Fruit food of Robins wintering in southern Spanish Mediterranean scrubland

by Carlos M. Herrera

IN THE SOUTHERN HALF OF the Iberian Peninsula the Robin *Erithacus rubecula* breeds sparsely in many mountain localities, but the species is above all an abundant winter visitor (October to March) which can be found in a great variety of habitats, both natural and man-made. The feeding ecology of birds wintering in oak woodlands has been described previously by Herrera (1977, 1978). In the present paper information is provided on the winter feeding ecology of the Robin in two southern Spanish scrubland habitats, mainly to emphasize the strong frugivory shown there.

STUDY SITES AND METHODS

Information presented in this paper refers to two Andalusian localities nearly 260 km apart, which will be referred to hereafter as Viso and Cazorla.

The Viso site is located near the village of El Viso del Alcor (Sevilla province), in the lowlands of the Guadalquivir valley, about 100 m above sea level. The study locality is a 3.5 ha stand of scrub vegetation surrounded by farmland. It is vegetated by sparse stone pines *Pinus pinea* (up to 8 m tall) and a dense scrub formation with an average height of 1.1 m. Despite being located in a highly disturbed area, the Viso site constitutes one of the few southern Spanish examples in which lowland Mediterranean scrub vegetation remains fairly well conserved, and it is to be considered representative of the natural vegetation in the area. At this site Robins are exclusively winter visitors.

The Cazorla site is located in the Sierra de Cazorla (Jaén province), a rough mountain range extending over 40 km (maximum elevation 2107 m) in the uppermost course of the Guadalquivir. Descriptions of the area can be found in Polunin and Smythies (1973). Data for this study were collected in an 8 ha plot (elevation 1,150 m asl) covered by dense Mediterranean montane scrub (mean height 2.2 m) virtually undisturbed in recent times. At this site Robins were present over most of the year, although by the end of the winter they became extremely scarce; the breeding population was relatively small.

As predictable from differences in elevation, winter climate differs markedly between the two study sites. January is the coldest month in both, with mean temperatures of 10.3°C (Viso) and 3.3°C (Cazorla). The warmest month is October, with monthly mean values of 19.6°C (Viso) and 12.4°C (Cazorla). Frosts are extremely rare in Viso (usually less than five days per winter), while they are very common in Cazorla. The relative composition of the tree and shrubby vegetation in both study sites is shown in Table I; note the high species diversity and the prominence of plants producing fleshy or pulpy fruits.

Robins were mist-netted and released in both localities between October 1978 and February 1979 (in Viso also in March). For most birds trapped, faecal samples were obtained by flushing the digestive tract with 1% sodium chloride water solution (see eg Moody 1970, Brensing 1977, Laursen 1978). Each sample was collected on filter paper, labelled, and dried at ambient temperature for storage. Prior to analysis, samples were wetted for 24 hours. Overall mortality attributable to the flushing procedure was well below 1%.

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TABLE I. RELATIVE COMPOSITION (PERCENT COVER) OF SHRUB AND TREE VEGETATION OF STUDY SITES

Plant species	*Has fleshy or pulpy fruits*	*Viso*	*Cazorla*	*Plant species*	*Has fleshy or pulpy fruits*	*Viso*	*Cazorla*
Arbutus unedo	x	P	15.9	*Phillyrea latifolia*	x	—	19.1
Asparagus acutifolius	x	P	—	*Pistacia lentiscus*	x	22.0	2.3
A. aphyllus	x	0.6	—	*P. terebinthus*	x	—	2.0
Ceratonia siliqua		P	—	*Quercus coccifera*		5.2	0.2
Chamaerops humilis	x	2.5	—	*Q. faginea*		—	0.7
Cistus crispus		5.7	—	*Q. ilex*		—	16.4
C. monspelliensis		2.3	—	*Rhamnus alaternus*	x	P	P
C. salvifolius		4.8	—	*R. lycioides*	x	1.5	—
Daphne gnidium	x	1.1	1.3	*Rosa* spp.	x	—	0.8
Erica arborea		P	0.4	*Rosmarinus officinalis*		4.3	5.8
Genista spp.		12.2	—	*Rubia peregrina*	x	P	2.1
Juniperus oxycedrus	x	—	0.8	*Rubus ulmifolius*	x	—	7.7
Lavandula stoechas		2.1	—	*Smilax aspera*	x	7.3	4.0
Lonicera implexa	x	0.4	0.9	*Sorbus torminalis*	x	—	P
Myrtus communis	x	10.0	—	*Tamus communis**	x	P	0.1
Olea europaea	x	5.2	—	*Teucrium fruticans*		P	—
Osyris quadripartita	x	6.0	—	*Viburnum tinus*	x	—	18.6
Phillyrea angustifolia	x	6.9	1.1				

	Viso	*Cazorla*
Number of fruit-producing species present	16	16
% of total species	61.5	76.2
% cover	63.5	76.7

NOTES. P = present but too infrequent to appear on transects.
* A herbaceous species, but listed due to its fruit-producing habit.

In autumn-winter, faeces from Robins inhabiting scrubland are made up of insect exoeskeletal remains together with seeds and skins from berries and other pulpy fruits. For each sample, the percentages by volume of animal and vegetable matter other than seeds were estimated visually. Usually Robins defecate only the smallest seeds ingested (below 2.5 mm length), while the bulk of seeds are regurgitated (Herrera unpublished). This behaviour necessitates the use of an analysis technique allowing for the identification of fruit skins, the commonest vegetable remains in the faeces. Fruit skins were added to Hertwig's solution (Baumgartner and Martin 1939) on a microscope slide, heated briefly on a flame, and examined under a microscope at ×125 magnifications. Identification was accomplished by comparison of size and shape of cells with an extensive reference collection of fruit skin microphotographs.

The insect fraction in the diet has already been described by Herrera (1977). Since that study revealed that the composition of the insect fraction appeared to be fairly constant between localities, while the main aim in the present instance was to study the fruit fraction in the diet, no further attention has been paid to the insect remains found in faecal samples. It was evident, however, that the predominance of ants found previously (Herrera 1977) occurred also in the samples from Viso and Cazorla.

RESULTS

Composition of the diet

In both localities Robins fed simultaneously on vegetable and animal (insect) food during the entire study period (Table II). From October to January, virtually all the faeces analysed contained vegetable remains, whereas in February and March (Viso) their frequency of occurrence decreased substantially. By far the largest part of vegetable remains were from fruits. In Viso during October and November, and in Cazorla between November–February, all faeces contained fruit remains; frequency of occurrence of fruits in Viso decreased steadily from November to March, while in Cazorla it was always very high. Occurrence of vegetable remains other than fruit is very infrequent in Cazorla, while in Viso this increases from early autumn to late winter (Table II). The origin of these remains is quite diverse and, although they appear frequently, their overall significance by volume is always very small; hence they will be ignored in the analyses below.

The mean percentage by volume of insect remains in the faeces (Table II) is only an approximate index to the significance of insect food in the diet since, most likely, animal and vegetable material have differential digestibilities and this must result in some under-representation of the softer fruits in the faeces. Nevertheless, that index may properly be used for comparative purposes in studying seasonal or geographical trends in the diet. The relative significance of insect food shows important seasonal changes (Table II). Mean percent per sample represented by insect remains is similar in both localities from October to January, with similar seasonal trends. In October, insects predominate in the samples, but their importance decreases sharply to a minimum in December-January. In Viso, this situation is immediately followed by a rapid increase in insect significance in March, but in Cazorla the low significance of insects persists until the birds' departures. Obviously,

TABLE II. RELATIVE IMPORTANCE OF INSECT AND VEGETABLE REMAINS IN FAECAL SAMPLES OF ROBINS

	Viso						*Cazorla*			
	Oct	***Nov***	*Dec*	*Jan*	*Feb*	*Mar*	*Oct*	*Nov*	*Dec*	*Jan–Feb*
No. of faeces analysed	21	32	15	8	7	11	28	13	5	
% with vegetable remains	100	100	100	100	87.5	57.1	90.9	100	100	100
% with fruit remains	100	100	92.3	86.7	37.5	0	90.9	100	100	100
% with vegetable remains other than fruit*	0	12.5	7.7	20.0	62.5	57.1	0	0	23.1	0
Mean % (volume) per sample of insect remains	64.5	49.2	10.0	13.4	37.5	68.6	68.6	16.3	19.2	12.0

* Includes debris, acorn endosperm, and seeds from *Cistus* and Chenopodiaceae.

TABLE III. SPECIES COMPOSITION OF THE FRUIT FOOD OF ROBINS OVER THE ENTIRE STUDY PERIOD

	Frequency of occurrence (%)	
Plant species	*Viso* ($n = 96$)	*Cazorla* ($n = 57$)
Arbutus unedo	1.0	50.9
Daphne gnidium	—	3.5
Juniperus oxycedrus	—	1.8
Lonicera implexa	—	1.8
Myrtus communis	6.3	—
Olea europaea	7.3	—
Osyris quadripartita	3.1	—
Phillyrea angustifolia	5.2	7.0
Phyllyrea latifolia	—	47.4
Pistacia lentiscus	74.0	33.3
Rhamnus lycioides	1.0	—
Rubia peregrina	—	3.5
Rubus ulmifolius	—	29.8
Smilax aspera	5.2	7.0
*Solanum nigrum**	8.3	—
Viburnum tinus	—	63.2
Species recorded	9	11
Species available †	14	13

* This herbaceous species is found growing on cultivated land edges outside the study site.
† Only those in Table I bearing ripe fruits in the period October–March.

the relative importance of fruits in the diet follows complementary seasonal trends: in Viso, fruits predominate in the diet in December and January, and in Cazorla from November through February. Hence it must be concluded that Robins wintering in lowlands feed on fruits to a lesser extent, and for a shorter period, than those inhabiting mountain habitats.

The composition of the fruit food of Robins is shown in Table III. In both localities birds eat fruits from a wide variety of species (64% and 85% of available species in Viso and Cazorla respectively), although their significance is very unequal. In Viso, only one species *(Pistacia lentiscus)* is of major importance, though in Cazorla there are up to five species showing frequencies of occurrence above 25%, with *Viburnum tinus* being present in 63% of faeces. These data reveal that the mountain wintering population of Robins is not only the more frugivorous one, but also that feeding on the widest variety of plant species, both in absolute and relative terms.

Changes in body weight

Mean body weights of mist-netted Robins reveal important changes over the autumn-winter study period (Figure 1). Within each locality, monthly differences are statistically significant (Viso: $F = 5.03$, $df = 5,102$, $P < 0.001$; Cazorla: $F = 8.39$, $df = 3,55$, $P < 0.001$). This seasonal variation is to be attributed to changes in levels of fat deposition, since no significant variation in the size (wing length) of birds occurs (Viso: $F = 0.50$, $df = 5,56$, $P > 0.75$; Cazorla: $F = 2.24$, $df = 3,52$, $P > 0.05$). These results are similar to those reported by Herrera (1977), where an analysis of fat deposition scores was also carried out.

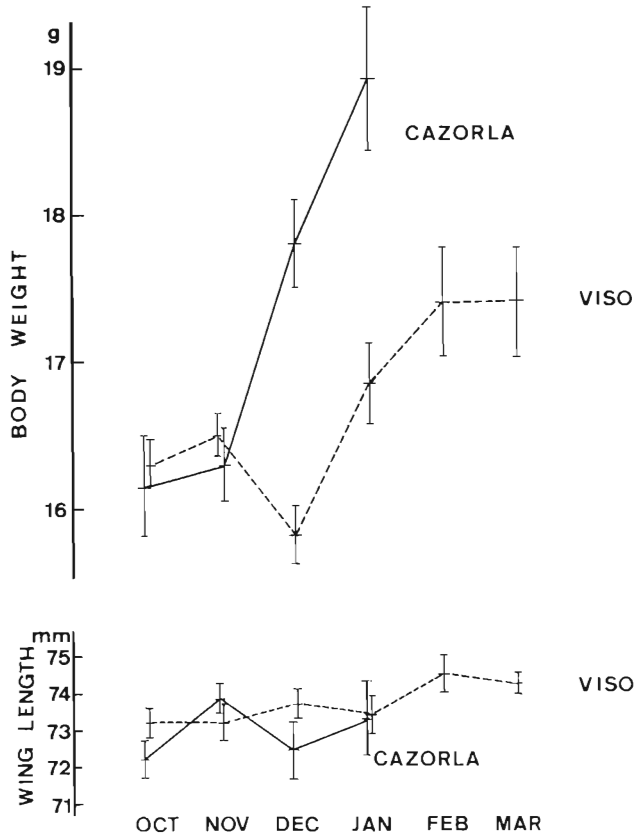

Figure 1. Monthly changes in mean body weight and wing length of the two Robin populations studied. Vertical segments extend over ± one standard error of the mean.

An increase in mean body weight takes place from early autumn to late winter in both localities, although the trajectories of the curves are very different (Figure 1). In Viso, mean weight declines from October to a December minimum, and then increases to a maximum in February and March. In Cazorla, no weight decrease is discernible and a steep increase begins in November to reach a maximum by the end of the study period. In absolute terms, mean weight is fairly similar in both localities during October and November, but in subsequent months the mountain-wintering Robins eventually become 2 g heavier on average (nearly 10% of body weight) than those inhabiting lowland habitat. Patterns of mean weight change shown by Figure 1 are also apparent in the weights of individual birds. Hence weights of recaptured Robins in Viso reflected both the December decrease and the subsequent steep increase between January–March. Increase rates in the late season may be high: two individuals gained 2.9 g and 4.1 g in 31 and 41 days respectively, an average of 0.1 g per day.

DISCUSSION

Both Robin populations studied have fruits as the main food during the central part of the autumn–winter period. The role of vegetable matter as an alternate food when insects become scarce has been pointed out previously for Robins wintering in oak woodlands of western Andalusia (Herrera 1977), although in that case the vegetable food ingested was acorn endosperm. In the present instance it may be argued similarly that fruits become most important in the diet when insect availability is lowest. Robins never prefer fruits to insects when the latter are abundant, and they do not have any endogenous rhythm controlling food preferences (Berthold 1976). On the other hand, fruit crops of favoured species experienced either a pronounced depletion *(Pistacia lentiscus, Phillyrea latifolia)* or a total exhaustion *(Arbutus unedo, Viburnum tinus)* by late January in both study localities, promoting contrasting responses by the two Robin populations. In the lowland locality, with a short and extremely mild winter, late January coincides with the beginning of the flowering and growing period in some shrub species, and the emergence of a much more abundant and diverse entomofauna. Thus, the end of a period characterized by high supply and consumption of fruits is followed immediately by a greater availability of insects. In the mountain site, where winter is much longer and harsher, the exhaustion of fruit crops is followed by nearly two months in which snow covers the ground and frosts are common; insects are extremely scarce and no flowering or growing activity is observed until early May. Here, the depletion of a previously widespread fruit supply is not followed by an increase in insect food and most Robins simply leave as soon as fruits are totally exhausted. These facts emphasize the importance of pulpy and fleshy fruits during those periods in which insect abundance is lowest.

It has been demonstrated for Robins wintering in oak woodlands that the substantial weight increase due to fat deposition which takes place in autumn–winter bears a close relationship to the consumption of the very nutritive endosperm of oak acorns (Herrera 1977). It was also argued that the higher weights reached by acorn-feeding Robins with respect to birds feeding on lowland fruits was due to the lower food value of the latter. In decreasing order, the maximum monthly mean weights reached in the course of the autumn–winter season are: Cazorla 19.0 g, oak woodlands 18.5 g, and Viso 17.4 g. At first sight, it is somewhat surprising that Cazorla birds are able to gain more weight than acorn-feeders despite having been feeding on pulpy fruits. The consideration of the nutritive value of the three main food types does not conflict with previous conclusions, but rather serves to emphasize the differential importance of vegetable winter food in promoting weight increase and fat deposition. One gram of fresh *Viburnum tinus* fruit including seeds contains (in the fruit flesh only) 75 mg crude fat and 13 mg crude protein; one gram of fresh endosperm of *Quercus ilex* acorn has 70 mg fat and 27 mg protein; and one gram of fresh, whole *Pistacia lentiscus* fruit contains in the pulp 30 mg fat and 15 mg protein (Herrera unpublished). Therefore *V. tinus* fruits, the basic food of Cazorla birds, are slightly richer in fat than acorns despite having an important fraction of useless material (to the bird) in the form of seed. Both *V. tinus* and acorns have a fat content which is twice that of *P. lentiscus* per unit fresh weight. The decrease in body weight of Robins taking place in Viso in December is not paralleled in Cazorla or in oak woodland. In the latter two populations December is, rather, the month showing the highest rate of weight increase. In all three habitats, the greater proportion of fruits in the diet also occurs at this time. All these findings suggest strongly that when the vegetable food ingested has a good nutritive value it is able to promote the fattening of birds, whereas if it is of only moderate value (Viso) a weight decrease may occur. Furthermore, a good correlation

appears to exist between the nutritive value of the main vegetable food ingested by a wintering Robin population and the magnitude of fat deposition reached by the end of the winter period and prior to spring migration. Further studies are in progress to determine the influence of the three basic diets in winter (*V. tinus*, acorns, *P. lentiscus*) on fat deposition (Herrera and Soriguer, in prep.).

Information presented in Table I reveals that most plant species in the two Mediterranean scrub habitats studied produce fleshy or pulpy fruits (61.5% and 76.2% of species in Viso and Cazorla, respectively), and that they also dominate these plant communities (63.5% and 76.7% of total cover). The great majority of these species have ripe fruits in autumn–winter, possess all the characteristics of bird-dispersed fruits (Pijl 1972), and are actually fed upon by a group of small to medium-sized passerines (Herrera unpublished). During this period of minimal abundance of active insects, the existence of the alternate food supply provided by fruits makes possible the winter survival of Robins and other generalist 'insectivorous' birds. In the past, when sclerophyllous scrubland was perhaps the most widespread vegetational formation in the Mediterranean Basin (eg Cody and Mooney 1978), winter availability of fruits must have played a decisive role in the evolution of certain migratory habits we still see today (when most natural habitats have been destroyed—Tomaselli 1976) and that make southern Europe and northern Africa the main wintering area of many birds (eg Robin, Blackcap *Sylvia atricapilla*, Starling *Sturnus vulgaris*, thrushes *Turdus* spp.—see Moreau 1971) whose diets are dominated by fruits (Bernis 1960, Tutman 1969, Herrera unpublished). Reciprocally, these circumstances must have represented a starting point for the development of coevolutionary relationships between fruit-eating birds and fruit-producing plants (Snow 1971, McKey 1975). These aspects have only recently begun to be investigated but results so far available suggest a close ecological link between migrant and wintering birds and plant features in Mediterranean habitats (Jordano 1979, Herrera 1981, Herrera and Jordano in press).

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SUMMARY

The fruit food of Robin populations wintering in two southern Spanish Mediterranean scrubland habitats are described. The diet comprised animal (insect) and vegetable matter, the latter consisting of fleshy and pulpy fruits from a great variety of species. In the lowland locality, drupes of *Pistacia lentiscus* were the most frequently consumed, whereas in the mountain locality those of *Viburnum tinus* predominated. Fruits formed the bulk of the diet in December, when active insects were scarcest. There was an overall increase in mean body weight from early autumn to late winter in both localities, but final levels reached in the mountainous site were higher than in the lowland. This is explained by the greater fat content of *Viburnum* fruits, compared with Pistacia drupes. The significance of fruits for winter survival of Robins is stressed, as well as the potential this must have provided for the development of plant-bird coevolutionary traits and the evolution of current migratory habits in some European passerine species.

REFERENCES

BAUMGARTNER, L. L. and A. C. MARTIN. 1939. Plant histology as an aid in squirrel food-habit studies. *J. Wildl. Manage.* 3: 266–268.

BERNIS, F. 1960. Migración, problema agrícola y captura del Estornino Pinto *(Sturnus vulgaris). Ardeola* 6: 11–109.

BERTHOLD, P. 1976. Animalische und vegetabilische Ernährung omnivorer Singvogelarten: Nahrungsbevorzugung, Jahresperiodik der Nahrungswahl, physiologische und ökologische Bedeutung. *J. Orn.* 117: 145–209.

BRENSING, D. 1977. Nahrungsökologische Untersuchungen an Zugvögeln in einem südwestdeutschen Durchzugsgebiet während des Wegzuges. *Vogelwarte* 29: 44–56.

CODY, M. L. and H. A. MOONEY. 1978. Convergence versus nonconvergence in Mediterranean-climate ecosystems. *Annu. Rev. Ecol. Syst.* 9: 265–321.

HERRERA, C. M. 1977. Ecología alimenticia del Petirrojo *(Erithacus rubecula)* durante su invernada en encinares del sur de España. *Doñana Acta Vert.* 4: 35–59.

HERRERA, C. M. 1978. Individual dietary differences associated with morphological variation in Robins *Erithacus rubecula. Ibis* 120: 542–545.

HERRERA, C. M. (1981). Fruit variation and competition for dispersers in natural populations of *Smilax aspera. Oikos* 36: 51–58.

HERRERA, C. M. and P. JORDANO (in press). *Prunus mahaleb* and birds: the high-efficiency seed dispersal system of a temperate fruiting tree. *Ecol. Monogr.* 51.

JORDANO, P. 1979. Estrategias reproductivas de *Rubus ulmifolius* (Rosaceae): coevolución con los pájaros dispersantes de las semillas. Tesis Licenc., Univ. Córdoba.

LAURSEN, K. 1978. Interspecific relationships between some insectivorous passerine species, illustrated by their diet during spring migration. *Ornis Scand.* 9: 178–192.

McKEY, D. 1975. The ecology of coevolved seed dispersal systems. Pp. 159–191 in: L. E. Gilbert and P. H. Raven (eds.), *Coevolution of Animals and Plants.* Austin, Texas.

MOODY, D. T. 1970. A method for obtaining food samples from insectivorous birds. *Auk* 87: 579.

MOREAU, R. E. 1971. *The Palaearctic-African Bird Migration Systems.* London.

PIJL, L. van der. 1972. *Principles of Dispersal in Higher Plants.* 2nd edition. Berlin.

POLUNIN, O. and B. E. SMYTHIES. 1973. *Flowers of South-west Europe.* London.

SNOW, D. W. 1971. Evolutionary consequences of fruit-eating by birds. *Ibis* 113: 194–202.

TOMASELLI, R. 1976. La dégradation du maquis méditerranéen. Pp. 35–76 in: UNESCO (ed.), *Forêts et maquis méditerranéens: écologie, conservation et aménagement.* Paris.

TUTMAN, I. 1969. Beobachtungen an olivenfressenden Vögeln. *Vogelwelt* 90: 1–8.

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