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Habitat use by Carrion Crows *Corvus corone corone* and Hooded Crows *C. c. cornix* and their hybrids in eastern Germany

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Abstract. The habitat use of crow phenotypes (Carrion Crow, Hooded Crow, hybrids) was studied in the hybrid zone between Magdeburg and Dresden in eastern Germany. 1326 individuals (n = 293 hybrids, 417 Hooded Crows, 616 Carrion Crows) were sampled between 8 April and 12 July 2006. The study area was divided into eleven grid rectangles, 20 geographical minutes latitude by 32 minutes longitude in size. Carrion Crows, Hooded Crows and hybrids differed significantly in their habitat use. Carrion Crows avoided stubble fields with stubble taller than 15 cm, whereas the Hooded Crows were found significantly more frequently on those fields. Even when the stubble field data was pooled into one category, differences remained, with the Hooded Crows preferring maize stubble and the Carrion Crows avoiding it.

Key words: Carrion Crow, Hooded Crow, ecological segregation, habitat choice, hybridization, hybrid zone

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Hybrid zones are geographical zones where two (sub-)species meet, mate and produce hybrids (Barton & Hewitt 1985, Randler 2006). The Carrion/Hooded Crow hybrid zone extends from Scotland in the northwest through much of Central Europe to northern Italy and the continental stretch of the zone is approx. 1300 km long and between 50 and 150 km wide (Meise 1928). This hybrid zone is considered to arise by secondary contact (Cook 1975, Barton & Hewitt 1985, Rolando 1993). Recent studies suggest that the zone is moving in some parts (Scotland: Cook 1975, Picozzi 1976; Austria: Aubrecht 1979), but less movement has been found in Denmark and Northern Germany (Haas & Brodin 2005) and in Northern Italy (Rolando 1993). Such hybrid zones provide opportunities to study factors affecting isolation, hybridisation and speciation (Barton & Hewitt 1985, Randler 2002, Brodin & Haas 2006). Differences between Carrion and Hooded Crows and their hybrids have been found in habitat preferences (Saino 1992, Rolando & Laiolo 1994), vocalisations (Palestrini & Rolando 1996) or in aggressiveness (Saino & Scatizzi 1991). Carrion and Hooded Crows further pair assortatively (Saino & Villa 1992, Risch & Andersen 1998), and

mixed or hybrid pairings have a lower reproductive success (Saino & Villa 1992). Data concerning habitat use have been obtained from the hybrid zone in Italy (Saino 1992, Rolando & Laiolo 1994) but Parkin et al. (2003) pointed out that the possible ecological differences merit further study. Therefore, I collected data on habitat use of crow phenotypes in another part of the hybrid zone, in eastern Germany.

Samplings were made in the core area of the hybrid zone in eastern Germany, between Magdeburg and Dresden. The study area ranges approx. from 11°28'E–52°15'N in the northwest to 13°36'E–51°00' in the southeast. Here, the hybrid zone stretches in a diagonal manner from NW to SE. Since the proportions of the two phenotypes change along the hybrid zone (see also Rolando & Laiolo 1994) and to cover the zone systematically, I divided the study area into eleven grids, each grid with 20 geographical minutes in latitude and 32 in longitude (Gauß-Krüger-grid). Every grid was visited at least twice, travelling slowly by car on public roads to search for crows using 10 x 50 binoculars and a 30 x telescope. In each of the eleven grids all three phenotypes occurred.

Crows were classified into three phenotypes (Saino 1992): Carrion Crows, hybrids and Hooded Crows. Hybrids are depicted e.g. in Parkin et al. (2003) and are easy to identify (Randler 2004).

I sampled 1326 individuals ($n = 293$ hybrids, 417 Hooded, 616 Carrion Crows) between 8 April and 12 July 2006. Habitat use of foraging Crows was considered, and resting and preening individuals were excluded. Each time a field was visited the number of crows foraging in the field was recorded (Saino 1992) and the kind of substratum was noted (Rolando & Laiolo 1994). I waited until I was able to assess whether the individual was foraging. Therefore, I did not compare fields with against fields without crows but sampled only fields with crows and compared them between the three forms. Further, I did not use random spots to control preferred against avoided habitat (as would be useful in a single species study) because the study focuses on differences between the three forms. Also, I made samplings largely on accessible land (by car). However, in this part of eastern Germany, the area is rather flat and it is easy to sample birds over large distances with a field scope. Observations of crows were mapped on 1:100 000 survey maps to avoid sampling the same individuals twice (pseudoreplication). To avoid the problem of pseudoreplication, three aspects should be mentioned. First, I used breeding pairs in my study, and, when sampled during the first visit I excluded these pairs (with or without offspring) during the second visit. This is possible since territories are not that large in crows. Second, if flocks of non-breeders were sampled, I noted flock composition to avoid sampling similar flocks more than once, and, further, if flocks of a different composition compared to the first visit were encountered, they were excluded when they occurred within the same area. Third, the area is very large in its extent (at least more than 10 000 breeding pairs, and additionally non-breeders) which, again, renders sampling the same individual twice unlikely.

As crow phenotypes were not equally distributed across the hybrid zone, I calculated expected frequencies for the chi-square statistic for each grid separately and added these expected frequencies to a total score to compare them with the total observed frequencies (see e.g. Saino 1992, Rolando & Laiolo 1994). For comparison I used an overall chi-square test (Sokal & Rohlf 1995) to compare the frequency of the three forms with each other in the same habitat category. This

technique is used to compare expected and observed habitat use (Rolando & Laiolo 1994) and to assess whether the phenotypes selected or avoided certain habitat categories (similar method in Rolando & Laiolo 1994). Thus, I did not compare the observed habitat use versus the habitat available in each grid (as e.g. in habitat use research that is based on only one species) but compared the observed habitat use between the three forms within all eleven grids. For each grid, expected and observed frequencies were calculated and added to achieve an overall assessment (method similar to Rolando 1993). Further, I used one single overall chi-square test (to avoid an inflated number of tests and to overcome the problem of multiple testing) and subsequently, I inspected the standardized residuals to look at differences in detail (Bühl & Zöfel 2000). Standardised residuals larger than a critical value of 2.0 were assessed as significant ($p < 0.05$, for details see Bühl & Zöfel 2000). All tests were carried out two-tailed and SPSS version 14.0 was used.

Carrion Crows, Hooded Crows and hybrids differed significantly in their habitat use ($\chi^2 = 46.59$, $df = 26$, $p < 0.01$, Table 1). In detail, Carrion Crows avoided stubble fields with stubbles higher than 15 cm and Hooded Crows were found significantly more on these stubbles. Other differences were not significant on the 5% level (based on the standardised residuals). This difference in maize stubble length was also found by Saino (1992). When pooling both categories of maize stubble differences remain among these three groups of crows ($\chi^2 = 37.81$, $df = 25$, $p < 0.05$). Hooded Crows preferred maize stubbles in comparison to Carrion Crows.

Saino (1992) further found that hybrids were less selective than the parental morphs. This is similar to the results of the present study in eastern Germany. In winter, Carrion Crows selected meadows and ungrazed pastures, and avoided maize, cereal crops and recently seeded grasslands (Saino 1992). Similar to my results, Carrion Crows avoided maize stubbles >15 cm. Hooded Crows preferred maize stubbles and ploughed field and avoided meadows, ungrazed pastures, cereals and recently seeded grass fields (Saino 1992). Rolando & Laiolo (1994), however, did not detect differences in habitat use between phenotypes in winter. During spring-summer, Carrion Crows were found more frequently in maize stubble but measurements about the height of the

Table 1. Comparison of expected (EXP) and observed (OBS) frequencies of habitat use in Carrion Crow, Hooded Crow and hybrids. ** — $p < 0.01$, * — $p < 0.05$. Stubble fields were divided into two categories (< 15 cm and > 15 cm according to Saino 1992).

Habitats	Hybrid (N = 293)		Hooded Crow (N = 417)		Carrion Crow (N = 616)	
	OBS	EXP	OBS	EXP	OBS	EXP
Anthropogenic structures	4	4.59	9	5.45	6	8.95
Set aside fields	10	6.53	5	6.4	13	15.06
Mowed grassland/meadows	21	27.07	54	49.09	48	46.83
Ploughed fields	29	25.96	24	30.99	68	64.08
Cereal crops	23	19.21	15	22.46	55	51.32
Root crops	18	15.44	11	17.47	45	41.08
Maize	44	45.67	57	63.3	96	88.01
Stubble fields < 15 cm	38	34.95	47	46.1	67	70.94
Stubble fields > 15 cm	18	22.67	54	35.74**	20	33.57*
Roadside	22	17.01	12	19.11	45	42.86
Ploughed stubble fields (with stubbles)	9	12.78	19	20.96	29	23.24
Pasture	17	15.96	35	31.6	23	27.42
Meadows	31	30.00	61	55.99	50	55.99
Others	9	15.11	14	12.26	51	46.61

stubble were not provided (Rolando & Laiolo 1994) and meadows treated with manure, while Hooded Crows were more abundant in non-manure meadows and maize fields. However, Rolando & Laiolo (1994) pointed out that the differences merged to non-significance when the data were pooled into the categories "meadows" and "maize". Carrion Crows preferred maize stubbles in contrast to Hooded Crows (Rolando & Laiolo 1994), while in eastern Germany it was vice versa. This divergence between both phenotypes requires consistent differences but results from the Italian studies are contradictory.

The results from the previous study and from the two Italian studies could be viewed from another point, namely that the differences are marginally significant, but they are probably insignificant from a biological/ecological point of view. Crows may be rather opportunistic foragers and the differences in these three studies (two in Italy, one in Eastern Germany) may indeed be rather small suggesting no difference at all.

Generally, in accordance with Parkin et al. (2003), it seems that Hooded Crows are birds of poorer land. The results from the three studies on habitat use may point towards an ongoing ecological segregation that may lead to a further speciation in the hybrid zone. Nevertheless, differences between phenotypes were small in all three study areas and it seems that other aspects, such as mate choice (Brodin & Haas 2006, Randler 2007), or predation (Randler in press) contribute more to the speciation process in crows than habitat differences.

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STRESZCZENIE

[Użytkowanie środowisk przez czarnowrona, wronę siwą i ich mieszańce we wschodnich Niemczech]

Strefa hybrydyzacji między dwoma podgatunkami wron rozciąga się od Szkocji, przez centralną Europę do północnych Włoch, na szerokości 50–150 km. Wcześniejsze prace wskazują, że oba podgatunki jak i ich mieszańce mogą różnić się preferencjami środowiskowymi, głosami czy agresywnością. Celem niniejszych badań było określenie użytkowania środowisk przez dwa podgatunki wrony i ich mieszańce we wschodnich Niemczech.

Materiał zbierano w strefie hybrydyzacji między Magdeburgiem a Dreznem. Teren podzielono na 11 pól o wielkości 20' szerokości i 32' długości geograficznej. Każde pole kontrolowano dwukrotnie między 8 kwietnia a 12 lipca 2006. Teren objeżdżano samochodem obserwując żerujące ptaki przy pomocy lornetki i lunety. Ptaki nie żerujące nie były analizowane. Każdorazowo opisywano środowisko, w którym ptaki żerowały. Ogółem opisano miejsca żerowania 616 wron siwych, 417 czarnowronów i 293 mieszańców. Mapowanie żerujących ptaków oraz opisywanie wielkości i składu stad nieleśnych pozwoliło na unikanie ponownego opisywania tych samych ptaków (pseudoreplikacja).

Czarnowrony, wrony siwe i ich mieszańce różniły się środowiskami, w których żerowały najczęściej (Tab. 1). Różnice te wynikały przede wszystkim z unikania przez czarnowrona ściernisk po uprawie kukurydzy z pozostałościami wyższymi niż 15 cm, oraz częstszym występowaniem w takich miejscach wron siwych. Łącząc oba rodzaje ściernisk w jedną kategorię różnice między dwoma podgatunkami pozostały istotne, natomiast nie stwierdzono różnic w pozostałych środowiskach.

Wydaje się, że różnice w miejscach żerowania mogą prowadzić do dalszej segregacji obu podgatunków, choć wydaje się, że inne procesy niż różnice środowiskowe (np. wybór partnera) są ważniejsze dla dalszego procesu specjacji.