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DIET OF CETTI'S WARBLERS *CETTIA CETTI* (TEMMINK, 1820) IN A LOCALITY OF SOUTHERN SPAIN

LA ALIMENTACION DEL RUISEÑOR BASTARDO *CETTIA CETTI* (TEMMINK, 1820) EN UNA LOCALIDAD DEL SUR DE ESPAÑA

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Diet is one of the less-known biological features in a high number of small insectivorous birds. This is due mainly to the difficulty in recognising their prey, usually tiny soft-bodied arthropods that decompose quickly during digestion. In spite of this, intensive studies of many of northern or central-European passerines has provided substantial information on the diet in these birds; however, data remains scanty for Mediterranean countries, where dietary information is completely unavailable for some species.

One such species is the Cetti's Warbler *Cettia cetti*, a passerine strictly linked to ponds, lakes, marshes and rivers, whose altitudinal distribution in southern Spain ranges from 0 to 1000 m a.s.l. (Jourdain, 1936, 1937; Pleguezuelos, 1992). Only scant dietary information is available from some localities within its distribution area, mainly England and France in Western Europe (Géroudet, 1963; Hollyer, 1975; Harvey, 1977; De Lust, 1979; Bibby, 1982; Bibby & Green, 1983) and the republics of the former Soviet Union (see references in Cramp, 1992). In most of these cases, data are sparse and fragmentary, with small sample sizes. The aim of the present work is to increase knowledge concerning the diet of this bird, with results from a locality of southern Spain throughout a seasonal cycle.

The field work was carried out at the site known as Charca de Suárez, near the mouth of the Guadalfeo river (Motril, Granada province, Spain). This area is situated 1 m a.s.l., less than 200 m from the seashore, and covers ca. 8 ha. The central part is water-logged and almost completely covered by reedmace *Typha dominguensis* and *Iris pseudacorus*, with pronounced variations in water level due to the irrigation schedules for nearby croplands. In the periphery, stands a hedgerow with *Tamarix* sp., willows *Salix fragilis*, castor-oil plants *Ricinus communis*, and reed *Phragmites communis* and *Arundo donax*. Crops in the surrounding area are mainly sugar cane and orchards of chirimoya and avocado, although some peaches, grapes and plums can be found.

The study was based exclusively on faecal analysis. We obtained the samples by catching the birds in mist nets, set twice monthly from March 1995 to October 1996. Mist nets were placed for 48 h each time, in the periphery of the marsh. Trapped birds were kept in a transpirable cellophane bag in a dark, quiet site until the deposition of excrements, and afterwards the birds were ringed and released. Ringing allowed us to avoid collecting more than one excrement per month from the same bird, thus ensuring the statistical independence of monthly diet samples.

Faeces were dispersed in water and examined under a 10x-40x binocular microscope equipped with a micrometer. The remains were separated into vegetal and animal fractions, and their relative volumes estimated. Animal prey were usually determined to the lowest taxonomic level possible. Measurements of characteristic prey parts remaining in the faeces allowed an estimate of the prey's body size, by means of a series of regression equations previously developed (Hódar, 1997). Due to the low number of items, we did not attempt to estimate the biomass provided by each group. We obtained size estimates for 24 prey belonging to eight of

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the taxonomic groups distinguished in the diet (Araneae, Opilionida, Homoptera others, Heteroptera, Neuroptera, Carabidae, Coleoptera others and Formicidae). These eight groups represent two thirds of the total prey found (Table 1), so that the sample could be considered as representative in spite of its low size.

The differential digestibility of soft- versus hard-bodied prey hampers the identification of the former by faecal analysis, and may produce severe biases in the estimates of the overall importance of these two types of prey in diets (see e.g. Custer & Pitelka, 1975; Jenni *et al.*, 1990; Pulido & Díaz, 1994), as well as in the estimation of prey lengths, since hard-bodied prey leave more measurable remains. Rather surprisingly, most work on bird-diet analysis ignore these digestibility effects. This may be because the biases caused by these differential rates of passage and digestibility remain scantily documented and thus poorly understood (Rosenberg & Cooper, 1990), and therefore authors prefer to offer crude data instead of corrected data in which they are not confident. In the present work, we have not applied correction factors for differential passage rates and digestibilities extracted from the literature, since such factors appear to be species-specific, nor have we computed such factors for the Cetti's Warbler because of logistic constraints; however, we comment on the possible effects of such corrections on our results.

Dietary data were computed on a seasonal basis (breeding, March-July; post-breeding, August-October; and winter, November-February), both as the percentage of occurrence (percentage of faeces in which an item appeared) and as the numeric frequency (percentage of items belonging to a prey class with respect to the total of prey items; Rosenberg & Cooper, 1990). Although some of the samples for each season may have belonged to the same individual, implying some degree of pseudoreplication, no attempt was made to completely eliminate this problem, since this would have supposed too low sample sizes (but see above). Comparisons of diet compositions were made with G tests, whereas prey sizes were compared with the Kruskal-Wallis test. To apply the G test, we used a pooling procedure in order to avoid empty cells in the analysis. This was done by combining rows having empty cells with the most taxonomically proximate row (Carabidae and Scarabeidae with Coleoptera others, Aphididae with Homoptera others) or, when this was not possible, by creating a new row for miscellaneous arthropods (Araneae, Opilionida, Lepidoptera larvae and Neuroptera). Non-parametric tests were applied because of the low sample sizes (Zar, 1996).

The analysis of 41 excrements gave a total of 114 animal prey, as well as many vegetal remains. Only one piece of grit was found. Animal prey were predominantly Hexapoda (73% in frequency), whereas Crustaceae (13.5%), Arachnida (7.2%) and Gastropoda (6.3%) were less numerous. Among insects, the most prevalent groups were Coleoptera, Homoptera, Heteroptera and Formicidae. It is remarkable that some of the most abundant groups in the diet, such as crustaceans and beetles, are hardly sclerotysed, which favours their identification in faeces. Correction factors applied to ants, aphids and spiders (from 1.5 to 2.5 following Pulido & Díaz, 1994 for Blue Tits *Parus caeruleus*) would have given a very different picture, with much more weight of these groups in the Cetti's Warbler diet. Nevertheless, it is difficult to assess to what extent these correction factors could be applicable from one bird species to another.

The prey composition of the diet was quite constant over time, without significant differences among the three seasons considered ($G_{14} = 11.6$, $P = 0.64$). Similarly, no differences were discerned in prey size ($H_2 = 1.3$, $P = 0.52$), which proved very small, 3.0±0.4 mm of body length on average ($n = 24$). However, this lack of significant differences may be the consequence of low sample sizes. Furthermore, since most of the prey for which length was estimated were hard-bodied insects, like beetles and ants, the actual average body length would be different if more aphids or spiders were included. There was a noteworthy presence of Amphipoda, a crustacean group linked to coastal habitats; in this case, the proximity to the sea and the salinity of the soil favoured the presence of this group in the study area. Both prey size and dietary composition corresponded with the feeding patterns of the bird, which is primarily a ground-gleaner (Géroudet, 1963; Noval, 1975; Hollyer, 1975; but see Hill, 1993).

A major part of the diet was comprised of vegetal remains. While Cetti's Warbler has been considered up to now to be almost exclusively insectivorous, we found vegetal food as a basic dietary component for this bird. Even

TABLE 1

Diet composition of the Cetti's Warbler in the Charca de Suárez (Motril, SE Spain). Diet composition is detailed, by seasons, as percentage of occurrence (% P) and numeric frequency (% F).
[Composición de la dieta del Ruiseñor Bastardo en la Charca de Suárez (Motril, SE España). La composición de la dieta se expresa, detallada por estaciones, como porcentaje de presencia (% P) y porcentaje de frecuencia (% F).]

	Breeding *[Reproducción]* (March-July)		Post-breeding *[Postrreproducción]* (August-October)		Winter *[Invierno]* (November-February)	
	% P	% F	% P	% F	% P	% F
Arachnida						
Araneae	40.0	13.3	18.8	9.4		
Opilionida	10.0	3.3				
Crustacea						
Amphipoda	20.0	6.7	25.0	12.5	46.7	15.4
Hexapoda						
Ephemeroptera	10.0	3.3	6.2	3.1		
Homoptera						
Aphididae		12.5	6.3	13.3	3.8	
Homoptera others	30.0	13.3	6.2	3.1	20.0	11.5
Heteroptera	30.0	10.0	18.8	9.4	46.7	13.5
Diptera	10.0	3.3	18.8	9.4	33.3	9.6
Lepidoptera larvae					6.7	1.9
Neuroptera					13.3	3.8
Coleoptera						
Carabidae		12.5	6.3	6.7	1.9	
Chrysomelidae	10.0	3.3	6.2	3.1	6.7	1.9
Scarabeidae	30.0	10.0		13.3	3.8	
Coleoptera others	60.0	23.3	31.2	15.6	53.3	10.0
Hymenoptera Formicidae	10.0	3.3	18.8	15.6	26.7	7.7
Gasteropoda	20.0	6.7	12.5	6.3	20.0	5.8
Seeds					20.0	5.8
Vegetal, % presence	30.0		81.3		60.0	
Vegetal, % volume ($\bar{x}$ ± SE)	19 ± 10		63 ± 9		39 ± 9	
Prey length (mm, $\bar{x}$ ± SE, n) *[Longitud de las presas]*	2.9 ± 1.3, 6		2.9 ± 0.6, 7		3.1 ± 0.6, 11	
Number of faeces *[Número de excrementos]*	10		16		15	
Number of prey *[Número de presas]*	30		32		52	

during the breeding period, 30% of samples contained some vegetal remains, and especially in the post-reproductive season and winter, this component reached considerable proportions. This may imply a lower importance of animal food, which was appreciable in the low number of prey per excrement ($\bar{x}$ = 2.8, range 0-8), in contrast with the results found by other authors. For instance, Bibby & Green (1983) found averages of 12.6 and 9.1 animal prey per excrement in two different zones of France. Although these data correspond to birds fattening for migration, and thus probably ingesting food at higher rates than the birds studied by us, some of the birds captured by us in the post-breeding period would also have been fattening. The fact that most of the vegetal remains were unidentifiable, the scarcity of fleshy-fruiting wild plants in the study site (see before), the scant number of seeds found in faeces and the maximum values reached in autumn (August-October, Table 1), suggest that, in contrast with other similar birds that feed on wild berries and other fleshy fruits during autumn and winter, a good part of the fruits consumed by Cetti's Warbler in our area came from crops, such as peaches, grapes or plums, available near the study area.

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