

WHY DO MONTAGU'S HARRIERS DISTURB FORAGING SESSIONS OF WHITE STORKS IN SOUTH-EAST POLAND?

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Abstract. Montagu's Harriers nest sympatrically with White Storks in SE Poland. Most of Montagu's Harrier females are capable of modifying the foraging efficiency of White Storks by performing selective dives on foraging birds in habitat patches, which are optimal for foraging the raptor. In such habitats storks are fiercely attacked, their foraging sessions are shortened and their foraging efficiency is reduced. This phenomenon may reflect simultaneous tendency of both species for optimal habitat monopolisation during breeding. It may be related to observed nest site fidelity of considered species.

Key words: White Stork, *Ciconia ciconia*, Montagu's Harrier, *Circus pygargus*, behaviour, foraging.

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Почему луговые луны мешают кормиться белым аистам на юго-востоке Польши? - И. Китовский. - Беркут. 16 (1). 2007. - На юго-востоке Польши оба вида гнездятся симпатрично. Большинство самок луны могут влиять на результативность кормежки аистов, атакуя птиц, собирающих корм на участках, оптимальных для охоты самих хищников. В таких местах луны часто нападают на кормящихся аистов, их кормовые сессии сокращаются, а результативность кормежки снижается. Это явление может отражать тенденцию монополизации оптимальных кормовых биотопов в гнездовой период.

Introduction

The process of selecting a patch of habitat for foraging involves choosing among habitat patches there that differ in the probability of attack of predators. Some habitat patches provide the highest rate of energetic gain but these may be dangerous because the risk of being killed, hurt, or having a foraging session disrupted (Bryant, Grant, 1995; Goldberg et al., 2001; Ovadia, Dohna, 2003). In such condition foragers to maximise energetic gain have to trade off between foraging and aggression in profitable patches (Lima, Dill, 1990; Brown, 1998).

In some areas of Europe White Stork (*Ciconia ciconia*) (hereafter stork) and Montagu's Harrier (*Circus pygargus*) (hereafter harrier) are sympatric. Nevertheless their social relation on foraging areas have not been studied in detail. It has been known that both species display similar preferences for open habitats and their feeding preferences are also much alike (Schipper, 1977; Clarke, 1996; Salamolard et al, 2000; Latus, Kujawa, 2005; Rachel, 2006). Both species on southern breeding sites

prefer insects, whereas in the northern breeding area a basic component of their diet are insects and small vertebrates (Lazaro, 1982; Muzinic, Rasajski, 1992; Tsachalidis et al., 2002; Kosicki et al., 2006). Moreover, it has been proven for both species in northern Europe the abundance of Common Vole (*Microtus arvalis*) is ultimate factor controlling a breeding success (Creutz, 1988; Pinowska et al., 1991; Pinowski et al., 1991; Tryjanowski, Kuzniak, 2002) *c.f.* (Krogulec, 1992; Butet, Leroux, 1993; Salamolard et al., 2000). Also it has been proven that meadows, especially when cut regularly, and pastures are basic foraging habitats for both species (Schipper, 1977; Clarke, 1996; Salamolard et al., 2000; Latus, Kujawa, 2005; Rachel, 2006). Cases of predation of Storks on Montagu's Harrier nestlings were observed in Spain (B. Arroyo, pers. com.). On the other hand attacks Montagu's Harrier on White Storks have been reported (Kitowski, 1994; Kitowski, 2003a). In the southeastern Poland, at major breeding sites Harriers occur with Storks (Piotrowska, 2000; Kitowski, 2002; Tomialojc, Stawarczyk, 2003). This paper attempts reveal pattern of



Table 1

Habitats of 378 foraging sessions of White Storks (first seen peck of foraging individual)
 Биотопы 378 случаев кормежки белого аиста (по первому клевку кормящейся особи)

Habitat	Areas near semicolony of Montagu's Harriers			χ^2	Areas far from semicolony of Montagu's Harriers			χ^2
	Availab., %	N	% N	df = 1	Availab., %	N	N %	df = 1
Meadows	28	64	39.8	4.49*	43	116	53.4	4.47*
Pasture	15	44	27.3	6.73**	25	74	36.4	4.00*
Arable lands	24	20	12.4	6.72**	27	8	3.7	42.9**
Wetlands	33	33	20.5	5.73*	5	19	8.8	1.75
Total	100	161	100	—	100	217	100	—

* $p < 0.05$, ** $p < 0.01$.

the impact of Montagu's Harriers on the foraging tactic of White Storks, especially regarding foraging habitat use.

Methods

In 2000–2003 I studied 8–12 nesting pairs of Storks in the villages Plawanice, Kroczyń, Barbarowka, Kolonia Rudolfin (Chelm district, SE Poland). They are close Roskosz Reserve (51° 08' N, 23° 37' E, SE Poland) where in 2000–2003 nested approximately 9–12 pairs of Harriers (Kitowski, 2002; Kitowski, unpubl. data). Observations were performed every year from 15 April – 15 August. Harriers were recognised as foraging if when the first observed they were cruising or hovering (Clarke, 1996; Kitowski, Wojtak, 2001; Kitowski, 2003b). Habitat use of foraging Storks was measured by recording the amount time spent foraging in a particular place. Prey availability was not assessed. Areas less than 2.5 km from semicolonies of Harriers were classed as “nearby foraging patches” of Storks (Johst et al., 2001). The hunting areas of 2.5–5 km from Harrier semicolonies were classed as “remote foraging patches” for Storks (Johst et al., 2001). Analyses of Stork foraging efficiency were only calculated for bouts of predation involving capture vertebrate. This because the biomass of vertebrates is so much greater and their energy value is so much higher the those invertebrates (Antczak et al., 2002; Kosicki et

al., 2006). The following habitat types were defined: a) meadows; b) pastures, areas grazed by cattle; c) arable lands; d) wetlands involving marshes, water filled ground excavations and drainage ditches. The distribution of these habitats in the study area was mapped and calculated their surface areas with a digital planimeter from a high-resolution aerial photo.

Meadows were considered intensive used if they were cut two or more times per year, non intensively cut meadows were cut once a year. Behavioural events were timed with an electronic stop-watch. Averages were compared using the Student's t test and ANOVA (parametric data, given in the text as mean \pm SD) and Mann-Whitney U-test and Kruskal-Wallis ANOVA (non-parametric data given in the text as mean \pm SE) (Sokal, Rohlf, 1981; Fowler, Cohen, 1992).

Results

Habitat use by foraging White Storks and Montagu's Harriers

Totally 378 Stork's foraging session were observed. Storks when foraging near the semicolonies of harriers ($n = 161$) preferred meadows and pasture (Table 1). Far from semicolony ($n = 217$) storks also tended to forage on meadows and pastures. Wetlands were seldom exploited, but were used in proportion to their availability (Table 1). In 12 cases (63.1 % of $n = 19$ bouts) used drainage ditches.



Table 2

Number caught vertebrates prey (when swallowing was observed) by White Storks
Количество пойманных белыми аистами позвоночных (наблюдалось проглатывание)

Habitat	N	Area near of Montagu's Harriers semicolony	N	Areas far from Montagu's Harriers semicolony	Statistics
Meadows	64	2.5 ± 1.2 range: 0–4	116	2.0 ± 1.1 range: 0–4	t = 2.74** df = 178
Pasture	44	1.3 ± 0.7 range: 0–4	74	1.0 ± 0.8 range: 0–4	t = 2.10* df = 116
Arable lands	20	1.9 ± 0.3 range: 1–7	8	2.1 ± 0.6 range: 1–6	Z = 1.49 n. s.
Wetlands	33	2.2 ± 0.2 range: 0–5	19	0.9 ± 0.1 range: 0–2	Z = -0.19 n. s.
Total	161	2.0 ± 1.1 range: 0–7	217	1.6 ± 1.3 range: 0–6	t = 3.78*** df = 276

In case of use of Mann-Whitney U-test data are given as mean ± SE, for Student's t-test was used mean ± SD.

* p < 0.05, ** p < 0.01, *** p < 0.001.

More vertebrate prey were captures per session by Storks on foraging areas near Harrier semicolonies (Table 2). However, for both foraging area the number of prey caught depended on habitat class with a significant preference of meadows. This was there near harrier semicolonies (*nearby foraging patches*) (ANOVA: $F_{3,157} = 9.65$, p < 0.001) and far located foraging area (*remote foraging patches*) (ANOVA: $F_{3,213} = 17.6$, p < 0.001).

Table 3

Frequency of attacks on 58 individuals of White Stork in relation to habitat of foraging
Частота атак на 58 особей белого аиста в зависимости от кормового биотопа

Habitat	Areas near semicolony of Montagu's Harriers		
	Observed frequency	Expected frequency	χ^2 df = 1
Meadows	23	14.5	6.6**
Pasture	9	14.5	2.8
Arable lands	2	14.5	14.4***
Wetlands	24	14.5	8.3**
Total	58	58	–

** p < 0.01, *** p < 0.001.

Foraging sessions White Stork near Montagu's Harrier's semicolonies and interactions Stork — Harrier

Of 161 foraging sessions near harrier semicolonies 97 (60.2 %) sessions did not involved interaction with harriers. And its finished by intrinsic patch-leaving decision of the White Stork individuals. However, 64 (39.7 %) Stork foraging sessions were disturbed by animals and people (no – intrinsic patch – leaving decision of individual). Among the disturbed sessions, a number of 58 (90.6 %, n = 64) involved harriers (Table 3). The remaining disturbances were by: Red Foxes (*Vulpes vulpes*) (n = 2), other storks (n = 1), people (n = 2) and cattle (n = 1). When compared to attacks by males 6 bouts (10.3 %, n = 58), harrier females (52 bouts, 89.7 %, n = 58) attack more frequently foraging storks. Differences were statistically significant ($\chi^2 = 36.5$, df = 1, p < 0.0001). Female harriers harassed foraging storks more severely, performing 3.3 ± 1.4 dives (range: 1–5 dives) also lasting 32.6 ± 6.9 sec (range: 3– 40 sec.). While males performed 1.8 ± 1.6 dives (range 1–5 dives lasting 30.7 ± 15.2 sec. (range: 3– 49 sec.). The differences in the number of performed dives



were found significant (Mann-Whitney U test: $Z = -2.11$, $n_1 = 52$, $n_2 = 6$, $p < 0.035$), but differences in time of these harassments (Mann-Whitney U test: $Z = -1.27$, $n_1 = 52$, $n_2 = 6$, n.s.) were not found.

Females harriers were more likely to interrupt stork foraging sessions in late nestling and early post-fledging periods (from 15 June till 15 July) compared to other phases of breeding of the raptor (37 events vs. 15 events: $\chi^2 = 9.3$, $p < 0.002$). During disturbed foraging sessions on meadows near semicolony were likely to occur on intensive cut meadows 17 (73.9 %) vs 6 (26.1 %), $\chi^2 = 5.2$, $p < 0.02$. For other foraging sessions on meadows near Harrier semicolony, storks preferred regularly cut meadows: 27(65.9 %) vs 14 (34,1 %), $\chi^2 = 4.12$, $p < 0.04$. Habitat types exploited by storks foraging near harriers' colonies was related to the number of caught vertebrates if the sessions were not disturbed by Harrier (ANOVA: $F_{3,99} = 24.51$, $p < 0.001$). Similar relation were not found when foraging was interrupted by no-intrinsic patch-leaving decision of an individual: Kruskal-Wallis ANOVA: $H = 0.81$, $df = 3$, n.s. (data for calculation included in Table 2). The number of

Table 4

Dives of Montagu's Harrier addressed into White Stork individuals close semicolony (mean \pm SE)

Нападения луговых луней на белых аистов возле полукolonии

Habitat	Areas near semicolony of Montagu's Harriers		
	N	Dives	Range
Meadows	23	2.7 \pm 0.3	1-5
Pasture	9	2.2 \pm 0.5	1-5
Arable lands	2	2.0 \pm 1.0	1-3
Wetlands	24	4.0 \pm 0.3	1-5
Total	58	3.14 \pm 0.18	1-5

harrier dives at storks foraging differed significantly for particular patches. The highest number of dives was performed on storks foraging on meadows and pastures (Kruskal-Wallis ANOVA: $H = 14.56$, $df = 3$, $p < 0.001$) (Table 4). Storks, during interrupted foraging sessions near Harrier colonies (*nearby foraging areas*), tended to forage in shorter bouts and catch fewer vertebrate prey when compared to uninterrupted sessions performed

Table 5

Comparison of foraging time sessions of White Storks in two contexts

Сравнение времени кормежки белых аистов в двух контекстах

Habitat	Time of disturbed by Montagu's Harriers foraging sessions near semicolony of Harriers		Time of other foraging sessions near semicolony of Harriers		Statistics
	N	Mean	N	Mean	
Meadows	23	745 \pm 690.2sec. range: 262 – 2457 sec.	41	2288 \pm 482.2 sec. range: 1928 – 4333 sec.	$t = 10.6^*$, $df = 62$
Pasture	9	2113.2 \pm 200.7 sec. range: 1213 – 2826 sec.	35	3073.3 \pm 117.1 sec. range: 1758 – 3994 sec	$Z = -4,14^*$
Arable lands	2	2636 \pm 547.5 sec. range: 2094 – 3178 sec.	18	2905.1 \pm 119.2 sec. range: 2409 – 4441 sec.	–
Wetlands	24	126.6 \pm 15.9 sec. range: 34 – 312 sec.	9	137.8 \pm 24.4 sec. range: 59 – 312 sec.	$Z = -0.8$, n. s.
Total	58	766 \pm 910.5 sec. range: 34 – 3178 sec.	103	2430.7 \pm 962.2 sec. range: 59 – 5522 sec.	$t = 10.7^*$, $df = 159$

Data are given as mean \pm SE for Mann-Whitney U-test and mean \pm SD for Student's t-test.

* $p < 0.001$.



Table 6

Comparison of number of vertebrate prey caught during foraging sessions of White Storks close Montagu's Harrier semicolony

Сравнение количества добытых позвоночных во время кормежки белыми аистами возле полукolonии луговых луней

Habitat	Number of vertebrate prey caught during ruptured foraging sessions		Number of vertebrate prey caught during no-ruptured foraging sessions		Statistics
	N	Mean	N	Mean	
Meadows	23	1.6 ± 0.9 prey, range: 0–3	41	3.0 ± 1.0 prey, range: 1–4	t = -5.71**, df = 62
Pasture	9	1.6 ± 0.3 prey, range: 0–3	35	1.3 ± 0.1 prey, range: 1–4	Z = -7.49**
Arable lands	2	2.5 ± 0.5 prey, range: 2–3	18	1.8 ± 0.33 prey, range: 1–7	–
Wetlands	24	1.7 ± 1.6 prey, range: 0–3	9	3.6 ± 0.4 prey, range: 2–5	Z = -3.5**
Total	58	1.6 ± 0.9 prey, range: 0–3	103	2.3 ± 1.3 prey, range: 1–7	t = -3.31*, df = 159

Data are given as mean ± SE for Mann-Whitney U-test and mean ± SD for Student's t-test.

* p < 0.01, ** p < 0.001.

(Table 5, 6). Uninterrupted Storks foraging sessions were observed mainly in June (n = 21) and July (n = 23). Interrupted sessions took place in April (n = 3), May (n = 4), and August (n = 7). The frequency of uninterrupted foraging sessions in particular months of observations diverged from the expected one ($\chi^2 = 32.0$, df = 4, p < 0.001). During study n = 3 communal defences were also observed into which 4.25 ± 0.96 (range: 3–5 individuals) Montagu's Harriers individuals were involved, which in the duration of 122 ± 55 sec. (range: 84–201 sec.) performed 3.7 ± 0.96 dives (range: 3–5 dives).

Foraging sessions of White Storks far from Montagu's Harriers semicolonies

Stork foraging sessions (n = 217) on areas further than 2.5 km from harrier semicolonies (*remote foraging areas*) (Table 1) lasted longer (Table 7) than sessions performed near harrier colonies but the number of vertebrate prey caught per unit time was smaller (Table 2) and in which were foraging bouts near harriers colonies on meadows and pastures 190 (87.6 %, n = 217) (Table 1, 2, 7). If storks foraged on

meadows, they exhibited stronger preference for pecking on frequently cut meadows than foraging on no-intensively managed meadows: 83 (71.6 %) vs. 33 (28.4 %), $\chi^2 = 21.5$, df = 1, p < 0.001. Here only 19 (8.7 %) sessions were disturbed by interactions, which 9 (4.1 %) were interactions with adult males of Montagu's Harrier, and all occurred on frequently cut meadows. The remaining were interactions with a Red Fox (n = 1), a Marsh Harrier (*Circus aeruginosus*) male (n = 1), other storks (n = 2), people on foot (n = 2), agricultural machinery (n = 4). One case, in which storks foraged for at least 57 minutes followed tractor plowing was excluded from this calculation.

Foraging of Montagu's Harriers

Female of harrier used to forage closer to the their semicolonies, and tended to prefer meadows and pastures, avoiding arable lands and wetlands (Table 8). Due to hunting duties males rarely foraged near semicolonies and exploited habitat patches in proportion to their presence. The exception was that wetlands which were quite distinctly avoided (Table 8). Harrier foraging preferences in areas far from semicolonies were reported elsewhere. There



Table 7

Comparison of the time lasting foraging sessions of White Storks
Сравнение продолжительности кормовых сессий белых аистов

Habitat	Area near semicolony of Montagu's Harriers		Area far of Montagu's Harriers semicolony		Statistics
	N	Time lasting session	N	Time lasting session	
Meadows	64	1822.7 ± 1012.3 sec. range: 262 – 4338 sec.	116	3237.9 ± 985.9 range: 1929 – 7111 sec.	t = -9.12*** df = 178
Pasture	44	2644.0 ± 807.9 sec. range: 1758 – 3994 sec.	74	3422.2 ± 1248.9 sec. range: 1132 – 6016 sec.	t = -3.69** df = 116
Arable lands	20	2878.2 ± 179.4 sec. range: 2094 – 4441 sec.	8	2979 ± 153.7 sec. range: 2779 – 3392 sec.	Z = -1.83*
Wetlands	33	129.7 ± 13.5 sec. range: 34 – 312 sec.	19	1930.8 ± 229.5 sec. range: 118 – 3267 sec.	Z = -5.71***
Total	161	1831.3 ± 1236.0 sec. range: 34 – 4441 sec.	217	3176.7 ± 1138.6 sec. range: 118 – 7111 sec.	t = -10.95*** df = 376

Data are given as mean ± SE for Mann-Whitney U-test and mean ± SD for Student's t-test.

* p < 0.034, ** p < 0.0003, *** p < 0.0001.

was a distinct preference for regularly cut meadows and pasture lands (Kitowski, Wojtak, 2001; Kitowski, 2003b).

Discussion

Many studies have demonstrated the effects of spatial and temporal clumping of resources on the frequency of competitive aggression (Grant, Guha 1993; Bryant, Grant, 1995; Goldberg et al., 2001; Plesner et al., 2005). These

have been helpful in understanding why harriers interfere with foraging storks in habitat patches covered with short vegetation (regularly cut meadows). White Storks (Creutz, 1988; Alonso et al., 1991; Struwe, Tomsen, 1991; Johst et al., 2001; Moritz et al., 2001) and Montagu's Harriers (Nieboer, 1973; Clarke, 1996; Kitowski, 2003b) prefer open areas with short vegetation. Here, prey is more accessible for harriers (Clark, Stanley, 1976) and storks (Moritz et al., 2001) than in areas

Table 8

Foraging sessions Montagu's Harrier females and males close semicolony
Кормовые сессии самок и самцов луговых луней возле полуколонии

Habitat	Females			χ^2	Males		χ^2
	Availability, %	N	% N	df = 1	N	% N	df = 1
Meadows	28	224	43.8	27.2*	29	30.8	0,1
Pasture	15	153	29.9	31.6*	24	25.6	2.7
Arable lands	24	35	6.9	56.7*	28	29.8	0,4
Wetlands	33	99	19.4	23.6*	13	13.8	8.6*
Total	100	511	100	–	94	100	–

Data based on every 30 minutes scanning first seen foraging individuals.

* p < 0.01.



with tall grass, where vegetation provides hides for prey. Increasing food patch quality (easier prey accessibility) results in a decrease in the intrinsic patch-leaving rate and an increase in the rate of aggressive interactions involving the White Storks and Montagu's Harriers. Storks and harriers seem to assess, at least in part, the quality of patch habitats in which foraging. The quality of the foraging habitat impact in harriers in the clutch size and the number of young fledged (Butet, Leroux, 1993; Arroyo, 1997; Salamolard et al., 2000). In storks quality of habitat near the nesting site is significant factors affecting on breeding density (Latus et al., 2000; Latus, Kujawa, 2005).

Other studies suggest that where food is more predictable in space, there is a strong tendency for monopolisation of foraging areas and defence prevalence increases abruptly with prey concentration or vulnerability (Grant, Grant, 1994; Bryant, Grant, 1995). A situation like this occurs in the study area Common Voles populations fluctuate from season to season because, in this species population explosions ("vole years") and depressions ("non-vole years") are observed every 3–4 years (Pucek, 1984). Nevertheless patches where prey is more accessible (such as regularly cut meadows) can persisted over many years and the probability of finding better access for food even in time "non-vole years" is greater here compared to other areas. The distribution of food can be partially predictable in for harriers and storks. Harriers probably become more aggressive towards storks learn which habitat patches are predictably offer prey. They then monopolising these patch during future reproductive cycles as has been observed in some other birds (Grant, Kramer, 1992; Grant, Grant, 1994; Goldberg et al., 2001). Undoubtedly, harriers benefit by invest energy in monopolising better quality patch habitats. The high probability of aggression of harriers to storks is also supported by observed nest site fidelity both species (Profus, 1991; Krogulec, 1992; Kitowski 2000; Kitowski, unpubl. data). In storks such fidelity is reflected by strong tendency to return to the nest of last year breeding (not to the nest of the birth) (Profus, 1991).

Most of the foraging sessions interrupted storks (76 %) occurred in June and July. This can be accounted to the increased rate of vertebrates in total prey biomass of storks as the reproductive season advances. Observations supported by other authors (Struwe, Thomsen, 1991; Antczak et al., 2002) including those and performed in south-eastern Poland confirm that in this time frequency small vertebrates increases in stork's diet (Kitowski, unpubl. data).

It has been demonstrated statistically that foraging storks suffer more from being harassed harrier females than males. This results from females being more regular present near semicolonies their in late nestling and early post-fledging period (Kitowski, 2003a; Kitowski, unpubl. data). When nestlings do not need to be brooded, females are know to forage within the area of about 1.5 km their nests, a males foraging further. This in turn results from the spatial separation of hunting areas or used varying habitat types related to the reverse sexual sized dimorphism, which itself serves to reduce prey competition between individuals of opposite sexes (Newton, 1979; Temeles, 1985). Surprising, this spatial separation of the hunting areas of males and females of Montagu's Harriers partially determines the foraging efficiency of White Storks. Females of harriers, having a limited time and area available for hunting due to their defensive duties (Kitowski, 2003a), must choose most effective patches for hunting. These must also be located near nests. These patches happen, also to be good *nearby foraging patches* of storks.

A detailed population study on common voles performed on study area (Trociuk, 1987; Maruchniak, 1988) showed that meadows immediately adjacent to the harrier's semicolonies were heavy depleted of voles due to the exploitation by nesting harriers contrary of the areas further away from semicolonies serves as the *remote foraging patches* of storks. Female harriers quickly remove competitor including White Storks, from the areas which they exploit. These factors contribute to higher rates of early departure of foraging White Storks. This raises their foraging costs. As sug-



gested White Stork foraging involves a trade off between highly effective foraging (especially of voles) and acute aggression from harriers. The time consuming technique of “wait and peck” (Struwe, Thomsen, 1991), particularly exposes storks to attacks by the raptor. The same trade off phenomenon has been shown for other animals as well (Ovadia, Dohna, 2003). The overall picture of repressing foraging of White Storks near Harriers colonies to avoid predation of harriers broods was observed in Spain (Extramadura) (B. Arroyo, pers. comm). Research in the southeastern Poland failed to find such predation, although this possibility might be indicated by penchant for mobbing storks by Montagu's Harriers (Kitowski, 2003a). In Spain and Poland Montagu's Harriers performed social defences only toward those species which were significant predators of their broods (Arroyo et al., 2000; Kitowski 2003b) and acute attacks were common only close harrier semicolonies.

In conclusion, Montagu's Harrier in south-eastern Poland are able to modify the foraging efficiency of White Storks selectively attacking them in habitat patch recognised as optimal by raptor. In such habitats, storks are attacked more fiercely, and stork foraging are shortened and thereby less efficient. This phenomenon reflects tendency for monopolisation of optimal habitats. It is related to the nest site fidelity observed in both considered species.

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