

SHORT NOTES

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**ECOLOGICAL NOTES ON AN
ISOLATED POPULATION OF THE
SNAKE *ELAPHE QUATUORLINEATA***

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The four-lined snake (*Elaphe quatuorlineata*), an oviparous colubrid up to 2.5 m long, is one of the largest European snake species (Bruno & Maugeri, 1990). Despite its broad European distribution, the ecology of *Elaphe quatuorlineata* is still poorly known because of its very secretive behaviour (Pozio, 1976; Cattaneo, 1979, and see Böhme & Seerbak, 1993 for a review).

In many areas of its Italian range, the four-lined snake is declining (Corbett, 1989), primarily because of habitat loss due to human activities. This decline seems to be more serious in very industrialized and intensively cultivated areas, such as the neighbourhood of Rome (central Italy), where the species is found in only small and scattered populations (Capula, 1989; Rugiero, unpubl.). The total lack of information on the biology of such scattered *E. quatuorlineata* populations is a major obstacle to the formulation of conservation strategies for preventing this species' further decline.

During a long-term research study on reptile biology in the Roman region conducted by one of us (L. Rugiero), ecological information on a four-lined snake population has been collected. This information may be of some interest either for conservation measures or for augmenting the scarce knowledge of *E. quatuorlineata* biology. Therefore, in this paper we present and discuss the results obtained on such a snake population.

All data given here were collected between February 1989 and early November 1994 in a forested area situated near the village of Tor Lupara, about 17 km east of Rome (latitude: 42° N; longitude: 12°40'E of Greenwich; about 70-100 m above sea level), where other studies on reptile ecology were simultaneously conducted (Rugiero, 1993; Rugiero & Luiselli, 1995). The total area surveyed was about 40 ha. The habitat was characterized by a forest (*Quercus cerris*, *Ulmus minor*, *Carpinus betulus*) bordered with herbaceous pastures. The forested zone was completely surrounded by cultivated fields, busy roads and urban areas which are inhospitable to snakes. Thus, the snake population studied here can be considered as virtually isolated. The climate of the area is typically Mediterranean, with mild and rainy winters, and hot and dry summers.

Thirty field trips per year were conducted, each eight hours long. This constant sampling effort was necessary to ensure that the number of snakes recorded per year was a true reflection of the population status and not just a representation of sampling effort.

When a four-lined snake was encountered, it was captured by hand, sexed, measured to total length (to the nearest 0.5 cm) and weighed (to 0.1 g with an electronic balance); scale-clipped and painted on the dorsal surface with a blue number for further visual identification. Moreover, its feeding status was determined by palpation of the abdomen. In order to avoid excessive disturbance to the few specimens in the area, we avoided forcing them to regurgitate their ingested prey, and limited our investigation of food habits to the analysis of faecal pellets collected from live specimens (e.g. Monney, 1990; Luiselli & Rugiero, 1993). The density of some prey types (lizards and small mammals) at the study site was estimated as a part of the field work (see Rugiero & Luiselli, 1995 for both methods and results). The clutch size of some ($n = 6$) gravid females was estimated by palpation of the abdomen, a method very useful and very accurate in the field (Bonnet & Naulleau, 1994). Two of these females were transferred to the laboratory, where they laid eggs. The eggs were incubated on vermiculite at ambient temperature, and all the offspring were permanently scale-clipped and then released in the field. The statistical analyses were done by Statgraphic 2.0 computer package, with α assessed at 5%.

Population size. The four-lined snake is very rare in the area, while sympatric *Coluber viridiflavus*, *Elaphe longissima*, *Natrix natrix* and *Vipera aspis* are more common. In fact, while the populations of all these other snakes consisted in each year of at least thirty adults, the highest number of different *E. quatuorlineata* specimens (including both adults and juveniles) captured during one year of research was 16 (in 1989, see Table 1). However, since 1990 this number decreased and then remained stable at around 10 (Table 1). The recaptures were frequent between years. The sex-ratio was apparently skewed in favour of the males in every study year, but the difference was never significant (binomial test, in all cases $P > 0.1$).

Food habits. Altogether, we obtained remains of 30 prey items from a total of 24 faecal pellets, most of

TABLE 1. Total number of snakes captured in each year. Juveniles and adults are pooled together, but sexes are counted separately.

Year	No. males	No. females	Total	Apparent sex-ratio
1989	10	6	16	1.67:1
1990	5	3	8	1.67:1
1991	6	4	10	1.50:1
1992	6	4	10	1.50:1
1993	7	4	11	1.75:1
1994	7	5	10	2.33:1

TABLE 2. Prey composition of *Elaphe quatuorlineata* at the study area

Prey type	N	%N
<i>Podarcis muralis</i>	7	23.3
Passeriformes (indeterminate)	5	16.7
<i>Apodemus</i> sp.	12	40.0
<i>Rattus</i> sp.	3	10.0
Muridae (indeterminate)	3	10.0
TOTAL	30	100.0

which came from endothermic vertebrates (Table 2). The small amount of data collected prevented us making comparisons of diet composition between sexes or between seasons. Lizard remains were found in faeces obtained only from immature individuals: the largest snake that preyed on a lizard was a male 89.4 cm long. Conversely, the diet of the adults was composed only of birds and rodents, as previously observed by Cattaneo (1979) in another area of the Roman countryside. Contingency-table analysis revealed that the ontogenetic shift in dietary composition (from ectotherm to endotherm prey) is statistically significant (χ^2 , $P < 0.005$, see Fig. 1). A similar dietary shift is present in other Mediterranean populations of snakes studied previously (e.g. Saint Girons, 1980; Luiselli & Agrimi, 1991). Comparing the dietary data of *E. quatuorlineata* with those of sympatric *C. viridiflavus* (see Table 1 in Rugiero & Luiselli, 1995), it should be noted that the food preferences of the juveniles of both species are very similar (χ^2 , $P > 0.1$), while the food preferences of the adults differ considerably (χ^2 , $P < 0.005$) because of either the high frequency of utilization of the lizard resource by adults *Coluber* or of the high frequency of utilization of the bird resource by adult *Elaphe*. *Podarcis muralis* and *Apodemus sylvatica*, respectively the most available lizard and rodent species in the area (Rugiero & Luiselli, 1995), were also the most common prey types in both *E. quatuorlineata* and *C. viridiflavus*. This occurrence suggests that both these colubrids are opportunistic predators (see also Capizzi *et al.*, 1995; Rugiero & Luiselli, 1995).

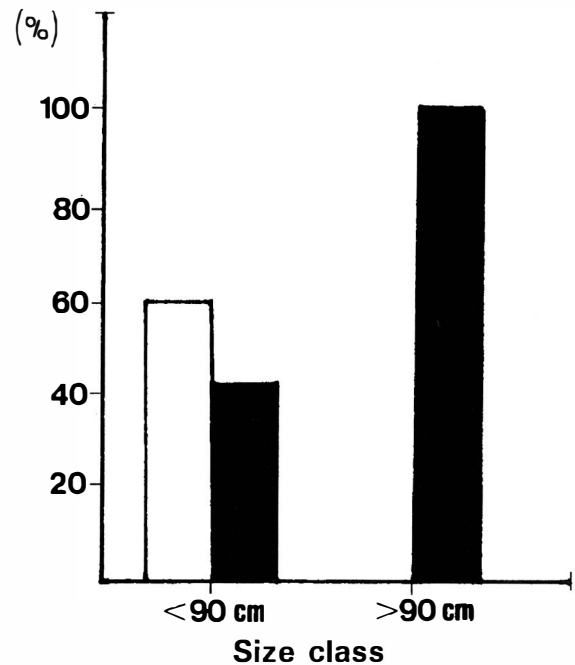


FIG. 1. Ontogenetic change in the diet of *Elaphe quatuorlineata* from Tor Lupara, Rome (central Italy). Black bars represent endothermic prey (small mammals and birds), while white bars represent ectothermic prey.

Growth. Growth was estimated in seven different specimens (five males and two females) of known age and recaptured throughout the years. Table 3 summarizes the size of these specimens at different ages. Maturation was estimated at a minimum age of over 3 years in the males and over 3.5 years in the females, although the gravid females in our sample were always older (at least five years of age). In fact, the males longer than 90 cm were found to participate in the spring sexual activity, while the smallest mature female was 117 cm long (although the smallest gravid female captured by us was 132 cm long).

Fecundity. Clutch size of six adult females was estimated. There was a significant positive relationship between female size (TL, in cm) and clutch size (Pearson's $r = 0.85$, $r^2 = 73\%$, $F_{1,4} = 10.8$, $P = 0.03$). This positive relationship is a widespread occurrence in snakes (e.g. see Saint Girons & Naulleau, 1981), espe-

TABLE 3. Size of males and females *Elaphe quatuorlineata* at different ages. Only specimens of known age are considered. Five specimens that were of unknown age at the moment of first capture are excluded from this table.

Year	Total length (cm) of each individual at different ages									
	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Individual:										
male 1	37.4	39.5	42.3			89.4		97.6		
male 2	33.6				61.1					
male 3	35.8	44.2				82.6	93.1			
male 4	36.7		59.7							
male 5	37.6				70.0			117.0	119.0	122.2
female 1	33.8			63.2	68.7					
female 2	34.7			63.6	81.4		102.5			

cially in those places where food is not a limited resource (Andr n & Nilson 1983; Capula & Luiselli, 1994; Luiselli *et al.*, 1996). The mean number of eggs produced by a female was 10.83 ± 1.17 , while the pregnant females averaged 155.16 ± 11.65 cm. In another Mediterranean area of central Italy (Tolfa mountains, province of Rome), where *E. quatuorlineata* is widespread and relatively common, the females copulate for the first time three years of age, and the mean length of the gravid females is about 125 cm TL (E. Filippi, unpublished data). Thus, compared with the small population studied here, the female *E. quatuorlineata* of Tolfa show (1) a slightly earlier maturation and (2) a lower mean body size when pregnant. Though more detailed comparisons are necessary before stressing firm conclusions, we suggest that these differences between our isolated population and these other populations living in more suitable areas indicate a declining status in the former population. According to Stearns (1976), in fact age at maturity may be a life-history trait acted on by natural selection and is dependent on the demographic environment of the various populations: individuals in growing populations may tend toward earlier maturity and individuals of declining populations may mature later. The small size of this isolated population is arguably another evidence of its declining status.

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