Diet of Common Chiffchaffs *Phylloscopus collybita* wintering in a wetland in south-east Spain

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The diet of Common Chiffchaffs *Phylloscopus collybita* wintering in a Mediterranean wetland (El Hondo Natural Park, SE Spain) was studied by analysing the gizzard content of 17 individuals that died accidentally when trapped for ringing. Prey availability was assessed via water-trap sampling over two winters. The bulk of the diet was composed of midges (Chironomidae), which were found in all the gizzards and represented approximately 95% of the prey. Brachycera flies were one of the most captured taxa in the water-traps but represented less than 0.5% of the total number of prey consumed. Compositional analysis revealed very strong prey selection, with Chiffchaffs selecting clumped and less mobile prey, such as chironomids, and avoiding abundant but fast-escaping prey, such as Brachycera.

Key words: Chiffchaff, *Phylloscopus collybita*, chironomid, compositional analysis, prey selection, winter density

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The Common Chiffchaff *Phylloscopus collybita* is one the most abundant short-distance-migrant passerines in Europe, together with the Song Thrush *Turdus philomelos*, the Robin *Erithacus rubecula* and the Blackcap *Sylvia atricapilla* (Hagemeijer & Blair 1997). Each autumn, thousands of individuals of these species arrive in different Mediterranean countries where, with the exception of the Common Chiffchaff, they survive on a diet based on a high intake of fruits (Cramp 1988, Cramp 1992). The Common Chiffchaff's diet has only a small plant component (Jordano 1987, Vogel *et al.* 1984), and its winter diet is predominantly insect-based. To our knowledge, only a few publications report on the composition of the Common Chiffchaff's diet outside the breeding season, these mainly dealing with stopover sites during migration (Laursen 1978, Bibby & Green 1983), and no information appears to be available on the diet of this species during winter.

Knowledge of the winter diet of the Common Chiffchaff may contribute to the understanding of the habitat use of this species in winter, given that food availability is a critical factor affecting habitat selection of birds in their wintering grounds (Hutto 1985). Habitat changes in the main wintering areas may produce sudden changes in the population trends of short-lived passerines, as has been shown for

other species (Winstanley *et al.* 1974, Peach *et al.* 1991). Common Chiffchaff populations across Europe appear to be stable (Tiainen & Wesolowski 1997) and no obvious threats cause conservation concern for the species, but identifying important wintering habitats and the factors behind their selection by Chiffchaffs may help to prevent such risks in the future.

The aim of this study is to document the diet of Common Chiffchaffs wintering in wetlands in south-east Spain. Data on diet composition are used as an explanatory driver of the species' habitat choice in its Mediterranean wintering grounds.

Material and Methods

The diet of Common Chiffchaffs wintering in El Hondo Natural Park (Alicante, SE Spain, 38° 11' N, 0° 42' W) was studied by analysing the gizzard content of 17 individuals that died accidentally in nets in which they had been captured for ringing. The study area consists of a system of ponds and channels built over a preexisting natural wetland in order to regulate water flux and to store water for irrigation. The park has an area of approximately 2400 ha, which includes large stretches of reedbeds. Since 1992 ringing has been carried out regularly in this area throughout the year, normally every week. Nets were open for four hours from dawn, and thus the birds always died in the first half of the day. Dead Chiffchaffs were collected between 1994 and 2000, most of them in December (10) and the rest in January (1), February (3) and March (3). Most of the analysed birds were killed in the nets by Southern Grey Shrikes *Lanius meridionalis* that also winter in the area.

Individuals were frozen until the stomach content was extracted, and this was then conserved in 70 % ethanol. Prey items were identified under a binocular microscope and fragments were categorized at family level wherever possible, using Barrientos (1998), Chinery (1988), McGavin (2000) and Papp & Darvas (2000). The minimum number of prey items in each gizzard was estimated by counting key body parts, such as wings, heads or elytra. Prey size was measured directly, or estimated by comparing recovered body parts with a collection obtained from water-trap captures.

To estimate prey availability we used water traps. Obtaining unbiased estimates of arthropod availability has traditionally been a problem in studies of avian foraging, and it is very difficult to solve because to date no single method has been found that adequately samples all potential prey (Cooper & Whitmore 1999). However, combining different sampling methods may be also problematic, and a compromise needs to be adopted. Most studies on arthropod prey availability in wetlands have used water traps (Bibby & Thomas 1985, Evans 1989, Hoi *et al.* 1995, Schmidt *et al.* 2005, among others) or sweep-netting (Poulin *et al.* 2000, Poulin *et al.* 2002). Sweep-netting is usually limited to the outer perimeters of reedbeds while water traps may be placed in the midst of the reeds, in situations where passerines also search for food but where it is difficult to sweep. Therefore, water traps were used in the present study.

Arthropod sampling was carried out during the winters of 1995/96 and 1996/97 (Pinheiro, 1999). In the first of these winters, two areas of reedbed were sampled, each with five traps, and during the second winter a third area, also containing five traps, was added. The traps consisted of green plastic vessels measuring 20 cm in diameter and 10 cm in depth. The colour of the water containers is important because bright colours, like yellow or white, may attract flowervisiting insects (Southwood 1980), whereas green vessels help in reducing this potential bias. Traps were placed on wooden platforms among the reeds at a height of approximately 1.5 m. The traps contained soapy water to a depth of approximately 2 cm, and were operated once every 15 days for 24 hours.

The average number of individuals of the identified taxa was calculated per trap and per day as a measure of prey availability, using only the sampling days corresponding to the months where Chiffchaff gizzards had been obtained (December–March). The length of the arthropods collected was measured to the nearest 0.5 mm, and only individuals measuring up to the maximum length recorded in gizzard samples were included in the availability estimates. This maximum length was 10 mm for Nematocera and 4 mm for the other taxa. The size distribution of Nematocera was wider than in other prey types so it was decided to subdivide families included within this taxon into three size

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groups: small (≤ 4 mm); medium (4–6 mm); and large (6–10 mm). We are assuming that the results from the two winters when arthropods were sampled are representative of the average relative prey availability for all of the years studied. In order to test to what extent arthropod abundance varies between years, we compared the average number of individuals captured per trap and per day during both winters. Most of the test results were far from significant, and significant differences between winters were found in only two taxa (Mann-Whitney U Test. Coleoptera: $U = 11.0$; $p = 0.015$. Brachycera ≤ 4 mm: $U = 12.0$; $p = 0.021$).

Statistical comparisons of diet composition and prey availability were carried out using compositional analysis (Aebischer *et al.* 1993). Compositional analysis is an appropriate method for analysing proportional data, such as diet composition or habitat use. To overcome the lack of independence of this kind of data, the proportion of the n-1 taxa in the diet of each individual is divided by the proportion of the remaining taxa and the ratios obtained are log-transformed (ln). Then, the difference between log-ratios of the prey consumed by each individual and the log-ratios of prey availability is calculated, and the resulting matrix is analysed using Multivariate Analyses of Variance (MANOVA, Aebischer *et al.* 1993). A significant test indicates the importance of overall prey selection, and the effect of other variables (for example, date, age, etc.) may be tested for inclusion in the model in a stepwise way. With this method, a ranking of prey types may be established in accordance with their relative preference (Aebischer *et al.* 1993). Compositional analysis was applied comparing prey types found in the Chiffchaff diet with their availability. All families found in the diet, except chironomids, were represented by few individuals, and so this analysis was performed with prey items classified to the order or suborder level, but when particular families presented ecological and/or morphological characteristics that might presumably affect their selection as prey they were considered as different prey classes. This was the case of Formicidae and Aphididae. Thus, the prey classes considered in the compositional analysis were: Aphididae; Chironomidae 6–10 mm; Other Nematocera (all sizes, excluding Chironomidae); Brachycera; Formicidae; Other

Hymenoptera; Coleoptera; and Araneae. Individuals of all taxa except chironomids and Other Nematocera were ≤ 4 mm. Proportions equal to zero were transformed to 0.0001 to make the calculation of logarithms possible (Aebischer *et al.* 1993), and the proportion of Araneae was used as a denominator for the calculation of logratios. In order to evaluate to what extent the results of this analysis were affected by biased water-trap sampling of flying and walking arthropods, we applied compositional analysis separately to the same prey types but classified into two groups: frequent fliers (Diptera and Hymenoptera excluding Formicidae); and walkers or less frequent flyers (Areneae, Coleoptera, Aphididae and Formicidae).

Results

Overall, 1064 prey items were counted in the 17 gizzards (mean: 62.6 prey items, SD = 39.2, range 9–136), most of them (95.3 %) being adult chironomids of the larger size class (Table 1). This type of prey was also the only one that was present in all the individuals analysed. Medium- or small-sized chironomids were not found in any of the birds, despite their higher availability. Given the extremely high predominance of chironomids in the diet, the percentage of other prey types is very small. The next-most-frequently-consumed types of prey were spiders (Araneae) and beetles (Coleoptera). These were found in about one third of the birds studied but each represented only 0.66 % of the prey items identified. The next prey type according to frequency of occurrence was Aphididae, which were found in 29 % of gizzards and represented 0.94 % of prey. Hymenoptera (excluding Formicidae), also represented 0.94 % of prey but were more scarcely found in our Chiffchaff sample (in only three individuals). Nematocera (excluding Chironomidae) and Brachycera were even less represented in the sample (less than 0.5 % of identified prey).

The MANOVA performed on the matrix of differences in log-ratios showed that diet composition differed significantly from prey availability (Wilk's $\lambda = 0.023$, $F_{7,10} = 61.15$, $p < 0.001$). Since most of the birds (n = 10) died in December we carried out a test to determine the effect of the month when samples were col-

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Table 1. Winter availability of arthropods and diet composition of Chiffchaffs wintering at El Hondo Natural Park. Only arthropods shorter than the maximum length of each taxon found in gizzards have been used to estimate availability. Occurrence: percentage of individuals in which a prey type was found.
Disponibilitat hivernal d'artròpodes i composició de la dieta dels mosquiters hivernants al Parc Natural del Fondo. Per estimar la disponibilitat només s'han considerat els artròpodes més petits que la longitud màxima trobada de cada taxó als pedrers. Presència: percentatge d'individus on s'ha trobat una presa-tipus.

	Availability (ind./trap·day)	%	Occurrence (%)	Number of prey items	%
O. DIPTERA					
SubO. Nematocera					
F. Chironomidae ≤ 4	3.484	25.88	0.00	0	0.00
F. Chironomidae 4 - <6	1.394	10.36	0.00	0	0.00
F. Chironomidae 6 - 10	0.322	2.39	100.00	1014	95.30
Other Nematocera ≤ 4	0.557	4.14			
F. Psychodidae	0.055		17.65	3	0.28
Other Nematocera 4 - <6	0.071	0.52			
F. Culicidae	0.061		5.88	1	0.09
Other Nematocera 6 - 10	0.020	0.15	0.00	0	0.00
SubO. Brachycera	4.880	36.25			
F. Ephydridae	0.231		5.88	2	0.19
F. Heleomyzidae	–		5.88	2	0.19
F. Phoridae	0.794		5.88	1	0.09
O. HYMENOPTERA					
F. Formicidae ≤ 4	0.786	5.84	5.88	1	0.09
Other Hymenoptera ≤ 4	0.718	5.33			
F. Braconidae	0.004		11.76	3	0.28
F. Pteromalidae	–		11.76	7	0.66
O. HEMIPTERA					
F. Aphididae	0.355	2.64	29.41	10	0.94
O. COLEOPTERA ≤ 4	0.390	2.90	35.29	7	0.66
O. ARANEAE ≤ 4	0.075	0.55	35.29	7	0.66
O. PSEUDOSCORPIONIDA	0.008	0.06	0.00	0	0.00
O. THYSANOPTERA	0.118	0.87	0.00	0	0.00
O. PSOCOPTERA	0.137	1.02	0.00	0	0.00
Unknown Item			29.41	6	0.56

lected. To do this, we included a dichotomous dummy variable in the MANOVA model to separate December data from the rest of the months. The introduction of this effect into the model is not significant (Wilk's $\lambda = 0.56$, $F_{7,9} = 1.01$, $p = 0.48$), so diet composition was shown not to differ between the two periods. In fact, the percentage of the main prey (large chironomids) in the diet is very similar in December (95.1 %) and during the rest of the months (96.2 %). When analysed separately, percentage in the diet of both frequent fliers (Wilk's $\lambda = 0.039$, $F_{3,14} = 115.57$, $p < 0.001$) and walking prey (Wilk's $\lambda = 0.386$, $F_{3,14} = 7.43$, $p = 0.003$) differed from availability.

We used the procedure described in Aebischer *et al.* (1993) to construct a ranking matrix of prey types. The results of pairwise comparisons of average differences in log-ratios between prey types are shown in Table 2. As expected from the results in Table 1, it can be seen that large chironomids are the favourite prey. Spiders are the second prey type in the ranking, although when compared to Coleoptera their average difference in log-ratio is not significant (Table 2). The greatest difference between availability and consumption occurs in the case of Brachycera, which represents 36.25 % of captures in water traps but only 0.47 % of the prey items found in gizzards and thus is ranked in the last position (Table 2). Ranking of prey in the compositional analyses performed for separate groups of prey matched the ranking in Table 2 (Flying prey: Large Chironomids >*** Other Nematocera >n.s. >Other Hymenoptera >** Brachycera. Walking prey:

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Araneae >n.s. Coleoptera >n.s. Aphididae >*** Formicidae).

Discussion

Our results show that the bulk of the diet (95 % of detected prey items) of the Common Chiffchaffs wintering in our study area is composed of chironomids of sizes between 6 mm and 10 mm. This was the only group present in all birds analysed and included the largest arthropods found in the sample. Thus, the contribution of large chironomids in terms of biomass consumed should be even higher and we may conclude that the energy budget of chiffchaffs wintering in this wetland relies mainly on these insects. No other information is available about the diet of Common Chiffchaffs wintering in the Mediterranean, but chironomids are abundant and widespread so it is quite possible that these findings can be generalized for other wetlands in this region. It has also been reported that there is a high incidence of chironomids in the diet of Common Chiffchaffs in Denmark, where they represent more than 50 % of prey consumption during spring migration (Laursen 1978). Some data obtained during autumn migration in France showed that in one area Diptera were the main prey (54 % of prey items) but in another locality with high aphid density these last insects represented 72 % of prey items (Bibby & Green 1983).

The compositional analysis showed that diet composition and prey availability as measured with water traps were significantly different, and that large chironomids were the favourite prey type. Prey-availability data were obtained during just two winters, whereas the Chiffchaff sample comes from a period of seven years; this could have affected the analysis result in some way. However, our data suggest that between-year variations in main-prey availability would have not been large enough to alter the main conclusion. For instance, the most preferred prey, large chironomids, represent 4.3 % of prey captured in water traps in the first winter sampled and 6.5 % in the second, while their consumption was always high in all chiffchaffs analysed (>75 % of prey items).

Another problem is to what extent the captures in water traps reflect the true availability of potential prey. It may be argued that water traps capture mainly flying insects, but in such a dense form of vegetation as reedbeds the water container is in close contact with reed leaves and stems and so vegetation-dwelling arthropods may also be easily captured. As an example, Schmidt et al. (2005) have found that a water trap captured about three times more beetles and spiders that a mug wired to 12 reed stems. To test if different capture probabilities of flying and

Table 2. Ranking of prey taxa according to their relative use. Prey taxa in the left-hand column are compared to taxa in the top row, which were used as the denominator in log-ratios following the procedure described by Aebischer et al. (1993). The table shows the significance of t-tests when comparing differences in log-ratios to zero. A significant test means that a prey taxon in the left-hand column is used more than expected in relation to a prey taxon in the top row. Chironomidae: only 6-10 mm size class. Nematocera: all sizes, excluding Chironomidae. Hymenoptera: excluding Formicidae.
Ranking dels taxons presa segons el seu ús relatiu. Els taxons presa de la columna esquerra es comparen a la primera fila, la qual s'ha utilitzat com a denominador dels log-ratios segons el protocol descrit per Aebischer et al. (1993). La taula mostra la significació dels t-tests quan es comparen amb diferències en log-ratios a zero. Un test significatiu indica que el taxó presa de la columna esquerra s'empra més de l'esperat en relació a la presa taxó de la fila superior. Chironomidae: només mides de 6-10 mm. Nematocera: totes les mides, excloent Chironomidae. Hymenoptera: excloent Formicidae.

	Araneae	Coleoptera	Aphididae	Nematocera	Hymenoptera	Formicidae	Brachycera
Chironomidae	***	***	***	***	***	***	***
Araneae		n.s	*	**	***	***	***
Coleoptera			n.s.	n.s.	*	**	***
Aphididae				n.s.	*	**	***
Nematocera					n.s.	*	**
Hymenoptera						n.s.	*
Formicidae							*

*p<0.05, **p<0.01, ***p<0.001, n.s. non-significant.

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walking arthropods are affecting the results of compositional analysis we have repeated this analysis but classifying prey types into two groups according to their flying behaviour. In both prey groups the result was highly significant and the ranking of prey types according to their consumption relative to their availability matched the ranking obtained in the global analysis, thus suggesting that these results are robust. The fact that some mainly walking prey types, like beetles, are captured in water traps with similar intensity to some frequent fliers, like large chironomids, also points in the same direction.

The behaviour of chironomids may explain why this group is an important prey for Chiffchaffs. Chironomids are mainly active at dusk and dawn, when they fly in swarms, but they settle during the day in the vegetation, when they are quite immobile and easy to catch. This behaviour probably causes a clumped distribution that would facilitate capture once the birds have found an area with abundant prey. Interestingly, the large chironomids found in the diet are captured much less frequently in the water traps than the medium or small chironomids, which were never found in the gizzards analysed (Table 1). The lack of medium or small chironomids in the sample can not be explained by a shorter processing time for smaller prey items, since birds died in the first hours of the day and other small and similarly or even less keratinized prey types, such as Psychodidae, Culicidae and spiders, were found in the gizzard sample. The disproportionate consumption of large chironomids could be explained if these, although less abundant than the smaller ones, could be easily located in sufficient numbers and, given their larger biomass, are thus preferred. Other families of Nematocera are also much less exploited than large chironomids despite their availability being similar.

After the large chironomids, the most consumed prey type relative to availability was Araneae, with a percentage in the diet similar to its recorded availability. The percentage of the rest of prey types in the diet is lower than their availability, although the difference is relatively small in Coleoptera and Aphididae, increasing in the other prey types. The prey taxon that was least consumed in relation to its availability was Brachycera, which, together with Nematocera, is the most abundant group in

water-trap captures but represents only 0.47 % of the prey found in the gizzard sample (Table 1).

Common Chiffchaffs forage mainly by gleaning from foliage and twigs (Cramp 1992), so it is expected that less mobile prey forms will be easier and less costly to obtain. This could explain the preference for chironomids and the relatively high consumption of spiders in contrast with the low consumption relative to availability of Brachycera and Hymenoptera. Wasps and flies behave quiet differently to midges, spiders and aphids, since they are more active in the daytime and escape quickly and are therefore a more difficult form of prey to catch.

The density of wintering Common Chiffchaffs in the Iberian meso- and thermomediterranean habitats have been reported to vary between 0.6 and 0.8 birds/ha in woods and between 0.1 and 0.3 birds/ha in other habitat types, such as scrubland and arboreal cropland (Tellería *et al.* 1999). However, transects performed through reeds in our study area by one of the team (Pinheiro 1999) have shown that the winter density of Chiffchaffs here ranges from 10 to 50 birds/ha, which is well over the values reported for other habitats. There is evidence that the local density of wintering birds is correlated to food abundance (Hutto 1985, Newton 1998), so it is likely that these extremely high densities of Chiffchaffs in El Hondo reedbeds are due to the great abundance of a profitable prey (i.e. large chironomids).

Acknowledgements

Resum

Dieta del Mosquiter Comú *Phylloscopus collybita* durant la hivernada en una zona humida del sud-est d'Espanya

S'ha estudiat la dieta del Mosquiter Comú *Phylloscopus collybita* durant la seva hivernada en una zona

humida mediterrània (Parc Natural del Fondo, SE d'Espanya) mitjançant l'anàlisi del contingut dels pedrers de 17 individus que van morir accidentalment durant la captura per a anellament. La disponibilitat de las preses es va estimar a través de mostratges amb trampes d'aigua en dos hiverns. La major part de la dieta va estar composta per mosquits quironòmids que es van trobar en tots els individus analitzats i van representar aproximadament el 95% de les preses. Les mosques (Brachycera) van ser un dels taxons més capturats en les trampes, però representen menys del 0.5% de las preses trobades en els pedrers. L'aplicació de l'anàlisi composicional va revelar que existeix una selecció de preses altament significativa. Els mosquiters comuns sembla que seleccionen preses poc mòbils i amb distribució contagiosa, como els quironòmids, mentre que eviten preses capaces d'escapar ràpidament como les mosques.

Resumen

Dieta del Mosquitero Común *Phylloscopus collybita* durante la invernada en una zona húmeda del sudeste de España

Se ha estudiado la dieta del Mosquitero Común *Phylloscopus collybita* durante su invernada en un humedal mediterráneo (Parque Natural de El Hondo, SE España) mediante el análisis del contenido de las mollejas de 17 individuos que murieron accidentalmente durante su captura para anillamiento. La disponibilidad de las presas se ha estimado a través de muestreos mediante trampas de agua en dos inviernos. La mayor parte de la dieta estuvo compuesta por mosquitos quironómidos que se encontraron en todos los individuos analizados y representaron aproximadamente el 95% de las presas. Las moscas (Brachycera) fueron uno de los taxones más capturados en las trampas, pero representan menos del 0.5% de las presas encontradas en las mollejas. La aplicación del análisis composicional reveló que existe una selección de presas altamente significativa. Los mosquiteros comunes parecen seleccionar presas poco móviles y con distribución contagiosa, como los quironómidos, mientras que evitan presas capaces de escapar rápidamente, como las moscas.

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