MORPHOMETRIC ANALYSIS AND SEXUAL DIMORPHISM OF EXTINCT ADDERS (*VIPERA BERUS*) OF THE PO PLANE (NORTHERN ITALY)

Stefano Scali[1] and Augusto Gentilli[2]

[1] *Museo Civico di Storia Naturale*
c.so Venezia 55, 20121 Milano, Italy
e-mail: scaliste@iol.it
[2] *Dipartimento Biologia Animale, Università degli Studi di Pavia,*
p.zza Botta 7, 27100 Pavia, Italy
e-mail: augusto.gentilli@unimi.it

Abstract: *Vipera berus* has been disappeared in the Po Plane about a century ago; it was present in some areas of the central and eastern lowlands of Northern Italy. The authors have been conducted a morphometric analysis of specimens still present in Italian museums. Some lepidotic and morphometric data have been collected. Data were analysed using descriptive, non-parametric and multivariate techniques; some body measures ratios have been also analysed.

Sexual dimorphism has been observed for the following variables: subcaudal scales, number of minor scales in the fore head, frontal and parietal scales length, tail length, body/tail length and body/head length ratios. Sexual dimorphism has been confirmed by stepwise discriminant analysis, that underlines the importance of subcaudal scales.

Key words: *Vipera berus*, sexual dimorphism, morphometry, lepidosis, Northern Italy.

Introduction

Vipera berus was present in the Po Plane in the last century, but it disappeared about one hundred years ago. This species is still present in Italy on the Alps. Some specimens belonging to these populations are preserved in some museum collections (Torino, Pavia, Verona, Treviso, Firenze, London).

Information about distribution of these adders are available in literature (Angelini, 1817; Bendiscioli, 1826; De Filippi, 1840; Prada, 1840; Balsamo Crivelli, 1844; De Betta, 1857, 1874, 1880; Massalongo, 1853, 1854, 1859; Scarpa, 1874; Lessona, 1877, 1879; Nardo, 1859; Ninni, 1879, 1880; Paglia, 1879; Camerano, 1888; Arrigoni degli Oddi, 1895; Capra, 1954; Bruno, 1992), but data regarding morphometry, lepidosis and sexual dimorphism are lacking (Camerano, 1888; Bruno, 1992). The aim of this paper is the knowledge of external morphometric characteristics of these extinct adders, in order to give instruments for further investigations about systematics and biogeography of *Vipera berus* in Italy (Gentilli and Scali, in prep.).

Material and Methods

We found 15 adders in the Museo Civico di Storia Naturale di Verona, 2 in the Museo Zoologico dell'Università di Firenze, 2 in the Museo Zoologico dell'Università di Pavia, 2 in the Museo Zoologico Scarpa di Treviso and 1 in the Museo Regionale di Scienze Naturali di Torino. Some information were also obtained from literature (Camerano, 1888; Boulenger, 1896). We recorded 26 variables for every specimen (tables 1, 2 and 3). All measures are in millimetres (R=right, L=left); we used a calliper to measure heads and major heads' scales. We measured head's length and width as reported in Fig. 1; we considered the maximum length and width for measured scales. Dorsal, ventral and subcaudal scales were counted in accordance with the method used by Saint Girons (1978). All data were analysed using univariate and multivariate techniques; in particular Mann-Whitney U test and discriminant analysis were applied. Discriminant analysis was performed with direct and stepwise methods, the first one to verify the existence of discrimination between sexes; the second one to define discriminant variables (Marnell, 1998). Statistical analysis was conducted using SPSS software, rel. 6.1.2.

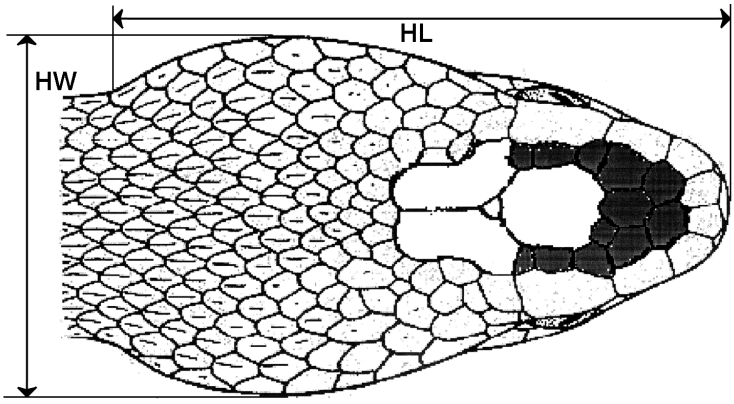

Fig. 1: Head's measures; front dorsal head scales (DH) are pointed out.

Head	Length	HL
	Width	HW
Body	Length	BL
Tail	Length	TL

Tab. 1: Body measures and abbreviations

Parietals (R, L)	Length	PL
	Width	PW
Frontal	Length	FL
	Width	FW

Tab. 2: Scales measures and abbreviations

Ventrals	V	Nasals (R, L)	N
Subcaudals	SC	Supralabials (R, L)	SL
Dorsals	D	N° of lines of suboculars (R, L)	LSO
Apicals (R, L)	A	Preoculars (R, L)	PRO
Canthals (R, L)	C	Postoculars (R, L)	POO
Sopraoculars (R, L)	SO	Lower labials (R, L)	LL
Front dorsal head scales (see Fig. 1)	DH	Mental (R, L)	M
Rostral	R	Anterior chin shields (R, L)	ACS
Prenasals (R, L)	PN	Posterior chin shields (R, L)	PCS

Tab. 3: Lepidosis: recorded variables and abbreviations

Results

24 specimens were measured, 11 males and 13 females. Descriptive statistics of HL, HW, BL, TL, BL/HL, PL, PW, FL, FW, V, SC and DH are reported in Table 4.

Sexual dimorphism was verified using Mann-Whitney U test for all variables in database. Tail length and number of subcaudal scales resulted significantly different: males have longer tails and a greater number of subcaudal scales (TL: Z=-2.7833, P=0.0054; SC: Z=-2.9653, P=0.0030). BL/HL ratio was significantly different comparing sexes (Z=-2.5350, P=0.0112). Mean male to female head length ratio in our sample was 93%.

Some differences were observed between sexes as far as head's scales are concerned. In particular, males have greater scales than females; the dimensions of some scales resulted significantly different comparing sexes (PW-R: Z=-2.0867, P=0.0369; PL-R: Z=-2.1963, P=0.0281; PL-L: Z=-2.0827, P=0.0373; FL: Z=-2.5955, P=0.0094). Females have a greater number of scales compared to males (DH: Z=-3.3560, P<0.0008; LSO-R: Z=-2.5100, P=0.0121). Discriminant analysis, using body scales and measures, produced a perfect distinction between sexes with direct method, classifying 100% of cases correctly (χ^2≤=24.612; d.f.=6; P=0.0004; Wilks' λ=0.214752).

Stepwise analysis underlines the importance of subcaudal scales and head width for discrimination (SC: Wilks' λ=0.36410, P=0.0000; HW: Wilks' λ=0.27014, P=0.0000). The first variable has a positive correlation with canonical discriminant function, while the second one is negatively correlated. These data demonstrate that males have a greater number of subcaudal scales and narrower heads.

Discriminant analysis was also used to test differences in number and dimension of head's scales between males and females. We observed a significant difference between sexes, with a correct classification of 100% (χ^2≤=13.652; d.f.=7; P=0.05; Wilks' λ=0.272481). Stepwise analysis showed that DH and FW are fundamental for sexual discrimination (DH: Wilks' λ=0.62528, P=0.01; FW: Wilks' (=0.36514, P=0.001). Males have a smaller number of front dorsal head scales and a larger frontal scale, as demonstrated by positive correlation of DH with canonical discriminant function and the negative one of FW.

Variable	Males (N=11)				Females (N=13)			
	Min.	Max.	Mean	S.E.	Min.	Max.	Mean	S.E.
HL	19.3	25.8	22.5	0.6	15.3	34.6	24.1	1.3
HW	10.7	15.9	13.6	0.6	9.2	19.0	14.0	0.8
BL	311.4	536.0	437.0	21.3	173.7	690.0	420.9	37.1
TL	44.0	92.0	76.3	5.0	28.0	100.0	56.6	5.7
BL/HL	14.4	23.3	19.5	0.8	9.0	22.0	15.5	1.2
PL-R	3.5	6.2	4.8	0.3	2.6	5.2	3.9	0.2
PL-L	3.8	6.3	4.8	0.3	2.8	5.0	4.0	0.2
PW-R	2.2	3.3	2.6	0.1	1.6	3.0	2.2	0.1
PW-L	2.0	3.4	2.6	0.1	1.8	2.8	2.3	0.1
FL	3.7	5.7	4.6	0.2	2.7	4.5	3.7	0.2
FW	2.6	3.7	3.3	0.1	2.3	3.7	2.9	0.2
V	136.0	148.0	142.1	1.1	140.0	154.0	145.9	1.3
SC	35.0	47.0	41.5	1.1	29.0	42.0	33.8	1.1
DH	7.0	13.0	10.5	0.8	11.0	30.0	17.6	1.7

Tab. 4: Descriptive statistics of adders' measures and main scales

Discussion

Sexual dimorphism was observed in measured specimens. Tail length resulted significantly greater in males than in females. Some other variables have different, but not significant, mean values: females have longer and wider heads; males have longer bodies and tails. So females have proportionally longer heads in relation to body length. Our result of mean male to female head length ratio (93%) is higher in comparison to Forsman's one (89%) (1991a). Some authors found longer females than males (Saint Girons, 1978; Kminiak and Kalúz, 1983; Forsman, 1991a, b; Lindell *et al*., 1993; Shine, 1994). Our data confirm, on the contrary, Zuffi observations (1992) about an Italian alpine population with larger males than females.

The number of subcaudal scales resulted significantly greater in males than in females; no significant differences were observed as far as ventral scales are concerned, but females have higher mean values than males. These observations confirm data of Saint Girons (1978) and Kminiak and Kal˙z (1983). Some authors (Kminiak and Kal˙z, 1983; Lindell *et al*., 1993) found females having a significantly higher number of ventral scales compared to males.

Discriminant analysis stressed the importance of subcaudal scales and head width for sexual distinction. Subcaudal scales' number is an important sexual discriminant factor in colubrid and viperid snakes (Van Gelder *et al*., 1988; Feriche *et al*., 1993; Scali and Montonati, in press; Scali, Montonati and Dimitolo, in press).

Although head's dimensions are different between sexes in many species (Camilleri and Shine, 1990; Shine, 1993; Werner, 1994; Springolo and Scali, 1998) or between similar species in relation to prey selection (Dwyer and Kaiser, 1997), no evidence were found in literature about it, as far as *Vipera berus* is concerned.

The increase of head's scales fragmentation is a derived state in evolved viperid snakes (Marx and Rabb, 1965; Saint Girons, 1978). Our data show a significant difference of fragmentation between sexes: females have a greater number of cephalic scales than males; moreover frontal and parietal scales are smaller in females. Discriminant analysis shows that the main variables in sexual distinction are the number of front dorsal head scales and frontal scale width.

Finally, adders of the Po Plain show a clear sexual dimorphism as far as body size and head's scales fragmentation is concerned.

Acknowledgements: We would like to thank all the museums which allowed us to study their collections. We also thank Dr. Marco Zuffi for precious help in measuring Florence's specimens. Thank you to Dr. Edoardo Razzetti for useful bibliographic suggestions.

References

- Angelini B. (1817): Del marasso o *Vipera chersea* rinvenuta nel territorio veronese. Bibl. Ital. Milano 2 (7): 451-459.
- Arrigoni Degli Oddi E. (1895): Materiali per la fauna padovana dei vertebrati. I. (Mammiferi, Rettili, Anfibi e Pesci). Atti Soc. Ven-Tren. Sci. nat. Padova, Serie 2 2 (1): 1-81.
- Balsamo Crivelli G. (1844): III. Rettili finora osservati in Lombardia. In Di CATTANEO C.: Notizie naturali e civili su la Lombardia. Tip. Bernardoni, Milano [tot: 1-492, 4 tavv.]: 386-389.
- Bendiscioli G. (1826): Monografia dei serpenti della provincia di Mantova. Giorn. Fis. Chim. Med. Stor. nat., Pavia 9 (2): 413-434.
- Boulenger G.A. (1896): Catalogue of the snakes in the British Museum (Natural History). Taylor and

Francis Ltd., London 3: XIV + 727 + 25 pl.
• Bruno S. (1992): Repertorio zoogeografico, geonemico, tassonomico, biografico e bibliografico degli studiosi e degli studi di erpetologia italiana. I. Serpentes: 1800-1899. Atti Acc. Rov. Agiati, a. 241 (1991), Serie VII 1, B: 5-256.
• Camerano L. (1888): Monografia degli ofidi italiani. Parte prima: Viperidi. Mem. R. Accad. Sci. Torino, Serie II 39: 195-243.
• Camilleri C., Shine R. (1990): Sexual dimorphism and dietary divergence: differences in trophic morphology between male and female snakes. Copeia 1990 (3): 649-658.
• Capra F. (1954): La *Vipera berus* L. in Piemonte. Ann. Mus. civ. Stor. nat. Genova 66: 301-312.
• De Betta E. (1857): Erpetologia delle provincie venete e del Tirolo meridionale. Atti Mem. Acc. Agr. Sci. Lett., Verona 35: 1-365.
• De Betta E. (1874): Rettili ed Anfibi. Parte IV. In: Fauna d'Italia divisa in due branche Vertebrati ed Invertebrati, Vallardi, Milano: 1-107.
• De Betta E. (1880): Sulla distribuzione geografica dei serpenti velenosi in Europa e particolarmente nell'Italia. Atti r. Ist. ven. Sci. Lett. Arti, Venezia 6: 359-392.
• De Filippi F. (1840): Catalogo ragionato e descrittivo della raccolta de' Serpenti del Museo dell'I. R. Università di Pavia. Bibl. Ital., Milano 99: 163-187, 306-343.
• Dwyer C.M., Kaiser H. (1997): Relationship between skull form and prey selection in the Thamnophiine snake genera *Nerodia* and *Regina.* J. Herp. 31 (4): 463-475.
• Feriche M., Pleguezelos M., Cerro A. (1993) - Sexual dimorphism and sexing of Mediterranean colubrids based on external characteristics. J. Herp. 27 (4): 357-362.
• Forsman A. (1991a): Adaptive variation in head size in *Vipera berus* L. populations. Biol. J. Linn. Soc. 43: 281-296.
• Forsman A. (1991b): Variation in sexual size dimorphism and maximum body size among adder populations: effects of prey size. J. Anim. Ecol. 60: 253-267.
• Gentilli A., Scali S. (in prep.): Morphometric comparison of present and extinct southern populations of *Vipera berus*.
• Kminiak M., Kal˙z S. (1983): Evaluation of sexual dimorphism in snakes (Ophidia, Squamata) based on external morphological characters. Folia Zoologica 32 (3): 259-270.
• Lessona M. (1877): Delle vipere in Piemonte. Atti R. Accad. Sci. fis. mat. Torino 12: 412-419.
• Lessona M. (1879): Nota intorno al *Pelias berus* in Piemonte. Atti R. Accad. Sci. fis. mat. Torino 14: 748-749.
• Lindell L.E., Forsman A., Merilä J. (1993): Variation in number of ventral scales in snakes: effects on body size, growth rate and survival in the adder, *Vipera berus*. J. Zool., Lond. 230: 101-115.
• Marnell F. (1998): Discriminant analysis of the terrestrial and aquatic habitat determinants of the smooth newt (*Triturus vulgaris)* and the common frog (*Rana temporaria*) in Ireland. J. Zool. Lond. 244: 1-6.
• Marx H., Rabb G.B. (1965): Relationships and zoogeography of the Viperine snakes (Family Viperidae). Fieldiana Zoology, 44 (21): 161-206.
• Massalongo A. (1853): Sopra un nuovo genere di rettili della provincia padovana. N. Ann. Sci. nat. Rend. Bologna, Serie III 7: 5-17.
• Massalongo A. (1854): Saggio di un'erpetologia popolare veronese, Verona, Tip. Giuseppe Antonelli: 1-56.
• Massalongo A. (1859): Catalogo dei rettili delle province venete. Atti R. Ist. Ven. Sci. Lett. Arti. Venezia 4: 300-310.
• Nardo G.D. (1859): Osservazioni ed aggiunte al catalogo de' rettili delle provincie venete pubblicato dal Prof. Massalongo. Atti R. Ist. Ven. Sci. Lett. Arti. Venezia, Serie III 4: 603-619.
• Ninni A.P. (1879): Breve nota intorno al marasso *Vipera (Pelias) berus* L. nel Veneto. Atti Soc.Ital.Sci. Nat., Milano 22: 175-181.
• Ninni A.P. (1880): Replica alle note del Comm. E. De Betta intitolata: sulla distribuzione geografica dei serpenti velenosi in Europa. Atti Soc. ital.Sci.Nat., Milano 23: 171-186.
• Paglia E. (1879): Saggio di studi naturali sul territorio Mantovano. V. Guastalla, Mantova: XII + 1-507.

• Prada T. (1840): Gli ofidiani della provincia di Pavia. Dissertazione inaugurale per laurea. Pavia: 1-55.
• Saint Girons H. (1978): Morphologie externe comparée et systématique des Vipères d'Europe (Reptilia, Viperidae). Revue Suisse Zool. 85 (3): 565-595.
• Scali S., Montonati S. (in press): Analisi multivariata del dimorfismo sessuale in due specie di colubrini italiani (*Coluber viridiflavus* e *Elaphe longissima*: Reptilia, Serpentes, Colubridae) su basi biometriche. Atti 1° Congresso S.H.I., Torino 2-6 Ottobre 1996.
• Scali S., Montonati S., Dimitolo G. (in press) - Analisi multivariata del dimorfismo sessuale nei natricini italiani (Reptilia, Serpentes, Colubridae) su basi biometriche. Atti 1° Congresso S.H.I., Torino 2-6 Ottobre 1996.
• Scarpa G. (1874): Catalogo di rettili ed anfibi del trevigiano. Atti Soc. ven.-tren. Sci. nat. Padova, 3: 192-199.
• Shine R. (1993): Sexual dimorphism in snakes. In: Seigel R.A., Collins J.T (eds.): Snakes - Ecology and behaviour. McGraw-Hill Inc., New York: XVI + 1-415.
• Shine R. (1994): Sexual size dimorphism in snakes revisited. Copeia 1994 (2): 326-346.
• Springolo M., Scali S. (1998): Sexual dimorphism and ontogenetic changes in *Coluber viridiflavus:* a head morphometric analysis. 9th S.E.H. O.G.M., Chambery 25-29 August 1998 (Abstract).
• Van Gelder J.J., Olders J.H.J., Mertens L.A.J.M., Kersten H.L.M. (1988): Field identification of the sex of the smooth snake (*Coronella austriaca* Laurenti). J. Herpetol. 22: 53-60.
• Werner Y.L. (1994): Head size variation in *Cerastes* (Ophidia: Viperidae) parallels body size variation in potential prey (Rodentia: Gerbillinae). Snake 26 (1): 57-60.
• Zuffi M. (1992): Il marasso, *Vipera berus* (L., 1758) in Trentino-Alto Adige: materiali per un approccio faunistico. Studi Trentini di Scienze Naturali, Acta Biologica 67 (1990): 255-262.