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Morphological data and notes on natural history of pond turtles *Emys orbicularis* (Linnaeus, 1758) of southern Apulia (Italy)

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Abstract: Morphological characters of *Emys orbicularis* (L., 1758) from the Salentine Peninsula (southern Apulia) are described. Phenotypic characteristics were analyzed for 69 adults (26 males and 43 females), using 15 linear parameters, 10 ratios and coloration of four body parts. The turtles, originating from nine populations in coastal ponds and wetlands, exhibit a clear sexual dimorphism in body length and weight, coloration of plastron and iris, pattern of head, tail and forelegs in the males are significantly smaller and lighter as well as darker coloured than females. The morphological features of most turtles correspond to *Emys orbicularis hellenica* (Valenciennes, 1832), a finding that is congruent with previously published molecular genetic results.
Key-words: Apulia, *Emys orbicularis hellenica*, Italy, sexual dimorphism.

Resumen: Datos morfológicos y apuntes de historia natural del galápago *Emys orbicularis* (Linnaeus, 1758) en el sur de Apulia (Italia). – Se describen los caracteres morfológicos de *Emys orbicularis* (L., 1758) de la Península de Salentine (sur de Apulia) a partir del análisis de las características fenotípicas de 69 adultos (26 machos y 43 hembras), usando 15 parámetros lineales, 10 índices y la coloración de cuatro partes del cuerpo. Los galápagos, procedentes de nueve poblaciones de estanques costeros y humedales, mostraron un claro dimorfismo sexual en la longitud corporal y el peso, coloración del plastrón y del iris, y diseño de la cabeza, siendo además la cola y extremidades anteriores de los machos significativamente menores y más oscuras que las de las hembras. Los rasgos morfológicos de la mayoría de los ejemplares corresponden a *Emys orbicularis hellenica* (Valenciennes, 1832), un hallazgo congruente con resultados genéticos y moleculares ya publicados.
Palabras clave: Apulia, dimorfismo sexual, *Emys orbicularis hellenica*, Italia.

INTRODUCTION

According to FRITZ (1998, 2001) and FRITZ *et al*. (2005), three *Emys orbicularis* subspecies occur in Italy: *Emys orbicularis galloitalica* is distributed along the Tyrrhenian coast, *Emys orbicularis hellenica* along the Adriatic coast and on the Salentine Peninsula, and *Emys orbicularis capolongoi* in Sardinia. Compared with other parts of the range, the systematics and natural history of European pond turtles from southern Italy have been poorly studied. Recent molecular investigations demonstrated the presence of cryptic pond turtle species, *Emys trinacris*, in Sicily that may also occur in Calabria (FRITZ *et al*., 2005). In southern Italy, considerable genetic variation was found to occur, exceeding by far other parts of the range of *Emys orbicularis* (LENK *et al*., 1999; FRITZ, 2001; FRITZ *et al*., 2005). For explaining the current diversity, it has been suggested that in southern Italy refugia for several ancient pond turtle lineages were located (FRITZ, 1996; LENK *et al*., 1999; FRITZ *et al*., 2005). FRITZ *et al*. (2005) demonstrated that the southern Apulian populations generally match the morphological and genetic characteristics of the subspecies *E. o. hellenica*.

Only a few individuals have been recorded resembling the neighbouring subspecies *E. o. galloitalica* (FRITZ *et al*., 2005). The present study is aimed to describe the morphology of Apulian pond turtles in more detail, contributing to a better knowledge of morphological variation of Italian *E. orbicularis*.

MATERIALS AND METHODS

Morphological data and information about natural history was obtained in the southern part of Apulia, the so-called "Salento", from April 2000 to October 2004. The study area extended from the village of Torre Santa Sabina (Carovigno - Brindisi) along the Adriatic coast to the southernmost part of Italian mainland, the Cape of "Santa Maria di Leuca", and then northwards to Taranto along the Ionian coast (Fig. 1).

A total of 69 adult turtles (26 males and 43 females) were collected from nine localities and sexual dimorphism was recorded. Turtles were captured using hand nets baited with meat. All captured individuals were weighed with an electronic balance (± 1.0 g) and measured with a manual calliper to the nearest 0.1 mm. Blood samples were taken to determine the mtDNA haplotypes according to LENK *et al*. (1999). Blood samples are housed permanently together with voucher photos and measurements in the Dresden Museum of Zoology.

Results of molecular genetic investigations were published in FRITZ *et al*. (2005). All captured turtles were photographed with a digital camera in order to obtain a visual reference of their phenotype: coloration and pattern was recorded according to FRITZ (1995) and the individuals were released after

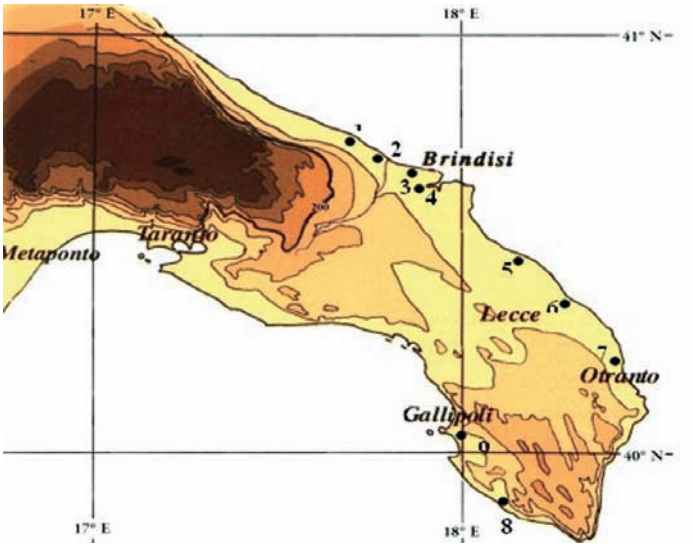

FIGURE 1. Map of the Salentine peninsula and study sites. 1: Pond of Torre Santa Sabina and marshes of Pantanaggianni (n = 21), 2: wetlands of Torre Guaceto (n = 10), 3: mouth of "Canale Giancola"(n = 7), 4: basin of Cillarese (n = 1), 5: marshland of Rauccio (n = 5), 6: wetlands of Le Cesine (n = 15), 7: Alimini lakes (n = 2), 8: basins of Ugento (n = 4), 9: "Li Foggi" marshlands (n = 4).

FIGURA 1. Mapa de la península de Salentine y localidades del estudio. 1: Estanque de Torre Santa Sabina y pantanos de Pantanaggianni (n = 21), 2: Humedal de Torre Guaceto (n = 10), 3: Desembocadura del "Canale Giancola" (n = 7), 4: Cubeta de Cillarese (n = 1), 5: Pantanal de Rauccio (n = 5), 6: Humedal de Le Cesine (n = 15), 7: Lagos de Alimini (n = 2), 8: Cubetas de Ugento (n = 4) y 9: "Pantanal Li Foggi" (n = 4).

taking photos and measurements on their capture place. In addition to the characters defined in FRITZ (1995), two new categories for plastral coloration have been used (entirely yellow and entirely black). To determine sex, the shape of the plastron (concave in males) and tail length (longer and thicker in males) was used.

All turtles with a carapace length (CL) exceeding 82 mm were treated as adults (MAZZOTTI, 1995). The morphometric characters used in this study are: BW (total body weight), CL (straight-line maximum carapace length), CW (maximum carapace width between 8th and 7th marginal scutes), PL (plastral length), PW (plastral hind lobe length), PLL (plastral fore lobe length measured between humeral and pectoral seam), GuL (gular seam length), HumL (humeral seam length), PecL (pectoral seam length), AbdL (abdominal seam length), FemL (femoral seam length), AnaL (anal seam length), TL (total length of the tail), CT (length cloaca-tail apex), SH (maximum carapace height from ventrum to dorsum) (Table 1). All these linear parameters and ten ratios CL/CW (as shape of carapace), PW/PL (as shape of plastron), SH/CL (as thickness of the body related to its dorsal length), SH/PL (as thickness of the body related to its ventral length), and PL/AnaL, PL/FemL, PL/GuL, PL/HumL , PL/AbdL, PL/ PecL (as ventral length related to its ventral scutes) were used to indicate similarities and differences between the sexes. Data are presented for males and females separately (Table 1).

Statistical analysis was carried out using the statistical software Statistica 6.0 for Windows. Metric characters were tested by a Mann-Whitney U test (t-test) for significant sexually dimorphic differences. Colour and pattern of carapace, plastron, head and throat, were also recorded for each specimen and a χ^2 test was used to test whether statistically

TABLE 1. Statistical analysis of morphometric features of the adult *Emys orbicularis* male and females from Salento (for abbreviations see text). Results of the biometric analysis: mean ± SD, range, P1 (probability after a *t-test* comparing means of both sexes) and P2 (probability after a Mann-Whitney U test).

TABLA 1. Análisis estadístico de los rasgos morfométricos de machos y hembras adultos de *Emys orbicularis* procedentes de Salento (ver Material y Métodos para las abreviaturas). Se incluye media ± SD, rango, P1 (probabilidad a partir de un test-t que compara las medias de ambos sexos) y P2 (probabilidad a partir de una prueba U de Mann-Whitney).

Variable	Males (n)	Min	Max	Females (n)	Min	Max	P1	P2
BW	199.6 ± 10.3 (26)	120	300	297.6 ± 19.7 (43)	142	600	< 0.001	< 0.05
CL	109.2 ± 2.1 (26)	90	128	119.9 ± 2.3 (43)	97	152	< 0.01	< 0.05
PL	93.1 ± 2.0 (26)	77	110	111.8 ± 2.4 (43)	88	147	< 0.001	< 0.001
CW	79.3 ± 1.9 (26)	60	101	89.1 ± 1.6 (43)	77	114	< 0.001	< 0.01
PW	56.4 ± 1.4 (26)	45	76	68.1 ± 1.4 (43)	54	90	< 0.001	< 0.001
PLL	48.3 ± 1.4 (18)	41	57	59.0 ± 1.8 (23)	47	75	< 0.001	< 0.001
GuL	15.8 ± 0.7 (18)	10	20	20.3 ± 0.9 (23)	14	26	< 0.001	< 0.01
HumL	7.8 ± 0.4 (18)	5	12	9.5 ± 0.5 (23)	6	16	< 0.05	< 0.05
PecL	16.0 ± 0.5 (18)	12	20	20.3 ± 0.7 (23)	14	26	< 0.001	< 0.001
AbdL	16.6 ± 0.5 (18)	14	20	18.9 ± 0.6 (23)	13	24	< 0.01	< 0.01
FemL	10.4 ± 0.5 (18)	8	14	12.4 ± 0.8 (23)	8	19	0.057	0.168
AnaL	22.7 ± 0.8 (18)	19	30	30.9 ± 0.9 (23)	23	39	< 0.001	< 0.001
TL	42.9 ± 0.8 (26)	31	49	47.4 ± 1.2 (33)	35	58	< 0.01	< 0.05
CT	60.7 ± 1.3 (26)	45	68	57.7 ± 1.5 (33)	42	72	0,148	0.304
SH	38.8 ± 0.7 (26)	32	45	49.3 ± 1.2 (43)	35	69	< 0.001	< 0.001

significant differences exist between males and females regarding the frequency distributions of coloration and pattern types.

RESULTS

Natural history notes

In Salento, permanent and reproducing populations of *Emys orbicularis* are confined to some marshes, canals, and ponds that are still persisting along the Adriatic and Ionian coastlines of the Salentine Peninsula. These areas are relictual habitats and correspond to the pristine landscape occurring there before the intense urbanization and reclamations of the 20th century (FATTIZZO, 2004a). Today, pond turtle populations are isolated, and there is generally no contact between them, even though single individuals or small groups of adults can move over land for some kilometres. Occasionally, after heavy spring and autumn rains, single turtles are found in cultivated fields or along the streets, far away from water.

In all investigated populations only low numbers of juveniles or immature turtles were found. The activity period extends from the end of February to the end of November. *Emys orbicularis* starts mating activities in late March, lasting until the end of June. Oviposition was most frequently recorded during June and July. Generally, females lay three to six eggs per clutch. Most hatchlings were recorded between August and October. A few hatchlings were also seen in February and March. These individuals are thought to originate from clutches of the previous year.

Analysis of excreta showed that plants play often a large part of the adult diet whereas the animal remains are represented mainly by insect (especially dragonfly larvae), molluscs, amphibians and their larvae, and *Gambusia* sp. fishes (LEBBORONI & CHELAZZI, 1991; FATTIZZO, 2004b).

Morphometric analyses

Morphometric data are summarized in Table 2 and some typical turtles illustrated in Figs. 2,3. Adult males are generally lighter thus females are heavier than males of the same length (Fig. 4). The shell of males is shorter (Fig. 5) and narrower than in adult females (Figs. 6, 7). Females have also deeper shells (Fig. 8). According to the Mann-Whitney U test no significant difference exists in the length of the femoral scutes (FemL) and the length of the cloaca-tail apex (CT) between males and females. On the other hand, adult turtles showed a clear sexual dimorphism in all linear parameters (Table 1).

We found significant differences between the sexes in the length of the plastron lobe,

TABLE 2. Patterns of coloration of adults of *Emys orbicularis* from salentine peninsula (southern Apulia). Phenotypic categories according to FRITZ (1995).

TABLA 2. Patrones de coloración de los adultos de *Emys orbicularis* de la península de Salentine (sur de Apulia). Categorías fenotípicas siguiendo a FRITZ (1995).

Character	Males	Females
Carapace		
orbicularis type	23	34
transition type	3	5
maculosa type	0	4
Plastron		
less than 1/3 dark	10	14
1/3-2/3 dark	4	3
more than 2/3 dark	6	0
Yellow	5	26
Black	1	0
Head dorsum		
Dotted	3	25
Intermediate	5	13
Reticulate	18	0
Monochrome	0	5
Throat		
predominantly yellow	26	43
predominantly black	0	0
Iris		
yellowish with dark elements	12	43
White-yellow immaculate	14	0

pectoral scute length and anal scute. Among ratios only PL/AnaL, PL/GuL, SH/CL and SH/PL show a significant difference between sexes (Table 3).

Colour and pattern

Table 3 summarizes the variation of colour and pattern that due to algal growth, on the carapace of some turtles, has not been always possible to determine.

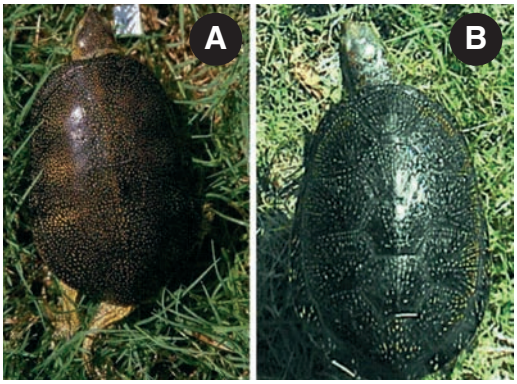

FIGURE 2. Carapace colouration in males (A) and females (B) of Salento pond turtles *Emys orbicularis.*

FIGURA 2. Coloración del espaldar de machos (A) y hembras (B) de *Emys orbicularis* de Salento.

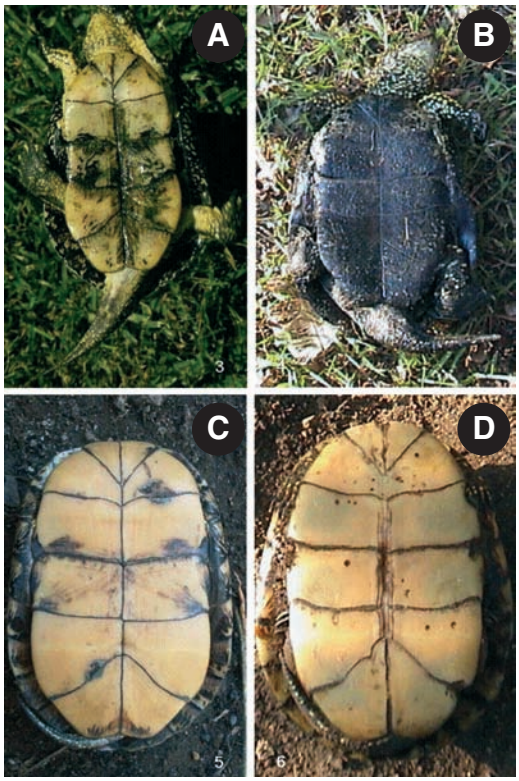

FIGURE 3. Plastron colouration extremes in males (A, B) and females (C, D) of Salento pond turtles *Emys orbicularis*.

FIGURA 3. Variabilidad en la coloración del plastrón de machos (A, B) y hembras (C, D) de *Emys orbicularis* de de Salento.

TABLE 3. Variation of morphological ratios per sex (mean ± SD, range). P1: probability after a *t-test* comparing means of both sexes, P2: probability after a Mann-Whitney U test.

TABLA 3. Variación de los indices morfológicos según el sexo (media ± SD, rango). P1: probabilidad a partir de un test-t que compara las medias de ambos sexos, P2: probabilidad a partir de una prueba U de Mann-Whitney,

Variable	Males (n)	Min	Max	Females (n)	Min	Max	P1	P2
CL/CW	1.4 ± 0.01 (26)	1.3	2.0	1.3 ± 0.01 (43)	1.0	1.5	0.088	0.193
PL/AnaL	4.3 ± 0.07 (18)	3.64	3.90	3.6 ± 0.14 (23)	1.7	4.2	<0.001	< 0.001
PL/FemL	9.5 ± 0.04 (18)	6.62	13.50	9. 9 ± 0.46 (23)	6.3	14.0	0.487	0.572
PL/GuL	6.2 ± 0.16 (18)	5.30	7.90	5.4 ± 0.33 (23)	1.2	6.9	0.035	< 0.05
PL/HumL	12.7 ± 0.52 (18)	8.92	17.67	12.6 ± 0.48 (23)	7.3	16.8	0.824	0.958
PL/AbdL	5.8 ± 0.10 (18)	5.27	6.93	6.2 ± 0.10 (23)	5.3	7.3	0.906	<0.01
PL/PecL	6.0 ± 0.11 (18)	5.40	7.00	5.9 ± 0.11 (23)	5.2	7.0	0.356	0.276
PW/PL	0.6 ± 0.01 (18)	0.45	0.70	0.60 ± 0.01 (43)	0.5	0.7	0.894	0.222
SH/CL	0.4 ± 0.01 (18)	0.30	0.42	0.5 ± 0.01 (43)	0.4	2.4	0.065	< 0.001
SH/PL	0.4 ± 0.01 (18)	0.35	0.48	0.5 ± 0.01 (43)	0.4	0.6	0.002	< 0.05

Shell coloration of the 69 mature turtles (26 males and 43 females) was studied: its primary coloration is dark (black) and yellow marks are dispersed on the primary coloration. Like in many other *Emys orbicularis* subspecies, the carapacial pattern of males consists of yellow spots while females have a radiating pattern consisting of more elongated yellow elements like lines or streaks (Fig. 9).

Among the studied individuals, 4.7% display a phenotype in which a light carapacial coloration predominated (the "maculosa" type) 11.6% have clear and dark colours in similar proportion ("transition" type) and 83.8% have dark colours predominating ("orbicularis" type).

The plastron coloration and pattern is very variable: mainly yellow with a faded dark pattern especially along the seams, more

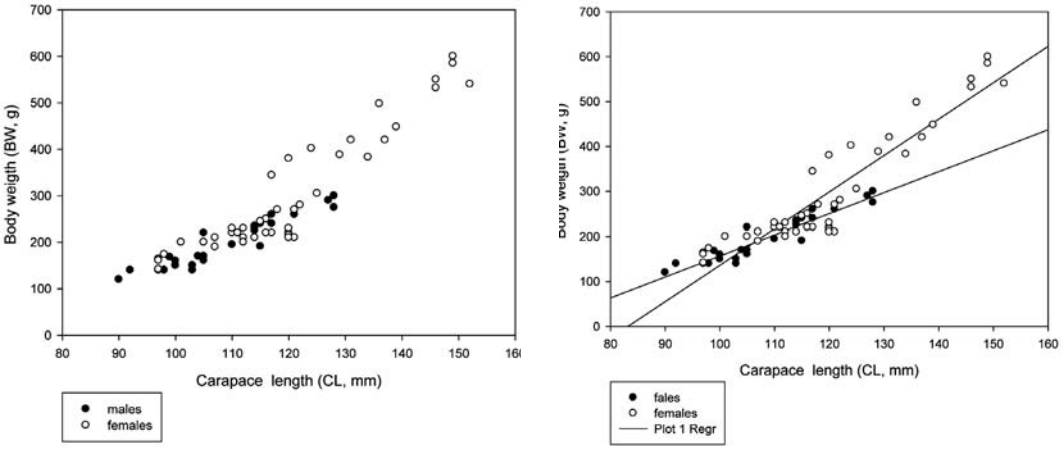

FIGURE 4. The relationship between carapace length and body weight.

FIGURA 4. Relación entre la longitud del espaldar y el peso corporal.

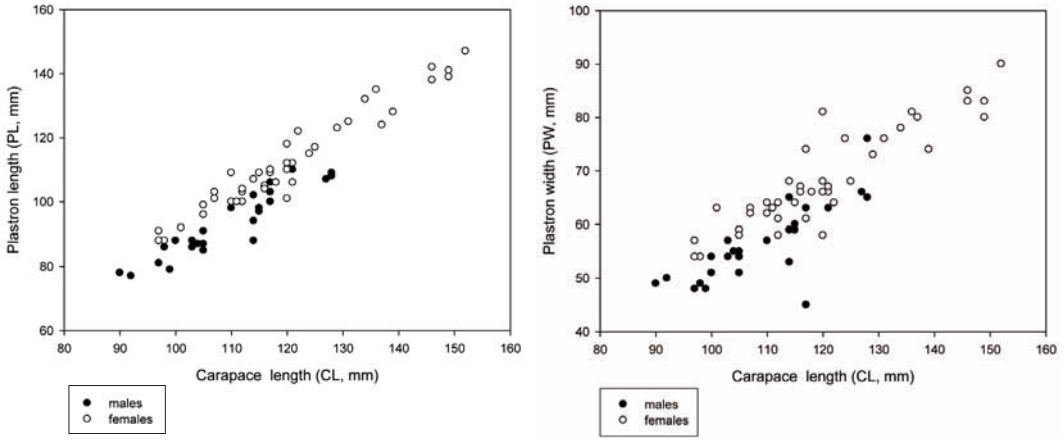

FIGURE 5. The relationship between carapace length and plastron length.

FIGURA 5. Relación entre la longitud del espaldar y la del plastrón.

FIGURE 6. The relationship between carapace length and plastron width.

FIGURA 6. Relación entre la longitud del espaldar y la anchura del plastrón.

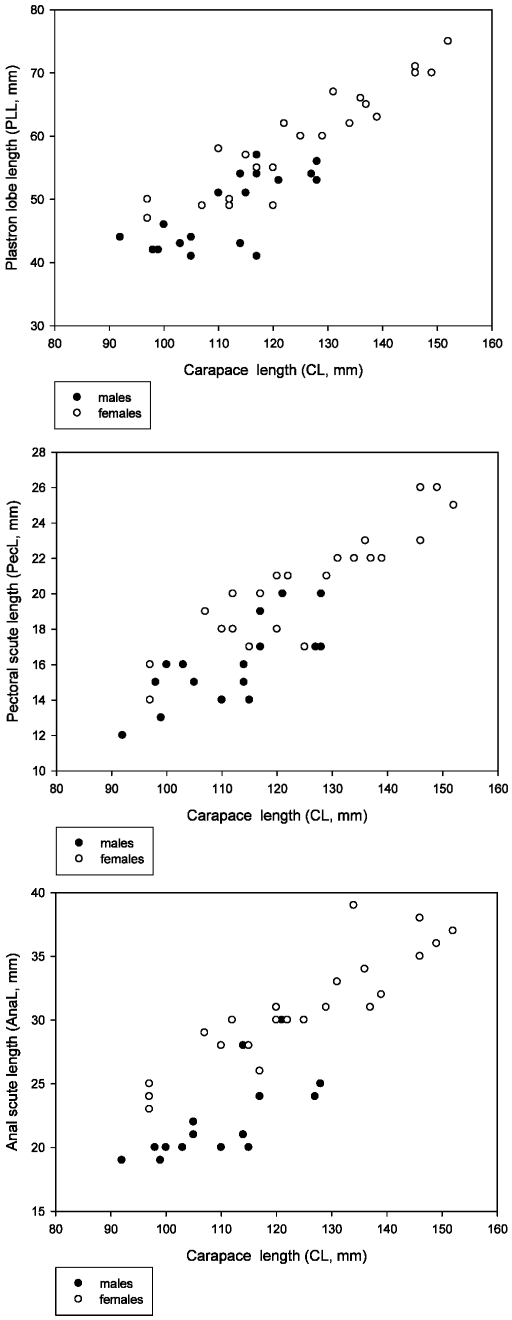

FIGURE 7. The relationship between carapace length and the length of **(a)** plastron lobe, **(b)** pectoral scute and **(c)** anal scute.

FIGURA 7. Relación entre la longitud del espaldar y la longitud del (a) lóbulo del plastrón, (b) placa pectoral y (c) placa anal.

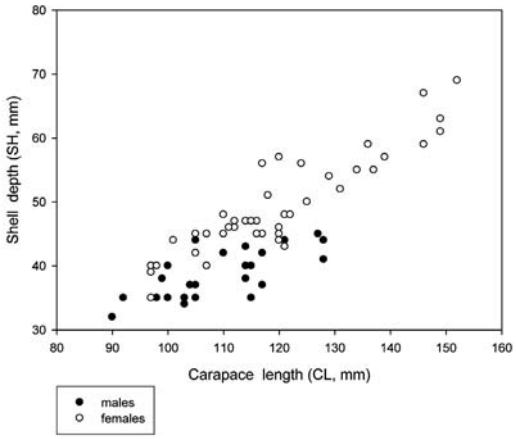

FIGURE 8. The relationship between carapace length and shell depth.

FIGURA 8. Relación entre la longitud del espaldar y la altura del caparazón.

FIGURE 9. Caparacial pattern of males (A) and females (B).

FIGURA 9. Diseño del espaldar en machos (A) y hembras (B).

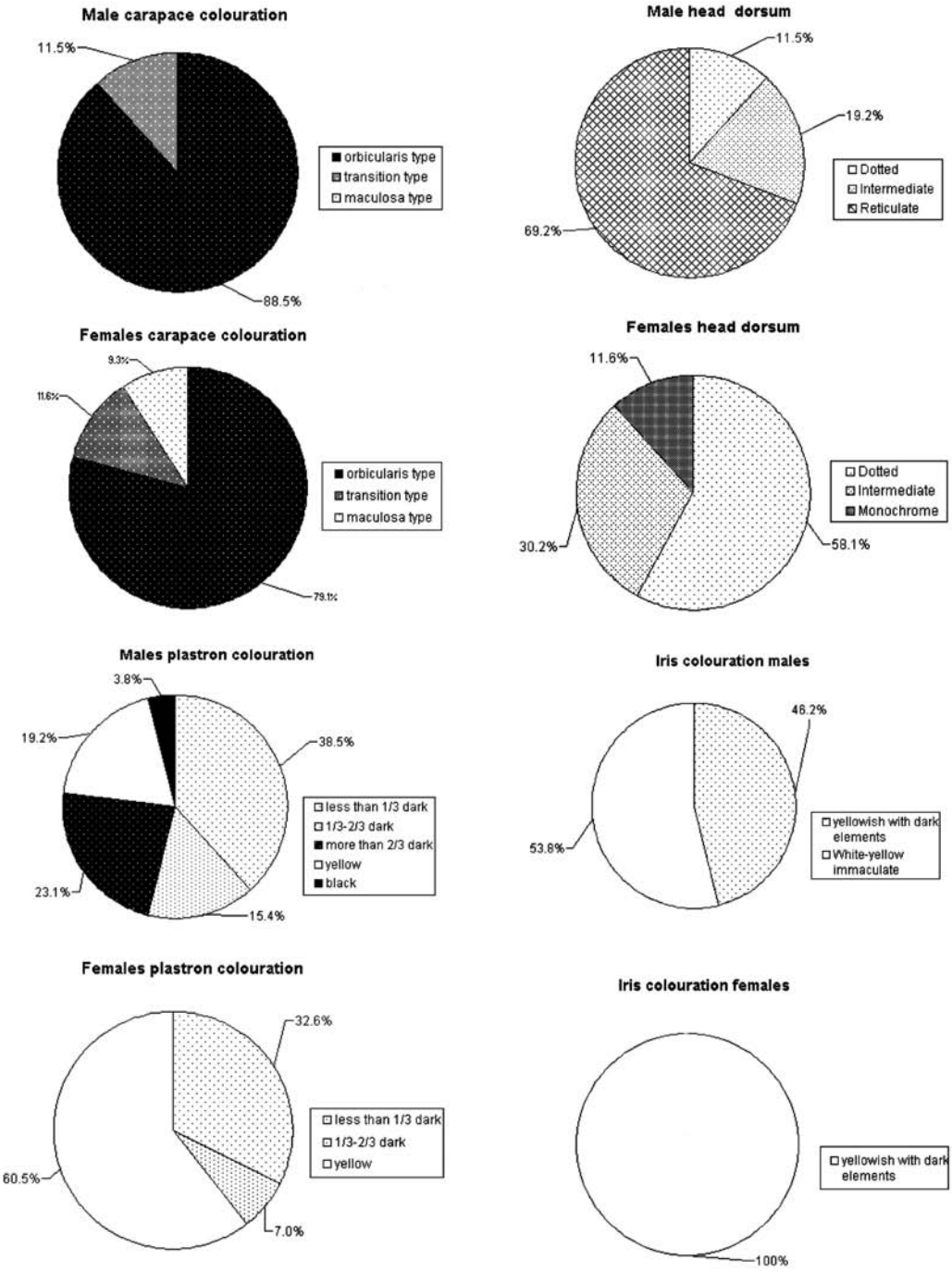

FIGURE 10. Percentage of different patterns and coloration of adults of *Emys orbicularis* from salentine peninsula (southern Apulia). Phenotypic categories according to FRITZ (1995).

FIGURA 10. Porcentaje de diseños de coloración en los adultos de *Emys orbicularis* de la península de Salentine (sur de Apulia). Categorías fenotípicas según FRITZ (1995).

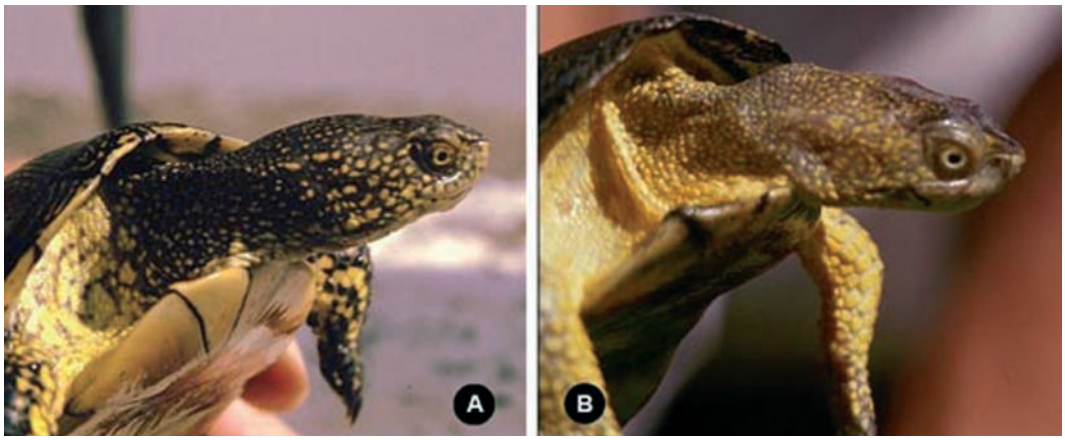

FIGURE 11. Head, throat and iris colouration in females (A) and males (B).

FIGURA 11. Cabeza, garganta y coloración del iris en hembras (A) y machos (B).

extensive in the males, in one male the plastron is predominantly black (Table 3, Fig. 3 and see also discussion). Generally, males have a darker plastron than females, in the mentioned specimen is completely black and only 19.2% have a completely yellow plastron; 60.5% of the females have a completely yellow plastron (Fig. 10). The χ^2 test suggests that these sexually dimorphic plastron coloration differences are highly significant ($\chi^2 = 19.00$, d.f. = 4, $p < 0.001$).

A similarly clear sexual dimorphism exists also in the dorsal coloration of the head ($\chi^2 = 42.22$, d.f. = 3, $p < 0.001$) and for the iris coloration ($\chi^2 = 28.66$, d.f. = 1, $p < 0.001$): 69.2% of males have a reticulate brownish head while the 58.1% of females have dark to black heads with round yellow dots (Table 3). In most males the iris is yellowish or bright white coloured (53.8%) and yellowish with dark elements in remaining males and in all females (Table 2) (Fig. 4). Coloration of the throat is predominantly yellow in both sexes (Table 2) (Fig. 4). Extremities and tail are intensely patterned with irregular yellow speckles in males; sometimes extremities and tail may be coloured entirely yellow (Figs. 4, 5). The forelegs of females bear two well-defined yellow lines. An indistinct V-shaped yellow figure occurs on the tail of females (FRITZ *et al*., 2005) (Fig. 5).

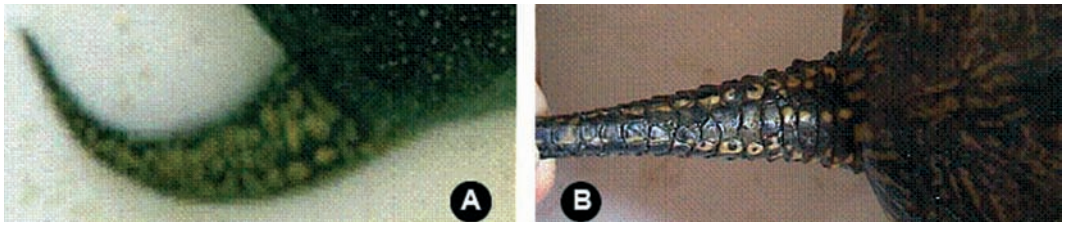

FIGURE 12. Tail colouration in males (A) and females (B).

FIGURA 12. Coloración de la cola en machos (A) y hembras (B).

DISCUSSION

Shell measurements, colour and pattern of male and female Salentine pond turtles correspond well to previously published data about Balkanic populations of *Emys orbicularis hellenica*, that occurs around the Adriatic Sea, along the Balkanic coast of the Ionian Sea and on the Peloponnese (FRITZ, 2001). Also previously published genetic data confirm this subspecies allocation for Salentine turtles (FRITZ *et al*., 2005). The finding of a very unusually coloured male with a nearly entirely black plastron and a rather dark throat (Fig. 3), fitting neither the characteristics *of E. o. hellenica* nor of the neighbouring subspecies *E. o. galloitalica*, is remarkable. This specimen resembles coloration European pond turtles from the south-eastern Balkans (U. Fritz, personal communication) and it cannot be excluded that this specimen could be introduced.

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