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GOSHAWK DIET IN A MEDITERRANEAN AREA OF NORTHEASTERN SPAIN

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Abstract.—The diet of the goshawk (*Accipiter gentilis*) is described throughout the year in La Segarra, a Mediterranean area of Catalonia (NE Spain) where one of the densest goshawk populations recorded in Europe was found. Red-legged partridge (*Alectoris rufa*), European rabbit (*Oryctolagus cuniculus*), wood pigeon (*Columba palumbus*), jay (*Garrulus glandarius*), magpie (*Pica pica*), thrushes (*Turdus* spp.) and red squirrel (*Sciurus vulgaris*) formed the bulk of the goshawk diet. Nestling and fledgling birds were very important during the breeding period, but the rabbit was the main source of biomass for most of the year, especially in winter. In the breeding season, pairs in heavily forested areas captured more squirrels and less rabbits than those in lightly forested areas. Changes in the diet involving a decrease in rabbit consumption and an increase in the proportion of red-legged partridge were detected following a rabbit population crash caused by the viral haemorrhagic disease.

Key Words: Accipiter gentilis; *goshawk; Spain; Mediterranean; food habits.*

Dieta del azor en una zona mediterránea del noreste de España

Resumen.—Se describe la dieta del azor (*Accipiter gentilis*) a lo largo del año en la Segarra, una zona mediterránea de Cataluña (NE de España) donde se encontró una de las poblaciones más densas de azor hasta ahora registradas en Europa. La perdiz roja (*Alectoris rufa*), el conejo (*Oryctolagus cuniculus*), la paloma torcaz (*Columba palumbus*), el arrendajo (*Garrulus glandarius*), la urraca (*Pica pica*), los zorzales y mirlos (*Turdus* spp.) y la ardilla (*Sciurus vulgaris*) fueron las presas principales. Las aves jóvenes constituyeron una buena parte de las presas del azor durante el período reproductor, pero el conejo fue la principal fuente de biomasa durante la mayor parte del año, especialmente en invierno. Las parejas de las zonas más forestadas capturaron más ardillas y menos conejos que las parejas de las zonas abiertas. La drástica reducción de las poblaciones de conejo como consecuencia de la pneumonía hemorrágica vírica, condujo a una disminución de su consumo y a un aumento del de perdiz.

The food habits of the goshawk (*Accipiter gentilis*) have been described in northern and central Europe (e.g., Sulkava 1964, Opdam et al. 1977, Wikman and Tarsa 1980, Marquis and Newton 1982, Goszczyński and Pilatowski 1986, Widén 1987), but not in the Mediterranean region. Although there are some some general descriptions of goshawk food habits from several regions of Spain (Morillo and Lalanda 1972, Veiga 1982, Garrigues et al. 1990, Mañosa et al. 1990), these are limited to the breeding season and a detailed study on this subject in a Mediterranean area is still lacking. The objectives of this paper are (1) to describe the diet of a goshawk population in a Mediterranean area of Catalonia, (2) to analyze diet changes throughout the year, and (3) to study diet variation in relation to changes in prey availability between habitat types and years.

Study Area and Goshawk Population

The study area was within the universal transverse mercator squares 31TCG50, 31TCG51, 31TCG60, 31TCG61, and 31TCF59 in La Segarra County in the northeastern portion of the Iberian peninsula. The relief of the area is tabular, altitude lies between 500–800 m, and the climate is a transition between continental Mediterranean and submediterranean. Natural vegetation communities cover only 30% of the area, the remainder being occupied mainly by cereal crops. Depending on the exposure and soil characteristics, different types of secondary pine forest (*Pinus nigra, P. sylvestris,* and *P. halepensis*) or oak forest (*Quercus faginea* and *Q. ilex*) cover the areas not suitable for agriculture. The southern and eastern parts of the study area are more forested, while the northern and western parts are mostly devoted to crops Nest sites were classified as heavily forested if more than 50% of the area within a 1-km radius of the nest was covered by wood or lightly forested if that percentage was less than 50%.

From 1987–89 the maximum number of goshawk pairs nesting simultaneously in a well-searched 176 km^2 area was 22, but the estimated total population from the patterns of use and distribution of nest sites was 26 pairs, giving a maximum density of 1 pair/6.8 km^2, one of the highest in Europe (see Kalchreuter 1981, Thissen et al 1981, Bijlsma 1991). The mean nearest-neighbor distance between the geometric mean locations of the nesting sites

Table 1. Percentage of prey obtained when analyzing goshawk diet by different methods (see Methods section) during the nestling period at two nests in 1989. (N = number of prey individuals.)

	OBSERVATIONS FROM HIDE $N = 74$	NEST REMAINS $N = 82$	PELLETS $N = 29$	MIXED $N = 102$
Reptilia	0.0	1.2	0.0	1.0
Phasianidae	21.6	25.6	6.9	21.6
Columbidae	18.9	15.8	17.2	17.6
Estrigiformes	0.0	2.4	0.0	2.0
Picidae	1.3	1.2	17.2	4.9
Turdidae	17.6	11.0	0.0	8.8
Corvidae	17.6	15.8	20.7	14.7
Sturnidae	0.0	3.7	6.9	4.9
Other Passer.	9.5	3.7	6.9	4.9
Other birds	4.0	2.4	3.4	2.9
Leporidae	4.0	14.6	10.3	11.8
Sciuridae	5.4	2.4	10.3	4.9

of every pair was 1535 m (SD = 455 m, range = 825–2800 m, N = 26). Pair dispersion, measured by the G statistic (Brown and Rothery 1978), showed a value of 0 844, indicating a regular distribution of pairs (Tjernberg 1985). The average laying date during the 1986–90 period, estimated by inspection of the nests every two days from mid-March until the first egg was laid, was 5 April ± 7.96 d (N = 73, range = 21 March–29 April).

METHODS

Prey Identification and Classification. Prey remains, bones, fur, nails and feathers found on nests, plucking sites and pellets were identified by macroscopic comparison with skeleton and skin reference collections. Arthropods were only considered as possible goshawk prey when found on the nests, but not in pellets, and were identified to taxonomic order. I tried to identify all vertebrate remains to species. When possible, the sex and age of prey was recorded. For nidicolous birds, I considered three age categories: nestlings, fledglings, and adults. Young red-legged partridges (*Alectoris rufa*) were considered nestlings if their size was less than three-fourths the adult size and fledglings if larger. Assigning avian prey to age class was based on size, plumage, feather characteristics, and degree of ossification. The adult category might have included some young birds no longer distinguishable from adults. European rabbits (*Oryctolagus cuniculus*) and red squirrels (*Sciurus vulgaris*) were classified as young or adult according to size or degree of ossification. When a prey could not be classified to age, it was not considered in the age selection analysis. Prey found complete or nearly complete were weighed with a spring balance. Otherwise, the live biomass was estimated using bibliographic information (Geroudet 1946–57) or data from the study area according to the age and, if necessary, sex of the prey. No wastage was considered, therefore the biomass figures in this paper refer to captured biomass.

Quantification of Diet During the Breeding Season. Between 1985–89, I studied nestling diet (May–July) by repeated visits to nest sites to collect all prey remains (feathers, fur, and bones) and pellets at the nests and known plucking sites. Recently delivered or partially eaten prey were recorded as prey remains, but not collected. In 1985 and 1986 nest visits were sporadic. From 1987–89, all nests containing chicks were visited every 4 d from hatching to a few days after fledging. To minimize disturbance, sampling was reduced during the laying and incubation periods (April).

The identity of the prey remains and the minimum number of prey individuals necessary to explain their presence was established for each visit, according to the number of bones or flight feathers encountered. All pellets from a visit were pooled into a single sample and analyzed together. The presence of different prey types in these samples was recorded, but no attempt was made to quantify the number of individuals represented. To avoid counting the same prey individual twice in the same visit (i.e., in remains and in pellets), prey found in pellets were computed only if they had not been found as remains in the same visit. I avoided counting the same prey individual in successive visits by comparing prey from successive collections: prey found in pellets or as an old remain were not considered if they had been detected in the previous visit as a fresh or partially eaten prey. In both cases, however, all methods of detection were recorded.

To assess the reliability of the method noted above, 322.5 hours were spent observing in hides installed 15–20 m away from two nests in 1989. During the nestling period, observation started at 1200 H, lasted until 1900 H and was continued the following day from 0500–1200 H. The process was alternated between the two nests until the young fledged. Only prey observed being delivered to the nest were recorded and identified with the aid of a 20–60× telescope. Sixty-seven out of 74 (90.5%) prey were identified to the species. The remaining seven prey were either unidentified small passerines or nestling birds. The results of these observations, which were assumed to be an unbiased sample of the nestling diet, were compared with the results obtained at the same nests and year by pellet counts alone, prey remains alone, and the combination of both as described above. The results given by none of these methods were significantly different from those obtained by direct observation, but the combined method gave the nearest approximation ($\chi^2 = 7.50$, df = 6, $P = 0.277$; $\chi^2 = 11.47$, df = 6, $P = 0.075$; $\chi^2 = 6.09$, df = 6, $P = 0.412$, respectively; Table 1). However, it still overestimated the percentage of rabbits in the diet and underestimated the proportion of thrushes (*Turdus* sp.) and other small birds (Table 1).

Quantification of Diet Outside the Breeding Season. Diet outside the breeding season (August–March) was studied from 1986–88 by looking for prey remains at plucking sites (Opdam et al. 1977, Ziesemer 1983). I tried to standardize the scanning pattern over different months and to avoid finding prey of common buzzards (*Buteo buteo*) or sparrowhawks (*Accipiter nisus*) by scanning only goshawk nesting areas. Two monthly inspections were

Table 2. Prey items of goshawk in La Segarra during 1987–89. Weight in grams. Species with $N < 10$ are grouped and listed underneath.

	N (%)	TOTAL WEIGHT (%)
Arthropods[a]	8 (0.40)	17 (0.00)
Reptiles	21 (1.05)	2906 (0.51)
Lacerta lepida	18 (0.90)	2728 (0.48)
Other reptiles[b]	3 (0.15)	178 (0.03)
Birds	1519 (75.85)	326 502 (56.90)
Alectoris rufa	362 (18.07)	140 845 (24.54)
Coturnix coturnix	21 (1.05)	2100 (0.37)
Columba palumbus	196 (9.79)	67 169 (11.70)
Columba livia	13 (0.65)	3950 (0.69)
Unidentified pigeon	39 (1.95)	11 470 (2.00)
Streptopelia turtur	28 (1.40)	3920 (0.68)
Otus scops	27 (1.35)	2160 (0.38)
Athene noctua	18 (0.90)	3060 (0.53)
Picus viridis	31 (1.55)	6160 (1.07)
Picoides major	15 (0.75)	1200 (0.21)
Turdus merula	134 (6.69)	10 989 (1.91)
Turdus viscivorus	38 (1.90)	4232 (0.74)
Unidentified thrush	25 (1.25)	1887 (0.33)
Garrulus glandarius	184 (9.19)	28 197 (4.91)
Pica pica	54 (2.70)	9345 (1.63)
Sturnus vulgaris	79 (3.94)	6516 (1.14)
Fringilla coelebs	23 (1.15)	529 (0.09)
Unidentified passerine	87 (4.34)	3504 (0.61)
Unidentified bird	36 (1.80)	3190 (0.56)
Other birds[c]	109 (5.44)	16 079 (2.80)
Mammals	455 (22.72)	244 486 (42.60)
Oryctolagus cuniculus	333 (16.63)	220 526 (38.43)
Sciurus vulgaris	86 (4.29)	21 330 (3.72)
Other mammals[d]	36 (1.79)	2630 (0.46)
Total	2003	573 858

[a] Arthropods: *Scolopendra* sp., Orthopterans, Coleopterans.

[b] Other reptiles: *Anguis fragilis, Psammodromus algirus,* unidentified reptiles.

[c] Other birds: *Accipiter gentilis* (nestlings from the same nest), *Accipiter nisus, Phasianus colchicus, Scolopax rusticola, Gallinula chloropus, Columba oenas, Clamator glandarius, Cuculus canorus, Tyto alba, Strix aluco,* unidentified owls, *Caprimulgus europaeus, Caprimulgus* sp , *Merops apiaster, Upupa epops, Galerida* sp., *Lullula arborea,* unidentified lark, *Luscinia megarhynchos, Turdus philomelos, Sylvia* sp., *Parus caeruleus, Parus major, Certhia brachydactila, Oriolus oriolus, Lanius excubitor, Corvus corone,* unidentified crow, *Passer domesticus, Serinus serinus, Carduelis carduelis,* unidentified Fringillidae, *Miliaria calandra.*

[d] Other mammals: *Crocidura russula, Eliomys quercinus, Microtus duodecimcostatus; Apodemus sylvaticus, Mus spretus, Rattus norvegicus, Rattus rattus,* unidentified mice, unidentified rodents.

made at 10 previously selected sites, but fresh remains found in sporadic visits to other nesting areas were also recorded. I recorded all fresh kills, bones, fur or feathers found, and established the minimum number of prey necessary to explain their presence according to the number of bones and flight feathers found. Because of the characteristics of the autumn and winter common buzzard diet in Catalonia, consisting mainly of small mammals and invertebrates (Mañosa and Cordero 1992), little confusion should have arisen with that species. However, some sparrowhawk prey could have been confused with goshawk prey. They can be distinguished by the extent of the feather plucking (larger and usually scattered in the goshawk) and the presence of legs or bill remains left by the sparrowhawk (Opdam 1975). When the predator identity could not be established with confidence, the prey was not considered.

Prey Availability Counts. European rabbit counts were carried out at dusk 1–5 times each month. A 19.7-km route (A) across the whole study area was covered with a vehicle, at a maximum speed of 40 km/h, from July 1987 to December 1989. All rabbits seen on the route were recorded and abundance was expressed as number of rabbits seen per kilometer. Another 25.4-km route (B), covering only the south of the study area, had been traversed in the same way between October 1986–October 1988. The results of the counts during the period when both transects were conducted simultaneously (July 1987–October 1988) were used to obtain a conversion index between them, which was used to obtain a estimate of rabbit abundance for the whole area from October 1986–June 1987 from counts conducted in route B. To obtain rough estimates of red-legged partridge abundance, I conducted car counts in April and May during the morning or before dusk, at a maximum speed of 20 km/h. A total of 57 km in 10 counts of different length and location within the study area were done in 1987 and 102 km in 19 different counts in 1989. Results were expressed as number of partridges seen per kilometer.

Data Analysis and Statistics. Chi-square tests were used to compare diet composition by numbers of prey at different times of the year, and one-way analysis of variance (ANOVA) combined with the Scheffe's test (Zar 1984) were used to compare average prey weights. Variations in the diet of the 1987–89 breeding seasons were analyzed by habitats (heavily forested versus lightly forested) and years. Prey were sorted according to the different nest sites and years. Samples containing less than 20 prey were discarded (to reduce bias caused by differential sampling), leaving 34 diet samples from 18 different nest sites, totaling 1590 prey items. The coefficient of variation between samples in the percentage of each prey type in each sample was calculated to determine the degree of homogeneity in the consumption of different groups of prey. Chi-square tests for mutual and partial independence in three-dimensional tables were performed following Zar (1984). When a two-dimensional chi-square test was globally significant, observed cell frequencies were considered to be significantly different from the expected frequencies when the absolute value of the standardized residual was $>Z_{\alpha/2}$. Statistical significance level was set at $\alpha = 0.05$. Statistical analyses were performed with SPSS (1990). The Shannon-Weaver index (H', log base 2) was used to describe dietary diversity (Margalef 1982). When appropriate, mean ± standard deviation are indicated.

RESULTS

General Diet Description. Samples for the nestling period (May–July) included 27 prey items in 1985–86, 391 prey items from 13 nests in 1987, 871 prey items from 26 nests in 1988 and 452 prey items from 12 nests in 1989. Only 23 prey items were obtained during the laying and incubation periods (April), and 239 prey were determined for the August–March period.

The diet of goshawks in La Segarra included 61 different types of prey (Table 2). Prey weight ranged from only a few grams to more than 1000 g for some adult rabbits. The average weight of prey was 286 ± 235 g ($N = 2003$). Arthropods were incidental and in no case did we have evidence that they had been captured by the goshawk (i.e., they could be prey of goshawk prey). Reptiles were only consumed during the nestling period. The diet consisted almost exclusively of endothermic vertebrate prey (98.9%). Red-legged partridge, European rabbit, wood pigeon (*Columba palumbus*), jay (*Garrulus glandarius*), magpie (*Pica pica*), blackbird (*Turdus merula*), European starling (*Sturnus vulgaris*) and red squirrel formed the 71.3% of goshawks' captures. In terms of biomass, the rabbit was the basic prey, followed by the red-legged partridge and the wood pigeon, which altogether accounted for 74.7% of the captured biomass.

Seasonal Variation. Only 1898 prey individuals could be assigned to a particular month of the year. Frequencies of capture varied significantly by season ($\chi^2 = 144.34$, df = 28, $P < 0.001$; Table 3). Rabbits and passerines accounted for more than 64% of the prey in the January–April period. In May and June passerines and game birds were the main prey, but rabbits, pigeons, and corvids were also important. In July, passerines lost their preponderant position in the diet and game birds made up the largest proportion of it, followed by pigeons, corvids and rabbits. In the August–December period rabbits were again the main prey, followed by pigeons and game birds. In terms of biomass, much less variation occurred, the rabbit being the dominant prey throughout the year, especially outside the breeding season. Game birds had a peak contribution in May, pigeons in the July–December period, and corvids in the June–July period.

Globally, diet was more diverse and contained smaller prey during the nestling period (May–July, Table 3). ANOVA showed significant differences in the average weight of prey between periods ($F_{4,1893} = 16.63$, $P < 0.01$), being lower in May, June and July than in the January–April and August–December periods (Table 3). Between May and July, nestling and fledgling birds accounted for 37.5% of the 781 birds for which age could be determined, or 18.1% of biomass (185 kg). Extrapolating to all prey, 28.8% of prey and 10.8% of the total biomass captured were young birds. The proportion of immature birds (both nidicolous and precocial) in relation to fully grown ones increased from the beginning of May to the end of July ($\chi^2 = 32.38$, df = 5, $P < 0.001$; Fig. 1) as the nesting season progressed. For nidicolous birds alone, the proportion of nestlings

Table 3. Percentages by numbers (*N*) and weight (*W*) of different prey categories found in the diet of the goshawk at different times of the year in La Segarra. (Only *N*% were tested for significance.)

	JAN–APRIL		MAY		JUNE		JULY		AUG–DECEMBER	
	N	*W*	*N*	*W*	*N*	*W*	*N*	*W*	*N*	*W*
Phasianidae	13.4	16.3	22.4	35.3	17.0	24.6	21.5	17.4	20.3	19.6
Columbidae	14.9	14.4	10.5	12.9	12.8	13.6	16.5	18.8	21.9[a]	21.1
Corvidae	0.7[a]	0.4	9.4	5.3	14.6[a]	8.4	16.2[a]	10.5	8.6	3.5
Passeriformes	29.1	4.0	28.3[a]	7.3	22.7	5.8	12.8[a]	3.5	12.5[a]	2.1
Other birds	2.2[a]	1.1	4.7[a]	1.6	9.9	6.5	12.1[a]	5.8	7.8	3.2
Leporidae	35.1[a]	60.9	15.0	30.8	14.3	35.3	14.5	40.3	26.6[a]	49.9
Sciuridae	2.2	1.4	5.6	5.0	5.0	4.7	3.4	3.2	0.8[a]	0.5
Other prey	2.2	1.3	4.0	1.7	3.7	1.0	3.0	0.2	1.6	0.1
Number of prey	134		446		893		297		128	
Total weight (kg)	53.1		122.4		240.7		76.9		50.5	
Average weight (g)	396 ± 276		274 ± 207		270 ± 235		259 ± 241		395 ± 256	
H'	2.26		2.70		2.83		2.80		2.57	

[a] Significantly different from expected frequency.

decreased and that of fledglings increased throughout the breeding season (May 32.8% and 14.3%, N = 119; June 21.3% and 27.1%, N = 314; July 13.6% and 28.8%, N = 66, respectively; $\chi^2 = 14.65$, df = 4, $P < 0.005$). The proportion of nestling corvids decreased from May to July as the proportion of fledglings increased ($\chi^2 = 23.66$, df = 4, $P < 0.01$; Fig. 2). The proportion of young partridges captured increased from May (0%) to July (74.6%, χ^2 = 124.80, df = 2, $P = 0.01$; Fig. 2). Similar but nonsignificant trends were found for pigeons and starlings, while thrushes showed a reverse trend (Fig. 2). The proportion of young to adult rabbits in May (100%, N = 38), June (69.6%, N = 79) and July (59.1%, N = 22) showed a significant decrease (χ^2 = 17.33, df = 2, $P < 0.01$). The proportion of young to adult squirrels in May (20%, N = 5), June (13%, N = 8) and July (0%, N = 5) did not show a significant trend ($\chi^2 = 1.04$, df = 2, $P = 0.594$).

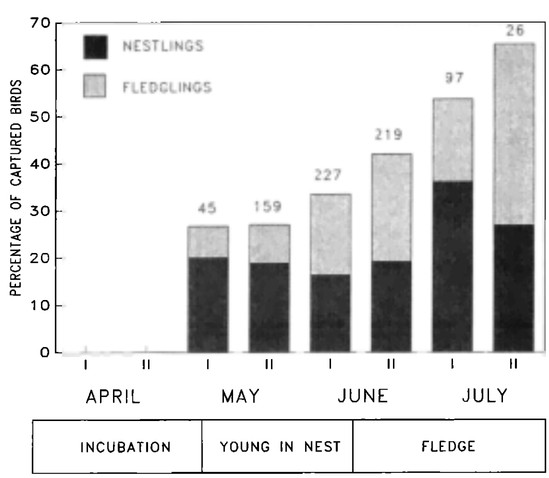

Figure 1. Proportion of young birds in relation to all birds (nidicolous and precocial) captured by goshawks in successive 2-wk periods during the breeding season. Numbers above the bars refer to the sample size used to estimate age composition in each case. The approximate timing of goshawk breeding is shown underneath.

Year-to-year and Habitat Variation. Significant variation in diet composition occurred between the 34 samples analyzed ($\chi^2 = 392.62$, df = 231, $P < 0.001$). According to the coefficients of variation of the different prey groups, game birds (C.V. = 31.2%), passerines (C.V. = 36.2%) and corvids (C.V. = 43.3%) were the prey more homogeneously represented in the samples, whereas squirrels (C.V. = 89.2%) and other prey (C.V. = 105.8%) were the most unevenly consumed groups. Pigeons (C.V. = 51.1%), rabbits (C.V. = 57.9%) and other birds (C.V. = 74.6%) showed intermediate levels of variation. Year-to-year and habitat differences in prey availability might be partially responsible for this variation. A test for mutual independence of prey composition, year, and habitat showed dependence of all three variables ($\chi^2 = 132.69$, df = 37, $P < 0.001$). Test for partial independence showed habitat being dependent on year and prey ($\chi^2 = 94.90$, df = 23, $P < 0.001$), year being dependent on prey and habitat ($\chi^2 = 70.82$, df = 30, $P < 0.001$) and prey being dependent on habitat and year (χ^2 = 121.93, df =

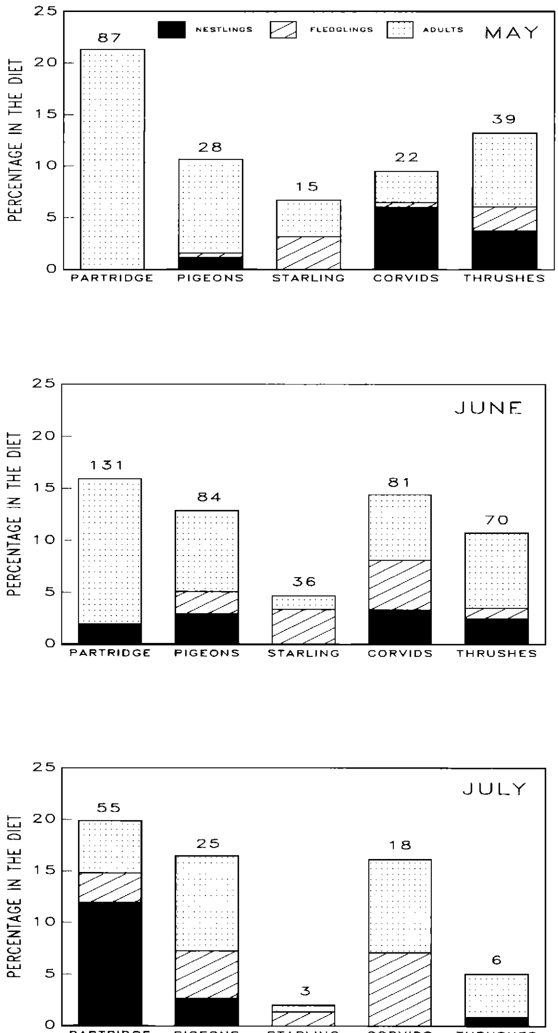

Figure 2. Percentages of nestlings, fledglings, and adult birds of some relevant groups in the diet of the goshawk in May, June, and July. Numbers above the bars refer to the sample size used to estimate age composition in each case.

35, $P < 0.001$). In consequence, three two-dimensional tables comparing diet between habitats independently for each year, and two two-dimensional tables comparing diet between years independently for each habitat were tested. In all three years, diet differences between heavily forested and lightly forested areas were statistically significant (1987, $\chi^2 = 21.53$, df = 7, $P = 0.003$; 1988, $\chi^2 = 39.39$, df = 7, $P < 0.001$; 1989, $\chi^2 = 18.83$, df = 7, $P = 0.009$;

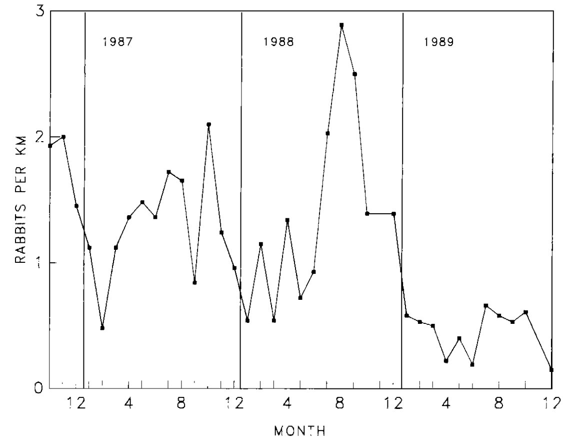

Figure 3. Changes in the index of European rabbit (*Oryctolagus cuniculus*) availability in La Segarra during the period 1986–89.

Table 4). When the three years were pooled, differences between habitats remained significant ($\chi^2 = 66.24$, df = 7, $P < 0.001$). Compared with lightly forested areas, diet in heavily forested areas included significantly less rabbits and more squirrels (Table 4). Habitat differences in the proportion of game birds, pigeons, corvids and passerines were non-significant, but consistent between years. Although the trends were similar in both habitats, year-to-year variation was significant in the lightly forested area ($\chi^2 = 33.69$, df = 14, $P = 0.002$) but not in the heavily forested area ($\chi^2 = 21.54$, df = 14, $P = 0.09$). A decrease in dietary diversity was noticed in both areas in 1989. After pooling the two habitats, differences between years remained significant ($\chi^2 = 41.84$, df = 14, $P < 0.001$). Diet in 1987 was characterized by a higher proportion of corvids, while diet in 1989 was characterized by a decrease in the proportion of rabbits and an increase in that of game birds (Table 4). The changes detected in 1989 followed a decline in the availability of rabbits (Fig. 3), whereas partridge availability had remained constant throughout the study period (1987: 1.02 partridges/km; 1989: 0.94 partridges/km).

DISCUSSION

The diet of the goshawk in La Segarra showed three main peculiarities when compared to other European areas: (1) presence of reptiles, (2) high proportion of red-legged partridges, and (3) high proportion of rabbits. The first characteristic was also found in all Iberian localities studied (Morillo

Table 4. Goshawk diet variation in La Segarra according to year and habitat. (L: lightly forested area; H: heavily forested area.)

	1987		1988		1989	
	L	*H*	*L*	*H*	*L*	*H*
Phasianidae	13.5	17.8	16.5	19.3	22.8[a]	24.1
Columbidae	11.9	15.5	8.7	14.0	14.6	17.9
Corvidae	22.7[a]	15.5	14.5	10.9	12.2	10.5
Passeriformes	16.7	20.1	20.2	24.6	22.8	30.9
Other birds	7.0	11.5	11.2	9.7	9.1	4.3
Leporidae	21.1[b]	9.8[b]	22.4[b]	10.1[b]	14.6[a,b]	4.9[b]
Sciuridae	1.6	6.9	2.5[b]	7.5[b]	2.4	6.2
Other prey	5.4	2.9	4.0	3.9	1.6	1.2
N	185	174	401	414	254	162
H'	2.74	2.84	2.76	2.82	2.69	2.54

[a] Significantly different from expected frequency when compared with the same habitat in other years.
[b] Significantly different from expected frequency when compared with the other habitat in the same year.

and Lalanda 1972, Veiga 1982, Garrigues et al. 1990, Mañosa et al. 1990), but only in some European localities (Sladek 1963, Goszczyński and Pilatoski 1986), and might be correlated with the abundance of ocellated lizards (*Lacerta lepida*) in the Mediterranean regions of the Iberian peninsula.

Game birds, mostly red-legged partridges, was the group most frequently captured and the least variable between samples and seasons, which might be caused by a certain degree of preference or local abundance of that prey. However, even taking into consideration that our methodology may over estimate the frequency of rabbits in the diet, in terms of biomass this was the more important prey species for goshawks in La Segarra especially outside the breeding season. Although rabbits have also been reported as an important prey for goshawks in other areas of Europe (Tinbergen 1936, Sladek 1963, Brüll 1964, Marquis and Newton 1982), only the Iberian localities studied so far shared this characteristic in a consistent geographic pattern.

The different methods used, as well as true seasonal trends, might be partially responsible for the differences between breeding and non-breeding season diet, because smaller or less conspicuous prey might be hard to detect when searching for pluckings outside the nesting season (Opdam et al. 1977). Also, seven of the 10 regularly surveyed pairs outside the breeding season were in the lightly forested area, which might have contributed to an overestimate of the proportion of rabbit in the diet of the whole population at this time of the year. However, the seasonal trends detected in dietary diversity and average weight of prey are consistent with those found in other European areas (Opdam et al. 1977, Widén 1987). This suggests that goshawk diet composition in La Segarra was largely determined by the diversity and availability of vulnerable prey, which was higher in spring and summer. The lowest proportion of resident and summer birds (Phasianidae, Corvidae and other birds) in the diet were reached in the January–April period, and coincided with their lowest population levels. This was not found for pigeons and passerines, in which the autumn and winter populations may be increased by wintering or migrant birds. The abundance of young birds could be as well a crucial factor determining the importance of different species in the spring and summer diet, and the goshawk would switch from one to another as they become available: from May–July, the total proportion of pigeons and corvids in the diet increased as the proportion of fledgling pigeons and fledgling corvids in the diet increased, whereas the total proportion of passerines decreased as fledgling thrushes (the main passerine group in the diet) decreased. Also, the increase in the consumption of partridges from June–July paralleled the increase in the proportion of young partridges in the diet. Similar importance of young birds and mammals in the diet of goshawks has been reported in other regions (Schnell 1958, Sulkava 1964, Opdam et al. 1977, Wikman and Tarsa 1980, Reynolds and Meslow 1984).

The versatility of feeding by the goshawk was further emphasized when comparing lightly forested and heavily forested areas. Rabbits and corvids on one hand, and squirrels and pigeons (mainly wood pigeon) on the other, favor farmland and forest habitats respectively, and goshawks took advantage of them differentially in each habitat type. However, the proportion in the diet of other prey types (game birds) did not seem to reflect relative abundance in each environment, which might be a consequence of the unit-sum constraint of proportions (Aebischer and Robertson 1993), or of differences in the vulnerability of these prey between habitats, regardless of their abundance. After the sudden decline on rabbit availability in La Segarra, probably as a consequence of the outcome of the viral haemorrhagic disease (Mañosa 1991), goshawks showed a functional response involving a reduction of rabbit consumption and an increased predation on red-legged partridge. This response, expressed as a proportional change in rabbit consumption, was larger than that observed in golden eagles (*Aquila chrysaetos*; Fernández 1993). In the golden eagle (a rabbit specialist in Mediterranean areas), diet diversity increased following rabbit population crash. This was less in the case of the goshawk, an essentially bird-eating raptor which seems to prey opportunistically on rabbits. The effect on the partridge population of that increase in goshawk predation will depend on the numerical response of goshawk after the rabbit population crash. Further long-term monitoring of breeding densities, breeding success and diet of goshawks and their prey in La Segarra would provide a better understanding of the mechanisms underlaying predator-prey interactions in Mediterranean agricultural landscapes.

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