Ardeola 57(2), 2010, 257-265

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

IMPORTANCIA DE LOS ORTÓPTEROS EN LA DIETA DE POLLOS DE ALCAUDÓN REAL EN ZONAS AGRÍCOLAS

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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, 41º 23' N 05º 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 pitfall 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 Dyctioptera 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, 41º 23' N 05º 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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tipo de hábitat (viñedos, cultivos de cereal, hábitat natural, otros) en un radio de 250 m alrededor de cada nido. La disponibilidad de presas se analizó con trampas pitfall dispuestas en tres tipos de hábitat del área estudiada. Los ortópteros fueron las presas más frecuentes (69,56%, N = 287) y, entre ellos, los grillos *Gryllus campestris* (85,5% del total de ortópteros). Los vertebrados estuvieron poco representados (3,05%). En todos los nidos los ortópteros fueron seleccionados positivamente por los adultos. Arácnidos y coleópteros no fueron seleccionados positivamente en ningún nido, pero sí negativamente en el 50% y 90% de nidos, respectivamente. Miriápodos, himenópteros y dictiópteros fueron capturados en similar proporción a la encontrada en las trampas pitfall. Miriápodos y ortópteros fueron las presas de mayor tamaño, y arácnidos y coleópteros las de menor. La elevada proporción de ortópteros en la dieta de los pollos puede ser una respuesta de los alcaudones a la transformación del hábitat en un agroecosistema, ya que: (i) son muy abundantes en viñedos, donde el elevado número de perchas disponibles y la ausencia de vegetación herbácea hace que los alcaudones accedan a ellos con facilidad; (ii) tienen un alto contenido en proteínas y agua, lo que probablemente facilita un mejor y más rápido crecimiento de los pollos.

*Palabras clav*e: alcaudón real, alimento de la pollada, áreas agrícolas, España, *Lanius meridionalis*, ortópteros.

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 (41º 23' N 05º 16' W), in May and June 2008. The vegetation of this area belongs to the *Junipero thuriferae – Querceto rotundifoliae* S. series of the supra-Mediterranean terrain (Rivas-Martínez, 1987). The mean annual temperature is 12.2 ºC 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 in habitat A * % of habitat A in territory 1) + (D in habitat B * % of habitat B in territory 1) + (D in habitat C * % of habitat C 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 be 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.

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 of 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 Dyctioptera 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 Dyctioptera 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.]

	Nests										
	1	2	3	4	5	6	7	8	9	10	**Average**
Arachnida	4.35	13.32	4.76	–	–	–	5.40	–	4.00	–	3.18
Myriapoda	–	–	9.53	5.26	2.56	–	8.10	–	8.00	–	3.35
Orthoptera	71.74	60.00	76.19	84.22	61.54	60.00	45.95	80.00	84.00	72.00	69.56
Dictyoptera	–	–	–	–	-	–	–	–	–	4.00	0.40
Coleoptera	2.17	6.67	–	–	-	–	5.40	–	–	12.00	2.62
Lepidoptera	6.52	6.67	–	5.26	23.08	4.00	2.71	–	4.00	8.00	6.02
Hymenoptera	4.35	6.67	–	–	-	–	2.71	–	–	–	1.37
Insecta indet.	10.87	–	4.76	5.26	7.69	32.00	29.73	10.00	–	4.00	10.43
Vertebrata	–	6.67	4.76	–	5.13	4.00	–	10.00	–	–	3.06
Total prey *[Total de presas]*	46	30	21	19	39	25	37	20	25	25	
% cereal crops *[Cereales]*	26.2	67.0	82.1	46.9	1.5	18.6	78.7	72.6	87.1	46.1	
% vineyards *[Viñedos]*	49.4	23.3	3.1	16.6	28.7	66.3	8.7	4.9	6.1	7.0	
% natural habitat *[Hábitat natural]*	20.6	4.4	11.4	32.6	54.2	0.4	8.6	18.8	4.2	14.5	
% others *[Otros]*	3.8	5.3	3.4	3.9	15.6	14.7	4.0	3.7	2.6	32.4	
T	5.00	4.77	4.27	3.98	4.25	2.62	5.37	3.10	4.60	3.55	

TABLE 2

Prey selection (arthropods) in ten southern grey shrike nests calculated using Savage's index. MS: Manly *et al*. (1993) statistics. S: diet selection (+: positive selection; –: negative selection; NS: no selection).
[Selección de presa (artrópodos) en diez nidos de alcaudón real calculada mediante el índice de Savage. MS: estadístico de Manly et al. *(1993). S: selección de presa (+: selección positiva; –: selección negativa; NS: no selección).]*

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

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.
[Valor medio (± SE) de tamaño de presa (mm), tiempo de manejo (Ht, en s) y número de intentos para alimentar con cada tipo de presa en nidos de alcaudón real. Se han agrupado los datos de todos los nidos para obtener un tamaño de muestra suficiente que permita comparaciones.]

	Size *[Tamaño]*	**No. attempts** *[Intentos]*	**Ht**
Arachnida (N = 9)	9.33 ± 1.10	1.22 ± 0.14	3.56 ± 0.86
Myriapoda (N = 8)	49.00 ± 2.47	1.38 ± 0.35	11.75 ± 2.67
Orthoptera (N = 183)	23.79 ± 0.34	1.83 ± 0.10	8.31 ± 0.66
Coleoptera (N = 8)	15.75 ± 2.05	1.50 ± 0.47	5.75 ± 2.61
Lepidoptera (N = 17)	16.47 ± 0.81	1.24 ± 0.13	2.00 ± 0.51
Hymenoptera (N = 5)	19.60 ± 2.34	1.40 ± 0.22	7.60 ± 1.69
Kruskal-Wallis test	$H_5 = 85.658$	$H_5 = 8.090$	$H_5 = 45.008$
	$P < 0.001$	$P = 0.151$	$P < 0.001$

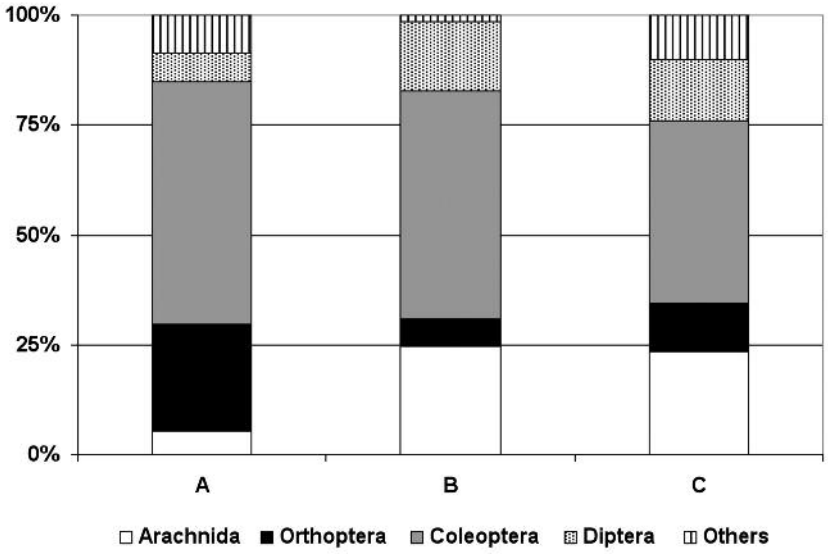

FIG. 1.—Percentage of the main groups of prey found in the pitfall traps in three sampled habitats (A: vineyards; B: cereal crops; C: natural habitat).
[Porcentaje de los principales grupos de presas potenciales encontradas en las trampas "pitfall" en los tres tipos de hábitats muestreados (A: viñedos; B: cultivos de cereal; C: hábitat natural).]

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

(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 ºC 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.

ACKNOWLEDGEMENTS.—This work was financed by the Obra Social de Caja España. J. J. Soler and two anonymous referees made valuable comments and improved the submitted manuscript. Our thanks to D. Alonso for the assistance in the field work. The Centro Meteorológico de Castilla y León provided meteorological data.

BIBLIOGRAPHY

BANBURA, J., BLONDEL, J., DE WILDE-LAMBRECHTS, H., GALAN, M. J. and MAISTRE, M. 1994. Nestling diet variation in an insular Mediterranean population of Blue Tits *Parus caeruleus*: effects of years, territories and individuals. *Oecologia*, 100: 413-420.

BANBURA, J., LAMBRECHTS, M. M., BLONDEL, J., PERRET, P. and CARTAN-SON, M. 1999. Food handling time of Blue Tit chicks: constraints and adaptation to different prey items. *Journal of Avian Biology*, 30: 263-270.

BUDDEN, A. E. and WRIGHT, J. 2000. Nestling diet, chick growth and breeding success in the southern grey shrike (*Lanius meridionalis*). *Ring*, 22: 165-172.

CAMPOS, F. and LEKUONA, J. M. 1997. Temporal variations in the feeding habits of the Purple Heron *Ardea purpurea* during the breeding season. *Ibis*, 139: 447-451.

COOPER, R. J. and WHITMORE, R. C. 1990. Arthropod sampling methods in ornithology. *Studies in Avian Biology*, 13: 29-37.

GARDEN, J. G., MCALPINE, C. A., POSSINGHAM, H. P. and JONES, D. N. 2007. Using multiple survey methods to detect terrestrial reptiles and mammals: what are the most successful and cost-efficient combinations? *Wildlife Research*, 34: 218-227.

GIRALT, D., BROTONS, L., VALERA, F. and KRISTIN, A. 2008. The role of natural habitats in agricul-

tural systems for bird conservation: the case of the threatened Lesser Grey Shrike. *Biodiversity and Conservation*, 17: 1997-2012.

GUTIÉRREZ-CORCHERO, F., CAMPOS, F., HERNÁNDEZ, M. A. and AMEZCUA, A. 2007. Biometrics of the Southern Grey Shrike *Lanius meridionalis* in relation to sex and age. *Ringing & Migration*, 23: 141-146.

HERNÁNDEZ, A. 1993. Dieta de los pollos de tres especies simpátricas de alcaudones (*Lanius* spp.): variaciones con la edad, estacionales e interespecíficas. *Doñana, Acta Vertebrata*, 20: 145-163.

HERNÁNDEZ, A. and INFANTE, O. 2004. Alcaudón Real, *Lanius meridionalis*. In, A. Madroño, C. González and J. C. Atienza (Eds.): *Libro Rojo de las Aves de España*, pp. 351-354. Dirección General para la Biodiversidad-SEO/Birdlife. Madrid.

HÓDAR, J. A. 2006. Diet composition and prey choice of the southern grey shrike *Lanius meridionalis* L. in South-eastern Spain: the importance of vertebrates in the diet. *Ardeola*, 53: 237-249.

KOKS, B. J., TRIERWEILER, C., VISSER, E. G., DIJKSTRA, C. and KOMDEUR, J. 2007. Do voles make agricultural habitat attractive to Montagu's Harrier *Circus pygargus*? *Ibis*, 149: 575-586.

LAVIGNE, A. J., BIRD, D. M., NEGRO, J. J. and LACOMBE, D. 1994. Growth of hand reared American kestrels. 1. The effect of 2 different diets and feeding frequency. *Growth Development and Aging*, 58: 191-201.

LEFRANC, N. and WORFOLK, T. 1997. *Shrikes. A Guide to the Shrikes of the World*. Pica Press. Sussex.

LEPLEY, M., THEVENOT, M., GUILLAUME, C. P., PONEL, P. and BAYLE, P. 2004. Diet of the nominate Southern Grey Shrike *Lanius meridionalis meridionalis* in the north of its range (Mediterranean France). *Bird Study*, 51: 156-162.

LOW, M., EGGERS, S., ARLT, D. and PÄRT, T. 2008. Daily patterns of nest visits are correlated with ambient temperature in the Northern Wheatear. *Journal of Ornithology*, 149: 515-519.

MANLY, B., MCDONALD, L. and THOMAS, D. 1993. *Resource selection by animals. Statistical design and analysis for field studies*. Chapman & Hall. London.

MARKMAN, S., PISHOW, B., WRIGHT, J. and KOTLER, B. P. 2004. Food patch use by parent birds: to gather food for themselves or for their chicks? *Journal of Animal Ecology*, 73: 747-755.

PADILLA, D. P., NOGALES, M. and PÉREZ, A. J. 2005. Seasonal diet of an insular endemic population of Southern Grey Shrike *Lanius meridionalis koenigi* on Tenerife, Canary Islands. *Ornis Fennica*, 82: 155-165.

PADILLA, D. P., GONZÁLEZ-CASTRO, A., NIEVES, C. and NOGALES, M. 2009. Trophic ecology of the Southern Grey Shrike (*Lanius meridionalis*) in insular environments: the influence of altitude and seasonality. *Journal of Ornithology*, 150: 557-568.

RIVAS-MARTÍNEZ, S. 1987. *Mapa de series de vegetación de España*. ICONA. Ministerio de Agricultura. Madrid.

SAVAGE, R. E. 1931. The relation between the feeding of the herring off the cast coast of England and the plankton of the surrounding waters. *Fishery Investigation, Ministry of Agriculture, Food and Fisheries, Series 2*, 12: 1-88.

STEPHENS, D. W. and KREBS, J. R. 1986. *Foraging theory*. Princeton University Press. Princeton.

TREMBLAY, I., THOMAS, D., BLONDEL, J., PERRET, P. and LAMBRECHTS, M. M. 2005. The effect of habitat quality on foraging patterns, provisioning rate and nestling growth in Corsican Blue Tits *Parus caeruleus*. *Ibis*, 147: 17-24.

WANG, D., ZHAI, S. W., ZHANG, C. X., BAI, Y. Y., AN, S. H. and XU, Y. N. 2005. Evaluation on nutritional value of field crickets as a poultry feedstuff. *Asian-Australasian Journal of Animal Sciences*, 18: 667-670.

WILKIN, T. A., KING, L. E. and SHELDON, B. C. 2009. Habitat quality, nestling diet, and provisioning behaviour in great tits *Parus major*. *Journal of Avian Biology*, 40: 135-145.

YOSEF, R. and GRUBB, T. C. JR. 1993. Effect of vegetation height on hunting behaviour and diet of loggerhead shrikes. *Condor*, 95: 127-131.

ZANDT, H. S. 1996. Water content of prey of nestling blue tits in a Corsican habitat. *Netherlands Journal of Zoology*, 47: 125-131.

[Recibido: 27-10-2009]
[Aceptado: 12-01-2010]