

## DENSITY AND BREEDING OF *Muscardinus avellanarius* L., 1758 IN WOODLANDS OF SICILY

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**ABSTRACT.** The common dormouse is the more rare terrestrial mammal living in Sicily. An inventory of its presence in woodlands of the Madonie Regional Park has been carried out by the use of artificial nest-boxes. From September 95 to September 98, six sample areas were monitored monthly, resulting in 3468 checks and 525 records of animals. Relative frequency, by the DAT index, proved to be higher in mixed deciduous oak woodlands (25 and 30.5%) of the colchic belt and in the mixed hazel groves (10.6%), than in the pure stands of beech (4.3%) or ilex (0.7%). The absence of a dense and rich in species understorey is one of the major factors limiting the species' abundance. Density per hectare proved also to be higher in the mixed deciduous wood than in the hazel grove (8.2 vs 4.6 adults). Nest-boxes occupancy is continuous throughout the year and shows two peaks; the first in May-June; the second in November-December, nest-boxes are deserted only during August. The 67% of the checked litters (n = 34) took place from September to December; this latter and November are the peak months of reproduction. The mean litter size was 4.2 ( $\pm$  1.4; min-max: 1-8), but the spring litter size was smaller than those occurring during fall and winter. Torpor is lacking or very reduced in the studied and occurs just for few days, or weeks during cold weather perturbations and snow. The average body weight is around 20 grams, and is steady all along the year, winter fattening being absent. The Sicilian population of common dormouse is at the southern limit of the species' range, but is well adapted to the Mediterranean biome, where the dry and hot summer seems the season more difficult to deal with. Reduced torpor, steady body weight, continuous reproduction and the consequent bimodal population cycle are the major features of this adaptative process.

**Key words:** *M. avellanarius*, Mediterranean ecosystems, Density, Breeding, Nest-boxes

### *Muscardinus avellanarius* L., 1758 'UN SICILYA ORMANLARINDAKI YOĞUNLUĞU VE ÜREMESİ.

**ÖZET.** Fındık faresi Sicilya'da yaşamakta olan en ender karasal memelidir. Bu çalışmada, yapay yuva-kutuları kullanılarak Madonie Regionale Park ormanlarındaki mevcut durum hakkında bir envanter araştırması yapılmıştır. Eylül 1995'den Eylül 1998 kadar beş örnek alandaki kutu yuvalar ayda bir kez olmak üzere toplam 3468 kez kontrol edilmiş ve 525 hayvanın kaydı yapılmıştır. DAT indeksleri, kolşik kuşağın karışık yaprakdöken meşe ormanlarında (%25-30,5) ve karışık fındık korularındaki (%10,6) göreceli çokluğun, saf kayın (%4,3) ya da pırnal meşeliklerdekinden (%0,7) daha yüksek olduğunu göstermiştir. Tür bakımından zengin ve yoğun bir ormanaltı vejetasyonunun bulunmaması türün bolluğunu kısıtlayan en önemli faktörlerden biridir. Yoğunluk da (ergin birey/1 ha) karışık yaprakdöken ormanlarda (8,2/1ha), fındık korularına göre (4,6/1ha) daha yüksek çıkmıştır. Kutu yuva kullanımı tümyıl boyu süreklilik gösterir, kullanım Mayıs-Haziran ve Kasım-Aralık olmak üzere iki devrede en üst düzeye çıkar, Kontrollerde toplam 34 kez yenidoğan yavrulara rastlanmıştır, bunların %67'si Eylül-Aralık ayları arasında yer alır. Üreme Kasım ve Aralık aylarında en üst düzeydedir. Ortalama yavru sayısı 4,2 ( $\pm$  1.4; min-max: 1-8) dir, İlkbahardaki yavru sayısı Sonbahar ve Kışa göre daha azdır. Uyuşukluk görülmez ya da kar ve soğuk hava koşulları sırasında bir kaç günlük ya da haftalık çok kısa bir süreye indirgenmiştir. Ortalama vücut ağırlığı 20g dolaylarındadır ve yıl boyunca bir değişim göstermez, kış yağlanması yoktur. Fındık faresinin Sicilya popülasyonu türün yayılış alanının tümyıl sınırında bulunur, ancak yazları kuru ve sıcak olan ve başedilmesi çok zor görülen bir mevsime sahip Akdeniz Biom'una çok iyi bir uyum sağlamıştır. İndirgenmiş uyuşukluk, kararlı vücut ağırlığı, sürekli üreme ve bunu izleyen bimodal popülasyon çevrimi bu uyumsal sürecin temel özellikleridir.

**Anahtar sözcükler.** *M. avellanarius*, Akdeniz ekosistemleri, Yoğunluk, Üreme, Yuva-kutuları

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## INTRODUCTION

Sicily is the sole Mediterranean island (together with Corfu), which hosts the common dormouse (*Muscardinus avellanarius*). Both islands are very close to their continental areas; but in the case of Sicily the deep Straits of Messina is thought to have played an active barrier for the diffusion of strictly arboreal species such as the common dormouse. Anthropocory, a reasonable explanation for the presence of some Gliridae species in some Mediterranean islands (1, 2) cannot be invoked for *M. avellanarius*; which has not had any value (commercial, food stuff, etc.) for the human beings who travelled and settled in Sicily, or elsewhere in the Mediterranean, during historical times.

Fossil records for this species are still lacking (3), and for the above reasons, a recent penetration during the last Glaciation (pleniglacial and tardiglacial Würm, around 75000-15000 years b.p.), is the more plausible date for its presence in the island.

Recent ecological adaptation to dry and warm condition in the Mediterranean area of this Middle European element, living at the limit of its distribution range, is worth of study and comparison with populations of North and Central Europe.

*M. avellanarius* is the rarest terrestrial mammal living today in Sicily and is localized in the mixed sclerophyll and deciduous woodlands of North-eastern mountain ridge, from the Peloritani to the Madonie (4).

## MATERIAL AND METHODS

A survey on *M. avellanarius* presence and relative density in different woodlands of the Madonie Regional Park (Palermo) has been carried out by the use of wooden nest-boxes of standard size for the species (5). During three years, from September 1995 to September 1998, six sample areas were monitored monthly (Table 1). Two areas (Polizzi and Gimmeti) were checked for the whole study period; in these areas the nest-boxes were mounted at 120-180 cm, spaced regularly at 20 m, to form grids of one hectare. The other areas were checked at least for twelve months, but the nest-boxes, even spaced at 20 m and mounted at the same height, formed smaller grids or transects of variable length (min 280; max 400 m). The Canne area, a habitat very similar to Gimmeti, was dismantled after eight months due to heavy human disturbance. Analysis of the vegetation structure of the sample areas was also performed (Table 2). The species relative frequency was run by the DAT index (6):  $[\frac{n \text{ individuals}}{n \text{ checks} * n \text{ boxes}}] * 100$ . Individuals found in the nest-boxes were weighted, sexed and marked formerly by leg ringing and later by ear tattooing. After data collection and analysis, they were considered as:

- adults or old adults, if weighting more than 20 grams and presenting well developed sexual characters (i.e. evident nipples and vagina perforated, evident scrotum in males);
- young adults or subadults, if weighting between 15 and 20 grams and not presenting developed sexual characters (i.e. vagina closed, nipples or scrotum not evident);
- juveniles, if weighting less than 15 grams; since 14.5 grams was the maximum weight at which we observed young individuals still dependent from a female or found together with brothers in a box.

The disappearance rate (T) of marked individuals was calculated as  $T = \frac{N-k}{N} * 100$ ; where N = total number of captures; k = number of recaptures (7).

**Table 1.** The six sample areas in the Madonie Regional Park (Palermo Province, Sicily) chosen for the survey on Common dormouse (*M. avellanarius*) in Mediterranean woodland ecosystems.

Sample area	Study period	Habitat	Dominant species	Altitude a.s.l.
MUNCIARRATI	Apr96-Apr97	Mixed termophilous wood	<i>Q. pubescens</i> , <i>F. excelsior</i>	650
POLIZZI	Sept95-Aug98	Mixed hazel grove	<i>C. avellana</i> , <i>C. sativa</i>	900
GIMMETI	Sept95-Aug98	Mixed mesophilous wood	<i>Q. robur</i> , <i>I. aquifolium</i>	1200
CANNE	Sept95-Apr96	Mixed mesophilous wood	<i>Q. robur</i> , <i>I. aquifolium</i>	1250
SERRE CORCO	Sept97-Sept98	Pure ilex oak forest	<i>Q. ilex</i>	1250
MONTE DAINO	May97-Sept98	Pure beech forest	<i>F. sylvatica</i>	1400

**Table 2.** Main habitat variables measured in the sample areas chosen for the study on *M. avellanarius* ecology.

	MUNCIARRATI	POLIZZI	GIMMETI	CANNE	CORCO	DAINO
Total canopy (%)	100	100	100	100	100	90
Tree canopy (%)	70	90	72.5	90	100	75
Tree height (m)	8	11	16	14	12	13.5
S tree species	7	5	7	7	2	2
S dominant trees (cov>20%)	2	2	3	3	1	2
S flowering-fruited trees	6	6	7	7	2	2
Shrubs canopy (%)	40	55	60	70	30	40
Shrubs height (m)	1	2.5	4	4.5	0.5	3
S shrub species	16	15	13	13	7	7
S dominant shrubs (cov>20%)	7	6	7	7	2	2
S flowering-fruited shrubs	3	3	9	9	2	4
Grazing pressure	moderate	absent	low	low	low	low
Age of coppice	<1	>5	20-40	20-40	10-20	20-40

## RESULTS

### Relative density

Colonization of nest-boxes was fast and began on average 36 days ( $\pm 23$ ; min-max: 7-72; n=5) after to have set them on place. A total sample of 525 individuals were captured, marked and recaptured during the 3468 checks of the nest-boxes (Table 3). The DAT index proved to be higher in mixed deciduous woodlands (25 and 30.5%) of the colchic belt (*Quercus petraea*, *Ilex aquifolium*, *Acer* spp, *Castanea sativa*), than in pure stands of *Fagus sylvatica* (4.28%) or *Quercus ilex* (0.66%). The DAT index for the hazel grove area resulted in 10.63% for the whole study period; but the initial high frequency in this area (15.4% at the end of first year: September 95- October 96) later dropped down (6.9% in the following two years).

**Table 3.** Sampling effort and relative frequency (DAT index) of *M. avellanarius* in the Madonie woodlands.

Sample area	N boxes*	N visits	N checks	N captures	DAT%
Mix term wood (MUNCIARRATI)	20	12	240	0	0.00
Hazel grove (POLIZZI)	25-46	36	1317	140	10.63
Mix mes wood (GIMMETI)	33-44	36	1324	331	25.00
Mix mes wood (CANNE)	15-18	8	131	40	30.53
Ilex wood (CORCO)	11-14	13	152	1	0.66
Beech wood (DAINO)	19	16	304	13	4.28
<b>TOTAL MADONIE WOODLANDS</b>	<b>123-161</b>	<b>121</b>	<b>3468</b>	<b>525</b>	<b>15.24</b>

\* N changed throughout study period because boxes were stolen or moved elsewhere

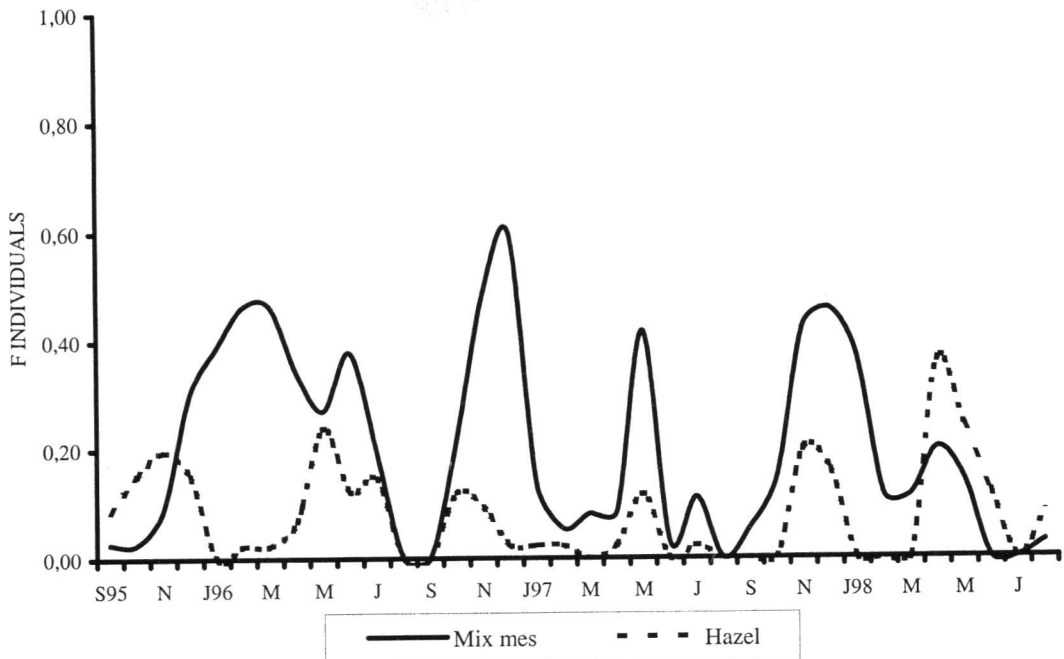
A forward stepwise regression among the habitat variables and the DAT index per area resulted in a statistically significant model of multiple regression (multiple  $R = 1$ ;  $R^2 = 0.99$ ,  $p = 0.02$ ), the stepwise analysis selected four  $\beta$ -coefficients, i.e. the shrub canopy ( $\beta = 0.751$ ,  $p < 0.05$ ); the species number (S) of flowering and fruited shrubs ( $\beta = 0.771$ ,  $p = 0.05$ ); and then S of dominant trees ( $\beta = -0.54$ ,  $p = ns$ ) and tree height ( $\beta = 0.054$ ,  $p = ns$ ).

The relative abundance of *M. avellanarius* appears, thus, to be lower in those areas where the wood is nearly monotypic, as in pure stands of beech or ilex, and/or in woodlands where an high understorey is

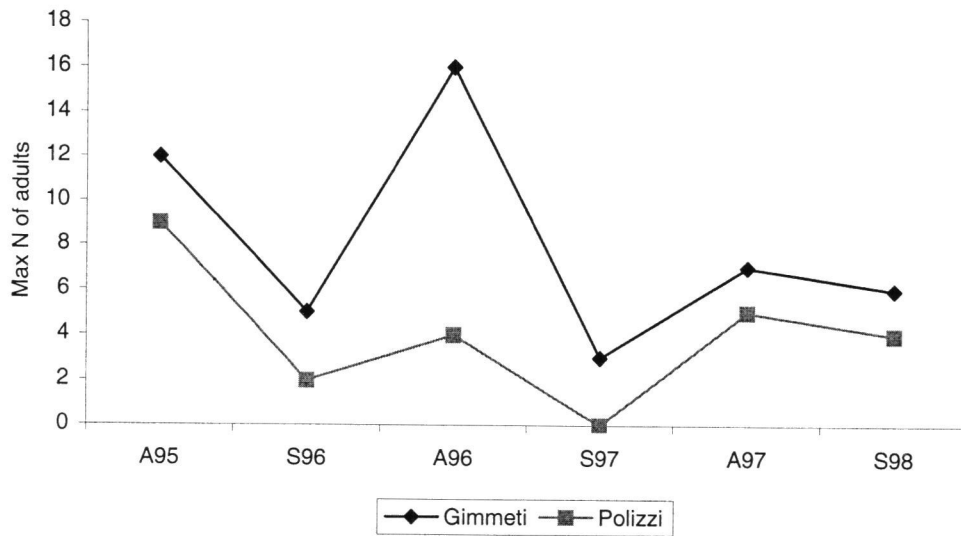
lacking or sparse, due to forestry clear-cutting and/or to grazing as in the Munciarrati area, which was coppiced the year before the beginning of study. The quantity and quality of vegetal species is also important and the presence of *Corylus avellana* and *Castanea sativa*, whose fruits are basic food for the dormice, can have improved the relative dormouse density at Polizzi. Holly berries; oak acorns and sweet chestnuts were the main food observed in the nest-boxes of the Gimmeti grid.

Almost the 90% of the 525 controlled individuals were recorded in the two areas continuously monitored for three years (Gimmeti and Polizzi). The population cycle showed a bimodal trend in both areas and it was also repeated during the three years (Fig. 1). The first peak of frequency occurs in late autumn-winter (i.e. February 96, December 96 and 97 at Gimmeti; November 95 and 96, December 97 at Polizzi); whereas the second is during springtime (i.e. July 96, June 97 and May 98 at Gimmeti; April 96, June 97 and 98 at Polizzi). The nest-boxes are deserted only during summer and early autumn (generally August and September, sometimes in July). The cyclic and coincident variation of population in the two areas is shown also, when the maximum number of adults has been considered (Fig. 2).

Onto the two grids, it was possible to sex and age a sub-sample of 286 animals, to gather some data about the structure of population. The mathematic means per each sex and age-class have been reported in Table 4. In both areas the adults' sex-ratio is nearly equal to 1:1 and there are only little differences in the age-class composition; these are always not statistically significant except for the case of the sub-adult females mean. The relative density per hectare was obtained summing the averages per class and resulted to be statistically significant higher in the mixed mesophilous wood of Gimmeti either considering only the adults (8.48 vs 6.76) or summing also the juveniles means (13.38 vs 10.41).



**Fig. 1.** Population cycle of Common dormouse (*Muscardinus avellanarius*) in Mediterranean woodland ecosystems (Madonie Regional Park, Palermo Province, Sicily). Frequency of individuals found in nest-boxes from September 1995 to September 1998 in two sample areas of 1 hectare, the mixed mesophilous wood of Gimmeti and the hazel grove of Polizzi.



**Fig. 2.** The maximum number of adults *M. avellanarius* found in two sample areas changed during the three years of research. In the mixed mesophilous wood of Gimmeti it varied from 6 individuals to 16 during the autumns (November) and from 3 to 6 during the springs (April). In the hazel grove of Polizzi, was indeed from 4 to 9 and from 0 to 4 respectively. Densities during autumn peaks were always higher than those during spring.

**Table 4.** *M. avellanarius* found in nest-boxes of two sample areas divided per sex and age-class. Mean and standard deviation have been calculated over the 36 monthly visits from September 95 to September 98. Sum of the means of adult dormice has given a relative density per hectare in each area. The 286 animals reported here represent the 60.7% of the 471 animals detected in the two areas and the 54.5% of those detected in all the considered areas.

	Hazel grove (POLIZZI)		Mix mes wood (GIMMETI)		Student's t
	N	Mean per visit	N	Mean per visit	
Mads	7	1.40±0.89	23	1.64±0.63	p = ns
Myads-subads	33	2.06±1.12	61	2.54±2.20	p = ns
Mys	7	1.40±0.89	29	2.90±3.11	p = ns
Fads	22	2.00±0.77	33	2.06±1.06	p = ns
Fyads-subads	13	1.30±0.67	29	2.23±1.54	p = 0.03
Fys	9	2.25±1.89	20	2.00±1.63	p = ns
Tot Mads	40	3.46	84	4.18	p = ns
Tot Fads	35	3.30	62	4.29	p = ns
Tot adults	75	6.76	146	8.48	p = 0.05
Tot individuals	91	10.41	195	13.38	p = 0.03

From the early spring of 1996 till August 1998, 160 individuals were marked (47 at Polizzi, during 29 months and 113 at Gimmeti, during 26 months). One third of the marked dormice were recaptured ( $n = 54$ ; 18 at Polizzi and 36 at Gimmeti) and the disappearance time was consequently high ( $T = 61.70\%$  at Polizzi and  $T = 68.14$  at Gimmeti). Anyway, it was possible to have the multiple recaptures of 29 individuals, which were considered to be resident on the grids. By dividing the number of territorial individuals to the period of observation it was possible to work out a relative index of density per hectare (Table 5). It is worth to say, that this latter is consistent with the former calculated by the arithmetic mean of individuals checked per visit. The permanence time was slightly higher at Gimmeti (on average 4.44 months vs 3.82 at Polizzi) and for males (on average 5.14 months vs 3.33 for females). The longest permanence time were recorded for one adult female with 7 recaptures in 16 months, and three males (2 at Gimmeti 1 at Polizzi) with 10, 13 and 18 months, but were recaptured only one time. This means that some animals (only subadult males?) are present and active in the study area, but frequent little the nest-boxes.

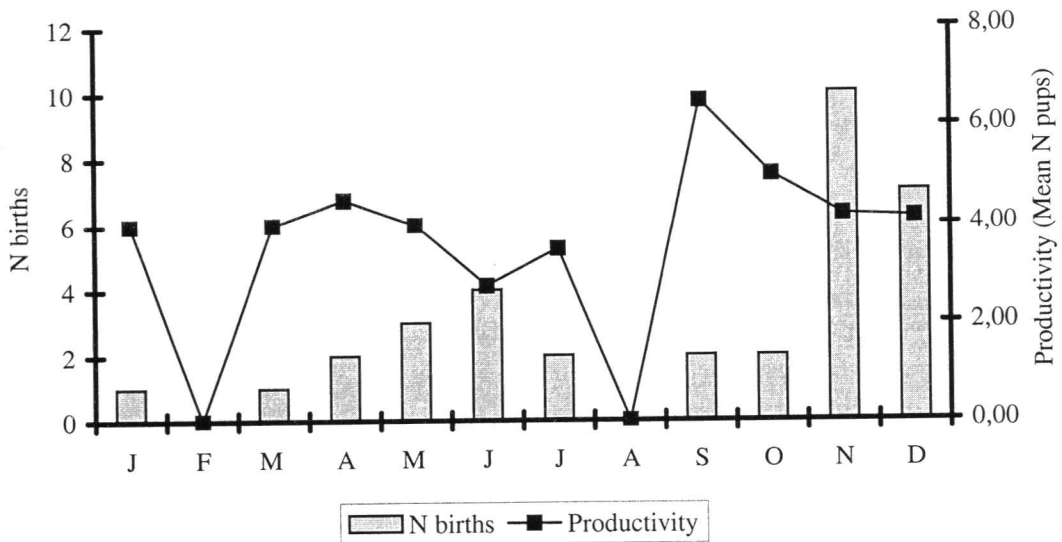
**Table 5.** Relative density of *M. avellanarius* in the areas of Polizzi and Gimmeti worked out by the analysis of resident adults (i.e. multiple recapture of marked animals). Time is the number of monthly marking sessions divided per one year (e.g.  $2.42 = 29/12$ ). Permanence is the interval of time presence on the grid from the first capture to the last recapture.

Sample area	Time	N Males	N Females	N Tot	N/ha	P(min-max)	P mean
Hazel grove (POLIZZI)	2.42	6	5	11	4.55	1-10 months	3.82
Mix mes wood (GIMMETI)	2.20	8	10	18	8.18	1-18 months	4.44

### Reproduction

The studied populations of the Madonie range have had a continuous reproduction throughout the year, but with seasonal peaks (Fig. 3, Table 6). November and December are the main months for breeding, followed by June and May; that results in a noteworthy coincidence with the population cycle reported in Figures 1 and 2. Breeding from September to December is much more frequent than in the rest of the year, in that the 67% of the checked litters ( $n = 34$ ) have taken place in these months. The mean litter was of 4.2 pups ( $\pm 1.4$ ; min-max: 1-8) but the spring ones are slightly smaller than those occurring during fall and winter (3.6 vs 4.5). However, the highest number of pups was found in the few litters produced in summer, even if these results were not statistically significant by the Student's t test.

The number of litters recorded per sample area depends from population density and the greater part of them occurred in the densest population of Gimmeti, but there is any significant difference by a Student's t test, among the three areas, when considering productivity. Number of litters and youngsters varied also according the years of study and the highest values were found in the period September 95-September 96, which has later determined the peak of adults during autumn 1996 (Fig. 2).



**Fig. 3.** Reproduction of Common dormouse (*M. avellanarius*) in Mediterranean woodland ecosystems (Madonie Regional Park, Palermo Province, Sicily) is uninterrupted during the year with differences in the frequency of litters and in the number of pups produced.

**Table 6.** Litters and pups of *M. avellanarius* recorded during the survey in the Madonie woodlands divided per sample area, per year and per season.

	N litters	N pups	X± ds	min-max
Total	34	141	4.15±1.44	1-8
<b>AREA</b>				
Mix-Mesophilous	23	94	4.10±1.00	2-7
Hazel	9	38	4.22±1.64	2-7
Beech	2	9	4.50±nc	1-8
<b>YEAR</b>				
Sept95-Aug96	17	68	4.00±1.32	2-7
Sept96-Aug97	6	24	4.00±0.89	3-5
Sept97-Aug98	11	49	4.45±1.86	1-8
<b>SEASON</b>				
winter	2	8	4.00±nc	4
spring	9	32	3.56±1.33	1-5
summer	4	20	5.00±2.16	3-8
fall	19	81	4.26±1.37	2-7

### Torpor and body weight

Related to the continuous presence of active dormice on the grids is the very low frequency of torpor, which was very reduced in the studied population (4.4% of 525 sampled animals). It was recorded to last just for few weeks (or even days) during cold weather perturbations and snow; not only during winter (n = 6 animals) but more in March (n = 9), April (n = 5) and May (n = 3). During these spring months the food shortage occurring at the end of winter, coupled with bad weather (March is very often one of the coldest months in Sicily and April was snowy during the study period) can have caused the relative increase of torpor (17 out the 23 individuals found). The mean recorded weight of these animals was 16.4 grams ( $\pm 3.2$ ; min-max: 11.5-21) typical of the young adults.

The body weight of 352 individuals was recorded; 111 of which were juveniles of different age (0-45 days) and their average weight was of 10.42 grams ( $\pm 3.1$ ; min-max: 2.0-14.5). The highest weight reached by youngsters, at the beginning of their independence, and thus found in the nest together with the mother or with the brothers was 14.5 grams (N = 11; 10% of the sample of N = 111).

These data permitted to cut the population at a 15 grams threshold, considering all the individuals below that weight as still juveniles. The average body weight of adults and their year trend was started, as consequence, at the assigned weight of 15 grams and resulted in 19.02 grams ( $\pm 2.66$ ; min-max: 15-28). The maximum weight recorded for an adult female was 28 grams (but it was perhaps pregnant), another female in lactation weighted 27.5 grams; whereas the maximum weight for males was 26.5 grams.

The year-round average body weight of 241 animals has been reported in Figure 4. This weight trend shows a very narrow range of fluctuation ( $\pm 3.5$  grams) from the minimum of April to the maximum of July, and the total lack of fattening during winter. The lowest mean weight recorded in April is consistent with the presence of some animals in torpor probably due to food shortage. It is, may be, not a chance that the highest value was recorded in July, before the nest-boxes desertion in August, this last was also another months of weight decrease.

This pattern appears also when considering a smaller sub sample of the population, i.e. by checking the weight on the multiple recaptured individuals (n = 29).

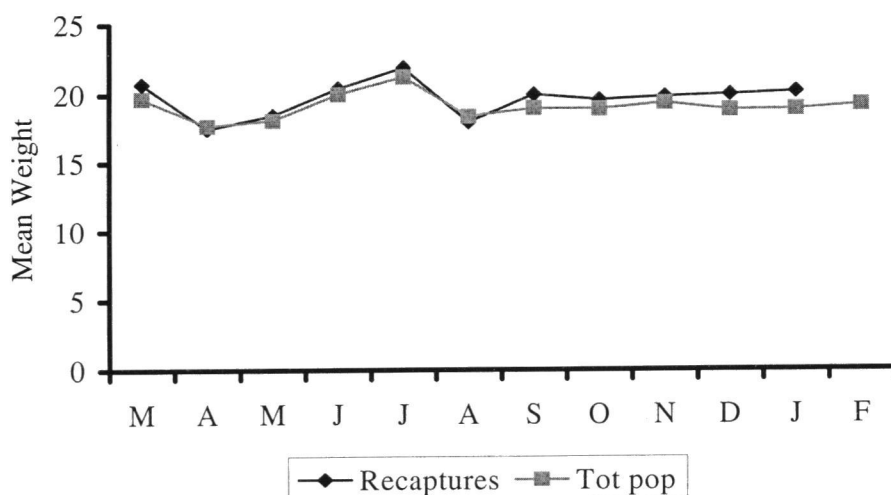


Fig. 4. Fluctuation during the year of the mean body weight of *M. avellanarius* in Mediterranean ecosystems. Checked on the total sample ( $n = 241$  individuals), excluded juveniles, and on the marked animals with multiple recaptures ( $n = 29$ ).

## DISCUSSION

The survey permitted to have a first sketch on the ecology of common dormouse in Sicily. As resulting from other studies (8), also in the case of the sample areas chosen in the Madonie, habitat structure and diversity seem to be the major factors limiting the abundance of the species and forward analyses can state, more precisely, which fine-graded variables are the best predictors of its presence and density. Presence of a dense understorey and of high and diverse shrubs and trees species seems, at this state of knowledge, the main habitat features necessary for supporting a rich dormouse population.

In its Northern range common dormouse has a shorter activity season and occupies the nest-boxes from April to the beginning of November (9, 10, 11), going to hibernate on or under the soil (12), during the rest of the year. The Sicilian population of common dormouse is at the Southern limit of the species' range and, on the Madonie Mountains, the continuous reproduction with the two yearly peaks, results in a bimodal population cycle. The summer breeding of Northern dormice has shifted here to late autumn and early winter; and this appears to be a characteristic of adaptation to the Mediterranean bio-climate. In Mediterranean ecosystems high palatable and energetic food (i.e. oak acorns and seeds such as holly berries, hazel nuts, sweet chestnuts, fruits as brambles, wild pear, etc.) is available almost exclusively during autumn and winter. In late spring, the presence of beech acorns, soft berries or flowers and blossoms (e.g. *Rosa canina*, *Crataegus monogyna*, *Lonicera etrusca* and *L. implexa*, *Acer* spp.) allows the lower second peak of reproduction.

The dry and hot summer appears to be the season more difficult to deal with; and at that period, dormice leave the nest-boxes and aestivate elsewhere. It is not possible to state now, if they live outside among the vegetation, or go underground in search of humidity and lower temperatures.

The mild weather conditions in autumn and winter favour the biological activities of dormice and the full growth of litters born in those months. Mediterranean winter allows, as consequence, to avoid the constraint of hibernation and to re-allocate energy and time, necessary for fattening, to reproduction. The average body weight of this population is stable and fluctuates very little, not showing the phase of winter increase recorded in Continental dormice due to hibernation (13). In this view, torpor seems to be more an individual strategy, rather than a population trait. This can be put in practice to save energy when singles are in bad nutritional condition, since the animals found in dormancy are very few and have lower body weights. The bad weather and snow, affect them, but not the greater part of the population, which is in full activity and reproduction; e.g. lactating their pups. The complex physiology of hibernation allows hypothesizing that those 'meagre' individuals that go in torpor without a previous fattening will have poor survival.



The showed changes of population biology are successful, even if there is an increasing evidence of juveniles mortality during unpredictable and sudden heavy climatic perturbations, since the species is still able to survive in its Sicilian range, producing litter size and having density per hectare similar or even higher to those found in England or in Lithuania (8, 10, 14).

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