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 jévenes constituyeron una buena parte de las presas del azor durante el periodo 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 pneumonia 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 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 31TGC50, 31TGC51, 31TGC60, 31TGC61, 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 km², 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...
of every pair was 1535 m (SD = 455 m, range = 825–
7.96 d (N = 73, range = 21 March–29 April).

mid-March until the first egg was laid, was 5 April +
estimated by inspection of the nests every two days from

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 cat-
egories: nestlings, fledglings, and adults. Young red-legged
partridges (Alectoris tufa) were considered nestlings if their
size was less than three-fourths the adult size and fledg-
lings 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. Eu-
ropean rabbits (Oryctolagus cuniculus) and red squirrels
(Sciurus vulgaris) were classified as young or adult ac-

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,
al all containing chicks were visited every 4 d from
hatching to a few days after fledging. To minimize dis-
turbance, 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 pres-
ence 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 to-
gether. The presence of different prey types in these sam-

elations: prey found in pellets or as an old remain were

numbers of prey individuals necessary to explain their pres-

cessive visits by comparing prey from successive col-

se of these methods were significantly different from

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 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.)

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
<th>NEST FROM HIDE</th>
<th>REMAINS</th>
<th>PELLETS</th>
<th>MIXED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 74</td>
<td>N = 82</td>
<td>N = 29</td>
<td>N = 102</td>
</tr>
<tr>
<td>Reptilia</td>
<td>0.0</td>
<td>1.2</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Phasianidae</td>
<td>21.6</td>
<td>25.6</td>
<td>6.9</td>
<td>21.6</td>
</tr>
<tr>
<td>Columbidae</td>
<td>18.9</td>
<td>15.8</td>
<td>17.2</td>
<td>17.6</td>
</tr>
<tr>
<td>Estrigiformes</td>
<td>0.0</td>
<td>2.4</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Picidae</td>
<td>1.3</td>
<td>1.2</td>
<td>17.2</td>
<td>4.9</td>
</tr>
<tr>
<td>Turdidae</td>
<td>17.6</td>
<td>11.0</td>
<td>0.0</td>
<td>8.8</td>
</tr>
<tr>
<td>Corvidae</td>
<td>17.6</td>
<td>15.8</td>
<td>20.7</td>
<td>14.7</td>
</tr>
<tr>
<td>Sturnidae</td>
<td>0.0</td>
<td>3.7</td>
<td>6.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Other Passer.</td>
<td>9.5</td>
<td>3.7</td>
<td>6.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Other birds</td>
<td>4.0</td>
<td>2.4</td>
<td>3.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Leporidae</td>
<td>4.0</td>
<td>14.6</td>
<td>10.3</td>
<td>11.8</td>
</tr>
<tr>
<td>Scurridae</td>
<td>5.4</td>
<td>2.4</td>
<td>10.3</td>
<td>4.9</td>
</tr>
</tbody>
</table>
Table 2. Prey items of goshawk in La Segarra during 1987-89. Weight in grams. Species with $N < 10$ are grouped and listed underneath.

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

$^a$ Arthropods: *Scolopendra* sp., *Orthopterans*, *Coleopterans*.
$^b$ Other reptiles: *Anguis fragilis*, *Pammobromus algorithm*, unidentified reptiles.

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 (Maños 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
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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 rab-
bbits seen per kilometer. Another 25.4-km route (B), cov-
ering 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
tranches were conducted simultaneously (July 1987–Oct-
tober 1988) were used to obtain a conversion index be-
tween them, which was used to obtain an 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 par-
trides 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 vari-
ance (ANOVA) combined with the Scheffe’s test (Zar
1984) were used to compare average prey weights. Vari-
ations in the diet of the 1987–89 breeding seasons were
analyzed by habitats (heavily forested versus lightly for-
ested) and years. Prey were sorted according to the dif-
ferent nest sites and years. Samples containing less than
20 prey were discarded (to reduce bias caused by differ-
ential 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 indepen-
dence in three-dimensional tables were performed follow-
ing 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 \( > Z_{0.05} \). 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 \( \pm \) standard deviation are indicated.

RESULTS

General Diet Description. Samples for the nest-
ling 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 Au-
tugust–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
\( \pm 235 \) 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 pi-
geon (\( Columba palumbus \)), jay (Garrulus glandarius),
mapie (\( Pica pica \)), blackbird (\( Turdus merula \)), Eu-
ropean 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 pro-
portion of it, followed by pigeons, corvids and rab-
bits. In the August–December period rabbits were
again the main prey, followed by pigeons and game
birds. In terms of biomass, much less variation oc-
curred, the rabbit being the dominant prey through-
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–De-
ember 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 cap-
tured 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 nestling 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.)

<table>
<thead>
<tr>
<th></th>
<th>JAN–APRIL</th>
<th>MAY</th>
<th>JUNE</th>
<th>JULY</th>
<th>AUG–DECEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>W</td>
<td>N</td>
<td>W</td>
<td>N</td>
</tr>
<tr>
<td>Phasianidae</td>
<td>13.4</td>
<td>16.3</td>
<td>22.4</td>
<td>35.3</td>
<td>17.0</td>
</tr>
<tr>
<td>Columbidae</td>
<td>14.9</td>
<td>14.4</td>
<td>10.5</td>
<td>12.9</td>
<td>12.8</td>
</tr>
<tr>
<td>Corvidae</td>
<td>0.7a</td>
<td>0.4</td>
<td>9.4</td>
<td>5.3</td>
<td>14.6a</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>29.1</td>
<td>4.0</td>
<td>28.3a</td>
<td>7.3</td>
<td>22.7</td>
</tr>
<tr>
<td>Other birds</td>
<td>2.2a</td>
<td>1.1</td>
<td>4.7a</td>
<td>1.6</td>
<td>9.9</td>
</tr>
<tr>
<td>Leporidae</td>
<td>35.1a</td>
<td>60.9</td>
<td>15.0</td>
<td>30.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Sciuridae</td>
<td>2.2</td>
<td>1.4</td>
<td>5.6</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Other prey</td>
<td>2.2</td>
<td>1.3</td>
<td>4.0</td>
<td>1.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Number of prey</td>
<td>134</td>
<td>446</td>
<td>893</td>
<td>297</td>
<td>128</td>
</tr>
<tr>
<td>Total weight (kg)</td>
<td>53.1</td>
<td>122.4</td>
<td>240.7</td>
<td>76.9</td>
<td>50.5</td>
</tr>
<tr>
<td>Average weight (g)</td>
<td>396 ± 276</td>
<td>274 ± 207</td>
<td>270 ± 235</td>
<td>259 ± 241</td>
<td>395 ± 256</td>
</tr>
<tr>
<td>$H'$</td>
<td>2.26</td>
<td>2.70</td>
<td>2.83</td>
<td>2.80</td>
<td>2.57</td>
</tr>
</tbody>
</table>

* 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%, $\chi^2 = 124.80$, df = 2, $P = 0.01$; Fig. 2). Similar but non-significant 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 ($\chi^2 = 17.33$, 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, $P = 0.594$).

**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 ($\chi^2 = 121.93$, 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.

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, $P = 0.009$).

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.)

<table>
<thead>
<tr>
<th></th>
<th>1987</th>
<th>1988</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phasianidae</td>
<td>13.5</td>
<td>16.5</td>
<td>22.8*</td>
</tr>
<tr>
<td>Columbidae</td>
<td>11.9</td>
<td>8.7</td>
<td>14.0</td>
</tr>
<tr>
<td>Corvidae</td>
<td>22.7*</td>
<td>14.5</td>
<td>10.9</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>16.7</td>
<td>20.2</td>
<td>24.6</td>
</tr>
<tr>
<td>Other birds</td>
<td>7.0</td>
<td>11.2</td>
<td>9.7</td>
</tr>
<tr>
<td>Leporidae</td>
<td>21.1b</td>
<td>22.4b</td>
<td>14.6*</td>
</tr>
<tr>
<td>Sciuridae</td>
<td>1.6</td>
<td>2.5b</td>
<td>7.5b</td>
</tr>
<tr>
<td>Other prey</td>
<td>5.4</td>
<td>4.0</td>
<td>3.9</td>
</tr>
<tr>
<td>N</td>
<td>185</td>
<td>401</td>
<td>254</td>
</tr>
<tr>
<td>H*</td>
<td>2.74</td>
<td>2.76</td>
<td>2.69</td>
</tr>
</tbody>
</table>

*Significantly different from expected frequency when compared with the same habitat in other years.

and Lalande 1972, Veiga 1982, Garrigues et al. 1990, Mañosa et al. 1990, but only in some European localities (Sladek 1963, Goszczyński and Piłatowski 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 overestimate 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
The effect on the partridge population of that increase in goshawk predation will depend on the numerical response of goshawks after the rabbit population crash. This was less in the case 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 underlying predator-prey interactions in Mediterranean agricultural landscapes.

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