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The breeding performance of the Common Buzzard *Buteo buteo* and Goshawk *Accipiter gentilis* in Central Poland

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Abstract. Both the Buzzard and the Goshawk nested mainly in pines. The mean clutch size in the former was 2.8, in the latter 3.6 eggs per breeding pair. There were statistically significant differences in clutch sizes in the Buzzard in particular breeding seasons. The mean number of hatchlings was 2.3 in the Buzzard and 2.6 in the Goshawk. Brood losses were similar in both raptors — 19% in the Goshawk and 24% in the Buzzard. The breeding success (the ratio of the number of fledglings to the clutch size) in the Buzzard was highest in clutches of 3 and 4 eggs, whereas in the Goshawk a similar level of success was achieved with smaller clutches (2 or 3 eggs). Only in the case of the Buzzard there were significant differences in clutch sizes and numbers of fledglings in the various years. In this species the mean number of fledglings was positively correlated with the rodent availability index in a given year. There was no such relationship between the abundance of prey items found in Goshawk nests and the number of fledglings. The correlation between the number of newly-fledged Buzzards and Goshawks in a given year could have been due to diet overlap between the two species.

Key words: clutch size, brood size, Common Buzzard, *Buteo buteo*, Goshawk, *Accipiter gentilis*, variability of breeding

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INTRODUCTION

The Common Buzzard (henceforth referred to as "Buzzard") and the Goshawk are common birds throughout Poland (Tomiałojć 1990). In some parts of the country the density of Goshawk is exceptionally high, equalling that of the Buzzard (Olech 1991, Goszczyński 1997). In such areas the breeding performances of these two predators can be compared. The present study location was selected for this very reason, supporting as it does equal numbers of Goshawks and Buzzards (Goszczyński & Piłatowski 1986, Goszczyński 1997). The aims of this study were to assess (1) the reproductive parameters of the two species, e.g. clutch sizes, hatching dates, numbers of fledglings and breeding success, and (2) the factors affecting breeding performance.

THE STUDY AREA

The study area is located near Rogów (51°48′N, 19°53′E) in central Poland and consists largely of a mosaic of arable fields and meadows (64% of the total area), woodland (23%) and orchards (5%). The remainder (8%) comprises villages and small towns, wasteland and roads. The dominant tree species in the woodland is the Scots Pine *Pinus sylvestris* with an admixture of other species (Oak, Birch, Larch and Spruce). The spatial distribution of woodland in the study area was the subject of an earlier paper (Goszczyński 1997).

On average 18 pairs of Buzzard and 17 pairs of Goshawk nested annually in these woodland areas; these numbers varied slightly from year to year. The respective densities of the two species were 1.73 and 1.63 pairs per 10 km^2 (Goszczyński 1997).

The population of Common Vole *Microtus arvalis*, an important food resource for Buzzards, ranged from just a few to nearly 80 individuals per ha (Goszczyński 1985). Nevertheless, the density of these rodents in the Rogów area was several times lower than the usual figure for western Poland. Domestic Pigeons *Columba livia*, commonly bred in this area, were a substantial food resource for the Goshawks. Small game — hares, partridges and pheasants — was moderately numerous during the period of the study (Wasilewski 1986, Dudziński 1988).

METHODS

In early spring (March) potential nesting sites were located from observations of soaring pairs and their courtship calls. In April and May sections of old woodland within the birds' territories were searched for nests (Goszczyński 1997). In 1982–1987 nests were inspected visually (the nest tree was climbed). Then and during the subsequent five breeding seasons (1988–1992), the nest tree species was recorded. If a Goshawk or Buzzard used the same nest more than once, only the first use was taken into account.

Most of the nests were inspected several times per season. The nest was usually inspected for the first time in the third week of April in order to establish the clutch size. Whenever possible, the second inspection took place on the expected day of hatching or the day after, so as to specify the hatching date as accurately as possible. During subsequent inspections, changes in the size, appearance and plumage of the nestlings were recorded.

Around 20% of Buzzard nests and 11% of Goshawk nests were discovered after the incubation period. The ages of the nestlings — accurate to within a week — were estimated by comparison with young birds of known age. Wherever possible, broods with the same number of young were compared. In the study area young Buzzards and Goshawks fledged after 9 and 7 weeks respectively.

During every nest inspection clutch and brood losses were recorded and attempts made to establish their causes. Since the breeding success of raptors can depend on the abundance of prey, its availability was assessed in each breeding season. The prey availability index was calculated: this was defined as the number of prey animals — small rodents in Buzzard nests and birds in Goshawk nests — per nest inspection. Because of restricted visibility, inspections performed from neighbouring trees were not included in the calculation of the prey availability index. In all, 241 Buzzard nest inspections and 202 Goshawk nest inspections were used for calculating this index. The diet overlap was calculated in the manner described in Goszczyński & Piłatowski (1986) and Goszczyński (1991).

RESULTS

Selection of nest trees, clutch sizes, hatching dates, and brood losses

Although both raptors usually nested in pines (93%, n = 185 in Buzzard, and 85%, n = 138 in Goshawk), the figure for Buzzard was significantly higher ($t = 2.54$, $p < 0.05$, test for comparison of two percentages, Bailey 1959). Goshawks tended to build their nests in larches more often than Buzzards did ($t = 3.15$, $p < 0.05$). No other differences in nest tree preferences were found (Table 1).

Table 1. The nest tree species distribution (data from 1982–1992).

Nest tree	Goshawk		Buzzard	
	N	%	N	%
Pinus sylvestris	138	84.7	185	93.0
Quercus sp.	5	3.1	3	1.5
Betula sp.	5	3.1	7	3.5
Larix sp.	9	5.5	1	0.5
Alnus sp.	4	2.4	3	1.5
Picea abies	2	1.2		
Total	163	100.0	199	100.0

The average distance from a Buzzard nest to the nearest Goshawk nest was about 500 m, while the average distance between nests belonging to the same species was roughly twice as great — 980 and 1020 m for Goshawks and Buzzards respectively.

The mean clutch size per breeding pair was 3.6 in the Goshawk and 2.8 in the Buzzard (Table 2). The median clutch size in the Buzzard was significantly lower than in the Goshawk ($p< 0.0001$, Mann-Whitney two sample test).

Table 2. Clutch size — number of eggs per nesting pair.

Clutch size	Goshawk		Buzzard	
	N	%	N	%
1	1	1	0	
2	6	8	20	28
3	17	24	42	59
4	43	60	9	13
5	5	7	0	
Total	72	100	71	100
Mean	3.62		2.84	
SD	0.8		0.6	

The young of both species hatched at the same time, in the first half of May (Table 3). Some Goshawk pairs laid a replacement clutch if their

Table 3. Hatching dates. *one replacement clutch, **three replacement clutches.

Year	Goshawk		Buzzard	
	N	Mean	N	Mean
1982	10	10 May (23April–2 June)*	10	4 May (29 April–9 May)
1983	9	7 May (26 April–15 May)	10	11 May (7–17 May)
1984	12	9 May (30 April–29 May)**	12	14 May (6–29 May)
1985	13	11 May (6–27 May)	11	14 May (8–20 May)
1986	12	11 May (7–17 May)	11	11 May (6–21 May)
1987	11	10 May (2–16 May)	10	10 May (28 April–18 May)
Mean		10 May (23 April–2 June)		11 May (28 April–29 May)

nest was destroyed in the early stages of incubation. Such situations occurred in 1982 and again in 1984, when nests collapsed under the weight of large amounts of fresh snow.

The hatching success (the percentage of hatchlings in relation to the clutch size) was 72% in the Goshawk and 81% in the Buzzard. Brood losses (the reduction in numbers of nestlings during the entire nesting period, i.e. from hatching to fledging) were similar in the two species: 19% in the Goshawk, and 24% in the Buzzard. The greatest losses were sustained during incubation and the first two weeks after hatching (Fig. 1).

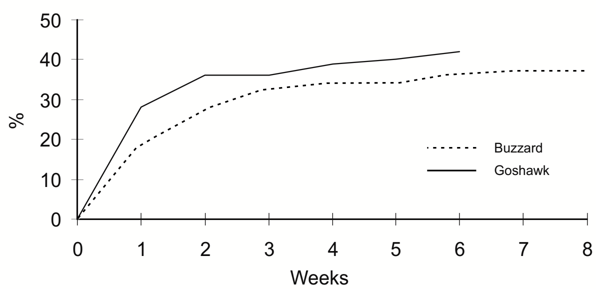

Fig. 1. Cumulative mortality of nestlings between egg laying and successive weeks of nestlings' life, expressed as ratio of brood losses to a mean clutch size.

A considerable proportion of the overall mortality in the two species (60%) was due to losses of entire clutches or broods. Human activities, chiefly disturbance within the nesting territories through forestry activities and deliberate nest destruction, were a more frequent cause of losses in the Goshawk (8:20 cases) than in the Buzzard (5:22). In turn, Buzzards lost more complete clutches or broods than Goshawks through predation (6:22 and 3:20 respectively) and nest collapse (4:22 and 2:20 respectively).

Breeding success

The measure of breeding success is taken to be the ratio of fledglings to the clutch size. In the Buzzard, clutches of 3 (67%) and 4 (72%) eggs were the most successful. The success of clutches of only 2 eggs was very low (30%) (Table 4). Differences in the mean number of fledglings from these three clutch categories were statistically significant (One-way ANOVA, $F = 18.78$, $p < 0.0001$, for 2 and 68 df). In the Goshawk, the situation was reversed: clutches of 2 or 3 eggs (70% and 73% respectively) were rather more successful than clutches of 4 and 5 eggs (62% and 52%), but the differences were not significant.

Table 4. Breeding success (%). Estimated number of broods (B), eggs (E) and fledglings (F).

Clutch	Goshawk				Buzzard			
	B	E	F	F/E %	B	E	F	F/E %
1	1	1	0	0				
2	5	10	7	70	20	40	12	30
3	16	48	35	73	42	126	85	67
4	39	156	97	62	9	36	26	72
5	5	25	13	52				
Total	66	240	152	63	71	202	123	61

Variability in clutch size and brood size

In the Buzzard clutch size variability in particular seasons was significant throughout the study period ($F = 4.90$, $p < 0.0008$, for 5 and 65 df, One-way ANOVA). This was not the case in the Goshawk.

There was no statistically significant correlation between clutch size in either species in successive breeding seasons. The mean number of fledging Buzzards per breeding pair varied considerably from year to year; in the Goshawk these differences were not significant (Table 5).

Table 5. Breeding results, index of prey availability, diet overlap and weather conditions in particular nesting seasons. B.b. — Buzzard, A.g. — Goshawk, n — number of clutch or number of nest in which the number of fledglings were estimated.

Parameters		1982 (n)	1983 (n)	1984 (n)	1985 (n)	1986 (n)	1987 (n)
Average clutch	B.b	3.1 (8)	2.9 (13)	2.3 (13)	2.7 (13)	3.3 (15)	2.8 (9)
	A.g.	3.2 (9)	3.7 (11)	3.3 (16)	3.8 (13)	4.1 (12)	3.5 (11)
Mean number of fledglings	B.b.	2.4 (13)	1.4 (16)	0.9 (16)	1.8 (13)	2.1 (15)	2.0 (12)
	A.g.	2.4 (13)	2.1 (15)	1.4 (16)	2.1 (15)	2.4 (12)	2.6 (9)
Number of nest controls	B.b.	31	40	52	37	55	26
	A.g.	24	27	55	39	39	18
Number of prey found in nests	B.b.	16	12	14	18	34	13
	A.g.	10	4	21	8	3	6
Index of prey availability	B.b.	0.52	0.30	0.27	0.49	0.62	0.50
	A.g.	0.42	0.15	0.38	0.21	0.08	0.33
Diet overlap (%)		26.1	35.7	47.6	38.7	33.8	30.3
Mean temperature during nesting period (°C, April-June)		10.9	13.7	11.3	11.9	12.6	11.3
Precipitation (mm, April-June)		186.0	117.3	138.5	179.9	110.2	155.7

Factors affecting breeding performance

In the Buzzard the mean number of fledglings in a given season was positively correlated with the rodent availability index ($r = 0.891$, $p = 0.017$, $n = 6$). In the Goshawk no relation was found between the number of fledglings and the bird availability index ($r = -0.161$, $p = 0.76$, $n = 6$).

The mean number of fledglings per breeding pair in both raptors were correlated from one year to the next ($r = 0.892$, $p = 0.017$, $n = 6$). However, weather conditions did not affect the productivity of either species to any significant extent: neither precipitation, nor temperatures during the breeding season, nor both factors taken together were correlated with the number of fledglings — in all cases $p > 0.05$. Moreover, diet overlap in particular years was negatively correlated with the number of fledglings ($r = -0.916$, $p = 0.01$, $n = 6$, and $r = -0.909$, $p = 0.012$, $n = 6$ for Goshawks and Buzzards respectively, Table 5).

DISCUSSION

The differences in Buzzard and Goshawk clutch sizes in the study area are in agreement with the figures given in the literature. Nevertheless, the Goshawk's mean clutch size there is one of the highest recorded anywhere in this species' range (Fisher 1980, Cramp 1982, Olech 1998). The fact that replacement clutches could be laid in the study area is probably due to a certain flexibility in the Goshawk's reproductive cycle and to the abundance of food (pigeons) there.

The literature mentions a diversity of factors possibly affecting the extent of brood losses in the two species, for example, persecution by humans, weather conditions, and nest construction techniques (Moeckel & Dietmar 1987, Kostrzewa & Kostrzewa 1990, Drazny & Adamski 1996, Austin & Houston 1997, Tornberg 1997, Kostrzewa et al. 2000). In the Rogów area nestling survival was similar in both species throughout the study period. However, losses were considerable during the incubation stage and during the first two weeks after hatching. It would appear, however, that the distribution of factors causing mortality in the two species is different. Some data suggest that losses in the Goshawk population are due largely to human pressure, whereas in the Buzzard important factors include predation and nest collapse.

It is well known that the breeding performance of many raptors can fluctuate widely in response to changes in the availability of food resources (Mebs 1964, Cramp 1982, Tornberg & Sulkava 1991, Sulkava et al. 1994, Selås 1997 et al.). In the study area both the clutch size and the number of fledglings in the Buzzard population are strongly dependent on the abundance of food in any given season. The small clutches of 2 eggs laid in some years were a response to the dearth of rodents in those years. The lack of any correlation between the prey availability index and breeding performance in the Goshawk found in the present study, and the fact that the seasonal variability in productivity in this species was lower than in the Buzzard (Goszczyński 1997), appear to indicate that food resources were stable in successive years. Studies conducted in the Kampinos National Park (Olech 1997) showed that the food resources available to the Goshawk were stable over an even longer period (30 years). In both locations pigeons were the staple diet of the Goshawk, and their constant availability could well have been the reason why clutch sizes and the numbers of fledglings varied so little over many years.

Despite there not being any dependence between the mean clutch sizes in the Goshawk and the Buzzard from year to year, distinct parallels in the productivity of the two species were perceived which had previously come to light during quite a long period (Goszczyński 1997). The possibility that the weather could affect the number of fledglings in the two species was unfounded. What could indeed have affected the number of fledglings, however, appears to have been interference competition between pairs of the two species, a factor which Kostrzewa (1991) drew attention to. In his view, Goshawks restricted the breeding success of Buzzards, the more so, the shorter the distance between the nests of the two species. However, in the Rogów area, in years of rodent scarcity, the Buzzard altered its diet to feed more often on birds, which increased the diet overlap of the two species. The Buzzard's disturbing or catching prey species that are normally the Goshawk's principle food resources may well have reduced the final breeding success in both raptors.

English translation by Peter Senn

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STRESZCZENIE

[Parametry rozrodu jastrzębia i myszołowa zwyczajnego w okolicach Rogowa, Wysoczyzna Rawska]

Badania przeprowadzono w latach 1982–1987 w okolicach Rogowa. Na tym terenie rozproszone i niewielkie lasy rozmieszczone są wśród pól, sadów i zabudowy wiejskiej (Goszczyński i Piłatowski 1976 i Goszczyński 1997).

Obydwa badane gatunki gnieździły się przede wszystkim na sosnach, które dominują w drzewostanie badanego terenu. Jednak myszołów, znacznie częściej niż jastrząb wybierał sosny jako drzewa gniazdowe (Tab. 1). Jastrząb był bardziej plastyczny w wyborze drzew na gniazdo i intensywniej wykorzystywał różne ich gatunki, np. modrzewie. Badania potwierdziły (Tab. 2) znany fakt przewagi wielkości zniesienia jastrzębia nad myszołowem. Nie odnotowano istotnych różnic w terminach klucia się piskląt (Tab. 3). Stwierdzono jednak, że jastrzębie tracące zniesienie we wczesnym etapie inkubacji zdolne są do jego powtórzenia, a myszołowy nie przystępowały do następnego lęgu.

Wydajność lęgów określono stosunkiem liczby odchowanych młodych do wielkości zniesienia. U myszołowa stwierdzono wyższą efektywność większych (3 i 4 jajowych) zniesień, a w przypadku jastrzębia nie było istotnych statystycznie różnic (Tab. 4). U myszołowa zarówno średnia wielkość lęgu jak i liczba odchowanych młodych w przeliczeniu na parę gniazdową różniły się istotnie między sezonami, podczas gdy u jastrzębia różnice były nieistotne. Może to wskazywać na lepsze i bardziej stabilne warunki pokarmowe dla jastrzębia niż dla myszołowa. W okolicach Rogowa, gdzie hodowla gołębi jest szeroko rozpowszechniona, właśnie one są podstawą pokarmu jastrzębia (Goszczyński 1997). Natomiast drobne gryzonie stanowiące ważną część pożywienia myszołowów, wykazują na badanym terenie wieloletnie fluktuacje liczebności.

Śmiertelność w gniazdach, określana stosunkiem średniej liczby odchowanych młodych w stosunku do średniej wielkości zniesienia, była podobna u obu gatunków (Fig 1) i wynosiła 38% (myszołów) i 42% (jastrząb) (rys. 1). Niszczenie gniazd przez ludzi i prace leśne w okolicy gniazd były najczęstszą przyczyną strat lęgów u jastrzębia a drapieżnictwo i upadki gniazd przeważały u myszołowa.

Związek między badanymi parametrami rozrodu a dostępnością pokarmu określano przeliczając liczbę ofiar znajdowanych w gniazdach na 1 kontrolę. W przypadku myszołowa brano pod uwagę drobne gryzonie a w przypadku jastrzębia ptaki-ofiary znajdowane w ich gniazdach. U myszołowa liczba odchowanych piskląt była skorelowana ze wskaźnikiem obfitości pokarmu, a u jastrzębia korelacja ta nie była istotna statystycznie (Tab. 5).

Brak było związków między wielkością zniesienia jastrzębia i myszołowa w poszczególnych sezonach, podczas gdy zależność między liczbą wyprowadzonych młodych u obu gatunków była istotna. Liczba odchowanych młodych w poszczególnych sezonach gniazdowych u obu gatunków była ujemnie skorelowana ze stopniem nakładania się ich nisz pokarmowych (Tab. 5). Może to wskazywać na antagonistyczne interakcje między parami obu gatunków.

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