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Composition of a small mammal community studied by three comparative methods

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Small mammal community composition of a Mediterranean area of central Italy was studied by comparing three different methods: (1) live-trapping, (2) owl pellet analysis and (3) snake gut analysis. All the methods employed provided useful data on both species composition and abundance in the field, although live-trapping and analysis of *Tyto alba* pellets allowed the detection of the higher number of small mammal species. When live-trapping is used, it seems necessary to place traps in every environmental type available in the study area.

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Introduction

Small mammals (rodents and shrews) are notoriously elusive animals due to their natural selection as prey. As a result, ecological and faunistic research on these animals is often logistically difficult to conduct. The most popular methods used to monitor the composition of small mammal communities have been the use of live-traps and the analysis of regurgitated pellets by avian predators. A detailed field study carried out in the province of Rome suggested (1) that regurgitated meals by adult vipers *Vipera aspis* provided reliable data on composition of small mammal fauna of a given area, and (2) that these data could be profitably used to integrate data obtained by more traditional methods (Capula and Luiselli 1990, Luiselli and Agrimi 1991). In fact, standard live-trapping could be not a perfect method for small mammal monitoring, as it may suffer from several factors including eg bait type, sampling season and relative biological phases of the target species, and trap sensitivity (Tanton 1965, 1969, Jensen 1975a, b, Smith *et al.* 1975, Flowerdew 1976, Chełkowska and Goszczyński 1983, Montgomery 1987).

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In a study area situated near Rome, from 1992 throughout 1995, we had the opportunity to study simultaneously several aspects of the ecology and population biology of small mammal species and their natural predators: snakes and owls (eg see Capizzi *et al.* 1995, Capizzi and Luiselli 1995, 1996a, b). We have collected a number of regurgitated remains of small mammals preyed on by both these types of predators. In this paper we compare the small mammal community composition as it emerges from (1) dietary data of both snakes and owls, and (2) live-trapping conducted in different habitat types. Our aim is to test whether standard live--trapping is an enough good method to investigate small mammal community composition.

Materials and methods

The study was carried out in an agro-forested area of Mediterranean central Italy ("La Marcigliana" hunting reserve, about 20–80 m a.s.l.), situated on the left bank of the river Tiber at about 15 km northeast of Rome. In the area several fragmented woodlots are present. These woodlots, with an area ranging between 10 and 150 ha, are surrounded by bushy ecotones and cultivated fields. The forested area is coppiced with a rotation cycle of 18 years (Capizzi and Luiselli 1996b). The wood is composed of oaks (*Quercus cerris, Q. robur, Q. pubescens*), but other common trees include elms *Ulmus minor* and field maples *Acer campestris*.

The composition of small mammal community was studied by three different procedures: (1) live trapping, (2) owl pellet analysis, (3) snake gut analysis. Detailed descriptions of the methodologies employed are given elsewhere (Capizzi *et al.* 1995, Capizzi and Luiselli 1995, 1996a, b). Here we briefly summarize the more relevant methodological points.

(1) Live-trapping: Self-made WEB live traps (Le Boulengé and Le Boulengé-Ngouyen 1987) were placed in four different environmental types: (a) mature wood, (b) bushy ecotonal area, (c) clearcut area, and (d) semi-cultivated area. To investigate which small mammal species inhabit each environmental type a grid composed of 9 × 9 traps was set out, each trap being 15 m apart. Trappings were performed twice per year (spring and autumn) during three consecutive years (1992, 1993 and 1994). The captured individuals were marked by toe-clipping (Montgomery 1987) and released at the capture point. Every trapping session lasted five nights. Traps were distributed in equal proportion in the different habitats available at the study area.

(2) Owl pellet analysis: Pellets of four different owl species (*Tyto alba, Strix aluco, Asio otus* and *Athene noctua*) inhabiting the study area were collected during the period 1992–1995. The pellets were usually found on the ground of some old and abandoned buildings, but occasionally also randomly spread on the ground of wooded areas. Small mammals were identified on the basis of cranial and mandibular remains.

(3) Snake gut analysis: The study area is inhabited by four sympatric snake species with predominantly mammalophagous habits: *Vipera aspis, Coluber viridiflavus, Elaphe longissima* and *Elaphe quatuorlineata* (Capizzi *et al.* 1995). To study dietary habits of these species, random routes throughout the study area were conducted (for more details see Capizzi *et al.* 1995). When a snake was encountered, it was captured by hand, identified to species, individually marked by ventral scale-clipping and processed for ingested food items (cf Luiselli *et al.* 1996a, b). Food items were obtained by forced squeezing of the snake abdomen and collection of faecal pellets (Monney 1990, Luiselli and Agrimi 1991). The methods employed were easy to apply and not dangerous for the handled specimens.

Due to the remarkable morphological similarity at the study area between sympatric *Apodemus* (*A. flavicollis* and *A. sylvaticus*) and *Crocidura* (*C. leucodon* and *C. suaveolens*) (eg see Filippucci *et al.* 1988), individuals belonging to these two genera were sometimes identified only to the genus level.

An overlap estimate (Pianka 1986) was used to calculate the similarity in the small mammal community composition resulting from different procedures (eg owl pellet analysis versus live--trapping). In this equation the values ranged from 0 (no similarity) to 1 (total similarity). The diversity of the small mammal community composition derived from the different methods was estimated by Simpson's (1949) diversity index.

The statistical analyses were done with a Statistical Analysis System pc package (SAS 1985, version 6.0), with all tests being two tailed and assessed at 5%. For the choice of statistical tests we generally followed recommendations in Zar (1984).

Results and discussion

Live-trapping provided a total of 586 small mammals belonging to nine different species (excluding undetermined *Apodemus* and *Crocidura* from the count). The species most frequently trapped was *Apodemus sylvaticus*, followed by *Clethrionomys glareolus*, *Microtus savii* and *Apodemus flavicollis* (Table 1 and Table 2).

Owl pellet analysis gave a total of 1187 small mammal remains, 654 of which came from *Tyto alba* pellets (Table 1). *Tyto alba* pellets provided a higher number of small mammal species than the pellets of the other three owls, and thus they are considered separately in Table 1. The most common small mammal in the

Table 1. Small mammal species composition (in % of total *n*) and relative abundance recorded with live-trapping, owl pellet analysis, and snake gut contents analysis. *n* – number of small mammal individuals trapped or separated from remainings.

Mammal species/ Variable	Live-trapping (n = 586)	*Tyto alba* pellets (n = 654)	Other owl pellets (n = 533)	Snake guts (n = 198)
Apodemus sp.	17.9	7.3	19.1	56.1
Apodemus sylvaticus	29.9	20.2	6.6	–
Apodemus flavicollis	8.0	2.0	3.6	–
Mus domesticus	3.6	7.0	4.9	2.0
Rattus rattus	3.2	0.3	0.8	3.5
Rattus norvegicus	2.0	–	–	2.5
Microtus savii	13.5	39.8	56.7	–
Clethrionomys glareolus	16.0	2.4	4.3	18.7
Muscardinus avellanarius	–	3.4	1.1	–
Crocidura sp.	2.4	1.1	1.5	17.2
Crocidura suaveolens	1.5	4.7	0.2	–
Crocidura leucodon	1.9	5.2	0.8	–
Suncus etruscus	–	5.0	0.6	–
Sorex samniticus	–	1.5	–	–
Species detected	9	11	10	6
Effectiveness (% of a total of 12 species detected)	75.0	91.6	83.3	50
Diversity measure	5.70	4.56	2.71	2.62

Table 2. Total number of small mammal individuals (n) and percentages of different species captured with live-traps in four different habitats.

Species	Mature wood (n = 133)	Bushy ecotone (n = 191)	Clearcut area (n = 173)	Semi-cultivated area (n = 89)
Apodemus sp.	12.0	25.1	23.1	1.1
A. sylvaticus	15.0	39.3	46.2	7.8
A. flavicollis	23.3	4.2	4.6	–
M. domesticus	1.5	3.7	1.7	9.0
R. rattus	7.5	3.7	1.2	–
R. norvegicus	0.8	2.6	3.5	–
M. savii	–	–	–	82.0
C. glareolus	37.6	16.8	6.9	–
Crocidura sp.	1.5	2.1	4.6	–
C. suaveolens	–	1.6	3.5	–
C. leucodon	0.8	1.0	4.6	–

pellets of both *Tyto alba* and the other Strigiformes was *Microtus savii*, followed by *Apodemus sylvaticus*. In this regard it should be considered that *Tyto alba* pellets may have provided a higher number of small mammal species than the pellets of the other three owls simply because of the different sample sizes.

From snake guts we obtained a total of 198 small mammal remains (Table 1). The dominant species were the two *Apodemus*, followed by bank voles and shrews. No *Microtus savii* was recorded with snake gut analysis, the same being true in another Mediterranean study in central Italy (Capula and Luiselli 1990, Luiselli and Agrimi 1991).

The values of Simpson's diversity measure obtained from the three procedures are given in Table 1, while the relative overlaps (measured by Pianka's symmetric equation) in the small mammal community composition are given in Table 3. A matrix correlation nonparametric Mantel test (see Banley 1985) showed that live-trapping and *Tyto alba* pellets provided significantly higher diversity estimates than other owl pellets and snake ingesta did ($p < 0.005$).

The comparative analysis of the various procedures tested here clearly indicates that live-trapping and the analysis of *Tyto alba* pellets provided the better

Table 3. Overlap values in small mammal communities calculated by using Pianka's (1986) symmetric equation as resulted from three different methods described in the text.

	Tyto alba pellets	Other owl pellets	Snake guts
Tyto alba pellets	–		
Other owl pellets	0.912	–	
Snake guts	0.170	0.318	–
Live-trapping	0.699	0.561	0.525

estimates of the whole small mammal community having permitted to detect the higher number of species, whilst the analysis of snake guts allowed the detection of only 50% of the expected species. Thus, our study supports the idea that live-trapping is better than any other method to study small mammal community composition, but also suggests that at least the analysis of *Tyto alba* pellets should be carefully considered when planning for such a kind of research.

However, all methods had some weak points. As expected, live-trapping proved to be suitable for faunistic research only if the traps were placed in all the available habitats. In fact, continued trapping in single environmental types at the study area did not allow the detection of some species (see Table 2). Furthermore, several species such as *Suncus etruscus, Sorex samniticus* and *Muscardinus avellanarius* were not captured at all.

Problems with the analysis of snake guts contents are: (1) the unreliability of discrimination between *Apodemus flavicollis* and *A. sylvaticus* and between *Crocidura suaveolens* and *C. leucodon* (as snakes begin to swallow their prey by the head, and thus the head is the first part of the prey body to be digested), and (2) the inability to detect the presence of the small mammal species inhabiting areas not suitable for snake activity, which in our study area are the open and cultivated fields (Capizzi and Luiselli 1996a). Our snake sample did not allow detection of *Microtus savii*, which is the dominant species in the cultivated fields. However, analysis of snake guts provides very good data on the small mammals inhabiting the bushy and woody areas that are the typical snake habitats in the Mediterranean regions (eg see Luiselli and Rugiero 1990, Filippi 1995). In these habitats the snakes not only preyed on all the available prey species but their predatory pressure was highly correlated with the availability of the various prey species, namely the frequency of appearance of the various small mammals in the field (Capizzi *et al.* 1995, Rugiero and Luiselli 1995, Luiselli 1996). In this regard it should be noted that the overlap in the percentage distribution of small mammals caught by snakes and by live-traps in the forest/bush habitats was very high (Capizzi and Luiselli 1996a).

Analysis of owl pellets provided a more complete sample than the snake guts, but the pellets from *Tyto alba* detected even higher number of species than those from *Athene noctua, Strix aluco* and *Asio otus* combined. Brown rats *Rattus norvegicus* were not captured by owls, but were detected by both live traps and snake gut analyses. Clearly, also analysis of owl pellets has some deficiencies. To begin with, the taxonomical composition of the owl diets may depend strongly on the surface occupied by the various habitats in the territory of these raptors. For instance, an high proportion of *Microtus savii* in their diet may be a result of a high proportion of cultivated fields in the owl territories. Moreover, it is not possible to exclude a preference by owls for Microtinae rather than for Murinae (the former being probably easier to capture than the latter ones), so that data from pellets may not mirror the relative abundance of the different prey species in the field.

In conclusion, our study demonstrates that the integration of methods can provide more accurate and reliable data on the small mammal community composition. The analysis of *Tyto alba* pellets and live-trapping represented the best methods in terms of both number of species detected and diversity. More precisely, owl pellets may provide data on small mammals over a wide area (because of the wide territories of the owls; cf Mikkola 1983, Shawyer 1994), while live-traps can associate each species with its proper habitat. Snake gut analysis can be very useful to study both the community composition and the relative abundance of the various species inhabiting wooded and bushy zones.

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References

Banley A. 1985. The statistics of natural selection. Chapman & Hall, New York.

Capizzi D. and Luiselli L. 1995. Comparison of the trophic niche of four sympatric owls (*Asio otus, Athene noctua, Strix aluco* and *Tyto alba*) in Mediterranean central Italy. Ecologia Mediterranea 21(3/4): 12–20.

Capizzi D. and Luiselli L. 1996a. Trophic relationships and competitive interactions between phylogenetically unrelated predators (owls and snakes). Acta Oecologica 17(3). (in press)

Capizzi D. and Luiselli L. 1996b. Ecological relationships between small mammals and age of coppice in an oak-mixed forest in central Italy. Revue d'Ecologie (Terre et Vie) 51(4). (in press)

Capizzi D., Luiselli L., Capula M. and Rugiero L. 1995. Feeding habits of a Mediterranean community of snakes in relation to prey availability. Revue d'Ecologie (Terre et Vie) 50: 353–363.

Capula M. and Luiselli L. 1990. [Analysis of the gut contents of *Vipera aspis* (Reptilia, Viperidae) from an area of central Italy (Tolfa Mountains: Latium): a new method to study the terrestrial small mammals]. Hystrix 2: 101–107. [In Italian]

Chełkowska H. and Goszczyński J. 1983. Numbers – Methods of assessment. [In: Ecology of the bank vole. K. Petrusewicz, ed]. Acta Theriologica 28, Suppl. 1: 94–101.

Filippi E. 1995. [Ecological aspects of two snake communities (Colubridae and Viperidae) in a Mediterranean region of central Italy (Mounts of Tolfa, Latium)]. Unpublished M Sc thesis, University of Rome "La Sapienza", Rome: 1–143. [In Italian]

Filippucci M. G., Shimon S. and Nevo E. 1989. Evolutionary biology of the genus *Apodemus* Kaup, 1829 in Israel. Allozymic and biometric analyses with description of a new species: *Apodemus hermonensis* (Rodentia, Muridae). Bollettino di Zoologia 56: 361–376.

Flowerdew J. R. 1976. Techniques in mammalogy. Chapter IV. Ecological methods. Mammal Review 6: 123–159.

Jensen T. S. 1975a. Trappability of various functinal groups of the forest rodents *Clethrionomys glareolus* and *Apodemus flavicollis*, and its application in density estimation. Oikos 26: 196–204.

Jensen T. S. 1975b. Population estimation and population dynamics of two Danish forest rodents. Vid. Medd. 138: 65–86.

Le Boulengé E. and Le Boulengé-Ngouyen P. Y. 1987. A cost-efficient live trap for small mammals. Acta Theriologica 32: 140–144.

Luiselli L. 1996. Food habits of an alpine population of the sand viper (*Vipera ammodytes*). Journal of Herpetology 30: 92–94.

Luiselli L. and Agrimi U. 1991. Composition and variation of the diet of *Vipera aspis francisciredi* in relation to age and reproductive stage. Amphibia-Reptilia 12: 137–144.

Luiselli L., Capula M. and Shine R. 1996a. Reproductive output, costs of reproduction and ecology of the smooth snake (*Coronella austriaca*) in the eastern Italian Alps. Oecologia 106: 100–110.

Luiselli L., Capula M. and Shine R. 1996b. Food habits, growth rates and reproductive biology of grass snakes, *Natrix natrix* (Colubridae) in the Italian Alps. Journal of Zoology, London 240. (in press)

Luiselli L. and Rugiero L. 1990. On habitat selection and phenology in six species of snakes in Canale Monterano (Tolfa Mountains, Latium, Italy) including data on reproduction and feeding in *Vipera aspis francisciredi* (Squamata: Viperidae). Herpetozoa (Wien) 2: 107–115.

Mikkola H. 1983. Owls of Europe. T & A D Poyser, Calton: 1–397.

Monney J.-C. 1990. Régime alimentaire de *Vipera aspis* L. (Ophidia, Viperidae) dans les Préalps fribourgeoises (ouest de la Suisse). Bulletin de la Société Herpétologique de France 53: 40–49.

Montgomery W. I. 1987. The application of capture-mark-recapture methods to the enumeration of small mammal populations. Symposia of the Zoological Society of London 58: 25–57.

Pianka E. R. 1986. Ecology and natural history of desert lizards. Princeton University Press, Princeton: 1–208.

Rugiero L. and Luiselli L. 1995. Food habits of the snake *Coluber viridiflavus* in relation to prey availability. Amphibia-Reptilia 16: 407–411.

Shawyer C. 1994. The barn owl. Hamlyn, London: 1–246.

Simpson E. H. 1949. Measurement of diversity. Nature 163: 688.

Smith M. H., Gardner R. H., Gentry J. B., Kaufman D. W. and O'Farrell M. H. 1975. Density estimation of small mammal populations. [In: Small mammals: their productivity and population dynamics. F. B. Golley, K. Petrusewicz and L. Ryszkowski, eds]. Cambridge University Press, Cambridge: 25–53.

Tanton M. T. 1965. Problems of live trapping and population estimation for the Woodmouse, *Apodemus sylvaticus* (L.). Journal of Animal Ecology 34: 1–22.

Tanton M. T. 1969. The estimation and biology of population of the bank vole (*Clethrionomys glareolus* Schreb.) and the wood mouse (*Apodemus sylvaticus* L.). Journal of Animal Ecology 38: 511–529.

Zar J. H. 1984. Biostatistical analysis. Prentice-Hall International, London: 1–718.

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