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Seasonal diet of an insular endemic population of Southern Grey Shrike *Lanius meridionalis koenigi* on Tenerife, Canary Islands

David P. Padilla*, Manuel Nogales & Antonio J. Pérez

*Padilla, D.P., Island Ecology and Evolution Research Group (IPNA-CSIC), La Laguna 38206, Tenerife, Canary Islands, Spain. dpadilla@ipna.csis.es (*Corresponding author)*
Nogales, M., Island Ecology and Evolution Research Group (IPNA-CSIC), La Laguna 38206, Tenerife, Canary Islands, Spain
Pérez, A.J., Department of Animal Biology (Zoology), University of La Laguna, 38206, Tenerife, Canary Islands, Spain

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The diet and prey selection of the Southern Grey Shrike (*Lanius meridionalis koenigi*) was studied in one of the scarce insular environments where it is present, the xeric coastal area of Tenerife (Canary Islands). The main aim of this study was to compare the general trophic patterns with respect to continental populations of Northern Grey Shrike (*Lanius excubitor*) and Southern Grey Shrike. The material analysed consisted in 440 pellets collected during the four seasons of the year in the period April 2003–March 2004. A total of 5,112 prey items were identified, 85.4% corresponding to beetles (mainly Curculionidae and Tenebrionidae) and the rest consisted of other arthropods and vertebrates. Biomass mainly constituted of vertebrates, especially lizards (64.0%). Slight seasonal variations in diet were recorded, beetles and lizards being highly consumed in all seasons. A positive selection of some beetles, non-Formicidae Hymenoptera and Orthoptera (*Schistocerca gregaria*) was observed. The data obtained in the present study confirms the hypothesis of how the Southern Grey Shrike relies on cold-blooded prey in hot climate (e.g. south of France), while the Great Grey Shrike mainly relies on warm-blooded prey in cold climate (e.g. Scandinavian Peninsula). The importance of lizards in the diet of this insular shrike population could be related to three different ecological factors: (1) the high abundance of these ectotherm vertebrates in island environments, (2) the higher effectiveness of predation and (3) lower investment of energy to capture them.

1. Introduction

The Southern Grey Shrike *Lanius meridionalis* only occurs in the old world, throughout the Saharo-Sindian xeric zone and in the extreme South-West of Europe, Iberian Peninsula and southern France, where ten subspecies are currently recognized (Lefranc & Worfolk 1997). The Canarian endemic subspecies *Lanius meridionalis koenigi* is the only island population in the Atlantic Ocean and one of the two existing insular subspecies throughout the species' range. The other is *L. m. uncinatus*, in Socotra Island (Yemen). In the Canaries it occupies the islands of Tenerife, Gran

Canaria, Fuerteventura and Lanzarote, in open shrub environments, inhabiting zones that extend from coastal xeric areas to high mountains (Martín & Lorenzo 2001). Contributions on the Southern Grey Shrike's diet ecology are scarce and restricted to only three continental zones: *Lanius meridionalis elegans/aucheri* in the Negev' desert in Israel (Yosef *et al.* 1991, Budden & Wright 2000) and *Lanius meridionalis meridionalis* in Spain (Hernández *et al.* 1993, Hernández 1995a, 1995b, 1995c) and southern France (Lepley *et al.* 2004). There, arthropods in Europe, and lizards and beetles in Israel were the most important kinds of prey.

The Southern Grey Shrike is currently considered to be a separate species from the Great Grey Shrike *Lanius excubitor* (Snow & Perrins 1998). The diet of the latter species has been studied relatively often (Cade 1967, Huhtala *et al.* 1977, Bassin *et al.* 1981, Grünwald 1983, 1984, Olsson 1986, Atkinson & Cade 1993, Hromada & Krištín 1996, Karlsson 2001, 2002). The Great Grey Shrike's main prey is small mammals (e.g. *Microtus* spp) all year round, with an increasing proportion of birds in winter and also in spring for some populations (Lorek *et al.* 2000). Schön (1998) and Lepley *et al*. (2004) showed that the Great Grey Shrike relies mainly on endothermic prey in cold climatic zones while the Southern Grey Shrike preys on ectothermic species in warmer areas. However, this hypothesis has not yet been confirmed in one of the southernmost populations of the species geographic range, which is essential for testing this latitudinal trend variation of the diet.

No reports on the shrike's diet in the Canary Islands have yet been published, and the only specific data available indicated that lizards and beetles also form a part of their staple diet (see Martín & Lorenzo 2001 and references therein). Other studies performed in the islet of Alegranza showed that *L. m. koenigi* is a legitimate secondary seed disperser of a Solanaceae plant (*Lycium intricatum*) when it preys intensively on the endemic frugivorous lizard *Gallotia atlantica* (Nogales *et al.* 1998, 2002).

Four main aims were pursued in the present study: First, we assess the seasonal diet composition of this insular endemic Shrike. Second, we evaluate trophic selection during each season. Third, we compare these insular trophic patterns with those of the different continental populations of Southern Grey Shrike. Lastly, we study how some prey items change in the shrike diet according to North-South latitudinal variation.

2. Material and methods

2.1. Study area

The volcanic Canarian Archipelago is situated in the Atlantic Ocean about 100 km from the African continent at its nearest point (27º37'–29º25'N and 13º20'–29º25'W). Fieldwork was carried out in "Malpaís de La Rasca" and surrounding areas, located at the southernmost point of Tenerife. This badland (hereafter "Malpaís") has been declared a "Special Nature Reserve" (Martín *et al*. 1995). The study area is a "Malpaís" of lava field (ca 3.15 km^2) which was produced by two main volcanic cones, Montaña Gorda and Montaña Guzada (Carracedo *et al*. 2003).

The climate is xeric, this area receiving the island's lowest mean annual rainfall (98 mm) and being one of the warmest (annual mean temperature: ca 22 ºC; Marzol Jaén 1988). However, two climatic periods can be identified in this semiarid habitat: drier (spring and summer; mean rainfall and temperature of 11.2 mm and 22.5 ºC respectively); and rainier (autumn and winter; 86.7 mm and 22.2 ºC). The vegetation consists of a sparse xerophytic shrub, mainly composed of *Launaea arborescens, Lycium intricatum, Salsola divaricata, Schizogyne glaberrima, Euphorbia balsamifera, E. canariensis, Reseda scoparia, Periploca laevigata, Plocama pendula* and the invasive *Opuntia dillenii* (for further information about vegetation see Arco-Aguilar *et al*. 1997).

2.2. Pellets sampling

The study was carried out from April 2003 to March 2004, and this period being divided into four seasons (spring: March, April and May; summer: June, July and August; autumn: September, October and November; and winter: December, January and February). A total of 440 adult pellets were collected (spring: 115, summer: 116, autumn: 93 and winter: 116) in 14 different territories (8 with breeding records and another 6 without any record of breeding). A mean number of ten pellets per territory and season was collected in order to have an adequate representation of the population diet. To minimize seasonal sample bias, only fresh pellets were collected after having regularly cleaned beneath the perches.

2.3. Diet analysis

We identified and counted all the remains of arthropods (heads, mandibles, legs and sclerotized parts) and vertebrates (bones, hair and teeth), estimating the minimum number of each prey item per pellet. To identify the ingested prey to family level, each pellet was analysed individually with a 16x binocular, following the methods of Calver & Wooller (1982), Ralph *et al*. (1985) and Moreby (1988). Doubtful prey remains were compared with the collection at the Department of Animal Biology (University of La Laguna). We also revised regularly the larders and determined those prey found in them.

The results are expressed in number of prey items that appeared each season and calculated the percentage of total number of prey items, frequency of occurrence and total biomass. Wet biomass was calculated using an average representative weight (M. Nogales unpubl.) of vertebrate prey species, lizards and geckos. Mean weights for mammals were obtained from the literature (Castells & Mayo 1993). As for arthropods, we collected several individuals (five at least) of each identified taxon in the diet, and took their live weight using an electronic balance (precision: 0.0001 g). It was decided to employ wet biomass because water is particularly essential in xeric habitats (Lepley *et al*. 2004).

2.4. Food availability

The Southern Grey Shrike hunts mainly on the ground (Cramp & Perrins 1993), although *L. m. koenigi* was observed capturing insects in shrubs. Thus, three different methods were employed to estimate invertebrate availability following Cooper & Whitmore (1990), Dahlsten *et al*. (1990) and Wolda (1990). To analyse ground arthropods, a square of 0.25 m^2 was sampled and all individuals larger than five millimetres were counted over two minutes. A total of 60 samples were taken per season, divided into 7 line transects (transect length: 200 m; and 20 m between sample square), in order to cover the major part of the shrike territories. Furthermore, 30 pitfall traps were placed in the same line transects and left in the field for one week. Propylene-glycol was placed inside to preserve the invertebrates. 10 Plants of the main species were also analysed per season (*Launaea arborescens, Lycium intricatum, Salsola divaricata, Schizogyne glaberrima, Euphorbia balsamifera* and *Plocama pendula*) to estimate the number of arthropods living in those shrubs. Each season, we placed a "beating tray" beneath these plants and gently struck them to remove the arthropods residing in the vegetation. Previously, flying insects on these plants were counted in order to identify and quantify all the arthropods in each one.

In regard to vertebrates, only the relative abundance of lizards (*Gallotia galloti*) was calculated because the remaining species were scarce in the Canarian shrike diet (see Martín & Lorenzo 2001 and references therein). Line transects (100 m length) were employed and lizards were counted from five metres on both sides of the observer (Díaz & Carrascal 1990). The censuses were begun at 12:00 hours (midday) on fair days and a total of 20 transects were performed in each season. Due to the fact that shrikes do not prey upon larger lizards (Hernández 1995c), these were classified in three different size categories (small: snout vent length, SVL: < 5 cm; medium: SVL: 5–10 cm; and large: SVL: > 10 cm).

2.5. Statistical and index analysis

In order to avoid sample bias among territories, the samples were standardised by analysing a mean of ten pellets per territory and season. Likelihood ratio tests were applied to study seasonal variations of the main items found in the diet. Similarity or overlap in Shrike diet among the different seasons was evaluated using the Morisita index of similarity for percentage of prey, in which values near "0" indicate low similarity and values near "1" indicate high similarity. Moreover, niche-breadth was assessed using the standardized Levin's niche-breadth index (B), where a value close to "0" indicates dietary specialization and a value close to "1" shows a broad diet (Krebs 1989).

To evaluate diet selection of the main groups of arthropods, the "forage index" FIS of Savage (1931) (eq. 1) was applied, being defined as

$$\mathrm{FIS} = \frac{U_i}{D_i}, \quad (1)$$

where the proportion of used units (U_i)is divided by the proportion of available units (D_i). The statistical significance of these measurements was tested by calculating the Manly statistic

$$\mathrm{MS} = \frac{(W_i - 1)^2}{\mathrm{SE}(W_i)^2}, \quad (2)$$

where W_i is the Savage "forage index" for the arthropod species i, and SE(W_i) its standard error. We compared MS with the corresponding critical value of a chi-square distribution with one degree of freedom (Manly *et al.* 1993). We estimated SE(W_i) on the *a priori* assumption that there was no prey selection, such that the standard error of W_i was approximated by

$$\mathrm{SE}(W_i) = \frac{\sqrt{1 - D_i}}{u_{tot} D_i}, \quad (3)$$

where u_{tot} is the total number of used resources in each season, and D_i is the proportion of available arthropods of the species i.

3. Results

3.1. General diet

A total of 5,112 prey items were identified, 96.3% corresponding to arthropods and the remainder consisted of vertebrates (mainly lizards) (Table 1). Beetles (85.4% of the prey items) represented the main invertebrate group, Curculionidae (49.5%) and Tenebrionidae (34.5%) being the most important. The other arthropods caught corresponded to Hymenoptera, Orthoptera, Hemiptera, Odonata, Dictyoptera, and Araneae in decreasing importance, no Lepidoptera larvae being found.

The main prey item with respect to vertebrates was constituted by reptiles (83.8%) and the remainder were small mammals. 93.7% of the reptiles corresponded to the endemic lizard (*Gallotia galloti*) while the other prey found consisted of Gekkonidae (*Tarentola delalandii*). With regard to small mammals, two introduced species in the Canary Islands, *Mus domesticus* and *Suncus etruscus,* were identified. Only five lizards and one Coleoptera (Tenebrionidae) were found in larders and, due to their low number, were not included in the diet analysis.

In terms of biomass, the diet mainly consisted of vertebrates (87.6%), the most important groups being lizards (64.0%) and house mice (21.3%). Arthropods accounted for the remainder, 12.4% (mainly Coleoptera: 9.2% and Orthoptera: 2.3%) (Table 1). Lastly, a total of 824 seeds were identified inside the pellets (13.6% of occurrence), *Lycium intricatum* (Solanaceae) being the principal species and constituting 95.4% of the total number.

3.2. Seasonal variation in diet

Despite the fact that beetles and lizards characterised the diet throughout the year, in regard to frequent presence and biomass respectively, the food spectrum of this shrike showed a seasonal variation when the data were analysed separately between two periods, one drier (spring and summer) and the other rainier (autumn and winter). A considerable overlap can be observed between seasons in these two periods (Morisita Index, spring–summer: $C_\lambda = 0.96$; autumn–winter: $C_\lambda = 0.99$). The minimum overlap corresponded to spring–autumn and summer–autumn with C_λ: 0.54 and C_λ: 0.73, respectively. Niche breadth was very restricted in all seasons, the minimum value being obtained in the drier period and the highest in the rainier one (Levin's niche-breadth index, spring: $B = 0.04$; summer: $B = 0.08$; autumn $B = 0.10$; winter $B = 0.14$).

Beetles appeared with the highest prevalence in all seasons but there were differences in composition at the family level. Curculionidae characterised the drier seasons ($G_1 = 853.53$, $P < 0.001$) and Tenebrionidae the rainier ones ($G_1 = 906.36$, $P < 0.001$). The highest frequencies of Hymenoptera,

Table 1. Diet composition of the Southern Grey Shrike *Lanius meridionalis koenigi* over a year (April 2003 – March 2004) in a dry coastal area of Tenerife, Canary Islands. NP, number of prey items;% P, percentage of prey;% O, occurrence frequency in pellets;% B, percentage of wet biomass; NS, number of seeds;% S, percentage of seeds; * values less than 0.1%.

	Spring				Summer				Autumn				Winter			
Prey items	NP	% P	% O	% B	NP	% P	% O	% B	NP	% P	% O	% B	NP	% P	% O	% B
Coleoptera	967	87.2	100.0	5.2	953	83.4	99.1	9	1081	90.9	100.0	13.7	1365	81.7	99.1	11.5
Curculionidae	866	78.0	96.5	3.9	706	61.7	94.8	3.9	378	31.8	92.5	3.2	579	34.6	88.8	3.5
Tenebrionidae	71	6.4	31.3	1.1	235	20.6	62.9	5	699	58.7	88.2	10.5	759	45.5	85.3	7.7
Scarabaeidae	11	1.0	8.7	0.1	3	0.3	2.6	*	–	–	–	–	9	0.5	6.0	0.1
Carabidae	–	–	–	–	–	–	–	–	–	–	–	–	4	0.2	3.4	*
Chrysomelidae	10	0.9	2.6	*	1	0.1	0.9	*	–	–	–	–	–	–	–	–
Staphylinidae	5	0.5	4.3	*	2	0.2	1.7	*	2	0.2	2.2	*	13	0.8	9.5	0.2
Cerambycidae	4	0.4	2.6	*	6	0.5	4.3	0.1	2	0.2	2.2	*	1	0.1	0.9	*
Hymenoptera	56	5.0	27.0	0.3	79	6.9	32.8	0.4	62	5.2	43.0	0.6	191	11.4	57.8	1.3
Formicidae	18	1.6	9.6	*	32	2.8	16.4	*	14	1.2	12.9	*	42	2.5	21.6	*
non-Formicidae	38	3.4	20.9	0.2	47	4.1	21.6	0.4	48	4.0	38.7	0.6	149	8.9	52.6	1.3
Orthoptera	8	0.7	7.0	0.3	25	2.2	18.1	1.1	3	0.3	3.2	0.2	41	2.4	25.9	8
Acrididae (small)	8	0.7	7.0	0.3	25	2.2	18.1	1.1	3	0.3	3.2	0.2	14	0.8	12.1	0.6
Schistocerca gregaria	–	–	–	–	–	–	–	–	–	–	–	–	27	1.6	17.2	7.4
Dictyoptera	–	–	–	–	1	0.1	0.9	*	–	–	–	–	–	–	–	–
Mantidae	–	–	–	–	1	0.1	0.9	*	–	–	–	–	–	–	–	–
Hemiptera	8	0.8	7.0	0.1	27	2.4	12.9	0.2	5	0.4	5.4	0.1	29	1.7	23.3	0.5
Coreidae	5	0.5	4.3	0.1	24	2.1	12.9	0.1	4	0.3	4.3	*	10	0.6	7.8	*
Pentatomidae	3	0.3	2.6	*	3	0.3	2.6	0.1	1	0.1	1.1	*	19	1.1	16.4	0.4
Odonata	5	0.5	3.5	*	1	0.1	0.9	*	–	–	–	–	2	0.1	1.7	*
Araneae	–	–	–	–	1	0.1	0.9	*	–	–	–	–	–	–	–	–
Hexapoda	–	–	–	–	1	0.1	0.9	–	5	0.4	5.4	–	5	0.3	4.3	–
Vertebrata	64	5.8	45.2	94.1	53	4.7	36.2	89.3	33	2.8	34.4	85.4	41	2.4	34.5	78.5
Lacertidae (*Gallotia galloti*)	47	4.2	39.1	61.5	44	3.9	30.2	72.1	23	1.9	24.7	56.5	36	2.1	31	63.7
Gekkonidae (*Tarentola delalandii*)	3	0.3	2.6	2.1	4	0.4	3.4	3.5	3	0.3	3.2	4.0	–	–	–	–
Muridae (*Mus domesticus*)	14	1.3	12.2	30.5	5	0.4	4.3	13.7	6	0.5	6.5	24.5	5	0.3	4.3	14.8
Soricidae (*Suncus etruscus*)	–	–	–	–	–	–	–	–	1	0.1	1.1	0.4	–	–	–	–
Total of prey	1108				1141				1189				1674			
Seed component	NS	% S	% O		NS	% S	% O		NS	% S	% O		NS	% S	% O	
Lycium intricatum	434	99.1	20.0		84	75.0	7.8		134	98.5	12.9		134	97.1	13.8	
Patellifolia patellaris	–	–	–		1	0.9	0.9		–	–	–		2	1.4	1.7	
Atriplex semibaccata	–	–	–		–	–	–		–	–	–		2	1.4	0.9	
Volutaria canarensis	3	0.7	2.6		–	–	–		–	–	–		–	–	–	
Plocama pendula	–	–	–		6	5.4	1.7		–	–	–		–	–	–	
Unidentified seeds	1	0.2	0.9		21	18.7	4.3		2	1.5	2.2		–	–	–	
Total of seeds	438				112				136				138			
Total of pellets	115				116				93				116			

Table 2. Trophic selection by the Southern Grey Shrike on arthropods using the "forage index" of Savage (1931) and following the method proposed by Manly *et al.* (1993), in Tenerife, Canary Islands. PA, proportion of invertebrate availability in shrike territories; FIS, values of the "forage index" of Savage; MS, values of the Manly statistic; DS, diet selection; S^+, positive selection; S^-, negative selection; NS, no selection.

	Spring				Summer				Autumn				Winter			
Prey items	PA	FIS	MS	DS	PA	FIS	MS	DS	PA	FIS	MS	DS	PA	FIS	MS	DS
Coleoptera	31.6	2.75	1581.9	S^+	46.6	1.78	622.7	S^+	50.7	1.79	769.7	S^+	31.4	2.6	1959.3	S^+
Curculionidae	25.7	3.03	1592.5	S^+	24.0	2.5	897.3	S^+	5.5	5.74	1569.6	S^+	4.3	7.99	3705.7	S^+
Tenebrionidae	5.9	1.07	0.4	NS	22.6	0.9	2.8	NS	45.2	1.30	89.15	S^+	23.8	1.90	429.1	S^+
Hymenoptera	13.9	0.36	71.9	S^-	22.7	0.30	161.3	S^-	23.1	0.22	213.1	S^-	38	0.30	497.1	S^-
Formicidae	13.9	0.17	138.9	S^-	22.7	0.12	256.8	S^-	22.6	0.05	311.5	S^-	36.4	0.06	823.3	S^-
non-Formicidae	–	3.4	67.2	S^+	–	3.08	67.3	S^+	0.5	8.7	331.5	S^+	1.6	5.48	556	S^+
Orthoptera	5.9	0.12	54	S^-	9.3	0.23	68.7	S^-	–	–	–	–	2.7	0.9	0.4	NS
Acrididae (small size)	5.9	0.12	54	S^-	9.3	0.23	68.7	S^-	–	–	–	–	2.2	0.38	13.9	S^-
Schistocerca gregaria	–	–	–	–	–	–	–	–	–	–	–	–	0.5	2.98	35.8	S^+
Dictyoptera	–	–	–	–	1.3	0.06	13.4	S^-	0.5	–	–	–	–	–	–	–
Mantidae	–	–	–	–	1.3	0.06	13.4	S^-	0.5	–	–	–	–	–	–	–
Hemiptera	17.9	0.04	221.2	S^-	1.3	1.77	9.2	S^+	0.5	0.91	0.04	NS	3.8	0.45	19.3	S^-
Coreidae	2.0	0.22	13.3	S^-	1.3	1.57	5.1	S^+	–	–	–	–	–	–	–	–
Pentatomidae	1.0	0.27	5.84	S^-	–	–	–	–	–	–	–	–	0.5	2.09	11	S^+
Araneae	19.8	–	–	–	9.3	0.009	115.2	S^-	12	–	–	–	15.2	–	–	–

Orthoptera and Hemiptera were reached in winter, coinciding with maximum niche breadth. Vertebrates were more frequently caught in drier seasons than in rainier ones ($G_1 = 23.81$, $P < 0.001$). Lizards and house mice, the principal vertebrate prey, peaked in spring, which was a different pattern than the other prey items showed (Table 1).

3.3. Food availability and diet selection

Beetles were positively selected in all seasons. Curculionidae were preferred all year round, whereas Tenebrionidae were chosen in autumn and winter (Table 2). With regard to Hymenoptera, shrikes showed a negative prey selection, but upon considering Formicidae and non-Formicidae (principally bees and wasps) separately, a positive prey selection was observed in all seasons for the latter group. Orthoptera species were negatively selected in all seasons with the exception of winter. In this period, small Acrididae were negatively selected while the Desert Locust (*Schistocerca gregaria*) showed a clear positive selection. Practically no spiders were found in the diet, but they frequently appeared in the arthropod availability samples, therefore shrikes were negatively selecting this invertebrate group. Total availability of small and medium size lizards was maximal during the spring, coinciding with the highest presence in pellets (Fig. 1).

4. Discussion

4.1. Diet composition, seasonal variation and prey selection

Beetles (mainly Curculionidae and Tenebrionidae) followed by hymenopterans and vertebrates were the most common prey consumed by the Southern Grey Shrike in the dry coastal habitat located in south Tenerife. However, in terms of biomass, vertebrates (especially lizards) provided the most important contribution. Despite the scant information available on the diet of this bird in the Canaries, these data agree with the greater part of the existing descriptive information, lizards and beetles being the principal prey (see Martín & Lorenzo 2001 and references therein).

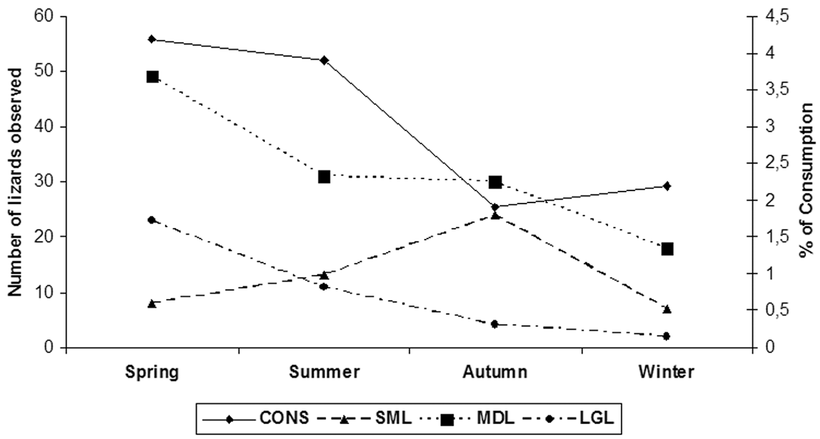

Fig. 1. Seasonal availability of lizards and their consumption by Southern Grey Shrike in a dry coastal area of Tenerife, Canary Islands. SML, small lizards; MDL, medium lizards; LGL, large lizards; CONS, consumption of small and medium size lizards.

The diet of the Canarian Southern Grey Shrike showed a slight seasonal variation, Coleoptera and vertebrates forming the most important prey throughout the year. However, some differences can be appreciated if the data are analysed as a function of the two previously defined periods (dry: spring and summer; and rainy: autumn and winter), as indicated by the results obtained in the Morisita index. These data, together with Levin's niche breadth, suggest that diet is more homogeneous during drier seasons than rainier ones, coinciding with the lowest availability of the main biomass source (the lizards). These results agree with the optimal foraging theory, in which niche breadth increases when availability of principal prey decreases (Krebs *et al.* 1983).

The relevant consumption of Curculionidae in the dry period and Tenebrionidae in the rainy one coincides with their respective population explosions in the field. The high relative importance shown by Orthoptera in winter, mainly represented by the Desert Locust (*Schistocerca gregaria*), has its origin in the arrival of the characteristically strong Saharan desert winds that carry this large insect. In general, this tendency to prey upon the most abundant available prey items coincides with the opinion of several authors, who consider the Southern Grey Shrike as a generalist predator that exhibits a great capacity to change its diet in relation to prey availability (Hernández 1993, Lefranc & Worfolk 1997).

Regarding the presence of vertebrates in this study, the highest number of captures (mainly lizards) was recorded in spring and summer (driest and hottest seasons), which coincides with shrikes nestling and fledgling periods. Furthermore, in the warmest and sunniest seasons, ectotherms such as lizards show their greatest activity. Moreover, lizards are available all year round and are thus attractive prey for Southern Grey Shrikes. In general, the abundance of some animals, such as lizards, is higher on islands than on the continent, because of lower predation and competition pressure, or larger trophic niche breadth (Case 1975, Benett & Gorman 1979, Evans & Evans 1980, Brown *et al.* 1992, Olesen & Valido 2003). The Canarian Archipelago is no exception to this phenomenon (Castanet & Báez 1988, Molina-Borja 1991, Rodríguez *et al.* 1994, Valido 1999, Olesen & Valido 2003).

Southern Grey Shrikes diet showed positive prey selection in groups such as Coleoptera and Hymenoptera (non-Formicidae) throughout the year, and Orthoptera (*Schistocerca gregaria*) in winter. This pattern coincides with those recorded in the Iberian Peninsula diet (Hernández *et al.* 1993). In addition, it is interesting to note that a total of 824 seeds were identified in pellets, the majority corresponding to *Lycium intricatum* (Solanacea). Some studies performed on Alegranza islet demonstrated that the Southern Grey Shrike is a legitimate secondary seed disperser when it catches the endemic frugivorous lizards (*Gallotia atlantica*) that have previously consumed *Lycium* fruits (Nogales *et al.* 1998, 2002). The seeds that appeared in the shrike pellets in Tenerife probably have their origin in these secondary seed dispersal processes (D.P. Padilla & M. Nogales unpubl.).

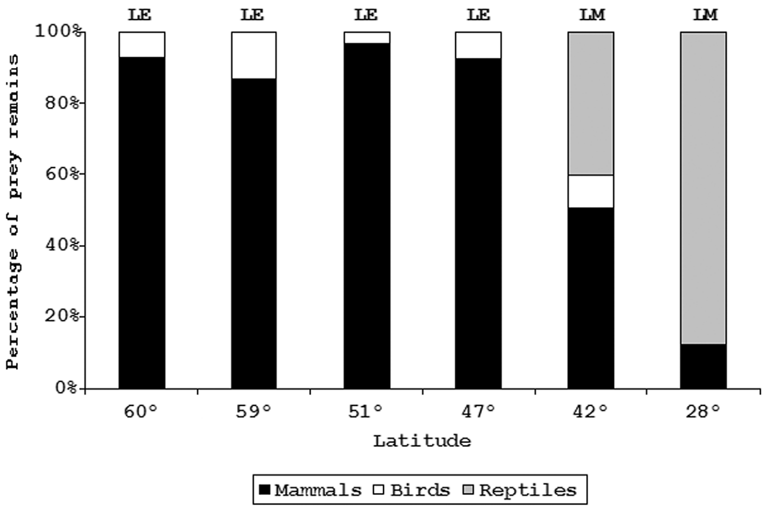

Fig. 2. Proportion of vertebrates in the diet of the Great Grey Shrike (LE) versus the Southern Grey Shrike (LM) during winter in Europe. Data taken from: 60º Finland (Karlsson 2002), 59º Sweden (Olsson 1986), 51º Germany (Grünwald 1984), 47º Switzerland (Bassin *et al*. 1981), 42º Iberian Peninsula-Spain (Hernández *et al*. 1993) and 28º Canaries (present study).

4.2. Geographical variations of species and subspecies

With regard to the latitudinal variation of the main prey consumed by the two related species of shrike, the Great Grey Shrike and the Southern Grey Shrike, important differences can be observed. One is the presence of mammals, which are the most important prey in northern geographical zones and whose frequency decreases with latitude (Bassin *et al*. 1981, Grünwald 1984, Olsson 1986, Schön 1998, Karlsson 2002). In the present study, one of the lowest latitudes examined, mammals were not frequently captured by *L. m. koenigi*, probably because the two small mammals available for the Shrike in Tenerife have nocturnal habits. We found that the highest predation on mammals occurs in spring. Nevertheless, in continental zones of Spain and France, *L. m. meridionalis* preys on mammals most frequently in autumn and winter (Hernández *et al.* 1993, Lepley *et al.* 2004). However, the presence of reptiles in the diet increases towards the southernmost latitudes (Fig. 2). It is interesting to note that the importance of reptile biomass in the Canarian shrike's diet could also be influenced by the high availability of lizards, one of the main ecological characteristics of these insular environments (Olesen & Valido 2003).

Birds could be important prey for the Great Grey Shrike in some cold habitats, especially in winter when mammals and arthropods are snowbound. Furthermore, passerine activity decreases in this season and an increased rate of successful attacks can be achieved (Grönlund *et al*. 1970, Grünwald 1983, Olsson 1986, Atkinson & Cade 1993, Hromada & Krištín 1996, Karlsson 2001, 2002).

The Southern Grey Shrike in southern France captures birds in two different seasons, summer and winter (Lepley *et al*. 2004). However, they are more successful in summer than in winter, probably because of availability of fledgling passerines. In the Iberian Peninsula the proportion of birds in Shrike diet increases in spring and summer, which coincides with the highest availability of young passerines (Hernández *et al*. 1993, Hernández 1995c). However, the absence of birds in the *L. m. koenigi* diet may be explained by greater lizard abundance, capture effectiveness, and possibly lower energy requirements for capture.

The general results obtained in this study partially agree with other continental reports on the Southern Grey Shrike diet, which suggest that the main food source is based on Coleoptera. However, the number of beetles observed in this diet study is practically twice that found in other geographical areas such as Israel, the Iberian Peninsula and France (Yosef 1991, Hernández *et al*. 1993, Lepley *et al*. 2004, respectively). Nevertheless, this high presence of beetles contrasts with the absence of other arthropod groups present in the diet in other areas, such as Arachnida or Lepidoptera. However, these last two groups could be underestimated in the pellet analysis due to their soft bodies (Tryjanowski *et al*. 2003).

In the Great Grey Shrike diet, the proportion of arthropods decreases in cold seasons (Bassin *et al.* 1981, Grünwald 1984, Olsson 1986, Karlsson 2002) due to the fact that their activity decreases along with their availability. Nevertheless, in Bulgaria, one of the lowest latitudes occupied by *L. excubitor* (c. 42º latitude), arthropods in winter are essential, forming 89.5% of the diet (Nikolov *et al*. 2004). With regards to latitudes occupied by the Southern Grey Shrike, the cold seasons are not harsh, and therefore arthropods are available throughout the year (Hernández *et al.* 1993, Budden & Wright 2000, Lepley *et al*. 2004). In the southernmost part of Tenerife, there is little seasonal climatic change, and thus arthropods are available all year round. However, we noted a drop in arthropod consumption from southern to northern latitudes in winter, probably caused by decreasing diversity and availability of insects (Munroe 1984).

Finally, the latitudinal cline described in the present contribution is in agreement with the hypothesis that the Southern Grey Shrike relies on cold-blooded prey in hot weather, while the Great Grey Shrike relies mainly on warm-blooded prey in cold weather (Schön 1998, Lepley *et al*. 2004).

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Endeemisen etelänisolepinkäispopulaation (*Lanius meridionalis koenegi*) ravinnonvalinta Teneriffalla, Kanarian saarilla

Teneriffalla tutkittiin etelänisolepinkäisen (*Lanius meridionalis koenegi*) ravintoa ja saaliinvalintaa. Tutkimuksen päätavoite oli vertailla saarella elävän populaation ravintoa mantereella elävien isolepinkäis- (*Lanius excubitor*) ja etelänisolepinkäispopulaatioihin. Huhtikuusta 2003 maaliskuulle 2004 kerättiin 440 oksennuspalloa, joista tunnistettiin 5 112 saaliseläintä. 85,4 % näistä oli kovakuoriaisia (pääosin Curculionidae ja Tenebrionidae) ja loput muita niveljälkaisia ja selkärankaisia. Pääosa ravinnon biomassasta oli selkärankaisia, erityisesti liskoja (64 %). Ravinnon koostumuksessa oli pientä vaihtelua vuoden eri aikoina, joskin kovakuoriaisia ja liskoja jäi saaliiksi paljon kaikkina vuodenaikoina. Etelänisolepinkäiset suosivat joitakin kovakuoriaisia, pistiäisiä (ei Formicidae) ja suorasiipisiä (*Schistocerca gregaria*).

Tutkimuksen aineisto tukee hypoteesia, jonka mukaan etelänisolepinkäiset panostavat vaihtolämpöisiin saaliseläimiin kuumalla säällä (Ranskan eteläosissa), kun taas isolepinkäiset suosivat tasalämpöisiä saaliseläimiä kylmässä säässä (Skandinavian niemimaalla). Liskojen suuri merkitys tämän populaation ravinnossa johtunee siitä, että niitä on saarilla paljon, niitä on tehokasta saalistaa ja täten saalistukseen kuluu vähemmän energiaa kuin muiden lajien kohdalla.

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