GRAZING INTENSITY AS A TOOL TO ASSESS POSITIVE SIDE EFFECTS OF LIVESTOCK FARMING SYSTEMS ON WADING BIRDS

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Abstract

French grasslands support important populations of waders. Grazing intensity is a key issue since these birds are very sensitive to sward height and heterogeneity. On 816 fields, grazing intensity was characterised by a combination of stocking rate and the proportion of days grazed on each day on which birds were observed. This made it possible to standardize stocking rates such that the various cumulative effects of time were minimised. We modelled the relationship between stocking rate and the proportion of days grazed on the fields occupied by birds and on those that were not. It appears that birds select plots with a mean spring stocking rate significantly lower than the global mean and that bird species richness is negatively correlated with intensity of spring grazing. Birds show a degree of specialisation towards grazing intensity: redshank and curlew being two extremes of a gradient going from low to high intensity. Those results indicate that a diversity of grazing regimes is necessary to preserve habitat quality for birds. From such analysis, useful indicators can be derived to assess positive side–effects of livestock farming systems.

Introduction

Most wetlands in the French Atlantic coast are the product of human activities including grazing, cropping and hunting. These practices have created a high degree of both landscape and biological heterogeneity, much of it of great natural interest. Over the last 50 years, wetlands have drastically diminished and wet grasslands have undergone an even greater decline (William, 1990). In some areas, like the Marais Poitevin, they were heavily drained for arable conversion, resulting in large changes in the landscape and greater homogenisation. The environmental consequences of these changes have been reported to be unfavourable in terms of diversity, in particular for many species of birds, particularly waterfowl and waders (Duncan et al., 1999). This is particularly true in the case of waders as wet grasslands are critical foraging and nesting habitats for these species. All over Europe, most wader species have declined in numbers and range as a consequence of increasing intensity of the agricultural management of wet grasslands (Beintema et al., 1997). The response to these declines has been both to acquire and manage protected areas as well as to encourage wider countryside measures, principally through agri-environment schemes. As breeding waders are very sensitive to sward structure defined in terms of height and heterogeneity (Milsom et al., 2000), the suitability of grasslands to these species is dependent upon grazing and mowing.
Grazing is a major process directly affecting sward heterogeneity. Large herbivores such as cattle not only respond to heterogeneity but also create and sustain it (Hirata, 2000; Parsons et al., 2000). Mechanisms by which grazing animals create sward heterogeneity are multiple. Among the most documented are selective defoliation, treading, nutrient cycling (Rook and Tallowin, 2003). According to the type grassland, these mechanisms have a varying influence and they also interact with the grazing pressure (Rook et al., 2004). For instance at moderate grazing pressure where animals can express their dietary choices, selective defoliation can be a key mechanism. Indirectly, at high livestock densities, grazing may induce secondary effects on invertebrate abundance and availability and may therefore create unsuitable foraging habitat for birds (Benton et al., 2002).
Several studies have emphasised the role of grazing management in the density of nesting waders (Norris et al., 1998; Hart et al., 2002),

unfortunately, they do not shed light on the grazing regimes which are likely to create suitable swards. This is mainly due to the fact that most studies simply provide comparisons of bird densities in presence and in absence of grazing. It is now recognised that grazing can contribute to the management of bird habitats (WallisDeVries et al., 1998). More knowledge is needed to explore if the suitability of grasslands to the species is dependant upon timing and intensity of grazing.

Methods

Study area

The study was undertaken in the Marais Poitevin, a large wetland area (96,000 ha) on the Atlantic coast of France (46°33'N, 1°48'W). It was located on the largest remaining fragment of wet grasslands called Ouest-du-Lay marsh. There are 2,700 ha of unimproved permanent grasslands, 400 ha of crops and 100 ha of non agricultural uses such as water for hunting and campsites (8.2% and 2% of total area respectively). The usage of some land is undetermined (1,770 ha). The study was restricted to permanent grasslands rather than arable land. The majority of permanent pasture is grazed throughout spring (62%), summer and autumn almost exclusively by cattle. The remaining permanent pasture is mowed.

The climate is warm Atlantic with a mean annual temperature of 12°C, a total annual rainfall of 800 mm and a summer deficit of 338 mm. These grasslands are criss-crossed by a complex network of freshwater ditches. The clay soils of high humidity and salinity ensure a distinctive assemblage of hygrophilous, meso-hygrophilous and mesophilous vegetation along a topographical gradient consisting of low-lying depressions and high level flats (Loucougaray et al., 2004). Such habitat is classified as "*community of interest whose conservation requires the designation of special area of conservation*" (Habitats Directive 92/43/EEC, Annex I). The marsh harbours some of the largest French population of lapwing (*Vanellus vanellus*), redshank (*Tringa tetanus*) and black-tailed godwit (*Limosa limosa*) (Deceuninck, 2001). As these species feature in Annex I or II of the European Birds (79/409/EEC), that makes of it a crucial area, particularly in the context of Natura 2000.

Data collection

A first general survey of the 816 fields of permanent grasslands made it possible to identify a sub-set of 150 fields actually used by birds. All bird species were counted in 1995 and again in 1996. Counts were made by LPO (Ligue de la Protection des Oiseaux) using the field method devised by Bibby et al. (1992). Each field was observed following a mapping route transect and using optimal observation points. Transect was carried out during spring a minimum of 6 times, every ten days by the same experienced observer. The location of each bird detected was plotted on a large scale map (1:25 000). Two species of nesting birds were recorded: lapwing (*Vanellus vanellus*), redshank (*Tringa totanus*), as well as three species of migratory: curlew (*Numenius arquata*), black tailed godwit (*Limosa, limosa*) and lapwing.

Grazing data were collected in 1994 and 1996 through interview of 113 farmers managing the 816 fields of permanent grasslands. Most of the farms were beef breeding farms and few were specialized dairy enterprises. Farm size ranged between 60 and 250 ha and all farm territories combined lowland (wet grasslands) and upland (mainly for arable, grass and maize silage). For each field an accurate recording of the following variables was done: number of livestock units, time spent in the field by animals, field size.

Data analysis

On each day where birds were observed, a stocking rate (I) expressed in Livestock Unit Days/ha was calculated. The stocking rate was thus a cumulative function of time, not only for each field individually, but also for the global population of fields since the number of grazed fields increased with time. The proportion of days grazed (pD_G) was taken into account in order to standardise the stocking rate for each field such that the various cumulative effects of time were minimized. It was calculated as the ratio of the number of days grazed to the date of observation. Dates of observation were calculated from January 1st. Combination of both variables (I, pD_G) made it possible to characterise grazing intensity. To model the relationship between stocking rate and proportion of days grazed, both variables were $\log_{10}$-transformed. The following linear models: $\log(I+1) = a \log(pD_G+1) + b$ were applied.

Relationship with smaller slope parameters indicated less intensive grazing since the stocking rate achieved (I) was lower given an equal proportion of time grazed (pD_G). ANCOVA (Fisher's exact test) was performed to test whether significantly more variance in the relationship between the stocking rate and the proportion of days grazed in spring was described by models involving (1) each species individually, (2) all species collectively or (3) each species richness (0, 1,.., 5 species), as compared with the Null model (all fields in the landscape and only fields on which birds were observed). When variance differed significantly (p>0.1), a Welsh test, which does not assume homogeneity of variance, was performed (Venables and Smith, 2003). T-tests were performed to test whether parameter estimates differed significantly. T-test were also performed to test whether the mean stocking rate (annual and autumn) differed significantly between all fields in the landscape and fields occupied by (1) individual species, (2) all species collectively and (3) different bird species richness.

Results

Our main results showed that grazing intensity influences bird habitat selection. Interestingly, species responded differently to grazing intensity according to periods (autumn, spring, whole year) and this result points out the crucial importance of the timing of grazing intensity. It also confirms the importance of a 'threshold date' related to nest trampling before which grazing may have detrimental effects, particularly for nesting waders.

Spring grazing intensity

The relationship between the proportion of days grazed and the stocking rate was significantly different for fields occupied by birds than for the entire landscape. Slope parameters estimates show that birds selected fields characterised by a significantly lower intensity of spring grazing (figure 1). Inclusion of bird species richness, as independent factor in the model, explained significantly more variation than the Null model (results not shown). However for species richness greater than one, parameter estimate did not differed significantly, presumably due to the scarcity of these data.

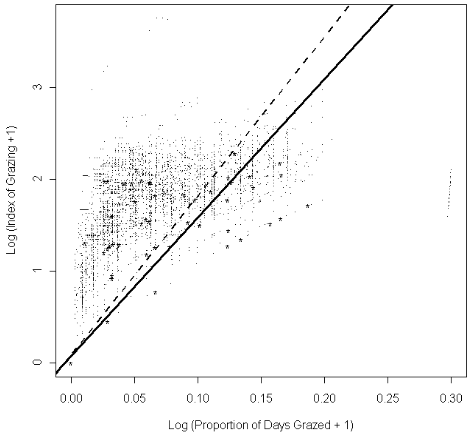

Figure 1. Relationship between proportion of days grazed and index of grazing (stocking rate) for all fields (dashed line) and those occupied by birds in 1996 (unbroken line). * Indicates a data point for a fields occupied by birds.

When analysis was performed only on occupied fields, niche differentiation between species with respect to grazing intensity appeared indicating that grazing was likely to be a critical factor influencing habitat suitability. This was evident since curlew occupied fields with a significantly larger, and redshank occupied fields with significantly lower, intensity of spring grazing than the mean of all fields occupied by birds (figure 2, table 1). Relationship for other species did not significantly differ from the mean for all bird species. However, lapwing parameters estimates were significant. This result is probably caused by lapwing accounting for most field occupancy.

Table 1. Parameter estimates for models describing the relationship between proportion of days grazed and grazing index (stocking rate) for fields on which birds were observed in 1996 (both grazed and ungrazed). Significance codes are given for parameter estimates and the result of Fisher's exact test after comparison of each model with the Null model.

Models	*Factor*	*Slope*	*Intercept*	R^2
Birds Null		15.102***	0.067***	0.746
Redshank	Absent	16.657***	0.049*	0.793††
	Present	12.854***	0.164**	
Lapwing	Absent	14.812***	0.041	0.786
	Present	15.161***	0.105***	
Curlew	Absent	14.296***	0.056**	0.795†††
	Present	17.978***	0.135*	
Black-tailed	Absent	15.052***	0.0721***	0.785
Godwit	Present	N/A	-0.001	
Migratory	Absent	14.600***	0.121***	0.792††
lapwing	Present	N/A	-0.001	

Pr (>t): ***(0.0001) **(0.001) *(0.01)
Pr (>F): ††† (0.0001) †† (0.001) †(0.01)

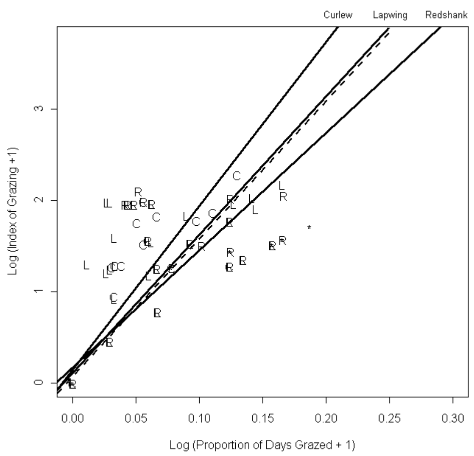

Figure 2. Relationship between proportion of days grazed and grazing index (stocking rate) for all fields occupied by birds (dashed line) and those occupied by individual bird species in 1996 (unbroken lines). Each data point corresponds to: L = Lapwing, C = Curlew, R = Redshank. Insignificant relationships are not shown.

Annual stocking rate

Annual stocking rate described the cumulative effects of grazing for each field throughout the year. The mean annual stocking rate for fields occupied by birds did not differ significantly from the mean for all fields in the marsh (table 2). However variance in the annual stocking rate was significantly lower in fields occupied by birds than in the whole marsh. Actually, birds also occupy ungrazed fields and therefore fields with the extreme lowest stocking rate (i.e. mowed grasslands). This reduction in variance was then attributed to birds not occupying fields with the extreme highest stocking rate.

Table 2. Comparisons between the mean and variance in index of grazing for 1996 for all fields (both grazed and ungrazed).

Models	*Mean*	*t*	*Variance*	*F*
Null	65.252	N/A	52690.470	N/A
Birds	55.775	1.065	6514.425	8.088***
Lapwing	58.939	0.539	6334.499	8.318***
Migratory Lapwing	55.891	0.907	5812.721	9.065***
Black-tailed Godwit	73.706	-0.434	5555.060	9.485***
Redshank	46.945	1.108	5522.278	9.541***
Curlew	85.035	-1.167	7624.845	6.910***

***(p<0.001) **(p<0.01) *(p<0.1)

When only grazed fields were taken into account in the analysis, mean and variance in annual stocking rate resulted significantly lower on fields occupied by all bird species, both collectively and individually (table 3). This result implies that each species is specialised to a particular annual stocking rate lower than the mean for all grazed fields. Such a result is in apparent contradiction with the finding of curlew occupying fields with a significant greater mean of spring grazing than that of the whole marsh. A plausible explanation could be that curlew habitat suitability was increased by grazing being more intense in spring but not throughout the rest of the year, such that the annual stocking rate remained lower than the mean for all grazed fields.

Table 3. Comparisons between the mean and variance in index of grazing (stocking rate) for 1996 for grazed parcels only.

Models	*Mean*	*t*	*Variance*	*F*
Null	187.071	N/A	128406.0	N/A
Birds	135.590	2.892**	4988.281	25.745***
Lapwing	123.976	3.112**	5223.017	24.585***
Migratory Lapwing	133.799	2.913**	3418.640	37.561***
Black-tailed Godwit	131.034	2.644*	1964.982	65.347***
Redshank	107.972	2.715*	6177.443	20.786***
Curlew	134.265	2.338*	5307.277	24.194***

***(p<0.001) **(p<0.01) *(p<0.1)

Autumn stocking rate

Effects of autumn stocking rate on field selection by birds was tested using data on grazing regimes during autumn 1994 and bird presence in early 1995 (between January 1st and April 1st) i.e. before the turn out to grass of herds. Birds selected fields with a significantly greater mean and variance in autumn stocking rate than for all fields grazed in autumn 1994 (figure 3). Bird species richness in early spring was also positively correlated with stocking rate of previous autumn. This result suggests that intense grazing in the previous autumn, as well as above average variation in fields stocking rate, increases habitat suitability for bird species occupying fields before turn out date.

Niche differentiation

Those different results indicated that niche differentiation exist with respect to grazing. For at least three species, we showed that birds respond differently to grazing intensity and that species requirements also differed according to time. Lapwing occupied fields with a lower than average annual stocking rate, a lower than average intensity of spring grazing and a higher than average autumn stocking rate, from which it is inferred that lapwing habitat suitability was improved by intense autumn grazing. This is in sharp contrast with curlew which occupied fields with a higher than average intensity of spring grazing and a lower than average annual stocking rate, from which it is inferred that intense spring grazing was essential to improve its habitat suitability. Redshank habitat suitability was increased by a lower than average intensity of spring grazing and the lowest mean annual stocking rate of all species. From this result it is inferred that redshank habitat is increased by a low intensity of grazing at all time.

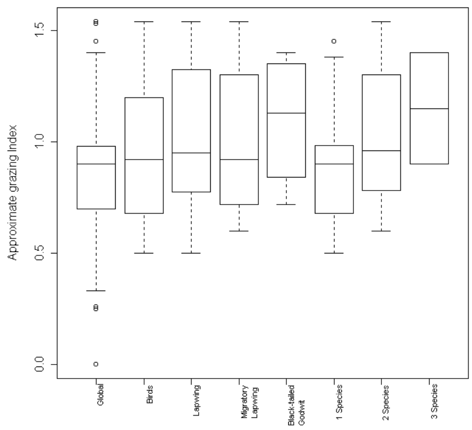

Figure 3. Box-plots showing the mean and variance in autumn stocking rate (1994) when only grazed fields are included in the analysis. Mean and variance tested for varying species richness and species occupancy in the following early spring 1995.
Birds: t=-2.445*, F=0.434***; One species: t=-0.741, F=0.514*; two species: t=-2.628*, F=0.399**; three species: t=-2.183*, F=0.318; Lapwing: t=-3.176**, F=0.368***; migratory lapwing: t=-2.328*, F=0.462**; black tailed godwit: t=-2.529*, F=0.405.
***(p<0.001) **(p<0.01) *(p<0.1)

Discussion

Our results indicating that spring grazing intensity can promote suitable habitat for lapwing are in contradiction with those from Hart et al. (2002) showing that breeding densities of lapwing were negatively correlated to livestock densities (0.2-0.51 LU/ha). From these results, authors inferred that exclusion of livestock is a desirable option on coastal grazing marsh. However, the simplicity of the livestock variables they used does not reflect the variation in grazing intensity that occurs due to varying turnout dates, stocking rates and proportion of days grazed. Furthermore, differences in grass growth rates during spring may also explain the apparent contradiction of our results with Hart & colleagues’ study. However, these authors raised an interesting point related to nest trampling by cattle. Those data were not available in our study and it is obvious that there may be a threshold on livestock densities above which the positive effects of grazing on sward state are mitigated by the negative effects on clutch survival.

Various studies have reported that short swards (10cm) are more suitable for lapwing (see for instance Milsom et al., 2000). In the context of Ouest-du Lay marsh, climate is warm Atlantic and grass growth is likely to occur during winter. This may explain why heavy autumn grazing can promote lapwing suitable habitat in the following spring. A strong defoliation on this period will slow down re-growth during the next one.

Concerning redshank, our results are in agreement with those of Norris et al. (1998) indicating that breeding densities are highest on slightly grazed fields in spring. This species tends to nest in small patches of relatively tall vegetation that are likely to be uncommon on fields heavily grazed. As it settles and nests later than lapwing, its breeding success is more likely to be sensitive to spring grazing. Late turnout date and tall sward associated with high livestock densities may have detrimental effects for nests survival and birds may avoid heavily grazed fields.

The variable sensitivity of the species to different critical period (e.g. autumn *versus* spring) needs to be analysed in the light of the timing of their settlement. In a study carried out in 2004 on the same marsh, we confirmed the difference between lapwing and redshank phenologies (Durant unpubl. data). Lapwing nests about one month earlier (mean date of settlement: March 24 ± 14 days, n = 37 pairs; mean hatching date: April 16 ± 9 days, n = 71) than redshank (April 21 ± 17 days, n = 6; May 21 ± 10 days, n= 42, respectively). Therefore, the trade-off between livestock densities and hatching success is likely to be also dependant on the breeding phenology of a given species. We conjecture that there may be a ‘threshold date’ before which grazing may have detrimental effects. From this perspective, it is interesting to note that delayed effects of autumn grazing can be useful to create the short sward needed for lapwing settlement. However these effects may also vary according to annual climatic conditions (see Tichit *et al.* in this congress).

Conclusion

Results on niche differentiation according to grazing intensity are globally congruent with the results provided by the model of habitat suitability that we built for this same wader community (see Renault *et al.* in this congress), in the sense that habitat preferences do not build on the same variables for all species. We identified two groups of birds, with respect to two different sets of variables: the first group, more attracted by “wetness”, is made of migratory lapwing and black-tailed godwit. The second group, more attracted by “usages” instead (in particular grazed grassland), is made of lapwing, redshank, and curlew. Because species-environment relationships operate at field and coarser scales such as the landscape, from both studies we conjecture that the assessment of positive and negative side effects of grazing should be implemented taking into account several spatial scales of observation. The definition of these scales should be made from the spatial resolution of bird behaviour and should be based on relevant ecological traits of breeding waders (home range size for instance).

On a more general way, our results highlight the need to maintain a variety of grazing regimes (in time and intensity) if conservation is to be achieved at the community level From this point of view, our results are in agreement with Benton et al. (2003) contending that habitat heterogeneity, at a range of spatial scales, is a key issue in maintaining biodiversity within agricultural landscapes. Surprisingly, it should be noted that agri-environment schemes implemented since the early 90’s have aimed at decreasing fertilisation, imposing upper limits on average spring stocking rates, and in some cases have postponed turnout date (Steyaert, 2001). The impact of such regulations deserves to be assessed, as they could reduce spread in timing of management operations that would previously have occurred.

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