

Nesting and Feeding Habits of the European Bee-eater (*Merops apiaster* L.) in a Colony next to a Beekeeping Site

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Abstract - Authors carried out a study on a population of bee-eaters colonising a former sand quarry next to a beekeeping site. Data were collected to estimate population size, evaluate microclimate differences inside and outside nest tunnels, calculate bill length and weight variation in relation to nest excavation and nest attendance by bee-eaters, and to analyse their feeding habits, in particular in relation to bee availability. Population size was estimated as much as 100-110 pairs. Bill length resulted to decrease during the nest excavation, growing again after one month. Weight on the contrary was increasing during egg laying and brooding, and decreasing during nestlings' attendance. Temperature outside nests resulted on average lower than inside the nest tunnel, which in turn resulted much more constant. Bee-eaters are specialized in hymenopterans predation, and considered in some countries a pest for beekeeping. The analysis of the relationships between availability of bees and bees preyed upon by bee-eaters in the study area consented to consider bee predation incidence actually acceptable to the bee colony for its future survival.

Introduction

Breeding biology of the European bee-eater (*Merops apiaster*) is well known (cf. Fry 1984); nevertheless, there are some aspects of nesting and feeding habits which show adaptation to local resources, that deserves further investigations. Considered "declining" in Europe (Heath *et al.* 2000), in the Mediterranean countries, their populations are generally fluctuating, with an evident recent increase only in Spain (Fry in Tucker and Heath 1994) and Italy (Fraissinet and Mastronardi 1997; Greci *et al.* 1997) (cf. also Heath *et al.* 2000). Bee-eaters are important predators of Hymenoptera and, in some instance, domestic bees may play an important role in their diet. For this reason, in some Mediterranean countries, they have sometimes been regarded as a rather serious nuisance or even a pest (Fry 1983, 1984; Galeotti and Inglis 2001 and references therein). In the European countries there are currently estimated to be about 500,000 beekeepers, very unevenly distributed; for many of them beekeeping is a hobby (up to 15 hives) or a part-time source of income (up to about 150 hives). Although statistics on this topic are few reliable, beekeeping is reported as an essential source of income for only 18,000 of the European beekeepers (4% of the total), who have more than 150 hives each. Between 1960' and 1996 beehives increased very much: in the European Union in 1968-

71 there were 5,841,000 hives, which increased to 7,550,000 in 1992; a remarkable increasing occurred since 1980s, particularly in Mediterranean countries, as France, Greece, Italy, Spain and Portugal (Zappi Recordati 1956; F.A.O. 1989; Williams *et al.* 1991; Barbattini 1998).

Since 1995, we began a research on the breeding biology of bee-eaters in a colony established on a former sand quarry next to a beekeeping site. We report here the main results regarding: a) the population size of the colony; b) temperature differences inside and outside nest tunnels; c) bill length and weight variation in relation to nest excavation and nest attendance by bee-eaters; d) feeding habits, particularly in relation to beekeeping next to the bee-eater colony.

Materials and methods

The study site (Campofelice di Roccella, Sicily) is located on a former sand quarry, deserted since 1994, when it was colonised by a few pairs of bee-eaters, which were increasing to reach in 1996 50 pairs (Greci *et al.* 1997). Each year they arrived on the middle of April, leaving on the second half of August, thus attending the area for a total of 120-130 days. A static beekeeping site, holding 140 hives is located at c. 1.5 km from the breeding site. As bee-eaters hunt-

ing range is 1-12 km (Tostain 1978; Fry 1984; pers. obs.) and forager bees flight range is 0.5-1.1 km (Free and Williams 1974; pers. obs.), we assume that in our study site hunting area of bee-eaters overlaps bees foraging area.

Bee-eaters 4-6 times a day regurgitate from their perches or nests a blackish pellet, 10-35 mm long, containing indigestible sclerites, including heads and wings of insects preyed upon; microscopic examination of these parts allows an accurate qualitative and quantitative analysis of prey. The diet of adults was analysed through the examination of pellets collected from June to August 1997 and from April to July 1998. Hymenoptera were identified comparing the heads recovered in the pellets with specimens previously identified and preserved in the collections of the Palermo University. The monthly number of bees as prey of bee-eaters was estimated by $N = (a \times b \times c \times d)$, where *a* is the mean number of bees (workers and drones) per pellet, *b* the total number of pellets regurgitated each day by a bee-eater, *c* the number of days per month, *d* the total number of bee-eaters in the colony (Inglisa *et al.* 1995). We assumed the mean daily number of pellets produced by an adult bee-eater to be five (Galeotti and Inglisa 2001).

Between 15 June and 15 July 1997, 1998 and 2001 food delivered to chicks was observed from c. 8-10 m with a Leitz 10 x 40 binocular. Observations were carried out between 9:00 a.m. and 6:00 p.m. on different nests and day times for a total amount of 28 hours; this let us to know the mean number of visits to chicks per hour by adults with prey and the occurrence of each prey item. When prey was not identifiable, only its size was estimated compared with bee-eater head size. Besides, 45 prey items delivered to chicks, lost by adults, were collected under the hole-nests and identified. The incidence of honeybees in the young diet was estimated by $N = (a \times b)$, where *a* is the number of bees daily brought to chicks by breeding pairs (estimated as reported above), and *b* is the number of days between the first bee-eater hatching and the last fledging (= 30).

The possible impact on apiculture was estimated as follows. A hive in spring-summer generally holds c. 40,000 workers and 500-700 drones; workers life expectancy in spring-summer is c. 40 days (Free 1993; T. Rinderer, pers. comm.) and consequently their daily turnover within a hive consists of c. 1000 individuals (2.5% of workers population). Besides, workers become foragers from the 2nd-3rd-life week, later flying out of the hive (Free 1993) and undergoing a predation risk. Drones are present in the hive from April to August, the mating occurring from April to June (Galeotti and Inglisa 2001). In the

study-site, where there are 140 hives, the total amount of bees in summer could be estimated as much as 5,600,000 workers and 84,000 drones, whose daily turnover results to be c. 140,000. Since workers spend c. 1/2 of their life as foragers, the number of the latter estimated to be subjected to predation in 140 hives is 1/2 of 5,600,000, that is 2,800,000, whose daily turnover is 1/2 of 140,000 (not including drone mortality).

During the breeding season 1999, from May to July, two small data loggers able to record the temperature every three hours were placed outside and inside one nest cavity, obtaining on the whole 720 measures from each thermometer, downloaded on a table format by the OTLM Software; afterwards data were plotted on a graph and their best curves were built by the algorithm described by McLain (1974). The depth to place the thermometer inside the nest cavity (c. 60 cm) was established measuring 28 nest cavities by a flexible feeler.

In 1998 and 1999, bee-eaters were captured by mist-nets, measured and ringed. Sexes were identified following Baker (1993). Bill length (to forehead) and weight of males and females of bee-eaters measured in different dates of the breeding season were compared using 1-way ANOVA (SAS 1987). Population was estimated by the weighted mean applied to Petersen Lincoln method (Begon 1979):

$$N = \frac{\sum M_i n_i}{(\sum m_i) + 1},$$

where M_i is the number of marked individuals in the population which are available for sampling immediately before the day *i* sample, n_i is the number of individuals caught on day *i*, m_i is the number of marked individuals caught on day *i*.

Results and Discussion

Population estimate

In 1998, we ringed 45 individuals, in 1999 another 113, recovering 20 ringed in 1998. According to Petersen-Lincoln method, we may estimate a whole population of 243 individuals, possibly including some helpers (first year young helping adults in the nest attendance). In 1999 we carried out five ringing sessions, capturing a higher number of males compared with females (96 vs. 62); then we estimated separately male and female populations, obtaining the values of 120 males and 85 females. The estimate of 100-110 pairs in 1999 is consequently reliable. It doubled from 1996, when was estimated as much as 50 pairs (Grenci *et al.* 1997). This agrees with the general increasing of Italian populations, recorded by

some authors (e.g.: Fraissinet and Mastronardi 1997), also noticeable in Sicily, where the whole population in 1993 was estimated less than 50 pairs (Lo Valvo *et al.* 1993), in 1996 as much as 500 pairs (Grenci *et al.* 1996) and in 2001 at least 1000 pairs (Massa, unpublished data).

Bill length and weight variation in relation to nest excavation and chicks attendance

Bee-eaters nest in tunnels excavated by themselves on sand cliffs, using bill and legs. Bill is worn out by this continuous activity, which begins at their arrival to nesting site and takes 10-20 days (Fry 1984; pers. obs.). We measured the bill length of newly arrived individuals on 20 April, obtaining both from males and females a measure (males: 45.3 ± 3.9 mm; females: 43.0 ± 3.4 ; Table 1) matching that obtained from a sample captured in Sicily during spring migration (males: 44.8 ± 3.7 mm; $t_{73} = 0.58$, $P = 0.56$; females: 43.3 ± 3.6 ; $t_{24} = 0.22$, $P = 0.82$), just longer than that recorded by Cramp (1985). The same measure, performed on 1st May, 10th May, 10th June and 20th June revealed an evident trend, with the smallest values on 20th May (males: 30.5 ± 2.6 ; females: 28.8 ± 1.8 ; Table 1), around the end of nest excavation; the bill reached nearly previous length on the middle of

June (males: 41.5 ± 2.1 ; females: 40.0 ± 1.7 ; Table 1). ANOVA analysis let us to find significant differences among the subsequent dates (Table 2). In particular, bill length, both of males and females, resulted significantly different almost all over the different dates from April to June, when we measured it (Table 3). Even if bill wear of bee-eater during nest excavation could have been easily foreseen, its variation was not previously measured.

Conversely, the weight shows an opposite trend, possibly due to the energy request during nestling attendance (Table 1). It increases, more in females than in males, peaking on the middle of May, when egg laying is starting (males: 57.7 ± 4.6 ; females: 63.6 ± 5.4 ; Table 1); this value is maintained to the first decade of June (males: 56.0 ± 2.8 ; females: 60.3 ± 5.6 ; Table 1). In these days, bee-eaters are involved in the chicks' attendance, which brings about a weight loss in the following days, mainly in females (48.4 ± 1.8 , c. 20% of loss), less so in males (51.4 ± 2.0 , c. 8% of loss) (Table 1). Differences among the subsequent dates were significant (ANOVA analysis, Table 2); in particular, the increase and the following decrease of male and female weight resulted significant (Table 3). Variation of bee-eater weight during reproduction was hitherto unknown.

Table 1. Bill length from forehead to tip (in mm) and weight (in grams) of bee-eaters measured in different dates of the breeding season.

Bill length/males	MEAN	S.D.	n	Bill length/females	MEAN	S.D.	n
20 April	45.3	3.9	36	20 April	43.0	3.4	10
1 st May	35.1	3.3	14	1 st May	35.7	4.2	11
10 May	31.9	3.4	12	10 May	32.5	1.8	8
20 May	30.5	2.6	39	20 May	28.8	1.8	12
10 June	37.3	2.8	11	10 June	36.1	5.5	6
20 June	41.5	2.1	18	20 June	40.0	1.7	23
Weight/males	MEAN	S.D.	n	Weight/females	MEAN	S.D.	n
20 April	54.0	3.7	23	20 April	54.1	3.1	17
1 st May	54.4	2.1	14	1 st May	54.6	1.8	11
10 May	57.3	2.2	12	10 May	59.1	3.2	8
20 May	57.7	4.6	38	20 May	63.6	5.4	12
10 June	56.0	2.8	11	10 June	60.3	5.6	6
20 June	51.4	2.0	18	20 June	48.4	1.8	23

Table 2. Summary of the 1-way ANOVA analysis of differences in bill length and weight (males and females separately) among six different dates through the breeding season

	fd	F	P
Bill length males	5	79.57	< 0.0001
Bill length females	5	36.22	< 0.0001
Weight males	5	10.08	< 0.001
Weight females	5	38.71	< 0.0001

Nest tunnels

The mean length of nest cavities resulted 57.5 ± 22.2 cm (min. 40, max 110), shorter than that recorded by Fry (1984) (70-150 cm), probably depending on the soil type. Temperature outside nests resulted on average lower ($26.9 \pm 4.3^\circ\text{C}$; min 18.8, max 38.5) in comparison with that inside the nest cavity, which in turn was much more constant ($28.2 \pm 1.2^\circ\text{C}$; min

Table 3. Tukey's test applied to bill length and weight of males and females of bee-eaters measured in six different dates of breeding season. Values in bold are significant. Bill = bill length; W = Weight.

Date	Variable	1 st May	10 May	20 May	10 June	20 June
20 April	Bill males	P = 0.0001	P = 0.0001	P = 0.0001	P = 0.0001	P = 0.003
	Bill females	P = 0.0001	P = 0.0001	P = 0.0001	P = 0.004	P = 0.08
	W. males	P = 0.99	P = 0.04	P = 0.0001	P = 0.51	P = 0.11
	W. females	P = 0.99	P = 0.01	P = 0.0001	P = 0.003	P = 0.0001
1 st May	Bill males		P = 0.11	P = 0.0002	P = 0.49	P = 0.0001
	Bill females		P = 0.10	P = 0.0001	P = 0.99	P = 0.002
	W. males		P = 0.26	P = 0.03	P = 0.84	P = 0.17
	W. females		P = 0.06	P = 0.0001	P = 0.02	P = 0.0002
10 May	Bill males			P = 0.0002	P = 0.49	P = 0.0001
	Bill females			P = 0.0001	P = 0.99	P = 0.002
	W. males			P = 0.99	P = 0.95	P = 0.0001
	W. females			P = 0.05	P = 0.98	P = 0.0001
20 May	Bill males				P = 0.0001	P = 0.0001
	Bill females				P = 0.0002	P = 0.0001
	W. males				P = 0.75	P = 0.0002
	W. females				P = 0.39	P = 0.0001
10 June	Bill males					P = 0.009
	Bill females					P = 0.005
	W. males					P = 0.007
	W. females					P = 0.0001

26.3, max 30.7); differences between variances were significant ($P < 0.001$) (Fig. 1). Temperature inside nests of bee-eaters was previously recorded in southern Spain by White *et al.* (1978), who found a soil surface variation from 13° to 51°C, while the brood-chamber temperature was uniformly around 25°C.

Hole nests have the invaluable function of providing their occupants with a stable microclimate and protection from wide temperature variation (Fry 1984). Thus, nesting inside a cavity should result in an advantage that certainly balances the energy costs for the nest preparation.

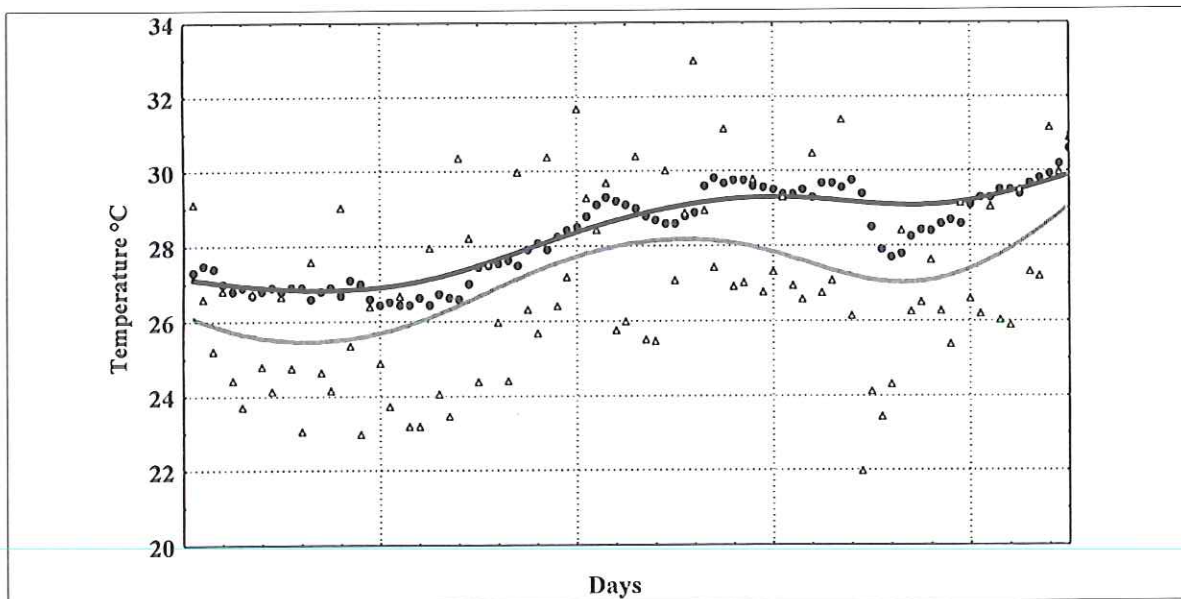


Fig. 1. Mean temperature, inside (black dots) and outside (white triangles) a nest tunnel, during 90 days of 1999 breeding season, and their best curves (black solid line: inside nest tunnel; grey solid line: outside). Differences between variances are significant ($P < 0.001$).

Feeding habits

Table 4 lists Arthropods preyed upon by bee-eaters in 1997 and 1998; the mean number of prey per pellet in 1997 ranged between 8.2 and 9.1, in 1998 between 7.9 and 11.1; the percentage of Hymenoptera in 1997 varied between 67 and 96%, in 1998 between 70 and 94%. Similar values were observed in 1996 in the same site (Grenci *et al.* 1997). In 1997 bees (both sexes) ranged between 34 and 51% of prey (mean number per pellet: 4.1), in 1998 between 30.5 and 69% (mean number per pellet: 5.1). Values exceeding over 50% have been recorded in Spain (Herrera and Ramirez 1974) and in Sardinia (Galeotti and Inglis 2001); they are remarkably higher than the average of 15-25% reported by Fry (1983, 1984 and references therein). In the two years, we also noticed as prey good numbers of wild pollinators (e.g.: *Bombus* and

Megabombus), and also of Dermaptera (mainly *Labidura riparia*) and Coleoptera (mostly dung-beetles and pollinators belonging to different families, like Cerambycidae, Buprestidae, Cleridae and Melolonthidae). Finally, we recorded also some aposematic prey and species certainly captured on the soil (e.g. Chilopoda and Coleoptera Tenebrionidae). We observed evident differences in the diet of young; among 300 identified prey, 21% were bees, 19% *Xylocopa* sp., 16% *Bombus/Megabombus*, 7% small Hymenoptera, 24% Odonata and 12% other prey. Among 45 prey collected under the nests 14 were *Xylocopa* sp., 18 *Bombus terrestris*, 7 *Halictus quadricinctus* and only 5 *Apis mellifera*. Prey size brought to chicks was significantly bigger than that consumed by adults ($\chi^2 = 62.1$, $P < 0.001$, $n = 600$); thus, adults chose smaller insects as their prey (among

Table 4. Incidence of Arthropods in the diet of the bee-eaters from June to August 1997 and from April to July 1998.

Month-year	VI-97	VII-97	VIII-97	IV-98	V-98	VI-98	VII-98
N. pellets	13	29	20	21	20	20	14
N. prey	118	238	208	212	202	159	156
Chilopoda	1 (0.9%)	0	1 (0.5%)	0	0	0	0
Odonata	1 (0.9%)	0	1 (0.5%)	0	0	0	0
Dermaptera	13 (11%)	0	7 (3.4%)	0	19 (9.4%)	7 (4.4%)	0
Orthoptera	1 (0.9%)	1 (0.4%)	0	0	1 (0.5%)	2 (1.2%)	5 (3.2%)
Heteroptera	1 (0.9%)	2 (0.8%)	3 (1.4%)	2 (0.9%)	4 (2%)	3 (1.9%)	1 (0.6%)
Lepidoptera	0	1 (0.4%)	1 (0.5%)	0	0	0	0
Coleoptera	22 (19%)	6 (2.5%)	27 (13%)	15 (7%)	38 (19%)	15 (9.4%)	3 (1.9%)
Hymenoptera	79 (67%)	228 (96%)	168 (81%)	195 (92%)	140 (70%)	132 (83%)	147 (94%)
<i>Apis mellifera</i> workers	21 (18%)	82 (34%)	52 (25%)	132 (62%)	40 (20%)	59 (37%)	74 (47%)
<i>Apis mellifera</i> drones	19 (16%)	39 (16%)	41 (20%)	15 (7%)	33 (16%)	14 (9%)	7 (4.5%)
Ichneumonidae	3 (2.5%)	24 (10%)	6 (2.9%)	0	0	0	0
<i>Polistes</i> sp.	2 (1.7%)	4 (1.7%)	8 (3.8%)	0	1 (0.5%)	1 (0.6%)	1 (0.6%)
<i>Paravespula</i> sp.	5 (4.2%)	35 (15%)	11 (5.3%)	1 (0.5%)	7 (3.5%)	2 (1.2%)	6 (3.8%)
<i>Vespa</i> sp.	0	0	0	0	1 (0.5%)	0	2 (1.2%)
<i>Anoplius viaticus</i>	2 (1.7%)	5 (2%)	0	2 (1%)	6 (3%)	4 (2.4%)	0
<i>Cerceris</i> sp.	1 (0.8%)	0	0	9 (4.2%)	0	2 (1.2%)	0
<i>Holandrena decipiens</i>	3 (2.5%)	20 (8.4%)	10 (4.8%)	0	4 (2%)	1 (0.6%)	5 (3.2%)
<i>Seladonia gemmea</i>	0	0	0	0	1 (0.5%)	0	0
<i>Halictus</i> sp.	8 (6.8%)	0	5 (2.4%)	0	10 (5%)	10 (6.3%)	35 (22%)
<i>Anthidium</i> sp.	0	0	0	0	0	0	1 (0.6%)
<i>Eucera nigrescens</i>	1 (0.8%)	1 (0.4%)	5 (2.4%)	19 (9%)	1 (0.5%)	1 (0.6%)	11 (7%)
<i>Xylocopa</i> sp.	2 (1.7%)	7 (2.9%)	2 (1%)	0	5 (2.5%)	1 (0.6%)	2 (1.2%)
<i>Bombus terrestris</i>	3 (2.5%)	3 (1.3%)	1 (0.5%)	10 (4.7%)	15 (7.5%)	16 (10%)	0
<i>Megabombus ruderatus</i>	9 (7.6%)	8 (3.4%)	27 (13%)	7 (3.3%)	16 (8%)	21 (13%)	3 (1.8%)
Bees/pellet	3.1	4.2	4.6	7.0	3.8	3.6	5.8
Prey/pellet	9.0	9.1	8.2	10.1	10.0	7.9	11.1
Bees estimated to be preyed on monthly by ad. bee-eaters	93,000	126,000	138,000	210,000	114,000	108,000	174,000
Bees estimated to be delivered monthly to young bee-eaters	134,200	134,200	0	0	0	134,200	134,200

which huge numbers of bees), while preyed on bigger insects to deliver to young, coherently with what Fry (1984) presumed. Feeding frequency in the period 15 June-15 July consisted of 35.5 ± 21.3 prey brought to chicks per hour (min. 11, max. 69); frequency in the morning and in the afternoon did not differ statistically (Student test: $t_{2,3} = 0.239$, $P = \text{NS}$). Inglis (1991) in July in Sardinia obtained a similar value (26.9).

Possible impact on apiculture

Considering at least 12 hours of predatory activity in the breeding season, a pair of adults in our study area delivered to chicks a mean daily number of 426 prey (range: 170-682). From the average bee number brought daily to chicks (21% of 426 = 89.5), we obtained 268,380 bees (= $89.5 \times 30 \text{ days} \times 100 \text{ nests}$) as food delivered to young during nestlings' attendance (between 15 June and 15 July). We added this value to the total amount of bees estimated to have been preyed upon by 100 pairs of bee-eaters during their permanence in the site (from 15 April to 15 August). On the whole, in the two years the monthly bee-eater predation ranged from 114,000 to 308,200 bees (Table 4).

Fig. 2 reports the total number of foragers' population monthly estimated to be preyed upon by bee-eaters in our study area and their percentage compared to the whole bee colony. The predation incidence ranged from 2.0 to 5.5%, higher than that (0.27 to 0.58%) recorded in Sardinia from Galeotti and Inglis (2001). However, it was only between 1 and 2.8% of whole

forager population, and between 2.7 and 7.3% of the bees monthly subjected to turnover. We would point out that in the Mediterranean area most hives contain up to 60-80,000 workers, with a mean of 30,000 foragers. The loss percentage here estimated has to be regarded as the average risk of predation next to a beekeeping site housing c. 150 hives. In fact, even if bee predation by bee-eaters should not be density dependent (Galeotti and Inglis 2001), small numbers of hives (50-60) may undergo a lower percentage of predation from bee-eaters. Additionally, in spring, there is a lower turnover of bees than in summer, and a 5-10% loss of foragers in summer probably may be acceptable to the bee colony for future survival. Although the loss of drones due to bee-eaters seems important, it is inversely density-dependent, so that it decreases at high bee-densities (Galeotti and Inglis 2001).

Part-time (up to 150 hives) often is static beekeeping and grouping hives could minimize bee-eater predation. Nevertheless, grouping hives may be unrealistic from the hobby beekeeper's standpoint. In the Mediterranean region, migratory beekeeping is practised to exploit transient nectar sources for honey production or to pollinate particular crops (Williams *et al.* 1991). If the bees are being used for pollination, it may be impractical to arbitrarily group 50 colonies into an apiary, whereas, if the bees are being used for honey production, then groups of 50 or more colonies may over saturate the available forage and make honey production impractical.

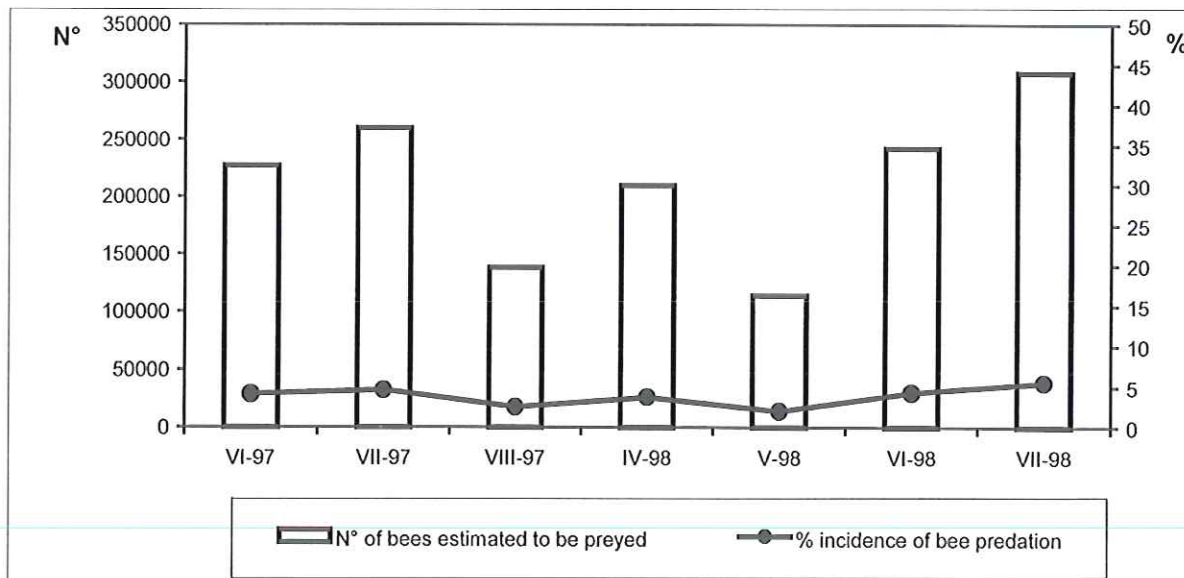


Fig. 2 - Total amount of bees estimated to be preyed on each month by the bee-eater population and its incidence on the whole bee colony in 1997 and 1998.

Acknowledgements - We thank very much Paolo Galeotti (University of Pavia), who critically reviewed the first draft of the manuscript, Thomas E. Rinderer (International Bee Research Association, Louisiana), who provided interesting information on bee biology, Vittorio Nobile (University of Catania), who identified some Hymenoptera, Fabio Lo Valvo and Natalino Cuti (Stazione Inanellamento, Palermo), who provided some biometrics of bee-eaters, Mario Lo Valvo (University of Palermo) and Giulia Casamento, for assistance during collecting and processing of data loggers. This research was funded by Assessorato Agricoltura e Foreste Regione Sicilia to Stazione di Inanellamento.

Riassunto - Tra il 1996 ed il 2001 è stata studiata una popolazione di Gruccioni che ha colonizzato una cava di sabbia abbandonata, situata in provincia di Palermo (Sicilia). Il numero totale di coppie nidificanti è stato stimato con il metodo della cattura-ricattura ed è risultato pari a circa 100-110, in incremento nel corso degli anni. Inoltre, mediante l'uso di due termometri, è stata misurata la temperatura all'interno di una tana-nido ed all'esterno per tutto il periodo riproduttivo; sebbene sia risultata una temperatura media più alta all'interno del nido, questa si è mantenuta significativamente più costante di quella esterna. Al momento dell'arrivo nel sito, è stata misurata la lunghezza del becco ed è stato rilevato il peso degli individui; le misurazioni sono state quindi ripetute periodicamente. Il becco si consuma in entrambi i sessi durante l'escavazione della tana-nido, ricrescendo nel corso del mese successivo. L'andamento del peso ha mostrato differenze nei due sessi, crescendo dal momento dell'arrivo nella colonia, soprattutto nelle femmine, con un picco in maggio, quando ha inizio la deposizione delle uova; questo valore si è mantenuto fino alla prima decade di giugno, ma subito dopo, quando gli adulti sono stati impegnati nell'allevamento dei piccoli, è avvenuta una perdita di peso, più consistente nelle femmine (c. 20%) che nei maschi (c. 8%). I Gruccioni sono specializzati nella predazione di insetti, soprattutto Imenotteri, e considerati in alcuni Paesi nocivi all'apicoltura. L'analisi del rapporto tra disponibilità di api e loro predazione da parte dei Gruccioni nell'area di studio ha permesso di concludere che l'incidenza del prelievo di api è accettabile per la futura sopravvivenza degli alveari.

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