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Habitat selection by 58 ring-necked pheasants *Phasianus colchicus* was studied using radio-telemetry during the breeding season (March-September) in an intensively farmed region of northern Italy, characterised by only 1.7% of woodland (shelter belt plantations), and a high density of pheasants (30.4 individuals/100 ha in the pre-breeding season). Habitat selection was tested using compositional analysis. We also tested for effects of sex and age, differences between seasonal and daily time periods, and nest site selection. Moreover, relationships between habitat and home-range size were examined. The analysis showed the importance of cover provided by the shelter belts, accounting for 24.7% of radio-locations, which strongly influenced both habitat selection and home-range size. Season affected habitat use with both sexes increasing their use of cropland in summer; in late summer cropland not only provides food (both vegetation and arthropods) but also cover. We did not find significant differences between habitats selected for nesting and other habitats used by hens. We found a clear negative correlation between distance from shelter belts and use by pheasants, with only 1% of radio-locations >800 m from shelter belts. Our results suggest that the introduction of arboreal shelter belt plantations in the countryside, set maximum 1,600 m apart, may improve habitat quality for pheasants.

Key words: compositional analysis, cover, home range, mating, nesting, reproduction, shelter belt

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Understanding the habitat requirements of the pheasant *Phasianus colchicus*, particularly during the breeding season, is important for prescribing management options for this species. Ecological needs are related not only to food and cover availability, but also to the male defended territories (Ridley & Hill 1987) and to nesting and brood rearing by females (Warner 1979, Boyd & Richmond 1983, Hill & Robertson 1988, Riley, Clark, Ewing & Vohs 1998). Therefore, during breeding, habitat conditions and particularly the proportion of feeding and cover areas may affect mating opportunities, nesting success, adult mortality, and chick survival (Warner 1979, Whiteside & Guthery 1983, Carroll & Slayer 1990, Riley et al. 1998).

Pheasants are usually associated with agricultural landscapes and may require >15-20% of farmed land in an area (Badi & Mayot 1990). The need is higher in the breeding season when habitats selected by hens with chicks largely reflect the amount of arthropod food present, and wooded habitats are avoided (Hill & Robertson 1988). In winter, cover becomes more important, also as protection from weather, and woods, wetlands and shrubland are selected more often. For hunting purposes, ideal habitat for pheasants consists of 70-85% cropland, 10-25% grassland, and less than 10% forest (Hill & Robertson 1988), while a higher proportion of woodland (15-25%) maximises breeding density. Pheasants are capable of adapting to varying habitat conditions. For example, pheasants can use different cover habitats depending on their availability, selecting, in different areas, woods, strip vegetation, tall grass or crops, such as sunflowers, that are open at ground level and have a dense canopy (Lachlan & Bray 1976, Whiteside & Guthery 1983, Riley et al. 1998).

In North America, habitat use of pheasants during the nesting season has been studied extensively, and the provisioning of nesting cover is the most widely used management technique (Robertson 1996). Little data are available on habitat use and selection during territory formation and mating season, although Robertson (1996, 1998) suggested that availability of territory cover can be a major limiting factor for pheasant populations.

Several authors (Warner 1979, Boyd & Richmond 1983, Hill & Robertson 1988, Riley et al. 1998) have provided insight into pheasant biology and management by studying the behaviour and habitat use of brood-rearing hens. Riley et al. (1998) concluded that in the north-central United States, where the highest densities of pheasants are recorded in areas with almost non-existent woodland, females tend to select grassland which is of vital importance for the survival of broods. We studied habitat use and selection and nest site selection by pheasants in an intensively farmed area of northern Italy characterised by <2% coverage by shelter belts and reed thicket, absence of shrubland, and hot summers and mild winters. The aim of the study was to determine habitat use by pheasants during the breeding season relative to limited availability of cover habitats, and to the intense land-use practices.

Methods

Study area

The study was carried out in a 4,168 ha area in the centre of the Mezzano valley (18,100 ha), Italy. The valley was originally part of the lagoon complex of Comacchio in the Po Delta region, but was reclaimed for agriculture in the early 1970s. In 1994, the mean daily temperature was 13°C, with a maximum of 25°C in August and a minimum of 1.5°C in January. Average annual precipitation was 65.5 cm with most in autumn and least in winter. The topography of the area is flat and ranging in altitude within 1-3 m a.s.l. The area was intensively farmed with many irrigation channels, 7-20 m wide, rich in reed *Phragmites* sp. thickets. The only arboreal vegetation were shelter belt plantations of elm *Ulmus pumila*, white poplar *Populus alba,* robinia *Robinia pseudoacacia* and tamarisk *Tamarix* sp.. Cultivated fields covered 87.2% of the area, drainage ditches 4.3%, strip herbaceous vegetation 3.2%, roads 2.2%, shelter belts 1.7%, irrigation channels 1.2%, and reed thickets 0.2%.

The study area was closed to hunting. About 20% of the total population of pheasants were captured every year for restocking in other areas. The winter density of pheasants, estimated by spot-light census (Genovesi, Besa, Scappi & Toso 1997), was 30.4 pheasants/100 ha. Few hand-reared pheasants had been released in the area during the past, and thus the present population was considered to be wild.

Field methods

Pheasant habitat use was studied during March-September 1994 using radio-telemetry. Animals were caught in cage traps baited with corn, sexed and classified as adults or juveniles by the diameter of the proximal primary wing feather (Cattadori, Gatti & Toso 1997). Pheasants were then fitted with necklace radio-tags (Biotrack, United Kingdom), and mostly located from cars using the extensive road system. To determine habitat use in the area, which is characterised by a fragmented mosaic of different habitats, particular effort was made in the accuracy of radio-locations (fixes); thus animals were located from distances of 25-100 m. To avoid bias related to differences in habitat use with respect to time of day, fixes were collected at all hours of the day. A sample of radio-locations was also collected in the period from one hour after sunset to one hour before sunrise to assess differences in habitat use between day and night hours. To avoid autocorrelation errors (Swihart & Slade 1985), we used a minimum time lapse of 24 hours between consecutive fixes. Habitat was classified as: cultivated fields (including 'set-aside fields'), drainage ditches, meadows, roads, shelter belts and reed thickets. Cultivated fields were classified as cereals (grain, barley), corn or sunflower, vegetables (e.g. tomatoes and beans), 'set-aside fields', and ploughed fields.

The study area was homogeneous, divided in 200 ha portions with identical habitat conditions: cultivated fields (regularly intersected by drainage ditches) interrupted by shelter belts, irrigation channels and reed thickets. Therefore, the availability of habitats did not change in respect to differences in the defined borders of the study area (Porter & Church 1987).

Data analysis

To assess habitat selection, we used compositional analysis that solves the unit-sum constraint typical of compositional data (Aebischer & Robertson 1992, Aebischer, Robertson & Kenward 1993, Dowell, Aebischer & Robertson 1993). Assumptions of the method are that each animal provides an independent measure of habitat use within the population, and that compositions from different animals are equally accurate. Because all pheasants were tracked in the same periods and the sample size was similar for all individuals, we assumed an identical weight for all animals. Only independent fixes were used in order to avoid autocorrelation which, in compositional analysis, may influence the significance level (Aebischer et al. 1993). Territoriality could lead to a bias in this procedure by violating the assumption of independence among individuals.

Home range was calculated for individuals with adequate samples of radio-locations (N ≅ 25 fixes: Harris, Cresswell, Forde, Trewhella, Woollard & Wray 1990, Kenward 1992). Home range was defined by 95% Minimum Convex Polygon (MCP) (calculated by the Kernel method; Worton 1989) for testing the correlation between home range size and proportion of habitats within the home range, whereas we used 100% MCP for habitat selection analyses to avoid underestimation of habitat availability.

As suggested by Aebischer et al. (1993), we compared utilised with available habitats at two levels: first examining home range selection within the study area by comparing proportion of habitats in the minimum convex polygon (MCP 100%) with that in the study area; then habitat use within the home range was examined, by comparing the proportion of radio-locations in each habitat with the proportion of the habitat in the MCP. At each level, assuming that use differs from random, habitats were ranked according to relative use, and the significance between rank differences was tested. Compositional analysis was performed using the Maccomp 0.90 software, developed by J.P. Carroll, University of Georgia. Part of the analyses was done using the SAS statistical package (SAS Institute Inc., Cary, North Carolina).

In addition to habitat selection analyses performed for the whole study period (March-September), to compare habitat selection in respect to territoriality, nesting and presence of chicks, we divided the study period into three subperiods: 1) March-April covering the breeding season (start of territorial and mating season), 2) May-15 June covering the nesting season, and 3) 15 June-September covering the post-nesting season (presence of chicks) (Hill & Robertson 1988). To test for differences in habitat selection between the three subperiods we assumed that individual availability did not change significantly among periods, and that differences in habitat selection are caused by shifts in the use of habitats. Therefore, for the three subperiod analyses, we performed only the second level of compositional analysis, comparing radio-locations collected in each subperiod with total availability, i.e. habitats in the home ranges calculated for the whole period of March-September.

One of the advantages of compositional analysis is that we can test independent variables in addition to the basic analysis. Therefore, we tested for differences between sexes, age groups, night and day, home-range size and periods, by adding these parameters as independent variables in the Wilks log-ratio matrices, and analysing the matrices by a MANOVA test (Aebischer et al. 1993) using SAS. We tested for seasonal effects by a MANOVA for repeated measures. In the analyses, habitats were assigned to the following seven types: cultivated fields, drainage ditches, meadows, roads, shelter belts, irrigation channels and reed thicket. Because of the potential non-normality of our data we used randomisation (Aebischer et al. 1993) to construct expected distributions to compare with the observed values. The Maccomp 0.90 program calculates 999 randomisations of the data to generate P-values.

To test for differences in the use of cultivated fields which changed markedly through the year in relation to agricultural activities, we tested for monthly variation in habitat use using the proportion of radio-locations in each habitat by month in an ANOVA. For this analysis we considered, for each individual and for each month, the proportion of radio-locations in all habitat types, including 10 different categories of cultivated fields. We did not test for selection of the 10 categories of cultivated fields (use in respect to availability) through the compositional analysis, because of the difficulty of measuring availability of a habitat that changes dramatically in relation to agricultural activities.

The influence of wood cover on habitat use was assessed calculating frequency of use by pheasants in respect to distance from shelter belts. Within the study area, maximum distance from shelter belts was 1,300 m. Each fix was assigned to one of six classes of distance from shelter belts (i.e. <50 m, 50-100 m, 100-200 m, 200-400 m, 400-800 m, 800-1,300 m). A selection index was calculated by comparing proportion of use U, i.e. proportion of fixes in each class of distance, and availability A, i.e. proportion of the total area in each class of distance, as follows: (U-A)/A (Chapin, Harrison & Phillips 1997).

To test for differences in habitat use with respect to time of day, we divided the 24 hours of the day into six periods: night, dawn (from one hour before to on hour after sunrise), dusk (from one hour before to one hour after sunset), and three periods of equal length for the day-time hours from one hour after sunrise to one hour before sunset. Because the number of fixes was limited during some periods (e.g. dawn and dusk), we considered only two categories of habitat: open (meadows, drainage ditches, cultivated) and cover (shelter belts, reed thickets). Then we calculated the use of these two habitat categories for the six periods, and tested for differences through a non-parametric ANOVA (Kruskal-Wallis test).

Nest site selection and clutch size was assessed by locating the nests of all radio-equipped hens and by recording habitat characteristics. To avoid sampling biases caused either by unequal trapping effort among habitats or by capture after spring dispersal (Robertson 1996), we homogeneously distributed traps among habitats and trapped before April. To test for selection of nest sites, we compared the frequency of nests in different habitats to: i) habitat availability in the study area; ii) hen habitat use in the breeding season based on frequency of radio-locations per habitat in the March-April period; iii) hen habitat use in the nesting season based on frequency of radio-locations per habitat in the May-15 June period. As individual nesting data had to be pooled, we could not apply the compositional analysis, and we tested habitat selection using the procedure proposed by Neu, Byers & Peek (1974) (and also suggested by Alldredge & Ratti 1986), although this method does not solve the unit-sum constraint (Dowell et al. 1993, Aebischer et al. 1993). This statistical procedure, which assumes independence of locations, first tests for habitat selection considering all habitats together through a χ^2-test, then tests for habitat selection for each habitat by using the Bonferroni statistic, allowing the calculation of confidence intervals.

Results

Habitat selection

From 8 March to 7 April, 97 pheasants (59 females; 38 males) were trapped; of these 70 (43 females, 27 males) were fitted with radio-tags. A total sample of 4,726 fixes was collected, but we did not include 42 fixes collected during the first day after capture (no unusual movements were recorded after 24 hours after capture) and 10 locations related to occasional movements of six individuals outside their normal activity range, mostly registered after disturbance

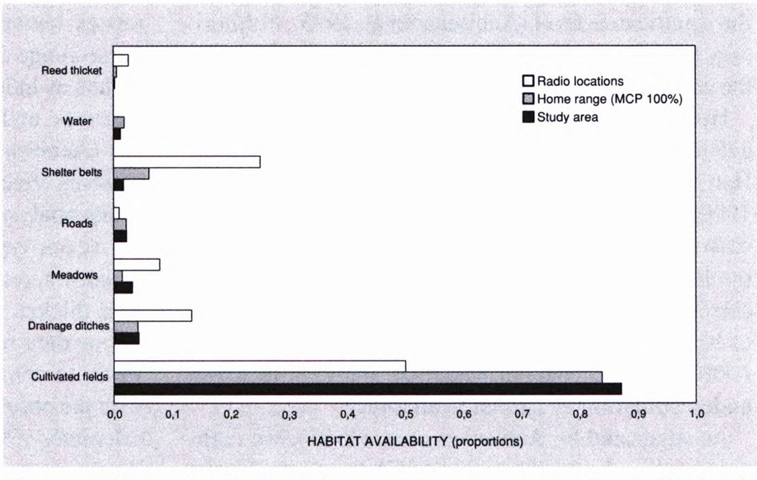

Figure 1. Habitat availability in the study area (■), mean proportion (+SD) of habitats in MCP 100% (▨), mean proportion (+SD) of radio-locations per habitat (□), of 58 radio-tagged pheasants in the Mezzano valley, northern Italy, during March-September 1994.

Table 1. Ranking of habitats based on the results of compositional analysis. For each rank, the analysed sample, the period considered, the values of Wilks λ and the relative P-values are reported.

Samples[a]	Period	Level of analysis[b]	Wilks λ	P-value	Ranking og habitats[c] (from most to least preferred)
Total sample	March-September	1	0.303	< 0.01	SB > CU > DR > RO > RT > IC > ME
Total sample (MCP 95%)	March-September	1	0.296	< 0.01	SB > DR > CU > RO > RT > IC > ME
Males	March-September	1	0.252	< 0.01	SB > CU > DR > RO > RT > IC > ME
Females	March-September	1	0.184	< 0.01	SB > CU > DR > RO > RT > IC > ME
Adults	March-September	1	0.300	< 0.01	SB > CU > DR > RO > RT > IC > ME
Juveniles	March-September	1	0.290	= 0.011	SB > CU > DR > RO > RT > IC > ME
Total sample	March-September	2	0.012	< 0.01	RT > SB > DR > ME > CU > RO > IC
Total sample (MCP 95%)	March-September	2	0.003	< 0.01	RT > ME > SB > DR > CU > RO > IC
Males	March-September	2	0.002	< 0.01	SB > ME > RT > DR > CU > RO > IC
Females	March-September	2	0.005	< 0.01	RT > SB > DR > ME > CU > RO > IC
Adults	March-September	2	0.004	< 0.01	ME > SB > RT > DR > CU > RO > IC
Juveniles	March-September	2	0.003	< 0.01	RT > SB > DR > ME > CU > RO > IC
Day	March-September	2	0.005	< 0.01	RT > SB > DR > ME > CU > RO > IC
Night	March-September	2	0.023	< 0.01	CU > ME > SB > RT > DR > RO > IC
Breeding season	March-April	2	0.027	< 0.01	SB > RT > DR > ME > CU > RO > IC
Nesting season	May-15 June	2	0.052	< 0.01	DR > CU > SB > RT > ME > RO > IC
Post-nesting season	15 June-September	2	0.045	< 0.01	DR > CU > ME > SB > RT > RO > IC
Breeding season - Males	March-April	2	0.007	< 0.01	SB > DR > RT > ME > CU > RO > IC
Breeding season - Females	March-April	2	0.038	< 0.01	SB > RT > DR > ME > CU > RO > IC
Nesting season - Males	May-15 June	2	0.007	< 0.01	DR > CU > SB > RT > ME > RO > IC
Nesting season - Females	May-15 June	2	0.028	< 0.01	CU > DR > SB > RT > RO > ME > IC
Post-nesting season - Males	15 June-September	2	0.002	< 0.01	DR > ME > SB > CU > RT > RO > IC
Post-nesting season - Females	15 June-September	2	0.065	< 0.01	DR > CU > ME > SB > RT > RO > IC

[a] Home range estimated by Minimum Convex Polygon 100% if not differently indicated.

[b] 1 = Study area vs home range; 2 = Home range vs radio-locations.

[c] SB = shelter belts; CU = cultivated fields; DR = drainage ditches; RO = roads; RT = reed thickets; IC = irrigation channels; ME = meadows.

caused by dog training or tillage. Analyses were performed for 58 individuals (34 females, 24 males) for which adequate samples of radio-locations were collected ($\bar{x}$ = 78.8 radio-locations/ individual, SD = 23.8, range: 24-107) over the whole March-September study period. Age was determined for 55 individuals (38 adults, 17 juveniles).

Pheasants spent most of their time in the cultivated fields ($\bar{x}$ = 50.1%, SD = 16.8), or in habitat providing cover: shelter belts ($\bar{x}$ = 25.2%, SD = 21.1) and drainage ditches ($\bar{x}$ = 13.3%, SD = 10.3) (Fig. 1). We found a significant selection of habitat in the 100% MCP compared to availability in the study area (Table 1). Shelter belts followed by cultivated fields were the most selected habitats whereas reed thickets and irrigation channels were the least selected habitats (Table 2). At this level a difference in habitat use was found between sexes (MANOVA: $\Lambda = 0.685$, P =

Table 2. Ranking of habitats as calculated by mean log-ratio and standard error matrix. Comparison between study area and home range (MCP 100%) of 58 radio-tagged pheasants in the Mezzano valley, northern Italy, during March-September 1994.

	Cultivated		Drainage ditches		Meadows		Roads		Shelter belts		Irrigation channels		Reed thickets	
Habitat	$\bar{x}$[a]	SE	$\bar{x}$[a]	SE	$\bar{x}$[a]	SE	$\bar{x}$[a]	SE	$\bar{x}$[a]	SE	$\bar{x}$[a]	SE	$\bar{x}$[a]	SE
Cultivated			+0.009	0.009	$+3.676^{**}$	0.485	+0.068	0.058	-0.552^{*}	0.285	$+2.454^{**}$	0.521	$+1.959^{**}$	0.449
Drainage ditches	-0.009	0.009			$+3.667^{**}$	0.485	+0.059	0.055	-0.562	0.287	$+2.445^{**}$	0.523	$+1.950^{**}$	0.454
Meadows	-3.676^{**}	0.485	-3.667^{**}	0.485			-3.608^{**}	0.516	-4.228^{**}	0.667	-1.222^{*}	0.554	-1.717^{*}	0.681
Roads	-0.068	0.058	-0.059	0.055	$+3.608^{**}$	0.516			-0.621^{*}	0.262	$+2.386^{**}$	0.543	$+1.891^{**}$	0.453
Shelter belts	$+0.553^{*}$	0.285	+0.562	0.287	$+4.228^{**}$	0.667	$+0.621^{*}$	0.262			$+3.007^{**}$	0.621	$+2.512^{**}$	0.406
Irrigation channels	-2.454^{**}	0.521	-2.445^{**}	0.523	$+1.222^{*}$	0.554	-2.386^{**}	0.54	-3.007^{**}	0.621			-0.495	0.418
Reed thickets	-1.959^{**}	0.449	-1.950^{**}	0.454	$+1.717^{*}$	0.681	-1.891^{**}	0.453	-2.512^{**}	0.406	+0.495	0.418		
Rank[b]	2		3		7		4		1		6		5	

[a] Positive values indicate that the habitats in the rows were used more than the habitats in the columns, negative values indicate the opposite; level of significance: * = P < 0.05; ** = P < 0.01.

[b] Ranks were determined by comparing relative use of each habitat with all other habitats. The smallest ranking value indicates the most used habitat, and the largest ranking value indicates the least used habitat.

Table 3. Ranking of habitat as calculated by mean log-ratio and standard error matrix. Comparison between the proportion of habitats in the home range (MCP 100%) and the proportion of radio-locations in each habitat for 58 radio-tagged pheasants in the Mezzano valley, northern Italy, during March-September period 1994.

	Cultivated		Drainage ditches		Meadows		Roads		Shelter belts		Irrigation channels		Reed thickets	
Habitat	$\bar{x}^{a}$	SE	$\bar{x}^{a}$	SE	$\bar{x}^{a}$	SE	$\bar{x}^{a}$	SE	$\bar{x}^{a}$	SE	$\bar{x}^{a}$	SE	$\bar{x}^{a}$	SE
Cultivated			-1.336**	0.184	-1.062	0.583	+3.555**	0.504	-1.711**	0.222	+7.182**	0.136	-2.128**	0.491
Drainage ditches	+1.336**	0.184			+0.366	0.569	+4.891**	0.552	-0.389	0.302	+8.383**	0.298	-1.017	0.614
Meadows	+1.062	0.583	-0.366	0.569			+4.737**	1.059	-0.474	0.789	+8.120**	0.744	-1.011	1.247
Roads	-3.555**	0.504	-4.891**	0.552	-4.737**	1.059			-5.379**	0.506	+4.306**	0.612	-5.293**	0.874
Shelter belts	+1.711**	0.222	+0.389	0.302	+0.474	0.789	+5.379**	0.506			+9.251**	0.195	-0.221	0.473
Irrigation channels	-7.182**	0.136	-8.383**	0.298	-8.120**	0.744	-4.306**	0.612	-9.251**	0.195			-8.933**	0.499
Reed thickets	+2.128**	0.491	+1.017	0.614	+1.011	1.247	+5.293**	0.874	+0.221	0.473	+8.933**	0.499		
Rank^{b}	5		3		4		6		2		7		1	

[a] Positive values indicate that the habitats in the rows were used more than the habitats in the columns, negative values indicate the opposite; level of significance: * = $P < 0.05$; ** = $P < 0.01$.

[b] Ranks were determined by comparing relative use of each habitat with all other habitats. The smallest ranking value indicates the most used habitat, and the largest ranking value indicates the least used habitat.

0.017), but not between age groups (MANOVA: $\Lambda = 0.794$, $P = 0.151$). Males and females showed the same ranking of habitats from the most to the least preferred, but males had a slightly higher proportion of shelter belts in the MCP than females (7% vs 5.4%). A difference resulted when comparing rankings calculated with 100% MCP and with 95% MCP; in the latter case cultivated fields dropped below drainage ditches in importance (see Table 1).

We found a significant selection of habitats when comparing home ranges and radio-locations (see Table 1). When considering level of significance in selection between habitats, we found that the only difference was between the four habitats with the highest ranking compared with the three habitats with the lowest ranking (Table 3). At the home range vs fixes level, we found no difference between sexes (MANOVA: $\Lambda = 0.658$, $P = 0.606$) or age groups (MANOVA: $\Lambda = 0.678$, $P = 0.649$).

Seasonal effects

Habitat selection (i.e. home range vs radio-locations) differed between breeding, nesting and post-nesting seasons (MANOVA: $\Lambda = 0.439$, $P < 0.01$) and between sexes (MANOVA: $\Lambda = 0.275$, $P = 0.032$). A difference between rankings of breeding season, nesting season and post-nesting season was found (see Table 1); in the breeding season, habitats with the highest rank were those providing cover, i.e. shelter belts and reed thickets, whereas for the nesting and post-nesting seasons, the habitats with the highest rankings were drainage ditches and cultivated fields. Males showed a limited seasonal variation in habitat selection, decreasing their selection of shelter belts and increasing their selection of meadows from the breeding to the post-nesting season (see Table 1). In contrast, females showed a more marked seasonal variation; cover habitats, i.e. shelter belts and reed thickets, were selected in the mating season, but not in the nesting and post-nesting seasons, when hens significantly increased their use of cultivated fields and drainage ditches (see Table 1). In the nesting season, females avoided meadows, resulting in a lower ranking for meadows than for roads (see Table 1).

Both sexes increased their use of cultivated fields by more than 25% in the post-nesting season (M: $\bar{x}$ = 26.2%, F: $\bar{x}$ = 50%) compared to the breeding season. Monthly variations in habitat use appeared to be related to agricultural activities. We found a significant difference in use by month for all habitats except meadows (ANOVA: $F_{4,126} = 0.479$, $P = 0.743$), retired plantation (ANOVA: $F_{4,126} = 0.686$, $P = 0.603$), and drainage ditches (ANOVA: $F_{4,126} = 0.987$, $P = 0.417$). These habitats are characterised by a limited fluctuation in vegetation height, compared to cultivated fields for example.

Home range size

Analysing the Wilks log-ratio matrices through MANOVA demonstrated that home range size, was a function of habitat selection by pheasants (MANOVA: $\Lambda = 0.637$, $P = 0.001$). Home range size also correlated to the proportion of habitats in the home range. The size of 95% MCP, which averaged 22.36 ha (SD = 18.73), was positively correlated to the proportion of cultivated fields (Spearman rank correlation: $r_s = 0.416$, $P < 0.01$) and meadows (Spearman rank correlation: $r_s = 0.499$, $P < 0.01$) present in the home range, and negatively correlated to the proportion of shelter belts (Spearman rank correlation: $r_s = -0.479$, $P < 0.01$).

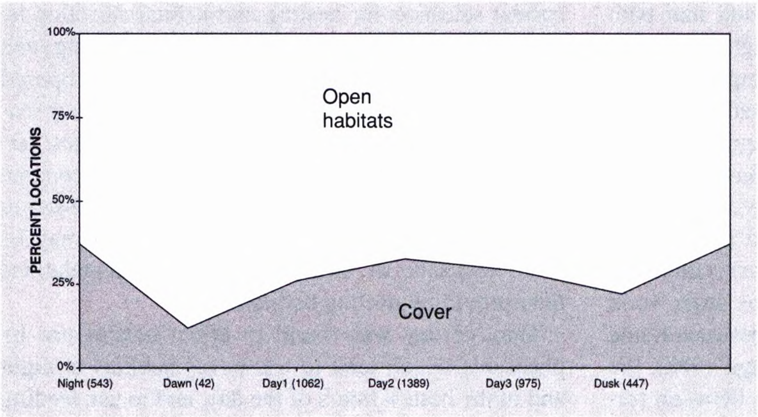

Figure 2. Habitat use (fixes: N = 4,458) by pheasants relative to time of day (Kruskal-Wallis: $\chi^2 = 238.4$, df = 5, $P < 0.01$) in the Mezzano valley, northern Italy, during March-September 1994. Cover = woods and reed thicket; open habitat = cultivated fields, drainage ditches and meadows. Dawn = one hour before and after sunrise. Dusk = one hour before and after sunset. Day 1, 2 and 3 were calculated by dividing the hours of the day from one hour after sunrise to one hour before sunset into three periods of equal length.

Time of day

The compositional analysis showed that habitat use during March-September (home range vs radio-locations) differed between day and night hours (MANOVA: $\Lambda = 0.123$, $P = 0.001$), with the pattern also differing between sexes (MANOVA: $\Lambda = 0.306$, $P = 0.049$). Thus, during daytime, the three most preferred habitats were those providing cover, while at night cultivated fields were the habitat with the highest ranking (see Table 1). Significant differences were found also between the different periods of the day (Kruskal-Wallis: $\chi^2 = 238.4$, df = 5, $P < 0.01$), and the results showed that pheasants used cover habitats during the hottest hours of the day, while open habitats were used more at dawn and dusk (Fig. 2).

Distance from cover

Pheasants avoided areas that were distant from trees. In fact, 45.8% of radio-locations (N = 4,674) were within 50 m of shelter belts and only 1% of fixes were >800 m away. Selection, calculated as use-availability/availability, decreased linearly with increasing distance (regression analysis: $F_{1,5} = 13.37$, $R^2 = 0.77$, $P = 0.022$) from shelter belts (Fig. 3). No difference was found between sexes in the use of habitat with respect to distance from shelter belts ($F_{1,5} = 1.23$ $P = 0.40$).

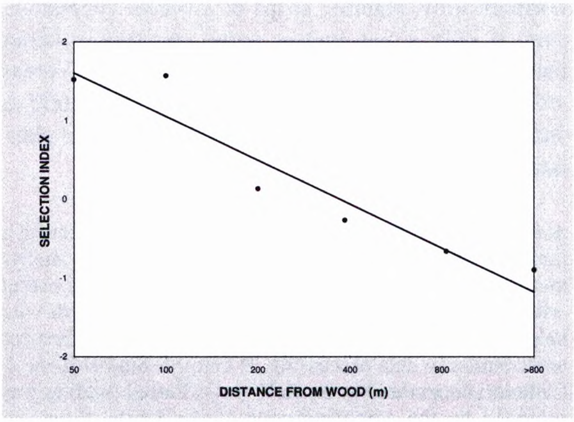

Figure 3. Selection (selection index: use-availability/availability) by 58 pheasants related to distance from woodlands (Regression analysis: $F_{1,5} = 8.94$, $R^2 = 0.69$, $P = 0.04$), in the Mezzano valley, northern Italy, during March-September 1994.

Nest site selection

Of 38 hens, 27 (71%) nested, and in 15 cases, following loss of clutches, we recorded renestings. In total we found 42 nests. Mean clutch size was 9.1 (SD = 2.7, range: 2-16). Nesting success was not estimated because we collected the entire clutch of 11 hens to allow genetic analyses (the results will be published elsewhere). Habitat of nest locations did not differ significantly from habitat use by hens in the breeding season (radio-locations: N = 611, $\chi^2 = 2.87$, df = 6, $P = 0.82$), or from habitat use by hens in the nesting period (radio-locations: N = 746, $\chi^2 = 0.37$, df = 6, $P = 0.99$). When comparing nest locations with habitat in the study area we found a significant selection ($\chi^2 = 275.2$, df= 6, $P < 0.01$); shelter belts were positively selected for nesting (Bonferroni statistics, $P < 0.05$), cultivated fields were avoided (Bonferroni statistics, $P < 0.05$), while meadows, reed thickets, drainage ditches used for nesting did not differ from what was expected (Bonferroni statistics: $P > 0.05$).

Discussion

In our study area, characterised by intensive agricultural activities and limited canopy, pheasants selected habitat providing cover. In fact, considering the whole March-September study period, at the first level of analysis, i.e. study area vs home range, shelter belt was the most selected habitat for both sexes. When looking at the second level of analysis, i.e.

home range vs radio-locations, we found that both vegetation types characterised by high structures (reed thicket and shelter belts) were important. The selection of shelter belts is also confirmed by the significant negative correlation between proportion of shelter belts and home range size. The importance of cover availability in affecting pheasants' movements is probably related to the very limited presence of cover in the study area, as in another cultivated region of northern Italy, characterised by large wood plantations, no correlation was found between home range size and type of vegetation (Meriggi 1983). We also found a clear negative correlation between frequency of radio-locations and distance from shelter belts which confirms the selection by pheasants of wood edges as described by Hill & Robertson (1988). This result differs from those of Meriggi (1983) who did not find a correlation between spacial use and distance from the edges of cover.

Habitat use varies by season, not only in respect to the breeding behaviour of pheasants, but also in relation to the vegetative phase of crops which affects both cover provided by vegetation and availability of vegetable and insects foods. In fact in summer, when some crop species can provide cover and food, pheasants increased their use of these habitats. The influence of crop availability in summer on habitat use of pheasants has been reported from several studies in North America (Hanson & Progulske 1973, Warner 1979, Whiteside & Guthery 1983). An influence of the crop's vegetative phase on habitat use is also confirmed by Hill & Robertson (1988), who found a marked preference for nesting in woodland early in the breeding season (April-May), and an increase in the use of cereal crops by June, when crops can provide both cover and trophic resources.

In contrast to what was recorded by Riley et al. (1998) in Iowa, females did not select meadows significantly more often than cropland and shelter belts when chicks were present in our study area. Nevertheless, the structure of grassland may change enormously from one area to another, mostly in respect to climate, and any comparison between studies should consider the structure of grass vegetation in respect to ease of movement through the crop, presence of insect food, and concealment from predators (Robertson 1997).

The absence of differences between habitat selection for nesting and habitat use by hens in the nesting season indicates a limited selection of specific nesting habitats. The absence of differences between habitat selection for nesting and habitat selection by hens in the breeding season is more surprising, and this result seems to confirm the hypothesis proposed by Robertson (1996, 1998) that in the breeding season hens select habitat more in respect to males' territories, and that territories influence nest placement. Our results also support the suggestion of Robertson (1996, 1998) that providing territory cover may be more effective in increasing pheasant populations than providing nesting habitats.

Time of day was found to affect habitat use by pheasants which tend to use cover habitats at night and in the hottest hours of the day, and to use feeding habitats more during dawn and dusk. This pattern appears to be related to the behaviour of the pheasant, which emerges to feed at dawn and dusk, but retires to cover in the middle of the day (Dalke 1937). This effect could be enforced by the particular climatic condition of the area, characterised by very hot and humid summers. Such patterns seem to confirm the importance of edge locations, with feeding areas close to cover habitats. The differences in habitat use during the different periods of the day indicate that non-homogeneous sampling during the 24 hours of the day may cause bias in habitat selection analyses.

Our results show the importance of undisturbed cover provided by shelter belt plantations (400-500 m long, 10 m wide) and by reed beds. Both habitats are characterised by a vertical structure of vegetation, suggesting that the structural character of the vegetation seems to be of greater importance than the species composition (Lachlan & Bray 1976). In landscapes characterised by scarce or absent natural vegetation, such as this intensively farmed region of northern Italy, planting strips of arboreal vegetation, even if only a few metres wide, can supply better habitat for pheasants. Because pheasants used areas <800 m from shelter belts, we suggest that 1,600 m should be the maximum distance between wood plantations.

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