HERPETOZOA 5(3/4): 95-98
Wien, 30. Dezember 1992

Biennial reproduction and clutch parameters in an alpine population of the Slow Worm, *Anguis fragilis* LINNAEUS, 1758 (Squamata: Sauria: Anguidae)

Zweijährige Reproduktionsperiode und Wurfgröße einer alpinen Blindschleichenpopulation, *Anguis fragilis* LINNAEUS, 1758 (Squamata: Sauria: Anguidae)

MASSIMO CAPULA & LUCA LUISELLI & CLAUDIO ANIBALDI*)

ABSTRACT

A biennial reproductive cycle was found in female *Anguis fragilis* LINNAEUS, 1758 from a locality in the eastern Italian (Carnic) Alps. Clutch size ranged from 6 to 13 and the constancy of the ratio of clutch size and female snout-vent length was statistically highly significant. The female reproductive pattern observed was quite similar to that of another ovoviviparous reptile from the same geographic area, i. e. *Vipera berus* (LINNAEUS, 1758). The occurrence of a biennial reproductive cycle in these two distantly related ovoviviparous reptiles could be due to scarce female foraging success, which is probably a consequence of unfavourable (e. g. high altitude) climate conditions.

KURZFASSUNG

Bei weiblichen Blindschleichen, *Anguis fragilis* LINNAEUS, 1758, eines Fundortes in den ostitalienischen (Karnischen) Alpen wurde ein zweijähriger Fortpflanzungszyklus festgestellt. Die Wurfgrößen lagen zwischen 6 und 13 und die Konstanz des Verhältnisses von Wurfgröße und mütterlicher Kopf-Rumpf-Länge erwies sich als statistisch hoch signifikant. Der beobachtete weibliche Fortpflanzungsrhythmus ähnelt stark dem eines anderen ovoviviparen Reptils desselben Gebietes, nämlich dem der Kreuzotter, *Vipera berus* (LINNAEUS, 1758). Das Vorhandensein eines zweijährigen Fortpflanzungszyklus bei zwei nicht näher miteinander verwandten ovoviviparen Reptilienarten könnte im geringen Jagderfolg der Weibchen begründet sein und wäre dann wahrscheinlich eine Folge des ungünstigen Klimas (z. B. in großen Höhen).

KEYWORDS

Anguis fragilis, Anguidae, reproductive biology, alpine environment, Italy

The Slow Worm, *Anguis fragilis* LINNAEUS, 1758, an ovoviviparous anguid, is a widespread species in the Italian Alps (MARCUZZI 1976; LAPINI 1983). Despite its abundance, peculiarities of the biology of the species in this part of the Alpine massif are almost completely unknown, apart from some scarce information (LANZA 1968; BRUNO 1986). In the present paper preliminary data on the reproductive biology of the Slow Worm in the Eastern Italian Alps are reported.

Data presented here were collected during July 1991 within a 250.000 m² area (Sella Nevea, Tarvisio Forest, NE Italy), located in the Carnic Alps, at about 1100 m a. s. l. This area, which was previously surveyed for field studies on *Vipera berus* (LUISELLI 1992a, 1993), has a typical alpine climate. Its morphology is characterized by the presence of dilapidated stone walls and piles of stones at the borders of a Swiss Mountain Pinewood (*Pinus mugo*) forest. Field studies were carried out by exploring standardized routes for 15 days. Sampling was performed mainly after rain, during the first daylight hours and the twilight, i. e. during the high activity periods of the Slow Worm. The reproductive condition of the captured females was deter-

*) The authors contributed in equal parts to this work.

mined by palpation of the abdomen. When found gravid, Slow Worm females were collected and kept in a laboratory terrarium until the time of parturition. After this, clutch size and snout-vent-length (SVL) of both females and offspring were recorded. Subsequently, all specimens were released to the field. Pregnant females which were found dead in the field were also collected, preserved in ethanol 70%, and then dissected in order to obtain data on clutch size. These specimens are now stored in the private herpetological collection of one of the authors (L. L.).

During the investigations we collected 15 pregnant and 13 non-pregnant adult females. Parturitions occurred from August 16th to September 9th, and were synchronous with those of other reptiles occurring in the study area, i. e. *V. berus* (CAPULA & al. 1992) and *Coronella austriaca* (ANIBALDI & al., unpublished).

Clutch size ranged from 6 to 13 ($\bar{x}$ = 9.13; v = 2.17), and a positive linear correlation between clutch size and female SVL (Fig. 1) was ascertained with high statistical significance (PEARSON's r = 0.96; determ. coeff. = 0.941; ANOVA F_1 = 138.08, p = 0.00; DURBIN-WATSON statistics = 1.49). Offspring SVL ranged from 25 to 33 mm. A clear correlation between offspring SVL and female SVL was not found (PEARSON's r = 0.16, slope not significantly different from 0; ANOVA F_1 = 0.24, p = 0.63). Lack of correlation in female and offspring SVL was also observed in *V. berus* from the same locality (CAPULA & al. 1992). Nearly half of the analyzed mature Slow Worm females were not able to reproduce: 15 out of 28 adult females (53.6%) captured in July were pregnant. This proportion is not significantly different from 50%, and one may hypothesize - according to the empirical measure of reproductive frequency based on the proportion of gravid females at a given point in time (ALDRIDGE 1979; SEIGEL & FORD 1987) - that in the study area female Slow Worms produce one litter every second year, just like sympatric female *V. berus* (CAPULA & al. 1992) and *C. austriaca* do. Our yet unpublished data on this latter species show that *C. austriaca* parturitions are especially concentrated in the last week of August and in the first one of September, although they may begin in mid-August and may end at about September 15th. Snout-vent-length of both reproductive and non-reproductive females did not differ in a statistically significant way ($p > 0.2$), clearly indicating that non-pregnant females were not immature.

A biennial reproductive cycle in female Slow Worms was already observed by PATTERSON (1983). Such type of reproductive cycle was also found in female snakes from temperate zones (SAINT GIRONS 1957; NILSON 1981), while female lizards from temperate zones are usually known to reproduce more frequently, once or more than once per year being the rule (SAINT GIRONS & DUGUY 1970; CHONDROPOULOS & LYKAKIS 1983; BARBAULT & MOU 1988; JAMESON 1988). *Eumeces okadae* (HASEGAWA 1984) and *Cordylus giganteus* (VAN WYK 1991) are among the few lizard species occurring in temperate zones having a biennial female reproductive cycle. Obviously, as pointed out by FITCH (1970) and ALDRIDGE & SEMLITSCH (1992), this frequency of reproduction represents a population mean. In several species where cycles have been continuously monitored, the individual frequency was found to be often neither annual, nor biannual, etc, but irregular. As it seems that female reproductive frequency essentially depends on energy availability (SEIGEL & FORD 1987), biennial reproductive cycles could be due to scarce foraging success between succeeding parturitions (often as a consequence of unfavourable climatic conditions in autumn and spring). If the foraging success is basic for explaining reproductive cycles of reptiles in temperate zones, the occurrence of the same type of female reproductive cycle in both lizards (e. g. *A. fragilis*) and snakes (e. g. *V. berus*) from the same geographic area may be surprising, because of the quite different foraging strategies of these reptiles. *V. berus* feeds on a small number of "large" preys per year, and shows alternate short feeding and non-feeding periods, depen-

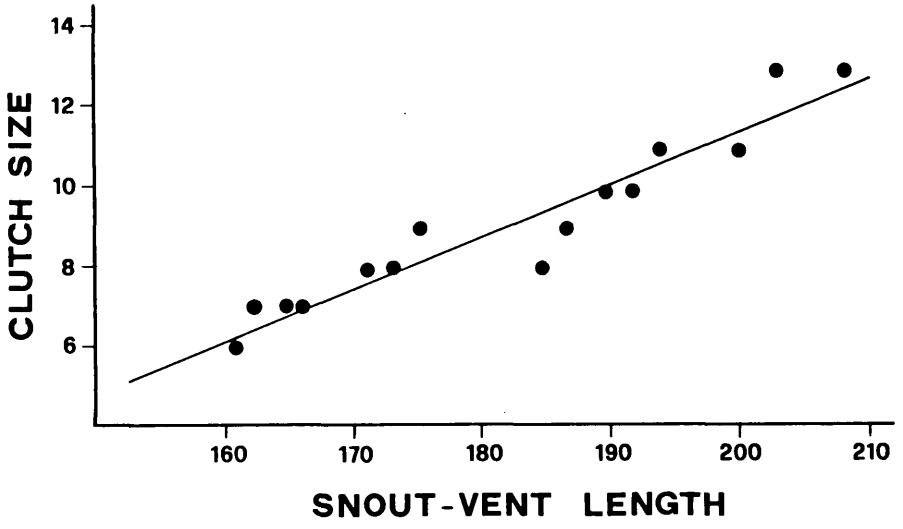

Fig. 1: Clutch size plotted against snout-vent-length of 15 female Slow Worms, *Anguis fragilis* LINNAEUS, 1758, from the locality Sella Nevea (Tarvisio, Carnic Alps, NE Italy). Snout-vent-length in mm.

Abb. 1: Das Verhältnis von Wurfgröße und Gesamtlänge des Muttertieres bei 15 Blindschleichen, *Anguis fragilis* LINNAEUS, 1758, des Fundortes Sella Nevea (Tarvisio, Karnische Alpen, NE-Italien). Gesamtlängen in mm.

ding on the reproductive stage (SAINT GIRONS 1979). On the other hand, *A. fragilis* feeds more frequently and on a large number of "small" organisms (LUISELLI 1992b), probably without any significant relationship to the reproductive cycle. For example, gravid Slow Worms continue to feed even during late pregnancy (LUISELLI 1992b), while gravid vipers usually do not so (SAINT GIRONS 1979).

In conclusion, our data indicate that female reproductive pattern (parturition dates, litter frequency, and some clutch parameters) of *A. fragilis* are quite similar to that of another ovoviviparous reptile from the same geographic area, i. e. *V. berus*. This similarity cannot be interpreted other than by convergency, as both species belong to two distinct phylogenetic lineages. Although our hypothesis requires further investigation, we think that the similarities observed in the reproductive pattern of these two reptile species may be related to the peculiar alpine climate, that represents an important external constraint for reptile life. In fact, it is well known that reproductive traits are much more influenced by selective pressure imposed by local environments than are other life-history features. It is therefore our opinion that the similarities in the reproductive strategies adopted by these two ovoviviparous (but not phylogenetically related) reptiles may simply reflect adaptation to the same bioclimatic regime.

REFERENCES

ALDRIDGE, R. D. (1979): Female reproductive cycles of the snakes *Arizona elegans* and *Crotalus viridis*.- Herpetologica; 35: 256-261.

ALDRIDGE, R. D. & SEMLITSCH, R. D. (1992): Female reproductive biology of the Southeastern Crowned Snake (*Tantilla coronata*).- Amphibia-Reptilia; 13: 209-218.

BARBAULT, R. & MOU, Y. P. (1988): Population dynamics of the Common Wall Lizard, *Podarcis muralis*, in southwestern France.- Herpetologica; 44: 38-47.

BRUNO, S. (1986): Guida a tartarughe e sauri d'Italia; Firenze (Giunti Martello).

CAPULA, M. & LUISELLI, L. & ANIBALDI, C. (1992): Complementary study on the reproductive biology in the female Adder, *Vipera berus* (L.) from the eastern Italian Alps.- Vie et Milieu (in press).

CHONDROPOULOS, B. P. & LYKAKIS, J. J. (1983): Ecology of the Balkan Wall Lizard, *Podarcis taurica ionica* (Sauria, Lacertidae) from Greece.- Copeia; 1983: 991-1001.

FITCH, H. S. (1970): Reproductive cycles of lizards and snakes.- Univ. Kansas Mus. Nat. Hist. Misc. Publ.; 52: 1-247.

HASEGAWA, M. (1984): Biennial reproduction in the lizard *Eumeces okadae* on Miyake-Jima, Japan.- Herpetologica; 40: 194-199.

JAMESON, E. W. (1988): Vertebrate reproduction; New York (Wiley).

LANZA, B. (1968) Rettili. In: TORTONESE, E. & LANZA, B (eds.): Piccola fauna italiana. Pesci, anfibi e rettili; Milano (Martello).

LAPINI, L. (1983): Anfibi e rettili; Udine (C. Lorenzini).

LUISELLI, L. (1992a): Reproductive success in melanistic Adders: a new hypothesis and some considerations on ANDRÉN & NILSON's (1981) suggestions.- Oikos; 64: 601-604.

LUISELLI, L. (1992b): The diet of the Slow Worm, *Anguis f. fragilis* LINNAEUS, 1758, in the Tarvisio Forest (Carnic Alps, NE Italy) (Squamata: Sauria: Anguidae).- Herpetozoa; 5 (3/4): 91-94.

LUISELLI, L. (1993): The ecological role of color polymorphism in male Adders, *Vipera berus*: testing the hypotheses.- Revue Ecologique (La Terre et la Vie); 48: 49-56.

MARCUZZI, G. (1976): La fauna delle Dolomiti; Trento (Manfrini).

NILSON, G. (1981): Ovarian cycle and reproductive dynamics in the female Adder, *Vipera berus* (Reptilia, Viperidae).- Amphibia-Reptilia; 2: 63-82.

PATTERSON, J. W. (1983): Frequency of reproduction, clutch size and clutch energy in the lizard *Anguis fragilis*.- Amphibia-Reptilia; 4: 195-203.

SAINT GIRONS, H. (1957): Le cycle sexuel chez *Vipera aspis* (L.) dans l'ouest de la France.- Bull. Biol. France Belgique; 91: 284-350.

SAINT GIRONS, H. (1979): Les cycles alimentaires des Vipères européennes dans des conditions semi-naturelles.- Ann. Biol. anim. Biochem. Biophys.; (1A) 19: 125-134.

SAINT GIRONS, H. & DUGUY, R. (1970): Le cycle sexuel de *Lacerta muralis* L. en plaine et en montagne.- Bull. Mus. nat. Hist. nat. Paris; 42: 609-625.

SEIGEL, R. A. & FORD, N. B. (1987): Reproductive ecology. In: SEIGEL, R. A. & COLLINS, J. T. & NOVAK, S. S. (eds.): Snakes, ecology and evolutionary biology; New York (Macmillan).

VAN WYK, J. H. (1991): Biennial reproduction in the female viviparous lizard *Cordylus giganteus*.- Amphibia-Reptilia; 12: 329-342.

DATE OF SUBMISSION: October 28th, 1992

AUTHORS: Dr. Massimo CAPULA, Dr. Luca LUISELLI, Dr. Claudio ANIBALDI, Dipartimento di Biologia Animale e dell'Uomo, Università di Roma "La Sapienza", Via Borelli 50, I-00161 Roma, Italy.