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Habitat use by the Partridge *Perdix perdix* during the breeding season in the diversified agricultural landscape of western Poland

Marek PANEK & Robert KAMIENIARZ

Polish Hunting Association, Research Station, Sokolnicza 12, 64–020 Czempiń, POLAND, e-mail: panekmar@polbox.com

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Abstract. The study was carried out in 1994–96 in an area of western Poland where field sizes range widely — from < 1 to 50 ha. The spring population density of Partridges was estimated by call counts on 1 km^2 study plots. The landscape structure was described by the proportion of crops and orchards, the number of arable fields and the length of permanent cover with spontaneous vegetation. Radio-tagged individuals (24 pairs and 6 single males) were tracked during the breeding season. The Partridge density in the study plots ranged from 0 to 7.7 pairs per km^2, and increased with the number of fields per km^2 and the proportion of small orchards among the arable fields. Radio-tagged pairs on small fields (< 10 ha) preferred field edges with permanent treeless plant cover and edges without permanent plant cover. On large fields (> 10 ha), a preference was shown for field edges with both wooded and treeless permanent plant cover. Partridges avoided the centres of both types of fields. Preferred nesting sites were in permanent plant cover and orchards; crops were used less frequently than expected. The spring carrying capacity of the field habitat for Partridges was dependent on the availability of field edges, including those devoid of permanent plant cover.

Key words: Partridge, *Perdix perdix*, habitat use, nesting, habitat heterogeneity, agricultural landscape

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INTRODUCTION

The structure of the agricultural landscape is an important factor affecting the population dynamics of the Partridge. For instance, a high proportion of areas permanently covered with spontaneous vegetation, such as hedgerows, ditches, fencelines or roadsides, which are preferred nesting sites of the Partridge, may be favourable to both nesting success and the recruitment of young birds to the breeding population (Potts 1980, 1986, Rands 1987, Carroll 1992, Panek 1994, 1997a, Panek & Kamieniarz 1998). In Poland, it has been found that the nesting success of Partridges also increases with the extent of field fragmentation (Panek & Kamieniarz 1998). The occurrence of permanent plant cover and the size of fields may also be factors benefiting the survival of Partridge chicks (Meriggi et al. 1990, Panek 1997b, Panek & Kamieniarz 1998). Nesting success and chick survival rate are the two population parameters chiefly responsible for determining Partridge density (Potts 1980, 1986, Carroll 1992, Panek 1992).

The importance to Partridges of permanent plant cover during reproduction has also been demonstrated in studies of habitat use by these birds. Both in Europe and North America, they display a strong preference for permanent plant cover, especially of shrubs or herbaceous plants (Weigand 1980, Smith et al. 1982, Mendel & Peterson 1983, Carroll et al. 1990, Meriggi et al. 1991). Therefore, local breeding densities have frequently been found to be positively correlated with the availability of permanent plant cover (Potts 1986, Rands 1986, Meriggi et al. 1990, Meriggi et al. 1992). Nevertheless, in France for instance, Partridges may occur in high densities in

areas with no typical permanent plant cover: there, they prefer the edges of arable land, especially grassy verges, as nesting sites (Birkan et al. 1990). Ricci & Garrigues (1986) have recorded even higher local densities in places with a smaller proportion of permanent plant cover. Thus, the Partridge's habitat preferences may differ depending on the nature of the agricultural landscape.

In Poland it has been found that the spring density of the Partridge population in several regions was positively correlated with the fragmentation of fields or with the presence of baulks (unploughed ridges), but not with the availability of typical permanent plant cover (Panek & Kamieniarz 1998). This gives an indication of the significance for these birds of field size and the proximity of field edges.

The aim of the present study was to estimate the habitat preferences of the Partridge during the breeding season, in particular the use of field edges with or without permanent plant cover in the diversified agricultural landscape of western Poland.

STUDY AREA

The study was carried out in an agricultural area (97 km^2) around Czempiń, near Poznań, western Poland. There were two types of arable land occurring in clusters several hundred hectares in area: small holdings of individual farmers from < 1 to 10 ha (40% of the land), and large fields (usually 10–50 ha in area) belonging to state farms (60%). Some of the fields were lined by ditches, strips or roadsides, usually 1–10 m in width, overgrown with spontaneous permanent vegetation with a diverse species composition, from herbaceous plants to dense shrubs or trees. The surface area of permanent plant cover among both large and small fields was similar (Table 1). Such vegetation was found along 84% of the edges of large fields but around only 26% of small fields. Cereals were the principal crop, but beets, oil-seed rape, maize, potatoes, alfalfa and grasses were also cultivated. The crop composition was similar in the large and small fields (Table 1). Accounting for almost 1% of the landscape, small orchards or gardens planted extensively with fruit-trees, vegetables and shrubs were laid out among the fields, particularly in the vicinity of villages. There were further small areas given over to other crops or covered with spontaneous vegetation.

Table 1. Crop structure in early spring and the occurrence of permanent plant cover in small (< 10 ha) and large (> 10 ha) fields and in the whole study area.

Variables	<10 ha	>10 ha	Whole area
Crops (% of area):			
Orchards	1.4	0.3	0.7
Winter cereals and oil-seed rape	48.5	46.1	47.1
Alfalfa and grasses	1.2	8.0	5.2
Ploughed fields (% of area)	47.3	43.6	45.2
Permanent plant cover:			
% of area	1.6	2.0	1.8
Length (km/km^2):			
treeless	1.6	1.2	1.4
wooded	1.0	1.3	1.1

METHODS

The population density of Partridges was estimated on 1 km^2 random circular study plots in three consecutive springs (1994–96). Each year 10 study plots were selected, i.e. 30 different plots during the three years. On the 10 plots selected in 1994 (5 plots on small fields and 5 on large ones) birds were also counted in the two subsequent years in order to assess the changes in density between years and between the two field types. The density of Partridge pairs was estimated during late March and early April by counting calling males, three times in the mornings or evenings. It was found that these counts were strongly related to Partridge density (Panek 1998).

The structure of the agricultural landscape in each study plot was described by taking measurements from maps and in the field. The proportion of crops (winter cereals, oil-seed rape, alfalfa and grasses) and orchards, the number of arable fields and the length of permanent plant cover were determined. An arable field was defined as a stretch of land where a single type of crop was grown or which was ploughed, and which was separated from other such land by a different crop, a ploughed strip of land, or by permanent plant cover > 1 m wide. All linear stretches of permanent plant cover > 1 m wide, such as strips, ditches and roadsides, were measured up. Where a patch of vegetation was not linear, its circumference was measured. Two variables describing the occurrence of permanent plant cover were used: treeless or wooded permanent plant cover (in km per km^2).

Radiotelemetry studies were carried out in 1995 and 1996 on a 24 km^2 section of the study area. Partridges caught in April and May were radio-

tagged with necklace tags and then located at various times of day from a short distance (typically < 20 m). In 70% of cases birds were observed directly; this is what we always tried to do, especially when they stayed close to field edges. We used data on Partridge pairs from the period beginning in late April and ending with the start of incubation of the last nest by individual pairs, that is, between the end of May and mid-July. 524 observations of 24 pairs (2–63 per pair) were made. Moreover, 87 observations of six unpaired males (1–38 per individual) from the same period were used for comparison. Twenty one nests of radio-tagged females were located.

The following information was noted each time Partridges were observed: the distance from the field edge (crop) and from the nearest permanent plant cover (accurate to within 5 m), and the type of permanent plant cover (treeless or wooded). Such information was not noted for orchards, which were treated as a separate habitat with a highly diversified structure. The whole area studied by radiotelemetry, including crops and permanent plant cover, was mapped on a scale of 1:5000. The maps were used to calculate the occurrence of field edges of different types (treeless or wooded permanent plant cover; no permanent plant cover).

The relationships between local Partridge densities and the landscape structure within the study plots were analysed using correlations and forward stepwise multiple regression. The use of different habitats by radio-tagged Partridges in relation to habitat availability was tested according to the statistical methods given by Ney et al. (1974) and Byers et al. (1984).

RESULTS

The spring density of the Partridge in 10 permanent study plots differed between the large and small fields, but it did not differ between years (Two-way ANOVA, $F_{1,24} = 17.398$, $p = 0.0003$ and $F_{2,24} = 2.094$, ns, respectively). The average density on the small fields was 2.4 times greater than on the large ones (3.9 ± 1.7 pairs per km², n = 15, vs. 1.6 ± 1.3 pairs per km², n = 15).

There were significant correlations between some of the variables describing the landscape structure in the 30 study plots: % of orchards vs. length of permanent plant cover without trees ($r = -0.40$, $p = 0.03$), % of winter cereals and oil-seed rape vs. % of alfalfa and grasses ($r = -0.36$, $p = 0.05$), % of alfalfa and grasses vs. length of permanent plant cover without trees ($r = 0.44$, $p = 0.01$). Partridge population densities in the study plots (ranging from 0 to 7.7 pairs per km²) were correlated positively with the number of arable fields and the proportion of orchards. In stepwise multiple regression analysis both the number of fields and the proportion of orchards displayed a significant positive effect (Table 2). After removal of the effect of these two variables, the length of permanent plant cover without trees had the highest partial correlation coefficient (0.314, $p = 0.1$) of the remaining non-significant variables.

Table 2. Correlations (r) and stepwise multiple regression (a) between the density of the Partridge population and variables describing the landscape structure (ranges) in study plots of 1 km² (n = 30). * — $p < 0.05$, ** — $p < 0.01$, ns $p > 0.05$.

Variables	r	a
Number of fields (per km²) (4–63)	0.506 **	0.066 **
Orchards (% of area) (0–5)	0.446 *	0.955 **
Winter cereals and oil-seed rape (% of area) (11–85)	ns	ns
Alfalfa and grasses (% of area) (0–38)	ns	ns
Permanent treeless plant cover (km/km²) (0–4.7)	ns	ns
Permanent wooded plant cover (km/km²) (0–2.7)	ns	ns
Constant	–	0.727
R^2	–	0.43

Observations of radio-tagged Partridge pairs in orchards accounted for 11.2% in the small fields (n = 374) and 2.0% in the large ones (n = 150). A comparison of these proportions with the occurrence of orchards in the study area (Table 1) shows that, at least in small fields, Partridge pairs preferred ($\chi^2 = 264.1$, $p < 0.001$) this habitat (the sample size for large fields was too small for any statistical comparisons). Further analyses excluded orchards. In 65% of cases Partridge pairs were observed 0–5 m from the field border (Fig. 1), and only 2.5% of observations were > 50 m from the field border. Thus, the field edge was taken to be a strip of land up to 5 m wide from the field border (including permanent plant cover if present), with the rest of field being referred to as its centre. In both large and small fields, Partridges preferred the edges with permanent treeless plant cover and avoided the centres. Among large fields permanent wooded plant cover was preferred,

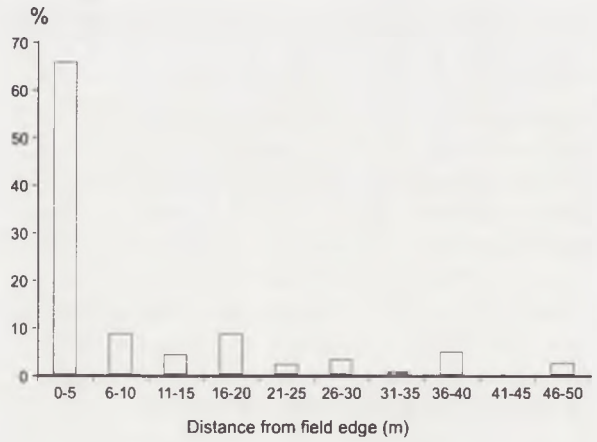

Fig. 1. Distribution of radio-tagged Partridge pairs at different distances from the field edge during the breeding season (n = 479).

but this was not the case among small fields. By contrast, among small fields, it was edges devoid of permanent plant cover that were preferred; this was not the case with large fields, where the proportion of this habitat was small (Table 3). The proportion of preferred habitats was 2.8 times greater among small fields than large ones.

Table 3. Expected (E) and observed (O) percentage use of habitats by radio-tagged Partridge pairs on small (< 10 ha) and large (> 10 ha) fields. For small fields $\chi^2 = 299.7$, df = 3, p = 0, for large fields $\chi^2 = 1059.8$, df = 3, p = 0. + preferred, – avoided, p < 0.01.

Habitat	Small fields (n = 332)			Large fields (n = 147)		
	E	O	p	E	O	p
Field edges:						
with permanent treeless plant cover	3.7	18.1	+	3.8	50.3	+
with permanent wooded plant cover	2.8	6.0	ns	4.1	23.1	+
without permanent plant cover	18.1	34.9	+	1.5	5.5	ns
Centres of fields	75.4	41.0	–	90.6	21.1	–

There were greater differences between the expected and observed frequencies of observations on field edges with permanent plant cover with respect to large fields than to small ones. Consequently, on large fields 73.4% of Partridge pairs were recorded on edges with permanent plant cover, whereas the corresponding figure for small fields was 24.1%. Thus, the average distances of observation stations of Partridge pairs from permanent plant cover were greater on small fields than on large fields (82 ± 90 m, n = 332 and 18 ± 44m, n = 147, respectively; $t_{477} = 8.208$, p < 0.0001). As far as observations of Partridge pairs on field edges with permanent plant cover among both types of fields were concerned, it was observed that permanent treeless plant cover was used proportionately more with respect to its availability, while the opposite was the case with regard to permanent wooded plant cover (Table 4).

Table 4. Expected (E) and observed (O) percentage use of two types of vegetation by radio-tagged Partridge pairs observed on field edges with permanent plant cover on small (< 10 ha) and large (> 10 ha) fields. For small fields $\chi^2 = 9.89$, df = 1, p = 0.002, for large fields $\chi^2 = 18.28$, df = 1, p < 0.001. + preferred, – avoided, p < 0.01.

Type of vegetation	Small fields (n=80)			Large fields (n=108)		
	E	O	p	E	O	p
Treeless	57.6	75.0	+	48.0	68.5	+
Wooded	42.4	25.0	–	52.0	31.5	–

In the case of single Partridge males, locations in orchards accounted for 9% on small fields (n = 58) and 3% on large fields (n = 29), but the sample size was too small to make any meaningful statistical comparisons. With respect to observations outside orchards, there was a preference on small fields for edges without permanent plant cover, and the centres of fields were avoided. The proportion of field edges with permanent plant cover used was similar to that throughout the study area. On large fields single males preferred field edges with permanent plant cover, whereas open fields (field edges without permanent plant cover and field middles together) were less attractive to the birds than expected (Table 5).

Table 5. Expected (E) and observed (O) percentage use of habitats by radio-tagged single (non-paired) Partridge males on small (< 10 ha) and large (> 10 ha) fields. In the case of large fields data for field edges without cover and for field centres were combined owing to the small sample size. For small fields $\chi^2 = 23.62$, df = 2, p < 0.001, for large fields $\chi^2 = 30.01$, df = 1, p < 0.001. + preferred, – avoided, * — p < 0.05, ** — p < 0.01.

Habitat	Small fields (n = 53)			Large fields (n = 28)		
	E	O	p	E	O	p
Field edges with permanent plant cover	6.5	7.5	ns	7.9	35.7	+ *
Field edges without permanent plant cover	18.1	43.4	+ **			
				92.1	64.3	– *
Centres of fields	75.4	49.1	– **			

Of 21 Partridge nests located, 9 were found in permanent plant cover, 3 in spontaneous vegetation in small orchards, and 9 in crops. For statistical comparisons, the permanent plant cover and orchards were combined. Partridges preferred permanent plant cover/orchards as a nesting habitat and avoided crops (expected frequency: 0.5 nests for permanent plant cover/orchards and 20.5 for crops; $\chi^2 = 270.9$, df = 1, $p < 0.001$). On large fields all 6 nests found were in permanent plant cover, whereas 6 of the 15 nests on small fields were located in permanent plant cover/orchards and 9 in crops, mainly in cereals.

DISCUSSION

The preference of Grey Partridges for field edges is well-known (Church et al. 1980, Weigand 1980, Mendel & Peterson 1983, Potts 1986, Meriggi et al. 1991, Dahlgren 1992) and may be a strategy to avoid predation by raptors. Predatory birds account for a significant share in the mortality of Partridges, amounting in some areas to over 50% (Pulliainen 1967, Potts 1986, Dudziński 1992a). According to Dahlgren (1992), Partridges are particularly attracted to the edges of vegetation patches of different height, the lower of which supplies food and the higher affords protection. Such edges probably ensure Partridges a favourable microclimate and source of food, enable them to observe the surroundings and provide cover if a predator should appear. However, this preference may not have much survival value with respect to nocturnal predatory mammals. The nocturnal habitat preferences of Partridges are not well known, but observations from western Poland indicate that Partridges usually spend the night in the centres of fields (R. Kamieniarz & M. Panek, unpubl. data).

Our studies have confirmed the preference of Partridges for permanent plant cover as a nesting habitat. The preference of permanent plant cover by pairs in the spring was clearly connected with reproduction. Single non-breeding males on small fields preferred only field edges without permanent plant cover. After the breeding period, in the summer and autumn, Partridges in western Poland displayed no preference for permanent plant cover (R. Kamieniarz & M. Panek, unpubl. data). Other studies of habitat use by Partridges did not find any preferences for permanent plant cover outside the breeding season either (Smith et al. 1982, Carroll et al. 1990, Dahlgren 1992). The reports of such preferences from some areas (e.g. Weigand 1980, Mendel & Peterson 1983, Meriggi et al. 1991) may be related to the shortage of free field edges or to the attractiveness of permanent plant cover as shelters or feeding places.

As there are numerous preferred field edges without permanent plant cover among small fields, Partridge pairs and their nests were more widely dispersed than among large fields, where they occupied only a small portion of the permanent plant cover. Nest dispersal is indicated as being one of the Partridges' strategies of avoiding nest predation (Potts 1980, 1986). It has also been suggested that predatory pressure on Partridges is usually greater near permanent plant cover, particularly wooded areas, than away from them, so such habitats are often avoided (Potts 1986, Rands 1987, Carroll et al. 1990, Meriggi et al. 1990, Dudziński 1992a,b, Meriggi et al. 1992, Panek 1994). However, on large fields in this study, Partridges also preferred wooded field edges. This may have been due to the poor availability of other edge types around these fields. Therefore, habitat use by Partridges in the spring may result in greater exposure of nests and adults to predation on large fields than on small ones.

According to Panek & Kamieniarz (1998), the autumn density of Partridges in different areas of Poland increases with greater field fragmentation and larger areas of unwooded permanent plant cover. In contrast, the spring density increased with the degree of field fragmentation, but not with the occurrence of typical permanent treeless plant cover. Likewise in England, no significant relationships were found between the breeding density of Partridges and the occurrence of hedges in different areas, although strong positive relationships did occur within these areas (Potts 1986, Rands 1986). This difference could be related to the fact that the presence of extensive permanent plant cover is usually conducive to the incidence of predators, thus causing higher mortality in Partridges at a time when permanent plant cover is less important for these birds, i.e. outside the breeding season. According to our studies, however, the fragmentation of fields makes it rather easier for Partridges to avoid predators.

It has been estimated in England that the carrying capacity for Partridges in spring is determined by the density of linear permanent plant cover, i.e. hedges (Potts 1980, 1986, Rands 1986, 1987). The habitat use of Partridges in western Poland points to the existence of such a relation-

ship on large fields where, as in the study areas in England, most field edges were overgrown with permanent vegetation. For the whole study area in western Poland, the local density depended primarily on the field sizes, which principally affected the availability of the preferred edges without permanent plant cover. Permanent treeless plant cover did not significantly affect local densities of Partridges, although a contributory factor here might also be the uselessness of some permanent plant cover structures for Partridges, i.e. some roadsides, because of their intensive use by humans. The difference in Partridge density between small and large fields (2.4 times) was similar to the difference in the availability of the preferred field edges between these fields (2.8 times). Therefore, the carrying capacity of the agricultural landscape in this study area may be dependent not only on the occurrence of the permanent plant cover preferred by Partridges as nesting sites, but also on the availability of field edges without permanent plant cover.

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STRESZCZENIE

[Wykorzystywanie przez kuropatwy w okresie lęgowym biotopów w zróżnicowanym krajobrazie rolniczym zachodniej Polski]

Liczebność kuropatw wiosną w różnych okolicach Polski jest pozytywnie skorelowana ze stopniem rozdrobnienia pól (Panek & Kamieniarz 1998). Wskazuje to na znaczenie dla tego ptaka wielkości pól lub związanej z nią dostępności brzegów pól. Celem badań była ocena preferencji środowiskowych kuropatw w okresie lęgowym, szczególnie wykorzystywania brzegów pól.

Badania przeprowadzono w latach 1994–1996 w okolicach Czempinia (powiat Kościan, Wielkopolska). Teren badań (97 km^2) charakteryzował się znacznym zróżnicowaniem wielkości pól od < 1–10 ha (małe pola) do 10–50 ha (duże pola). Część brzegów pól stanowiły pasy nieużytków, w postaci rowów, poboczy dróg i miedz, z roślinnością zielną, krzewami lub drzewami (Tab. 1).

W terenie badań wyznaczono losowo 30 powierzchni próbnych w kształcie koła o wielkości 1 km^2. Wiosną na powierzchniach tych oceniano zagęszczenie par kuropatw metodą liczenia odzywających się samców. Dla każdej powierzchni opisano strukturę krajobrazu rolniczego: udział różnych upraw i sadów, liczbę pól, długość pasów nieużytków bez drzew i z drzewami. 24 pary i 6 pojedynczych samców kuropatw oznakowano radiotelemetrycznie i lokalizowano w ciągu dnia od końca kwietnia do zakończenia sezonu rozrodczego. Rejestrowano odległość miejsc ich przebywania od brzegów pól i od najbliższego nieużytku. Dla całego terenu badań radiotelemetrycznych wykonano mapy upraw i nieużytków, z których wyliczono dostępność brzegów pól różnego typu: bez nieużytków, z nieużytkami bez drzew, z nieużytkami zadrzewionymi.

Zagęszczenie kuropatw na powierzchniach próbnych (zakres od 0 do 7.7 par/km^2) zwiększało się ze wzrostem liczby pól i udziałem małych ekstensywnych sadów (Tab. 2). Średnie zagęszczenie na małych polach było 2.4 razy większe niż na polach dużych. Pary kuropatw obserwowano w 65% przypadków w odległości 0–5 m od granic pól (Fig. 1), stąd przyjęto, że brzeg pola to pas szerokości 5 m od jego granicy oraz nieużytek (jeśli był obecny). Pary występujące na małych polach preferowały sady oraz brzegi pól bez nieużytków i z nieużytkami bez drzew, natomiast środkowe części pól (>5 m od brzegu) wykorzystywały rzadziej niż wynikało to z ich dostępności w terenie. Na dużych polach, gdzie brzegi pól bez nieużytków były nieliczne, pary preferowały brzegi pól zarówno z nieużytkami bez drzew jak i z drzewami, oraz unikały środków pól (Tab. 3). Dla próby zawierającej wyłącznie obserwacje przy brzegach pól z nieużytkami, stwierdzono wykorzystywanie nieużytków bez drzew w większej proporcji niż ich dostępność, natomiast zadrzewień w stopniu mniejszym od oczekiwanego (Tab. 4). Pojedyncze nielęgowe samce na małych polach preferowały brzegi pól bez nieużytków, natomiast na polach dużych brzegi pól z nieużytkami (Tab. 5). Na próbie 21 gniazd stwierdzono preferowanie przez kuropatwy nieużytków jako miejsc gniazdowania, oraz unikanie upraw, chociaż na małych polach ponad połowa gniazd zlokalizowna była w uprawach, głównie w zbożach.

Powyższe wyniki wskazują, że pojemność krajobrazu rolniczego dla kuropatw wydaje się zależeć od dostępności brzegów pól, zarówno zawierających nieużytki, zwłaszcza bez drzew, jak i w postaci bezpośrednich granic między różnymi uprawami. W terenach z rozdrobnionymi polami, pary kuropatw i ich gniazda mogą być rozproszone w przestrzeni, co powinno sprzyjać unikaniu drapieżnictwa, podczas gdy w terenach z uprawami wielkopowierzchniowymi skupiają się przy nielicznych brzegach pól, często w postaci pasów z nieużytkami lub zadrzewień, co może być przyczyną dużych strat w lęgach wskutek drapieżnictwa.

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THIRD CONFERENCE
of the EUROPEAN ORNITHOLOGISTS' UNION

(22–26 August 2001)

The avian calendar: exploring biological hurdles in the annual cycle

Following meetings in Bologna (1997) and Gdańsk (1999) the third conference of the European Ornithologists' Union (EOU) will take place in Groningen, The Netherlands from Tuesday 21 (registration) to Saturday 28 August 2001. The three day conference (plus one day excursions) will be jointly organised by the Nederlandse Ornithologische Unie (NOU), the animal ecology group of the Centre for Ecological and Evolutionary Studies of the University of Groningen and the EOU. The overall aim is to explore the biological hurdles in the annual cycle of birds. Of course, also talks and posters on all other ornithological subjects are encouraged.

The EOU invites European ornithological community to offer talks and posters. Abstracts (maximum 250 words including title and authors' addresses) should be submitted — preferably by e-mail — to:

Andreas J. Helbig, University of Greifswald, Vogelwarte Hiddensee, D–18565 Kloster, GERMANY, e-mail: helbig@mail.uni-greifswald.de

Abstracts must be submitted **no later than 1 February 2001.** For the format of submissions, and for more information about the Conference — consult the NOU website: **http://www.nou.nu**