Abundance and seasonal fluctuations of the rabbit (Oryctolagus cuniculus) in agrocoenoses of Mount Etna, Sicily

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Note e Comunicazioni

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Riassunto - Abbondanza e variazioni stagionali del coniglio selvatico (*Oryctolagus cuniculus*) in agro-ecosistemi del Monte Etna.

E' stata studiata l'abbondanza e la variazione stagionale di una popolazione di coniglio selvatico *(Oryctolagus cuniculus)* in agro-ecosistemi del Parco dell'Etna. La stima del numero degli individui è stata effettuata mediante conteggio degli escrementi. Le densità (8,6 ind./ha e 7,0 ind./ha) rilevate non mostrano differenze tra i due anni di studio (1998-1999) sebbene esista una certa variabilità tra le aree campione. L'analisi statistica non ha evidenziato fluttuazioni stagionali significative. Le più elevate densità sono state riscontrate nei vigneti consociati e negli incolti. Viene inoltre discussa l'importanza della qualità del cibo e della composizione dell'habitat.

Parole chiave: Parco Regionale dell'Etna, *Oryctolagus cuniculus*, abbondanza, variazioni stagionali.

Introduction

The rabbit (*Oryctolagus cuniculus*) is a very important species in the trophic web of terrestrial vertebrates (Delibes & Hiraldo, 1981). Native of the western Mediterranean and introduced into many other regions, the rabbit is a staple food for the predator communities (Cheylan, 1977; Dobson, 1998). In Sicily, the rabbit has become the most important prey for several predators, including rare species such as the Bonelli's eagle (*Hieraaetus fasciatus*), the Golden eagle (*Aquila chrysaetos*) and the Wild cat (*Felis silvestris*) (Massa, 1981; Di Vittorio *et al.*, 2000). Nevertheless, in response to favourable habitat conditions, this lagomorph can increase excessively causing serious damage to crops. Thus, the management of rabbit populations is often needed, especially in protected areas.

Although the important role of rabbits in agricultural lands, there is a lack of studies on the ecology of this species in Italy. The aims of this paper are to assess

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the abundance of rabbit populations in the agro-ecosystems of the Mount Etna (Sicily), to determine their seasonal fluctuations and their variation among different habitats. Results can be useful for the species management into the Etna Natural Park, where serious damages to crops are reported by farmers and hunting is forbidden.

Study area and methods

The study was conducted from January 1998 to December 1999 in eight sample areas of 3 hectares each, located at different altitudes (750, 950 and 1,150 m a.s.l.) on the north and south-west slopes of Mount Etna. To avoid possible bias deriving from the interchange of rabbits among the populations, the sample areas were selected more than 1.5 km from each other as suggested by Moreno & Villafuerte (1992).

All the sample areas were representative of the typical local country landscape: an habitat mosaic with cultivated fields and interspersed areas of natural vegetation including abandoned fields re-colonized by spontaneous plants. Each of the eight sample areas contained both natural and agricultural habitats. Natural habitats were mainly chestnut (*Castanea sativa*) and oak (*Quercus virgiliana*) woods, scrublands with *Spartium junceum* and *Genista aetnensis* and abandoned fields with grassland and sparse blackberry (*Rubus ulmifolius*) and oak. Agricultural habitats reflected the traditional agriculture of Mount Etna with vineyards, orchards and mixed cultivation (grape vines together with fruit trees).

The climate is meso-Mediterranean (Bagnouls & Gaussen, 1957) with hot summers (the average temperature in August during the study was 27.7 °C, with a maximum of 44 °C) and cold winters (average temperature in January 5 °C, with a minimum of -5 °C). Rainfalls were most intense in autumn (100 mm/month) and very scarce in summer (5 mm/month).

The estimation of rabbit abundance was made by pellet counts as described by Taylor & Williams (1956). This method has been widely used to obtain an index of population size of lagomorphs (Angerbjorn, 1983) and a strong relationship between pellet abundance and rabbit density has been demonstrated (Wood, 1988). Pellet counts were made in 406 circular sampling plots (an average of 51 plots per sample area), 1.54 m^2 each, which were randomly distributed in both the agricultural and natural habitats of each sample area. All mentioned habitats were sampled, with a minimum number of 35 plots in scrublands and a maximum of 111 in orchards.

Pellets were counted and removed every month (except for October 1999). Rabbit density (D) was calculated using the formula proposed by Eberhardt & Van Etten (1956):

$$D = d / rt$$

where (d) is the average number of pellets per plot, (t) is the time (number of days) elapsed from the last removal of pellets, and (r) is the average number of pellets daily produced by a rabbit. Due to the lack of valuable data for our study area, we

considered *r* corresponding to 350 pellets, as recorded by Moreno & Villafuerte (1992) for a Mediterranean ecosystem and close to other experimental values (Wood, 1988).
The differences in rabbit densities were tested by Mann-Wihitney U test and Kruskal Wallis test.

Results

Rabbit density varied widely among the sample areas, from 1.2 ± 0.8 ind./ha (area 4 in 1998) to 38.4 ± 17.7 ind./ha (area 2 in 1998) (Tab. 1). Comparing the data between the two study years, significant differences were recorded for area 3, 6 and 8, while the mean annual values were similar (U = 66.0; P not significant).

The highest monthly mean value was found in January 1998 (20.1 ± 32.8 ind./ha), and the lowest in June 1999 (3.5 ± 2.7 ind./ha) (Tab. 2). Differences among seasons were not significant (H = 8.992, d.f. = 7, P = 0.262), seasonal variation in rabbit density was found only for the sample area 1 in 1998 (H = 9.667, d.f. = 3, P = 0.028) and the sample area 2 in 1999 (H = 8561, d.f. = 3, P = 0.046) (Tab. 3) .

In cultivated habitats abundance values seemed to fluctuate quite sharply with an evident breakdown in spring, in natural habitats the number of rabbits remained relatively constant from winter to summer and showed a sharp decrease in autumn.

Comparing rabbit densities among the habitats, the highest were in mixed cultivation (associated vineyards) and abandoned fields. Vineyards followed while woodland and orchards were scarcely frequented (Tab. 4). Seasonal fluctuations in each habitat suggested a large variability of rabbit densities without a well defined temporal strategy.

Tab. 1 - Average (±SD) densities (ind./ha) of rabbits during the two study years (* Z = 2.986; P = 0.003 ** Z = 3.079; P = 0.002 *** Z = 3.263; P = 0.001).
Tab. 1 - Densità (media ± DS) del coniglio selvatico durante i due anni di studio (* Z = 2.986; P = 0.003 ** Z = 3.079; P = 0.002 *** Z = 3.263; P = 0.001).

Sample areas	1998 (n=12)	1999 (n=11)
1	12.0 ± 5.96	8.7 ± 4.34
2	38.4 ± 17.69	30.7 ± 11.07
3*	4.1 ± 5.63	1.4 ± 0.93
4	1.2 ± 0.82	1.8 ± 1.20
5	2.7 ± 2.00	2.3 ± 1.66
6**	1.5 ± 1.46	4.2 ± 1.98
7	3.8 ± 1.98	4.3 ± 1.93
8***	4.8 ± 2.84	2.5 ± 1.74
Mean	8.6 ± 12.51	7.0 ± 9.87

Tab. 2 - Monthly changes in rabbit density (ind./ha) in the two study years; *Nr.* = not surveyed.
Tab. 2 - Variazioni mensili dell'abbondanza del coniglio selvatico nei due anni di studio; *Nr.* = non rilevato.

	1998	1999
January	20.1	7.9
February	10.6	8.4
March	8.5	9.8
April	5.7	5.2
May	7.4	5.2
June	8.7	3.5
July	8.5	10.5
August	8.2	8.0
September	9.5	7.6
October	6.2	*Nr.*
November	8.0	5.2
December	6.8	6.1

Tab. 3 - Seasonal variation in density (ind./ha) of rabbits in sampled areas (seasonal sample size is n=3 except for autumn 1999 where n=2); n.s. = not significant.
Tab. 3 - Variazioni stagionali della densità di conigli nelle aree campione (la dimensione del campione stagionale è n=3 eccetto per l'autunno 1999 dove n=2); n.s. = non significativo.

1998	**Winter average**	**SD**	**spring average**	**SD**	**summer average**	**SD**	**Autumn Average**	**SD**	**P**
1	20.8	0.93	10.1	2.42	11.8	1.47	5.5	1.26	**<0.05**
2	53.1	33.67	29.8	6.86	37.5	6.74	33.1	4.16	n.s.
3	9.1	11.00	2.5	1.73	2.9	0.49	2.0	0.4	n.s.
4	1.4	1.38	1.2	0.80	1.1	0.31	1.3	1.02	n.s.
5	2.1	1.10	2.1	1.40	3.9	3.9	2.6	0.53	n.s.
6	0.8	1.02	0.2	0.30	1.8	1.17	2.9	1.19	n.s.
7	4.2	1.39	3.8	3.62	3.8	1.87	3.6	1.65	n.s.
8			9.9	4.18	7.0	1.07	5.0	1.94	n.s.
Total	13.1	18.99	7.4	9.78	8.7	12.13	7.0	10.6	n.s.

1999	**Winter average**	**SD**	**spring average**	**SD**	**summer average**	**SD**	**autumn average**	**SD**	**P**
1	7.6	1.85	6.5	1.71	13.5	5.93	6.7	2.98	n.s.
2	40.5	5.58	17.1	9.55	35.9	5.95	34.1	5.32	**<0.05**
3	1.5	1.16	1.6	1.25	1.7	0.26	0.4	0.36	n.s.
4	3.1	1.08	2.1	0.45	0.6	0.39	1.2	1.00	n.s.
5	3.6	0.47	1.8	1.18	3.1	1.96	0.5	0.59	n.s.
6	5.6	2.22	2.7	0.08	5.1	0.02	3.7	3.85	n.s.
7	4.1	1.42	4.3	1.82	6.1	1.92	2.1	0.50	n.s.
8	3.7	2.23	0.9	0.10	3.5	1.05	1.6	1.05	n.s.
Total	8.7	12.97	4.6	5.30	8.7	11.69	6.3	11.43	n.s.

Tab. 4 - Rabbits density in habitats of the study areas. (a) Mean number of pellets found in each habitat (b) Comparison of habitat use among habitat categories (statistical test: Mann-Whitney U test).
Tab. 4 - Densità di conigli in singoli habitat nell'area di studio. (a) Numero medio di pellets trovati in ogni tipologia ambientale (b) Comparazione tra singole tipologie ambientali (Mann-Whitney U test).

Habitat	**Mean**	**SD**	**N**
Abandoned cultivation	18.78	31.84	126
Oak /chestnut woods	8.60	24.94	149
Scrubland	9.72	20.51	70
Orchards	5.62	14.14	219
Mixed cultivation	27.67	36.04	108
Vineyards	3.77	6.69	140

a

	Abandoned cultivation	Oak/chestnut woods	Scrub-land	Orchards cultivation	Mixed
Oak /chestnut woods	**0.002**				
Scrubland	0.595	**0.002**			
Orchards	0.411	**0.000**	0.128		
Mixed cultivation	0.137	**0.000**	0.350	**0.020**	
Vineyards	0.054	0.110	**0.002**	0.064	**0.000**

b

Discussion

The rabbit density in the Mount Etna Park was similar to those observed in other Mediterranean protected areas such as the Camargue in Southern France (also 40 – 50 ind./ha) and the Doñana National Park in Southern Spain (3.0 – 13.7 ind./ha) (Biadi & Le Gall, 1993; Moreno & Villafuerte, 1992). The high density found in area 2 was explained by Caruso & Siracusa (2001) who found that the extension of wasteland together with altitude positively affected the size and temporal variability of rabbit populations. The slight variation in abundance observed in the two years suggests a temporary stability of the populations that might depend on favourable climatic and environmental conditions and no epidemics broke out during the study period.

As for the seasonal fluctuations, statistical data do not reveal significant variations except for two sample areas where the populations showed the highest density in winter with a decline in spring.

In some zones, intense autumn rainfalls could reduce the winter population

size when burrows are flooded causing death or diseases of cubs (Reynolds, 1979). The high permeability of the volcanic soil of Mount Etna prevents floods and excessive dampness. This probably contributed to the high number of rabbits detected in winter. Decreases in early spring may be explained by the adverse winter conditions which are known to determine an increase of mortality of young and pregnant females (Villafuerte *et al*., 1997).

Differences in number among rabbit populations in cultivated and natural areas could partially depend on the food quality; generally, rabbits are more abundant when large amount of grass is available (Rogers, 1981; Moreno & Villafuerte, 1995). Rabbits density in sample areas confirms this trend: rabbits were more abundant in abandoned open fields with grasslands and in mixed cultivation fields where tillage methods are traditional and grass is removed only once a year. Also, vine branches were allowed to grow low above the ground level thus supplying rabbits with extra food and shelter.

We suggest that the main factors affecting abundance of rabbit populations in the Etna agricultural ecosystems are food availability and habitat composition, both depending on land use. It is well known that small-patch crops, typical of the Mediterranean rural landscape, are advantageous for many species (Moreno & Villafuerte, 1995). This study suggests that the progressive abandonment of land cultivation may produce a further increase of suitable microhabitats for rabbits.

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