

## MATERIAL AND METHODS

Pellet samples were collected between 29th April and 13th May 1973 at three western Andalusian nesting colonies, as follows:

*Locality 1 (sampling dates 29th April, 2nd and 11th May)* Close to Villanueva de Córdoba (Córdoba), 700 metres above sea level. The surrounding habitat consists of open woods of evergreen oak *Quercus ilex* with extensive pastures and cultivated farmlands.

*Locality 2 (one sample, 13th May)* Near Puebla del Río (Sevilla), 5 metres above sea level. Open grasslands with some sparse wild olive trees *Olea europaea* on one side and large open marshlands on the other. This locality is just on the border of the marshes of the River Guadalquivir.

*Locality 3 (one sample, 2nd May)* El Mustio, in the north of Huelva province, 500 metres above sea level. Habitat a mixture of open evergreen oak woods with variable amount of shrubs, pure shrubs (mainly *Cistus ladaniferus*) with no trees and, to some extent, shrubs afforested with stone pines *Pinus pinea*.

Each sample of pellets was cleaned and dried to a constant weight, the whole sample, as well as individual unbroken pellets, being weighed to the nearest 0.01 gm. Identifiable prey remains were sorted under a low-power binocular-microscope. These were mainly insect heads and wings or fragments of these. Identification was often made by comparing the remains with specimens in the insect collection of the Department of Zoology, University of Sevilla.

The diet of young Bee-eaters is known to differ substantially from that of adults, but we are certain that all the samples we collected were from adults for the following reasons. Because Bee-eater pellets are extremely weak, they are broken down by rain and wind between one breeding season and the next; furthermore, in all three colonies studied, Bee-eaters did not breed at all in 1972. The pellets were therefore all ejected by birds occupying the colonies in spring 1973. Although Bee-eaters arrive in Andalusia from the last week of March and first week of April, arrival at nest-sites occurs later, from mid-April throughout early May. The pellet samples were collected under perches near the nests and never inside the nest-holes and, in any case, by the dates of collecting the birds were still excavating and egg-laying had not yet begun.

Results obtained from pellet analyses of insectivorous birds can be mistaken to some extent, because remains of weak-bodied prey, such as butterflies (Lepidoptera), dragonflies (Odonata) and some flies (Diptera), often might not be detected, whole insects being digested or their remains being too small to be found (Swift 1959). For example, remains of caddis flies (Trichoptera) and mayflies (Ephemeroptera) have been detected in several analyses of stomach contents (Valverde 1967), but we identified none in the pellets; it is possible that they were taken by the Bee-eaters but fully digested. Numbers of weak-bodied prey may therefore have been

## Food of Bee-eaters in southern Spain

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Despite the fact that many studies on the food of the Bee-eater *Merops apiaster* have been undertaken in several European countries (mostly quoted in Swift 1959) and Africa (e.g. Fry 1973), practically no work has been done hitherto on the diet of this species in Spain. Up to the present study, the only published data are a few field observations (Mountfort 1957, Cano 1960) and analyses of some stomach contents (Gil Lletget 1927-28, 1944-45). In this paper we deal with the food of Bee-eaters in the first stages of their occupation of southern Spanish breeding sites, on the basis of pellet analyses.

underestimated. On the other hand, remains of many very small hard-bodied insects, such as some beetles (Coleoptera) and bugs (Hemiptera), were readily found in the pellets and their numbers correctly ascertained. These sources of bias should be borne in mind when interpreting pellet analyses.

## RESULTS

The dry weights of the 28 whole Bee-eater pellets collected by us ranged from 0.10 to 0.55 gm (mostly 0.15-0.30), averaging 0.207 gm (standard deviation 0.088). These data do not agree well with those recorded by Lomont (1946) and Swift (1959), who gave mean weights of about 0.5 gm and 4 gm respectively. This disparity might be due to differences in the moistness of pellets when weighed or to possible individual or seasonal variation in pellet size.

The numerical totals of prey insects revealed by our analyses are given in table 1. No attempt was made to assign a conversion factor to each prey insect and compute the total 'prey units', as is often done in analyses of mammal prey. In many cases identification could not be made beyond the level of genus, family or order, and live weights of all the species taken are not available. Hymenoptera were found in the greatest numbers, forming numerically between 44.5% and 84.8% of the prey in the various samples. Of these, bees (Apidae: *Apis*, *Bombus*, *Xylocopa*, *Andrena*, *Anthophora* and *Eucera*) were the most numerous prey at every locality, the Honeybee *Apis mellifica* being the commonest species found, ranging from 34.1% to 63.8% of all prey insects and accounting for 51.6% of the total. Other Hymenoptera recorded in lesser numbers were ants (Formicidae), true wasps (Vespididae: *Vespa* and *Polistes*), ruby-tails (Chrysididae), perhaps potter and mason wasps (Eumenidae) and ichneumons (Ichneumonidae), though we are not certain of our identification of the last two families.

Beetles (Coleoptera) were also important in the diet, forming 6.3% to 29.9%. The main families involved were dung beetles and chafers (Scarabaeidae: *Onthophagus* and *Aphodius*, to a lesser extent *Potosia* and *Epicometis*, and *Scarabaeus*?) with 10.6% of the total; and ground beetles (Carabidae: mainly *Harpalus*, *Agonum* and *Anisodactylum*, also *Chlaenius* and *Poecilus*) with 2.7% of the total. We also found longhorn beetles (Cerambycidae: mostly *Acmaeops* and *Leptura*), carnivorous water beetles (Dytiscidae: *Brychius*, *Colymbetes fuscus* and *Rhantus pulverosus*), carrion beetles (Silphidae: *Silpha*), silver water beetles (Hydrophilidae: *Hydrophilus* spp. including *H. caraboides*), Histeridae (*Hister uncinatus*), weevils (Curculionidae), nocturnal ground beetles (Tenebrionidae) and rove beetles (Staphylinidae), but none of these families comprised more than 1.4% of the total.

Table 1. Food taken by Bee-eaters *Merops philaster* at three breeding sites in southern Spain, spring 1973, from pellet analyses

	LOCALITY (see page 159)						TOTALS
	1	2	3				
Collecting dates (1973)	29-4	2-5	11-5	All	13-5	2-5	29-4 to 13-5
Total dry weight of sample (grams)	11.39	18.05	6.56	36.00	7.36	6.08	49.44
Total number of prey insects	483	821	272	1,576	328	237	2,141
DERMAPTERA: <i>Forficula</i> (earwigs)	15	-	32	47	26	-	73 3.4%
ODONATA (dragonflies)	3	3	2	8	29	5	42 2.0%
ORTHOPTERA: Acrididae (grasshoppers)	6	1	2	9	6	7	22 1.0%
HETEROPTERA: Pentatomidae (shield-bugs)	4	4	6	14	5	-	19 0.9%
Notonectidae (backswimmers)	-	-	1	1	1	-	2 0.1%
HOMOPTERA: Cercopidae (froghoppers)	-	-	-	-	-	2	2 0.1%
COLEOPTERA: unidentified beetles	21	12	15	48	8	2	58 2.7%
Scarabaeidae (dung beetles and chafers)	80	110	26	216	11	1	228 10.6%
Carabidae (ground beetles)	19	6	16	41	16	-	57 2.7%
Cerambycidae (longhorn beetles)	5	1	1	7	2	3	17 0.8%
Dytiscidae (carnivorous water beetles)	5	4	4	13	3	-	21 1.0%
Silphidae (carrion beetles)	1	-	-	1	1	-	2 0.1%
Hydrophilidae (silver water beetles)	-	-	-	-	5	4	9 0.4%
Histeridae	-	2	-	2	1	-	3 0.1%
Curculionidae (weevils)	3	-	7	10	11	-	21 1.0%
Tenebrionidae (nocturnal ground beetles)	-	-	-	-	5	-	5 0.2%
Staphylinidae (rove beetles)	-	-	-	-	39	-	39 1.4%
LEPIDOPTERA (butterflies and moths)	2	2	4	8	15	2	25 1.2%
DIPTERA (flies)	-	12	-	12	2	5	19 0.9%
HYMEOPTERA: unidentified bees, etc.	23	62	7	97	7	55	159 7.4%
Formicidae (ants)	3	4	28	35	2	-	37 1.7%
Apidae (bees): Honeybee <i>Apis mellifica</i>	243	524	99	871	112	121	1,104 51.6%
Other bees	38	60	19	117	22	21	160 7.5%
Vespididae (true wasps)	2	11	3	16	1	-	17 0.8%
Eumenidae (potter and mason wasps)?	-	-	-	-	-	4	4 0.2%
Chrysididae (ruby-tails)	-	3	-	3	-	-	3 0.1%
Ichneumonidae (ichneumons)?	-	-	-	-	2	-	2 0.1%
DERMAPTERA (earwigs)	3.1%	-	11.8%	3.0%	7.9%	-	73 3.4%
ODONATA (dragonflies)	0.6%	0.4%	0.7%	0.5%	8.8%	2.1%	42 2.0%
ORTHOPTERA (grasshoppers, etc.)	1.2%	0.1%	0.7%	0.6%	1.8%	3.0%	22 1.0%
HETEROPTERA (bugs)	0.8%	0.5%	2.6%	1.0%	1.8%	-	21 1.0%
HOMOPTERA (bugs)	-	-	-	-	-	0.8%	2 0.1%
COLEOPTERA (beetles)	27.7%	16.4%	23.4%	21.4%	29.9%	6.3%	451 21.0%
LEPIDOPTERA (butterflies and moths)	0.4%	0.2%	1.5%	0.5%	4.6%	0.8%	25 1.2%
DIPTERA (flies)	-	1.5%	-	0.8%	0.6%	2.1%	19 0.9%
HYMEOPTERA (ants, bees, wasps, etc.)	68.0%	80.9%	57.4%	72.3%	44.5%	64.8%	1,486 69.4%

Insects other than Hymenoptera and beetles made up 9.5% of the total. These were earwigs (Dermaptera: *Forficula*), dragonflies (Odonata), grasshoppers (Orthoptera: Acrididae), bugs (Heteroptera: Pentatomidae and Notonectidae; Homoptera: Cercopidae: *Cercopis*), butterflies (Lepidoptera) and flies (Diptera). Of these, earwigs were the commonest, forming 3.4% of the total and ranging from 3.1% to 11.8% in three of the samples but entirely absent from the other two. The remaining groups together made up 6.1% of the total and accounted for between 2.7% and 17.7% in the five samples, the most numerous being dragonflies which comprised as

much as 8.8% of the prey at locality 2. Fig. 1 compares the percentages of the commonest prey at the three localities.

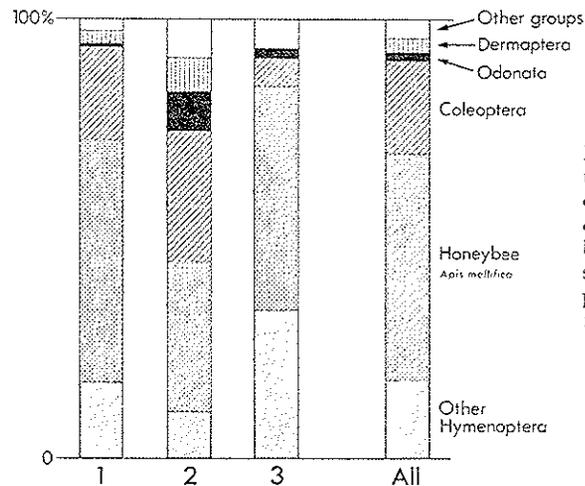


Fig. 1. Percentage totals of main prey of Bee-eaters *Merops apiaster* at three breeding sites in southern Spain (see page 159), spring 1973, from pellet analysis

#### DISCUSSION

The qualitative composition of the diet does not differ essentially from those reported in several other European countries by, for example, Lomont (1946), Rivoire (1947), Bastien (1957), Le Sueur (1957), Swift (1959) and Alleijn *et al.* (1966). However, we have found no mention in the literature of Bee-eaters taking earwigs, backswimmers, homopterid bugs, nocturnal ground beetles, rove beetles or ants in Europe. The presence of mainly terrestrial prey such as earwigs and ants is especially notable. Although these could have been taken on the ground, we must not reject the possibility of the birds having caught them in flight. Swift (1959) pointed out that Bee-eaters can sometimes take food on the ground, and lepidopterid caterpillars reported in the diet of Bee-eaters in Rhodesia (Fry 1973) were obviously not caught in flight. However, such hunting behaviour is not described at all in the general literature (e.g. Géroudet 1951, Dementiev and Gladkov 1966-68, Valverde 1967). Although Bee-eaters have been recorded diving into water (e.g. Tree 1960, 1961), aquatic insects, such as carnivorous and silver water beetles and backswimmers, must have been captured in the air while in flight.

Because all the samples analysed were collected within a short period (15 days), the quantitative and qualitative composition of the diets at that time of year at the three study localities could be compared to some extent, but in our opinion the data are too few for a full statistical treatment.

Fig. 1 and table 1 show that the proportion of dragonflies in the diet was highest at locality 2 (8.8%) and much lower at the others (0.5% and 2.1%). This was not unexpected, since locality 2 is close to large marshlands (*marismas*) where dragonflies are widespread for much of the year. Moreover, they would be even more common in the diet later in the season (Cano 1960).

Beetles were commonest at localities 1 and 2 (21.4% and 29.9% respectively), the proportion being as low as 6.3% at locality 3. A partial explanation may be that the land around localities 1 and 2 is used mainly for cattle-raising, and dung beetles such as *Onthophagus* and *Aphodius* can find many propitious sites there for living on cattle droppings. Furthermore, marshlands near locality 2 support carnivorous and silver water beetles for the Bee-eaters' diet. However, we can find no explanation for the strong presence of rove beetles at this locality, where they formed 9.1% of the entire diet, and their complete absence from pellets collected at the other two. Presumably this difference must be due to unknown factors connected with the habitat, and the same may be said about the variation between localities in the percentage of earwigs in the diet.

There was a considerable observed difference between localities in the proportion of Hymenoptera in the pellets, the highest value being reached at locality 3, which also showed the greatest species diversity (this is not obvious from table 1, but 'unidentified Hymenoptera', which clearly included many species, formed by far the highest proportion at locality 3). This locality was the least disturbed by man, and the surrounding habitats were more varied than at the other two (see the descriptions on page 159). These factors may have accounted for the greater diversity of Hymenoptera and, perhaps, made these insects more readily available to the birds.

Thus several of the main observed differences in the diet between localities may be explained if one supports the view that Bee-eaters take any available flying insect within a wide size range and do not select food. Further, human practices seem likely to exert a strong influence on the diet, because of inevitable changes in insect populations due to agricultural management. However, as stated above, we believe that our data are too few for a statistical treatment of this subject.

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## SUMMARY

Pellets of Bee-eaters *Merops apiaster* were collected at three nesting colonies in western Andalusia, southern Spain, during the spring of 1973. Of the 2,141 prey insects identified in them, the great majority were Hymenoptera, Honeybees *Apis mellifica* forming 51.6% and other species 17.8%. Beetles (Coleoptera, ten families) made up 21.0% of the total, the main families involved being dung beetles and chafers (Scarabaeidae, 10.6%) and ground beetles (Carabidae, 2.7%). The remaining 9.5% comprised earwigs (Dermaptera: *Forficula*), dragonflies (Odonata), grasshoppers (Orthoptera: Acrididae), bugs (Heteroptera: Pentatomidae and Notonectidae; Homoptera: Cercopidae), butterflies and moths (Lepidoptera) and flies (Diptera), the proportions of each of these groups in the diet ranging from 0.1% to 3.4% of the total. Several observed differences in the composition of the diet between localities are discussed, and likely influences of cattle-raising and agriculture are pointed out.

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