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Biometric characterization of two Sicilian pond turtle (*Emys trinacris*) populations of south-western Sicily

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Abstract: Up to a very short time ago, the taxonomic position of the pond turtle living in Sicily was still uncertain. However, on the basis of close DNA enquiries, the Sicilian population has now resulted to be clearly distinguished from other congeneric species as much as to be described as *Emys trinacris,* most certainly endemic of Sicily. The current knowledge regarding this new species in Sicily is still limited. For a few years now we have taken on a work of research of two populations, both part of this new species, respectively living in the natural resort located in the South West of Sicily. The results obtained from the use of biometrical analyses applied to twelve biometrical variables, of the body, about 257 specimens captured and measured, show that in both populations, the male's average size, as it is the case with the other populations of the *Emys* genera, are statistically inferior, compared to the respective females. Even more, biometric differences were found between two studied populations. The body size of the population living in one of two areas proves to be statistically larger that the one living in the other area mostly constituted by young and sub-adult specimens. This difference in age structure could be related to the difference that the two areas exercise on this species: the first one could be considered as an area more suitable for reproduction, while the other as a more marginal population for specimen growth.
Key words: biometric characterization, *Emys trinacris*, Sicilian pond turtle.

Abstract: Caracterización biométrica de dos poblaciones de galápago siciliano (*Emys trinacris*) del suroeste de Sicilia. – Hasta hace poco el status taxonómico de los galápagos de Sicilia era incierto. Sin embargo, en base a estudios de ADN, la población siciliana ha resultado ser tan claramente diferente de otras congenéricas como para describirla como *Emys trinacris*, endémica de Sicilia. Dado que el conocimiento sobre la misma es todavía limitado, se han investigado dos poblaciones, incluidas en su área de distribución, en el suroeste de Sicilia. Los resultados se obtuvieron a partir del análisis biométrico de 12 variables corporales obtenidas de 257 individuos. Como en otras especies congenéricas, el tamaño medio de los machos es estadísticamente inferior al de las hembras. También se encontraron diferencias en el tamaño medio de ambas poblaciones y en su estructura de edad, mostrándose una de las zonas estudiadas como un área conveniente para la reproducción y, la otra, como un área habitada por una población marginal mayoritariamente constituida por juveniles y subadultos.
Palabras clave: Caracterización biométrica, *Emys trinacris*, galápago siciliano.

INTRODUCTION

Not very long ago, the taxonomic position of Sicilian Pond Turtle was uncertain. In fact, two *taxa* were present: *Emys orbicularis galloitalica,* distributed in the eastern part of Sicily, and a form indicated as "southern Italian", distributed in the entire island of Sicily (FRITZ, 1998; LENK *et al.*, 1998). However, mostly based on DNA investigations, the Sicilian population has now been clearly differentiated from the other species of the same genus, and it is described as *Emys trinacris,* which is almost certainly endemic in Sicily (FRITZ *et al.*, 2005). Unfortunately, as a consequence of the new taxonomic position, the current knowledge regarding this new species in Sicily is still limited. Because of this, it is impossible to act with an appropriate conservation policy towards this Sicilian Pond Turtle population, which is certainly vulnerable.

As far as the biometric characterization is concerned, there are not many studies carried out on Sicilian specimens. Up to date, the information available is referred to three small samples for a total of 42 specimens (ARDIZZONI & FRITZ, 1998; ZUFFI & BALLASINA, 1998; FRITZ *et al.*, 2005). A few years ago, we started a research on two populations belonging to this new species, present in two protected areas: the natural reserve "Lago Preola e Gorghi Tondi" and the natural reserve "Torre Salsa", respectively. Both protected areas are located in south-western Sicily, at a distance of approximately 100 km from each other. This article indicates the results obtained through the biometric analysis applied to some biometrical variables.

MATERIALS AND METHODS

The natural reserve "Lago Preola e Gorghi Tondi" is located within the municipality of Mazara del Vallo (Trapani). This is a karstic depression behind sand dune line, one kilometer long approximately, with four lake basins: Lake Preola and three "gorghi": Gorgo Alto, Gorgo Medio and Gorgo Basso. Lake Preola is a temporary basin, which is now in a senile status, with a surface of 24.8 ha approximately, filled with a thin layer of water occasionally deeper than 30 cm during very rainy seasons. The three "gorghi" are lake environments in a mature status, with an average surface area of approx. 2 ha each, and average depth of approximately 7 m. The area is within a larger territory, stretching over approx. 335 ha, where a Natural Reserve has been established.

The natural reserve "Torre Salsa" stretches over approx. 760 ha, within the municipality of Siculiana (Agrigento). This area is characterized by an approximately 6 km long coastal area, bordering a relict sand dune environment. The other part of the reserve is characterized by mainly agricultural landscape. The area is crossed by several streams, with several ramifications and sometimes quite deep water, with marsh vegetation along their banks.

As the "Lago Preola e Gorghi Tondi" reserve is concerned, turtles have been caught over a period of approximately eight months, from March to October 2003 for research purposes. Traps were placed directly in the water of the lakes, and some specimens were caught on the land. Catches in the natural reserve "Torre Salsa" took place over a shorter period of time, five months approximately, from March to July 2004, using the same technique. On every specimen caught, 12 biometric variables were measured, some of which according to the conventions established by (GRAHAM, 1979; ZUFFI & GARIBOLDI, 1995a) for European pond turtles (*Emys orbicularis*) (Table 1) (Fig. 1). A digital caliper with tenth-

TABLE 1. Morphometrical data (mean ± SD, range and N), t-test (t) and level of significance (P) between males and females of two populations of *Emys trinacris*. * Not significan.

TABLA 1. Datos morfométricos (media ± SD, rango y N), test-t (t) y nivel de significación (P) entre machos y hembras de dos poblaciones de *Emys trinacris*. * No significativo.

	Lago Preola e Gorghi Tondi				Torre Salsa			
	Males	Females	t	P	Males	Females	t	P
Carapace Length (mm) (CL)	112.9 ± 7.3 (100.7 – 143.4) 79	118.9 ± 10.6 (102.5 – 155.2) 47	–3.7	0.000	(128.6 ± 8.6) (103.7 – 152.3) 57	(134.6 ± 12.4) (103.3 – 149.9) 45	–2.7	0.008
Carapace Width (mm) CW	84.5 ± 6.2 (73.4 – 108.0) 78	91.8 ± 8.4 (79.2 – 120.6) 47	–5.5	0.000	99.5 ± 7.9 (73.7 – 122.1) 58	107.4 ± 9.8 (82.0 – 123.6) 34	–4.2	0.000
Carapace Height (mm) CH	42.1 ± 4.1 (30.8 – 54.5) 78	48.3 ± 5.4 (37.7 – 63.2) 47	–7.2	0.000	45.3 ± 2.9 (40.7 – 54.2) 58	53.4 ± 6.6 (35.0 – 64.7) 35	–8.1	0.000
Plastron Length (mm) PL	100.8 ± 7.1 (83.9 – 125.6) 79	112.1 ± 10.7 (93.5 – 148.5) 47	–7.2	0.000	116.5 ± 8.3 (93.2 – 134.0) 55	124.5 ± 17.1 (87.5 – 147.2) 20	–2.7	0.008
Plastron Width (mm) PW	63.6 ± 3.8 (56.4 – 75.8) 76	71.2 ± 7.0 (62.9 – 96.3) 46	–7.8	0.000	73.3 ± 5.0 (61.0 – 87.1) 56	80.6 ± 8.3 (56.9 – 91.2) 34	–5.2	0.000
Bridge Width (mm) BW	24.4 ± 2.5 (15.8 – 29.8) 79	30.0 ± 3.7 (23.0 – 43.7) 47	–10.2	0.000	30.8 ± 3.0 (24.7 – 37.9) 58	38.7 ± 8.9 (23.5 – 81.9) 34	–4.1	0.000
Tail Length (mm) TL	68.8 ± 7.0 (49.7 – 82.4) 74	64.3 ± 7.7 (46.9 – 90.1) 43	3.3	0.001	78.7 ± 8.6 (54.0 – 99.7) 48	69.1 ± 10.7 (47.2 – 91.6) 32	4.4	0.000
Cloaca-apex Distance (mm) CA	45.4 ± 6.0 (27.8 – 58.2) 74	50.9 ± 6.7 (35.5 – 70.5) 43	–4.5	0.000	53.4 ± 5.8 (41.5 – 68.1) 46	54.9 ± 8.7 (37.1 – 68.1) 31	–0.9	0.385*
Diverging angle of first marginal scutes (mm) DC	28.0 ± 3.0 (19.1 – 36.0) 78	28.0 ± 3.5 (21.9 – 37.5) 47	–0.1	0.913*	31.4 ± 3.6 (22.9 – 42.2) 55	29.1 ± 3.5 (22.0 – 37.7) 32	2.8	0.006
Latit. Circumference (cm) LatC	21.4 ± 1.6 (18.3 – 27.5) 77	23.3 ± 2.3 (20.5 – 31.0) 46	–5.5	0.000	24.6 ± 1.5 (20.5 – 28.5) 55	26.2 ± 2.9 (19 – 30) 34	–3.2	0.002
Long. Circumference (cm) LonC	27.0 ± 1.8 (24.5 – 34.0) 77	28.6 ± 2.4 (25 – 37) 46	–4.2	0.000	30.8 ± 2.0 (25.0 – 36.5) 55	32.5 ± 3.5 (24 – 37) 34	–2.8	0.006
Weight (g) W	223.4 ± 45.2 (166 – 435) 77	292.6 ± 89.4 (183 – 682) 47	–5.7	0.000	362 ± 68.0 (224 – 590) 55	474.0 ± 122.3 (195 – 678) 33	–5.5	0.000

millimeter accuracy and an electronic balance with 1 g accuracy were used to measure specimens. Gender differentiation was based on morphological differences (*sensu* LANZA, 1983). All specimens were marked with combined notches on marginal carapace scales to avoid any possible sampling errors (STUBBS *et al.*, 1984).

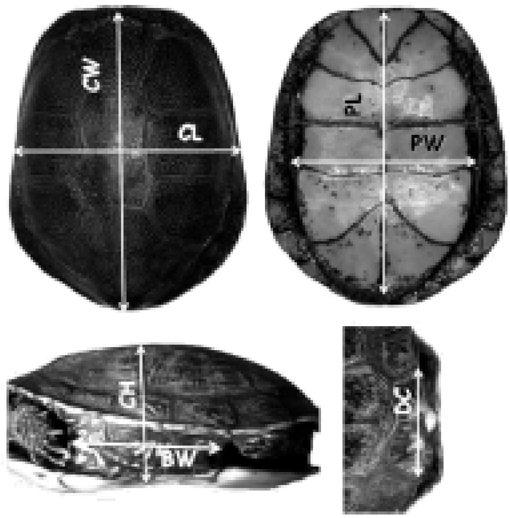

FIGURE 1. Biometric variables of *Emys trinacris*. For abbreviations see Materials and Methods. For acronyms, see Table 1.

FIGURA 1. Variables biométricas de *Emys trinacris*. Véase el capítulo Material y Métodos para la explicación de las abreviaturas y la Tabla 1 para los acrónimos.

The data collected was used for the estimation of statistical description (average, standard deviation, and range), while the univaried statistics (t-test) were used to analyse the differences between genders. Possible shape differences were checked using the PCA analysis, applied to the correlation matrix, which eliminates the dimentional effect of components that followed the first component (CHESSEL & AUDA, 1986; CAMUSSI *et al.*, 1991). Finally, a Discriminant Analysis (DA) was used, in order to obtain linear functions (predictive equations) through the combination of biometrical variables, which provide the maximum variability among groups (LEGENDRE & LEGENDRE, 1979; DIGBY & KEMPTON, 1987; SOKAL & ROHLF, 1989).

RESULTS

275 specimens were caught, of which 146 (79♂♂, 47♀♀ and 20 young specimens) within the reserve "Lago Preola e Gorghi Tondi", and 129 (58♂♂, 35♀♀and 36 young specimens) in the reserve "Torre Salsa". In both cases,

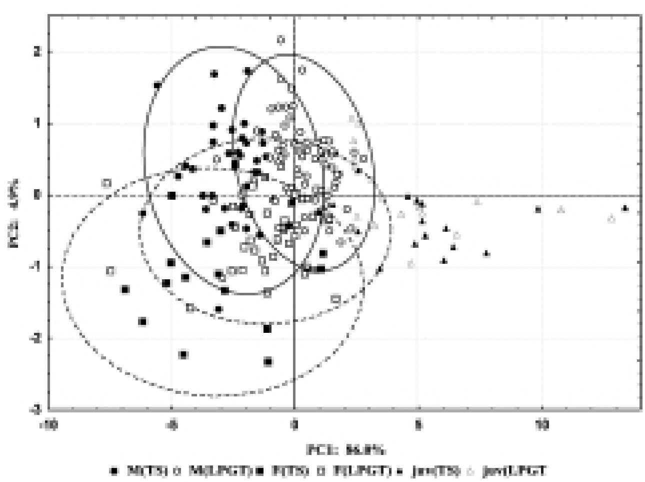

FIGURE 2. Plot of scores of male and female specimens of *Emys trinacris* on the first two principal components axes (PC1 and PC2), and 95% probability ellipse. M = male; F = female; LPGT = "Lago Preola e Gorghi Tondi"; TS = "Torre Salsa".

FIGURA 2. Representación gráfica de machos y hembras de *Emys trinacris* en los dos primeros ejes de componentes principales (PC1 y PC2) y 95% de la elipse de probabilidad. M = machos; F = hembras; LPGT = "Lago Preola e Gorghi Tondi"; TS = "Torre Salsa".

sex ratio values were in favor of males, respectively 1.68:1 and 1.67:1. The Table 1 shows the descriptive statistic of both populations and genders. The t-test shows statistically significant differences ($p < 0.001$) between males and females for all variables, except for diverging angle of first marginal scutes. The factorial organization model, obtained through PCA, shows a certain distinction between both genders in the two areas (Fig. 2). Except for the length of the tail and bridge width –related to the factorial axis PC2– the remaining variables are related to each other and to the factorial axis PC1, which mainly represents the turtle's body dimension. Also organization models on factorial planes DA1-DA2 (Fig. 3), obtained with the first three statistically significant discriminating functions ($r = 0.86$; Wilks'$\lambda = 0.032$; $F_{(60,856)} = 15,4$; $P < 0.0001$), show the differences between sexes, size-age, and areas. Applied to single variables, the DA confirms the difference in biometric values for all variables, and the ability to discriminate the two sexes through discriminate functions was between 62% and 84%.

In the sample from "Lago Preola e Gorghi Tondi", the bridge width was the best discriminating variable between sexes (84.1% correct reclassification), while in the sample from "Torre Salsa" the best result was obtained with carapace height (80.1% correct reclassification).

DISCUSSION

In an animal species, the sex-ratio is a very important ecological factor, which influences the dynamics of populations (GIRONDOT & PIEAU, 1993). According to FISHER (1929), the optimum primary sex-ratio should be 1:1, but several studies have shown the existence of unbalanced sex-ratios (GIBBONS, 1990).

In the *Emididae* family, various researches have been carried out on the connections between sexes; in several cases, this ratio varies. Such variations, if they are not due to

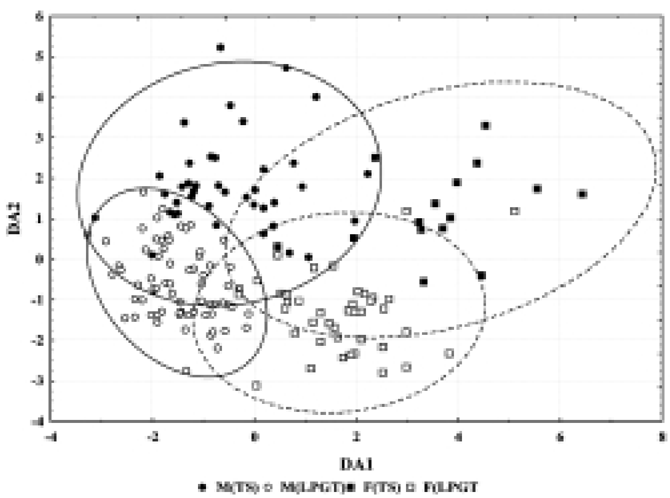

FIGURE 3. Plot of scores of male and female specimens of *Emys trinacris* on the first two discriminant analysis axes, and 95% probability ellipse. M= male; F= female; LPGT = "Lago Preola e Gorghi Tondi"; TS= "Torre Salsa".

FIGURA 3. Representación gráfica de machos y hembras de *Emys trinacris* en los dos primeros ejes del análisis discriminante y 95% de la elipse de probabilidad. M = machos; F = hembras; LPGT = "Lago Preola e Gorghi Tondi"; TS = "Torre Salsa".

sampling errors (BURY, 1979), are usually referred to various causes; the influence of temperature on the development of embryos' gonads, in the case of temperature values higher than 28.5-29° C, may determine an unbalance of primary sex-ratio at birth in favor of females (BULL & VOGT, 1981; PIEAU, 1982; SERVAN *et al.*, 1989). On the other hand, other causes that may influence secondary sex-ratio are a different mortality rate (GIRONDOT & PIEAU, 1993), or different behavior between sexes (KOFRON & SCHREIBER, 1987; DODD, 1989). Finally, another hypothesis is based on different age when the two sexes reach sexual maturity (GIBBONS, 1990).

Researches on sex-ratio in *Emys trinacris* have never been carried out before; however, very variable sex-ratio values have been measured in Italian samples of *Emys orbicularis*, between 1:1 and 1:2.4 (MAZZOTTI, 1995; ZUFFI & GARIBOLDI, 1995b; MAZZOTTI *et al.*, 2007), and any unbalance is always in favor of females.

As concerns Sicilian populations, located at low latitudes and both almost at sea-level, high sex-ratio values are strongly unbalanced in favor of males; thus, they would not be referred to unbalanced primary sex-ratio. Furthermore, considering that the natural habitat is homogeneous and excluding an unjustified different mortality rate, the possible cause of this unbalance is due to higher mobility of males.

About the morphometry, as in most *Emys orbicularis* subspecies (ZUFFI *et al.*, 1999; FRITZ, 2001, 2003), also in Sicilian pond turtle populations, males are considerably smaller in size than females.

The comparison between the biometric values obtained showed that the mean specimen size of the population in the reserve "Lago Preola e Gorghi Tondi" is significantly smaller than specimens in "Torre Salsa", where mean sizes are similar to those found in another area in Sicily (ARDIZZONI & FRITZ, 1998). Considering that there is a positive correlation between the number of laid eggs and female size (MITRUS & ZEMANEK, 1998; ZUFFI *et al.*, 1999), the two areas probably have different ecological functions. In fact, the former may be a growing area for Sicilian Pond Turtles, characterized by a larger number of non-breeding subadult and small-size adult specimens, with a low productivity rate. The reserve "Torre Salsa", on the other hand, should host a more mature population, characterized by higher productivity, due to the presence of a larger number of adult specimens, even of large size. This should also be supported by the different number of young specimens seen and/or caught during the research periods: 27.9% in the reserve "Torre Salsa" and 13.7% in the reserve "Lago Preola e Gorghi Tondi".

REFERENCES

ARDIZZONI, C. & FRITZ, U. (1998): Some morphological data on pound turtle (*Emys orbicularis*) in Sicily. Pp. 287-288, *in*: Fritz, U., Joger, U., Podloucky, R., Servan, J. & Buskirk, J.R. (eds.), *Proceedings of the EMYS Symposium Dresden 96. Mertensiella, Rheinbach*, 10.

BULL, J.J. & VOGT R.C. (1981). Temperature-sensitive periods of sex determination in emydid turtles. *Journal of Experimental Zoology*, 218: 435-440.

BURY, R.B. (1979). Population ecology of freshwater turtles. Pp. 571-602, *in*: Harless, M. & Morlock, H. (eds.), *Turtles: Perspective and Research*. John Wiley & Sons, New York.

CAMUSSI, A., MÖLLER, F., OTTAVIANO, E. & SARI GORLA, M. (1991): *Metodi statistici per la sperimentazione biologica*. Zanichelli.

CHESSEL, D. & AUDA, Y. (1986): Analyse en composantes principales sur matrice de correélation. (ACPN). Institut d'Analyse des Systemes Biologiques et Socio-Economiques. Universitè de Lion 1: 1-39.

DIGBY, P.G.N. & KEMPTON, R.A. (1987). *Multivariate analysis of ecological communities*. Chapman and Hall, London.

DODD, C.K. (1989). Population structure and biomass of *Sternotherus odoratus* (Testudines: Kinosternidae) in a northern Alabama lake. *Brimleyana,* 15: 47-56.

FISHER, R.A. (1929). *The genetical theory of natural selection*. Oxford Univ. Press, Oxford, U.K.

FRITZ, U. (1998): Introduction to zoogeography and subspecific differentiation in *Emys orbicularis* (Linnaeus, 1758). Pp. 1-17, *in*: Fritz, U., Joger, U., Podloucky, R., Servan, J. & Buskirk, J.R. (eds.), *Proceedings of the EMYS Symposium Dresden 96. Mertensiella, Rheinbach*, 10.

FRITZ, U. (2001): *Emys orbicularis* (Linnaeus, 1758) – Europäische Sumpfschildkröte. Pp. 343-515, *in*: Fritz, U. (ed.), *Handbuch der Reptilien und Amphibien Europas*. Vol. 3/IIIA, Schildkröten I. AULA-Verlag, Wiebelsheim.

FRITZ, U. (2003): Die Europa ̈ische Sumpfschildkro ̈ te (*Emys orbicularis*). Bielefeld: Laurenti Verlag.

FRITZ, U., FATTIZZO, T., GUICKING, D., TRIPEPI, S., PENNISI, M.G., LENK, P., JOGER, U. & WINK, M. (2005): A new cryptic species of pond turtle from South Italy, the hottest spot in the range of the genus *Emys*. *Zoologica Scripta,* 34: 351-371.

GIBBONS, J.W. (1990). Sex ratios and their significance among turtle populations. Pp. 171-182, *in:* Gibbons, J.W. (ed.), *Life History and Ecology of the Slider Turtle*. Smithsonian Institution Press, Washington.

GIRONDOT, M. & PIEAU, C. (1993). Effects of sexual differences of age at maturity and survival on population sex ratio. *Evolut. Ecol*., 7: 645-650.

GRAHAM, T.E. (1979): Life history techniques. Pp. 73-95, *in*: Harless, M. & Morlock, H. (eds.), *Turtles: Perspective and Research*. John Wiley & Sons, New York.

KOFRON C.P. & SCHREIBER A.A. (1987). Observations on Aquatic Turtles in a Northeastern Missouri Marsh. *The Southwestern Naturalist*, 32: 517-521

LANZA, B. (1983): Guida per il riconoscimento delle specie animali delle acque interne. 27. Anfibi, Rettili (Amphibia, Reptilia). Verona (Consiglio Nazionale delle Ricerche AQ/1/205), 196 pp.

LEGENDRE, L. & LEGENDRE, P. (1979): *Ecologie numerique*. Vol. II - Masson, Paris.

LENK, P., JOGER, U., FRITZ, U., HEIDRICH, P. & WINK, M. (1998): Phylogeographic patterns in the mitochondrial cytochrome b gene of the European pond turtle *Emys orbicularis*, first results. Pp. 159-175, *in*: Fritz, U., Joger, U., Podloucky, R., Servan, J. & Buskirk, J.R. (eds.), *Proceedings of the EMYS Symposium Dresden 96. Mertensiella, Rheinbach*, 10.

MAZZOTTI. S. (1995). Population structure of *Emys orbicularis* in the Bardello (Po Delta, Northern Italy). *Amphibia-Reptilia*, 16: 77-85.

MAZZOTTI, S., MONTANARI, F., GREGGIO, N. & BAROCCI, M. (2007). La popolazione della testuggine palustre (*Emys orbicularis*) del Bosco della Mesola**.** *Quad. Staz. Ecol. civ. Mus. St. nat. Ferrara*, 17: 117-123.

MITRUS, S. & ZEMANEK, M. (1998). Reproduction of *Emys orbicularis* (L.) in Poland. Pp. 187-191, *in*: Fritz, U., Joger, U., Podloucky, R., Servan, J. & Buskirk, J.R. (eds.), *Proceedings of the EMYS Symposium Dresden 96. Mertensiella, Rheinbach*, 10.

PIEAU, C. (1982). Modalities of the Action of Sexual Differentiation in Field Developing Embryos of the European Pond

Turtle *Emys orbicularis. The Journal of Experimental Zoology*, 220: 353-360.

SERVAN, J., ZABORSKI, P., DORIZZI, M. & PIEAU, C. (1989). Détermination du sexe ratio adulte de la tortue *E. orbicularis* dans des populations provenant de 7 étangs de Brenne (Indre, France). *Canadian Journal of Zoo*logy, 67: 1279-1284.

SOKAL, R.R. & ROHLF, F.J. (1989): *Biometry*. W.H. Freeman, New York.

STUBBS, D., HAILEY, A., PULFORD, E. & TYLER, W. (1984): Population ecology of European tortoises: review of field techniques. *Amphibia-Reptilia*, 5: 57-68.

ZUFFI, M.A.L. & BALLASINA, D.L. (1998): Contribution to the knowledge of regional polymorphism of in Italy, and notes on the husbandry activities at the CARAPAX Centre. Pp. 279-286, *in*: Fritz, U., Joger, U., Podloucky, R., Servan, J. & Buskirk, J.R. (eds.), *Proceedings of the EMYS Symposium Dresden 96. Mertensiella, Rheinbach*, 10.

ZUFFI, M.A.L. & GARIBOLDI, A. (1995a): Geographical patterns of Italian *Emys orbicularis*: a biometrical analysis. Pp. 120-123, *in*: Llorente, G.A., Montori, A., Santos, X., & Carretero, M.A. (eds.), *Scientia Herpetologica*. Barcelona.

ZUFFI, M.A.L. & GARIBOLDI, A. (1995b). Sexual dimorphism in Italian populations of the European pond terrapin, *Emys orbicularis*, pp. 124-129. *In*: Llorente G.A., Montori A., Santos X. & Carretero M.A. (eds.), *Scientia Herpetologica*. Barcelona.

ZUFFI, M.A.L., ODETTI, F. & MEOZZI, P. (1999). Body-size and clutch-size in the European pond turtle, *Emys orbicularis*, from central Italy. *Journal of Zooogy*, 247: 1-8.