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Some Investigations on the Taxonomic Status of *Emys orbicularis* from the Aegean and Central Anatolian Regions of Turkey

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Abstract: A total of 219 *Emys orbicularis* specimens collected at 7 localities featuring different ecological and geographical characteristics in western and central Anatolia were examined. We compared 25 different ratios to investigate the morphological differences and similarities among populations. Male-female sex ratios and growth parameters ($W = aL^b$) were also considered. A discriminant analysis based on these 14 morphometric characters and 25 ratios clearly confirmed the differences between the *E. orbicularis* specimens from the Aegean and Central Anatolian regions. Considering differences in morphological characters found in both discriminant analyses and pair-wise comparison, we assume that the Boget specimens, an isolated population, are not an intermediate form between *E. o.* cf. *hellenica* in coastal areas of the Aegean region and *Emys orbicularis luteofusca*, from Ereğli (Konya) in Central Anatolia. The Boget specimens also differentiate statistically from those in Mogan (about 180 km north of Boget) and Kayseri (about 230 km east of Boget).

Key words: *Emys orbicularis,* emydidae, anatolia, Turkey

INTRODUCTION

Four species of fresh water turtles occur in Turkey, namely *Mauremys caspica* and *Emys orbicularis*, *Rafetus euphraticus* and *Trionyx triunguis*. In spite of suitable biotopes, the species have an interrupted distribution in Turkey and are not predictably abundant in all suitable habitats (Eiselt and Spitzenberger, 1967; Baoolu and Baran, 1977). The presence of *E. orbicularis* was mentioned in various papers relevant to Greece and Greek Islands (Broggi, 1978; Bringsoe, 1985; Ioannides *et al*., 1994). However, Baran (1984) did not record this species in the Turkish islands between Marmaris and Iskenderun, nor between Izmir and Bodrum. Various researchers have subsequently reported specimens of *E. orbicularis* from different regions of Turkey (Lambert, 1970; Clark and Clark, 1973; Andrén and Nilson, 1976; Kasparek, 1990; Dazsak and Cawthraw, 1991; Baran *et al*., 1992; Mulder, 1995).

Mertens and Wermuth (1960) and Wermuth and Mertens (1961), who gave information on general taxonomy and distribution of turtles, consider *E. orbicularis* to be monotypic. A subspecies of *E. orbicularis* from Central Anatolia was described by Fritz (1989) as *Emys orbicularis luteofusca* and subsequent studies (Fritz, 1992; 1996; Fritz and Obst, 1995; Fritz *et al*., 1998) indicate that *Emys orbicularis* is not monotypic, but rather a highly polytypic species, with thirteen subspecies currently recognized. Four of them in Turkey: *E. o.* cf. *hellenica*, *colchica*, *luteofusca* and *eiselti* (Fritz *et al*., 1998).

We here aim to clarify the taxonomic status and distribution of *E. orbicularis* in the Aegean and Central Anatolian regions of Turkey.

MATERIALS AND METHODS

In this survey, a total of 219 *E. orbicularis* specimens collected at 7 localities were examined. Of these, only nine Kütahya specimens were preserved at the museum of the Zoology Department of Ege University (ZDEU) for future osteological studies. The 210 remaining *E. orbicularis* specimens were kept in captivity for breeding. The localities where the specimens were captured in 2000, 2001 and 2002 are given in Fig. 1. Locality 5 (Kayseri) represents 3 different sampling areas, Gömeç (7♂ and 3♀), Sarımsaklı (8♂ and 4♀) and Soysallar (17♂ and 7♀).

Although colour and pattern of the turtles were recorded, these parameters were not taken into consideration in the present study. Nine specimens were anaesthetized and killed humanely and a fixative solution prepared previously with 9 mL 40% formaline and 91 mL 70% ethyl alcohol was injected later into the body cavity and extremities.

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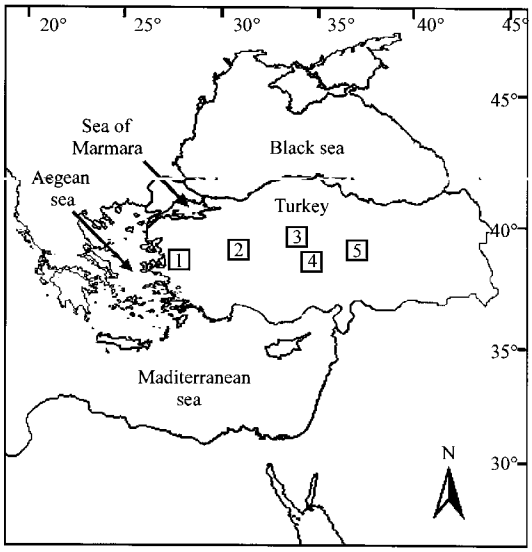

Fig. 1: Map of localities where the specimens were collected 1-Izmir (39° 10'N 26° 49'E), 2-Kütahya (39° 28'N 29° 58'E), 3-Mogan (39° 51'N 32° 48'E), 4-Boget (38° 19'N 33° 27'E), 5-Kayseri (38° 23'N 35° 25'E; 38° 52'N 35° 39'E; 38° 51'N 35° 52'E)

We utilized most of the morphometric characters defined by Fritz (Fritz, 1994). Those used for specimens from seven different localities are: TW (total weight), SCL (straight-line maximum carapace length), CCL (curved carapace length), CW (maximum carapace width), CH (maximum carapace height), PL (midline plastron length), GuL (gular suture length), HumL (humeral suture length), PecL (pectoral suture length), AbdL (abdominal suture length), FemL (femoral suture length), AnL (anal suture length), PW-1 (plastron width from humeral), PW-2 (plastron width from abdomina) HW (head width), HL-1 (head length from pupil of the aye to the tip of rostrum), HL-2 (head length from rostrum to posterior of squmosal wing) HH (head height), NuL (nuchal length), NuW (nuchal width), TL (length from cloaca to tip of tail) and TTL (length from base to tip of tail). The specimens were measured to the nearest 0.05 mm with a dial caliper; carapacial height measurements were taken with wooden calipers to the nearest 0.1 cm and weighed to closest 1 g. Animals with a straight-line carapace length greater than 10 cm were considered adult (Winden and Bogaerts, 1992). Twenty-five ratios developed from combinations of two characters were used to investigate differences between specimens. These ratios were used due to an uncertainty regarding the specimens' age groups and because it was not known whether growth was isometric or not. It is a common belief that the specimens having a straight-line carapace length less than 10 cm are

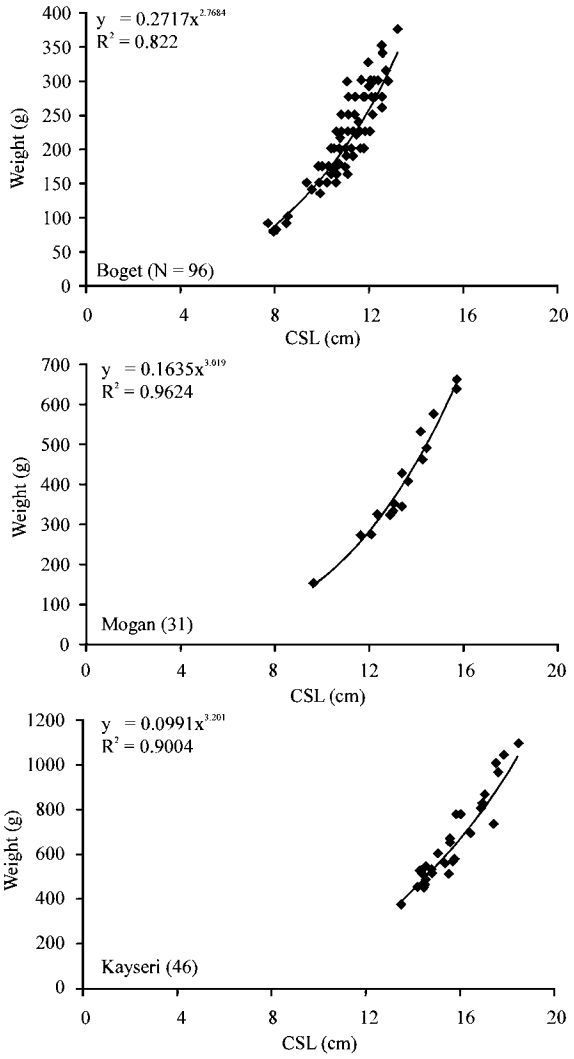

Fig. 2: Relation between straight-line carapace length and total weight of *Emys orbicularis* specimens for combined sexes

considered as subadult and eliminated form statistical analyses. All specimens taken into consideration in this study were kept in captivity for 3-4 years and we observed that the specimens less than 10 cm straight-line carapace length have copulating and productive capacities. Thus, we considered the specimen having a straight-line carapace length less than 10 cm in all statistical analyses. Statistical analyses were carried out using the IBM Statgraph program. Besides, in order to compare the different populations, one of the multivariate methods, discriminant analysis, was utilised. Male: female sex ratios of *E. orbicularis* for five sampling areas were determined as well.

No statistical differences were found between specimens from Soysallar (17♂ and 7♀) and Sarımsaklı

(8♂ and 4♀), Soysallar and Gömeç (7♂ and 3♀), Sarımsaklı and Gömeç, using a one-way variance analysis. Thus, samples from very close places were pooled to produce regional samples large enough for analysis (Kayseri includes the localities of Soysallar, Sarımsaklı and Gömeç).

RESULTS AND DISCUSSION

Statistical values of the morphometric characters of five separate populations are given in Table 1A-E.

Male:female sex ratios of specimens examined were 1:1.25 in Kütahya, 1:1.82 in Mogan, 1:2.28 in Kayseri, 1:2.88 in Boget and 1:1 in Izmir. According to growth parameters ($W = aL^b$) based on the data available, the equations for length-weight relationships for combined sexes were computed as $W = 0.2717L^{2.7684}$ ($r = 0.822$) for Boget, $W = 0.1635L^{3.019}$ ($r = 0.9624$) for Mogan and $W = 0.0991L^{3.201}$ ($r = 0.9004$) for Kayseri (Fig. 2). Correlation coefficients computed for the length-weight relationship suggested that growth in the population was harmonious and balanced. The "b" values in these formulae indicate that habitats in the study areas are well suited for *E. orbicularis* populations in Mogan and Kayseri.

According to an overall frequency analysis (indiv.) for the straight line carapace length regarding specimens from Kütahya, Mogan, Izmir, Kayseri and Boget, it is obvious that specimens in the Kayseri population are statistically larger than those from the other four localities (Fig. 3). Specimens from Boget are the smallest ones.

The plastral formulae for each specimen from a given population and a formula based on average values are given in Table 2. The plastron formula (An>Abd>Pec>Gul>Fem>Hum) given by Ernst and Barbour (Ernst and Barbour, 1989) for the species in question is discordant with all populations taken into

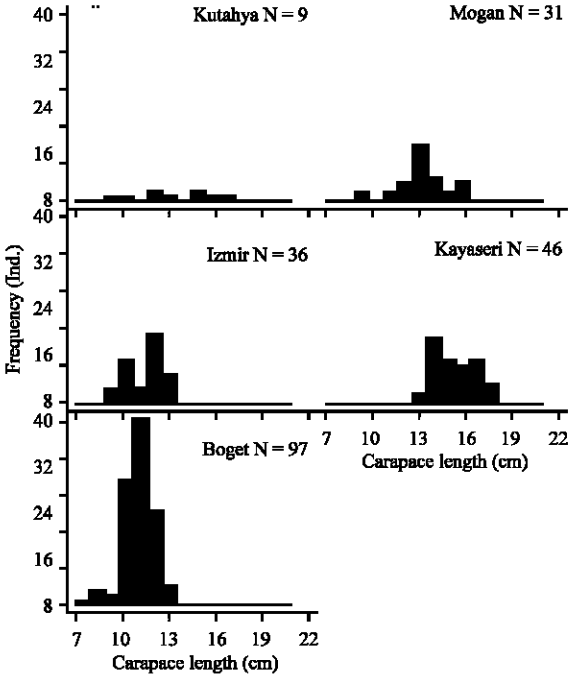

Fig. 3: Frequency distribution of straight-line carapace length for five localities including all specimens examined

Table 1A: The summarized statistical analyses of raw morphometric measurements (cm and g) of female male and overall *Emys orbicularis* specimens from Boget (Text for abbreviations)

	Boget specimens											
	Females				Males				Overall specimens			
	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD
TW	25	90.00-375.00	257.00±15.47	77.37	72	80.00-300.00	199.31±4.78	40.53	97	80.00-375.00	214.18±5.88	57.92
SCL	25	7.77-13.20	11.36±0.28	1.40	72	7.95-12.80	10.93±0.09	0.80	97	7.77-13.20	11.04±0.10	1.00
CCL	25	-	-	-	72	-	-	-	97	-	-	-
CW	25	6.78-9.75	8.74±0.16	0.78	72	6.34-9.67	8.29±0.07	0.55	97	6.34-9.75	8.40±0.07	0.65
CH	25	3.13-5.27	4.57±0.12	0.59	72	3.20-4.89	3.95±0.04	0.31	97	3.13-5.27	4.11±0.05	0.48
PL	25	7.20-12.00	10.47±0.25	1.25	72	1.08-11.15	9.35±0.14	1.17	97	1.08-12.00	9.64±0.13	1.28
GUL	25	1.24-2.31	1.87±0.057	0.28	72	0.85-2.13	1.70±0.03	0.22	97	0.85-2.31	1.74±0.03	0.25
HUML	25	0.50-1.42	0.95±0.05	0.25	72	0.48-1.86	0.88±0.03	0.23	97	0.48-1.86	0.90±0.02	0.23
PECL	25	0.96-2.42	1.86±0.06	0.31	72	1.39-2.10	1.69±0.02	0.17	97	0.96-2.42	1.73±0.02	0.23
ABDL	25	1.13-2.31	1.79±0.05	0.24	72	1.24-2.14	1.59±0.02	0.19	97	1.13-2.31	1.64±0.02	0.22
FEML	25	0.82-1.45	1.14±0.03	0.16	72	0.76-2.69	1.15±0.03	0.27	97	0.76-2.69	1.15±0.02	0.24
ANL	25	2.10-3.59	3.03±0.07	0.37	72	1.63-5.00	2.71±0.04	0.37	97	1.63-5.00	2.79±0.04	0.40
PW-I	25	4.27-6.84	6.11±0.14	0.69	72	4.10-6.27	5.42±0.04	0.38	97	4.10-6.84	5.60±0.06	0.56
PW-II	25	4.52-7.65	6.31±0.16	0.80	72	4.26-6.49	5.62±0.04	0.38	97	4.26-7.65	5.80±0.06	0.60
NUL	25	0.30-0.67	0.51±0.02	0.10	72	0.32-0.66	0.48±0.01	0.07	97	0.30-0.67	0.48±0.01	0.08
NUL	25	0.15-0.46	0.33±0.02	0.08	72	0.15-0.63	0.32±0.01	0.08	97	0.15-0.63	0.32±0.01	0.08
TTL	25	4.05-7.47	6.24±0.17	0.83	72	4.86-8.46	7.13±0.07	0.61	97	4.05-8.46	6.90±0.08	0.77
TL	25	3.29-5.93	4.85±0.12	0.59	72	3.50-5.49	4.67±0.06	0.48	97	3.29-5.93	4.72±0.05	0.51

Table 1B: The summarized statistical analyses of raw morphometric measurements (cm and g) of female male and overall *Emys orbicularis* specimens from Kütahya (Text for abbreviations)

	Kutahya specimens											
	Females				Males				Overall specimens			
	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD
TW	4	-	-	-	5	-	-	-	9	-	-	-
SCL	4	9.00-17.10	12.73±1.91	3.82	5	12.00-15.50	13.44±0.68	1.53	9	9.00-17.10	13.12±0.87	2.61
CCL	4	10.00-19.50	14.48±2.22	4.43	5	13.40-18.00	15.14±0.92	2.05	9	10.00-19.50	14.84±1.03	3.10
CW	4	7.20-12.90	9.96±1.38	2.77	5	8.93-12.10	10.30±0.63	1.40	9	7.20-12.90	10.15±0.66	1.97
CH	4	3.70-7.10	5.33±0.86	1.73	5	4.60-5.60	5.04±0.20	0.44	9	3.70-7.10	5.17±0.37	1.11
PL	4	8.10-15.70	11.83±1.82	3.65	5	10.73-13.51	11.82±0.54	1.22	9	8.10-15.70	11.82±0.80	2.39
GUL	4	1.50-2.84	2.15±0.31	0.63	5	1.87-2.31	2.10±0.08	0.17	9	1.50-2.84	2.12±0.13	0.40
HUML	4	0.69-1.47	1.01±0.19	0.39	5	0.90-1.39	1.14±0.11	0.24	9	0.69-1.47	1.08±0.10	0.30
PECL	4	1.40-3.14	2.28±0.39	0.79	5	1.67-2.55	2.08±0.15	0.33	9	1.40-3.14	2.17±0.18	0.55
ABDL	4	1.40-2.66	1.98±0.28	0.56	5	1.68-2.25	1.89±0.12	0.27	9	1.40-2.66	1.93±0.13	0.40
FEML	4	0.80-1.30	1.05±0.13	0.25	5	0.90-1.42	1.16±0.08	0.19	9	0.80-1.42	1.11±0.07	0.21
ANL	4	2.40-4.71	3.43±0.56	1.12	5	2.83-3.76	3.32±0.18	0.39	9	2.40-4.71	3.37±0.25	0.74
PW-I	4	4.60-8.06	6.29±0.87	1.74	5	5.80-6.90	6.23±0.23	0.52	9	4.60-8.06	6.26±0.38	1.13
PW-II	4	4.90-9.34	7.02±1.07	2.14	5	6.32-8.34	7.06±0.38	0.84	9	4.90-9.34	7.05±0.48	1.44
NUL	4	0.49-0.81	0.63±0.08	0.16	5	0.47-0.61	0.52±0.02	0.05	9	0.47-0.81	0.57±0.04	0.12
NUL	4	0.30-0.43	0.37±0.03	0.06	5	0.24-0.46	0.38±0.04	0.09	9	0.24-0.46	0.38±0.02	0.07

Table 1C: The summarized statistical analyses of raw morphometric measurements (cm and g) of female male and overall *Emys orbicularis* specimens from Izmir (Text for abbreviations)

	Izmir specimens											
	Females				Males				Overall specimens			
	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD
TW	18	-	-	-	18	-	-	-	36	-	-	-
SCL	18	9.30-13.30	11.37±0.36	1.51	18	10.50-12.60	11.63±0.18	0.78	36	9.30-13.30	11.50±0.20	1.19
CCL	18	10.80-15.10	12.93±0.38	1.61	18	11.90-14.20	13.12±0.18	0.76	36	10.80-15.10	13.03±0.21	1.25
CW	18	7.60-10.90	9.20±0.30	1.25	18	8.20-9.80	9.17±0.14	0.61	36	7.60-10.90	9.18±0.16	0.97
CH	18	3.90-6.10	4.77±0.19	0.81	18	4.30-4.80	4.50±0.04	0.17	36	3.90-6.10	4.63±0.10	0.59
PL	18	8.90-12.70	10.80±0.36	1.51	18	9.20-11.20	10.52±0.17	0.73	36	8.90-12.70	10.66±0.20	1.18
GUL	18	1.60-2.40	1.95±0.07	0.28	18	1.50-2.30	1.88±0.07	0.31	36	1.50-2.40	1.92±0.05	0.29
HUML	18	0.70-1.10	0.92±0.03	0.14	18	0.70-1.20	0.85±0.04	0.18	36	0.70-1.20	0.88±0.03	0.16
PECL	18	1.20-2.50	1.83±0.10	0.44	18	1.60-2.00	1.85±0.03	0.14	36	1.20-2.50	1.84±0.05	0.32
ABDL	18	1.30-2.10	1.78±0.06	0.27	18	1.60-1.90	1.75±0.02	0.10	36	1.30-2.10	1.77±0.03	0.20
FEML	18	0.90-1.40	1.15±0.05	0.19	18	1.00-1.50	1.18±0.05	0.20	36	0.90-1.50	1.17±0.03	0.20
ANL	18	2.50-3.60	3.02±0.10	0.43	18	2.50-3.20	2.95±0.06	0.27	36	2.50-3.60	2.98±0.06	0.35
PW-I	18	4.80-6.60	5.60±0.17	0.73	18	4.80-5.90	5.42±0.09	0.37	36	4.80-6.60	5.51±0.10	0.58
PW-II	18	5.20-7.50	6.35±0.22	0.91	18	5.50-6.60	6.22±0.09	0.38	36	5.20-7.50	6.28±0.12	0.69
NUL	18	0.40-0.70	0.50±0.03	0.12	18	0.50-0.70	0.60±0.02	0.10	36	0.40-0.70	0.55±0.02	0.12
NUL	18	0.40-0.70	0.52±0.03	0.11	18	0.40-0.50	0.43±0.01	0.05	36	0.40-0.70	0.48±0.02	0.09
HW	18	1.90-2.60	2.23±0.06	0.26	18	2.10-2.40	2.25±0.03	0.13	36	1.90-2.60	2.24±0.03	0.20
HL-I	18	1.00-1.10	1.05±0.01	0.05	18	1.00-1.20	1.05±0.02	0.08	36	1.00-1.20	1.05±0.01	0.07
HL-II	18	2.30-3.40	2.77±0.09	0.37	18	2.60-2.90	2.82±0.03	0.12	36	2.30-3.40	2.79±0.05	0.27
HH	18	1.00-1.20	1.10±0.02	0.10	18	1.00-1.10	1.05±0.01	0.05	36	1.00-1.20	1.08±0.01	0.08

consideration here. Only three individuals show the plastral formula given by authors (Ernst and Barbour, 1989). Consequently, regarding the high variation seen among members from same localities (Table 2), we believe that plastron formulae are not very useful in taxonomic discrimination of *E. orbicularis*.

Samples from different localities were compared by one-way variance analyses and multiple range tests, utilizing 14 morphometric characters. In order to emphasize the similarities and differences between four populations, results from the multiple range analyses were superimposed onto Table 3. As a result, it is obvious that specimens in the Mogan and Kütahya populations are statistically similar to each other, considering 13 morphometric characters, while only one character was significantly different between Mogan and Kütahya. A set of 14 different characters differentiated the Boget population from Kayseri and Mogan and the Kayseri population from Izmir. While 12 characters were statistically significantly different between Izmir and Mogan and Gölcük, a set of ten characters differentiated Izmir from the Boget and Kütahya populations. Similarly, a significant difference in ten morphometric measurements was found between Kayseri and Mogan. In a pairwise comparison of specimens, it is evident that the Izmir material is totally different from Mogan specimens in

Table 1D: The summarized statistical analyses of raw morphometric measurements (cm and g) of female male and overall *Emys orbicularis* specimens from Mogan (Text for abbreviations)

	Mogan specimens											
	Females				Males				Overall specimens			
	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD
TW	11	325.00-660.00	538.18±36.96	122.58	20	155.00-490.00	337.00±20.22	90.41	31	155.00-660.00	408.39±25.25	140.58
SCL	11	12.16-15.50	14.30±0.37	1.24	20	9.48-14.21	12.54±0.29	1.28	31	9.48-15.50	13.16±0.27	1.51
CCL	11	13.50-17.50	16.01±0.43	1.43	20	10.50-16.00	13.95±0.32	1.43	31	10.50-17.50	14.68±0.31	1.73
CW	11	10.00-12.27	11.27±0.26	0.86	20	8.26-11.65	10.08±0.20	0.90	31	8.26-12.27	10.50±0.19	1.04
CH	11	5.27-6.40	5.94±0.12	0.40	20	3.85-5.55	4.88±0.10	0.43	31	3.85-6.40	5.26±0.12	0.66
PL	11	11.50-14.82	13.56±0.36	1.19	20	8.98-12.44	10.97±0.20	0.88	31	8.98-14.82	11.89±0.29	1.60
GUL	11	2.21-3.00	2.52±0.08	0.27	20	1.71-2.59	2.21±0.05	0.23	31	1.71-3.00	2.32±0.05	0.29
HUML	11	0.95-1.51	1.23±0.07	0.24	20	0.66-1.34	0.98±0.04	0.20	31	0.66-1.51	1.07±0.04	0.24
PECL	11	2.13-2.61	2.36±0.05	0.17	20	1.68-2.29	1.89±0.05	0.20	31	1.68-2.61	2.06±0.05	0.30
ABDL	11	1.75-2.44	2.11±0.07	0.24	20	1.34-1.81	1.60±0.03	0.15	31	1.34-2.44	1.78±0.06	0.31
FEML	11	1.32-2.52	1.71±0.13	0.43	20	1.01-1.64	1.30±0.04	0.20	31	1.01-2.52	1.45±0.06	0.36
ANL	11	3.19-4.39	3.80±0.14	0.48	20	2.72-3.56	3.17±0.06	0.27	31	2.72-4.39	3.40±0.08	0.46
PW-I	11	6.91-8.61	7.65±0.18	0.60	20	5.29-7.08	6.12±0.11	0.48	31	5.29-8.61	6.66±0.16	0.90
PW-II	11	7.20-9.18	8.26±0.21	0.69	20	5.51-7.95	6.85±0.15	0.65	31	5.51-9.18	7.35±0.17	0.95
NUL	11	0.54-0.83	0.69±0.03	0.11	20	0.31-0.79	0.60±0.03	0.13	31	0.31-0.83	0.63±0.03	0.13
NUL	11	0.26-0.65	0.50±0.04	0.13	20	0.31-0.64	0.41±0.02	0.10	31	0.26-0.65	0.44±0.02	0.12
TTL	11	6.00-9.62	7.18±0.39	1.29	20	6.15-8.34	7.42±0.14	0.63	31	6.00-9.62	7.33±0.16	0.91
TL	11	4.49-7.16	5.46±0.28	0.93	20	4.26-5.22	4.80±0.07	0.33	31	4.26-7.16	5.03±0.12	0.68

Table 1E: The summarized statistical analyses of raw morphometric measurements (cm and g) of female male and overall *Emys orbicularis* specimens from Kayseri (Text for abbreviations)

	Kayseri specimens											
	Females				Males				Overall Specimens			
	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD	N	Range	Mean±SE	SD
TW	14	660.00-1090.00	880.00±35.49	132.78	32	375.00-730.00	537.66±14.63	82.76	46	375.00-1090.00	641.85±27.65	187.56
SCL	14	15.25-18.09	16.74±0.23	0.85	32	13.20-17.10	14.79±0.16	0.91	46	13.20-18.09	15.38±0.19	1.27
CCL	14	17.30-20.60	18.99±0.27	1.02	32	15.00-19.20	16.59±0.19	1.05	46	15.00-20.60	17.32±0.22	1.52
CW	14	11.54-13.32	12.63±0.16	0.59	32	10.02-12.50	11.20±0.12	0.68	46	10.02-13.32	11.64±0.14	0.93
CH	14	6.25-8.45	7.40±0.17	0.64	32	5.07-6.26	5.58±0.06	0.34	46	5.07-8.45	6.13±0.14	0.96
PL	14	13.92-17.59	15.92±0.26	0.98	32	12.20-14.90	13.27±0.14	0.81	46	12.20-17.59	14.07±0.22	1.50
GUL	14	1.89-2.83	2.42±0.08	0.32	32	1.52-2.64	2.20±0.04	0.25	46	1.52-2.83	2.27±0.04	0.29
HUML	14	1.13-4.16	1.75±0.28	1.04	32	0.66-1.52	0.98±0.04	0.23	46	0.66-4.16	1.22±0.10	0.69
PECL	14	2.22-3.39	2.96±0.08	0.31	32	2.05-2.74	2.35±0.03	0.16	46	2.05-3.39	2.53±0.05	0.35
ABDL	14	2.14-2.71	2.51±0.06	0.21	32	1.63-2.51	1.98±0.05	0.26	46	1.63-2.71	2.14±0.05	0.35
FEML	14	1.73-2.32	1.92±0.06	0.22	32	1.15-2.58	1.69±0.06	0.32	46	1.15-2.58	1.76±0.05	0.31
ANL	14	3.16-4.91	3.99±0.15	0.55	32	2.75-3.82	3.35±0.06	0.35	46	2.75-4.91	3.54±0.08	0.51
PW-I	14	6.96-8.68	8.01±0.16	0.61	32	6.04-7.31	6.64±0.08	0.43	46	6.04-8.68	7.06±0.12	0.80
PW-II	14	8.00-9.96	9.08±0.18	0.67	32	6.80-8.44	7.51±0.09	0.52	46	6.80-9.96	7.99±0.14	0.92
NUL	14	0.50-0.85	0.67±0.03	0.11	32	0.38-0.80	0.61±0.02	0.12	46	0.38-0.85	0.63±0.02	0.12
NUL	14	0.22-0.64	0.41±0.04	0.15	32	0.16-0.55	0.35±0.02	0.13	46	0.16-0.64	0.37±0.02	0.13
TTL	12	6.93-10.00	8.78±0.22	0.77	26	6.75-11.50	8.85±0.22	1.14	38	6.75-11.50	8.83±0.17	1.03
TL	12	4.70-7.21	6.66±0.21	0.73	26	4.12-7.50	5.66±0.17	0.87	38	4.12-7.50	5.97±0.15	0.94

twelve different characters and the difference between Boget and Kütahya is eleven of characters.

For further analyses as indicated above, we used the ratios developed from the morphometric characters. Discriminant analyses were applied to specimens collected from Kütahya, Mogan, Izmir, Kayseri and Boget. Both the ratios developed by combination of straight line carapace length and carapace width with other morphometric measurements [13+12 ratios (SCL/CW, SCL/CH, SCL/PL, SCL/GuL, SCL/HumL, SCL/PecL, SCL/AbdL, SCL/FemL, SCL/AnL, SCL/PW-I, SCL/PW-II, SCL/NuL, SCL/NuW) and (CW/CH, CW/PL, CW/GuL, CW/HumL, CW/PecL, CW/AbdL, CW/FemL, CW/AnL, CW/PW-I, CW/PW-II, CW/NuL, CW/NuW) respectively, Fig. 4 and 5] and morphometric measurements [14 morphometric measurements (SCL, CW, CH, PL, GuL, HumL, PecL, AbdL, FemL, AnL, PW-I, PW-II, NuL, NuW) Fig. 6] indicated three groups of populations: Boget, Kayseri and the others between them.

Taskavak and Reimann (1998) determined the existence of two different populations of *E. orbicularis* at Cihanbeyli and Boget, in central Anatolia. They stated that specimens from Cihanbeyli were statistically similar to the subspecies *luteofusca* described by Fritz (1989), but different from Izmir specimens. They also claimed that the Boget population (about 90 km from Cihanbeyli) was

Table 2: Various plastral formulae observed in each specimen and population (N = number, % = percentages (Text for abbreviations)

N	%	Plastron formulae
Boget population (N: 97)		
24	24.74	An>Pec>Gu>Abd>Fem>Hum
23	23.71	An>Gu>Pec>Abd>Fem>Hum
12	12.37	An>Gu>Abd>Pec>Fem>Hum
8	8.25	An>Pec>Abd>Gu>Fem>Hum
5	5.16	An>Abd>Gu>Pec>Fem>Hum
5	5.16	An>Pec>Gu>Abd>Hum>Fem
3	3.09	An>Gu>Abd>Pec>Hum>Fem
3	3.09	An>Abd>Pec>Gu>Fem>Hum
2	2.06	An>Gu>Pec>Abd>Hum>Fem
3	3.09	An>Pec>Abd>Gu>Hum>Fem
1	1.03	An>Abd>Gu>Fem>Pec>Hum
1	1.03	Pec>Gu>An>Abd>Fem>Hum
1	1.03	An>Gu>Pec=Abd>Fem>Hum
1	1.03	An>Abd>Pec>Fem>Gu>Hum
1	1.03	An>Fem>Gu>Abd>Pec>Hum
1	1.03	An>Pec>Abd>Hum>Gu>Fem
1	1.03	An>Pec>Hum>Abd>Gu>Fem
1	1.03	An>Fem>Pec>Abd>Gu>Hum
1	1.03	An>Pec>Fem>Abd>Gu>Hum
General An>Gu>Pec>Abd>Fem>Hum		
İzmır population (N: 36)		
9	25	An>Gu>Pec=Abd>Fem>Hum
6	16.67	An>Gu>Pec>Abd>Fem>Hum
3	8.33	An>Gu>Abd>Pec>Fem=Hum
3	8.33	An>Gu=Abd>Pec>Fem>Hum
3	8.33	An>Abd>Pec=Gu>Fem=Hum
3	8.33	An>Pek>Gu>Abd>Fem>Hum
3	8.33	An>Pec=Abd>Gu>Fem>Hum
3	8.33	An>Pek=Abd>Gu>Hum>Fem
3	8.33	An>Gu=Pec>Abd>Fem>Hum
General An>Gu>Pec>Abd>Fem>Hum		
Mogan population (N: 31)		
21	67.74	An>Gu>Pec>Abd>Fem>Hum
4	12.90	An>Pec>Gu>Abd>Fem>Hum
2	6.45	An>Gu>Fem>Abd>Pec>Hum
2	6.45	An>Pek>Gu>Abd>Hum>Fem
2	6.45	An>Gu>Pec>Abd>Hum>Fem
General An>Gu>Pec>Abd>Fem>Hum		
Kayseri population (N: 46)		
18	39.13	An>Pec>Gu>Abd>Fem>Hum
8	17.39	An>Pec>Abd>Gu>Fem>Hum
3	6.52	An>Gu>Pec>Fem>Abd>Hum
3	6.52	An>Pec=Abd>Gu>Fem>Hum
2	4.35	An>Gu=Pec=Abd>Fem>Hum
2	4.35	An>Gu>Abd>Pec>Fem>Hum
2	4.35	An>Gu>Pec>Abd>Fem>Hum
2	4.35	An>Hum>Abd>Gu>Pec>Fem
2	4.35	An>Pek>Gu>Fem>Abd>Hum
1	2.17	An>Fem>Pec>Gu>Abd>Hum
1	2.17	An>Pec>Fem>Gu>Abd>Hum
1	2.17	An>Pek=Gu>Fem>Abd>Hum
1	2.17	An>Pek>Abd>Gu=Hum>Fem
General An>Gu>Pec>Abd>Fem>Hum		
Kütahya population (N: 9)		
4	44.44	An>Pec>Gu>Abd>Fem>Hum
2	22.22	An>Gu>Abd>Pec>Hum>Fem
1	11.11	An>Gu>Pec=Abd>Fem>Hum
1	11.11	An>Pec>Gu>Abd>Hum>Fem
1	11.11	An>Gu>Pec>Abd>Fem>Hum
General An>Pec>Gu>Abd>Fem>Hum		

Plastral formulae for each specimen and population

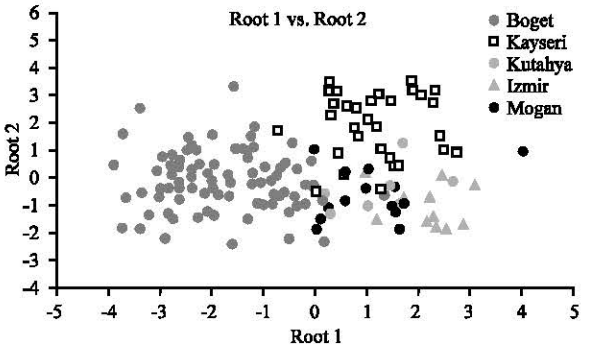

Fig. 4: Discriminant analysis of the *Emys orbicularis* specimens from five localities for ratios [N: 218; Grouping: 5; Wilks' Lambda: 0.09454, Approx. F (52, 780) = 12.589, p< 0.00; Number of variables in the model: 13 (SCL/CW, SCL/CH, SCL/PL, SCL/GuL, SCL/HumL, SCL/PecL, SCL/AbdL, SCL/FemL, SCL/AnL, SCL/PW-I, SCL/PW-II, SCL/NuL, SCL/NuW)

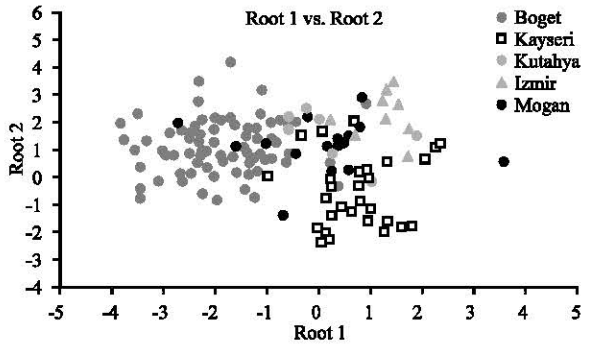

Fig. 5: Discriminant analysis of the *Emys orbicularis* specimens from five localities for ratios [N: 219; Grouping: 5; Wilks' Lambda: 0.12283, Approx. F (48, 784)= 11.818, p<0.00; Number of variables in the model: 12 (CW/CH, CW/PL, CW/GuL, CW/HumL, CW/PecL, CW/AbdL, CW/FemL, CW/AnL, CW/PW-I, CW/PW-II, CW/NuL, CW/NuW)

statistically different from the Cihanbeyli population, having the morphometric characteristics of *luteofusca*, but very similar to those from Izmir.

Our specimens from Izmir were quite similar to *E. o.* cf. *hellenica* as stated by Fritz (1992) for the Aegean and Marmara specimens, due to their small size and their CL/HL ratios being approximately 4. In this study, the CL/HL ratio was computed as being 4.1 for Izmir specimens. Ayaz *et al.* (2004) stated that turtles from Afyon and Kütahya had intermediate characteristics

Table 3: Statistically significant pairwise differences among *Emys orbicularis* populations from Boget, Kütahya, Kayseri, Mogan and Izmir (according to the raw morphometric measurements). For abbreviations, +indicates statistically significant differences ($p<0.05$)

	Characters considered for pairwise comparison													
Localities compared	SCL	CW	CH	PL	GUL	HUML	PECL	ABDL	FEML	ANL	PW-1	PW-2	NUL	NUW
Boget (97)-Kayseri (46)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Boget (97)-Izmir (36)	+	+	+	+	+	-	-	+	-	+	-	+	+	+
Boget (97)-Mogan (31)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Boget (97)-Kutahya (9)	+	+	+	+	+	-	+	+	-	+	+	+	+	-
Kayseri (46)-Izmir (36)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Kayseri (46)-Mogan (31)	+	+	+	+	-	-	+	+	+	-	+	+	-	+
Kayseri (46)-Kutahya (9)	+	+	+	+	-	-	+	+	+	-	+	+	-	-
Izmir (36)-Mogan (31)	+	+	+	+	+	+	+	-	+	+	+	+	+	-
Izmir (36)-Kutahya (9)	+	+	+	+	+	-	+	-	-	+	+	+	-	+
Mogan (31)-Kutahya (9)	-	-	-	-	-	-	-	-	+	-	-	-	-	-

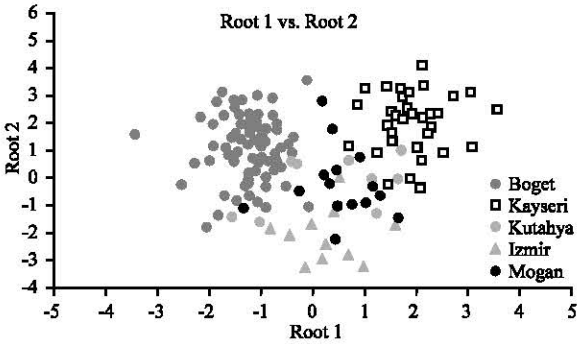

Fig. 6: Discriminant analysis of the *Emys orbicularis* specimens from five localities for ratios [N: 219; Grouping: 5; Wilks' Lambda: 0.04633, Approx. F (56, 784)= 16.841, p< 0.00; Number of variables in the model: 14 (SCL, CW, CH, PL, GuL, HumL, PecL, AbdL, FemL, AnL, PW-I, PW-II, NuL, NuW)

between *E. o.* cf. *hellenica* and *E. o. luteofusca* because of their large carapace length and long femoral suture, their carapace length and head length ratio of 4.5 and, finally, their relatively light coloration.

From the analysis of our data, we conclude that: the statistical differences found in both measurements as well as ratios derived from measurements between the five sampling groups indicate that the coastal and inland populations of *E. orbicularis* are clearly different. The morphometric characteristics of the Izmir specimens correspond to those given by Fritz (1989, 1992) and Taskavak and Reimann (1998). However, pairwise comparison discriminate the Izmir specimens from the Kütahya specimens, the closest sampling locality to Izmir.

Considering changes in morphological characters found in both discriminant analyses and pairwise comparison, we assume that the Boget specimens, an isolated population, are not an intermediate form between *E. o.* cf. *hellenica* in coastal areas of the Aegean region and *E. o. luteofusca*, described by Fritz (1989), from Ereğli (Konya) in Central Anatolia. Furthermore, the Boget specimens differentiate statistically from those in Mogan (about 180 km north of Boget) and Kayseri (about 230 km east of Boget). Could the Boget specimens be m embers of a dwarf population due to the lower "*b*" value computed in the length-weight relationship, or a representative of an unnamed population of *E. orbicularis*? Consequently, we believe that it is desirable to get a better understanding of these questions relevant to the distribution of *E. orbicularis* and therefore, more specimens are needed from localities in Kütahya as well as Central Anatolia and Mediterranean regions of Turkey.

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