GORTANIA Botanica, Zoologia | 32 (2010) | 193-201 | Udine, 31.X.2011 | ISSN: 2038-0402

Antonio Borgo

CHECK-LIST HABITAT REQUIREMENT, THREAT AND CONSERVATION OF THE *CREX CREX* (RALLIDAE) IN THE ITALIAN ALPS

ESIGENZE AMBIENTALI, MINACCE E CONSERVAZIONE DEL RE DI QUAGLIE (*CREX CREX*) NELLE ALPI ITALIANE

Abstract - The breeding range of Corncrake (*Crex crex* Linnaeus, 1758) in Italy is limited to mountains meadows of the Eastern Alps. The reafforestation process caused by land abandonment risks to involve an important loss of Corncrake Italian population. Since studies on species habitat selection in the Alps are lacking, I analysed the habitat requirements of Corncrake in the Julian Pre-Alps Natural Park (Eastern Alps). I recorded habitat characteristics and invertebrate abundance in 23 randomly selected calling sites and 37 unoccupied sites, and I performed discriminant function analysis and ANOVA to compare two samples. The results showed that the meadows suitability is affected more by the structural than by the compositional characteristics. The invertebrate abundance is higher in occupied sites, but suitable structure and food availability result related. Discriminant analysis provide an habitat suitability model that could help managers in identifying priority habitats to preserve from reafforestation and suitability loss. Seeing that the calling male density was higher in 2000 than in 2001, I compared by ANOVA the habitat characteristics of calling sites occupied in both years with those of sites occupied only in 2000. According with the ideal free distribution theory, in the low density year Corncrake seems to select the more suitable sites.
Key words: Corncrake, Habitat requirements, Preservation, Reforestation, Alps.

Riassunto breve - *La presenza riproduttiva del Re di quaglie in Italia è limitata ai prati e pascoli montani delle Alpi orientali. La riforestazione determinata dall'abbandono del territorio rischia di comportare un'importante riduzione della popolazione italiana del Rallide. Questo studio è stato condotto nel Parco Naturale Prealpi Giulie, per colmare la mancanza di studi sulle esigenze ecologiche della specie nelle Alpi. Sono state misurate variabili ambientali e abbondanza di invertebrati in 23 siti di canto e 37 siti di confronto, e i due campioni sono stati confrontati mediante ANOVA e analisi di funzione discriminante. I risultati evidenziano come l'idoneità del prato o pascolo sia determinata più dalle sue caratteristiche strutturali che dalla composizione floristica. L'idoneità strutturale e la disponibilità trofica risultano essere tra loro correlate. La discriminante fornisce un modello predittivo di valutazione che può aiutare ad identificare i siti prioritari da preservare dal processo di riforestazione e conseguente perdita di idoneità. Confrontando i siti occupati solo in anni di alta densità di popolazione (2000) e quelli occupati anche negli anni di scarsa densità, si rileva che, in accordo con la teoria dell'Ideal Free Distribution, i siti occupati anche negli anni di bassa densità hanno idoneità maggiore.*
Parole chiave: Crex*, Esigenze ecologiche, Conservazione, Riforestazione, Alpi.*

Introduzione

Since late 19th century the Corncrake (*Crex crex* Linnaeus, 1758) in Europe has been characterized by a marked decline of its range and population size (Green et al. 1997), and it is therefore included on the 1st enclosed of the Directive Birds 115/91/CEE and in the Appendix II of the Berna Convention. At present the Corncrake is looked upon as a near threatened species (IUCN 2005) and listed as SPEC II by Tucker & Heath (1994). In Europe, the Corncrake strongly depends on agricultural habitats. Changes in the management of agricultural grassland, namely the mechanization of mowing, are the main causes of this decline (Green et al. 1997; Shäffer & Green 2001). The European populations show marked annual fluctuations (Glutz et al. 1973; Cramp & Simmons 1980; Tucker & Heath 1994; Frühauf 1997) so that the number of singing males in the same areas greatly vary from year to year. These fluctuations seem to be mainly related to large-scale weather conditions and don't depend on local factors (Frühauf 1997). The alpine populations, consisting of about 1400 singing males (Green et al. 1997; Frühauf 1997), represent the South-Western edge within the Corncrake distribution range. In Italy the Corncrake shows a distribution that is limited to the South-eastern Alps (Farronato 1994; Tout, unpublished data; Borgo et al. 2001; Gottardo et al. 2001; Odasso et al. 2002). The Italian breeding population was estimated in 100-500 (Tucker &

Heath 1994) or 250-300 (Green et al. 1997) singing males, but after analysing the most recent available data for the different regions (Farronato 1994; Gottardo et al. 2001; Odasso et al. 2002) the presence of about 500-600 singing males seems to be more likely. At least half of the Italian population is concentrated in the South-eastern Italian Alps (Friuli Venezia Giulia region) (Gottardo et al. 2001; 2003). The preservation of the alpine populations is primary in Central-Western Europe because their contraction would consequently cause the contraction of the species' range.

The alpine populations are less threatened by the modernisation of grassland farming than the lowland populations (Trontelj 1997), because the mountain meadows are largely inaccessible to the large reaping-machines. In Austria the intensification of the grassland management seems to induce a progressive avoidance of the bottoms of the valleys, and a progressive increase in the number of calling males in the upper meadows of the mountain slopes between 600 and 1000 m a.s.l. (Frühauf 1997). In the South-eastern Alps the present situation of general abandonment of the mountain meadows guarantee a lower agricultural impact than in the lowlands of the Central Europe. Grasslands occurring in the valleys of the region of Friuli Venezia Giulia are often fractioned in many patches belonging to different owners. The fact that there are very small properties increases the abandonment of the regular mowing and determines a suitable situation of grassland patchy mowed. All the habitats selected by Corncrakes in the Italian South-eastern Alps (Borgo et al. 2001) are anthropogenic meadows obtained, in the past centuries, by means of forest cutting under the tree-line. Consequently, when abandoned for a long time, these meadows are overgrown with bushes and trees following the vegetational succession within a short time. In the future the grasslands and meadows abandonment, although at first favourable, will become the greatest threat to the Corncrake preservation in the South-eastern Alps. The preservation of the Corncrake Italian population seems therefore to be strictly dependent on the artificial preservation of the mountain meadows and on their preservation by the re-forestation process.

In spite of the necessity of the management of the Corncrake's habitat, the studies on the habitat requirements (both habitat structure and food availability) of the Corncrake in the alpine range are lacking. In my study I wanted to define the habitat requirements of the Corncrake in the South-eastern Alps. The applicatory purpose of the study was to obtain a habitat suitability model able to predict the suitability of existent meadows, and to define a map of suitable and unsuitable meadows, in order to put in evidence those that effectively need a conservation strategy (mowing and grazing limitation) and management (contrast to spontaneous reafforestation).

As recorded in all the Corncrake's European range, marked annual fluctuations in calling males number were observed also in the study area (Borgo et al. 2001; Gottardo et al. 2001; 2003). In accordance with the Ideal Free Distribution theory (Fretwell & Lucas 1970; Fretwell 1972) it seems possible that the sites occupied by singing males in the years of low density, are characterized by an optimal habitat, whereas some of the sites occupied in the years of high singing males density could be sub-optimal. In my work I tried to verify this hypothesis, also in order to evaluate the possibility of increasing the suitability in sub-optimal sites.

Study area

The study area was the Julian Pre-Alps Natural Park (PGNP), a 100 km^2 mountain range of the South-eastern Alps (Friuli Venezia Giulia region, Italy). About 10% of the Italian Corncrake population is concentrated in the study area (Tucker & Heath 1994; Borgo et al. 2001; Gottardo et al. 2001; Odasso et al. 2002), or 17-30% when following the estimate of Green et al. (1997).

Elevations of the study area range from 400 to 2587 m. The average annual temperature (at 500 m a.s.l.) ranged, in the different valleys, between 8 °C and 12 °C (January 2,8 °C and July-August 19 °C). Very abundant precipitations (average from 2500 to 3400 mm/year) characterize the area because of the East-West valleys orientation, and the vicinity of the Adriatic Sea. Woods (mainly composed by *Fagus sylvatica, Ostrya carpinifolia* and *Pinus nigra*) cover 62% of the Park, the rocky areas 20%, the prairies and meadows 16%. In the study area the composition and structure of meadows strongly differ between the Southern and Northern slopes, and relatively according to the soil structure and permeability (Simonetti & Mainardis 1996). Four principal prairie and meadow types were present in the study area: meadows of the bottom valley (*Centaureo carniolicae-Arrhenatheretum elatioris*), meadows of the mountain slopes (*Arrhenatheretum* and *Trisetetum*), meadows of the southern slopes (*Festuco-Brometea*), alti-mountain and sub-alpine prairie occurring above the tree line (*Seslerio-Caricetum*). Only the meadows of the bottom valley are actually mowed, whereas all the other meadow types have no longer been mowed or grazed in the study area for the last twenty-fifty years. Corncrake used all these habitats, from 600 to 1800 m a.s.l., selecting only the meadows of the mountain slopes (Borgo et al. 2001). 10% of Italian Corncrake population was concentrated in the study area.

Methods

The number and distribution of the singing sites of Corncrake's males in the PGNP was surveyed in 2000 and 2001 (Borgo et al. 2001). Nocturnal spontaneous or play back stimulated calls were recorded and mapped (Blondel 1969; Braun et al. 1973; Falls 1981; Oelke 1981) from May to June following Bibby et al. (1993). In 2000 we recorded a high singing male density (0.41/km^2) and 49 singing males were censused. In 2001 we recorded a low density (0.18/km^2) and only 21 singing males were censused (Borgo et al. 2001). To analyse the habitat requirements of the Corncrake in the study area, I randomly selected 25 of the 49 calling sites occupied by Corncrake in 2000. In each calling site I identify one calling point, calculated as the geometric centre between the locations of calling male. I employed discriminating function analysis (DFA; Magnusson 1983) with a step-wise procedure to analyse the environmental and biotic factors (Appendix A) discriminating between the calling points and 40 random locations. One-way ANOVA was used to identify factors showing significant differences between calling points and random locations. All random locations were generated by means of the extension "animal Movement" of the GIS software Arc-View 3.2 (Hooge & Eichenlaub 1997). Because Corncrakes settled exclusively in meadows, random locations were only plotted in this habitat. In addition, because Corncrakes males are territorial, I retained only random locations in meadows unoccupied by Corncrake's males during the investigation period (2000-2001). Finally, random locations were plotted within the same range of elevation of the calling points, so as to avoid plotting them in unsuitable locations (e.g., because of extreme climate at high elevations).

Only data from 23 occupied and 37 unoccupied sample points were retained for analysis, because the habitat characteristics of 2 occupied and 3 unoccupied sample points were modified among the census period (2000, 2001) by grazing occurrence. The variables of the Appendix A were measured in the field during 2001 and were chosen so as to measure: 1) the elevation and morphology (lying position) of the sample sites, 2) the compositional and structural characteristics of the habitat in the immediate surroundings of the sample points, 3) the invertebrate availability in the sample point. The variables concerning grass height and density (Appendix A) were measured every 2.5 metres along two 10 metres long transects centred on the sample point, and north-south and east-west oriented. The height of grass was measured with a sward stick consisting of a 20 cm in diameter disc weighing 140 g (Sutherland et al. 2005). The density of the grass was measured using a chequerboard and recording the number of grid intersections that were visible through the vegetation. For each sample point, the grass density and height were measured by means of the 8 values recorded every 2.5 m along the two transects. I measured the vegetation height in the calling and mating period (may 15th), in the incubation period (June 10th) and in the chicks rearing period (July 1th). I measured the density of the grass on July 1th, both at the upper layer (40 cm above the soil) and at the lower layer (at 15 cm above the soil). Within a 20 m radius circle centred on each sample point I assessed the average height of shrubs (vegetation below 2 m height) and tree (vegetation above 2 m height) using a clinometer, and I visually estimated shrub and tree percentage cover.

To assess the habitat selection in relation to the morphological characteristics of the sites I compared the observed and expected use of four lying position types: hollow, top, slope and flat land, by means of the Bonferroni confidence interval analyses (Neu et al. 1974). Observed use was calculated as the proportion of calling sites observed within each lying position type, whereas expected use was calculated as the availability of the four lying position types in the total set (n = 60) of sample sites.

In each sample point I surveyed the abundance of invertebrates by one pitfall-trap (Skuhravy 1957; Newton & Peck 1975; Baars 1979). The traps were plastic glasses (upper diameter 9 cm, height 12 cm) with a hole-drain at ¾ of the height, containing a saturated solution of salt and vinegar to attract Carabidae and Stafilinidae beatles and Araneae (Adis & Kramer 1975; Baars 1979; Dennison & Hodkinson 1984; Halsall & Wratten 1988; Jantscher & Paill 1998). Carabidae and Stafilinidae prey other insects or invertebrates and their abundance is therefore correlated with those of other families of insects and other invertebrates (Oliver & Beattie 1996). Thus, the sampling of these insect families allows us to compare the invertebrates abundance among the sample points. The pitfall-traps were placed on 15th May, activated (opened and baited) on 10th June and picked up on 1st July. The effective capturing time was 20 days. For the analysis I considered the number of individuals of the different families of Coleoptera and the number of spiders collected in each sample point.

To reduce collinearity and the number of variables presented to the discriminant model, I employed the method of variable reduction proposed by Green (1979). Following this method, pairs of strongly inter-correlated, explanatory variables ($r > 0.6$) are considered as estimates of one underlying factor. Only one of the two is retained for analysis, usually the one likely to be perceived as more important by the study organism.

Because only 15 out of the 23 selected calling sites occupied in 2000 were also occupied in 2001, I compared by one-way ANOVA the habitat characteristics of calling points occupied by males also in the low density year 2001 (n = 15), with those of calling sites occupied only in high density year 2000 (n = 8). I carried this analysis in order to understand whether, in the year of lower Corncrake presence, males selected the most suitable sites or if they randomly occupied the available sites. My hypothesis was that if in the low density year Corncrakes were selecting among the available settlement sites, it should have been possible to evidence a few differences in the habitat characteristics between the suitable sites occupied and unoccupied by males.

Results

Some habitat characteristics differed significantly from the sample points occupied and unoccupied by Corncrake calling males (table I). During all the monitoring period, but mainly in June and July, the occupied sample points were characterized by higher grass than the unoccupied points. The density of the upper grass layer was significantly higher in the occupied than in the unoccupied sites, whereas the lower layer density was less. The ratio between the lower and upper layer density was consequently much lower in the occupied sites than in the unoccupied.

The grass height in early summer (1st July) was related to the grass height in May ($r_s = 0.577$, $P < 0.001$) and June ($r_s = 0.842$, $P < 0.001$). The summer grass density of the upper layer was related to the grass height in summer ($r_s = 0.816$, $P < 0.001$), but also in May ($r_s = 0.548$, $P < 0.001$) and June ($r_s = 0.707$, $P < 0.001$). Similarly, the summer ratio between lower and upper layers was related to the summer grass height ($r_s = -0.783$, $P < 0.001$), but also to the grass height in May ($r_s = -0.664$, $P < 0.001$) and June ($r_s = -0.734$, $P < 0.001$).

In the occupied sites the Umbelliferae density in the upper grass layer was greater than in the unoccupied sites. The Umbelliferae density was related to the grass height in summer ($r_s = 0.534$, $P < 0.001$), and July ($r_s = 0.385$, $P = 0.003$), and negatively to the summer ratio between lower and upper grass layers density ($r_s = -0.633$, $P < 0.001$). The dicotyledonous/monocotyledonous ratio was higher in the occupied than in the unoccupied sites, and was related to the grass height in summer ($r_s = 0.318$, $P = 0.017$) and to the upper layer density ($r_s = 0.377$, $P = 0.004$). The felted turf thickness, aspects and slope did not differ significantly between occupied and unoccupied sites. The shrubs and tree percent coverage was greater in the unoccupied sites, whereas their height did not differ between occupied and unoccupied sites.

The data about insect and spider abundance were available only for 42 sample points, because 10 pitfall traps were destroyed by wild boars (*Sus scrofa*), 2 by sheep, and 6 by vandalisms. 4172 arthropods were collected: 2638 Coleoptera, 67 Orthoptera, 43 Hemiptera and 1424 spiders. Within Coleoptera the most abundant were taxa attracted by bait solution: Silphidae (n = 1467), Carabidae (n = 707) and Staphilinidae (n = 243). The sites occupied by Corncrakes were characterized by a significant greater abundance of Coleoptera, and, namely, of Carabidae, Stafilinidae and Silphidae. In particular, in the occupied sample points I recorded a greater abundance of large Carabidae (more than 15 mm long: mostly *Carabus* and *Abax*) and of small Stafilinidae (less than 15 mm long). Spider's abundance doesn't differ between occupied and unoccupied sample points (table II).

The abundance of Carabidae and Staphilinidae was positively related to the grass height on 10th June ($r_s = 0.346$, $P = 0.025$ and $r_s = 0.360$, $P = 0.019$) and on 1st July ($r_s = 0.442$, $P = 0.003$ and $r_s = 0.352$, $P = 0.022$), to the upper grass layer density ($r_s = 0.562$, $P < 0.001$ and $r_s = 0.344$, $P = 0.026$), and negatively to the ratio between the lower and upper layer density ($r_s = -0.526$, $P < 0.0001$ and $r_s = -0.294$, $P = 0.065$ N.S.). The spiders abundance, although particularly related to the abundance of Carabidae ($r_s = 0.334$, $P = 0.030$) and *Carabus* ($r_s = 0.369$, $P = 0.016$), was not related to the measured habitat variables.

Since the invertebrate abundance were strongly related to the grass structure, I carried out a DFA without considering invertebrate variables (see Appendix A). The DFA (table III) significantly discriminated occupied (n = 23) and unoccupied (n = 37) sample sites, and correctly classified 100.0% of sample cases. The variables entered in the function were the density of the upper grass layer, the ratio between lower and upper layers density, the grass height on 10th June, and the felted turf thickness.

Habitat use of Corncrakes was related to topography: they preferred hollows ($P < 0.05$), avoided flat lands ($P < 0.05$) and tops ($P < 0.01$) and used slopes like expected (table IV). However habitat characteristics differed significantly among the four lying position classes (oneway ANOVA), and explained their different selections. The hollow had the highest grass ($F = 4.983$; $P = 0.004$), and the greatest upper layer density ($F = 5.116$; $P = 0.003$), and Stafilinidae abundance ($F = 4.742$; $P = 0.007$). In particular, the grass height was significantly higher than in flat lands and in tops, whereas upper layer grass density and Stafilinidae abundance were significantly greater than in flats land and slopes (post hoc Tukey test).

The 15 sample sites occupied by Corncrakes also in the low male's density year (2001) showed a higher grass on 10th June and 1st July than the 8 sample sites occupied only in the high density year (2000), and a greater abundance of Carabidae and Stafilinidae (oneway ANOVA, table V).

Discussion

The habitat requirements of Corncrake has been investigated in the course of several studies carried out on the European populations living in the lowlands (Shaffer & Munch 1993; Stowe et al. 1993; Green & Williams 1994; Hirler 1994; Helmecke 2000), but little is known about the alpine populations. In the South-eastern Alps,

Habitat variables	**Occupied (n = 23)**		**Unoccupied (n = 37)**		**F**	**P**
	Average	**SE**	**Average**	**SE**		
Felted turf (cm) thickness	2.50	0.60	3.80	0.70	1.850	0.179
Grass height (cm) on May 15th	39.10	1.60	29.70	2.40	7.6230	0.008
Grass height (cm) on June 10th	74.48	3.72	43.08	3.23	38.850	0.000
Grass height (cm) on July 1st	112.17	3.20	63.27	4.26	67.120	0.000
% grass density at lower layer (A)	43.17	1.26	50.50	2.71	4.250	0.044
% grass density at upper layer (B)	65.04	2.07	14.67	1.85	313.720	0.000
Ratio A/B	0.67	0.02	5.23	0.76	25.170	0.000
% Umbelliferae density	10.04	3.16	0.33	0.28	14.630	0.000
Ratio dicotiled./monocotiledonous	1.06	0.25	0.45	0.09	7.330	0.009
% shrubs cover	1.60	0.50	18.8	4.00	11.300	0.001
% tree cover	0.10	0.10	4.10	1.30	5.890	0.018
Shrubs height (m)	1.20	0.20	1.50	0.20	0.728	0.400
Tree height (m)	4.50	0.50	5.50	0.50	0.588	0.450

Table I - Average values (SE) of habitat variables in sample points occupied and unoccupied by Corncrake males and significance of the differences (one-way ANOVA).
- *Valori medi (SE) delle variabili ambientali nei punti campione occupati e non occupati da maschi di Re di quaglie e significatività delle differenze (one-way ANOVA).*

Variable	**Occupied (n = 23)**		**Unoccupied (n = 37)**		**F**	**P**
	Average	**SE**	**Average**	**SE**		
Total N° Silfidae	71.94	27.80	7.17	2.64	7.18	0.011
Total N° Stafilinidae	9.56	2.27	2.96	0.56	10.20	0.003
N° Stafilinidae > 15 mm	2.83	0.97	2.00	0.51	0.66	0.421
N° Stafilinidae ≤ 15 mm	6.72	2.38	0.96	0.27	7.69	0.008
Total N° Carabidae	27.06	4.67	9.17	2.35	13.52	0.001
N° Carabidae ≤ 15 mm	18.00	4.32	7.75	2.25	5.08	0.030
N° Carabidae > 15 mm	9.06	1.84	1.42	0.56	19.86	0.000
N° *Carabus* sp.	4.89	1.60	0.71	0.37	8.37	0.006
Total N° Coleoptera	114.33	28.35	24.17	5.04	12.87	0.001
N° Araneidae	35.56	4.75	32.67	5.96	0.13	0.721
Ratio Coleoptera / Araneidae	3.93	0.79	1.00	0.22	16.17	0.000

Table II - Average values (SE) of arthropod index groups abundance in sample points occupied and unoccupied by Corncrake males and significance of the differences (one-way ANOVA).
- *Valori medi (SE) di abbondanza dei gruppi indice di artropodi nei punti campione occupati e non occupati da maschi di Re di quaglie e significatività delle differenze (one-way ANOVA).*

Habitat variables	**Standardized coefficients**	**Coefficients of correlation with DF**
% grass density at upper layer (B)	1.323	0.645
Felted turf thickness	-0.683	-0.065
Grass height on June 10th	0.525	0.337
Ratio A/B	0.831	-0.185
% grass density at lower layer (A)	-0.709	-0.112
Eigenvalue = 13.606; Canonical correlation = 0.965; χ^2 = 138.093 $p < 0.0001$		

Table III - Discriminating function analysis between sample points occupied (n = 23) and unoccupied (n = 37) by Corncrake's males.
- *Analisi di funzione discriminante tra punti campione occupati (n = 23) e non occupati (n = 37) da maschi di Re di quaglie.*

the high heterogeneity in meadow types available in the same study area permits to investigate the habitat requirements of the Corncrake in a complete gradient of structural and compositional grass situation.

Spring census of the territorial singing males is the easiest method to locate the possible breeding sites of the Corncrake. The location of nests or nesting females is in fact possible only if females are fitted with transmitters and surveyed with telemetry. Since the Corncrake nests are usually very close (less than 100 m) to the calling sites (Stowe & Green 1997; Schaffer 1999), it is possible to consider the calling sites as potential breeding sites, and to analyse their habitat characteristics in order to investigate the requirements of Corncrake's breeding

Lying types	Expected proportions of usage	Observed proportions of usage	Bonferroni intervals
Flat land	0.365	0.231 *	$0.363 \le p_i \le 0.098$
Hollow	0.111	0.269 *	$0.409 \le p_i \le 0.129$
Top	0.048	0.000 **	$0.000 \le p_i \le 0.000$
Slope	0.476	0.500	$0.657 \le p_i \le 0.342$

* P < 0.05; ** P < 0.01

Table IV - Results of Bonferroni confidence intervals analysis on expected and observed lying types habitat usage proportions for settlement points of Corncrake males (n = 60).
- *Risultati dell'analisi degli intervalli fiduciali simultanei di Bonferroni tra le proporzioni d'uso attesa e osservata dei punti di insediamento di maschi di Re di quaglie (n = 60) rispetto ai tipi di giacitura.*

Habitat variables	Sites A (n = 8)		Sites B (n = 15)		F	P
	Average	SE	Average	SE		
Altitude	991.00	88.00	1134.00	45.00	2.60	0.122
Incline(°)	11.75	3.15	13.47	2.93	0.14	0.715
Grass height on June 10th	60.13	5.15	78.47	5.12	5.28	0.032
Grass height (cm) on July 1st	95.13	7.98	116.80	3.83	7.75	0.011
Felted turf (cm) thickness	2.25	0.82	2.53	0.82	0.05	0.826
N° Stafilinidae	3.29	1.32	12.82	3.27	4.99	0.040
N° Carabidae	13.57	2.34	34.36	6.56	5.96	0.027
Lower layer grass density (A)	47.25	4.96	42.87	1.07	1.30	0.267
Upper layer grass density (B)	59.00	8.32	63.87	2.33	0.52	0.480
Ratio A/B	1.74	1.07	0.68	0.02	1.90	0.183
% Shrubs cover	1.50	0.78	1.73	0.75	0.04	0.844
% Tree cover	1.63	1.22	0.00	0.00	3.45	0.077

Table V - Average values (SE) of habitat variables and of arthropod index groups abundance in sample points occupied by Corncrake males only in the high Corncrake density year (sites A) and both in the high and low density year (sites B), and significance of the differences (one-way ANOVA).
- *Valori medi (SE) delle variabili ambientali e di abbondanza dei gruppi indice di artropodi nei punti campione occupati da maschi di Re di quaglie solo negli anni di alta densità di Re di quaglie (siti A) e occupati in entrambi gli anni di alta e bassa densità (siti B) e significatività delle differenze (one-way ANOVA).*

habitat (Helmecke 2000). Thus, in the calling sites I measured the height of the grass in the calling and mating period (may 15th), but also in the incubation (June 10th) and chicks rearing (July 1st) periods. Similarly, I measured the grass density in the incubation period and I trapped invertebrates within the incubation and first chicks rearing period.

The main structural factors affecting the settlement of Corncrake in the study area were the height, density and vertical distribution of the grass. The importance of high grass when determining the suitability to the Corncrake settlement has been emphasized also in several studies in different European populations (Shaffer & Munch 1993; Stowe et al. 1993; Green & Williams 1994; Trontelj 1997; Helmecke 2000; Hirler 1994). Sites occupied by Corncrakes in the Julian Pre-Alps Natural Park have showed since May a higher vegetation than unoccupied sites. But the difference of the grass height between occupied and unoccupied sites increased in June and July. Therefore, at the spring arrival from the winter range, Corncrakes settled in sites namely suitable to supply a higher vegetation during the nesting and chicks rearing periods. This fact is mainly evident at upper altitude, where the grass growth started later. The height of the grass recorded in the calling sites at the middle of May was lower than in other areas of central or northern Europe (Helmecke 2000), whereas the grass height recorded in the chicks rearing period is in accordance with the one recorded in Slovenia by Trontelj (1997).

During the breeding season, sites occupied by Corncrakes were characterized by a greater density of the upper grass layer than the unoccupied sites, and by a lower density of the lower layer. The lower layer is the vital space used by birds for feeding, moving and running away. The upper layer is not used directly by birds, but supplies protection from predators (Hirler 1994), sunstroke, wind and precipitations. In the occupied sites the ratio between lower and upper density was less than 1 (more dense at the upper layer), while in the unoccupied sites the ratio was higher than 1 (more dense at the lower layer). Corncrakes seem therefore to select habitats with a typical "cathedral structure" of the grassy mantle, optimal to supply at the same time protection from predators and climatic adversity, and an easy and quick mobility of adult birds and broods.

The sites occupied by calling males showed a higher grass than the unoccupied ones from the settlement period, but were especially characterized by a higher suitability in the next incubating and chicks rearing period. Therefore it seems that Corncrake's males were already able to estimate at their spring arrival the future summer suitability of the available sites.

The floristic composition of the occupied sites is very different from one habitat to the other. Corncrake settled in grass with a dominance of high dicotyledonous (namely genus *Veratrum, Myrris, Aconitum, Lilium, Urtica*), but also in meadows composed only by monocotyledonous (*Molinia* sp.). However the occupied sites showed a higher average abundance of dicotyledonous than the unoccupied sites. I think that the dicotyledonous abundance could be important because a greater dicotyledonous/monocotyledonous ratio supplies a higher density of the upper layer. Moreover, a greater frequency of dicotyledonous could determine, perhaps in consequence of the flowers presence, a greater availability of insects. In fact I recorded a significant correlation between the dicotyledonous/monocotyledonous ratio ($r_s = 0.358$, $p = 0.023$) and the abundance of *Carabus* sp.. Therefore I think that the greater average frequency of dicotyledonous in the occupied sites can be largely explained with their positive and synergic effects on the structural and trophic suitability of the meadows, but it does not mean that dicotyledonous are indispensable for Corncrake.

The felted turf thickness significantly contributed to discriminate occupied and unoccupied sites in synergy with the structural parameters of the grass mantle. I think that the higher felted turf could represent a negative factor for the habitat suitability of the Corncrake because it hampers the rapid bird walking and limits the food availability. In fact, beetles and other invertebrates find hiding-places in the higher felted turf becoming less available not because less numerous, but because less locatable and reachable.

Although the diet of the Corncrake was studied (Dementiev & Gladkov 1951; Kistyakivski 1957; Gilmour 1972; Glutz et al. 1973; Cramp & Simmons 1980), little is now about the importance of the food availability on the habitat selection of the Corncrakes. Crockford et al. (1996) asserted that the species is more specialised in the structure of the vegetation that it occupies than in the food it takes, because the principal preys (beetles, other large insects, earthworms, snails, slugs) are widespread in habitats other than those used by Corncrakes. My study showed that Coleoptera were more abundant in the occupied sites than in sites unoccupied by Corncrakes, while spider's abundance did not differ between occupied and unoccupied sites. This difference between Coleoptera and spiders is in accordance with the big trophic importance of Coleoptera in the Corncrake's diet and the little or negligible importance of spiders (Dementiev & Gladkov 1951; Kistyakivski 1957; Gilmour 1972; Cramp & Simmons 1980). Within Coleoptera, Carabidae and Stafilinidae (predators of other invertebrates) showed the greatest difference between occupied and unoccupied sites, allowing to affirm that the invertebrates were more abundant in the occupied sites. Considering the correlations between Carabidae and Staphilinidae abundance and grass height and density, it seems that Corncrakes selected habitat conditions able to provide at the same time structural and trophic suitability. In these terms I agree with Crockford et al. (1996): the structure is more important than food in the habitat selection of the Corncrakes because a suitable structure however involves a suitable food availability.

The lying position use showed by Corncrakes seems to be largely dependent on the consequences of the topography in soil humidity and grass structure. In fact birds preferred the hollow, that was the lying type providing the highest grass and the greatest density in the grass upper layer. Similarly Corncrakes avoided flat lands and tops because characterized by more xeric conditions and, consequently, by a less high and dense grass. The avoidance of flat lands may be only a local factor, because of the xericity of the soils in the valley bottom, characterized by a very gravely structure. In fact, in other alpine areas, where valley bottoms are less warm and xeric, flat lands do not seem to be avoided (Frühauf 1997).

The monitoring calling males distribution in a high density year (2000) and in a low density year (2001), allowed me to compare sites occupied in both years with those sites occupied only in the high density year. Although the small size of the sample, sites occupied by Corncrake's males also in the low male's density year differ significantly from those occupied only in high density year. In particular, the sites occupied also during the low density year showed to be more suitable, because characterized by a higher grass and a greater food abundance than those occupied only in the high density year. Therefore the settlement pattern of Corncrake males seems to fit the model of an ideal free distribution (Fretwell & Lukas 1970; Fretwell 1972). In fact this model predicts that a species colonizing a new area occupies and selects firstly the optimal areas, and then the suboptimal. The sites occupied in low density conditions could therefore be considered as the optimal areas available in the Park and with a greater priority of habitat preservation. The sites occupied only in the high density year could be investigated in order to understand if their suitability can be improved.

In the Julian Pre-Alps Natural Park the Corncrake selected only meadows of the mountain slopes between 800 and 1400 m a.s.l. (*Arrhenatheretum* and *Trisetetum*) (Borgo et al. 2001). These habitat types have no longer been mowed or grazed in the study area for the last twenty-fifty years. Since the abandonment, these meadows have actually provided a significantly higher vegetation (F = 4.266, p = 0.009) and less dense on the lower layer (ANOVA F = 2.871, p = 0.045) than the other three herbaceous habitat types available in the study area (altimountain-subalpine prairie, mowable meadows of the valley bottom, meadows of the southern slopes). In the study area, as a consequence of land abandonment, mowing concerns only a part (50%) of the meadows of the bottom valley. Considering that the meadows of the bottom valley were used by Corncrakes less than expected (Borgo et al. 2001) also if not mowed, the impact of the mowing in this Corncrake population seems to be very low. On the contrary, all the habitats selected by Corncrake are actually abandoned and without any management. Since occurring under the tree-line, these habitats are destined to the spontaneous reforestation if abandoned. Therefore, unlike the large part of its range, in the South-eastern Alps Corncrake seems more threatened by land abandonment than by the mechanization of mowing. Consequently, without a policy of habitat management, the spontaneous reforestation process will lead to the loss of suitable habitat and to the extinction or the drastic decrease of the Italian Corncrake population. The habitat suitability model carried out in this study can be useful to evaluate the grass suitability of the meadows for the settlement of the Corncrake, in order to concentrate economic resources to contrast the reforestation only in suitable meadows, allowing the spontaneous reforestation in the habitat patches not suitable for Corncrakes.

Manoscritto pervenuto il 22.VI.2010 e approvato il 17.I.2011.

Acknowledgements

I am grateful to the direction and staff of the Julian Pre-Alps Natural Park for the cooperation and for the study financing. I'm indebted to dr. Alberto Meriggi for the helpful comments on the first draft of the manuscript and for its faithful willingness.

Appendix

Environmental variables measured at Corncrake calling sites and random sites. Variables are divided in three groups (a, b, c) following the survey method.

Variable

a) *Sample point*
   Elevation (m a.s.l.)
   Slope (degrees)
   Lying types (flat land, hollow, top, slope)
   Felted turf thickness (cm)
   Total N° Silfidae
   Total N° Stafilinidae
   N° large Stafilinidae (> 15 mm)
   N° small Stafilinidae (≤ 15 mm)
   Total N° Carabidae
   N° large Carabidae (> 15 mm)
   N° small Carabidae (≤ 15 mm)
   N° *Carabus* sp.
   Total N° Coleoptera
   Total N° Araneidae
   Ratio Coleoptera/Araneidae

b) *Transect 10 metre long centred on sample point*
   Grass height on May 15th (cm)
   Grass height on June 10th (cm)
   Grass height on July 1st (cm)
   % grass density at lower layer (15 cm above soil) (A)
   % grass density at upper layer (40 cm above soil) (B)
   Ratio A/B
   % Umbelliferae density at upper layer
   Ratio dicotyledonous/monocotyledonous at upper layer

c) *Sample plot 20 m radius centred on sample point*
   % shrubs cover
   % tree cover
   Average shrubs height (m)
   Average tree height (m)

References

Adis, J., & E. Kramer. 1975. Formaldehyd-Lösung attrakiert *Carabus problematicus* (Coleoptera - Carabidae). *Ent. Germ.* 2: 121-5.

Baars, M.A. 1979. Catches in pitfall traps in relation to mean densities of carabid beetles. *Oecologia (Berl.)* 41: 25-46.

Bibby, C.J., N.D. Burgess & D.A. Hill. 1993. *Bird census techniques*. London: Academic Press.

Blondel, J. 1969. Méthodes de denombrement des populations de oiseaux. In *Problèmes d'écologie: l'échantillonage des peuplements d'animaux des milieux terrestres*, cur. M. Lamotte & F. Bourlière, 97-151. Paris: Masson et Cle.

Borgo, A., F. Genero & M. Favalli. 2001. Censimento e preferenze ambientali del Re di quaglie *Crex crex* nel Parco Naturale Prealpi Giulie. *Avocetta* 25: 181.

Braun, C.E., R.K. Schmidt & G.E. Rogers. 1973. Census of Colorado white-tailed ptarmigan with tape recorded calls. *J. Wildl. Manage.* 37: 90-3.

Collar, N.J., M.J. Crosby & A.J. Stattersfield. 1994. *Birds to watch* 2. *Birdlife Conservation Series* 4. Cambridge, UK: Birdlife International.

Cramp, S., & K.E.L. Simmons. 1980. *The birds of the Western Palearctic* 2. Oxford: Oxford University Press.

Crockford, N., R. Green, G. Rocamora, N. Shaffer, T. Stowe & G. Williams. 1996. *Action Plan for the Corncrake (*Crex crex*) in Europe.* Cambridge, UK: Birdlife International.

Dementiev, G.P., & N.A. Gladkov. 1951. *Ptitsy Sovietskogo Soyuza* 3. Moskow.

Dennison, D.F., & I.D. Hodkinson. 1984. Structure of the predatory beetle community in a woodland soil ecosystem III, Seasonal activity patterns as revealed by pitfall trapping. *Pedobiol.* 26: 45-56.

Falls, J.B. 1981. Mapping territories with payback: an accurate census method for song birds. In *Studies in Avian Biology* 6. *Estimating numbers of terrestrial birds*, cur. C.J. Ralphs & J.M. Scott, 86-91. Lawrence, Kansas: Cooper Ornitol. Soc., Allen Press.

Farronato, I. 1994. Primi dati sulla distribuzione del Re di quaglie *Crex crex* in provincia di Vicenza. *Riv. Ital. Ornitol.* 63: 129-36.

Fretwell, S.D. 1972. *Populations in a seasonal environment*. Princeton: Princeton University Press.

Fretwell, S.D., & H.L. Lucas. 1970. On territorial behaviour and other factors influencing habitat distribution in birds. Theoretical development. *Acta Biothe.* 19: 16-36.

Frühauf, J. 1997. The Corncrake *Crex crex* in Austria: long-term trends, current situation, and perspectives. *Vogelwelt* 118: 195-207.

Gilmour, J.G. 1972. Corncrakes breeding in Stirlingshire. *Scotish Birds* 7: 52-3.

Glutz von Blotzheim, U.N., K.M. Bauer & E. Bezzel. 1973. *Handbuch der Vogel Mittel-Europas* 5. *Galliformes und Gruiformes*. Frankfurt: Akademische Verlagsges..

Gottardo, E., R. Luise, T. Zorzenon, D. Ota & F. Florit. 2001. Il censimento del Re di quaglie *Crex crex* nel Friuli-Venezia Giulia nel 2000. *Avocetta* 25: 212.

Gottardo, E., R. Luise, T. Zorzenon, D. Ota, M. Di Gallo, G. Facchin & F. Florit. 2003. Il censimento del Re di quaglie *Crex crex* in Friuli-Venezia Giulia negli anni 2001 e 2002. *Avocetta* 27: 111.

Green, R.E. 1979. *Sampling Design and Statistical Methods for Environmental Biologists.* New York: John Wiley and Sons.

Green, R.E., & G. Williams. 1994. The ecology of the corncrake *Crex crex* and action for its conservation in Britain and Ireland. In *Nature Conservation and Pastoralism in Europe*, cur. E. Bignal & D.J. Curtis, 69-74. Peterborough: Proceedings of the third European Forum, JNCC.

Green, R.E., G. Rocamora & N. Schaffer. 1997. Populations, ecology and threats to the Corncrake in Europe. *Vogelwelt* 118: 117-34.

Halsall, N.B., & S.D. Wratten. 1988. The efficiency of pitfall trapping for polyphagous predatory *Carabidae*. *Ecol. Entomol.* 13: 293-9.

Helmecke, A. 2000. Space and habitat use of the Corncrake (*Crex crex*) in the Lower Odra Valley. PhD. Diss., Humboldt-Universität Berlin.

Hirler, A. 1994. Losses in bird nests by predation in different vegetation types - an experimental study. PhD. Diss., Universität Konstanz.

Hooge, P.N., & S.D. Eichenlaub. 1997. *Animal Movement Extension to ArcView ver. 1.1.* Anchorage: Alaska Biol. Sci. Cent., US Geological Survey.

Kistyakivski, O.B. 1957. *Fauna Ukrainy* 4. *Ptakhy* [Fauna der Ukraine 4. Vögel; Fauna of Ukraine 4. Birds]. Kiev: Acad. Sci. UkrSSR Press.

Jantscher, E., & W. Paill. 1998. Die epigäische Spinnen- und Laufkäferfauna eines mittelsterischen Rotbuhenwaldes (*Aracnida: Araneae; Coleoptera: Carabidae*). *Mitt. Naturwiss. Ver. Steiermark* 128: 209-20.

Magnusson, W.E. 1983. Use of Discriminant Function to characterize ruffed grouse drumming sites in Georgia: a critique. *J. Wildl. Manage.* 47: 1151-2.

Neu, C.W., C.R. Byers & J.M. Peek. 1974. A thechnique for analysis of utilisation-availability data. *J. Wildl. Manage.* 38: 541-5.

Newton, A., & S.B. Peck. 1975. Baited pitfall traps for beetles. *The Coleopterist Bull.* 29: 45-6.

Odasso, M., S. Mair, P. De Franceschi, S. Zorzi & S. Mattedi. 2002. *Miglioramenti ambientali a fini faunistici*. Provincia Autonoma di Trento.

Oelke, H. 1981. Limitations of mapping method. In *Studies in Avian Biology* 6. *Estimating numbers of terrestrial birds*, cur. C.J. Ralphs & J.M. Scott, 114-8. Lawrence, Kansas: Cooper Ornitol. Soc., Allen Press.

Oliver, I., & A.J. Beattie. 1996. Designing a cost-effective invertebrate survey: A test of methods for rapid assessment of biodiversity. *Ecol. Appl.* 6: 594-607.

Poldini, L., & G. Oriolo. 1994. La vegetazione dei prati da sfalcio e dei pascoli intensivi (*Arrhenatheretalia* e *Poo-Trisetetalia*) in Friuli (NE Italia). *Studia Geobot.* 13: 3-48.

Schäffer, N. 1999. Habitatwahl und Partnerschaftsystem von Tupfelralle *Porzana porzana* und Wachtelkonig *Crex crex. Okol. der Vogel* 21: 251-67.

Schäffer, N., & S. Münch. 1993. Investigations on habitat selection and breeding biology in the Corncrake *Crex crex* in the Murnauer Moos-Oberbayern. *Vogelwelt* 114: 55-72.

Skuhravy, V. 1957. Die Fallenfangmethode. *Acta Soc. Entomol. Cechosl.* 54: 27-40.

Simonetti, G., & G. Mainardis. 1996. Vegetation map of the North-western Julian Pre-Alps between the Tagliamento river and the Canin mountain range. *Gortania. Atti del Mus. Friul. St. Nat.* 18: 111-60.

Stowe, T.J., A.V. Newton, R.E. Green & E. Mayes. 1993. The decline of the Corncrake *Crex crex* in Britain and Ireland in relation to habitat. *J. Appl. Ecol.* 30: 53-62.

Stowe, T.J., & R.E. Green. 1997. Response of Corncrake populations in Britain to conservation action. *Vogelwelt* 118: 161-8.

Sutherland, W.J., I. Newton & R.E. Green. 2005. *Bird ecology and conservation. A handbook of techniques.* Oxford University Press.

Tout, P. 1995. The status and distribution of Corncrake (*Crex crex*) during 1995 in Friuli-Venezia Giulia (NE Italy). Udine: Osserv. Faun. del Friuli-Venezia Giulia, unpublished report.

Trontelj, P. 1997. Distribution and habitat of the Corncrake (*Crex crex*) at the Upper Soca basin (Julian Alps, Slovenia). *Annales* 11: 65-70.

Tucker, G.M., & M.F. Heath. 1994. *Birds in Europe: their conservation status. Birdlife Conservation Series* 3. Cambridge, UK: Birdlife International.

Author's address - Indirizzo dell'Autore:
- dott. Antonio Borgo
Studio Tecnico
Via dei Fanti 154, I-36040 TORRI DI QUARTESOLO (VI)
e-mail: studio.antonioborgo@gmail.com