wave height: 10 mm ^ **:** 8 5 mm ·* : 4 3 mm ° : 2 1 mm < 1 mm : 1 *******



- Aim: To obtain an expression for the presence of birds in the Experimental fields with the following characteristics:
- It expresses the presence of birds for each field relative to the total presence of birds in all fields together using density (birds/ha.) as a measure.
- It becomes zero for fields with no birds in them.
- It takes on a discrete value when all the birds present are in one field.

The last requirement proved the most difficult one to meet. Finally Vincent Boy, Tour du Valat's biometrist, came up with the following mathematical construction, which proved very satisfactory:

First, let us take the case of two fields of equal area:

birds per field: n1, n2, with n1+n2=N

fractions of total: $\frac{n1}{N}$ and $\frac{n2}{N}$

Property: $\frac{n1}{N} + \frac{n2}{N} = 1$ Both are maximally 1, which value is attained when the other equals 0.

The following picture can thus be drawn:



This expression is, of course, easily expandible to a multidimensional one for more than two fields.

Because the fields are not of equal are, we "standardize" by taking the density (birds/ha.) rather than the absolute number of birds present. In fact, the situation is thus reduced to that of a number of SITES with a standard area of 1 ha. each.

Then: areas fields s1, s2, s3,....si ; total: S numbers of birds n1, n2, n3,....ni ; total: N $\frac{n1}{s1}$, $\frac{n2}{s2}$, $\frac{n3}{s3}$, ..., si birds per ha. 2 2 2 $\frac{(n1/s1)^{2} + (n2/s2)^{2} + (n3/s3)^{2} + \dots}{2}$ 2 Which gives us H = (n1/s1 + n2/s2 + n3/s3 +) 2 (ni/si) 2 And $\cos \propto_1 =$ 2 , WHICH IS OUR Ip (ni/si) It fulfills the requirements stated above: - if ni=0, then Ip=0 - if ni=N, then Ip=1 (all birds in one field)

In practice, it turned out that, when $\frac{\text{ni}}{N} = \frac{N}{S}$ (density in a given field equals the average density over all fields), then Ip approaches $\frac{1}{m}$, where m is the number of fields involved.