THE FRUGIVOROUS DIET OF BLACKCAP POPULATIONS *SYLVIA ATRICAPILLA* WINTERING IN SOUTHERN SPAIN

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It has been traditionally accepted that, for most non-tropical birds, fruits are only a minor element in the diet and it has been similarly suggested that extensive frugivory in non-tropical habitats is precluded by the low nutritive quality of fruits in these areas (e.g., Snow 1971, Berthold 1976). Nevertheless, fruit consumption among temperate birds has been repeatedly documented (e.g., McAtee 1947, Turček 1961). Furthermore,

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extreme cases of frugivory have been occasionally described among non-tropical species (Berthold 1975, Walsberg 1977) as well as some extreme adaptations such as endogenous rhythms in food preferences involving fruit consumption (Berthold 1976) or modifications of the digestive tract for efficient fruit processing (Walsberg 1975). The importance of fruits in the diet of a particular species has been, however, rarely quantified in temperate bird food studies. In the case of the Blackcap *Sylvia atricapilla* a tendency to frugivory has been known for some time (e.g., Turček 1961, Tutman 1969) but, to our knowledge, no attempt has been made to assess the extent of this feeding behaviour. We document, in this note, the strongly frugivorous habit of Blackcaps in several southern Spanish habitats, where the species is a regular and abundant winter visitor.

STUDY SITES AND METHODS

Our study is based on the analysis of faecal samples taken from mist-netted birds at four southern Spanish localities during October to March of the years 1978–80. Faecal samples were obtained by flushing the digestive tract with saline solution (Moody 1970) and analysed following the microscopical procedure described in Herrera & Jordano (in prep.). Plant species of which fruit remains (seeds and/or skins) were present and the percentage of the volume made up of fruit remains other than seeds, were recorded for every sample. The sampling period encompassed the whole wintering season of Blackcaps in southern Spain (Murillo & Sancho 1969) and, therefore, most trapped individuals must be considered winter residents. These birds are mainly of central European and British origin (Klein, Berthold & Gwinner 1973, Langslow 1979).

The four study localities exemplify varying levels of disturbance in natural Mediterranean scrubland and also differences in elevation and vegetational composition. They may be considered representative of the main habitat types of the southern third of the Iberian Peninsula.

The Viso site (37°26′N, 5°45′W), is at 100 m elevation on the lowlands of the lower Guadalquivir River valley, in Sevilla province. Birds were netted in a 3·5 ha plot of fairly undisturbed lowland Mediterranean scrub with sparse Stone Pines *Pinus pinea*, surrounded by extensive agricultural land. Dominant fleshy, fruit-producing species are *Pistacia lentiscus*, *Phillyrea angustifolia*, *Myrtus communis*, *Smilax aspera* and *Osyris quadripartita*.

The Cazorla site (37°56′N, 2°52′W) is at 1150 m, in the Sierra de Cazorla, southeastern Jaén province. Birds were netted at a virtually undisturbed stand of dense Mediterranean montane sclerophyllous scrub. The netting site is surrounded by extensive areas of similarly undisturbed scrub habitat in which the dominant fruit-producing plant species are *Phillyrea latifolia*, *Viburnum tinus* and *Arbutus unedo*. More detailed descriptions of Cazorla and Viso localities can be found in Herrera (in press).

The Bañuelo site (37°55′N, 4°48′W) at 500 m, is in a small valley in Sierra Morena, northern Córdoba province. The valley bottom is dedicated to Olive Tree *Olea europaea* var. *europaea* groves. The adjoining hillsides are vegetated by fairly disturbed Mediterranean sclerophyllous woodland with Oaks *Quercus* sp. and planted Stone Pines in the tree stratum and an understory of *Cistus* sp. with scattered fruit-producing plant species. Among these *Rubus ulmifolius*, *Arbutus unedo*, *Daphne gnidium* and *Lonicera implexa* dominate. A more detailed description can be found in Jordano (1979).

The Cabra site (37°28′N, 4°30′W) at 350 m, is in a highly disturbed area in the lowlands of southern Córdoba province. Remnants of seriously altered natural vegetation are found only along the margins of small streams which are surrounded by thousands of hectares of extensive Olive Tree monoculture. At this site birds were mist-netted close to a stream in which the natural fruit-producing vegetation was represented principally by *Asparagus* sp., *Rosa* sp., *Crataegus monogyna* and *Lonicera periclymenum*.

RESULTS AND DISCUSSION

There was an appreciable variation between sites and dates in the relative abundance of fruits in the faeces (Table 1). The largest amounts were found at Bañuelo and the lowest at Cabra, while the importance of fruit remains was usually highest in December and January, intermediate in October and November and lowest in February and March. Disregarding the severely altered Cabra site, 44·7–92·3% of faecal samples had more than 95% by volume of fruit remains, irrespective of date and locality. Faeces containing exclusively fruit remains were quite frequent and represented 5·9–45·9% of samples. At the opposite extreme, faeces with less than 30% volume of vegetable matter made up only 0–5·9% of the total.

The relative proportion by volume of fruit remains in faeces may not adequately reflect the proportion in the diet. Differences in digestibility and/or transit time through the digestive tract may result in an overestimation of the most resistant and slowly-passing items. Information from captive Blackcaps suggests that insects take longer to pass through the gut and are less digestible than fruit pulp, as would be expected from their chitinous exoskeleton. Thus, figures in Table 1 may underestimate the importance of fruit in the original diet.

TABLE 1

Significance of fruit remains in faecal samples from Blackcaps wintering in four southern Spanish localities

Percent volume of fruit remains other than seeds	Percent of faecal samples: Viso			Cazorla		Bañuelo		Cabra		
	Oct.–Nov.	Dec.–Jan.	Feb.–Mar.	Oct.–Nov.	Dec.–Jan.	Oct.–Nov.	Dec.–Jan.	Oct.–Nov.	Dec.–Jan.	Feb.–Mar.
100	21·2	45·9	18·4	5·9	37·5	24·8	23·1	3·9	5·0	0
95–100	44·3	43·3	26·3	52·9	25·0	58·2	69·2	11·5	32·5	7·7
60–95	29·2	10·8	42·1	23·5	31·3	14·9	7·7	42·3	32·5	38·5
30–60	5·3	0	7·9	11·8	6·3	2·1	0	30·8	12·5	30·0
<30	0	0	5·3	5·9	0	0	0	11·5	17·5	23·1
n	113	74	38	17	16	141	13	26	40	13

TABLE 2

Species composition of the fruit fraction of Blackcap diet. Figures represent frequencies (%) of occurrence in faecal samples

	Viso			Cazorla		Bañuelo		Cabra		
	Oct.–Nov.	Dec.–Jan.	Feb.–Mar.	Oct.–Nov.	Dec.–Jan.	Oct.–Nov.	Dec.–Jan.	Oct.–Nov.	Dec.–Jan.	Feb.–Mar.
Arbutus unedo (Ericaceae)	0·9			76·5	75·0	7·1	38·5			
Asparagus spp. (Liliaceae)	0·9	2·7				3·2	23·1	23·1		
Celtis australis[1] (Ulmaceae)						40·3				
Cydonia oblonga[1] (Rosaceae)								11·5		
Daphne gnidium (Thymaelaeaceae)	3·5	2·7				1·3				
Ficus carica[1] (Moraceae)	10·6					55·8				
Iris foetidissima (Iridaceae)									7·7	
Juniperus oxycedrus (Cupressaceae)							5·9			
Ligustrum japonicum[1] (Oleaceae)										22·5
Lonicera implexa (Caprifoliaceae)	0·9						29·4		1·9	
Lonicera periclymenum (Caprifoliaceae)									3·8	
Myrtus communis (Myrtaceae)	2·7	21·6	15·8						1·3	
Olea europaea[2] (Oleaceae)	14·2	37·8	60·5							7·7
Osyris alba (Santalaceae)									1·3	23·1
Osyris quadripartita (Santalaceae)	35·4	33·8	42·1							
Phillyrea angustifolia (Oleaceae)	26·5						11·8	12·5		
Phillyrea latifolia (Oleaceae)							47·1	87·5		
Pistacia lentiscus (Anacardiaceae)	85·0	50·0	13·2				52·9	6·3	0·6	
Pistacia terebinthus (Anacardiaceae)								6·3	1·9	
Rhamnus lycioides (Rhamnaceae)	3·5									
Rosa sp. (Rosaceae)							5·9		0·6	
Rubia peregrina (Rubiaceae)	10·6	2·7	5·3				11·8	37·5		
Rubus ulmifolius (Rosaceae)	2·7						23·5	6·3	58·4	
Smilax aspera (Liliaceae)	30·1	16·2	5·3				23·5		0·6	30·8
Solanum nigrum[1] (Solanaceae)	25·7	37·8	28·9							
Solanum dulcamara[1] (Solanaceae)										
Tamus communis (Dioscoreaceae)	1·8								0·6	
Viburnum tinus (Caprifoliaceae)								12·5		
Vitis vinifera[1] (Vitaceae)										
Undetermined									1·4	15·4
Species ingested	16	9	7				10	8	15	6
Species with ripe fruits	16	9	7				13	11	17	10

	Cabra		
	Oct.–Nov.	Dec.–Jan.	Feb.–Mar.
Iris foetidissima (Iridaceae)			
Juniperus oxycedrus (Cupressaceae)			
Ligustrum japonicum[1] (Oleaceae)			
Lonicera implexa (Caprifoliaceae)			
Lonicera periclymenum (Caprifoliaceae)			
Myrtus communis (Myrtaceae)			
Olea europaea[2] (Oleaceae)	50·0	82·5	92·3
Osyris alba (Santalaceae)	7·7		
Osyris quadripartita (Santalaceae)			
Phillyrea angustifolia (Oleaceae)	3·8		
Phillyrea latifolia (Oleaceae)			
Pistacia lentiscus (Anacardiaceae)			
Pistacia terebinthus (Anacardiaceae)			
Rhamnus lycioides (Rhamnaceae)			
Rosa sp. (Rosaceae)	38·5	2·5	
Rubia peregrina (Rubiaceae)	7·7		
Rubus ulmifolius (Rosaceae)	11·5		
Smilax aspera (Liliaceae)			
Solanum nigrum[1] (Solanaceae)			
Solanum dulcamara[1] (Solanaceae)	19·2		
Tamus communis (Dioscoreaceae)	7·7		
Viburnum tinus (Caprifoliaceae)			
Vitis vinifera[1] (Vitaceae)	11·5		
Undetermined	11·5		
Species ingested	14	3	1
Species with ripe fruits	15	5	2

Notes: [1] Cultivated or weedy species.
[2] This widely cultivated species (var. *europaea*) is often found wild (var. *sylvestris*), but its fruit remains are indistinguishable.

The composition by species of the fruit fraction of the diet is shown in Table 2. A minimum of 29 plant species belonging to 18 families has been recorded, including eight cultivated or weedy species. The number of species recorded per locality varies from 12 (Cazorla) to 16 (Viso and Bañuelo). The diversity of species ingested is highest in October and November and lowest in February and March. This reflects monthly variations in the availability of ripe fruits, most species fruiting in October and November and only a few in February and March. The number of species ingested per locality and period is

close or equal to the number of plant species with ripe fruits available (Table 2). At each site, however, birds feed mainly on two or three species which appear in more than 30% of faecal samples. It is clear from Table 2 that there are a few plants whose fruits are ingested with great frequency at most localities (e.g., *Arbutus unedo*, *Olea europaea*, *Pistacia lentiscus*), while others appear infrequently but consistently (*Osyris* spp., *Rubia peregrina*, *Smilax aspera*). There is also a group of species whose presence is restricted to particular sites (*Celtis australis*, *Juniperus oxycedrus*), probably because of differences in plant species composition and abundance, although feeding preferences cannot be ruled out.

Results reported here demonstrate that Blackcaps wintering in Mediterranean habitats rely heavily on fruits, at least for a six-month period and include insects only as a minor element in their diets. Almost all individuals feed predominantly on fruits and this occurs at different elevations (relating directly to winter harshness, habitat type and vegetational composition) fruit consumption is lowest in the highly disturbed Cabra site where natural vegetation has been almost totally extirpated and replaced by extensive Olive Tree monocultures. There is a significant negative correlation (all sites and dates combined) between the percentage of faecal samples containing less than 30% of fruit remains and the number of plant species appearing in more than 30% of samples (r_s corrected for ties $= -0{\cdot}759$, $n = 10$, $P < 0{\cdot}01$). This suggests that the diversity of fruit species available may influence the amount of insects ingested. Blackcaps wintering in impoverished plant communities and/or during periods with few species available, are more likely to include insects in their diets.

Berthold (1976) has demonstrated the existence of an endogenous rhythm in food preferences among Blackcaps native to central Europe which prefer fruits to insects in autumn and winter. He has also shown that Blackcaps fed exclusively on fruits in the laboratory lose weight and eventually die if not provided with some insect food. He concluded that the poor nutritive value of fruits was responsible. Nevertheless, Blackcaps in southern Spain are able to feed almost exclusively on fruits for six consecutive months without any apparent detrimental effect. Monthly averages of body weight of birds in the Viso site from October to March are: (sample size in parentheses, both sexes combined) 18·6 g (31), 18·1 g (51), 18·1 g (37), 18·5 g (34), 18·6 g (34) and 19·4 g (13). This striking constancy in the birds' condition must be related to the high nutritive value of Mediterranean fruits. Average percentages (on a dry weight basis) of crude fat and protein in fruit pulps from 21 species of southern Spanish plants are 10·2 and 4·9 (Herrera & Jordano 1981). These figures are substantially higher than those reported by Snow (1971) and Berthold (1976) for central European plants. Fruit pulp of *P. lentiscus* and *O. europaea*, two dominant species in Blackcap's diet (Table 2, see also Tutman 1969) have fat values of 15·9 and 41·9% respectively and both have a protein value of 7·9%. Blackcaps are therefore feeding on highly nutritious fruits in southern Spain and this may account for their extensive and sustained frugivory. The endogenous rhythm demonstrated by Berthold (1976) cannot have evolved in connection with the central European fruits he used in the experiments but rather with the highly rewarding fruits Blackcaps actually find in their normal winter quarters. Plant seeds appeared regularly in Blackcap faeces—a total of 3360 were found in an apparently intact condition. This suggests a significant role for Blackcaps in the dispersal of Mediterranean fruit-producing plants. The production of very nutritive fruits during the birds' wintering period represents the other side of a tightly coevolved seed dispersal system (McKey 1975).

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