

HOME RANGE AND HABITAT SELECTION OF THE SARDINIAN WILDCAT (*Felis silvestris libyca*) IN AN AREA OF SOUTHERN SARDINIA

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Abstract. Four wildcat adult females and four adult males (*Felis silvestris libyca*, Forster 1780) were monitored with the radio-telemetric technique in several time periods from July 1994 to March 2002, in the faunal park of Monte Arcosu (southwestern Sardinia). 4,356 radio localisations were gathered. The different home-range configurations were calculated with two different methods: the minimum convex polygon method (MCP) and the kernel method. Selection was measured with the Ivlev preference index. The home ranges of the cats calculated with the 100% MCP varied between 75.5 and 469.5 ha. The home ranges calculated with the kernel method varied between 810.0 ha and 133.7 ha. In the summer the wildcats move in a smaller area than in the other seasons. The overlap of the home ranges of a few animals in the different seasons was between 24.5% and 82.5%. High maquis is the most represented vegetational typology in the home ranges of the wildcats followed by low maquis for the females and by the riparial vegetation for the males; both are used in relation to their local availability. Both the selectivity index and the preference index show that only a few wildcats distinguish among the different habitats.

Introduction

Many canids tend to follow their prey, while felids approach it stealthily (Eisenberg 1986, Kruuk 1986). In general the prey are caught more effectively in a solitary way, by single individuals, than by groups. Consequently many felids defend a single territory by joining their partners only for a short period during the mating season (Kleiman-Eisenberg 1973, Seidensticker et al. 1973, Corbett 1979, Stahl et al. 1988). The territories may be partially superimposed, in the event of a mutual alliance (Leyhausen 1965; Hornocker 1969). The factor limiting the reproductive success of felid males is the availability of females, while the availability of food limits the reproductive success of females. Consequently, the

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males tend to settle in large territories covering the territory of many females thus preventing access to other males, while the females tend to defend the food resource (Eisenberg 1986). The cost benefit ratio of this system determines the use of space by the felids (Eisenberg 1986).

Wildcats use activity areas (home range) which include a series of paths linking the hunting areas, several places of refuge and breeding dens (Kitchener, 1991). The home ranges vary in size but can be very large: 184-1090 ha in France (Stahl, 1986), 174-176 ha monthly areas in Scotland (Colbett, 1979). Males generally have larger home ranges than females (Stahl, 1986), the males move on larger surfaces, especially during the breeding season (Kitchener, 1991). Within the home range, the use of space is not always uniform (Genovesi and Boitani, 1993) and often there are areas of more frequent occurrence in which territorial defense is concentrated. The model of social organization of the wild cat is based on exclusive territories between adults of the same sex and the overlapping territories of males and females (Stahl, 1986). The wild cat is bound to forest habitats, particularly hardwoods. The distribution or dispersion of the species appear to be related to forest cover (Jenkins, 1962; Parent, 1975). The forests generally occupy more than 50% of the individual areas of activity but it was detected a significant variability in the use of habitat (Stahl, 1986) in relation to different environmental conditions and prey availability.

There are few works on the Sardinian wild cat *Felis silvestris libyca*, Forster 1780 (Ragni, 1981; Murgia *et al.*, 2005; Murgia *et al.*, 2007), for some authors attributed to the same species as the European wildcat *Felis silvestris* (Randi and Ragni 1991, Ragni and Possenti, 1994, 1996). It is a very elusive small carnivore (males about 2.6 kg) that lives in Sardinia and Corsica (Murgia *et al.*, 2005). Although it is a common mammals on these islands, its biology is virtually unknown. The aim of this work is to improve knowledge on some aspects of the Sardinian wild cat behavior, especially on home range and habitat selection.

1. Study area

The study area is located in the WWF Park of Monte Arcosu (N 39°09'44", E 08°52'53") in south western Sardinia (fig. 1). The landscape is rough and tormented, the morphology clearly mountainous. Granitic and schistose formations dominate with steep slopes and narrow, confined, winding valleys. There are few level or sub-level areas covering not more than 0.5÷1% of the total. The watercourses are torrential and remain dry for long periods. The mean annual rainfall is 487 mm. The mean temperature is 15/17°C with minimum values of between 6 and 9°C in January and a maximum value of about 24°C in July. The flora of the reserve has been described by Bacchetta (1997). It is typical Mediterranean vegetation, divided into five typologies degrading towards garrigue,

represented by low-shrubby formations (*Helicrisum italicum*, *Genista corsica*, *Thymus capitatus*). The vegetable formation with the highest degree of cover is the high maquis with a dominance of strawberry tree, mock privet, lentisk, and holm oak. The fifth typology is made up of forest maquis in which the arboreal layer is monospecific (*Quercus ilex*), but not very tall (4-10 m), with well represented shrubby and lianas layers. The Monte Arcosu park plays a fundamental role also on account of the presence of numerous endemic forms of the island.



Fig. 1 – Sardinian wildcat and study area

2. Materials and methods

The wild cats, were captured by cassette traps (40x30x120 cm) using living quails as bait. Identified using the method suggested by Toshi (1965), and Ragni Possenti (1996), and were fitted with radio-collars of the weight of about 55g (TXP 2, Televilt, Störa, Sweden), after anaesthesia with a intramuscular injection of ketamine (1.5cc/kg). The wild cats were monitored in different periods from July 1994 to March 2002. The position of each animal was recorded, using triangulation, every 20 minutes by means of a radio receiver (Custom electronics). Due to the standard measurement error (Springer 1979), the map relating to the study area at a 1:10000 scale was subdivided in 1x1 cm cells. The different configurations of the home range were calculated with two different methods not affected by the intradependence of the recordings:

a) the 100% Minimum Convex Polygon (MCP) method (Dalke, 1942; Mohr, 1947), which yields results comparable to many other research studies, was used to calculate both the annual and seasonal home range. The 95% MCP was

used to exclude animal position recordings due to occasional excursions. The core areas were estimated considering 50% of the MCP.

b) the kernel method on the other hand estimates a density from the selected points (fix). The output consists of isopleths of constant estimated density enclosing a specified percentage of points (Worton, 1989). This method was used as the preceding one to calculate 100%, 95%, and 50% of the available recordings.

The availability of habitats was measured within home range (MPC 100%) of each cat (third order selection) and compared with its use (number of fixes found in that habitat). Selection was measured with the preference index method of Ivlev (E) (1961), represented by the following formula:

$$E = (U_i - D_i) / (U_i + D_i)$$

where U_i is the proportion of use of the i^{th} habitat and D_i the availability of that habitat. The value of E varies between -1 (completely avoided habitat) and $+1$ (strongly preferred habitat); the values near 0 show that there is no preference. The types of habitats included in the analyses are garrigue, low maquis, high maquis, forest maquis and riparian vegetation, identified using the vegetation map.

3. Results

Four adult females and four adult male were captured (tab.1). On a total 4,356 radio-localisations, the mean (\pm SE) home range for the male cats (290.6 ± 98.6 ha) was greater than the mean value for the females (205.6 ± 33.0 ha), calculated with the 100% MCP method. The values recorded for the single cats varied greatly (tab.2). The home ranges of two males (M2 and M3) were comparable to those of the females. Even excluding the excursions (95% MCP), the mean home range for the males (236.1 ± 93.3 ha) was larger than the mean home range for the females (162.3 ± 29.1 ha). Considering the core areas, the mean values were 56.8 ± 24.4 ha for the males and 56.8 ± 10.5 ha for the females. The mean home range value for the males was greater than the corresponding value for the females by 29.2% with the 100% MCP, and by 31.3% not considering the excursions, but only by 5.0% considering the core areas. The kernel method yields 100% home range values ranging from 810.0 ha (M1) to 133.7 ha (M2); these are all greater than those calculated with the 100% MCP (except F4). The 95% calculated values on the other hand are all lower than those calculated with the 95% MCP, except for cat M1.

Considering the cats monitored contemporaneously, only F2 and F3 among the females had a partial overlap of their home ranges (100% MCP and 95% MCP). Moreover their core areas were adjacent but not superimposed. M1 moves both on F2's and on F3's areas of use, including their core areas. Among the males M3 and M4 present a partial overlap (100% MCP and 95% MCP) but this does not refer to their core areas.

The sizes of the home ranges vary considerably with the seasons, in particular of those of the males (tab.3).

Tab. 1 - Descriptive parameters of radiotagget wildcats.

	Females				Males			
	F1	F2	F3	F4	M1	M2	M3	M4
Weight (kg)	2.1	2.1	1.8	1.8	2.8	2.5	2.3	2.7
Tracking period	Jul/94 Jun/95	Jul/94 Jun/95	Aug/95 Dec/95	Oct/01 Mar/02	Aug/94 Dec/94 May/95 Aug/95	Nov/97 Aug/98	Sep/00 Jun/01	Oct/00 Jul/01
age	adult	adult	adult	adult	adult	adult	adult	adult

Tab. 2 – Sizes of the home ranges in ha, calculated with the MCP and Kernel methods.

	N. fixes	MPC			Kernel		
		100%	95%	50%	100%	95%	50%
1.	768	124,0	84,0	28,5	294,7	64,6	13,0
F2	552	265,5	204,5	59,0	625,8	166,8	10,2
F3	460	252,5	208,5	79,5	549,1	115,9	17,3
F4	474	180,5	152,2	60,0	142,9	71,1	1,3
M1	228	469,5	337,5	114,0	810,0	337,0	19,4
M2	606	75,5	42,5	4,0	133,7	29,7	7,0
M3	646	171,5	120,5	37,0	239,1	95,6	7,1
M4	622	446,0	444,0	84,0	627,5	261,0	34,7

In summer the wild cats move in a smaller area than in the other seasons and in no case were the home ranges of one single season larger than 78% of the total. Generally the seasonal overlap of the areas used by F2 and M1 was less than the overlap calculated for the entire year. Even in the case of F3 and M1, the overlap was less if we consider the only season in which the two cats were monitored contemporaneously. In fact, the overlap percentage was 16% only in the summer of 1995. An overlap of the home range of F1 and F2 was never observed in any of the four seasons in which both cats were monitored. In the case of the males M3 and M4, there was no overlap in autumn, while a considerable overlap appeared in winter and a smaller one in spring (tab.4).

Tab. 3 – Size of the seasonal home ranges (ha) and average percentage on the total home

	2. (94-95)	F2 (94-95)	F3 (95)	F4 (01-02)	M1 (94-95)	M2 (97-98)	M3 (00-01)	M4 (00-01)
Summer	43,5	98,0	182,0		118	28,0		
Autumn	90,0	112,0	194,5	61,5	288,5	35,0	54,0	203,0
Winter	88,5	142,0		140,5		45,2	117,0	194,0
Spring	61,5	149,0			54	33,5	86,0	320,5
% mean	57,2	47,2	74,6	101	26,3	49,6	49,9	53,6
±es	±9,0	±4,6	±1,8	±39,5	±12,4	±23,5	±9,2	±7,9

Tab. 4 – Percent overlap of the seasonal home ranges of the cats with the 95% MCP

	Summer 1994	Autumn 1994	Spring 1995	Summer 1995	Winter 2000/2001
F2	11,1	24,7	8,9		
M1	32,0	18,6	33,3		
F3				6,7	
M1				15,4	
M3					76,0
M4					42,0

The kernel method shows that in all seasons, the cats preferably use two or three areas inside their total home range, linked together by a few tracks. Moreover the resting locations (50% inactive fixes) appear small (less than a hectare) and scattered in the normally used area. There are not significant difference in land use between male and females ($U=12$; $p\leq 0.05$; Mann-Whitney U-Test). Habitat use in each season is independent of its availability (Autumn: $\chi^2=687.7$, $gl=15$, $p\leq 0.01$; Winter: $\chi^2=821.6$, $gl=15$, $p\leq 0.01$; Spring: $\chi^2=1339.6$, $gl=20$, $p\leq 0.01$; Summer: $\chi^2=232.3$, $gl=12$, $p\leq 0.01$). Sardinian cats are more active during darkness hours (Murgia *et al.*, 2007) and, in every season, land use is significantly different during day or night (Autumn: $\chi^2=293.2$, $gl=28$, $p\leq 0.01$; Winter: $\chi^2=460.9$, $gl=28$, $p\leq 0.01$; Spring: $\chi^2=472.1$, $gl=28$, $p\leq 0.01$; Summer: $\chi^2=332.1$, $gl=28$, $p\leq 0.01$). Nevertheless high maquis is the most widely represented vegetable typology in the home range of the Sardinian cats, followed by low maquis for the females and riparian vegetation for the males. The home range of F3 includes only 3 environments (excluding garrigue and riparian vegetation), that of F4 only 4 environments (excluding forest maquis), while the home ranges of the other cats includes 5

environments, though in different proportions. No cat showed a marked selective behaviour (Ivlev's index) towards high maquis and only M3 negatively selected low maquis. Riparian vegetation was selected negatively by all females (except F4) and by the male M1, which presents a positive selection for forest maquis, while it was positively selected by the other males. F2 and to a lesser extent M1 showed that they preferred garrigue (fig.2).

3. Discussions

The only detailed study on home range of wild cats in Europe (Stahl *et al.*, 1988) has shown that the seasonal home ranges of 17 adult males were larger (573 ± 259 ha) and more variable in size than those of the 7 females (158 ± 51 ha). The home ranges of the males overlapped with those of 3-5 females, while the overlap was poor among individuals of the same sex. Our results partly disagree with this picture. Only two of the captured male cats showed a home range double in size the mean home range of the females (using both the 100% and the 95% MCP), but the other two males showed values even lower than those of some of the females. The male M1, which frequented the same valleys as the captured females, overlaps its home range very extensively with the home ranges of two of them. The overlap between areas of individual use is never so marked, especially if we consider the core areas, suggesting the existence of the male-female couple as the basic social unit. Moreover we also observed a partial overlap also between areas of use of two males which were monitored contemporaneously. The comparison between the extension of the area of overlap of the individual home ranges shows that in none of the cases did the overlap seem to be the result of excursions outside the normally used area.

Nevertheless, none of the couples of animals showed concordance in the use of space. This agrees with the hunting strategy of these felids, in which the presence of a conspecific near the hunting animal could have a negative effect on its predatory efficiency. It can be expected therefore that in the areas of overlap the animals tend to avoid each other except in the mating season. In the Sardinian wild cat this avoidance seems to be achieved through the use of different portions of the overlapping strip. In the European wild cat Corbett (1979) found that the seasonal sizes did not change, in spite of changes in the main prey population.

The seasonal sizes of the home range of Sardinian cats, compared to the total sizes, and the partial overlap between areas used by the same animal in all the seasons suggest a seasonal use of a reduced, partially different portion of the home range. It could be hypothesised that the difference between our data and those reported by Corbett is due to the characteristics of the vegetation, which offers cover to a hunting cat in every environment. In such a situation, seasonal variations in the availability of food may affect the size of the home ranges. The small home

range of M2 could be justified by the fact that this cat frequents a maquis area bordering on an open field, with a high density of wild rabbits, and therefore needs smaller movements to find its prey. Even the sites suited to resting, when limited, may determine the size of the home range with their spatial distribution, especially in the case of the females, which need adequate shelters to raise their offspring. Like other felines (Eisenberg, 1986; Leyhausen 1965), the home range of Sardinian wild cat are used uniformly and are made up of a variable number of more or less regularly visited areas, linked together by an elaborate network of tracks. The choice of the habitats is likely to be affected by the temporal dispersion of the resources and of their abundance and concentration within the different sectors of each environment.

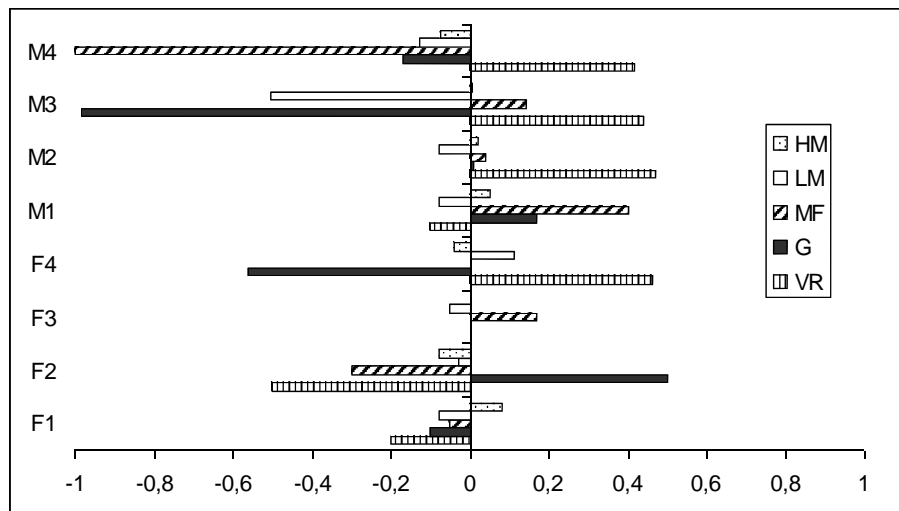


Fig.2 – Ivlev preference index (HM=high maquis; LM=low maquis; MF=forest maquis; G=garrigue; VR=riparian vegetation)

The study area is characterised by a rather uniform vegetation and by a relatively scarce variety of habitats. In this environmental typology we may expect a relatively homogeneous spatial dispersion of the resources and therefore not a very marked preference by the wild cats. The results of the selection indices in fact seem to suggest a poor selectivity. All home ranges include a relatively similar area of high maquis. It can be hypothesised therefore that the high maquis is an important habitat for the cats and that each individual may need a more or less similar area of this habitat within its family area and that the lack of selection in the

use of high maquis is precisely related to its abundance in the home ranges. Nevertheless, a few individual variations in the selection of the other environments emerge.

The overall results, in particular the individual variations in the size of the home range, in the portion of home range used seasonally, in selecting the habitat, in the dispersion of the resting sites, in the size of the home ranges, and in the distance covered during moves seems to be a complex strategy of use of the environment, which probably allows the cats to better exploit the variety of resources present in the area and reduce interindividual competition to a minimum.

References:

- Bacchetta G. (1997).** *La Riserva Naturale di Monte Arcosu*. Il Golfo Editore, Cagliari.
- Corbett L.K. (1979).** *Feeding ecology and social organization of Wildcats (*Felis silvestris*) and domestic cats (*Felis catus*) in Scotland*. Ph.D. thesis. Univ. Aberdeen, Scotland 296 pp.
- Dalke P.D. (1942).** *The cottontail rabbit in Connecticut*. State Geol. Nat. Hist. Survey Bull., 65: 1-97.
- Eisenberg J.F. (1986).** *Life history strategies of the Felidae: variations on a common theme*. Pp 293-305 in: *Cats of the world: Biology, conversations and management*. Miller S.D. and Everett D.D. ed., National Wildlife Federation. Washington, D.C..
- Genovesi P., Boitani L. (1993).** *Spacing patterns and activity rhythms of a wildcat (*Felis silvestris*) in Italy*. Seminar on the biology and conservation of a wildcat (*Felis silvestris*). Council of Europe, Strasbourg, Environmental encounters, 16: 98-101.
- Hornocker M.G. (1996).** *Winter territoriality in mountain lions*. J. Wildl. Manage. 33: 457-464.
- Ivlev V.S. (1961).** *Experimental ecology of the feeding of fishes*. New Haven: Yale University Press.
- Kitchener A. (1991).** *The natural history of the wild cats*. Christopher Helm, London.
- Kleiman-Eisenberg J.F. (1973).** *Comparison of canid and felid social systems from an evolutionary perspective*. *Aim. Behav.* 21: 637-659.
- Kruuk H.H. (1986).** *Interactions between felidae and their prey species: a review*. Pp 353-374 in: *Cats of the world: Biology, conversations and management*. Miller S.D. and Everett D.D. ed., National Wildlife Federation. Washington, D.C..
- Jenkins D. (1962).** *The present status of the wild cat (*Felis silvestris*) in Scotland*. *Scott. Nat.*, 70: 126-139.
- Leyhausen P. (1965).** *The communal organization of solitary mammals*. *Symp. Zool. Soc. Lond.* 14: 249-263.
- Mohr C.O. (1947).** *Table of equivalent populations of North American small mammals*. *Am. Midl. Nat.*, 37: 223-249.
- Murgia C., Murgia A., Deiana A.M. (2005).** *Caratterizzazione biometrica di popolazioni selvatiche di gatto selvatico sardo*. *Rendiconti Seminario Facoltà Scienze Università Cagliari* • Vol. 75, Fasc. 1-2.

- Murgia C., Murgia A., Luiselli L., Angelici F.M. (2007).** *Movements and activity patterns of radiotracked Sardinian wildcats, Felis silvestris libyca Forster, 1780.* Rev. Écol. (Terre Vie), vol. 62:121-126.
- Parent H.G. (1975).** *La migration recente, a caractère invasionnel, du Chat sauvage, Felis silvestris silvestris Schreber, en Lorraine belge.* Mammalia, 39:251-288.
- Ragni B. (1981).** *Gatto selvatico Felis silvstris Schreber, 1777.* Pp105-113 in: *Distribuzione e Biologia di 22 specie di Mammiferi in Italia.* Consiglio Nazionale delle Ricerche, Roma.
- Ragni B., Possenti M. (1994).** *Predatory behaviour of Felis silvestris.* Boll. Zool. Suppl. 61:44.
- Ragni B., Possenti M. (1996).** *Variability coat-colour and markings system in Felis silvestris.* Ital. J. Zool. ,63: 285-292.
- Randi E., Ragni B. (1991).** *Genetic variability and biochemical systematics of domestic and wild cat populations (Felis silvestris: Felidae).* J. Mamm. 72:79-88.
- Seidensticker J.C., Hornocker M.C., Wiles M.V., Messick L.P. (1973).** *Mountain lion social organization in the Idaho Primitive Area.* Wildl. Monogr. 35: 1-60.
- Springer J.T. (1979).** *Some source of bias and sampling error in radio triangulation.* J. Wildl. Manage. 43: 926-935.
- Stahl P. (1986).** *Le Chat forestier d'Europe (Felis silvestris, Schreber, 1777): exploitation des ressources et organization spatiale.* Ph.D Thesis, Univ. Nancy.
- Stahl P., Artois M., Aubert M.F.A. (1988).** *Organisation spatiale et déplacements des chats forestiers adultes (Felis silvestris, Schreber, 1777) en Lorraine.* Rev. Ecol. (Terre et Vie), vol.43: 113-132.
- Toschi A. (1965).** *Fauna d'Italia, vol. 7.* Mammalia: Lagomorpha, Rodendia, Carnivora, Ungulata, Cetacea. Calderini, Bologna.
- Worton B.J. (1989).** *Kernel methods for estimating the utilization distribution in home-range studies.* Ecology 70: 164-168.