NAT. CROAT. | VOL. 8 | No 3 | 201–210 | ZAGREB | September 30, 1999

ISSN 1330-0520
UDK 504.54:598.112(450.2/.4)

original scientific paper / izvorni znanstveni rad

CLIMATIC AND ENVIRONMENTAL INFLUENCES ON THE DISTRIBUTION OF LACERTID LIZARDS IN THE SOUTHERN PO RIVER BASIN (NORTHERN ITALY)

STEFANO MAZZOTTI

Museo di Storia Naturale, Via De Pisis 24, I–44100 Ferrara, Italy
(e-mail: conszool@comune.fe.it)

Mazzotti, S.: Climatic and environmental influence on the distribution of lacertid lizards in the southern Po River Basin (Northern Italy). Nat. Croat., Vol. 8, No. 3., 201–210, 1999, Zagreb.

The present study is a synthesis of data collected from 1980 to 1997 on lacertid lizards in the southern Po river basin (Northern Italy), investigated using the data from the Herpetological Data base of the Natural History Museum of Ferrara. In this area three species of lacertid lizards were recorded: *Lacerta bilineata, Podarcis siculus* and *Podarcis muralis*. The ordination of the UTM 10x10 km squares showed that *P. muralis* and *L. bilineata* had no particular distribution whereas *P. siculus* was restricted to the coastal areas and the Po plain zone. The climatic analysis reflected the altitudinal differentiation as the three species showed quite evident differences in distribution in relation to temperature rainfall and the thermo-pluviometric index distribution. In general the frequency of all species was considerable in urban areas; *P. siculus* and *L. bilineata* were present above all in fallow fields while *P. muralis* preferred ruins and walls. The former species were also present in shrubs; whereas *P. siculus* preferred dunes and beaches, *P. muralis* gravel and stones.

Key words: Po River Basin, *Podarcis siculus*, *Podarcis muralis*, *Lacerta bilineata*, thermo-pluviometric gradient, altitudinal range, habitat selections

Mazzotti, S.: Utjecaj klime i okoliša na rasprostranjenje lacertidnih guštera u južnom porječju rijeke Po (Sjeverna Italija). Nat. Croat., Vol. 8, No. 3., 201–210, 1999, Zagreb.

Rad je sinteza podataka o lacertidnim gušterima, prikupljenih od 1980. do 1997. godine u južnom porječju rijeke Po (Sjeverna Italija) pri čemu su korišteni podaci Herpetološke baze podataka Prirodoslovnog muzeja u Ferrari. Na ovom području zabilježene su tri vrste lacertidnih guštera: *Lacerta bilineata, Podarcis siculus* i *Podarcis muralis*. Položaj UTM 10x10 km kvadranata pokazao je da *P. muralis* i *L. bilineata* imaju cjelovitu raspodjelu, dok je *P. siculus* ograničen na obalna područja i dolinu rijeke Po. Klimatska analiza odražavala je visinsku diferencijaciju, jer su tri vrste pokazale dosta evidentne razlike u distribuciji s obzirom na temperaturu, količinu oborina i termopluviometrijski indeks. Frekvencija svih vrsta uglavnom je bila znatna u gradskim područjima; *P. siculus* i *L. bilineata* bile su prisutne prije svega u zapuštenim poljima, dok je *P. muralis* preferirala ruševine i zidove. Ta je vrsta također bila nađena u niskom raslinju, dok je *P. siculus* više tražila dine i plaže, a *P. muralis* šljunak i kamenje.

Ključne riječi: porječje rijeke Po, *Podarcis siculus*, *Podarcis muralis*, *Lacerta bilineata*, termopluviometrijski gradijent, visinski raspon, izbor staništa

INTRODUCTION

Of the eighteen Lacertidae species present in Italy only three are found throughout the Italian peninsula (SHI, 1995): *Podarcis siculus* (Rafinesque-Schmaltz 1810) whose specific name was rectified by BÖHME (1997) has a circum-Tyrrhenian-Apennine-Dinaric distribution (CORTI *et al*., 1997); *Podarcis muralis* Laurenti, 1768 has a medio-South European-Anatolic distribution (GUILLAUME, 1997) and *Lacerta bilineata* Daudin, 1802, recently considered a species separate from *L. viridis* by RYKENA (1991) and AMANN *et al*. (1997), is a western European species. *Zootoca vivipara* is present in some sites in the north Po river plain (DELY & BÖHME, 1984; SALMASO & OSELLA, 1989; RICHARD & SEMENZATO, 1991). In the southern Po river basin it has been reported in historical literature (VANDONI, 1914; IMPARATI, 1940), but the present investigation did not confirm its occurrence. The distribution patterns of groups of cold-blooded vertebrates are influenced by climatic factors (DARLINGTON, 1957; HARVEY POUGH *et al*., 1998) in particular temperature and precipitation, which play also an important role in the regional distribution pattern of lacertid lizards (OWEN, 1989). The present study is a synthesis of data collected from 1980 to 1997 on lacertid lizards in the southern Po river basin (Northern Italy), using the data from the Herpetological Database of the Natural History Museum of Ferrara (MAZZOTTI & STAGNI, 1993; MAZZOTTI *et al*, 1999). This study represents the first eco-biogeographical analysis based on thermo-pluviometric gradients, altitudinal range and preferential selection of habitats.

STUDY AREA

The study area of 22,122 km^2, corresponding to the Emilia-Romagna Region, borders with the Po river to the North, the Apennines to the south and the Adriatic Sea to the East. This area may be subdivided into geophysical districts: mountain with a mean altitude of 1000 m plain and coast (Fig. 1). The climate is characterised by a thermo-pluviometric gradient in fact the temperature tends to decrease by 0.6 °C, while the annual rainfall increases by approximately 50 mm for each 100 m in height (SERVIZIO METEOROLOGICO REGIONALE, 1995). In the Apennine area this climatic gradient determines a phytoclimatic differentiation characterised by three vegetational belts: 1) mountain; 2) cool sub-Mediterranean; 3) warm sub-Mediterranean. The first belt is composed of beech woods and *Vaccinium* heaths the other two belts of *Ostryo-Aceretum* with *Sorbus aria*, *Calamagrostis varia* and *Aremonia agrimonoides* in the cool belt and *Ruscus aculeatus* and *Pyracantha coccinea* in the warm belt. In addition to these three belts the study area includes a plain district in which the Adriatic coastal zone and the inland Po plain zone are distinguishable (UBALDI *et al*., 1996) (Fig. 2). On the Adriatic coast there is a small residual portion of pine-woods and holm-oak woods (PICCOLI *et al*., 1983; CORBETTA *et al*., 1984). In the Po plain intense human influence has led to poor habitat differentiation. In fact the natural vegetation cover has almost completely been replaced by agricultural fields, arable land and orchards, fallow fields, grasslands and pastures.

Fig. 1. Map of the study area with UTM 10 10 km square grid system. In boldface 69 territorial units UTM 20 20 km used for the correlation of the distribution patterns of lacertid lizards in relation to climate.

Fig. 2. Phytoclimatic division of the study area: 1) mountain 2) cool sub-Mediterranean 3) warm sub-Mediterranean vegetation belts of the Apennine district and 4) the Po plain zone (modified from UBALDI *et al.*, 1996).

METHODS

The data were collected according to MAZZOTTI & STAGNI (1993) and the species distribution is reported on a UTM 10 10 km square grid system. In order to assess the distribution patterns of the three lacertid lizards in relation to climate the study area was divided into 69 UTM squares of 20 20 km (Fig. 1); the climatic data of the SERVIZIO METEOROLOGICO REGIONALE (1995) allowed us to estimate for each territorial unit the mean temperatures, the highest temperature value of the warmest month and the lowest temperature value of the coldest month, the mean annual rainfall and the thermo-pluviometric index according to EMBERGER (1971) (in UBALDI *et al.*, 1996): E = 1000 P/(M-m) (M+m)/2) where P is the mean annual rainfall (mm), M is the highest temperature value (°K) of the warmest month, and m is the lowest temperature value (°K) of the coldest month. The definition of habitat categories was made in part according to CORINE Biotopes (DEVILLERS *et al.*, 1991).

The species were analysed using one-way ANOVA according to the distribution of the relative frequency of temperature, rainfall, the thermo-pluviometric index, altitudinal range and preferential habitats.

RESULTS AND DISCUSSION

This investigation yielded 1074 records: *P. muralis* and *L. bilineata* occurred in 70.5 % and 66.8 % of the UTM square grid, respectively, more frequently than *P. siculus* (Tab. 1). The relative frequency of syntopic combination, calculated from all the data collected, showed a greater affinity between *P. muralis* and *L. bilineata* (40.2 %); *P.*

Tab. 1. Summary of the census of lacertid lizards of the southern Po river basin. Temperature rainfall and thermo-pluviometric index values corresponding to mean distribution area of each species.

	L. bilineata	*P. muralis*	*P. siculus*
n. records	407	465	202
n. UTM (10 10 km) squares	179	189	103
n. records per UTM squares	2.3	2.5	2.0
% UTM squares	66.8	70.5	38.4
altitudinal means (m)	333.8	529.4	156.4
SD	350.8	486.9	206.2
temperature means (°C)	12.0	11.4	12.7
SD	1.7	2.3	1.1
rainfall means (mm)	889.8	1025.6	769.4
SD	286.6	367.4	175.8
thermo-pluviometric index means	110.9	136.0	92.7
SD	57.2	87.0	30.2

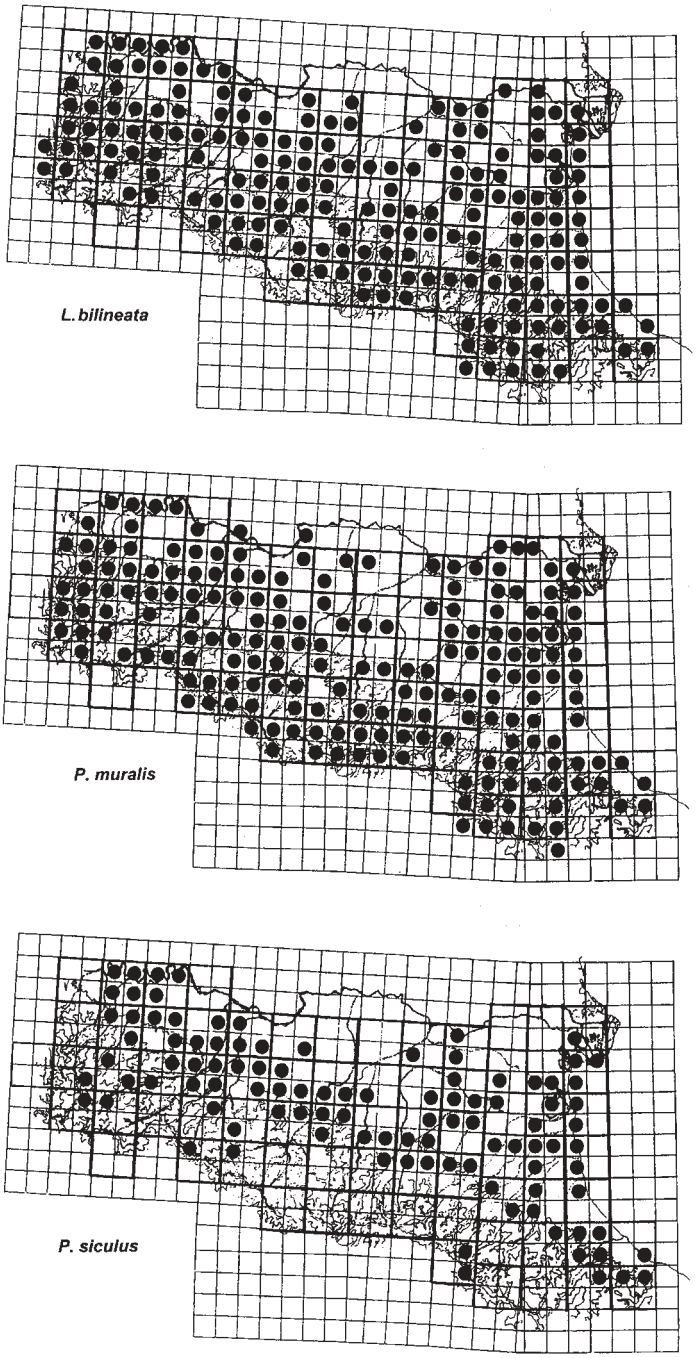

Fig. 3. Distribution map of three lacertid lizards in the southern Po river basin.

siculus presented a greater affinity with *L. bilineata* (19.1 %). The three species were in a syntopic situation in 31.2 % of the sites. The ordination of the UTM 10 10 km squares showed that *P. muralis* and *L. bilineata* had no particular distribution while *P. siculus* was found to be restricted to coastal and Po plain zones (Fig. 3). In fact this pattern of distribution of the Italian wall lizard was reflected in the mean value of altitudinal range (Tab. 1): the greatest distribution of *P. siculus* was found at altitudes ranging from 0 to 200 m (70.9 %) *P. muralis* and *L. bilineata*, on the other hand, were also present at high altitudes (Fig. 4). The result of ANOVA on the number of altitudinal observations revealing significance confirmed these differences (Tab. 2). The climatic analysis reflected the altitudinal differentiation. In fact the three species showed quite evident differences in distribution according to temperature rainfall and thermo-pluviometric index (Tab. 1). The result of ANOVA on the climatic parameters was significant (Tab. 2)

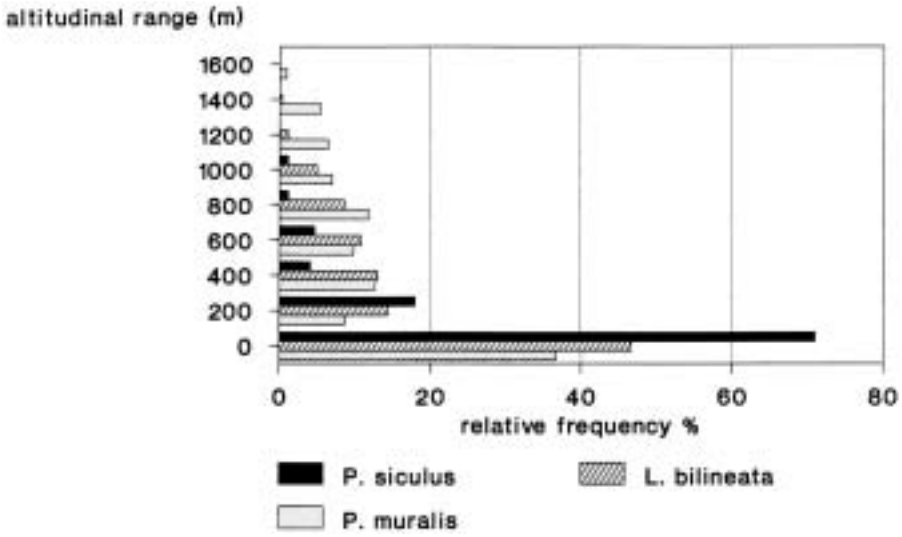

Fig. 4. Comparison of the relative frequency % of altitudinal range among three species of lacertid lizards in the southern Po river basin.

Tab. 2. One-way ANOVA and significant of *F*-values for lacertid lizards in relation to climatic and environmental factors. df = degree of freedom ns = not significant * = $p < 0.01$

Factor	df	*F*-values
temperature	2/1075	37.50*
rainfall	2/1075	52.65*
thermo-pluviometric index	2/1075	37.49*
altitudinal distribution	2/1029	63.82*
habitat categories	2/27	1.28 ns

The relative frequency of the habitat categories was high in the anthropic categories. In general the frequency of all species was considerable in urban areas; *P. siculus* and *L. bilineata* were present above all in fallow fields while *P. muralis* preferred ruins and walls. The former species were also present in shrubs, whereas *P. siculus* also preferred dunes and beaches, *P. muralis* gravel and stones (Tab. 3). The

Tab. 3. Comparison of relative frequency % of habitats of three lacertid lizards in the southern Po river basin.

Habitats	***L. bilineata*** %	***P. muralis*** %	***P. siculus*** %
Anthropics			
arable fields and orchards	5.13	1.60	4.71
towns, urban areas	18.27	19.86	14.71
ruins, walls	3.65	27.63	4.71
fallow fields	17.63	7.67	21.76
grasslands and pastures	2.24	2.05	2.35
Surface geology			
gullies	1.28	0.68	–
quarries	–	0.46	0.59
dolines	0.32	–	–
gravels	1.60	9.82	1.18
stones	0.96	4.57	–
dunes, beaches	1.60	0.23	7.06
Forests and shrubs			
coastal pine-woods	2.56	3.42	3.53
coastal holm-oak woods	0.64	–	0.59
swamp woods	1.28	1.83	1.76
riparian woods	4.49	1.83	2.35
conifer reforestation and plantations	–	0.46	–
Pinus sylvestris woods	0.32	–	–
chestnut woods	0.64	1.37	0.59
thermophilic white-oak woods	2.24	1.37	2.35
Quercus cerris woods	2.56	0.23	3.53
thermophilic hornbeam woods	4.81	1.37	5.88
beech woods	1.28	4.11	–
shrubs	14.74	4.11	11.76
dwarf mountain pine scrubs	–	0.23	–
hedges	11.54	1.60	6.47
Vaccinium heaths	–	0.23	–
Wetlands			
river banks	–	2.05	0.59
lake and pond shores	–	1.15	2.36
salt and brackish marshes	–	–	1.18

differences observed in ten principal habitats were significant (^{2} = 243.64; df = 18; P<0.01) however this result was not obtained with the ANOVA (Tab. II), which did not yield significance. The Wilcoxon sign-rank text showed significant differences between the Green lizard and the two other lizards (*P. muralis*: T = 9, P<0.01; *P. siculus* T = 4.5, P<0.05) while no significant differences were found between *P. muralis* and *P. siculus* (T = 22.5, P<0.05).

The southern Po river basin is characterised by altitudinal and thermopluviometric gradients factors that influence the distribution patterns of lacertid lizards in the study area. In particular the distribution of the Italian wall lizard is mostly restricted to coastal and plain zones and warm sub-Mediterranean vegetation belts characterised by the highest temperature and the lowest rainfall. The distribution patterns of the Common wall lizard and Green lizard on the other hand varied. The analysis of habitat selection gave contradictory results; the ANOVA analysis did not reveal any significant differences. This was due to the fact that habitat preferences were influenced by ecological factors such as prey abundance (DIAZ & CARRASCAL, 1991), competition and niche segregation (CAPULA *et al*., 1993), structural characteristics of habitat (RUBIO *et al*., 1994) or population parameters (VOGRIN, 1998). In the Italian peninsula the southern Po river basin is a biogeographic transition territory representing a bridge between the continental and Mediterranean districts. The three lacertid lizards of the study area are clearly three different chorotypes, climatic factors playing a fundamental role in their distribution patterns.

Received November 6, 1999

REFERENCES

AMANN, T., RYKENA, S., JOGER, U. & VEITH, M., 1997: Zur artlichen Trennung von *Lacerta bilineata* Daudin 1802 und *L. viridis* (Laurenti 1768). Salamandra **33**(4) 255–268.

BÖHME W., 1997: A note on the gender of genus *Podarcis* (Sauria: Lacertidae). Bonn. Zool. Beitr., **47** (1–2), 187–188.

CAPULA, M., LUISELLI, L. & RUGIERO, L., 1993: Comparative ecology in sympatric *Podarcis muralis* and *P. sicula* (Reptilia: Lacertidae) from the historical centre of Rome: What about competition and niche segregation in an urban habitat?. Boll. Zool. **60**, 287–291.

CORBETTA, F., PUPPI, G., SPERANZA, M. & ZANOTTI, A. L., 1984: Vegetational outlines of North Adriatic coasts. Acta. Bot. Croat. **43**, 191–206.

CORTI, C., NISTRI, A. & VANNI, S., 1997: *Podarcis sicula* in: GASC, J.-P., CABELA, A., CRNOBRNJA-ISAILOVIC, J., DOLMEN, D., GROSSENBACHER, K., HAFFNER, P., LESCURE, J., MARTENS, H., MARTINEZ RICA, J. P., MAURIN, H., OLIVEIRA, M. E., SOFIANIDOU, T. S., VEITH, M. & ZUIDERWIJK, A. (Eds.): Atlas of Amphibians and Reptiles in Europe. Societas Europaea Herpetologica & Museum National d'Histoire Naturelle (IEGB/SPN), Paris.

DARLINGTON, P. J. Jr., 1957: Zoogeography. Robert E. Krieger Publishing Company Malabar Florida.

DELY, O. G. & BÖHME, W., 1984: *Lacerta vivipara*. In: BÖHME W. (Eds.): Handbuch der Reptilien und Amphibien Europas. Band 2/I. Echsen (Sauria) II AULA-Verlag Wiesbaden.

DEVILLERS P., DEVILLERS-TERSCHUREN, J., LEDANT, J.-P. & CORINE BIOTOPES EXPERTS GROUP, 1991: CORINE biotopes manual. Part 2. Habitats of the European Community Brusselles.

DIAZ, J. A. & CARRASCAL, L. M., 1991: Regional distribution of a Mediterranean lizard: influence of habitat cues and prey abundance. Journal of Biogeography **18,** 291–297.

GUILLAUME, Cl. P., 1997: *Podarcis muralis* in: GASC, J.-P., CABELA, A., CRNOBRNJA-ISAILOVIC, J., DOLMEN, D., GROSSENBACHER, K., HAFFNER, P., LESCURE, J., MARTENS, H., MARTINEZ RICA, J. P., MAURIN, H., OLIVEIRA, M. E., SOFIANIDOU, T. S., VEITH, M. & ZUIDERWIJK, A. (Eds.), 1997 – Atlas of Amphibians and Reptiles in Europe. Societas Europaea Herpetologica & Museum National d'Histoire Naturelle (IEGB/SPN), Paris.

HARVEY POUGH, F., ANDREWS, R. M., CADLE, J. E., CRUMP, M. L., SAVITZKY, A. H. & WELLS, K. D., 1998: Herpetology. Prentice Hall New Jersey.

IMPARATI, E. 1940: I Rettili del piacentino. Ist. Naz. Cult. Fasci., Sez. PC, **18**, 151–162.

MAZZOTTI, S. & STAGNI, G., 1993: Gli Anfibi e i Rettili dell'Emilia-Romagna (Amphibia, Reptilia). – Quad. Staz. Ecol. Civ. Mus. St. nat. Ferrara **5**, 1–148.

MAZZOTTI, S., CARAMORI, G. & BARBIERI, C., 1999: Atlante degli Anfibi e dei Rettili dell'Emilia-Romagna. Quad. Staz. Ecol. civ. Mus. St. nat. Ferrara **12**, 1–121.

OWEN, J. G., 1989: Patterns of herpetofaunal species richness: relation to temperature, precipitation, and variance in elevation. Journal of Biogeography **16**, 141–150.

PICCOLI, F., GERDOL, R. & FERRARI, G., 1983: Carta della vegetazione del Bosco della Mesola (Ferrara). Atti Ist. Bot. e Lab. Critt. **2**, 3–23.

RICHARD, J. & SEMENZATO, M., 1991: Nuovi rinvenimenti di *Bombina variegata* (Linnaeus 1758) e *Lacerta* (*Zootoca*) *vivipara* Jacquin 1787 nella Pianura Veneta. Atti Soc. Ital. Sci. Nat. Museo Civ. Storia Nat. **132**(15), 181–191.

RYKENA, S., 1991: Kreuzungsexperimente zur Prüfung der Artgrenzen im Genus *Lacerta* sensu stricto. – Mitt. zool. Mus. Berlin, **67**, 55–68.

RUBIO, J. L. & CARRASCAL, L. M., 1994: Habitat selection and conservation of an endemic spanish lizard *Algyroides marchi* (Reptilia, Lacertidae). Biol. Cons. **70**, 245–250.

SALMASO, R. & OSELLA, G., 1989: L'Erpetoauna. In: Studi sulla palude del Busatello (Veneto – Lombardia). Mem. Mus. civ. St. nat. Verona **7**, 237–257.

SERVIZIO METEOROLOGICO REGIONALE, 1995: I Numeri del Clima. Temperature, Precipitazioni, Vento. Tavole Climatologiche dell'Emilia-Romagna 1951–1994. Regione Emilia-Romagna. Servizio Meteorologico Regionale, Bologna.

SOCIETAS HERPETOLOGICA ITALICA, 1996: Atlante provvisorio degli Anfibi e dei Rettili italiani. Annali Mus. civ. St. nat. G. Doria, Genova **91**, 95–178.

UBALDI, D., PUPPI, G. & ZANOTTI, A. L., 1996: Carta fitoclimatica dell'Emilia-Romagna. Regione Emilia Romagna Assessorato Territorio Programmazione e Ambiente, Studi e Documentazioni **47**, 1–79.

VANDONI, C., 1914: I Rettili d'Italia. U. Hoepli, Milano.

VOGRIN, N., 1998: Population parameters of syntopic population of three species of *Podarcis* in the Slovenian Istra (Reptilia, Lacertidae). Gortania **20**, 225–232.

SUMMARY

Climatic and environmental influence on distribution of lacertid lizards in the southern Po River Basin (Northern Italy)

S. Mazzotti

The present study is a synthesis of data collected from 1980 to 1997 on lacertid lizards in the southern Po river basin (Northern Italy), investigated using the data from the Herpetological Data base of the Natural History Museum of Ferrara. In

this area three species of lacertid lizards were recorded: *Lacerta bilineata*, *Podarcis siculus* and *Podarcis muralis*. The ordination of the UTM 10 10 km squares showed that *P. muralis* and *L. bilineata* had no particular distribution whereas *P. siculus* was restricted to the coastal areas and the Po plain zone. *P. siculus* was mostly found at altitudes ranging from 0 to 200 m (70.9 %); *P. muralis* and *L. bilineata*, on the other hand, were present at high altitudes as well. The result of ANOVA on the number of altitudinal observations that revealed significance confirmed these differences. The climatic analysis reflected the altitudinal differentiation as the three species showed quite evident differences in distribution in relation to temperature rainfall and the thermo-pluviometric index distribution. The result of ANOVA on the climatic parameters reached the level of significance. In general the frequency of all species was considerable in urban areas; *P. siculus* and *L. bilineata* were present above all in fallow fields while *P. muralis* preferred ruins and walls. The former species were also present in shrubs; whereas *P. siculus* preferred dunes and beaches, *P. muralis* gravel and stones.

SAŽETAK

Utjecaj klime i okoliša na rasprostranjenje lacertidnih guštera u južnom porječju rijeke Po (Sjeverna Italija)

S. Mazzotti

Rad je sinteza podataka o lacertidnim gušterima, prikupljenih od 1980. do 1997. godine u južnom porječju rijeke Po (Sjeverna Italija) pri čemu su korišteni podaci Herpetološke baze podataka Prirodoslovnog muzeja u Ferrari. Na ovom području zabilježene su tri vrste lacertidnih guštera: *Lacerta bilineata*, *Podarcis siculus* i *Podarcis muralis*. Položaj UTM 10 10 km kvadranata pokazao je da *P. muralis* i *L. bilineata* imaju cjelovitu raspodjelu, dok je *P. siculus* ograničen na obalna područja i dolinu rijeke Po. *P. siculus* je većinom bila zabilježena na visinama od 0 do 200 m (70.9 %); *P. muralis* i *L. bilineata* bile su prisutne i na većim visinama. Ove razlike potvrdilo je kao značajne i testiranje na temelju visinskih opažanja. Klimatska analiza odražavala je visinsku diferencijaciju, jer su tri vrste pokazale prilično evidentne razlike u distribuciji s obzirom na temperaturu, količinu oborina i termopluviometrijski indeks. Rezultat testiranja u odnosu na klimatske parametre dosegao je razinu značajnosti. Frekvencija svih vrsta uglavnom je bila znatna u gradskim područjima; *P. siculus* i *L. bilineata* bile su prisutne prije svega u zapuštenim poljima, dok je *P. muralis* preferirala ruševine i zidove. Ta je vrsta također bila nađena u niskom raslinju, dok je *P. siculus* više tražila dine i plaže, a *P. muralis* šljunak i kamenje.