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Shell size relationships in the consumption of gastropods by migrant Song Thrushes *Turdus philomelos*

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It is well known that gastropods constitute one of the most important food resources for some thrushes (Simms 1978). This is particularly true for the Song Thrush *Turdus philomelos*, which uses "anvils" to break open the shells of medium-sized or large gastropods, that otherwise cannot be completely swallowed (Morris 1954, Herring 1984, Henty 1986). Previous studies of the species of gastropods preyed on by Song Thrushes have been carried out using the shells collected at the anvils (Goodhart 1958, Cameron 1969, Fraticelli 1982, Sueur 1985, Hartley 1987). However, this method gives biased information, as pointed out by Sueur (1985) and Hartley (1987), since it fails to take into account either the small-sized species or the juvenile forms of larger species which can be completely ingested. Moreover, some studies on the diet of this species consider the tem "gastropods" without reference to size or consider only adult forms (Davies and Snow 1965, Dyrcz 1969, Tejero *et al.* 1984, Debussche and Isenmann 1985).

We describe gastropod size and species consumed by Song thrushes in Spain during the autumn migration on the basis of stomach contents.

We analyzed the contents of 155 stomach collected from Song Thrushes shot by hunters. For the analysis procedures see González-Solís and Ruiz (1990).

Samples came from three different sources: (1) Mallorca (Balearic Islands) c. 39.35N 2.39E (n=55); (2) Montsià (Tarragona, NE Spain) c. 40.43N 0.34E (n=45); and (3) Ribera d'Ebre (Tarragona, NE Spain) 41.17N 00.40E (n=55). Birds from samples 1 and 2 were caught in October 1986, and those from sample 3 in October 1989. At this time Song Thrushes are migrating through the Mediterranean area (Santos 1982). We determined the gastropod species and measured the high of the shell when the gastropod was whole. We also determined the number of gastropods present in each stomach based on the number of whole individuals. Small fragments of shell that were impossible to determine were considered "undetermined" and quantified as one gastropod. The consumption of gastropods by Song Thrushes was calculated as the corresponding percentage of ocurrence in respect to the total number of stomachs; abundance was estimated as the percentage over the total number of prey.

Fifteen snail species were identified (Table 1).

Table 1. Frequency percentatges of gastropod species found in 92 stomachs of Song Thrush for each area. * Approximate size of an adult individual, according to Bech (1990).

	Mallor. (n=68)	Mont. (n=51)	R. Ebre (n=20)	size* (mm)
Theba pisana	11.8	54.9	0.0	14-20
Cochlicella acuta	8.8	0.0	0.0	10-15
Cochlicella ventricosa	11.8	0.0	0.0	8-12
Xeroplexa sp.	2.9	0.0	15.0	3-6
Xerotricha apicina	22.0	0.0	5.0	3.5-5
Clausilia bidentata	1.5	0.0	0.0	13
Trochoidea elegans	1.5	0.0	0.0	6-8
Helix aspersa	0.0	3.9	0.0	14-20
Ferussacia folliculus	0.0	3.9	5.0	8-9
Abida sp.	0.0	2.0	0.0	6-10
Granopupa granum	0.0	2.0	0.0	3-5
Pomatias elegans	0.0	0.0	5.0	10-17
Monacha carthusiana	0.0	0.0	10.0	6-9
Vallonia sp.	0.0	0.0	5.0	1.2
Trochoidea (Xerocrassa) murcica grata	0.0	0.0	10.0	4-5.5
Undetermined	39.7	33.3	45.0	

Gastropods showed a variable percentage of occurrence between 31-51%, with abundances between 15-38% (Table 2). Birds collected in Mallorca consumed primarily three species: *Xerotricha apicina, Cochlicella ventricosa* and *Theba pisana*. In Montsià, birds fed mainly on *Theba pisana*, whereas those from Ribera d'Ebre preyed upon *Xeroplexa* spp., *Monacha carthusiana* and *Trochoidea murcica*. The shell size of these gastropods was in all cases less than 1 cm. No gastropods without shells were recorded.

Table 2. Sample size, total number of gastropods, percentage presence (% P) and percentage abundance (% N) of gastropods found in the stomachs.

Origin	N stomachs	N gastropods	% P	% N
Montsià	45	51	51.16	38.34
Mallorca	55	68	61.81	20.24
Ribera d'Ebre	55	20	30.91	15.27

In the case of *T. pisana* and *H. aspersa*, the individuals recorded were juvenile forms. The remaining individuals were adults from species that do not reach more than 1cm in width or depth. These species have not previously been reported in the Song Thrush's diet (Table 1).

Several researchers have stated that gastropods smaller than 1cm are swallowed whole (Goodhart 1958, Tejero *et al.* 1984, Debussche and Isenmann 1985), which agrees with our results. Larger individuals are consumed without the shells, after being broken on anvils. When analyzing stomachs contents, varying digestibility can produce a bias in favour of the detectability of the small gastropods. However, the presence of other soft-bodied prey in the stomach does not justify the total absence of snails without shells.

The consumption of small snails seems primarily related to their availability. The passage of Song Thrushes through NE Iberia and the Balearics in autumn coincides with an abundance of invertebrates because of the rainfall and mild weather after the summer drought (see e.g. Santos 1982), and also with the abundance of juvenile forms of several gastropod species (per. obs.). Thus, in the Mediterranean area, gastropods are present in the diet of the Song Thrush both during migration and wintering (Fraticelli 1982, Tejero *et al.* 1984, Debussche and Isenmann 1985, González-Solís and Ruiz 1991).

It is commonly assumed that avian diet analysis provides merely an approximation of the actual food ingested (Rosenberger and Cooper 1990). In the case of the gastropods, Song Thrush prey on them throughout the year using anvils for larger individuals or swallowing the smaller ones whole. However, the analysis of stomach contents from autumn (present study) and winter (Tejero *et al.* 1984, Debussche and Isenmann 1985) suggests that small gastropods are a common resource, widely used by Song Thrush, thought this is not the case of the larger gastropods as is suggested from the study of anvils. It is difficult to determine whether birds select a fixed sized gastropod. Further studies are required to find out if the costs of handling snails on anvils in terms of time invested or risk of predation are compensated by their larger contents or if this behaviour is restricted to specialized individuals.

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Resumen - Los gasterópodos constituyen uno de los principales recursos tróficos del Zorzal común *Turdus philomelos*. Anteriores estudios sobre las especies de gasterópodos consumidas por el Zorzal común se han basado en las conchas recolectadas en "anvils", donde los zorzales rompen las conchas de los gasterópodos de tallas superiores a 1cm, para obtener su contenido. Sin embargo, este método está claramente sesgado, puesto que no registra los gasterópodos de pequeña talla que son ingeridos enteros. En este trabajo se describen las tallas y especies de gasterópodos consumidos por el Zorzal, durante su paso otoñal por España, en base al análisis del contenido de 155 estómagos, provenientes de tres localidades de Catalunya. Se identificaron 15 especies distintas de gasterópodos. El porcentaje de presencia varió entre 31-51% mientras que el de frecuencia varió entre 15-38%, según la localidad. No se halló ningún gasterópodo desprovisto de concha, a pesar de que se hallaron otras presas blandas como larvas de insecto. Todos los gasterópodos fueron deglutidos enteros y la talla de la concha, usualmente entera, fue menor a 1cm en todos los casos. El consumo de pequeños gasterópodos parece estar primordialmente relacionado con la disponibilidad de las distintas especies en cada localidad. El análisis de los contenidos estomacales sugiere que los gasterópodos de pequeña talla son un recurso habitual para el Zorzal común. Asimismo, el consumo de gasterópodos de tallas superiores a 1 cm no parece estar muy extendido, en contra de lo que pueden sugerir los estudios basados en "anvils".

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