ACTA ORNITHOLOGICA
Vol. 33 (1998) No. 3–4

Dorota ZAWADZKA, Jerzy ZAWADZKI

The Goshawk *Accipiter gentilis* in Wigry National Park (NE Poland) — numbers, breeding results, diet composition and prey selection

Zawadzka D., Zawadzki J. 1998. The Goshawk *Accipiter gentilis* in Wigry National Park (NE Poland) — numbers, breeding results, diet composition and prey selection. Acta orn. 33: 181–190.

Abstract. The population of Goshawks in Wigry National Park was studied in the years 1989–97. The number of breeding pairs nesting was in the range 8–11, giving a density of 6.0–7.3 (mean 6.7) per 100 km^2, or 8.0–11.0 (mean 9.5) per 100 km^2 of forest area. 69% of broods were successful, mean clutch size was 3.1 and the production of young was at 2.7 per successful pair or 1.9 per pair overall. Food taken in the breeding season was studied by collecting pellets and prey remains from nests and the ground beneath. Prey were identified from fragments of feathers, fur or bones, and food biomass estimated by multiplying the number of prey items of a given species by a mean mass. 1539 prey items with a total biomass of 332 kg were identified. Birds accounted for 94% of prey in terms of number of items and 92% in terms of biomass. The most frequent prey species were Jays *Garrulus glandarius* (19% of prey items), pigeons *Columba* spp. (18%), thrushes *Turdus* spp. (14%) and woodpeckers *Picidae* (6%). The greatest shares of biomass were taken by pigeons — 35%, Jays — 16%, hens — 15%, field corvids — 5% and hares *Lepus* sp. — 4%. The most significant influences on the diet composition of a given pair were distances from the forest edge and from villages. Birds nesting in the forest interior took less advantage of Feral Pigeons and hens as prey. An avifaunal count using a combined-variant cartographic method was followed by the use of Ivlev's selectivity index to assess the predation pressure exerted by Goshawks on wild species of bird. This revealed greatest selective preferences towards Jays, field corvids, woodpeckers and thrushes as prey.

Key words: breeding results, density, Goshawk *Accipiter gentilis*, prey selection, diet composition

ul. 25 Czerwca 68 b/15. 26-600 Radom, POLAND

Received — March 1998, accepted — Nov. 1998

INTRODUCTION

The Goshawk is one of Poland's most abundant birds of prey, which has enjoyed species protection since 1976. It nests throughout the country, reaching densities of between 2 and 16.3 pairs per 100 km^2 (respectively in Poznań province — Pielowski 1991, and in Rogów, Central Poland — Goszczyński 1997). Various types of forest are inhabited, and the species is relatively numerous in both fragmented stands among fields (Goszczyński 1997) and large forest complexes (Olech 1991, Pugacewicz 1996). The density of the Polish population varies little (Pugacewicz 1996, Drazny & Adamski 1996, Goszczyński 1997), unlike those in Scandinavia, which fluctuate markedly with changes in the availability of prey (Selas 1997, Widen 1997).

The production of young achieved across Europe is relatively constant, at between 1.5 per breeding pair (e.g. Schneider *et al.* 1986) and 2.3 (e.g. Petty 1989). However, the composition of the diet varies considerably through the European range, with major prey species being Black Grouses *Tetrao tetrix* and Capercaillies *T. urogallus* in Scandinavia (Widen 1987, Tornberg & Sulkava 1990, Tornberg 1997); pigeons, thrushes and corvids in Germany (Bezzel *et al.* 1997); and Red-legged Partridges *Alectoris rufa*, Rabbits *Oryctolagus cuniculus* and Woodpigeons *Columba palumbus* in Iberia (Manosa 1994). The share of particular groups of prey in the diet

also varies from region to region within Poland: Feral Pigeons *Columba livia f. urbana*, hens and Jays *Garrulus glandarius* have all been identified as most important prey species (Goszczyński & Piłatowski 1986, Drazny & Adamski 1996, Jędrzejewska & Jędrzejewski 1998).

STUDY AREA

Located at 53°58'–54°10'N, 23°00'–23°15'E, within the Suwałki-Augustów Lakeland of NE Poland, 15.085 ha Wigry National Park (WNP) includes the part of the extensive Augustów Forest surrounding Lake Wigry — one of the country's largest lakes — as well as the lake itself. Forests account for 63% of the Park (9946 ha), lakes for 19% (2907 ha) and non-forest open areas for 15% (2229 ha). There are about 25 villages within the Park boundaries. 82% of the forest is of Scots pine *Pinus sylvestris*, 12% of Norway spruce *Picea abies*, 3% of black alder *Alnus glutinosa*, 2% of the birch *Betula verrucosa* and 1% of pedunculate oak *Quercus robur*. Young forests and plantations account for 26% of the forest area, and stands more than 80 years old for 22%.

METHODS

The work centred on two forest areas; plot I of 46 km^2 to the NW of Lake Wigry, studied between 1989 and 1993; and plot II of 50 km^2 to the SE where research was continued in the years 1995–1997. Certain nests in area I were also checked in the latter period. Goshawks were assumed to occupy the total number of home ranges recorded in the whole period in both areas, as these were in two separate forest complexes separated by the extensive (2187 ha) Lake Wigry (Fig. 1), and as the majority of breeding home ranges in the two were occupied regularly.

A breeding home range was considered occupied if found to include an occupied nest; if characterized by the frequent presence of agitated birds; if pellets, the remains of prey, feathers or faeces were found; or if fledged young were heard.

Most checking was from the ground, though one or two ascents to nests were made in the cases of 26 broods. Pellets and the remains of prey (a total of 867 items) were collected from monitored nests or from nearby areas beneath. Data on diet derived from 9 home ranges, with food material collected between April and July in the years 1989–1992, and mainly in late May and June in the years 1993–1997. In the case of remains found in both pellets and food residues, double counting of prey items was avoided by assuming the lowest probable number of individuals eaten. The mean masses of prey items were taken from Goszczyński (1974) and Busse (1990).

The G-test for the homogeneity of percentages was used to assess differences in diet composition in relation to distance from a village, as well as to analyze the several-year variability in the compsotion of the diets of Goshawks from particular breeding home ranges (3 classes). The assumed null hypothesis was of 1:1:1 (Sokal & Rohlf 1981).

4–7 counts of the local avifauna were made using the combined variant of the cartographic method from Tomiałojć (1980), between April and July 1996, in 13 sample areas representative of the naturally-varied environment in the Park and covering a total of 208.9 ha. The constancy of composition of the bird community was estimated using the results of several earlier years of research on the WNP avifauna (Zawadzka & Zawadzki 1995). The pressure imposed by Goshawks on wild-living avian prey was assessed using Ivlev's selectivity index $D = (r - p)/(r + p - 2rp)$, where r is the percentage share of a given prey species in a predator's diet and p the percentage of individuals of that species in the bird community (Jacobs 1974). The index takes on values between –1 and 1 where the latter indicates a strong selective preference for a species on the part of the predator, the former active avoidance, and 0 the consumption of the given species in proportion to its abundance in the environment.

RESULTS

Distribution and abundance

Plot I of WNP had 4–6 occupied home ranges and plot II had 4–5 (Fig. 1, Tab. 1). A total of 8–11 pairs of Goshawk nested in the Park. The density was thus 6.0–7.3 (mean 6.7) per 100 km^2 of Park and 8.0–11.0 (mean 9.5) per 100 km^2 of forest. The distribution of nests tended towards even (Fig. 1), with the Nearest Neighbour Distance being 3689 ± 1192 m (maximum 5400,

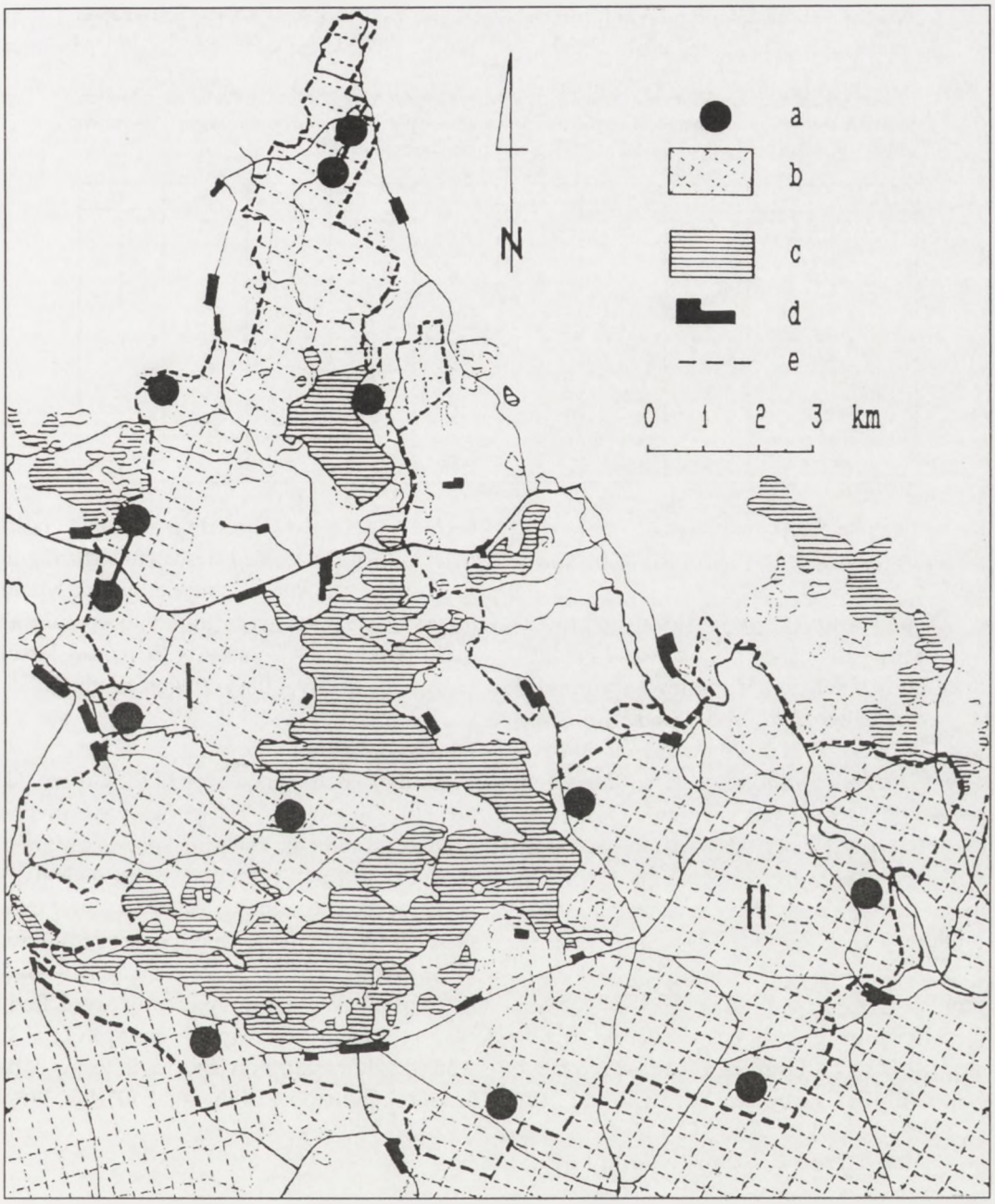

Fig. 1. Wigry National Park with home ranges (a) of Goshawks. b — forests, c — lakes, d — villages, e — borders of the WNP, I and II — study plots.

[Ryc. 1. Rewiry lęgowe jastrzębia (a) w Wigierskim Parku Narodowym. b — lasy, c — jeziora, d — osady, e — granica Parku, I i II — powierzchnie badawcze.]

minimum 1800). Different nests were at between 100 and 1400 m (mean 453 ± 407 m) of the forest edge, and 500–2800 m (mean 1160 ± 775 m) of a village.

Measured as circular field of radius equal to half NND, home ranges had a mean area of c. 1068 ha. On average, 62% of a home range was forest (range 30–95%, SD = 20.8%), 25% non-forest and open areas (0–45%, SD = 15.8%) and 13% lake (0–45%, SD = 13.3%).

Goshawks nested in 60–100 years old stands. In the study period, the birds in a given home range utilized 1–4 nests at distances of between 50 and 650 m of one another. An exceptional find in 1996 concerned a shift

Table 1. Checks on nest-occupancy in 11 home range of Goshawks in WNP (1989–97); + — nest occupied (nesting confirmed), – — nest not occupied, O — home range occupied (nesting probable), * — nest not checked.

[Tabela 1. Kontrole zajęcia gniazd jastrzębi w 11 rewirach lęgowych w Wigierskim Parku Narodowym w latach 1989–97; + — gniazdo zajęte (gniazdowanie pewne), – — gniazdo nie zajęte, O — rewir zajęty (gniazdowanie prawdopodobne), * — gniazdo nie kontrolowane.]

Plot	1989	'90	'91	'92	'93	'94	'95	'96	'97
I	O	+	–	+	+	*	*	*	*
I	+	+	+	–	–	*	*	*	*
I	+	+	+	+	+	+	O	+	+
I	+	-	+	–	+	*	*	+	+
I	+	+	+	+	–	*	+	+	*
I	+	+	*	+	+	*	*	*	*
II	*	*	O	O	*	*	+	O	*
II	*	*	O	*	*	*	+	-	+
II	*	*	*	*	*	*	+	+	+
II	*	*	*	*	*	*	+	+	+
II	*	*	*	*	*	*	*	+	+

of c. 1800 m in the place a particular pair bred. This reflected the felling of the stand around the previous breeding site.

19 of the 23 nests found were in Norway spruces, with single other nests in Scots pines, oaks and birches. Nests were built near the trunk, in the lower or middle parts of the crown between 12 and 28.5 m from the ground (mean 20.8 ± 3.7 m). Fifteen nests were in trees in the immediate vicinity of a road or gap in the stand (area of limited tree cover, not clearing). Goshawks were not found to use the old nests of other raptors, though their own nests were occupied by Common Buzzards *Buteo buteo*, Lesser Spotted Eagles *Aquila pomarina* and Hobbies *Falco subbuteo*.

Reproduction

Data on 26 Goshawk broods were collected. Mean breeding success was 69% (Tab. 2). Clutch size varied from 2–4 eggs, with 58% of broods having 3 and 21% each 2 or 4. Of the 6 breeding attempts ending in complete failure, 5 involved destruction during incubation. In 3 cases, eggs were destroyed by Pine Martens *Martes martes*. Two nests were found to contain abandoned eggs. Among the 7 cases with partial losses, five involved the death of the youngest nestling.

Diet composition

Birds were the main prey of the Goshawks in Wigry NP (Tab. 3). At least 53 species were involved, along with 8 of mammal. The prey species caught most often were Jays (19% of prey items) and pigeons (18%, with Feral Pigeons accounting for 10%). Other frequent prey were thrushes (10%), woodpeckers (6%) and corvids other than Jays (4%). 3% of prey items were hens. The mammals taken most frequently were Red Squirrels *Sciurus vulgaris* and hares *Lepus* sp. (Tab. 3). Pigeons were the dominant prey species in terms of biomass — accounting for 35% of the total. Of this, 19% consisted

Table 2. Breeding results of Goshawks in the study area.

[Tabela 2. Wyniki lęgów jastrzębia na badanym terenie]

	1989	'90	'91	'92	'95	'96	Overall/mean (CV%)
No.of broods	5	5	4	4	4	4	26
Clutch size	3.2	3.3	2.8	3.0	3.0	3.3	3.1 ± 0.20 (6%)
Broods with losses	1	–	2	–	1	2	6
Broods with partial losses	4	3	–	–	1	–	7
Successful broods	4	5	2	4	1	2	18 (69%)
Production of young per successful pair	2.3	2.5	3.5	2.3	2.0	3.5	2.7 ± 0.65 (24%)
Production of young per breeding par	1.8	2.5	1.8	2.3	1.0	1.8	1.9 ± 0.52 (28%)

Table 3. Diet composition of Goshawks in WNP in the breeding seasons of 1989–97; + — share below 0.1%.

[Tabela 3. Skład pokarmu jastrzębia w WPN w sezonach lęgowych 1989–97; + — udział poniżej 0.1%.]

Species (Individual biomass — g)	Items		Biomass
	N	%	%
1	2	3	4
Podiceps sp. (700)	1	0.1	0.2
Anas platyrhynchos (800)	4	0.3	1.0
Anas sp. (700)	5	0.3	1.1
Pernis apivorus (700)	1	0.1	0.2
Accipiter nisus (250)	4	0.3	0.3
Bonasa bonasia (420)	16	1.0	2.0
Perdix perdix (400)	7	0.4	0.8
Domestic hen (1000)	51	3.3	15.3
Fulica atra (600)	1	0.1	0.2
Vanellus vanellus (150)	14	0.9	0.7
Scolopax rusticola (300)	2	0.1	0.2
Gallinago gallinago (100)	4	0.3	0.1
Larus ridibundus (275)	16	1.0	1.3
Larus sp. (250)	7	0.4	0.5
Domestic pigeon (420)	146	9.5	18.5
Columba oenas (300)	1	0.1	0.1
Columba palumbus (475)	18	1.2	2.6
Columba sp. (450)	105	6.8	14.2
Cuculus canorus (100)	3	0.2	0.1
Strix aluco (400)	1	0.1	0.1
Asio otus (300)	5	0.3	0.5
Caprimulgus europaeus (70)	2	0.1	+
Alcedo atthis (30)	1	0.1	+
Dryocopus martius (300)	1	0.1	0.1
Dendrocopos major (70)	69	4.5	1.5
Dendrocopos minor (20)	7	0.4	+
Dendrocopos sp. (40)	15	0.9	0.2
Alauda arvensis (35)	6	0.4	0.1
Hirundo rustica (18)	1	0.1	+
T. troglodytes (10)	1	0.1	+
Ph. phoenicurus (20)	1	0.1	+
Turdus merula (70)	19	1.2	0.4
Turdus pilaris (70)	3	0.2	0.1
Turdus philomelos (50)	56	3.6	0.8
Turdus viscivorus (80)	4	0.3	0.1
Turdus sp. (60)	78	5.1	1.5
Regulus regulus (5)	1	0.1	+
Parus major (20)	6	0.4	0.1
Parus caeruleus (10)	1	0.1	+
Parus ater (10)	1	0.1	+
Parus sp. (15)	3	0.2	+
Garrulus glandarius (175)	294	11.2	15.5
N. caryocatactes (200)	5	0.3	0.3
Pica pica (200)	36	2.3	2.1
Corvus monedula (200)	13	0.8	0.8
Corvus frugilegus (450)	16	1.0	2.2
Corvus corax (1100)	1	0.1	0.3
Sturnus vulgaris (80)	14	0.9	0.3
Fringilla coelebs (20)	10	0.6	0.1
Carduelis spinus (13)	1	0.1	+
Pyrrhula pyrrhula (25)	7	0.4	0.1
C. coccothraustes (55)	5	0.3	0.1
Emberiza citrinella (30)	3	0.2	+
Large birds (450)	14	0.9	1.9
Medium-sized birds (60)	138	8.9	2.5
Small birds (20)	206	13.4	1.2
Birds total	1451	94.3	92.3
Talpa europaea (80)	1	0.1	+
Lepus sp. (1000)	14	0.9	4.3
Sciurus vulgaris (300)	18	1.2	1.5
Ondatra zibethicus (700)	3	0.2	0.6
Arvicola terrestris (80)	2	0.1	+
Clethrionomys glareolus (20)	4	0.3	+
Microtus oeconomus (42)	1	0.1	+
Microtus sp. (32)	4	0.3	+
Rattus norvegicus (250)	2	0.1	0.2
Rodents (80)	6	0.4	0.1
Small rodents (275)	11	0.7	0.1
Mammals (100)	7	0.4	0.4
Small mammals (50)	8	0.5	0.1
Medium-sized mammals (200)	6	0.4	0.4
Mammals total	87	5.7	7.7
Total	1539	100%	100%

of Feral Pigeons. As much as 14% of the food biomass was of pigeons not identified to the species level, though Feral Pigeons probably predominated. Jays accounted for 16% of total prey biomass and hens for 15%. Field corvids accounted for 5% of the diet by mass, thrushes for only 4% and woodpeckers for 2%. Mammals together represented 8% of prey biomass, with hares accounting for 4% and squirrels 2% (Tab. 3).

Adult birds predominated among prey, with the proportions of young birds ranging from 6% in the case of hens to 41% for Jays. 7% of the Lapwings *Vanellus vanellus* taken were newly-fledged, along with 11% of the Magpies *Pica pica*, 16% of the Song Thrushes *Turdus philomelos* and 29% of the Great Spotted Woodpeckers *Dendrocopos major*.

The mean mass of prey specimens was 215 g, while items weighing more than 40 g accounted for 83% of individuals and 99% of biomass (Fig. 2). Study of the several-year variability in diet composition involved material from 3 home ranges analyzed over 3, 4 and 6 years. The shares in the diet of prey from farmland and forest areas were constant in each case (Tab. 4). Food taken in each home range each year included the most frequent prey specimens (i.e. pigeons, Jays, thrushes, woodpeckers and field corvids), though given birds did vary slightly from year to year in the levels of consumption of different prey species. The greatest variability characterized the diet in the home range studied for 4 years, with the shares taken by prey of 6 of the 9 analyzed groups differing from one year to the next.

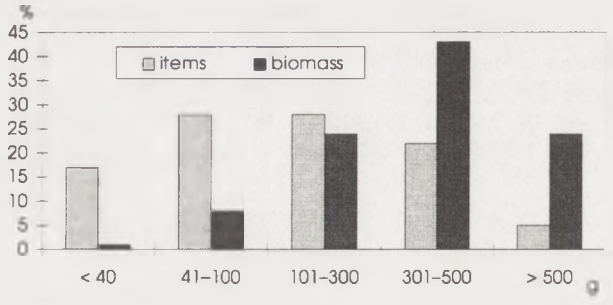

Fig. 2. Frequency distribution of prey specimens of various body masses identified in the diet of Goshawks in Wigry National Park.

[Ryc. 2. Procentowy udział ofiar w zależności od masy ciała w pokarmie jastrzębia w Wigierskim Parku Narodowym.]

The greatest constancy of diet composition was noted for the home range studied over 6 years.

Dependence of diet on habitat

There were differences in the proportions of prey taken by Goshawks from forest, farmland and aquatic biotopes (Tab. 5). This variability in the share and biomass of the main groups of prey was analyzed in relation to the diets of Goshawks occupying home ranges with 30–50, 50–70 or >70% forest cover. No significant differences were found, and nor were there any significant correlations between the share of forest species in the diet and the forest cover of the home range. However, the abundance of prey from open areas was correlated with percentages of farmland land in home ranges ($r = 0.68$, $p = 0.045$, $n = 9$), while the link with biomass approached significance ($r = 0.66$, $p = 0.055$, $n = 9$).

Table 5. Percentage shares of prey specimens from forest (f), open areas (nf) and water habitats (w) in the diets of Goshawks from home ranges differing in level of forest cover (%F).

[Tabela 5. Procentowy udział zdobyczy z powierzchni leśnej (f), nieleśnych terenów otwartych (nf) i powierzchni wodnej (w) w pokarmie jastrzębia z rewirów lęgowych o różnym stopniu lesistości (%F).]

	%F	Percentage of prey		
		f	nf	w
	55	65	35	–
	50	47	45	8
	30	52	43	5
	40	72	28	–
	65	49	50	1
	80	68	17	15
	60	62	36	2
	80	60	40	–
	95	93	7	–
Mean	62	64	33	3

Distances of nests from the forest edge exerted a much greater influence on diet composition. There was a highly-significant correlation between the frequency of prey specimens caught in forest and the distance of the nest from the forest edge ($r = 0.84$, $p = 0.005$, $n = 9$). The biomass of forest prey was also correlated with this distance ($r = 0.78$, $p = 0.013$, $n = 9$). The distances of nests from a village were inversely correlated with both the frequency of prey from open areas ($r = -0.87$, $p = 0.002$, $n = 9$) and the biomass of food taken from agricultural biotopes ($r = -0.79$, $p = 0.01$, $n = 9$).

Goshawks with nests at greater distances from a village caught fewer pigeons on average, and more gulls *Larus* spp. and hares. Distance from a village had no influence on the frequency with which hens

Table 4. Several-year variability (G-test) in the shares of the main prey categories from three home ranges of Goshawks: studied for 3 years (df = 2), 4 years (df = 3), 6 years (df = 5).

[Tabela 4. Kilkuletnia zmienność udziału głównych ofiar w składzie pokarmu pochodzącego z trzech rewirów lęgowych: badanego przez 3 lata, 4 lata i 6 lat.]

Prey	3 years		4 years		6 years	
	G-test df = 2	(p)	G-test df = 3	(p)	G-test df = 5	(p)
Hens	6.59	(< 0.05)	11.21	(< 0.02)	6.77	(NS)
Columba spp.	5.31	(NS)	12.95	(< 0.01)	16.54	(< 0.01)
Picidae	2.91	(NS)	11.32	(< 0.02)	13.34	(< 0.05)
Turdus spp.	10. 97	(< 0.005)	14.13	(< 0.01)	6.77	(NS)
G.glandarius	13.10	(< 0.005)	12.07	(< 0.01)	8.72	(NS)
Corvidae	6.95	(< 0.05)	13.79	(< 0.01)	5.31	(NS)
Lepus spp.	5.82	(NS)	4.49	(NS)	–	
Larus spp.	2.82	(NS)	–		16.97	(< 0.01)
Forest species	1.07	(NS)	5.29	(NS)	6.12	(NS)
Non-Forest species	2.28	(NS)	5.40	(NS)	6.27	(NS)

were taken (Tab. 6). Similarly, there were no significant differences in the roles played by *Picidae*, *Turdus* spp., *Garrulus glandarius*, *Corvidae* and *Sciurus vulgaris* in the diets of pairs nesting at different distances from a village, though the shares of non-forest species were higher for pairs nesting nearer to the forest edge (Tab. 6).

All other groups of birds appeared less frequently in the diet than would be expected in line with their abundance in forest or open habitats. They were little more than chance prey of the Goshawks, which clearly avoided taking bird species weighing less than 20 g (Fig. 2).

Table 6. Frequency of main prey groups in the diet of Goshawks in relation to distances (km) of nests from villages.

[Tabela 6. Udział (%) głównych grup ofiar w diecie jastrzębia w zależności od odległości (km) gniazda od wsi.]

Prey	2.0–2.8 km (%)	0.9–1.2 km (%)	0.5–0.7 km (%)	G-test df = 2	p
Hen	1	4	3	1.99	NS
Columba spp.	9	14	25	8.22	< 0.025
Picidae	6	7	4	0.86	NS
Turdus spp.	15	12	6	4.12	NS
Garrulus glandarius	15	17	24	2.32	NS
Corvidae	3	5	3	0.70	NS
Larus spp.	6	1	0	9.64	< 0.01
Lepus spp.	4	0	0	8.79	< 0.025
Sciurus vulgaris	4	1	1	2.77	NS
Forest species	74	59	52	4.04	NS
Non-Forest species	26	41	48	6.90	< 0.05

Prey selection

Counts in sample areas of WNP revealed that small birds (of up to 10–20 g) were most abundant (authors' data). Dominants were Chaffinches *Fringilla coelebs*, Coal Tits *Parus ater* and Chiffchaffs *Phylloscopus trochilus* in forests; Sky Larks *Alauda arvensis*, scrub warblers *Sylvia* spp., swallows and martins *Hirundinidae* and sparrows *Passer* spp. in non-forest areas; and *Acrocephalus* spp. at the water's edge. However, most of the prey items taken by Goshawks were of the species of greater body size only present at relatively low densities.

Ivlev's selectivity index was applied to describe the predation preferences shown (Tab. 7). Pigeons and hens were excluded from this analysis, as it was difficult to determine their real abundance. From among the remaining species, a preference was shown for 6 groups. The most intense predation pressure was exerted on Jays, with strong selective preferences also being shown towards woodpeckers, thrushes, Hazel Grouse *Bonasa bonasia*, Hawfinches *Coccothraustes coccothraustes* and pigeons (Tab. 7). Among the prey species from agricultural areas, corvids were subject to a strong selection preference (D = 0.96). The masses of the prey preferred most strongly ranged from 60–450 g.

Table 7. Selection of bird species captured by Goshawks from the available avian community in WNP. %b — percentage share in bird community, %p — percentage share of prey, *D* — Ivlev's selectivity index.

[Tabela 7. Selekcja przez jastrzębia ptaków z zespołu w Wigierskim Parku Narodowym. %b — udział ptaków w zespole, %p — udział w pokarmie jastrzębia, *D* — wskaźnik selekcji Ivleva.]

	Selection by Goshawk		
Species	%b	%p	*D*
Fringilla coelebs	22.4	1.6	–0.89
Paridae	14.3	1.7	–0.81
Phylloscopus spp.	11.9	–	–1
Regulus regulus	5.2	0.2	–0.93
Turdus spp.	4.7	25.0	0.74
Anthus trivialis	3.6	–	–1
Pyrrhula pyrrhula	3.3	1.1	–0.51
Erithacus rubecula	3.2	–	–1
Troglodytes troglodytes	3.1	0.2	–0.88
Picidae	2.3	14.4	0.75
Garrulus glandarius	1.7	45.9	0.96
Columbidae	1.6	3.0	0.31
Accipitridae	1.3	0.8	–0.25
Bonasa bonasia	0.7	2.5	0.57
C. coccothraustes	0.3	0.8	0.46
Other species	20.4	2.8	
Total N (%)	100%	641(100%)	

DISCUSSION

Goshawk densities vary markedly from one study area in Poland to another. They are lowest (up to 2 pairs per 100 km^2) in agricultural landscape with limited forest cover (Pielowski 1991, Chmielewski *et al.* 1996). The figure of 6.9 pairs per 100 km^2 obtained here for Wigry NP is similar to the 7.4 noted in the Wrocław area with its 23% forest cover (Drazny & Adamski 1996), and the 7.6 recorded by Sosnowski (1991) in the Spała Forest of Central Poland where forest cover is 65%. Much higher densities of 14–16 pairs/100km^2 have been noted in Kampinoski National Park (Olech 1991), the Niepolomice Forest (Czuchnowski 1993) and the Rogów area (Goszczyński 1997).

Previous studies reveal breeding success for Polish Goshawks in the range 67–75% (Pielowski 1991, Drazny & Adamski 1996, Pugacewicz 1996, Goszczyński 1997). The 69% recorded here for WNP may be a slight overestimation, on account of the lateness with which checks on broods were made: the possibility that single broods ending in losses during incubation were omitted from calculations cannot be excluded.

Total breeding losses among Goshawks are induced by predators (mainly Pine Martens and Ravens *Corvus corax*), by people, by forestry work or by unfavourable atmospheric conditions (Moeckel & Guenther 1987, Olech 1991, Drazny & Adamski 1996, Goszczyński 1997). In Scandinavia, the greatest losses occcur in the first few days after hatching (Tornberg 1997), while in WNP they nearly all occurred in the course of incubation. It is thus probable that the level of breeding success in the study area is most influenced by predation, with the availability of food resources not constituting a limiting factor.

The recorded shares of birds in the diet of the Goshawks were 72–95% in terms of individuals and 85–95% in terms of biomass. There was a prevalence of one or several most important groups of prey which were taken in large numbers. The average list included c. 50–80 animal species, among which only a very few were utilized frequently. The most abundant prey specimens weighed more than 50 g. The mean mass of prey items noted elsewhere in Poland varied from the 307 g (Goszczyński & Piłatowski 1986) in Rogów, through 260 g in Kampinoski NP (Olech 1997), 215 g in Wigry NP (this study) to only 69–75 g in the Białowieża Primaeval Forest (Jędrzejewska & Jędrzejewski 1998).

As at WNP, the diet composition of Goshawks elsewhere in Poland seems to vary little from year to year (Goszczyński & Piłatowski 1986, Manosa 1994, Tornberg 1997). This is first and foremost a consequence of the constant availability of the main prey species.

The composition of the diets of Goshawks has been shown to change in relation to the position of the nest vis-a-vis the forest edge (Goszczyński 1985, Jędrzejewska & Jędrzejewski 1998). Likewise, at WNP, diets were most influenced by this factor, as well as by distances from the nearest village. The birds studied made greater use of forest in hunting than did those in Kampinoski NP or the Rogów area. The share of forest species in their diets was much greater than in Central Poland (Goszczyński & Piłatowski 1986, Olech 1997), but lower than in the Białowieża Primaeval Forest (Jędrzejewska & Jędrzejewski 1998).

Translated by dr James Richards

REFERENCES

Bezzel E., Rust R., Kechele W. 1997. Nahrungswahl suedbayerischer Habichte *Accipiter gentilis* waehrend der Brutzeit. Orn. Anz. 36: 19–30.

Busse P. (ed.) 1990. Mały słownik zoologiczny. Ptaki. t. 1–2. Wiedza Powszechna.

Chmielewski S., Dombrowski A., Kot H., Rzępała M. 1996. [Numbers of birds of prey in the agricultural landscape of the region of Mazowsze and southern Podlasie.] Not. orn. 37: 39–53.

Czuchnowski R. 1993. [Birds of prey in the Niepołomicka Forest during 1987–1990.] Not. orn. 34: 313–318.

Drazny T., Adamski A. 1996. The number, reproduction and food of Goshawk *Accipiter gentilis* in Central Silesia (SW Poland). In: Populationsoecologie von Greifvoegel und Eulenarten. 3. Halle.

Goszczyński J. 1974. Studies on the food of foxes. Acta theriol. 21: 527–534.

Goszczyński J. 1985. [The effect of structural differentiation of ecological lanscape on the predator-prey interaction.] Wyd. SGGW-AR 46: 1–80.

Goszczyński J. 1997. Density and productivity of Common Buzzard and Goshawk populations in Rogów, Central Poland. Acta orn. 32: 149–155.

Goszczyński J., Piłatowski T. 1986. Diet of common buzzards (*Buteo buteo* L.) and goshawks (*Accipiter gentilis* L.). Ecol. pol. 34: 655–667.

Jacobs J. 1974. Quantitative measurements of food selection; a modification of the forage ratio and Ivlev's selectivity index. Oecologia 14: 27–36.

Jędrzejewska B., Jędrzejewski W. 1998. Predation in vertebrate communities. The Białowieża Primaeval Forest as a case study. Springer Verlag. Berlin, Heidelberg,, New York

Manosa S. 1994. Goshawk diet in a mediterranean area of Northeastern Spain. J. Raptor Res. 28: 84–92.
Moeckel R., Guenther D. 1987. Die Reproductionsrate des Habichts *Accipiter gentilis* (L.) im Westerzgebirge in den Jahren 1974–1983. Populationsoekologie Greifvoegel und Eulenarten 1: 217–232.
Olech B. 1991. [Protection of birds of prey in Kampinoski National Park. Status and recommendations.] Ochr. Przyr. 49: 65–79.
Olech B. 1997. Diet in the Goshawk *Accipiter gentilis* in Kampinoski National Park (Central Poland) in 1982–1993. Acta orn. 32: 191–200.
Petty S. J. 1989. Goshawsks: Their Status, Requirements and Management. Forestry Commission Biulletin 81: 1–18.
Pielowski Z. 1991. [The population and breeding success of predatory birds on farmland near Czempin (western Poland).] Acta orn. 26: 107–118.
Pugacewicz E. 1996. [Birds of prey breeding in the polish part of the Bialowieza primaeval forest.] Not. orn. 37: 173–224.
Schneider H., Gottman A., Wilke M. 1986. Ergebnisse langjaehriger Untersuchungen zur Bestandsenwicklung, Siedlungsdichte, Siedlungsweise und Brutbiologie des Habichts *Accipiter gentilis* auf drei Probeflaechen in Nordhessen. Voegelkundliche Hefte Edertal. 12: 15–28.
Selas V. 1997. Influence of prey availability on re-establishment of Goshawk *Accipiter gentilis* nesting territories. Orn. Fenn. 74: 113–120.
Sokal R. R., Rohlf F. J. 1981. Biometry. W. H. Freeman and Company. New York.
Sosnowski J. 1991. Fauna ptaków drapieznych Puszczy Pilickiej. Wyd. Muzeum Okręgowe. Tomaszów Mazowiecki.
Tomialojc L. 1980. [The combined version of the mapping method.] Not. orn. 21: 33–54.
Tornberg R. 1997. Prey selection of the Goshawk *Accipiter gentilis* during the breeding season: The role of prey profitability and vulnerability. Orn. Fenn. 74: 15–28.
Tornberg R., Sulkava S. 1990. [The effect of fluctuations in tetraonid populations on the nutrition and breeding success of the goshawk in Oulu district in 1965–88.] Suomen Riista 36: 53–61.
Widen P. 1987. Goshawk predation during winter, spring and summer in a boreal forest area of central Sweden. Holarctic Ecology 8: 273–279.
Widen P. 1997. How, and why, is the Goshawk (*Accipiter gentilis*) affected by modern forest management in Fennoscandia? J. Raptor Res. 31: 107–113.
Zawadzka D., Zawadzki J. 1995. [Preliminary characteristics of the Lake Wigry National Park avifauna.] Not. orn. 36: 297–310.

STRESZCZENIE

[Jastrząb w Wigierskim Parku Narodowym — liczebność, wyniki lęgów, skład pokarmu i selekcja ofiar]

Badania prowadzono w latach 1989–97. WPN, obejmujący zachodnią część Puszczy Augustowskiej wokół jeziora Wigry, zajmuje obszar ca 150 km^2. Lasy pokrywają 63% powierzchni Parku, jeziora — 19% i tereny rolnicze — 15%. W lasach dominuje sosna pospolita (82% powierzchni). Drzewostany w wieku powyżej 80 lat zajmują 22% powierzchni leśnej.

W latach 1989–93 prowadzono badania na I powierzchni (ok. 46 km^2), a od 1995 — na II powierzchni (ok. 50 km^2). Obserwacji lęgów dokonywano z ziemi. W celu oceny parametrów rozrodu 26 lęgów kontrolowano przez 1–2 krotne wchodzenie do gniazd. W gniazdach oraz w ich sąsiedztwie na ziemi zbierano wypluwki i resztki zjedzonych ofiar. Skład pokarmu oznaczano ilościowo, identyfikując spożyte ofiary na podstawie znalezionych piór, kości i sierści. Oszacowaną liczbę spożytych ofiar mnożono przez średnia masę osobniczą danego gatunku zdobyczy. Dane o pokarmie pochodziły z 9 rewirów lęgowych. Zebrano łącznie 867 wypluwek i resztek ofiar. Zidentyfikowano 1539 ofiar jastrzębia o łącznej biomasie 332 kg. Przeprowadzono liczenia awifauny kombinowaną odmianą metody kartograficznej wykonując 4–7 liczeń na 13 powierzchniach próbnych. Określano procentowy udział poszczególnych gatunków ptaków w zespole i porównano z frekwencją w diecie jastrzębia, przy zastosowaniu wskaźnika selekcji Ivleva.

Na terenie badań stwierdzono 4–6 par lęgowych na I powierzchni i 4–5 na II powierzchni badawczej (tab.1), łącznie 8–11 par. Zagęszczenie wynosiło 6,0–7,3, średnio 6,7 par/100 km^2 powierzchni ogólnej i 8,0–11,0, średnio 9,5/100 km^2 powierzchni leśnej.

Jastrzębie gnieździły się najczęściej na świerkach, w drzewostanach ponad 60–letnich. Średnia odległość między gniazdami wynosiła 3689 ± 1192 m. Gniazda rozmieszczone były dosyć równomiernie (ryc. 1). Przeciętna wielkość rewiru lęgowego wynosiła około 1068 ha. Dla badanych 26 lęgów średnia wielkość zniesienia wynosiła 3,1 ± 0,20, produkcja młodych na parę z sukcesem –2,7 ± 0,65, a produkcja młodych na parę lęgową –1,9 ± 0,52. Sukcesem zakończyło się 69% lęgów (tab. 2). Łącznie 6 lęgów zakończyło się stratą, w tym 5 podczas wysiadywania. Najczęstszą przyczyną strat było drapieżnictwo kuny.

Ptaki stanowiły 94% ofiar i 92% biomasy pokarmu jastrzębia w Wigierskim Parku Narodowym (tab. 3). Do najczęściej chwytanych ofiar należała sójka (19%), gołębie (18%), drozdy (10%), dzięcioły (6%) oraz polne krukowate (4%). Najwyższy udział w biomasie pokarmu miały gołębie (35%), następnie sójki (16%) i kury domowe (15%) (tab. 3). Najważniejsze ofiary jastrzębia, których udział w diecie przekraczał 5%, czyli sójka,

gołębie, drozdy i dzięcioły, stanowiły łącznie 53% wszystkich ofiar i 56% biomasy pokarmu. Wśród oznaczonych ofiar dominowały osobniki dorosłe. Średnia masa ofiary jastrzębia wynosiła 215 g.

Jastrzębie najliczniej chwytały ofiary o masie z przedziału 40–100 g i 100–300 g (po 28% frekwencji) — ryc. 2. W ciągu kilku lat badań nie stwierdzono istotnych różnic w składzie pokarmu zbieranego w poszczególnych rewirach lęgowych (tab. 4). Udział w pokarmie ofiar polnych i leśnych był zróżnicowany w poszczególnych rewirach. Jastrzębie zdobywały średnio 63% ofiar w lesie, 33% — na polach i 3% — nad wodą (tab. 5). Nie stwierdzono zależności pomiędzy lesistością rewiru a udziałem ofiar leśnych w pokarmie. Na skład pokarmu jastrzębia istotnie wpływała odległość gniazda od brzegu lasu oraz od wsi. Stwierdzono wysoką korelację pomiędzy frekwencją ofiar łapanych w lesie a odległością gniazda od brzegu lasu ($r = 0{,}84$, $p = 0{,}005$, $n = 9$). Nie stwierdzono zależności pomiędzy odległością gniazda od wsi a częstością chwytania kur przez jastrzębie. Pary jastrzębia gnieżdżące się bliżej brzegu lasu miały jednak w pokarmie wyższy udział ofiar zdobywanych pod lasem (tab. 6).

Do dziko żyjących ofiar, najsilniej selekcjonowanych przez jastrzębia, należały ptaki leśne: sójka, dzięcioły, drozdy, a także jarząbek, grubodziób i dzikie gołębie (tab. 7). Spośród ptaków polnych jastrząb najchętniej polował na krukowate. Masa ofiar preferowanych przez jastrzębia wahała się od 60 do 450 g. Grupy ptaków o innej masie występowały w pokarmie jastrzębia rzadziej niż wynikałoby to z ich liczebności w środowisku. Jastrząb zdecydowanie unikał ptaków o masie poniżej 20 g (ryc. 2).

PODZIĘKOWANIE

Autorzy składają serdeczne podziękowania Panu Prof. dr hab. Jackowi Goszczyńskiemu za pomoc w ustaleniu metodyki badań oraz krytyczną ocenę pierwszej wersji maszynopisu. Pani dr hab. Bogumile Jędrzejewskiej dziękujemy za krytyczne uwagi do tekstu niniejszej pracy. Kolegom: Jarosławowi Borejszo, Sławomirowi Kołodziejskiemu i Jackowi Łozińskiemu składamy podziękowania za pomoc w prowadzeniu prac terenowych.

rys. J. Dyczkowski