Movements and activity patterns of Hedgehogs *(Erinaceus europaeus)* in Mediterranean coastal habitats

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Abstract

Studied the activity patterns and movements of fourteen hedgehogs by radio-telemetry in a typical Mediterranean maquis environment. Activity periods had a constant pattern up to the first half of December, when they began to decrease. In January and February activity was almost absent, and it commenced again in March. The mating season lasted from the middle of March to the second half of October. Out of 990 observations, the most frequented environments were wet meadows (36.5 %), bushy areas of the maquis (26.4 %) and dry meadows of the maquis (25.2 %). Of 120 located nests, 28 % were under the bushes of the maquis, 25 % under brambles, 22 % in tall grass. Sixty percent of all nests were used more than once. Females used the same nests consecutively for periods significantly longer than the males. Homes range sizes were highly variable, ranging from 5.5 to 102.5 ha. Ranges were found to overlap widely, and each range included several different habitats. The maquis was frequented particularly in spring, when the animals covered greater distances, while the wet meadows were mostly used in the summer and autumn months. Food availability apparently determined the pattern of habitat use.

Introduction

The most extensive review of the hedgehog *(Erinaceus europaeus)* biology was written by Herter in 1938. More recently, researches were focused on animals kept in the laboratory or in captivity, while little attention was paid to animals in the wild (Morris 1973; Campbell 1973; Parkes 1975). However, in recent years the development of telemetric techniques has opened up new possibilities for field studies of many vertebrate species. Radio tracking of hedgehogs has been used in Europe (Kristiansson and Erlinge 1977; Berthoud 1978; Reeve 1979; Esser pers. comm.) and in New Zealand (Moors 1979).

This paper reports on the study of a small number of hedgehogs marked with radio-transmitters: the aim of the study was to define the activity patterns and movements of the species in a typical Mediterranean environment, i.e. the waste maquis, which is still largely unknown with regard to the existing relationships among its flora and fauna.

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Study area

The study area covers one of the rare remaining stretches of the Mediterranean coastal maquis along the coastlines of Tuscany and Lazio. "Lago di Burano", a brackish water lake, is bordered on the west side by a series of sandy dunes which separate the lake from the sea. These dunes occupy an area of about 160 ha, and are covered by low, dense bush, interspersed with open meadows of typical grassy vegetation. The predominant species of bushes are *Juniperus oxycedrus macrocarpa, Juniperus phoenicea, Quercus ilex, Pistacia lentiscus, Phyllirea variabilis, Myrtus communis, Cistus* spp.

Since 1968, this area has been granted to the W.W.F. Italy, in order to protect the total environment, as a refuge for migratory and native bird-life. Human activity within this area is reduced to a minimum.

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Table 1

Climatic variables obtained from September 1980 to July 1981, by the Grosseto metereological station

	Temperature (°C)		Rainfall	
	max.	min.	total (mm)	rainy days
September	29.0	12.4	47.0	1
October	26.5	6.5	144.4	12
November	20.0	3.0	191.0	12
December	18.0	–5.0	43.4	6
January	15.0	–5.5	51.2	5
February	19.5	–1.0	16.8	5
March	19.5	1.5	39.8	9
April	22.0	4.0	48.4	6
May	24.0	5.5	49.4	6
June	34.0	10.0	22.0	5
July	30.0	13.5	25.6	3

The lacustrine strip beyond the sand dunes covers about 82 ha, and consists of alternating tracts of marshes with reeds *(Carex, Typha, Juncus)*, patches of *Rubus*, and wet meadows used for pasture, an area extensively subdivided by drainage systems. Towards the center of the area there is a low lying plain of about 50 ha used mostly for cereal and vegetable cultivation. The areas characterized as refuse sites, are considered as separate environments, which are divided into three centres covering an area of 0.8 ha. Such a subdivision into 5 separate habitats is employed during analysis of the environmental preferences of the hedgehog.

The climate of the entire zone is particularly mild, due to its proximity to the sea (Table 1).

Methods

The capture of the animals was achieved either through the use of live-traps (Woodstream Corp., Lititz, Pennsylvania), by chance encounters or by capture in the company of radio-marked animals, during the mating season (Table 2).

The body-weight, sex and size of captured individuals were recorded, and animals were marked with small numbered metal tags, attached on the ear. Radio transmitters were attached to those animals weighing more than 500 g, using an epoxidic glue (Esser pers. comm.). The body-weights of these animals were recorded periodically during the observation period.

Ten transmitters (model no. SB2, AVM Instrument Co., Illinois, USA) were completely encased in a resistant, water-proof, acrylic resin, whilst allowing the Lythium battery to be changed easily. The dimensions of the entire transmission unit ranged between 3 × 3 × 2 cm, 30 g (Li 1/2 A) and 4 × 4 × 2 cm, 40 g (Li 2/3 A), lasting respectively 3 and 6 months. An antenna about 20 cm long, obtained from a bicycle brake cord, hung loosely to the ground. Radio signals covered a reception distance ranging over 1500 m.

From September 1980 to July 1981, the transmitters were attached to 14 hedgehogs that carried them for periods extending from 24 to 248 days (Table 4). In 123 days of radio-tracking, three kinds of observation were made: night spotting of animals (at least twice a night); extended following of a single hedgehog, tracking it at 10–15 minute intervals; day spotting of all the hedgehogs. Observations were coded NO, when the animal was immobile; M, when active or moving within a limited area; T, when traveling along a relatively straight line. During night-spotting, visual contact was prolonged whenever possible by shining a torch on the animals and following them from a distance of approximately 20 m. The coordinates of the 25 × 25 m square of a map at 1 : 5000 of the study area in which every animal was observed were recorded on the respective individual animals card along with time elapsed, climate and environment variables, the activity and behaviour of the animals.

Results

Captures and number of population under observation

Between March 1980 and July 1981, 28 hedgehogs (17 males and 11 females) were captured in the study area (Table 2). Only 14 of these were followed by radio-tracking.

In May 1981, the maquis zone within the study area (160 ha) was regularly frequented by at least 6 animals. All animals in this period even those encountered by chance, proved to be radio-tagged, an observation which supports the hypothesis that they constituted the entire resident population. In the following months of June and July the maquis was almost completely abandoned by all individuals that were considered residents in May. These animals had moved on to the pasture or into the crops beyond the maquis. During these months the 82 ha of the pasture were occupied by a least 10 animals. Four of these were always somewhat peripheral to the study area and may have come from surrounding areas.

Table 2

Captured animals and their data

Hedgehog No.	Sex	Weight	Date of capture	Recapture
201	♂	700 g	31. 5. 80 T	3. 6. 80 T
202	♂	740 g	1. 6. 80 T	
+203	♀	1020 g	13. 9. 80 T	15. 6. 81 S
+204	♀	960 g	19. 9. 80 C	
+205	♀	1000 g	21. 9. 80 T	14. 4. 81 T
+206	♂	710 g	22. 9. 80 T	
207	♂	225 g	30. 10. 80 C	
208	♀	220 g	30. 10. 80 C	
209	♀	215 g	30. 10. 80 C	
–	♂	320 g	5. 11. 80 C	
+210	♂	740 g	5. 11. 80 C	
212	♀	550 g	10. 11. 80 C	
+213	♂	800 g	21. 3. 81 S	4. 6. 81 T
+214	♂	815 g	29. 3. 81 S	1. 5. 81 C 5. 7. 81 S
+215	♂	620 g	13. 4. 81 C	
+216	♂	520 g	1. 5. 81 C	
+217	♂	670 g	3. 5. 81 S	
+218	♀	725 g	9. 5. 81 S	
+219	♀	770 g	10. 6. 81 S	
+220	♂	625 g	12. 6. 81 C	
+221	♂	895 g	12. 6. 81 C	
222	♀	470 g	14. 6. 81 C	3. 7. 81 C 10. 7. 81 C
223	♂	740 g	14. 6. 81 C	
224	♀	220 g	13. 6. 81 C	
226	♂	880 g	15. 6. 81 S	26. 6. 81 C
227	♀	700 g	3. 7. 81 C	5. 7. 81 S
228	♂	450 g	3. 7. 81 C	

+ = radio-tagged animals; T = captured by traps in 86 trapping days; C = captured by chance encounters; S = captured after their encounters with radio-tagged animals.

Body weight variations during the course of the year

Captured animals were divided into 3 age groups according to their weight: those with body-weigths less than 500 g were considered to be juveniles (Parkes 1975). For individuals with body-weights between 500 and 600 g we were unable to determine whether they had only recently reached maturity or as mature individuals had underweight at the time. The animals in the third age group were considered to be adults, weighing more as 600 g (Parkes 1975; Kristoffersson 1971).

Based on longitudinal examination of animals that carried transmitters for the longest period of time, it was possible to trace individual variations in body-weight during the year

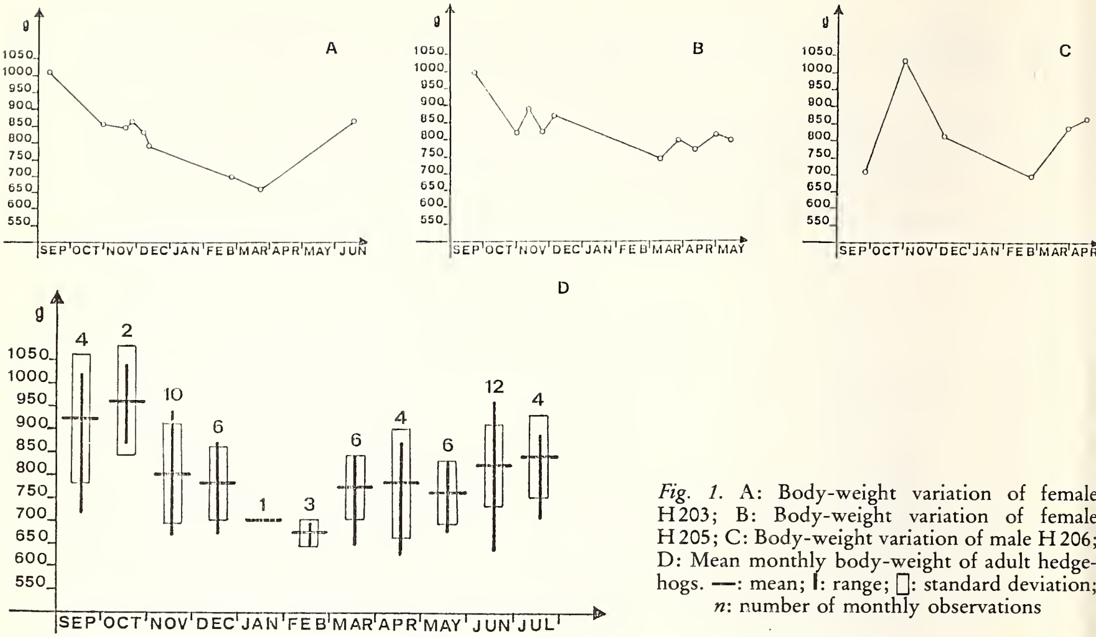

Fig. 1. A: Body-weight variation of female H203; B: Body-weight variation of female H205; C: Body-weight variation of male H206; D: Mean monthly body-weight of adult hedgehogs. —: mean; I: range; ▯: standard deviation; *n*: number of monthly observations

(Fig. 1). The weights of all the hedgehogs, both captured and those found dead are presented in Fig. 1D. A seasonal pattern in the variation of body-weight is evident with a peak in the autumn and the lowest point at the end of the winter.

Daily and seasonal activity

Using data on animal activity gathered by observation, we were able to reconstruct their movement patterns. Figure 2 shows two movements for one female. The black triangles represent the radio fixes which, besides indicating the route direction, also indicate the speed of movement, having been recorded at regular intervals (every 10 minutes).

Figure 3 presents the monthly and daily activity, calculated as a percentage of the sum M + T over the total length of observations (M + T + NO) at various hours of the night. This figure shows limited nocturnal inactivity from September to November, due to the fact that the hedgehogs rest for only a few minutes before resuming their search for food. In December, activity is restricted to the early hours of the night. During January and February the activity of hedgehogs becomes rare and unpredictable and observations were suspended. Activity resumed fully from March onwards, reaching a level peak at each hour of the night, while in May and June several daytime movements were noted, predominantly during the warmest hours of the day or in the early morning.

Environmental preferences

In 990 observations conducted during the year, the most frequented environments turned out to be the pastures and the enbankments of the canals that characterize the flat land of the study area (wet meadows), a reported 36.5 %. These are followed by the bush and the dry meadows (maquis) with very similar percentages (26.4 %; 25.2 %), while the agricultural land and the refuse sites appear to be rarely frequented (Fig. 4B). Figure 4A shows the percentage relative to the use of the five habitats during different months of the year. We

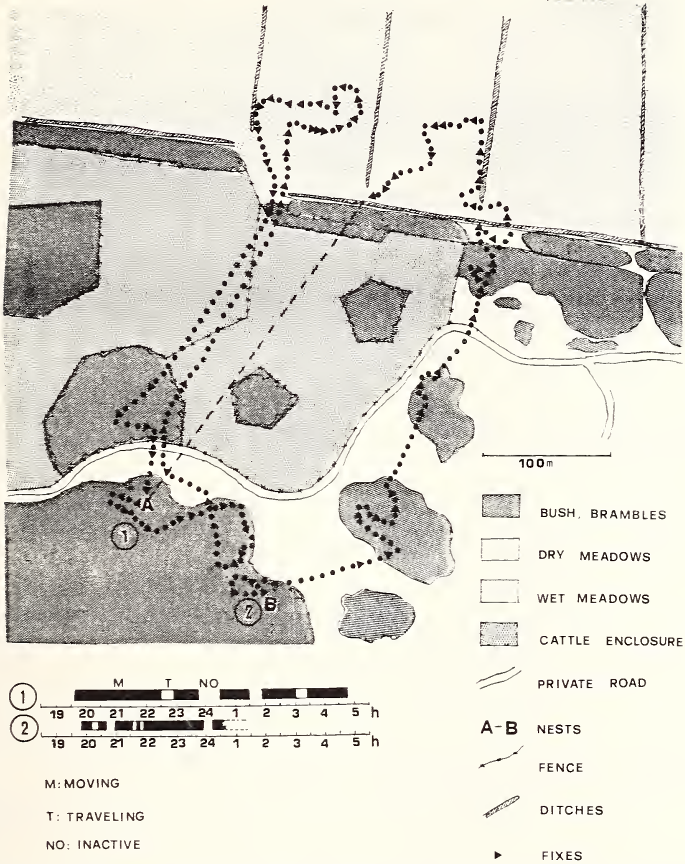

Fig. 2. Two nocturnal routes of female H203, and related activity pattern. The radio fixes (▲) were at 10 minutes intervals

can notice the inverse relationship between the use of the wet and dry meadows, the latter being particularly frequented in spring, while they are rarely used in the summer months. This may be due to the fact that the maquis area, while blooming in spring, by June is already dry and lacking in fresh vegetation, while the pasture, due to the presence of the ditches and its marshy origins remains rich and moist even in summer.

Interaction between the sexes

The first mating after the winter period was noted on March 21st. From this date until June 10th, the total number of observations of encounters between males and females was 18, and of these, 10 different individuals (5 males and 5 females) were involved. Every animal had several encounters with the same partner, or others of the opposite sex. There did not seem to be peak periods of reproductive activity, the number of observations of encounters between male and female remaining constant at 4/mths. Furthermore, every animal continued to frequent members of the opposite sex for long periods (up to 3 months). From September to October mating was never observed. The reproductive season extends to October, since at the end of this month and in the beginning of November, animals with a body-weight of less than 200 g, corresponding to an age of 3–4 weeks, were captured or found dead.

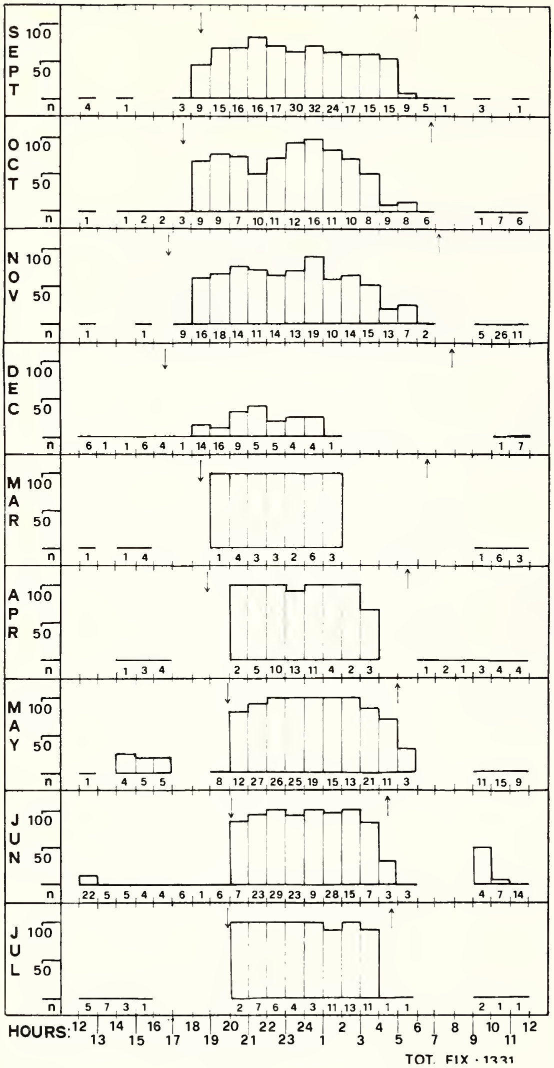

Fig. 3. Burano hedgehogs' seasonal and daily-night activity pattern. The activity was calculated as a percentage of the sum M + T over the total amount of observations (M + T + NO) for every one hour interval (↓: sunset; ↑: sunrise)

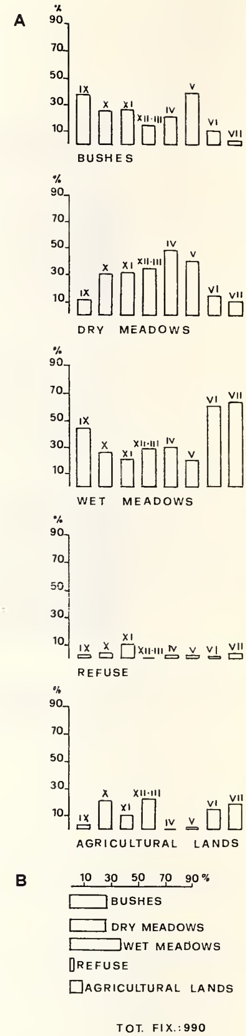

Fig. 4. Monthly (A) und total (B) percentages of the hedgehogs' locations in the five habitats of the study area (I–XII: months)

Construction and use of the nests

Nests of hedgehogs are spherical in shape and are always built by rolling within the available material from around the site (Morris 1973; Moors 1979).

On five occasions hedgehogs were seen sleeping rolled up within a thicket, they had not built a nest. 120 nest spots were sighted; of these, 34 (28. 3 %) were located within the bushes of the sand dunes, 30 (25.0 %) were under brambles, 24 (21.7 %) were in tall grass, usually on the enbankments of ditches, 7 (5.8 %) were constructed with dry leaves under thickets of *Quercus pubescens*, 7 (5.8 %) at the base of the reed clumps *(Juncus)*, 5 (4.2 %)

Table 3

Nests' use

Hedgehog No.	203	204	205	206	210	213	214	215	216	217	218	219	220	221
Located nests No.	12	9	11	10	1	10	9	16	11	10	5	4	4	8
More than once reoccupied nests No.	11	6	8	9	1	5	3	7	2	8	4	4	2	2
Later than one day reoccupied nests No.	5	4	4	7	–	4	2	2	2	6	3	4	2	1
Maximum No. days between successive reoccupations	5	47	169	127	–	12	29	6	7	12	16	8	4	8
Maximum No. days of use of the same nest	12	20	13	[16]	[26]	7	4	6	2	10	7	6	3	5
Maximum No. days of continuous use of the same nest	12	20	13	[16]	[23]	3	2	3	–	8	7	3	2	4
Mean distance between consecutively used nests (range)	140 m (375––50)	133 m (225––75)	270 m (950––50)	535 m (950––50)	– – –	1351 m (4300––150)	923 m (2360––100)	675 m (1750––50)	437 m (750––125)	341 m (700––50)	386 m (590––250)	292 m (600––100)	233 m (350––125)	251 m (550––100)

[ ] = hibernation nests

under pine needles, 4 (3.3 %) under ferns, 4 (3.3 %) among cane. Nests situated in grass were found in summer above all, while of the seven nests used by hedgehogs during hibernation, 6 were in the brambles and under dry leaves, and 1 was among the cane.

Table 3 summarizes observations on the number and use of nests for every hedgehog. The distance between those used consecutively is measured in a straight line. Each hedgehog used more than one nest, some were used for a few days and then abandoned, while others are re-inhabited after a period of time, varying from 1 to as many as 169 days. Of 120 nests located, 72 (60 %) were used more than once, and of these 46 (64 %) were reinhabited after an interval of a least one day.

The females used the same nest consecutively for significantly longer periods than the males ($t = 2.76$; $0.01 < P < 0.001$). This especially happened during the reproductive season and can be explained by the birth and rearing of the young.

Correlated with an increase in general activity and with the increase in the number of displacements in the spring, the nests, in this period, are changed more frequently, and the time lapse between the consecutive use of the nests is greater.

Whilst in the warm period the hedgehogs tend to build mostly hide-outs in the vegetation, with the lowered temperatures the nests are increasingly important as a defence against the cold, and as a result are built with far greater care. They are usually located in drier surroundings slightly further down in the hollows, and the building materials are carefully selected and transported, and then compacted to form thicker walls.

The distribution of nests within the home range seems to be closely linked to that of vegetation coverage. The hedgehogs that frequented the open spaces usually had all their nests concentrated at the limits of the tallest vegetation; at the time when the maquis was most frequented, nests were distributed over the entire area.

Home ranges

The home ranges pertaining to the period of time in which every animal had carried a radio transmitter, has been calculated using the convex polygon system (Mohr 1947) (Table 4). Those areas which were not habitually frequented by the hedgehogs (e.g. the lake) have been excluded from the area calculation (Ables 1969). Table 5 indicates the percentage of overlap of the home ranges, taking into consideration those animals of which there is at least a minimum overlap of observation time; the female H 203 was included because the site

Table 4

Radio-tagged hedgehogs' data

Hedgehog No.	First radio location	Transmission failures	Last radio location	Total days	Total observ. days	Total fixes	Home range (ha)
203	16. 9. 80		30. 4. 81	227	88	212	25.5
204	21. 9. 80		13. 3. 81	174	64	134	11.2
205	25. 9. 80	12. 4. 81/14. 4. 81	1. 6. 81	248	98	152	42.5
206	25. 9. 80		21. 4. 81	209	76	159	67.0
210	5. 11. 80		23. 2. 81	111	32	50	5.5
213	22. 3. 81	22. 5. 81/4. 6. 81	1. 7. 81	90	53	75	90.5
214	30. 3. 81	31. 3. 81/1. 5. 81	10. 6. 81	43	32	51	102.5
215	14. 4. 81		24. 6. 81	72	45	97	95.0
216	1. 5. 81		10. 6. 81	41	30	44	30.0
217	3. 5. 81		13. 7. 81	72	53	124	70.0
218	10. 5. 81		24. 6. 81	46	31	66	56.2
219	10. 6. 81		10. 7. 81	31	23	51	10.0
220	12. 6. 81		5. 7. 81	24	17	23	13.5
221	12. 6. 81		13. 7. 81	32	24	58	40.2

Table 5

Overlap estimates between hedgehogs' home ranges

The table shows the percentage of one home range (x) overlapping with any other home range (y)

y \ x	203	204	205	206	210	213	214	215	216	217	218	219	220	221	Home range size (ha)
203	–	–	–	3.9	–	32.2	47.5	30.2	–	87.8	32.9	–	28.6	22.0	25.5
204	–	–	–	–	4.5	++	++	++	++	++	++	++	++	++	11.2
205	–	–	–	3.3	–	93.6	89.6	76.9	52.9	24.5	8.9	++	++	++	42.5
206	1.5	–	2.1	–	–	20.6	++	77.0	++	++	++	++	++	++	67.0
210	–	9.1	–	–	–	++	++	++	++	++	++	++	++	++	5.5
213	9.0	++	43.8	15.2	++	–	59.2	59.8	25.0	41.0	26.6	–	5.0	8.0	90.8
214	11.8	++	3.7	++	++	52.4	–	75.9	15.9	42.5	53.3	1.6	++	++	102.5
215	8.1	++	34.4	54.3	++	57.2	81.9	–	7.5	46.7	57.5	2.3	2.7	5.3	95.0
216	++	++	75.0	++	++	75.7	54.3	23.7	–	–	–	++	++	++	30.0
217	32.0	++	14.9	++	++	53.1	62.3	63.4	–	–	55.1	–	12.7	11.9	70.0
218	14.9	++	6.8	++	++	42.9	96.6	97.2	–	68.7	–	–	6.8	9.8	56.2
219	++	++	++	++	++	–	16.0	22.0	++	–	–	–	–	–	10.0
220	54.1	++	++	++	++	33.3	++	–	++	65.9	28.1	–	–	69.6	13.5
221	13.9	++	++	++	++	18.2	++	12.4	++	20.6	13.7	–	23.4	–	40.2

– = absence of overlap; ++ = observed at different times.

where she was captured on 3. 6. 81, supports the hypothesis that she kept her home range constant. The overlap of home ranges is consistent. In fact, we were often able to spot the simultaneous presence of more than one animal within a limited area, without manifesting any territorial defence reactions. However, it seems the animals tend to maintain a personal distance because direct encounters, apart form those concerned with reproductive purposes, are completely non-existent. The distance between two animals of the same sex was never less than 20 m.

The size of the areas frequented by the hedgehogs varied greatly. In order to ascertain whether this variability was significantly dependent upon the number of surveys carried out on every animal, we calculated the correlation coefficient between the sizes of home ranges and the total number of days the animals carried the radio-transmitter ($r = -0.11$), the total number of observation days ($r = +0.10$) and the number of fixes for every hedgehog ($r = +0.05$), respectively. The results of this statistical test do not reveal a significant linear correlation between the areas and the three variables under examination, therefore, its importance can be eliminated from the final demarcation of the home ranges.

Hence, the analysis of the home range's use was deepened by the grid-cell method (Voigt and Tinline 1979), which reveals the actual use of the range in relation to

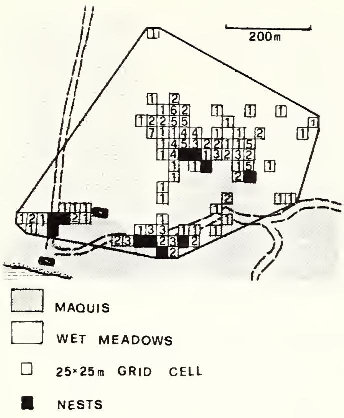

Fig. 5. Female H203 showed a preference for the pasture, but she continued to concentrate her nest sites in areas offering denser vegetation cover

the frequency of fixes in each grid's square representing the study area. The number inside each cell refers to the number of actual sightings in the corresponding area.

A separate use of different areas of their home range which corresponds to the different environments present in the study area by the animals was immediately evident. The fixes in the pasture, agricultural land or in the vicinity of the refuse sites (open spaces) – areas which were visited by all the animals – always appear to be rather concentrated, and the re-use of the same cell often occurs in these areas. The fixes relating to the maquis area, instead, are generally much more dispersed and the occupied cells often turn out to be defined by a single observation. No animal frequented this zone only, although 8 animals did show a preference for open spaces; yet, they continued to concentrate their nests in areas offering the most vegetation coverage within their home range (Fig. 5). Six animals, then, frequented both the open spaces and the typical maquis environment, and their home range showed zones of concentrated fixes and zones of dispersed fixes (Figs. 6 and 7).

Since the observations were fairly evenly distributed throughout the study period, the

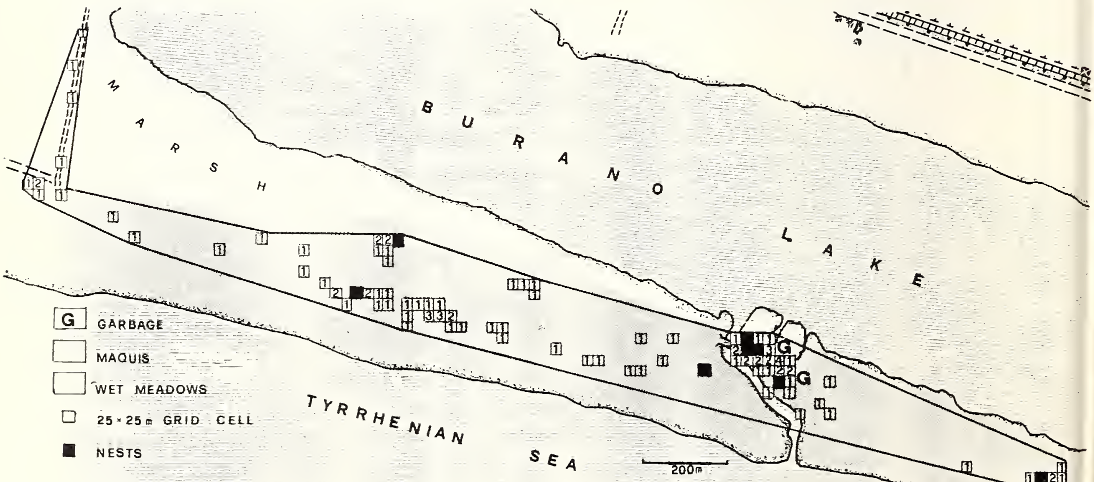

Fig. 6. The home range of female H205 shows a zone (on the right) in which the frequented cells are extremely concentrated and where numerous nests are sited, and a much larger zone (on the left) where the fixes are less constant and spread farther apart. These zones are located near a refuse site and a typical maquis environment, respectively

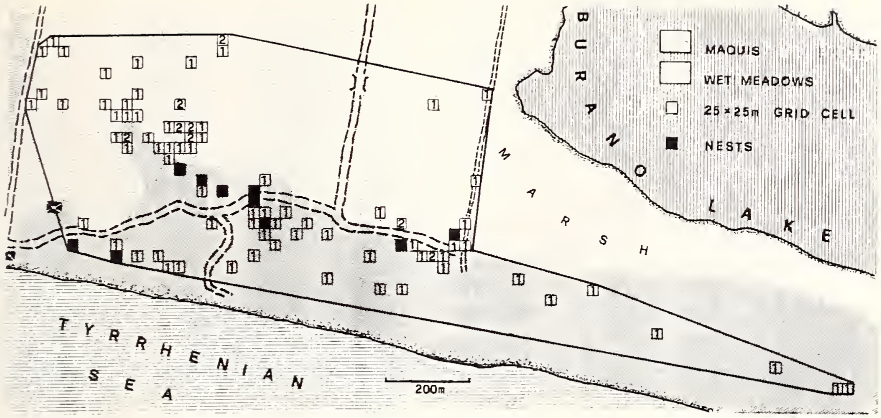

Fig. 7. Male H217's home range shows an area of dispersed fixes in the maquis and a more concentrated area of fixes in the pasture

configuration of occupied cells is indicative of the pattern in which the displacements occur. The concentrated configuration, with frequent re-use of the same cell, stems from the animal's constant use in time of a limited zone, while a dispersed configuration results from sporadic excursions covering greater distances.

In order to verify whether the use of different environments was linked to seasonal changes, the year was divided into three periods on the basis of the trends observed during field work. This division does not include the observation period for every hedgehog, which always covered, at most, two of these periods; on the grid-cell we have differentiated those occupied cells, representing each period with a different symbol.

The use of the various environments presents in the study area appears to be strictly linked to seasonal changes. In the first period, corresponding to the months from September to February, all five hedgehogs under observation frequented a restricted area which covered the pasture, the agricultural land, or the vicinity of the refuse sites, an area

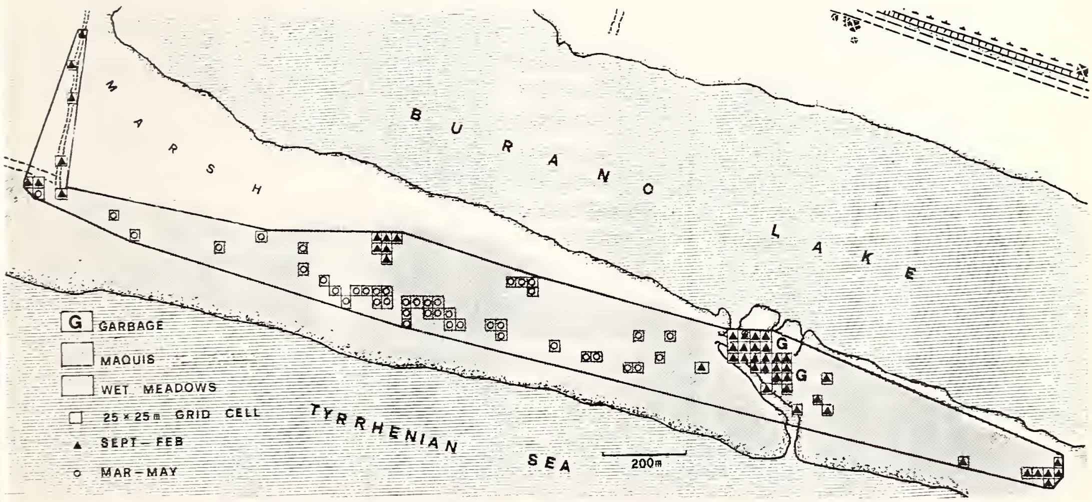

Fig. 8. From September '80 to February '81, female H205 frequented restricted areas in the vicinity of a refuse site. From March '81 to May '81 she frequented larger areas in the maquis

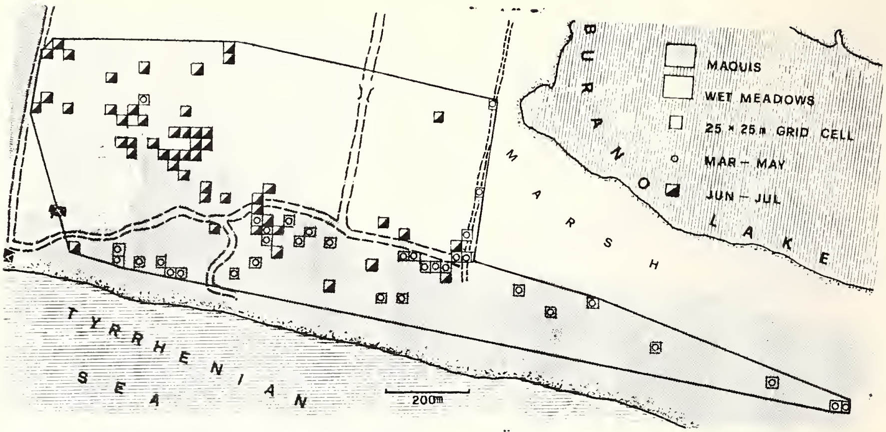

Fig. 9. From March '81 to May '81, male H217 frequented the maquis area, but abandoned it in favour of the pasture from June onwards

which was progressively reduced in the course of the autumn and winter months. In the second period, from March to May, nine animals were under observation. Six used larger areas in comparison to the first period, located almost entirely in the typical maquis environment. The acitvity area of another animal was displaced but still located in the pasture, where it traveled greater distances. In the third period, i.e. in June and July, when the open spaces of the maquis began to get much drier, the six animals studied in the second period gradually abandoned it in favour of the pasture and agricultural land, where another three animals were caught and radio-marked. Until the end of the study period, all the animals were always tracked or encountered in this environment. In contrast to the second period, the animals in the pasture and agricultural land frequented more restricted areas and showed a preference for a particularly humid zone, in which they were concentrated, attaining the highest population density value for the entire study. Figures 8 and 9 show the seasonal variations in the use of the range by the animals represented in Figures 6 and 7, studied in the first and second period and in the second and third period, respectively. The overlapping of the areas frequented during the different times of the year is minimal, since the maquis is only frequented regularly during the second period.

The nests, or concentration of nests, constitute an important center of activity for all the animals, but expecially for the females who appear to be particularly tied to them. For this reason the observations of the range expansion in the second period, in the case of the males, even if the actual distances covered in one night may be the same for both sexes (up to 3–4 km), appears to be pronounced.

The difference between the size of the home ranges of both sexes did not prove to be significant ($t = 1.59$; $0.2 < P < 0.1$).

Discussion

Although a precise estimate of the number of population under observation do not emerge in this study, it is evident that the population density of the hedgehogs in the study area is far lower than that found in New Zealand by Campbell (1973), who estimated a population density of 8/ha, or by Parkes (1975), who calculated a density of 2/ha. The reason for this difference is probably linked to the availability and distribution of food resource in the area under investigation.

The seasonal pattern in the variation of the animals' body-weight conforms to field observations in New Zealand (Parkes 1975) and it is supported by both the availability of food in the study area, and by the rhythms of fat distrubution (Kristoffersson and Suomalainen 1964).

The hibernation period of hedgehogs within the study area seems to be considerably less than that encountered in other European studies (Walhovd 1975, 1978, 1979; Burton 1969), but it coincides with the studies conducted in New Zealand (Parkes 1975). These results appear to be consistent with the climatic conditions of those countries under consideration and they support the hypothesis that the external temperature is one of the most important factors that determines the length of the hibernation period (Kristoffersson and Soivio 1964a, 1964b). Just as the reproductive season depends on climatic conditions, it is of longer duration in places where the hibernation period is shorter, as in the case of the Mediterranean maquis of Burano.

Our observations showed that nests are preferably located within the bushes of the sand dunes, under brambles and in tall grass. These results appear to be in accordance with those reported by Morris (1973) for the higher percentages. However, there are differences in the values related to nests located on grass tussocks which, in Morris' research, are low. This contrast may be explained by the fact that Morris' research refers solely to winter nests. Even if Morris (1973) claims that a lenghty survival of nests is due to their internal structure, we add that they can be re-adapted by each new occupancy.

Our results are in accordance with the majority of observations on the definition and overlapping of the animals' home ranges and on the complete absence of territorial limits and associated behaviour (Campbell 1973; Parkes 1975; Reeve 1979). Movements of the hedgehogs in the study area followed a peculiar pattern: the maquis is frequented particularly in spring, when the animals covered greater distances, while the pasture are used in the summer and autumn months. Furthermore, we can note that the percentage of the maximum use of the refuse sites increases in November, when presumably other resources become scarces. Usage of the environment, thus movements, appears to be closely linked to food availability, being the search for food the main activity of the animals. In the mating season, movements are also motivated by the search for a mate, but its influence on the pattern of displacements cannot be defined on the basis of the collected data.

Until now published literature on the home range of the hedgehog has dealt mostly with its dimensions (Campbell 1973; Parkes 1975; Berthoud 1978; Reeve 1979). While all authors note an increase in distances travelled by the hedgehogs, which starts at the beginning of the mating season, an observation supported by our own results, our data relating to the size of the home range appears, instead, to be extremely different from previous estimates: Campbell (1973) calculated individual values ranging from 0.8 to 4.6 ha; Parkes (1975) between 0.4 and 6.5 ha, while Reeve (1979) calculated average areas of 20.7 ha for males and 7.9 ha for females, and Berthoud (1978) calculated areas ranging between 1.8 and 2.5 ha. In our case, the calculated areas varied between 5.5 ha, in the period preceding the onset of hibernation, and 102.5 ha, in a period of maximum activity. Therefore, the areas frequented by the hedgehogs studied in the Burano area are often far larger than the average, in fact, even larger than the maximum values previously reported for this species.

Examining the results obtained from the population density analysis, environmental preferences and the animals' home range dynamic, the hypothesis emerges that the Mediterranean maquis does not provide enough resources to support a high population density of hedgehogs, to the extent that these are constrained to travel considerable distances in order to meet their food and reproductive needs.

Zusammenfassung

Ortsveränderungen und Aktivitätsmuster von Igeln (Erinaceus europaeus) in mediterranen Küstenregionen

Vierzehn Igel wurden mit radiotelemetrischen Methoden in einem Küstengebiet der Mittelmeermacchie in Mittelitalien untersucht. Die Aktivitätsperioden hatten ein konstantes Muster bis zur

ersten Dezemberhälfte, dann nahmen sie ab. Im Januar und Februar traten kaum Aktivitäten auf, erst im März setzten sie wieder ein. Die Paarungszeit der Igel dauerte von Mitte März bis in die zweite Oktoberhälfte. 990 Beobachtungen zufolge waren die am meisten besuchten Biotope feuchte Wiesen (36,5 %), Buschregionen der Macchie (26,4 %) und trockene Wiesen der Macchie (25,2 %).

Von 120 georteten Nestern lagen 28 % unter Büschen der Macchie, 25 % unter Brombeerbüschen und 22 % im hohen Gras. 60 % aller Nester wurden mehr als einmal benutzt. Aus den Untersuchungen ergibt sich, daß die Igelweibchen dasselbe Nest ununterbrochen über längere Zeiträume benutzten als die Igelmännchen. Die Größe der Aktionsräume ist sehr unterschiedlich und reicht von 5,5 bis zu 102,5 ha. Ferner wurde festgestellt, daß sich die Aktionsräume weitläufig überlagerten und jeder Aktionsraum verschiedenen Habitate einschloß. Die Macchie wurde insbesondere im Frühling aufgesucht, als die Tiere längere Strecken zurücklegten, während die feuchten Wiesen am meisten im Sommer und Herbst besucht wurden. Dieses Modell der Habitatnutzung scheint durch das Nahrungsangebot bedingt.

References

Ables, E. D. (1969): Home ranges studies of red foxes *(Vulpes vulpes)*. J. Mammalogy **50**, 108–120.

Berthoud, G. (1978): Note preliminaire sur les deplacements du herisson europeen (*Erinaceus europaeus* L.). Terre vie 32, 73–82.

Brockie, R. E. (1959): Observation on the food of the hedgehog (*Erinaceus europaeus* L.) in the New Zealand. N. Z. J. Sci. 2, 121–136.

Burton, M. (1969): The hedgehog. London: André Deutsch.

Campbell, P. A. (1973): The feeding behaviour of the hedgehog (*Erinaceus europaeus* L.) in pasture land in New Zealand. Proc. N. Z. Ecol. Soc. 20, 35–40.

Herter, K. (1938): Die Biologie der Europäischen Igel. Mongraphien der Wildsäugetiere V. Leipzig.

Kristiansson, H.; Erlinge, S. (1977): Movements and home range of the hedgehog. Fauna och Flora 72, 149–155.

Kristoffersson, R. (1971): A note on the age distribution of hedgehog in Finland. Ann. Zool. Fenn. **8**, 554–557.

Kristoffersson, R.; Soivio, A. (1964a). Hibernation of the hedgehog (*Erinaceus europaeus* L.). The periodicity of hibernation of indisturbed animals during the winter in a constant ambient temperature. Ann. Acad. Sci. Fenn. A IV 80, 1–22.

– (1964b): Studies on the periodicity of hibernation in the hedgehog *(Erinaceus europaeus* L.). A comparison of induced hypothermia in constant ambient temperature of 4.5 and 10 °C. Ann. Zool. Fenn. **1**, 370–372.

Kristoffersson, R.; Suomalainen, P. (1964). Studies on the physiology of the hibernating hedgehog. Changes of body weight on hibernating and non-hibernating animals. Ann. Acad. Sci. Fenn. A IV **76**, 1–11.

Mohr, C. O. (1974): Table of equivalent populations of North American small mammals. Am. Midl. Nat. **37**, 223–249.

Moors, P. J. (1979): Observations on the nesting habits of the european hedgehog in the Manawatu sand country, New Zealand. N. Z. J. Zool. **6**, 489–492.

Morris, P. (1973): Winter nests of the hedgehog *(Erinaceus europaeus)*. Oecologia **11**, 299–313.

Parkes, J. (1975): Some aspects of the biology of the hedgehog *(Erinaceus europaeus* L.) in the Manawatu, New Zealand. N. Z. J. Zool. 2, 463–472.

Reeve, N. J. (1979): A simple and cheap radio-tracking system for use on hedgehogs. In: A Handbook on Biotelemetry and Radio Tracking. Ed. by Amlaner and Macdonald. Oxford: Pergamon Press. 169–173.

Voigt, D. R.; Tinline, R. R. (1979): Strategies for analyzing radio tracking data. In: A Handbook on Biotelemetry and Radio Tracking. Ed. by Amlaner and Macdonald. Oxford: Pergamon Press. 387–404.

Walhovd, H. (1975): Winter activity of Danish hedgehogs in 1973/74. with information on the size of the animals observed and location recordings. Nat. Jutl. 18, 53–61.

Walhovd, H. (1978): The overwintering pattern of Danish hedgehogs in outdoor confinement, during three successive winters. Nat. Jutl. **20**, 273–284.

Walhovd, H. (1979): Partial arousals from hibernation in hedgehogs in outdoor hibernacula. Oecologia (Berlin) 40, 141–153.

Yalden, D. W. (1976): The food of the hedgehog in England. Acta Theriol. 21, 401–424.

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