SEXUAL SIZE DIMORPHISM, MORPHOMETRY AND PHENOTYPIC VARIATION IN THE WHIP SNAKE *HIEROPHIS VIRIDIFLAVUS* FROM A CENTRAL MEDITERRANEAN AREA

Sara Fornasiero[1,2], Claudia Corti[3], Luca Luiselli[4] & Marco A. L. Zuffi[1,5]

Résumé. — *Dimorphisme sexuel, morphométrie et variation phénotypique de la Couleuvre verte et jaune* Hierophis viridiflavus *dans une région du centre de la Méditerranée*. — Généralement les populations animales qui vivent dans des environnements différents divergent dans leurs caractéristiques phénotypiques. Chez les serpents, la taille corporelle varie fortement entre populations disjointes. La Couleuvre verte et jaune *Hierophis viridiflavus* est largement distribuée en Méditerranée occidentale et sur les îles tant petites que grandes de la mer Tyrrhénienne. Nous avons comparé les patterns biométriques relatifs à l'écaillure ventrale, la taille du corps et de la tête dans divers échantillons provenant du continent, de petites et de grandes îles. Le dimorphisme sexuel est très marqué chez cette espèce, les mâles étant corporellement plus grands, avec une tête plus grosse et moins d'écailles ventrales que les femelles. Une relation forte entre le nombre d'écailles ventrales et l'origine géographique a été clairement mise en évidence, les individus provenant des petites îles étant caractérisés par un nombre significativement élevé d'écailles ventrales. Cette relation se maintient quand on prend en compte la taille corporelle, les individus insulaires étant plus petits que ceux du continent. Nos résultats indiquent clairement une forte différenciation entre les populations étudiées et éclairent l'importance relative de la variation phénotypique.

Summary. — Animal populations living in different environments generally exhibit divergent phenotypic characteristics. In snakes, body size varies greatly among disjunct populations. The European Whip snake, *Hierophis viridiflavus*, is widely distributed in the western Mediterranean area, and on most of both small and large islands of the Tyrrhenian Sea. We compared biometrical patterns regarding ventral scalation, body size and head size among different samples from mainland, large islands and small islands. Sexual Size Dimorphism was very marked in the species, with males attaining larger body size and larger relative head size than females and a lower number of ventral scales. There was a clear evidence of a strong relationship between ventral scale number and the geographic origin, with smaller island snakes characterized by a significantly higher number of ventral scales. This relationship was true even when considering body size, with insular snakes significantly smaller than mainland ones. Our results clearly indicated a strong differentiation among the considered populations, and provided basis to clarify the relative importance of phenotype variation.

An organism's external morphology is the result of the interaction between the organism itself and the environment in which it lives (Seigel & Collins, 1993; Greene, 1997). Body size, together with several other external characteristics, strongly influences an organism's life,

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[1] Museum of Natural History and Territory, University of Pisa, via Roma 79, I-56011 Calci (Pisa), Italy

[2] Present address Department of Biology (Protistology-Zoology unit), via Volta 6, I-56100 Pisa, Italy

[3] Department of Animal Biology and Genetics, University of Florence, via Romana 17, I-50125 Florence, Italy

[4] Istituto di Studi Ambientali "Demetra" (E.N.I. S.p.A., Environmental Dep.), via dei Cochi 48/b, I-00133 Rome, Italy and Department of Applied and Environmental Biology, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria

[5] Reference author. E-mail: marcoz@museo.unipi.it

acting on its capacity of reacting in an appropriate way to the situations it has to face in order to grow up, survive, and reproduce. Not only body shape is the interface between the organism and its environment, but it is itself the result of several selective pressures (e.g. Lomolino, 2005). Therefore, the study of an organism's external morphology may be a valuable approach to our understanding of the main factors influencing its life.

The study of intraspecific variability offers a good opportunity to observe how different variables (i.e. body size, body mass) can act to determine different morphologies: it impedes us to take into account eventual biological traits due to events occurred during ancient phylogenetic history of the organisms (i.e. ventral scale number) and to focus our attention exclusively on those patterns that have likely originated as a response to current conditions (i.e.: body mass) (Pearson *et al*., 2002). Widespread species can therefore represent good models of study, and in this context, several studies have been conducted in mammals (e.g. Dobson & Murie, 1987; Ebenhard, 1990), as well as on amphibians (e.g. Morrison & Hero, 2003) and on reptiles (e.g. Forsman & Shine, 1995).

Due to their relatively simple structure and organization, snakes are particularly suitable to test how morphological and morphometrical variables are subjected to variations as a consequence of different ecological pressures. Many snake species showing a broad distribution have been object of comparisons concerning populations inhabiting different kind of environments, with particular attention dedicated on mainland *vs* island populations (e.g. Shine, 1987; Schwaner & Sarre, 1988; King, 1989; Boback, 2003). The comparison of island populations, due to their intrinsic isolation characteristics, versus mainland snake populations, offers several points of interest and opens possible analyses of variation of meristic and functional body features. Area effect and geographic isolation have been recently claimed as the main source of variation in phenotypic plasticity as well as in systematic implications (see Lenk *et al.,* 1999; Nilson *et al*., 1999; Nagy *et al*., 2002). Continuous (i.e. SVL, body mass) as well as discrete (i.e. ventral scales) body size characteristics are often involved in determining systematic differences (Lenk & Wüster, 1999). Moreover, variations in body size and relative body mass have been especially correlated to prey abundance and availability over time (e.g. Schwaner & Sarre, 1988); extreme plasticity, thus capacity of adaptation, has been documented and confirmed thanks to manipulations conducted on captive snakes (Madsen & Shine, 1993; Bonnet *et al*., 2001).

The effects of prey dimensions and prey availability on snout-vent length, or on relative head size of snake individuals and populations, may also give deeper information on adaptive significance of phenotypic plasticity and micro-evolutionary patterns. For instance, it has been suggested that the relative head size of snakes may be correlated to the relative prey dimension (Forsman, 1991, 1994, 1996), and that fluctuations in prey availability have influenced survivorship of snakes attaining large body size during periods of low food availability (Andrén & Nilson, 1983). Thus, the study of the differences in mean head and body size and proportions (i.e. phenotypic features) between populations inhabiting separate geographical regions, could give us a potential tool to measure the pattern of the resources available and exploited by individuals.

The number of ventral scales in snakes is linked to a genetic basis (Dohm & Garland, 1993) and is interspecifically strictly correlated to body size (Shine, 2000). However it may also represents the adaptation to particular habits, notably constriction or arboreal life (e.g. Lindell, 1994; Wüster *et al.,* 2005): the number of ventral scales reflects the number of vertebrae (Lindell, 1994 and references therein), having an effect on locomotor performances (Arnold & Bennet, 1988), hence on the capacity of the organism to move in different environments. Moreover, several studies demonstrated that variation of thermal conditions (thus climatic and geographical effects) occurring during embryogenesis can have strong influence on offspring phenotypes (Webb *et al.,* 2001), and among all, on the number of ventral scales (e.g. Lourdais *et al.,* 2004).

Once more, the importance of analyzing intraspecific geographical patterns of variation for this parameter results clear in understanding possible phylogenetic relationships and/or the results of adaptive processes linked to different ecological pressures.

The European Whip snake *(Hierophis viridiflavu*s: Colubridae) is considered monotypic in most of its distribution range (Schätti & Vanni, 1986), while recent preliminary data suggest that Sardinian, southern and Sicilian populations belong to different subspecies (Nagy *et al.,* 2003; Scali *et al.,* 2003).

The European Whip snake populations of central Italy are until now considered as a unique taxonomic unit. We have then chosen snakes from this area as a model to test for intraspecific geographic variability, focusing our attention particularly on Tyrrhenian coastal and insular populations. More specifically, we want to test the following key-questions: (i) what is the degree and the extent of sexual dimorphism, and the expression of such dimorphism (Houston & Shine, 1993), in central Italy snakes? (ii) what could be, within a unique sex, the pattern of variation among different areas (Forsman, 1991) and which could the degree of such variation be (Boback, 2003)?

MATERIALS AND METHODS

STUDY SPECIES

The European Whip snake (*Hierophis viridiflavu*s) is a medium-sized (100-140 cm total length), non venomous European colubrid which inhabits a great variety of environments from sea level up to 2000 m a.s.l**.** The species is widely distributed throughout southwestern Europe (Naulleau, 1997). Despite its abundance, this species has been poorly studied in general (e.g. Ciofi & Chelazzi, 1991, 1994; Capula *et al.,* 1995, 1997; Capula & Luiselli, 1995; Rugiero & Luiselli, 1995), most previous studies being focused mainly on morphological variability (Scali *et al.,* 2003), taxonomy (Kramer, 1971; Shätti & Vanni, 1986), home range (Ciofi & Chelazzi, 1991, 1994), dietary habits (Rugiero & Luiselli, 1995; Capizzi & Luiselli, 1996), and ecological modelling of its habitat features (Luiselli, 2006). Previously divided in three different subspecies (*H. v. viridiflavus, H. v. carbonarius* and *H. v. kratzeri*) (Kramer, 1973), the general tendency in last years has been to consider the species as monotypic and highly polymorphic (Shätti & Vanni, 1986). New interest has recently arisen and the current trend is again to consider the existence of different subspecies on the basis of morphological (Scali *et al.,* 2003) and genetic studies (Nagy *et al.,* 2003).

However, accurate data about sexual size dimorphism (SSD) and geographic variation within the species distribution range are still missing. Therefore it is of great interest to describe the occurrence of any geographic variation of meristic and morphometric features and its possible correlation with different ecological patterns (i.e. dietary habits, reproductive strategies), as in the case of mainland versus large or small island populations (Zuffi, 2001; Scali *et al.,* 2003; Fornasiero, 2004; Zuffi *et al.,* 2005).

STUDY AREA AND METHODS

264 adult specimens of *H. viridiflavus* were considered, both from herpetological collections of Florence, Pisa and Milan and from several field researches. The living snakes were captured by hand, then measured, marked (by ventral scale clipping) and released at their capture sites. Adult size (=sexual maturity) was determined from available literature on the species (Bruno & Maugeri, 1990) and from dissections of preserved or freshly killed snakes as in Shine (1988): immature females have small follicles (less than 5 mm diameter) and males have not spermatozoa in the deferent ducts (Zuffi unpubl.). The study areas from where our *H. viridiflavus* specimens originated are illustrated in Figure 1.

For every living or dead specimen standard morphological measures were considered (to ± 1 mm): snout-vent length (SVL), obtained stretching animals along a rule, to their physical extent so muscle contraction was no longer an issue; number of ventral scales (VS) according to Dowling (1951); head width (HW), inter-orbital distance (IO), head length (HL). Head size parameters were selected in order to test for any possible source of variation of head shape when compared to sex and area. We pooled together in the analyses both alcohol preserved and living specimens, due to the fact that muscle contraction in preserved as well as in living snakes is similar, reducing variability to a minimum and acceptable extent (Reed, 2001). For some specimens not all the measures were available, so the sample size is subjected to variations depending on the variable considered. In Table I we report sample sizes for sex and each locality. Data were at first analyzed in order to test for any general pattern of sexual dimorphism within the species. We then considered a more specific analysis to highlight any possible difference among the populations considered. These analyses were performed only on males, due to the reduced female sample size for some populations. The examined sample was then subdivided into three groups corresponding to areas with different geographic characteristics: mainland, large island and small island populations, to underline any possible area effect. Large islands are those islands of great surface (i.e. Corsica, Sardinia and Elba), while small islands are those that have an average surface lower than or about 50 square kilometres (see Table I). At this stage we did not consider habitat characteristics, relative position between and among islands and altitude at the higher point in each island. Also in this set of analyses we considered only male sample. Data are presented as average ± 1 SD (e.g. in Table II). Prior to any analysis, all the measurements were tested for normality and natural-log transformed to reach the assumption of normality when violated. All analyses were then performed on log-transformed data. When even transformation failed for this purpose, data were analyzed using non parametric statistics. We used Student t test and Mann-Whitney U test to compare male and female data sets; an ANOVA, for

Figure 1. — Geographic source of the material examined. Line bar equals 220 km.

TABLE I

Sample sizes for sex and each locality (island surface area in squared km) considered

		Pisa	Montecristo	Capraia	Corsica	Sardinia	Asinara	Giglio	Pianosa	Elba
Surface (Km^2)			10.40	19.30	8722	24000	52.00	21.20	10.25	223.50
Males	SVL	43	53	6	13	19	23	8	8	5
	TL	33	40	5	12	12	15	1	5	3
	VS	34	53	6	13	19	23	7	8	5
	HL	20	39	6	12	21	22	8	8	5
	HW	15	39	6	10	21	21	8	7	5
	IO	20	39	6	12	21	23	8	8	5
Females	SVL	12	30	4	2	5	9	/	1	1
	TL	11	22	4	2	2	7	/	1	1
	VS	9	30	4	2	5	9	/	1	1
	HL	6	21	4	2	5	9	/	1	/
	HW	5	21	4	2	5	8	/	1	1
	IO	5	21	4	2	5	9	/	1	1

single variable (i.e. VS) as the dependent variable and locality as the factor and a Bonferroni post-hoc multiple test for any significant factor; an ANCOVA, with single head measurement as dependent variable, lnSVL as the covariate and locality as the factor was performed for male variation among localities, using then a Bonferroni post-hoc multiple test for any significant factor. A MANCOVA was then performed for head variables, using lnSVL as a covariate and sex or area type as factor. The homogeneity of slopes assumption was met for the analyses. All tests were two-tailed, and set at $\alpha = 0.05$. Statistical procedures were performed with SPSS 8.0.

RESULTS

Sexual dimorphism

The species presented a strong sexual size dimorphism (SSD), with males being significantly longer than females (lnSVL, unpaired Student t-test, $t = 6.070$, df = 143, 160, $P < 0.001$). All head size measures (HL, HW, IO) were strongly correlated to body size (Pearson correlation, all $P < 0.001$), therefore, we took into account such relationship to examine sexual dimorphism for head parameters. A MANCOVA with lnSVL as a covariate, sex as the factor, lnHL, lnHW and lnIO as the dependent variables was then performed. The overall model MANCOVA was significant for sex (Wilks' lambda, $\lambda = 0.642$, $P < 0.001$) and between-subjects effects suggested that males had significantly longer (lnHL, $F_{1,171} = 57.927$, $P < 0.001$) and larger (lnHW, $F_{1,171} = 48.008$, $P < 0.001$; lnIO, $F_{1,171} = 89.581$, $P < 0.001$) heads than females. VS also differed between sexes, with females showing a higher number of VS than males (Mann-Whitney U-test, $U = 205$, n males = 168, n females = 61, $P < 0.001$).

Intraspecific differences and area effect

A first ANOVA revealed that SVL significantly varied in the considered sample (ANOVA, with lnSVL as the dependent variable and locality as the factor, $F_{8,169} = 32.681$, $P < 0.001$). A Bonferroni post-hoc test revealed that mainland coastal snakes from Pisa attained larger SVL than animals from the other populations considered (all with $P < 0.001$), except snakes from Elba which, in fact, did not differ significantly from the mainland ones. All island snakes tended to be smaller in terms of SVL, with Montecristo animals being the shortest ones. All multiple comparisons results are shown in Figure 2.

HW also differed significantly among populations (ANCOVA, with lnHW as the dependent variable, lnSVL as the covariate and locality as the factor, $F_{8,157} = 8.506$, $P < 0.001$). However, Bonferroni post-hoc test failed to reveal any clear pattern of head width variation: only a few comparisons were statistically significant (with Sardinian animals showing larger heads than Montecristo and Capraia ones, $P < 0.001$ and $P = 0.018$ respectively and with Corsica snakes having larger heads than Montecristo ones, $P = 0.003$). An ANCOVA, with lnHL as the dependent variable, lnSVL as the covariate and locality as the factor revealed that HL significantly varied among areas ($F_{8,128} = 6.133$, $P < 0.001$), but Bonferroni post-hoc test revealed significant differences only for Sardinia *vs* Pisa, Montecristo, Capraia and Corsica (all comparisons, $P < 0.005$). IO distance differed significantly (ANCOVA, with lnIO as the dependent variable, lnSVL as the covariate and locality as the factor, $F_{8,129} = 3.579$, $P = 0.001$) and once more Sardinian animals had greater IO than samples from Montecristo (Post-hoc Bonferroni test, $P = 0.009$) and Pisa ($P = 0.016$). All other multiple comparisons were not statistically significant.

Male VS significantly differed among localities (ANOVA, with VS as the dependent variable and locality as the factor, $F_{8,159} = 5.132$, $P < 0.001$), and, after Bonferroni post-hoc test, it resulted that snakes from Montecristo, Capraia and Corsica tended to have a high number of VS, while those from Pisa, Sardinia and Asinara island showed a very low value for this parameter (Figure 3).

Geographic characteristics of the areas considered had a strong effect on snake SVL (ANOVA, with lnSVL as the dependent variable and area type as the factor, $F_{2,175} = 108.519$, $P < 0.001$). All Bonferroni Post-hoc multiple comparisons were highly significant (all $P = 0.001$), showing the importance of insularity and of island surface on snake mean size (Figure 4).

TABLE II

Average value (mm) ± 1 SD for sex and each locality considered

|		Pisa	Montecristo	Capraia	Corsica	Sardinia	Asinara	Giglio	Pianosa	Elba
Males	SVL	998.91 ± 101.72	726.44 ± 68.71	791.5 ± 95.5	807.08 ± 104.53	769.63 ± 77.76	745.96 ± 67.4	798.12 ± 63.3	831.63 ± 76.4	903 ± 122.25
	TL	1302 ± 121.09	1004.76 ± 96.07	1082.6 ± 148.28	1089.42 ± 137.71	1065.67 ± 92.91	1014.53 ± 86.51	1045	1154.4 ± 104.21	1055.67 ± 66.98
	VS	201.47 ± 2.79	205.38 ± 3.86	207.5 ± 3.67	206.23 ± 5.28	201.84 ± 5.36	202.13 ± 4.84	206.14 ± 2.41	204.75 ± 2.31	203.8 ± 1.64
	HL	24.985 ± 2.166	20.103 ± 1.16	21.4 ± 2.403	21.925 ± 2.589	22.974 ± 2.47	21.275 ± 1.916	22.825 ± 1.422	22.9 ± 1.694	24.48 ± 1.615
	HW	19.98 ± 3.45	13.064 ± 1.633	14.567 ± 2.862	16.6 ± 3.033	16.843 ± 2.676	14.881 ± 1.966	16.063 ± 1.954	17.343 ± 2.579	18.26 ± 2.831
	IO	11.43 ± 0.821	9.354 ± 0.577	9.95 ± 1.033	10.333 ± 1.559	10.395 ± 0.859	10.026 ± 1	10.325 ± 0.573	10.463 ± 0.773	10.82 ± 1.182
Females	SVL	851.33 ± 94.53	694.77 ± 58.51	749.75 ± 75.36	748.5 ± 99.7	649 ± 41.84	662.44 ± 46.35	/	810	785
	TL	1116.73 ± 136.73	926.36 ± 66.4	1016.75 ± 92.89	1005 ± 123.04	902.5 ± 88.39	889.43 ± 57.39	/	1087	1090
	VS	214.22 ± 3.49	217.47 ± 3.95	219.75 ± 4.99	215.5 ± 2.12	215.6 ± 3.29	215.56 ± 4.61	/	221	216
	HL	21.283 ± 1.671	18.681 ± 0.785	19.85 ± 0.971	18.85 ± 1.909	18.62 ± 1.279	17.989 ± 0.993	/	21.1	/
	HW	15.94 ± 0.835	10.743 ± 1.040	13.65 ± 0.705	12.15 ± 1.344	12.84 ± 0.948	11.138 ± 1.303	/	14.8	11.6
	IO	9.96 ± 0.59	8.262 ± 0.466	9.2 ± 0.283	8.45 ± 0.212	8.56 ± 0.568	8.383 ± 0.492	/	9.5	7.7
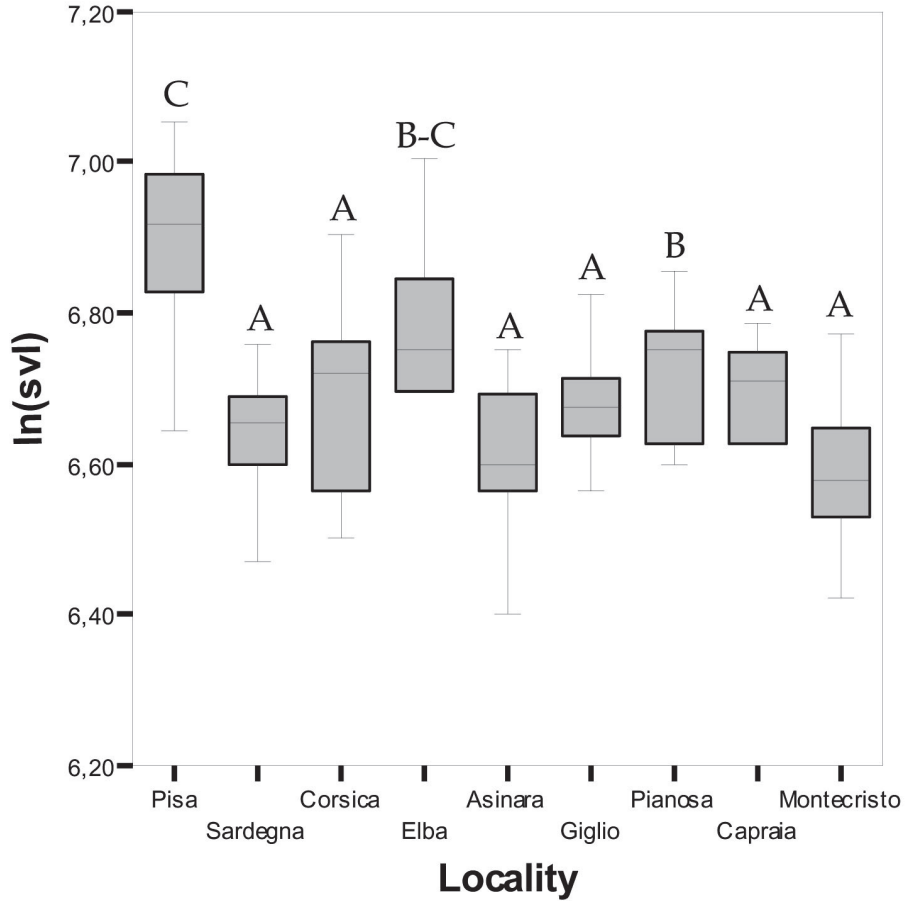
Figure 2. — Geographic variations in males SVL. Box represents the interquartile range, the line across the box indicates the median, the minimal and maximal values are provided with the whiskers. The same letters correspond to statistically similar groups, while different letters designate statistically different groups.

We did not find any significant area effect on snake IO, while HL and HW significantly varied among the considered groups (MANCOVA, with lnIO, lnHL and lnHW as the dependent variables, lnSVL as the covariate and area type as the factor, overall model MANCOVA Wilks' lambda, $\lambda = 0.822$, $P < 0.001$, $F_{2,125} = 2.769$, $P = 0.067$, $F_{2,125} = 4.378$, $P = 0.015$ and $F_{2,125} = 8.396$, $P < 0.001$ respectively). Large island animals had significantly longer and larger heads than mainland ones (Post-hoc Bonferroni test $P = 0.012$ and $P = 0.014$) and significantly larger than small insular ones $(P = 0.001)$. All other multiple comparisons were not statistically significant.

Insularity had also a strong effect on male VS (ANOVA, with VS as the dependent variable and area type as the factor, $F_{2,165} = 7.027$, $P = 0.001$, small island *vs* mainland animals $P = 0.001$, all other Post-hoc Bonferroni tests were n.s. See Figure 5 for details).
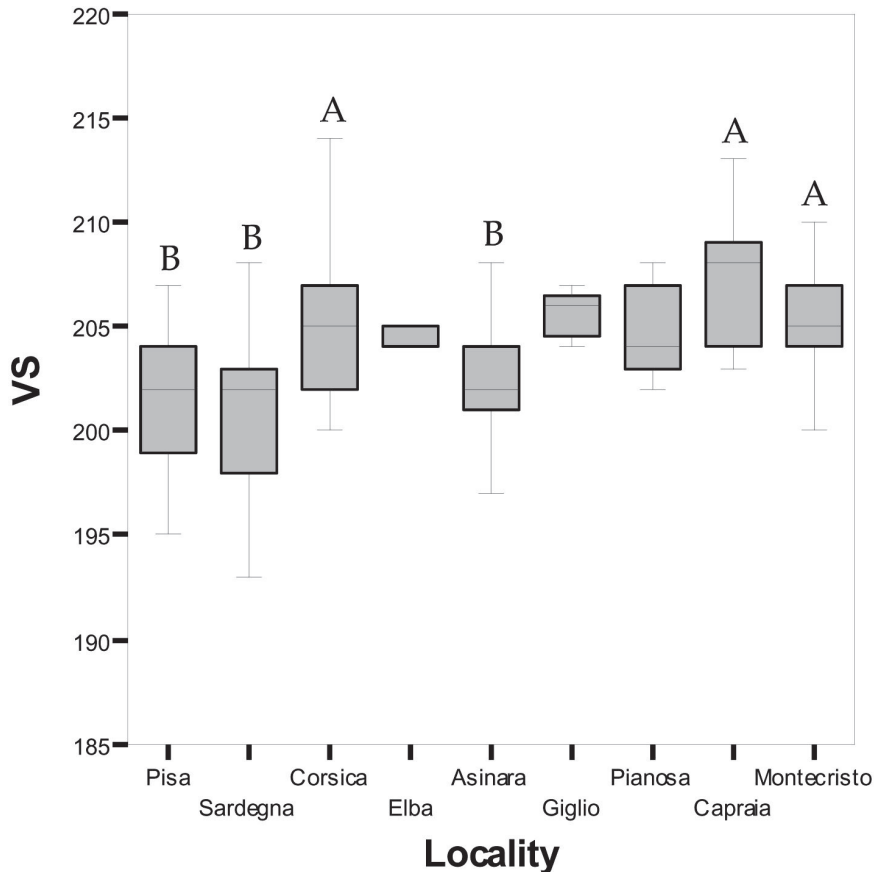
Figure 3. — Geographic variations in males VS. Box represents the interquartile range, the line across the box indicates the median, the minimal and maximal values are provided with the whiskers. The same letters correspond to statistically similar groups, while different letters designate statistically different groups.

DISCUSSION

The recently established concept of living in a cylinder (Shine *et al.,* 2000) has, in most snake species, produced several adaptive features. The overall body size in the European Whip snake was markedly different between sexes, with males significantly larger than females, in contrast with the general pattern already highlighted in most colubrid snakes (Shine, 1993, 1994). Nevertheless our work confirms, using a large data set never considered before on such a wide geographical range, previous scattered results (Shine, 1994) and descriptive, but not statistically analyzed, data already reported for this species (Schätti & Vanni, 1986). Given that male-male combats occur in our study species (Bruno & Maugeri, 1990; Capula *et al.,* 1997), the most probable hypothesis is that larger-male oriented SSD can be evolved in *H. viridiflavus* as a consequence of the sexual selection favouring the largest male during the mating bouts (Shine, 1994).

Head size and shape was markedly dimorphic in our species. Significance of head size dimorphism has been longly debated (e.g. Shine, 1993; Forsman, 1994) with contrasting hypotheses, ranging from the efficiency in male-male combat behaviour favouring those specimens having larger head size (but see Shine, 1993 and references therein) to the evolution of
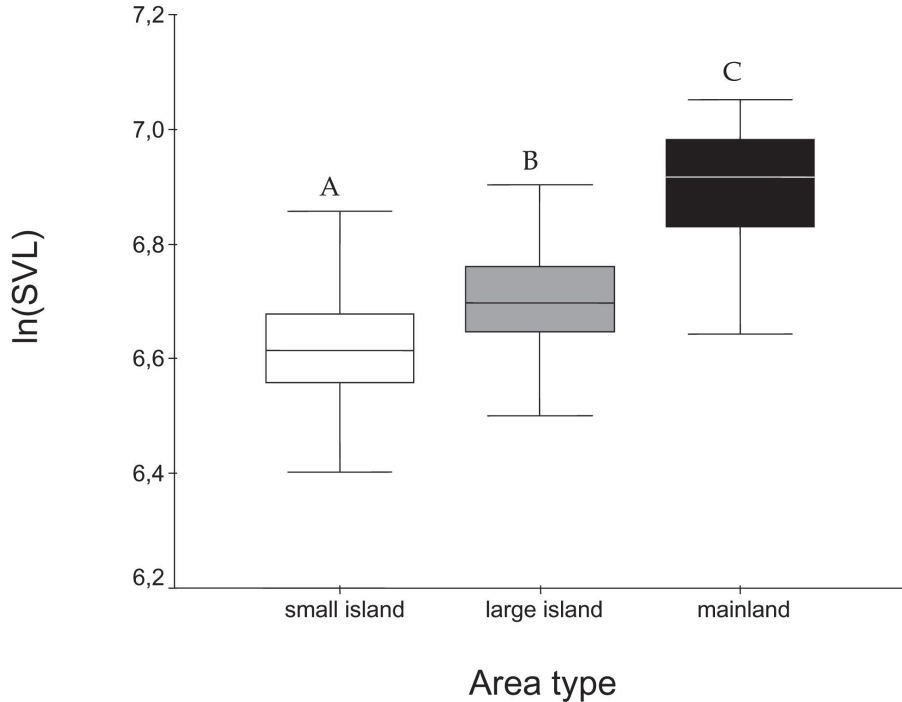
Figure 4. — Area effect on males SVL. Box represents the interquartile range, the line across the box indicates the median, the minimal and maximal values are provided with the whiskers. The different letters designate statistically different groups.

a larger head size to limit or avoid any possible intersexual competition for food (e.g. Houston & Shine, 1993; Shetty & Shine, 2002; Shine *et al.,* 2002). The various sets of hypotheses have also been complicated by the fact that there are a few species where, at the same body length, the females have the larger heads (Luiselli *et al.,* 2002). In our study area, body size variation interestingly suggests an allometric and differentiated system between small islands, large islands and continental areas. Nevertheless any body size-age relationship in the European Whip snake has not yet been described (but see Fornasiero, 2004), nor any possible interpretation of significant body size differences is still available for the whole Mediterranean area. It therefore should be logical to hypothesize that possible interaction between local food availability (Zuffi, 2001) and local growth rate patterns are strictly related to the pattern observed (Forsman, 1991, 1994; Bonnet *et al.,* 2001).

Other than body size *per s*e, we also found that the meristic parameters were highly dimorphic, with females showing an higher number of ventral scales than males (Shine, 2000). Particularly evident, at least in the male studied sample, are the strong relationships between higher ventral scale number and the geographic origin, with smaller island snakes characterized by a significantly higher number of ventral scales.

It has been since long time documented that ventral scale number has a strong genetic determinism (Dohm & Garland, 1993), but also that any within-population ventral scale variation may be the result of a differentiated thermal profile during embryogenesis (Lourdais *et al.,* 2004). Despite any possible local variations, our study clearly reveals that snakes from large islands and from the mainland are significantly characterized by a lower belly fragmentation when compared to conspecifics from small islands. As reported above, the snakes of the considered area are still monotypic and no genetical studies are yet available. However, small Tyrrhenian islands have been geographically separated from mainland from a minimum of 18 000
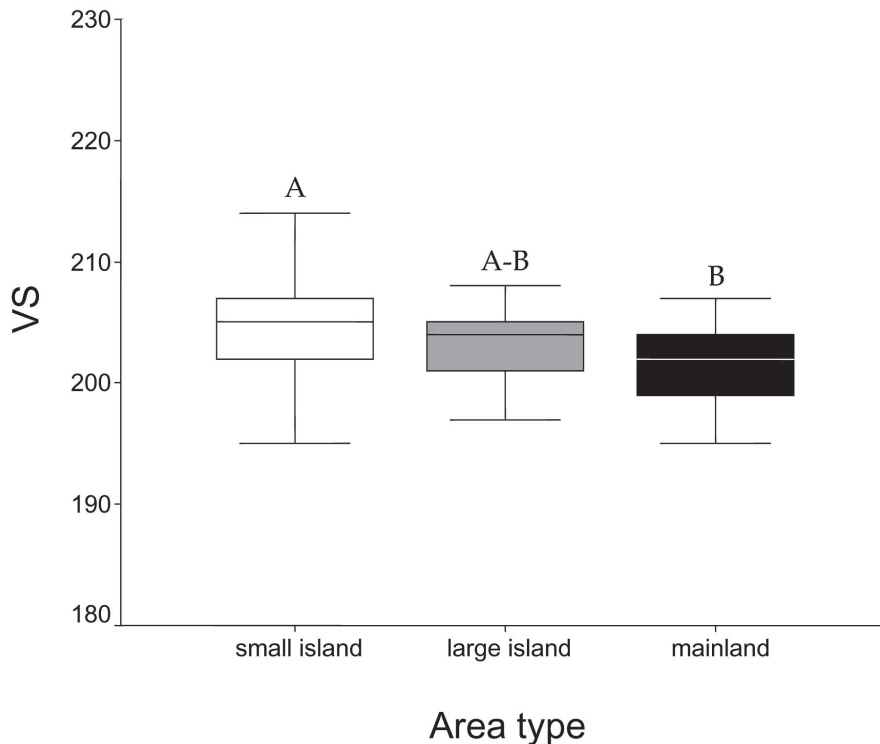
Figure 5. — Area effect on males VS. Box represents the interquartile range, the line across the box indicates the median, the minimal and maximal values are provided with the whiskers. The same letters correspond to statistically similar groups, while different letters designate statistically different groups.

(Würm) to at least 125 000 years (Lower Pleistocene) (Bossio *et al.,* 2000). As a consequence isolation time may have originated the observed patterns of variation. Hence, the hypothesis that our samples could be controlled by a phylogenetic origin is not so controversial.

It should be therefore noted that our results may likely represent a mixed scenario. It has yet to be demonstrated whether the selective pressure of a differentiated energy intake model (low *vs* high food energy) may minimize or maximize whip snake body size and growth rates (Bonnet *et al.,* 2001; Wüster *et al.,* 2005) independently of the phylogeographic frame. Or, as alternative hypothesis, whether the phylogenetic inertia has definitely influenced and determined any possible range of variation of allometric growth rate in these Mediterranean populations.

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APPENDIX 1

List of voucher specimens of scientific collections

MSNM1185	MSNM1350	MSNM1368	MSNM1368	MSNM1606	MSNM3274
MSNT1042	MSNT1074	MSNT1134	MSNT1135	MSNT1136	MSNT113
MSNT1138	MSNT1140	MSNT1141	MSNT1147	MSNT1159	MSNT1160
MSNT1161	MSNT1162	MSNT1163	MSNT1164	MSNT1165	MSNT1175
MSNT1176	MSNT1177	MSNT1178	MSNT1179	MSNT1180	MSNT1181
MSNT1182	MSNT1183	MSNT1184	MSNT1184/2	MSNT1191	MSNT1215
MSNT1215/1	MSNT1221	MSNT1222	MSNT845	MSNT14	MZUF10170
MZUF10171	MZUF10172	MZUF10173	MZUF10542	MZUF15588	MZUF15589
MZUF1559	MZUF15591	MZUF15592	MZUF15593	MZUF15594	MZUF15665
MZUF18203	MZUF19180	MZUF20310	MZUF22195	MZUF22196	MZUF22444
MZUF22658	MZUF22659	MZUF25298	MZUF25363	MZUF25364	MZUF25365
MZUF 25483	MZUF2859	MZUF29147	MZUF29624	MZUF29631	MZUF29657
MZUF30081	MZUF30536	MZUF30537	MZUF30539	MZUF30700	MZUF30714
MZUF3138	MZUF31389	MZUF31390	MZUF31728	MZUF31729	MZUF31731
MZUF31732	MZUF32278	MZUF32299	MZUF32763	MZUF32764	MZUF32765
MZUF 32789	MZUF32790	MZUF32791	MZUF33505	MZUF35708	MZUF35845
MZUF36704	MZUF36709	MZUF36710	MZUF36711	MZUF36720	MZUF38266
MZUF38548	MZUF4124	MZUF4125	MZUF7841	MZUF7863	MZUF7864
MZUF9842	MZUF9843	MZUF7839	MZUF7840		

MSNM = Museo Civico di Storia Naturale di Milano; MSNT = Museo di Storia Naturale e del Territorio, Università di Pisa; MZUF = Museo di Storia Naturale, sezione di Zoologia, Università di Firenze