IMP IMPORTANCE OF ORTHOPTERA IN THE NESTLING DIET OF SOUTHERN GREY SHRIKES IN AGRICULTURAL AREAS

Francisco CAMPOS1 *, Miguel MIRANDA1 and Raúl MARTÍN2

SUMMARY.—Importance of Orthoptera in the nestling diet of southern grey shrikes in agricultural areas.

This paper describes the nestling diet of southern grey shrikes in agricultural areas (Castronuño, Valladolid province, Spain, 41° 23’ N 05° 16’ W). A video-camera was used to record the prey used for feeding nestlings by adult southern grey shrikes of ten different nests. Nestling age varied from 5 to 13 days. The percentage of occupancy of each kind of habitat (vineyards, cereal crops, natural habitat, others) within a radius of 250 m around each nest was computed from aerial pictures. Prey availability was analysed with pitfalls traps placed in three different habitats in the study area. Orthoptera were the most frequent prey (69.56%, N = 287), in particular crickets Gryllus campestris (85.5% of all Orthoptera). Vertebrates comprised 3.05% of the total prey. Orthoptera were positively selected by feeding adults in all the studied nests. Arachnida and Coleoptera were not positively selected in any of the nests and in fact were negatively selected in 50% and 90% of the nests, respectively. The percentage of feedings with Myriapoda, Hymenoptera and Dytiscidae were similar to the frequency of these prey in the pitfall traps. Myriapoda and Orthoptera were the largest prey, whereas Arachnida and Coleoptera were the smallest. Differences with previous studies from other location can be ascribed to the shrike’s adaptation to the transformation of the habitat into an agroecosystem since: (i) Orthoptera are highly abundant in vineyards, where the large number of available perches and the lack of herbaceous vegetation enable shrikes to capture them; (ii) they have a high content of proteins and water, and they probably favour a more rapid nestling growth.

Key words: agricultural areas, food nestling, Lanius meridionalis, Orthoptera, southern grey shrike, Spain.

RESUMEN.—Importancia de los ortópteros en la dieta de pollos de alcaudón real en zonas agrícolas.

El objetivo de este trabajo es averiguar la composición de la dieta de los pollos del alcaudón real en zonas agrícolas (Castronuño, provincia de Valladolid, España, 41° 23’ N 05° 16’ W). Se empleó una cámara de video para grabar las presas aportadas por los alcaudones adultos en diez nidos diferentes, con pollos entre 5 y 13 días de edad. A partir de fotografías aéreas se calculó el porcentaje ocupado por cada

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INTRODUCTION

Human action has converted wide areas of Mediterranean vegetation into agricultural areas, forcing birds to modify their strategies to enable them to live in them. Agricultural intensification results in changes in the number and accessibility of potential prey: these favour the presence of some species (Koks et al., 2007) and may render their detectability more difficult with vegetation growth (Yosef and Grubb, 1993). Therefore, predators have to adapt their strategies to capture prey and the composition of their diet in order to survive in these new conditions.

During the breeding season, adult birds have to feed themselves and their offspring and therefore their feeding requirements are at the highest point. Prey availability appears to be one of the major factors influencing breeding success in passerines (Tremblay et al., 2005). Adults need to dedicate a lot of time to obtain and deliver food to the nest during the growth period of the nestlings. They are expected to catch prey that are highly profitable for the nestlings, i.e., those which have a high energy content and a low handling time (Stephens and Krebs, 1986).

The southern grey shrike, *Lanius meridionalis meridionalis*, is a medium-size (25 cm) passerine that occurs in open, natural habitats and also in extensively cultivated areas of the Iberian Peninsula and Southern France (Lefranc and Worfolk, 1997). In Spain, its abundance has decreased in recent years, especially in agricultural areas (Hernández and Infante, 2004), probably as a result of habitat modification.

In France, Lepley et al. (2004) studied the diet of southern grey shrike adults and fledglings in summer. In the Iberian Peninsula, the diet of adult shrikes has been analysed in central and Southern Spain (Hernández, 1993; Hódar, 2006), two areas with strong climatic differences. In the Canary Islands, Padilla et al. (2005, 2009) studied the diet of the subspecies *L. m. koenigi*. These studies proved that the proportion of lacertids in their diet decreases with latitude. However, less attention has been paid to the diet of nestlings, as only Hernández (1993) in the Iberian Peninsula and Budden and Wright (2000) in Israel (subspecies *L. m. aucheri*) have analysed it through the content of pellets and a video camera respectively. Pellets, however, can bias diet estimations given that some remains are
not found in them (e.g. some insect larvae). In these cases, the results show the importance of insects in the diet.

In this study the diet composition of nestlings has been analysed in relation to habitat characteristics, including the availability of different prey items.

**Material and Methods**

**Study area**

The study was carried out in the surroundings of Castronuño, Western Spain (41° 23’N 05° 16’W), in May and June 2008. The vegetation of this area belongs to the *Juniperus thuriferae – Quercus rotundifoliae* S. series of the supra-Mediterranean terrain (Rivas-Martínez, 1987). The mean annual temperature is 12.2 °C and mean annual rainfall is 385 mm (Castronuño weather station data).

The natural vegetation here has been modified by man who has transformed the study area into an agricultural system. Four types of habitat have been identified:

(i) Cereal crops in which wheat *Triticum* spp. and barley *Hordeum* spp. are predominant.

(ii) Vineyards of *Vitis vinifera*.

(iii) Natural habitat, with holm oak *Quercus ilex*, dog rose *Rosa* sp. bushes, and small areas of stone pine *Pinus pinea*.

(iv) Other habitats, mainly quarries and roads.

**Prey availability and prey selection**

In order to estimate the relative abundance of potential prey, 20 pitfall traps that were active with no interruption through May and June were placed in three types of habitat (cereal crops, vineyards and natural habitat). No pitfalls were placed in quarries and on roads as they are seldom used by the shrikes to feed because of the high degree of human presence. Traps were visited every 15 days and their contents emptied. These traps are appropriate to sample terrestrial arthropods (Cooper and Whitmore, 1990) but they are less efficient for small mammals (Garden et al., 2007). However, the importance of the latter in the diet is so limited in the study area that they do not have a relevant influence (see below).

Prey availability was calculated for each nest, taking into account habitat percentage within the territory. For example, for nest 1, availability of Orthoptera (D) was calculated as 

\[D = (D_{habitatA} \times \% \text{ of habitat } A \text{ in territory } 1) + (D_{habitatB} \times \% \text{ of habitat } B \text{ in territory } 1) + (D_{habitatC} \times \% \text{ of habitat } C \text{ in territory } 1)\]

where A, B and C are cereal crops, vineyards and natural habitat, respectively.

Prey selection was analysed using Savage’s W index (1931) 

\[W = U_i / D_i\]

where \(U_i\) is the use of the resource i, and \(D_i\) is the availability of this resource. This index allows verification of its statistical significance compared to a Chi-squared test with one degree of freedom (Manly et al., 1993).

Prey size was calculated according to southern grey shrike bill length, from the tip to the distal edge of the nostril (14 mm, Gutiérrez-Corchero et al., 2007), as has also been done for other species (Campos and Lekuona, 1997). Prey were grouped by size class 0.5 times the length of the bill.

The efficacy of a shrike in handling a prey item has been measured through handling time, i.e., time elapsed from the moment an adult arrives at the nest to the time a chick swallows the prey item. Another method of measuring handling efficiency is through the number of attempts of the adults to try to feed the chicks with a particular prey (Banbura et al., 1999).

In this study, both variables were measured from the video tapes.

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**Video recording**

Ten nests were located in holm oak and dog rose bushes, nine of which had nestlings that fledged and one which was preyed upon before fledging. The nests were filmed with a JVC Everio GZ-MG365 video camera, from a 1 m distance, during one day per nest. A minimum of 2.6 h was recorded at each nest (maximum of 5.4 h) and time was counted from the time the adults normally arrived at the nest to feed the nestlings, generally 15 minutes after placing the camera (range 4-22 min). All the filming was performed at the same time of day (starting 3 h after sunrise), given that the feeding rate in some species of passerines may vary significantly with the time of day (Low et al., 2008).

Each type of habitat within a radius of 250 m around the filmed nests was computed from digitalized aerial photographs taken in 2005. The photographs were obtained from the Regional Government of Castilla y León (available at www.sitcyl.jcyl.es) and allowed us to work within a scale 1:2000. The surface occupied by each type of habitat was calculated by means of the software ArcMap 9.2. Mean distance ± SE between nests in the study area was 748.0 ± 54.5 m (N = 21). Shrikes rarely reach the limits of their territory while feeding their chicks (pers. obs.). It is for this reason why the 250 m radius around each nest was chosen to calculate the type of habitat for each nest.

**Statistical analysis**

The Kruskal-Wallis test was used to compare mean size, mean handling time values and mean number of feeding attempts according to the kind of prey. This non-parametric test was applied because the residuals of the three variables (size, handling time and number of feeding attempts) were not normally distributed (Kolmogorov-Smirnov test). In the statistical analysis, the established level of significance was P < 0.05. All analyses were carried out using SPSS for Windows, release 17.0.

**RESULTS**

The diet of the nestlings consisted of vertebrates and arthropods (3.05% and 96.95% respectively, in the total set of nests, N = 287, table 1). Vertebrates were represented by two lacertids, one passerine and five voles Microtus spp. (table 1). Among the arthropods, the insects stood out (90.43% of prey). Orthoptera were the most abundant prey group at all nests (range 45.9%-84.2%, table 1), and among those, crickets Gryllus campestris were the most captured prey (85.5% of prey items in this group). Lepidoptera (mainly larvae, 95.8% of prey items in this group) were present in eight nests (range 5.2%-23.1%). The remaining groups of prey were poorly represented in the nestlings’ diet, mainly Coleoptera, Hymenoptera and Dytiscidae that were present only in 4, 3 and 1 nest, respectively (table 1).

The most abundant potential prey in the three habitats sampled within the study area (cereal crops, vineyards, natural habitats) were Coleoptera, whereas the percentage of Orthoptera was greater in vineyards than in the other habitats (fig. 1). Among the arthropods, adult southern grey shrikes positively selected Orthoptera in all the nests, and positively selected Lepidoptera in 80% of all nests (table 2). On the contrary, Arachnida and Coleoptera were not positively selected in any nest but in fact were negatively selected in 50% and 90% of nests, respectively. Myriapoda, Hymenoptera and Dytiscidae were eaten in a proportion similar to that recorded in the pitfall traps (50%, 70% and 90% of nests, respectively, table 2).

Considering all prey (arthropods) from each group detected in all the studied nests,
statistically significant differences were detected (Kruskal-Wallis test) in size and handling time for each kind of prey (table 3). Myriapoda and Orthoptera were the largest prey, and Arachnida and Coleoptera the smallest.

**DISCUSSION**

The results obtained in this study show that Orthoptera are the basis of the diet of southern grey shrike nestlings in the study area. It is known that, in passerines, diet com-

### Table 1

Percentage of prey recorded in the diet of southern grey shrike nestlings in ten nests (based on total prey at each nest) and area covered by the four types of habitats within a 250 m radius around each nest. T: filming time (in hours).

[Porcentaje de presas registradas en la dieta de pollos de alcaudón real en diez nidos (calculados sobre el total de presas de cada nido) y de superficie ocupada por los cuatro tipos de hábitat en un radio de 250 m alrededor de cada nido. T: tiempo de grabación en horas.]

<table>
<thead>
<tr>
<th>Nests</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arachnida</td>
<td>4.35</td>
<td>13.32</td>
<td>4.76</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>5.40</td>
<td>–</td>
<td>4.00</td>
<td>–</td>
<td>3.18</td>
</tr>
<tr>
<td>Myriapoda</td>
<td>–</td>
<td>–</td>
<td>9.53</td>
<td>5.26</td>
<td>2.56</td>
<td>–</td>
<td>8.10</td>
<td>–</td>
<td>8.00</td>
<td>–</td>
<td>3.35</td>
</tr>
<tr>
<td>Orthoptera</td>
<td>71.74</td>
<td>60.00</td>
<td>76.19</td>
<td>84.22</td>
<td>61.54</td>
<td>60.00</td>
<td>45.95</td>
<td>80.00</td>
<td>84.00</td>
<td>72.00</td>
<td>69.56</td>
</tr>
<tr>
<td>Dictyoptera</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4.00</td>
<td>0.40</td>
</tr>
<tr>
<td>Coleoptera</td>
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<td>6.67</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>5.40</td>
<td>–</td>
<td>12.00</td>
</tr>
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<td>Lepidoptera</td>
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<td>6.67</td>
<td>–</td>
<td>5.26</td>
<td>23.08</td>
<td>4.00</td>
<td>2.71</td>
<td>–</td>
<td>4.00</td>
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<td>6.67</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2.71</td>
<td>–</td>
<td>1.37</td>
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<td>Insecta indet.</td>
<td>10.87</td>
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<td>5.26</td>
<td>7.69</td>
<td>32.00</td>
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<td>10.00</td>
<td>–</td>
<td>4.00</td>
<td>10.43</td>
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<td>Vertebrata</td>
<td>–</td>
<td>6.67</td>
<td>4.76</td>
<td>–</td>
<td>5.13</td>
<td>4.00</td>
<td>–</td>
<td>10.00</td>
<td>–</td>
<td>–</td>
<td>3.06</td>
</tr>
<tr>
<td>Total prey</td>
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<td></td>
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<td></td>
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<td><strong>46</strong></td>
</tr>
<tr>
<td>% cereal crops</td>
<td><strong>26.2</strong></td>
<td><strong>67.0</strong></td>
<td><strong>82.1</strong></td>
<td><strong>46.9</strong></td>
<td><strong>1.5</strong></td>
<td><strong>18.6</strong></td>
<td><strong>78.7</strong></td>
<td><strong>72.6</strong></td>
<td><strong>87.1</strong></td>
<td><strong>46.1</strong></td>
<td></td>
</tr>
<tr>
<td>% vineyards</td>
<td><strong>49.4</strong></td>
<td><strong>23.3</strong></td>
<td><strong>3.1</strong></td>
<td><strong>16.6</strong></td>
<td><strong>28.7</strong></td>
<td><strong>66.3</strong></td>
<td><strong>8.7</strong></td>
<td><strong>4.9</strong></td>
<td><strong>6.1</strong></td>
<td><strong>7.0</strong></td>
<td></td>
</tr>
<tr>
<td>% natural habitat</td>
<td><strong>20.6</strong></td>
<td><strong>4.4</strong></td>
<td><strong>11.4</strong></td>
<td><strong>32.6</strong></td>
<td><strong>54.2</strong></td>
<td><strong>0.4</strong></td>
<td><strong>8.6</strong></td>
<td><strong>18.8</strong></td>
<td><strong>4.2</strong></td>
<td><strong>14.5</strong></td>
<td></td>
</tr>
<tr>
<td>% others</td>
<td><strong>3.8</strong></td>
<td><strong>5.3</strong></td>
<td><strong>3.4</strong></td>
<td><strong>3.9</strong></td>
<td><strong>15.6</strong></td>
<td><strong>14.7</strong></td>
<td><strong>4.0</strong></td>
<td><strong>3.7</strong></td>
<td><strong>2.6</strong></td>
<td><strong>32.4</strong></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>5.00</td>
<td>4.77</td>
<td>4.27</td>
<td>3.98</td>
<td>4.25</td>
<td>2.62</td>
<td>5.37</td>
<td>3.10</td>
<td>4.60</td>
<td>3.55</td>
<td><strong>5.00</strong></td>
</tr>
</tbody>
</table>
Table 2


<table>
<thead>
<tr>
<th>Nest</th>
<th>Arachnida</th>
<th>Myriapoda</th>
<th>Orthoptera</th>
<th>Dictyoptera</th>
<th>Coleoptera</th>
<th>Lepidoptera</th>
<th>Hymenoptera</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.97/NS</td>
<td>0.07/NS</td>
<td>2015.64/+</td>
<td>1.45/NS</td>
<td>11.62/-</td>
<td>275.60/+</td>
<td>418.62/+</td>
</tr>
<tr>
<td>2</td>
<td>11.88/-</td>
<td>0.06/NS</td>
<td>861.36/+</td>
<td>0.77/NS</td>
<td>6.43/-</td>
<td>226.60/+</td>
<td>468.65/+</td>
</tr>
<tr>
<td>3</td>
<td>2.39/NS</td>
<td>518.48/+</td>
<td>1209.89/+</td>
<td>0.13/NS</td>
<td>17.56/-</td>
<td>0.09/NS</td>
<td>0.12/NS</td>
</tr>
<tr>
<td>4</td>
<td>6.40/-</td>
<td>86.83/+</td>
<td>688.39/+</td>
<td>0.65/NS</td>
<td>17.31/-</td>
<td>45.89/+</td>
<td>0.14/NS</td>
</tr>
<tr>
<td>5</td>
<td>4.55/-</td>
<td>59.40/+</td>
<td>1062.65/+</td>
<td>1.25/NS</td>
<td>16.92/-</td>
<td>2348.27/+</td>
<td>0.17/NS</td>
</tr>
<tr>
<td>6</td>
<td>2.78/NS</td>
<td>0.01/NS</td>
<td>304.16/+</td>
<td>1.82/NS</td>
<td>18.88/-</td>
<td>22.38/+</td>
<td>0.10/NS</td>
</tr>
<tr>
<td>7</td>
<td>0.00/NS</td>
<td>1399.18/+</td>
<td>1116.44/+</td>
<td>0.32/NS</td>
<td>6.11/-</td>
<td>97.34/+</td>
<td>108.31/+</td>
</tr>
<tr>
<td>8</td>
<td>7.76/-</td>
<td>0.12/NS</td>
<td>1073.18/+</td>
<td>0.21/NS</td>
<td>17.40/-</td>
<td>0.12/NS</td>
<td>0.13/NS</td>
</tr>
<tr>
<td>9</td>
<td>2.17/NS</td>
<td>692.00/+</td>
<td>1961.19/+</td>
<td>0.22/NS</td>
<td>17.82/-</td>
<td>132.53/+</td>
<td>0.11/NS</td>
</tr>
<tr>
<td>10</td>
<td>7.19/-</td>
<td>0.11/NS</td>
<td>1134.63/+</td>
<td>26.40/+</td>
<td>2.39/NS</td>
<td>301.20/+</td>
<td>0.13/NS</td>
</tr>
</tbody>
</table>

Table 3

Mean value (± SE) of prey size (mm), handling time (Ht, in s) and number of feeding attempts with each type of prey in southern grey shrike nests. Data from all nests have been combined to obtain a sample size allowing for comparisons.

<table>
<thead>
<tr>
<th>Size [Tamaño]</th>
<th>No. attempts [Intentos]</th>
<th>Ht</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arachnida (N = 9)</td>
<td>9.33 ± 1.10</td>
<td>1.22 ± 0.14</td>
</tr>
<tr>
<td>Myriapoda (N = 8)</td>
<td>49.00 ± 2.47</td>
<td>1.38 ± 0.35</td>
</tr>
<tr>
<td>Orthoptera (N = 183)</td>
<td>23.79 ± 0.34</td>
<td>1.83 ± 0.10</td>
</tr>
<tr>
<td>Coleoptera (N = 8)</td>
<td>15.75 ± 2.05</td>
<td>1.50 ± 0.47</td>
</tr>
<tr>
<td>Lepidoptera (N = 17)</td>
<td>16.47 ± 0.81</td>
<td>1.24 ± 0.13</td>
</tr>
<tr>
<td>Hymenoptera (N = 5)</td>
<td>19.60 ± 2.34</td>
<td>1.40 ± 0.22</td>
</tr>
<tr>
<td>Kruskal-Wallis test</td>
<td>$H_5 = 85.658$</td>
<td>$H_5 = 8.090$</td>
</tr>
<tr>
<td>$P &lt; 0.001$</td>
<td>$P = 0.151$</td>
<td>$P &lt; 0.001$</td>
</tr>
</tbody>
</table>

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position of adults and nestlings may differ (Lepley et al., 2004; Markman et al., 2004). This is the reason why diet composition comparisons must take place between the same life periods. In other areas where the diet of southern grey shrikes has been studied, the percentage of Orthoptera was smaller than the one obtained in this study: 8.2% in Israel (Budden and Wright, 2000), 0-15.9% in Northern Spain (Hernández, 1993), 22.2% in France for fledglings (Lepley et al., 2004).

Furthermore, the limited presence of Coleoptera in the diet in spite of its high availability in all the sampled habitats is noteworthy. The small size of the Coleoptera recorded is probably explains their limited presence. This also differs from the results obtained in Northern Spain where Coleoptera (46.2%) and Hymenoptera (29.0%) were the most abundant prey (Hernández, 1993). Both study areas are close to one another (a distance of 140 km between them), and both belong to the supra-Mediterranean terrain, suggesting a high flexibility in the southern grey shrike in adapting its diet to different local conditions.

The importance of lacertids was limited, as opposed to the data obtained in Southern Iberia where they constitute a common prey for shrikes (Hódar, 2006), although not in Northern Spain (Hernández, 1993) or Southern France (Lepley et al., 2004).

The high availability of arthropods in natural habitats has been put forward as a factor influencing breeding success of shrikes (Giralt et al., 2008). The data from the present study show that the southern grey shrike positively selects Orthoptera (mainly crickets) which are abundant in vineyards and less abundant in natural habitats.

An elevated protein content has been recorded in species of the *Gryllus* genus

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**Fig. 1.**—Percentage of the main groups of prey found in the pitfall traps in three sampled habitats (A: vineyards; B: cereal crops; C: natural habitat).

[Porcentaje de los principales grupos de presas potenciales encontradas en las trampas “pitfall” en los tres tipos de hábitats muestreados (A: viñedos; B: cultivos de cereal; C: hábitat natural).]
(58.3% in *G. testaceus*, Wang et al., 2005). Feeding with a high protein content favours the rapid growth of nestlings (Lavigne et al., 1994, among others). This could therefore be one of the reasons why, in the area studied, the southern grey shrikes select crickets to feed nestlings.

Furthermore, in dry environments, prey with a high water content may be positively selected by passerines feeding nestlings (Banbura et al., 1994). High values of water content have been recorded in Orthoptera of Mediterranean environments (up to 79.5%, Zandt, 1996). In the area under study, annual rainfall is low and environmental temperatures may reach up to 25-30 °C during the breeding period, a reason why southern grey shrike adults could be selecting crickets to maintain the chicks’ water balance.

It is known that, in shrikes, vegetation height decreases preying success on the ground (Yosef and Grubb, 1993). Vineyards are a simplified habitat where herbaceous vegetation is practically absent during the shrikes’ breeding season. In addition, the majority of vineyards in the area studied are currently planted using trellises and, therefore, the number of perches from which to observe and hunt prey is very high. Therefore, it seems plausible to assume that shrikes find abundant prey to feed their nestlings in the vineyards, and that they mainly select Orthoptera there.

Competition and selection operate at the level of individual territories, not at the habitat level (Wilkin et al., 2009). If this is so, the high proportion of Orthoptera recorded in the diet of southern grey shrike’s nestlings would be the result of local adaptation to the local conditions (e.g., high availability). Moreover, feeding nestlings with food of high protein and water content would also be a parental strategy favouring faster and appropriate growth of the nestlings. In Southern Iberia, availability of prey is the primary factor influencing shrike diet composition (Hódar, 2006). However, given the different environmental conditions of our study area, it is advisable to verify more accurately whether availability is the only primary factor determining nestling diet.

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