J. Field Ornithol., 65(4):482–489

CONSUMPTION RATES OF OLIVES BY CHOUGHS IN CENTRAL SPAIN: VARIATIONS AND IMPORTANCE

GUILLERMO BLANCO, JUAN A. FARGALLO AND JESÚS A. CUEVAS
Departamento de Biología Animal
Universidad de Alcalá de Henares Alcalá de Henares. 28871 Madrid, Spain

Abstract.—Olives have been recorded as food of many species of corvids and other birds. The winter energetic importance and the seasonal variation of the consumption of olives by Choughs (*Pyrrhocorax pyrrhocorax*) in an area of central Spain were studied. Choughs roosted in a large vertical crevice from which olive stones were collected to estimate an index of monthly consumption. Choughs fed on olives year round with a major peak in winter. In mid-December an estimated minimum of 13% of the daily energetic demand for each Chough was supplied by olives. Results are discussed in the context of the availability of olives and the role of olives as a valuable resource for the winter survival of Choughs.

CONSUMO DE ACEITUNAS POR PARTE DE *PYRRHOCORAX PYRRHOCORAX* EN ESPAÑA CENTRAL: VARIACIONES E IMPORTANCIA

Sinopsis.—Las aceitunas forman parte de la dieta de muchas especies de aves incluyendo córvidos. La variación estacional en el consumo de aceitunas por parte de la Chova piquirroja (*Pyrrhocorax pyrrhocorax*) y su importancia energética invernal se estudiaron en el sureste de Madrid, España. Las chovas utilizaron como dormidero una grieta vertical situada en cortados fluviales, en cuyo interior se recogieron, regularmente, las semillas de aceituna regurgitadas durante la noche para estimar un índice de consumo mensual. Las chovas consumieron aceitunas durante todo el año, especialmente durante el invierno. A mediados de diciembre se estimó que un mínimo del 13% de los requerimientos energéticos diarios de cada ave fueron proporcionados por las aceitunas. Se discuten los resultados en el contexto de la disponibilidad de aceitunas y su papel como valioso recurso para la supervivencia invernal.

Olive orchards are one of the most extensive cultivations in the Iberian peninsula; with several hundred million trees they constitute a major proportion of the wooded area of Spain (Muñoz-Cobo 1987). Although olive crop production varies among years depending on weather, a large quantity of olives is always available to be eaten by birds every winter (Muñoz-Cobo 1987, Rodriguez de los Santos et al. 1986). The importance of olive orchards in maintaining a rich, winter avifauna has been repeatedly emphasized (Jordano 1985, Muñoz-Cobo and Purroy 1980, Santos and Telería 1985, Suarez and Muñoz-Cobo 1984), and the accessibility, abundance and nutritive value of olives allow the existence of high winter densities of frugivorous birds. Olives form an important fraction of the diet of many species (Muñoz-Cobo 1987, Tutman 1969), with some species feeding almost exclusively on them (Bernis 1960; Manzanares 1983; Soler et al. 1986, 1988; Tejero et al. 1983).

The adaptable and opportunistic feeding behavior of crows makes it possible for these birds to utilize a wide variety of food (Goodwin 1986) including fruit (Snow and Snow 1988). Despite this, corvids are not especially abundant in southern Spanish olive groves (Muñoz-Cobo 1987, Suarez and Muñoz-Cobo 1984). Nevertheless, olives have been recorded as a small part of the diet of *Garrulus glandarius, Cyanopica cyaneus, Pica*

pica, Corvus monedula, Corvus corone and *Corvus corax* (Alvarez and Aguilera 1988, Soler et al. 1990, Soler and Soler 1991, Tutman 1969). Unlike any other Corvidae, the Chough (*Pyrrhocorax pyrrhocorax*) is comparatively rare and patchily distributed in Europe (Bignal and Curtis 1988). In some Spanish localities Choughs coincide with olive cultivars but olives have never been mentioned as food of this species.

In this paper, we report on the exploitation of olives by Choughs in central Spain. We analyze seasonal variations in consumption rates in relation to fruit availability and discuss the importance of the energetic role played by olives during winter.

MATERIAL AND METHODS

Between August 1990 and August 1991, we examined the variation in the consumption rates of cultivated olives (fruits of the olive tree *Olea europaea var europaea*) by Choughs in an area to the southeast of Madrid, central Spain. The study area and the Chough population have been described elsewhere (Blanco et al. 1991). Cultivation of olives in the study area is predominantly in small patchily distributed orchards. Fruiting phenology and availability of fruit was measured on 39 olive trees corresponding to two medium sized olive groves in which the crops are not harvested. In the exploited orchards there were ripe olives from November to April, and the crop was harvested in December (for general details of fruiting and availability times in harvested groves see Muñoz-Cobo 1987). Each tree in the sample was visited monthly and the state of maturity of the fruit recorded according to a five-point scale: (0) no fruit, (1) all unripe fruit, (2) 25% ripe fruit, (3) 50% ripe fruit, (4) 75% ripe fruit and (5) all ripe fruit. Mean percentages of monthly ripening states were calculated, such that 100% indicated that all the trees had only ripe fruit. Average monthly availability was checked by counting the fruit (only ripe fruit) beneath each tree, recording abundance in the following categories: (0) no fruit, (1) 1–5 fruit, (2) 6–15 fruit and (3) >15 fruit. Consumption rates of olives by Choughs were assessed by collecting olive stones (endocarp and kernel, "seeds" hereafter) falling on a 1.5 m^2 sheet of plastic placed inside a vertical crevice used as a roosting site. The plastic sheet was always placed in the same location once or twice every month for 5–6 d. The lack of a significant difference ($\chi^2 = 6.7$ $P > 0.10$ df $= 4$) in the number of seeds collected on the plastic or on other similar-sized sheets placed side by side and 2 m away, indicated the lack of any important changes in the Chough roosting positions. We carried out counts of Choughs attending the roost during the periods in which the plastic was in position. A simple consumption index (CI) was used to compare the number of regurgitated seeds by Choughs:

$$CI = \frac{NS/ID}{NCH} \times 100,$$

where NS is the number of seeds on the plastic sheet, ID is the number of interval days and NCH is the average number of Choughs in the roost

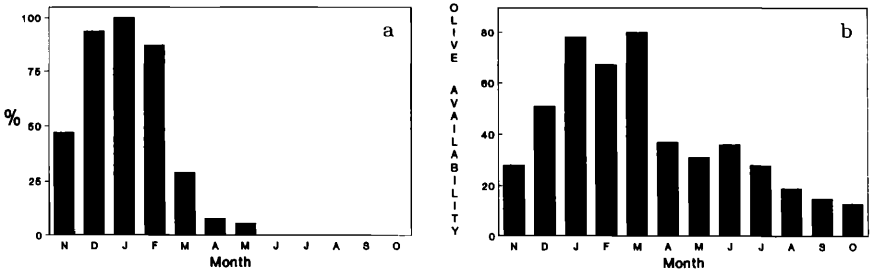

FIGURE 1. Mean percentage of monthly ripening state for the sampled trees (a) and average monthly availability of olives (b), expressed as the sum of scores for fruit abundance beneath the sampled trees (see Methods).

during each sampling period. During one night in July and August 1991, a 17m-long plastic sheet was also positioned to cover all the crevice floor area. Lack of any difference in the number of seeds collected on the two plastic sheets on these nights ($\chi^2 = 0.02$ $P = 0.90$ df = 1) further supports the assumption of no important changes in the roosting positions.

Daily energetic requirements (DER) of Choughs were calculated according to the equations proposed by Kendeigh et al. (1977), and were estimated using the mean mass of 67 Choughs captured with nets at the roosting sites in this area. Bromatologic composition and energy-efficiency data of ripe olives were taken from Muñoz-Cobo (1987) and Herrera (1983, 1987).

RESULTS

Fruiting phenology and availability of fruits.—Olive trees flower in May and bear green unripe fruits from June to November, thereafter acquiring mature black coloration. Mean percentage of monthly ripening is shown in Figure 1a. Olives ripen gradually from November onwards. The peak period for trees bearing ripe fruits is in January; the number of trees with ripe fruits begins to decrease from February onwards as the ripe fruit begins to fall. In April–May a very small number of trees containing desiccated olives was observed, and by June not a single ripe olive could be found on the trees.

Olive availability on the ground extends throughout the year with a peak in March (Fig. 1b). The quantity of available fruit decreases from April onwards, reaching the lowest values in October, just before a new crop is produced. If it is assumed that Choughs only ingest olives when they fall to the ground, then Figure 1b shows the seasonal variation in olive availability to the birds. The difference in the availability period between groves was highly significant ($\chi^2 = 66.0$ $P < 0.001$ df = 11) when considering the number of trees with some olives beneath, and not significant ($\chi^2 = 6.8$ $P > 0.30$ df = 7) when taking into account the trees below which there was a lot of fruit (>15). Fruit abundance reached remarkably high levels in both olive groves, and there were no significant

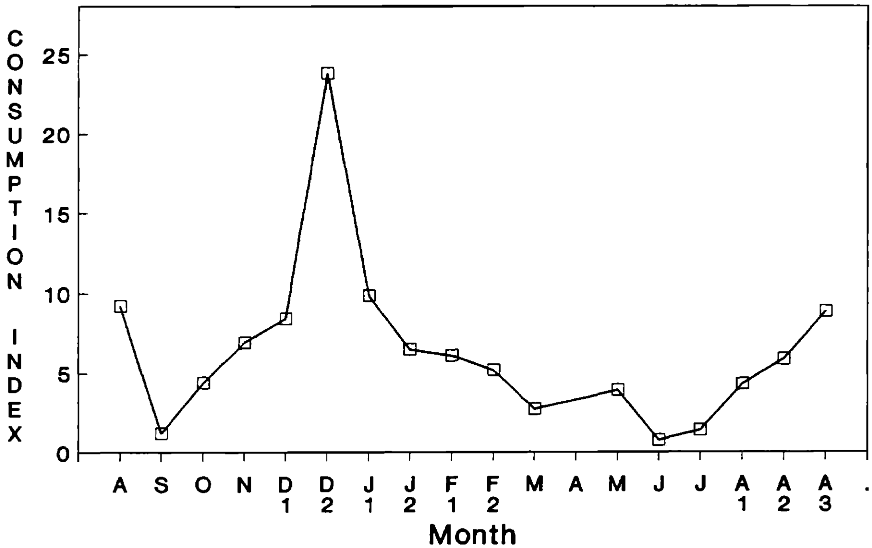

FIGURE 2. Consumption index of olives by Choughs in Central Spain. Numbers below the months indicate consecutive samplings in those months. April values were not estimated (see text).

differences in the fruit supply for each site (Mann-Whitney *U*-test $U = 15.5$ $P > 0.05$ $n = 14$).

Consumption rates and regurgitation patterns.—Choughs ingest olives throughout the year. Consumption-index (CI) variation (Fig. 2) shows a strong peak halfway through December, quickly increasing and decreasing just before and afterwards. CI shows lowest values in spring and summer, except for August when a high and similar peak occurred in both years. We lack CI scores in September 1991, but CI in October gave similar values (4.08 and 4.37) in both years. In April, the roost was occupied by only 2–3 breeding pairs of Choughs, but these too consumed olives. In this month, however, we did not estimate the consumption index because breeding Choughs usually roost near their nest sites, and therefore, roosting positions were not comparable. For the rest of the year the number of Choughs attending the roost ranged from 100 to 367.

The consumption index, grouping samples into the months except for April, was not significantly correlated with fruit availability in the olive groves studied ($r_s = 0.21$ $P > 0.05$ $n = 11$). This lack of correlation was due to a very different spatio-temporal availability among unexploited and harvested groves (see methods), the latter being those where Choughs mainly forage (pers. obs.).

Olive seed regurgitation occurred both in a simple, individual-seed manner and together with other indigestible remains grouped in pellets. The majority of seeds ($n = 2018$) were regurgitated in the first manner;

although pellets were scarce they sometimes contained up to five seeds. The number of seeds regurgitated per Chough each night at the roost ranged from 0.06 to 1.87 (June to December, respectively).

Energetic importance.—DER estimation for Choughs in winter (photoperiod: 10:14 L:D; ambient temperature: 0 C) gave a value of 90 Kcal/bird-day. The number of olives required to meet DER on a diet consisting only of olives in winter was approximately 15. The energy supplied by the olives calculated from the number of seeds regurgitated per Chough at roost ranged between 0.37 Kcal (June) and 11.4 (December). The percentage of DER supplied by olives in winter ranged from 3.3 to 12.7.

DISCUSSION

Data from previous studies (Cowdy 1973, Holyoak 1967, Meyer 1990, Roberts 1982) suggest that although the Chough is a specialist invertebrate feeder, vegetable matter, especially weed seed and cereal grain, occurs in the diet at certain times of the year (Goodwin 1986, McCracken et al. 1992, Warnes and Stroud 1988). The presence of fruit as part of the Chough's diet is rarely mentioned in the literature, and would therefore suggest that it is of little importance to the birds. Observations by Spanish authors (Garcia-Dory 1983, Martín and Cardona 1989) together with those of our own, however, show that Choughs can consume the fruit of at least 20 species of trees and shrubs. This study demonstrates that Choughs in central Spain feed on olives year round with a major peak in winter.

In the two groves we sampled, the different fruiting phenology allowed the existence of a lengthy period of fruit availability. In both these orchards, however, the olives were not harvested, and our field observations suggest that Choughs forage mainly in the few large exploited groves, where the fruit is a very punctual yet patchily distributed resource because of the time and methods of harvesting. The quantity of ingested olives was in agreement with the peak in availability on the ground (mid-December) for harvested olive groves (see also Muñoz-Cobo 1987). In addition, Choughs consumed olives even in spring-summer, when our studies show that the fruit is very scant on the ground and only present in a desiccated state. Olives do not occur on the ground in harvested groves except in August, when a natural fruit-fall occurs, and this is reflected in a high CI for this month in both years. Furthermore, a large (though unquantified) number of olive seeds has been observed inside and around Chough nesting cavities during several years of studying breeding Choughs. The presence of such seeds in nests suggests to us that olives perhaps also form a small part of nestlings diet. One explanation for the fact that Choughs consume olives during the long periods when fruit is unavailable in harvested groves, could be that the birds hoard olives during the winter months. Alternatively, Choughs could occasionally forage in the small, non-harvested plots. Food caching has been extensively reported in corvids (Vander Wall 1990) and the Chough is no exception (Holyoak 1972, Turner 1959).

At dawn during winter, Choughs fly directly every day from the roosting sites to olive groves. Probably the greatest part of the olive ingestion-seed regurgitation process occurs during the morning because food passes through the digestive system in 90–120 min (Bullock 1980) and this transit is always shorter than the interval for seeds that pass through the bird by regurgitation (Herrera 1981, 1984). Our data have revealed that by eating olives, Choughs obtain an important fraction of the DER in winter; in mid-December almost 13% of daily energetic demands for each Chough attending the roost (mean December counts of 284 Choughs) were supplied by olives. These results could be representative of olive consumption by the entire population in southeastern Madrid (about 1000 individuals) because we have found great numbers of olive seeds in all the communal roosting sites in this area. These figures are almost certainly underestimated, however, because: (1) the percentage of DER is calculated only from seeds regurgitated at night, and the seeds corresponding to olives eaten during the morning would be regurgitated also in the morning (see above); (2) a proportion of seeds remains on the crevice walls, and many are removed by rodents (unpubl. data); (3) Choughs seem to select the largest olives (pers. obs.) and (4) Choughs possibly also fed on abortive, seedless fruit. Assuming that pellets regurgitated at night are the indigestible remains ingested during the day, some Choughs might obtain up to 34% of DER from olives.

As is the case for many bird species wintering in olive groves (Herrera 1983), feeding on olives could play an important role by increasing survival rates of Choughs during winter in the whole population of southeastern Madrid. Juvenile Choughs may gain experience from older birds about this valuable, easy-to-locate and abundant food resource, so reducing mortality due to foraging inexperience (Bignal et al. 1988, Roberts 1985); in other studies, winter mortality has been partially attributed to the Chough's specialized feeding requirements (Bullock et al. 1983, Holyoak 1971). By foraging in flocks, Choughs could profit from the better location and exploitation of this patchily distributed, seasonally abundant and nutritive resource. In fact, the function of communal roosting aggregations has been interpreted as information centers, where daily activity is organized to take maximum advantage of food resources (Blanco et al. 1994; Still et al. 1987).

ACKNOWLEDGMENTS

We thank Fernando Gómez for help with the field work, and Eric Bignal, Jaime Potti, Davy McCracken and an anonymous referee for comments on the manuscript and for correcting the English. We also thank Aurelio Capilla for advising us on the olive tree cycle.

LITERATURE CITED

Alvarez, F., and E. Aguilera. 1988. Sobre el dimorfismo sexual en el Rabilargo *Cyanopica cyanea.* Ardeola 35:269–295.

Bernis, F. 1960. Migración, problema agricola y captura del Estornino Pinto *Sturnus vulgaris.* Ardeola 6:11–95.

Bignal, E., S. Bignal, and D. J. Curtis. 1988. Functional unit systems and support ground for choughs—the nature conservation requirements. Pp. 102–109, *in* E. Bignal and D. J. Curtis, eds. Choughs and land-use in Europe. Scottish Chough Study Group. Argyll, United Kingdom.

———, AND D. J. CURTIS. 1988. Choughs and land-use in Europe. Scottish Chough Study Group. Argyll, United Kingdom, 112 pp.

BLANCO, G., J. A. CUEVAS, AND J. A. FARGALLO. 1991. La población de Chova Piquirroja *Pyrrhocorax pyrrhocorax* en el sureste de Madrid (Centro de España). Ardeola 38:91–99.

———, J. A. Fargallo, and J. A. Cuevas. 1994. Seasonal variations in number and levels of activity in a communal roost of Choughs *Pyrrhocorax pyrrhocorax* in Central Spain. Avocetta, 17:41–44.

BULLOCK, I. D. 1980. Some aspects of the ecology of the chough. M.Sc. thesis. University of Wales., Bangor, United Kingdom.

———, R. R. DREWETT, AND S. P. MICKLEBURGH. 1983. The Chough in Britain and Ireland. Brit. Birds 76:377–401.

COWDY, S. 1973. Ants as a major food source of the Chough. Brit. Birds 20:117–120.

GARCIA-DORY, M. A. 1983. Datos sobre la ecologia del Género *Pyrrhocorax* (*Pyrrhocorax pyrrhocorax* y *P. graculus*) en el Parque Nacional de la Montaña de Covadonga. Alytes 1: 411–448.

GOODWIN, D. 1986. Crows of the world. Cornell Univ. Press. Ithaca, New York. 299 pp.

HERRERA, C. M. 1981. Are tropical fruits more rewarding to dispersers than temperate ones? Am. Nat. 118:896–907.

———. 1983. Coevolución de plantas y frugivoros: la invernada mediterránea de algunos paseriformes. Alytes 1:177–189.

———. 1984. Adaptation to frugivory of mediterranean avian seed dispersers. Ecology 65: 609–617.

———. 1987. Vertebrate-dispersed plants of the Iberian Peninsula: a study of fruit characteristics. Ecol. Monogr. 57:305–331.

HOLYOAK, D. T. 1967. Food and feeding actions of Choughs. Bird Study 14:61–62.

———. 1971. Movements and mortality of Corvidae. Bird Study 18:97–106.

———. 1972. Behaviour and ecology of the Chough and Alpine Chough. Bird Study 19: 225–237.

JORDANO, P. 1985. El ciclo anual de los paseriformes frugívoros en el matorral mediterráneo: importancia de su invernada y variaciones interanuales. Ardeola 32:69–94.

KENDEIGH, S. C., V. R. DOLNICK, AND M. GAVRILOV. 1977. Avian energetics. Pp. 127–204, *in* J. Pinowski and S. C. Kendeigh, eds. Granivorous birds in ecosystems. Cambridge Univ. Press, Cambridge, United Kingdom.

MCCRACKEN, D. I., G. N. FOSTER, E. BIGNAL, AND S. BIGNAL. 1992. An assessment of Chough *Pyrrhocorax Pyrrhocorax* diet using multivariate analysis techniques. Avocetta 16:19–29.

MANZANARES, M. 1983. Contribución al conocimiento de la alimentación del Zorzal Común *Turdus philomelos* durante su período invernal en Córdoba. Alytes 1:369–372.

MARTÍN, P. AND A. CARDONA. 1989. Avifauna Canaria IV. Aves de Laurisilva y pinar. Cabildo insular de Gran Canaria. Las Palmas de Gran Canaria, España. 128 pp.

MEYER, R. M. 1990. Observations on two Red-billed Choughs *Pyrrhocorax pyrrhocorax* in Cornwall: habitat use and food intake. Bird Study 37:199–209.

MUÑOZ-COBO, J. 1987. Las comunidades de aves de los olivares de Jaen. Ph.D. thesis. Universidad Complutense de Madrid. Madrid, España.

———, AND F. J. PURROY. 1980. Wintering bird communities in the olive tree plantations of Spain. Pp. 185–189, *in* H. Oelke, ed. Bird census work and nature conservation. Gottingen, Germany.

ROBERTS, P. J. 1982. Foods of the Chough on Bardsey Island, Wales. Bird Study 29:155–161.

———. 1985. The Choughs of Bardsey. Brit. Birds 78:217–232.

RODRIGUEZ DE LOS SANTOS, M., M. CUADRADO, AND S. ARJONA. 1986. Variation in the abundance of Blackcaps *Sylvia atricapilla* wintering in Olive *Olea europaea* orchard in southern Spain. Bird Study 33:81–86.

SANTOS, T., AND J. L. TELLERÍA. 1985. Patrones generales de la distribución invernal de paseriformes en la Península Ibérica. Ardeola 32:17–30.

SNOW, B., AND D. W. SNOW. 1988. Birds and berries. A study of an ecological interaction. T. and A. D. Poyser, Calton, United Kingdom. 268 pp.

SOLER, M., E. TEJERO, AND I. CAMACHO. 1986. Alimentación de la Curruca capirotada *Sylvia atricapilla* en olivares de la provincia de Jaén durante el periodo de otoño-invierno. Alytes 4:93–104.

———, J. A. PEREZ-GONZALEZ, E. TEJERO, AND I. CAMACHO. 1988. Alimentación del Zorzal Alirrojo *Turdus illiacus* durante su invernada en olivares de Jaén (Sur de España). Ardeola 35:183–196.

———, N. ALCALA, AND J. J. SOLER. 1990. Alimentación de la Grajilla *Corvus monedula* en tres zonas del sur de España. Doñana Acta Vertebrata 17:17–48.

SOLER, J. J., AND M. SOLER. 1991. Análisis comparado del régimen alimenticio durante el período otoño-invierno de tres especies de córvidos en un área de simpatria. Ardeola 38:69–89.

STILL, E., P. MONAGHAN, AND E. BIGNAL. 1987. Social structuring at a communal roost of Choughs *Pyrrhocorax pyrrhocorax*. Ibis 129:398–403.

SUAREZ, F., AND J. MUÑOZ-COBO. 1984. Comunidades de aves invernantes en cuatro medios diferentes de la provincia de Córdoba. Doñana Acta Vertebrata 11:45–63.

TEJERO, E., J. CAMACHO, AND M. SOLER. 1983. La alimentación de la Curruca cabecinegra *Sylvia melanocephala* en olivares de la provincia de Jaén (otoño-invierno). Doñana Acta Vertebrata 10:133–153.

TURNER, B. C. 1959. Feeding behaviour of Choughs. Brit. Birds. 52:388–390.

TUTMAN, V. I. 1969. Beobachtungen an olivenfressden Vogeln. Die Vogelwett 90:1–8.

VANDER WALL, S. B. 1990. Food hoarding in animals. Univ. Chicago Press, Chicago, Illinois. 445 pp.

WARNES, J. M., AND D. A. STROUD. 1988. Habitat use and food of choughs on the island of Islay, Scotland. Pp. 46–51, *in* E. Bignal and D. J. Curtis, eds. Choughs and land-use in Europe. Scottish Chough Study Group. Argyll, United Kingdom.

Received 1 Aug. 1993; accepted 30 Nov. 1993.