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SIZE, DYNAMICS AND STRUCTURE OF THE LESSER HORSESHOE BAT (*RHINOLOPHUS HIPPOSIDEROS*) WINTER AGGREGATIONS IN CENTRAL ITALY (*)

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ABSTRACT - The paper presents a study regarding the aggregations of the Lesser Horseshoe bat *Rhinolophus hipposideros* in Latium, Central Italy, based on data collected during 27 years in natural caves (limestone) and artificial buildings (abandoned mines, ancient monuments and others). Furthermore some parameters including size, dynamics, sex ratio and age structures are investigated. The number of bats that occur at the hibernacula in winter is low over the whole territory of this region, the most numerous aggregations being 18 individual bats with an average of about 4 bats/visit. In the shelters of the area, the highest numbers of *R. hipposideros*, a stenotherm thermophilous species, is reached at the end of January, while at the beginning of spring (April) few bats are generally observed. **As** in many other European populations, males are more commonly represented in winter samples; some caves harbour only adult males over a long time span, about 20 years. The results would suggest that some conservation measures should be introduced to protect this widespread but uncommon and threatened species.

Key words: Chiroptera, *Rhinolophus hipposideros*, Italy, winter aggregations, dynamics, sex ratio, age, conservation

INTRODUCTION

Rhinolophus hipposideros Bechstein, 1800, is a widely distributed species in western, central and southern Europe (Mitchell-Jones *et al*., 1999). The Lesser Horseshoe bat is the smallest European rhinolophid; body mass and forearm length of individuals from Central Italy captured in winter are as follows: females, 4.4-6.1 g and 36.5-40.3 mm; males, 4.0-5.4 g and 33.2-37.7 mm (unpubl. data). The animals reach sexual maturity at 1-2 years; parturition may occur during the first year of life; litter size is one young per parturition. Average longevity is 3-4 years (Gaisler, 1965, 1966; Dinale, 1968). However, a banded male at the date of the last recapture was found to be at least 19.5 years old (Gaisler and Chytil, 2002). *R. hipposideros* is a strongly phylopatric sedentary bat, with winter and summer quarters within a distance of 5-10 km (Mitchell-Jones *et al.*, 1999) or 27 km (Gaisler and Chytil, 2002). Summer shelters comprise derelict or semi-derelict buildings (Gaisler, 1963; Gaisler *et al.*, 1988). In Central Italy, underground cavities provide suitable shelters during the hibernating period for singly or small groups, termed aggregations. Common roosting sites comprise narrow galleries and low vaults of natural/artificial caves where individual bats can be found in

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deep torpor at the beginning of November (Crucitti, 1985). The Lesser Horseshoe bat is widespread through mainland Italy, Sicily and Sardinia (Fornasari *et al.,* 1997) but, despite the relative abundance of information concerning its distribution, quantitative data on Italian populations are still lacking with the exception of a nursery colony of the Lessini Mts., NE Italy (Bonato and Fioretto, 2000). One of the main goals of this paper is to analyse the shifts in number of *R. hipposideros* over a long time span in some underground hibernacula of Central Italy; a second goal is to analyse the composition and the structure of its aggregations. In fact, the general agreement regarding this species is that it is vulnerable across most of its present range and that population declines have resulted over the past fifty years (Mitchell-Jones *et al.,* 1999), whereas such a decline in its abundance has not been revealed in the eastern section of the European range (Gaisler, 1991).

METHODS

In order to provide a data analysis of some parameters of hibernating aggregations of *R. hipposideros,* field monitoring was performed in Latium, Central Italy. Sampling of bats was undertaken during 107 visits to 23 sites at 40-915 m a.s.l., over the entire territory of the region. Visits ranged between from October and May, mostly from November to April. Data characterizing the shelters and the number of bats for each shelter are provided in the Appendix. Many caves were visited once or few times; one cave (Allumiere) was visited monthly over three semesters (November-April) in consecutive years, from 1992 to 1995 (Crucitti *et al.,* 1998). Two caves were regularly visited, monthly or yearly, during periods separated by a long time span; Grotta La Pila, 1973-1977 and 1982-1986 (Crucitti *et al.*, 1993); Grotta San Luca, 1973-I977 and 1999-2000. Over 27 years (1973-2000), 429 individual bats were captured, Since animals were not banded, an overestimation is likely because many specimens were repeatedly counted. For this reason considerations upon dynamics and structure are generally referred to as aggregations of a single cave or few caves. Data on individual bats are based on the results of captures inside shelters. During each visit to a cave the total number of observed bats were checked and for each individual bat, sex and age classes were identified; after which, bats were immediately released hanging them back on the same roost (Crucitti and Chink, 1994). Due to its exposed hibernation, the Lesser horseshoe bat can be found easily. Nevertheless, numbers ascertained at a shelter are close to reality (Bezem *et al.,* 1964; Gaisler and Chytil, 2002).

RESULTS

Physical patterns of the environment

It would seem that *R. hipposideros* is less thermophile than *Rhinolophus ferrumequinum* which often resides in the same shelters; 63% of the Lesser Horseshoe bat (compared to 24% of *R. ferrumequinum*) hibernating in Latium were found in caves between 601 and 1200 m a.s.l. (Crucitti, 1991). A marked characteristic of the roosting behaviour of ***R. hipposideros*** consists in their adoption of different types of caves as winter shelters. For example, Grotta dell'Arco together with other 16 winter quarters of the Appendix, is a limestone cave; Santa Barbara is a hundred-year-old mine; La Coccumella is an Etruscan grave; Acqua dei Cardellini is a water tunnel. However, these hibernacula contain completely dark areas with a relative humidity >90% and a range of ambient temperature between 10.0 and 12.2 "C (Santa Barbara, November-April), 10.2 and 12.2 "C (Grotta La Pila, November-March), 11.8 and 13.2 "C (Acqua dei Cardellini, November-April), 9.5 and 13.5 "C (Grotta San Luca, December-April).

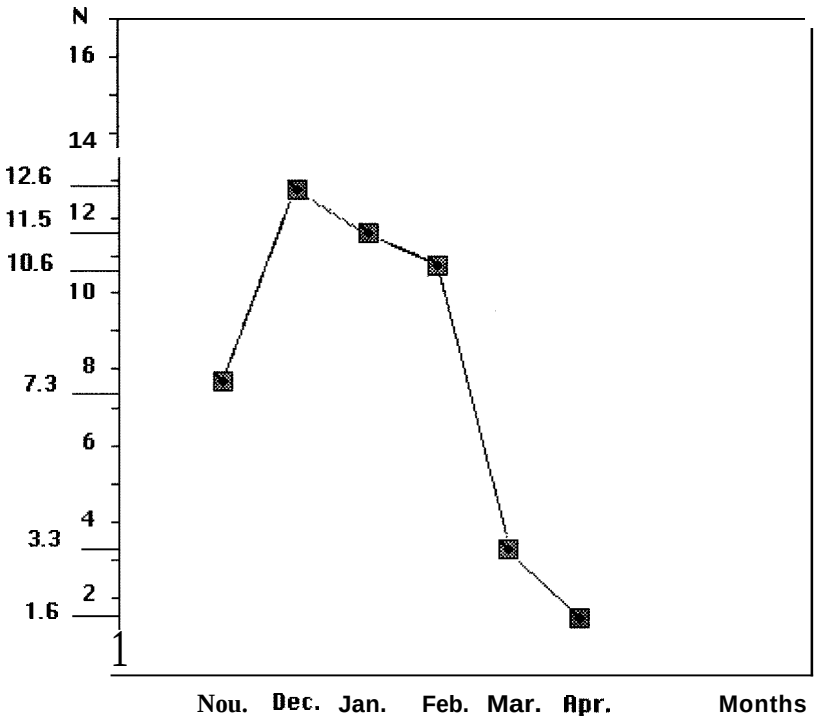

Figure 1 - Seasonal dynamics of *Rhinolophus hipposideros* at Santa Barbara (Allumiere, Rome) from November to April of three semesters (1992-1993; 1993-1994; 1994-1995). For each month, the average of the three values is reported. N: number of individual bats as in the following figures.

Aggregation size

The number of bats (N) observed during a single visit in winter ranged from 1 to 18. Only in three out of 23 caves, N>10 bats/visit; altogether, in 8 out of 23 caves, N>5 batshisit were recorded. By applying the total number of bats/total number of visits ratio (429/107), we obtained a value of 4.01 batshisit. The same ratio applied to each of the seven caves visited at least five times, is as follows: Santa Barbara, 7.83 (141/18); Grotte Penta, 1.88 (17/9); Tarquinia, 2.14 (15/7); Acqua dei Cardellini, 2.37 (19/8); Grotta San Luca, 8.45 (93/11); Grotta di Collepardo, 2.83 (17/6); Grotta La Pila, 2.35 (54/23). The average value among the seven ratios is 3.98 batshisit. Naturally, the highest ratios concern those of two caves (Santa Barbara and Grotta San Luca) in which the most numerous aggregations per visit (18 and 16 individuals, respectively) were observed. However, the value of 4 batshisit is strongly influenced by the "weight" represented by these two shelters. The average value among the other five shelters is 2.31.

Dynamics

The winter cycle of the Lesser Horseshoe bat may be synthetically described as follows; during November, the number of bats which harbour in caves increased rapidly reaching, at the end of this month, a level which was generally maintained during the following two months. In most caves the maximum number of individual bats was reached at the end of January. A marked decline was evident during February and March; few bats were monitored during April and they were totally

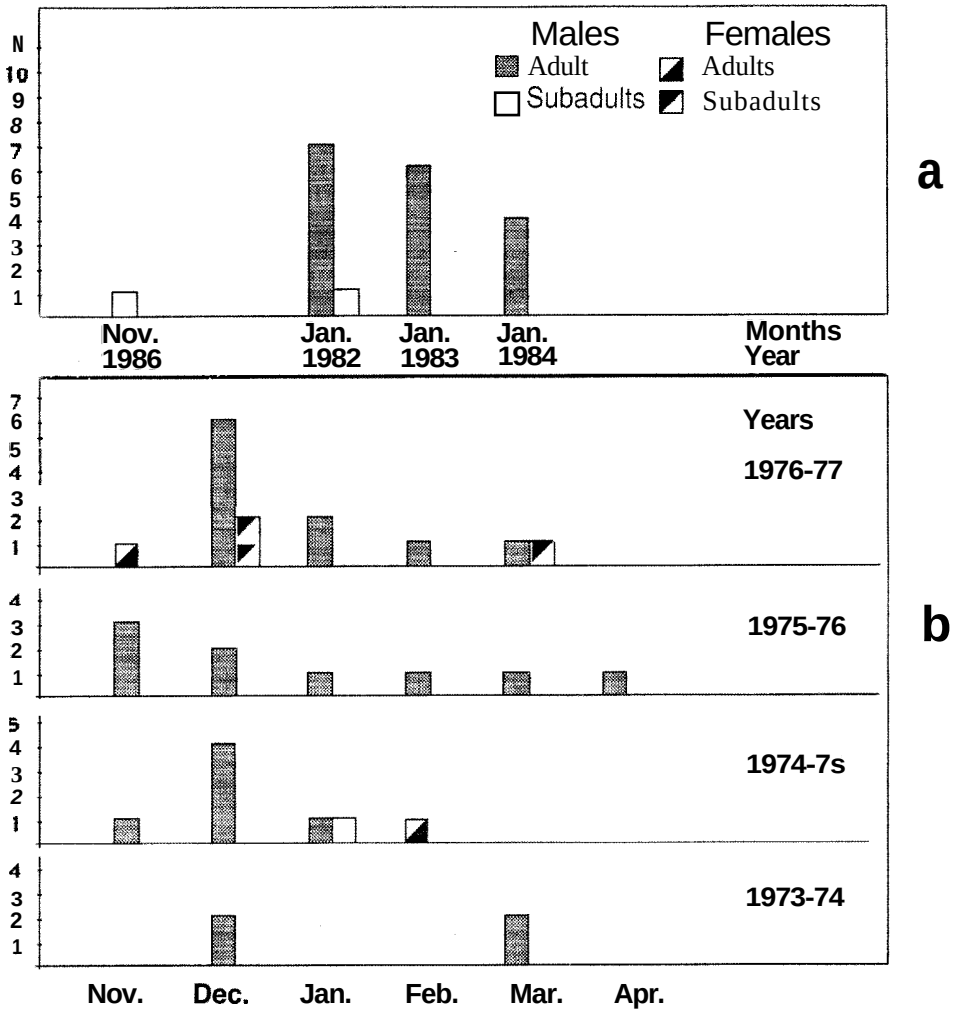

Figure 2 - Structure (sex ratio and age classes) of winter aggregations of *R. hipposideros* at Grotta La Pila (Poggio Moiano, Rieti) obtained from 21 visits at the shelter made during two different periods: 1982-1986 (a) and 1973-1977 **(b).**

absent in May (Fig. 1). This trend is particularly noticeable in the Santa Barbara and Grotta San Luca cave aggregations studied over the semester November-April of three consecutive years and from December 1999 to April 2000, respectively.

Structure

An unbalanced sex ratio among adults (tertiary sex ratio) especially in favour of males would be expected in most bats hibernating in Europe (Gaisler, 1979) and ***R. hipposideros*** is no exception. Many caves, periodically visited, harbour only males. This tendency is maintained in some shelters, year after year and over a long period of time (Figs. 2, 3, 4). Another general feature is overabundance of adult males in the largest

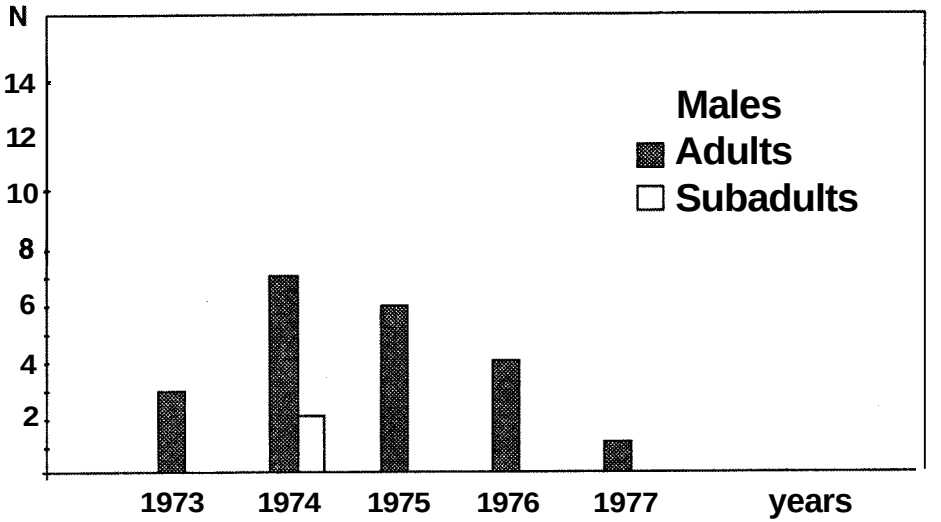

Figure 3 - Structure of the winter aggregations of *R. hipposideros* at Grotta San Luca (Guarcino, Frosinone) according to data obtained from 5 visits to the shelter from 1973 to 1977.

aggregations. The entire aggregation at La Mola Vecchia (April 2000) was composed of six adult males. In the Grotta Grande di Muro Pizzo, adult males numbered 5 of the 6 individuals in the aggregation of November 1976 and 13 out of 15 individuals in December 1979. Among the most numerous aggregations of Santa Barbara, 17, 14, 12 and 10 individual bats, adult males numbered 13, 9, 11 and 9, respectively (Crucitti *et al.*, 1998). These observations and those made by Russo and Picariello (1998) on winter aggregations of Campania (Southern Italy) are quite similar. On the contrary, most of the few, counted, females were subadults. The outstanding difference between the structure of the Greater and the Lesser horseshoe bat winter aggregations lies in the abundance of subadults of both sexes in the aggregations of *R. ferrumequinum* (Crucitti and Chid, 1994). The winter aggregations of *R. hipposideros* with predominance of males are similar, especially according to size, to those of the monosexual aggregations (being composed by few males) of the small vespertilionid bat *Myotis capaccinii* (Crucitti, 1981, 1993; Crucitti and Chink, 1990).

Discussion

Contrary to other species which select underground hibernacula in winter and are considered eurytherm *(M. myotis* and some small *Myotis* spp.) or stenotherm psychrophilous *(B. barbastellus, P. auritus* and *E. nilssonii), R. hipposideros* (together with *M. emarginatus)* is considered a stenotherm thermophilous bat (Rehak and Gaisler, 1999) and our data seem to support this evaluation. *Rhinolophus hipposideros* is commonly described as Vulnerable in Europe according to the IUCN Red List (Mithchell-Jones *et al.*, 1999). According to this classification, a species has at least a 10% probability of becoming completely extinct in the next 100 years (Massa and Fornasari, 1999).

As Racey pointed out, "conservation strategies and recovery programs for *R. hipposideros* must take into account both the

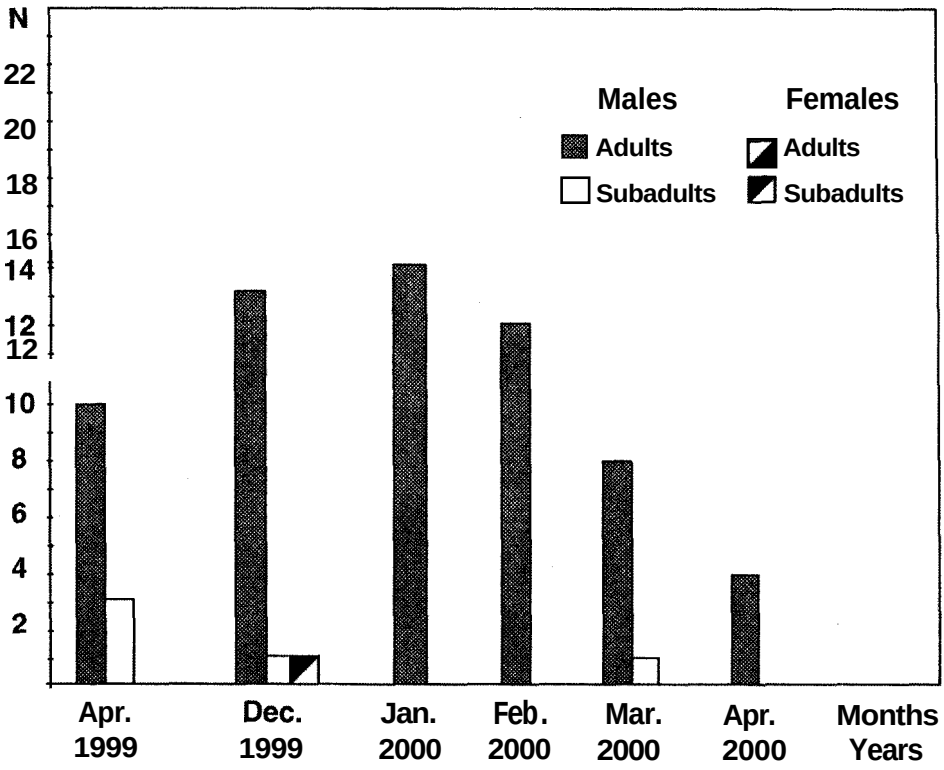

Figure 4 - Structure of a winter aggregation of ***R. hipposideros*** at Grotta San Luca according to data obtained from 6 visits, 1999-2000.

roosting and landscape requirements of this species" (1998, p. 254). Consequently, in every discussion concerning this bat, the number of observations emerging from studies regarding its roosting winter behaviour together with its local abundance in a given area cannot be neglected. It is worth mentioning the similarity of our data to many authors concerning the size of ***R. hipposideros*** winter aggregations in various Italian regions; Piedmont and Aosta Valley, NW Italy (Sindaco ***et al.***, 1992), Tuscany, Central Italy (Agnelli ***et al.***, 1999; Vergari and Dondini, 1998); Campania, Southern Italy (Russo and Picariello, 1998); and, finally, Sardinia (Mocci Demartis and Secci, 1997; Mucedda ***et al.***, 1995). Unfortunately, our knowledge about the status of many Italian populations is still limited and hence controversial. For example, ***R. hipposideros*** is considered to be rare in Tuscany, where it is localized mainly in hilly areas (Agnelli ***et al.***, 1999), rare in Sardinia where the greatest winter colony was 20 bats (Mucedda ***et al.***, 1995) and uncommon but less rare than ***R. ferrumequinum*** in the Abruzzo National Park (Zava and Violani, 1995). On the contrary, Russo and Picariello (1998) considered this species to be quite common and resistant to the impact of human disturbances in Campania. However, patterns of distribution and abundance in this region, referred by these authors, appear not to be very different from those of other, previously mentioned, Italian territories. Cautiously, Crucitti ***et al.*** stated that «At present, it is doubtful to consider the Lesser Horseshoe bat really threatened in Latium, in spite of its low

density>>(1999, p. 54). Winter dynamic features of the Lesser Horseshoe bat are apparently quite similar to those **of** other rhinolophid bat species living in the same area (Crucitti *et al.*, 1998). Evidence from the census carried out at Grotta La Pila from 1982 to 1984 and at Grotta San Luca from 1973 to 1977 suggests there are possible detrimental effects due to human disturbance emerging from the relationship between the prolonged period of observations and the decline, in the given time, of populations hibernating at these shelters (cfr. Brosset *et al.*, 1988). However, data from repeatedly monitored aggregations, during a prolonged period, at one site (Grotta San Luca) do not support the hypothesis of a general decline of this species over the whole Central Italy territory. Altogether, evidence suggests that this species is widespread but rare everywhere and the aim of ensuring protection for all, small and extremely scattered populations, seems particularly difficult. Nevertheless, at present, some useful conservation measures over the whole Italian territories could be established. General protection measures require the conservation of suitable habitats taking into consideration, above all, that foraging territories are usually associated with broadleaved woodland and water (Racey, 1998). In Latium, the greatest winter aggregations roost in small caves with a single chamber represented by a long corridor with a low vault located in areas with mixed oak woods and water such as streams and ponds. The training activity of spelaeologists in these shelters together with uncontrolled visits and ringing, especially in mid winter, should be forbidden or strictly controlled. In addition, restoration of old buildings, the recovery of important summer (breeding and nursery) aggregations, must be avoided. There is evidence that after a period of prolonged disturbance, generally associated with banding and/or unauthorized human activity in caves, clear-cut changes in the population density of local populations becomes inevitable. However, if hibernacula are put under total protection (for example, entrance of caves closed with solid gates), the numbers of bats stabilise and start to increase over a period of 15-20 years (Gaisler and Chytil, 2002). One should not forget, as stated by Rehak and Gaisler: «Insectivorous bats represent terminal or subterminal links in trophic chains and a decrease in their numbers may be considered indicative of environmental deterioration,, (1999, p. 113).

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APPENDIX

Data characterizing the shelters of *R. hipposideros* in Latium, the number of visits to each shelter, number of bats counted and date of the census.

Site and description	Altitude (m)	N. of visits	N. of bats counted	Census date
Santa Barbara, Allumiere (Rome) Old mine	580	18	6	22.XI.1992
			18	20.XII.1992
			12	24.1.1993
			17	21.II.1993
			3	21.III.1993
			2	25.1V.1993
			12	21.XI.1993
			14	19.XII.1993
			12	23.1.1994
			10	20.11.1994
			5	20.111.1994
			3	24.IV.1994
			4	20.XI.1994
			6	18.XII.1994
			10	22.1.1995
			5	19.11.1995
			2	19.III.1995
			0	23.1V.1995
Grotte Penta, Blera (Viterbo) Artificial	210-230	9	1	14.XII.1980
			2	24.XII.1986
			2	27.III.1988
			1	19.XI.1989
			1	20.XII.1989
			5	21.I.1990
			3	25.11.1990
			1	25.III.1990
			1	22.IV.1990
Tarquinia football ground . Tarquinia (Rome) Artificial	133	7	3	9.II.1975
			3	11.11.1977
			2	14.1.1979
			3	13.XII.1981
			1	23.1.1983
			2	29.XII.1983
			1	8.XII.1985
La Coccumella, Vulci (Viterbo) Artificial	40	3	1	19.XI.1978
			1	29.III.1980
			1	8.XII.1980
Acqua dei Cardellini, Jenne (Rome) Artificial	450	8	5	5.1V.1999
			0	30.V.1999
			4	20.XI.1999
			1	27.XII.1999
			2	22.1.2000
			3	26.11.2000
			2	25.III.2000
			2	20.IV.2000

Site and description	Altitude (m)	N. of visits	N. of bats counted	Census date
La Mola Vecchia, Jenne (Rome) Artificial	500	1	6	21.IV.2000
Grotta dell'Arco, Bellegra (Rome)	410	3	1	27.11.1983
			1	27.1V.1983
			2	10.II.1985
Grotta San Luca, Guarcino (Frosinone)	750	11	3	27.XI.1973
			9	31.X.1974
			6	27.XII.1975
			4	3.XI.1976
			1	6.XI.1977
			13	3.1V.1999
			16	27.XII.1999
			15	22.1.2000
			13	26.11.2000
			9	25.III.2000
			4	22.IV.2000
Grotta di Collepardo	502	6	4	17.III.1974
Collepardo (Frosinone)			4	1.XI.1974
			1	13.IV.1975
			1	3.XI.1976
			1	6.XI.1977
			6	30.XI.1980
Grotta di S.Angelo, Contigliano (Rieti)	800	1	2	28.XII.1976
Grotta Grande di Muro Pizzo	860	2	6	20.XI.1976
Poggio Moiano (Rieti)			15	28.XII.1979
Grotta La Pila, Poggio Moiano (Rieti)	831	23	2	29.XII.1973
			2	3.111.1974
			1	3.XI.1974
			4	15.XII.1974
			2	19.I.1975
			1	23.II.1975
			0	31.III.1975
			3	23.XI.1975
			2	7.XII.1975
			1	11.I.1976
			1	22.11.1976
			1	21.III.1976
			1	11.IV.1976
			1	1.XI.1976
			8	12.XII.1976
			2	9.1.1977
			1	6.11.1977
			2	13.III.1977
			0	9.IV.1977
			8	2.1.1982
			6	4.1.1983
			4	3.1.1984
			1	2.XI.1986

Site and description	Altitude (m)	N. of visits	N. of bats counted	Census date
Pertuso di Trevi Trevi del Lazio (Frosinone)	699	1	1	7.II.1981
Grotta di Capo Tosto, Cori (Latina)	390	1	1	27.XI.1983
Arnale Cieco, Con (Latina)	580	2	1	6.III.1977
			3	13.XI.1983
Grotta Patrizi, Cerveteri (Rome)	320	1	8	14.111.1976
Buca del Frulicchio, Arcinazzo (Rome)	790	1	6	23.11.1981
Grotta di Val di Varri, Pescorocchiano (Rieti)	825	2	1	4.1.1974
			3	3.1.1984
Grotta della Portella, Nespolo (Rieti)	820	3	2	1.IV.1979
			3	20.IV.1984
			3	28.III.1986
Grotta degli Ausi, Prossedi (Latina)	65	1	1	27.XII.1983
Grotta Cantocchio, Bassiano (Latina)	330	1	2	23.IV.1978
Grotta di Pacello, Carpineto Romano (Rome)	915	1	1	12.1V.1981
Grotta di Santa Vomma, Lenola (Latina)	425	1	1	6.XI.1987