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Sexual dimorphism and morphometric study of Caspian pond turtle, *Mauremys caspica* (Testudines : Geoemydidae) in Golestan Province, southeast of the Caspian Sea

Yazarloo M., Kami H.G.*, Bagherian Yazdi A.

Department of Biology, Faculty of Sciences, Golestan University, Gorgan, Iran

** Corresponding author's E-mail:hgkami2000@yahoo.com*

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ABSTRACT

The Caspian pond turtle, *Mauremys caspica*, is a terrapin belonging to family Geoemydidae. Totally, 130 specimens (67 males and 63 females) were collected manually and by net from different aquatic habitats in Golestan Province from 2016 through 2017. Morphometric characteristics such as length were measured using digital caliper and weight by electronic weighting scale. Skin of this turtle was dark olive green in color and had rows of longitudinal yellow stripes around the head and neck. Their carapace was relatively flat, the bridges between the dorsal and ventral shells were bony, and the ends of anal scutes were found to be pointed. Fingers and toes had swimming membranes. Sexes were identified using the location of vent on the tail. Sex ratios of males to females were nearly 1:1. The maximum straight carapace length (SCL_2) was 80.66-230.16 (156.72 ± 42.93) and 56.96-236.84 (147.02 ± 50.76) in males and females, respectively. Ratios of SCL_2 to maximum plastron length (PL_2) were found to be 1.013-1.32 (1.15 ± 0.04) in males and 1.01-1.15 (1.08 ± 0.03) in females; ratios of SCL_2 to straight carapace width (SCW) were 1.24-2.60 (1.40 ± 0.16) in males and 1.20-1.47 (1.35 ± 0.07) in females; ratios of SCL_2 to carapace height (CH) were 2.28-3.55 (2.79 ± 0.22) in males and 2.05-8.78 (2.87 ± 1.11) in females; ratios of SCL_2 to tail $length_2$ (TL_2) were 2.33-7.59 (3.76 ± 0.91) in males and 2.34-4.78 (3.06 ± 0.62) in females. Ratios of straight width of femuro-anal suture (FASW) to anal seam length (AnSL) were 2.95–5.89 (3.78 ± 0.54) in males and 2.65-4.13 (3.23 ± 0.40) in females. The ratio of TL_2 to TL_1 and TL_1 to RBrL are found to be the fast and simple grouping index to determine sex of the specimens.

Key words: Caspian pond turtle, Golestan Province, Morphometric, Sexual dimorphism.

INTRODUCTION

Testudines are reptiles that typically exhibit a long lifespan, delayed sexual maturity, and slow growth (Rueda-Almonacid *et al.* 2007; Moura *et al.* 2015). These characteristics have been associated with a low rate of individual substitution among populations, making this group more susceptible to anthropogenic threats and environmental weathering (Rodrigues 2005; Moura *et al.* 2012). There is strong relation between population dynamics of testudines and climatic variation, resulting in a seasonal reproductive cycle (Souza 2004). The duration and level of biological activities such as foraging, thermal regulation and migration are determined by genetic interactions and environmental conditions (Molina 1992). These aspects directly impact the population density and sex ratio; they are responsible for variations in the population dynamics of testudines (Gibbons 1990; Brito *et al.* 2009). Nine species and six subspecies of turtles, terrapins and tortoises belonging to nine genera and six families (Rastegar-Pouyani *et al.* 2008) and 12 species of turtles and tortoises have been reported in Iran, two of them are exotic (Safaei-Mahroo *et al.* 2015). The Caspian pond turtle, *Mauremys caspica* (Gmelin 1774), is a medium-sized freshwater Geoemydid turtle that is widespread throughout the Middle East, where it is distributed from Inner Anatolia and Syria over the Caucasus region to Iraq and Iran; isolated relict populations are known from Bahrain and adjacent Saudi Arabia (Yadollahvand & Kami, 2014). Caspian pond turtle has three subspecies in Iran. *M. c. caspica* (Gmelin 1774) is widely distributed in Golestan, Mazandaran, Guilan, Ardabil, East and West Azarbaijan provinces; *M. c. siebenrocki* Wischuf & Fritz 1997 in Bushehr, Kordestan, Kermanshah, Lorestan, Ilam, Khuzestan, Fars and Chahar Mahal Va Bakhtiari provinces and *M. c. ventrimaculata* in Fars and Esfahan provinces (Fritz & Wischuf 1997; Kami *et al.* 2006; Fritz *et al.* 2007; Rastegar-Pouyani *et al.* 2008; Safaei-Mahroo *et al.* 2015). Researchers often understand body size as a linear measurement based on anatomical landmarks (Gosler *et al.* 1998; Regis & Meik 2017), for example snout-vent length in most amphibians and reptiles, total length in others (Olalla-Tárraga & Rodríguez 2007; Meiri 2010), and different other linear measurements are often used among invertebrates. To other researchers, body size is compared with some other physical characters such as mass or volume. Recently, progresses in geometric morphometrics have allowed three-dimensional evaluations of size and shape of biological structures (Chiari *et al.* 2008). Carapace length often is used as a stable measurement of size across turtles, with little or no apparent daily or seasonal variation. However species vary, in the relative size and shape of the shell when compared with other aspects of body size (Pritchard *et al.* 1983; Bolten 1999). There is a difference in mean body size between males and females in many species of turtles. The development of external (e.g., elongate tail, bright colors, elongate claws, etc.), or internal (e.g., biochemical and brain structure) characters between the sexes is common (Harvey & Bradbury 1991; Bonnet *et al.* 2001; Leuteritz & Ganz 2013). These differences in size and special characters are referred to sexual size dimorphisms (SSD) (Harvey & Bradbury 1991). There are two major theories to explain SSD. One theory is based on sexual selection, which was first proposed by Darwin (1871). This states that sexual selection can result from either intra- or intersexual selection. In intrasexual selection, selection acts on traits that give an advantage to the possessor in competition among members of the same sex. In intersexual selection, selection acts on traits that make the possessor more likely to be chosen by the opposite sex (Berry & Shine 1980; Gibbons & Lovich 1990; Harvey & Bradbury 1991; Lovich & Gibbons 1992). Another theory to explain SSD as a result of natural selection (Darwin 1859). Differences in size can be related to differential interactions of each sex with its environment as the result of natural selection, or ecological forces (Slatkin 1984; Lovich & Gibbons 1992). Turtles exhibit a wide variety of size differences between the sexes (Berry & Shine 1980). It was suggested that female optimal body size may depend primarily on the number of eggs she lays, and secondarily on the degree of nest predation occurring. These factors may be similar between females of closely-related species, but are of course different than the factors affecting male body size. This suggests that the mating system of males is responsible for the variability in direction and degree of interspecific SSD (Leuteritz & Ganz 2013). In addition to body size, other different characters exist that have often been used to determine the sex of turtles, including shell morphology, claw length, eye color, tail size, and distance of cloacal vent to posterior body margin (Gibbons & Lovich 1990; Bonnet *et al.* 2010).There is a concavity in the abdominal and femoral scutes of plastral shell that is indicative of males in many species (Carr 1952; Ernst & Barbour 1989; Ernst & Lovich 2009). Results of some researches were reported on Caspian pond turtle in Iran, including morphologic and morphometric, biological study (Hojjati *et al.* 2005; Kami *et al*. 2006; Karimpour*et al.* 2011; Kami *et al.* 2012; Yazarloo *et al.* 2016), cytogenetic characterization (Yadollahvand *et al.* 2013), and assessment trace element concentrations in its tissues (Yadollahvand *et al.* 2014), and impacts of habitat change on the turtle (Yadollahvand & Kami 2014) as well as phylogeographies (Fritz *et al.* 2007), conservation genetics and phylogeography (Vamberger *et al.* 2012). The purpose of this study was to investigate sexual dimorphism in terms of much more specimens and characters that have not been carried out yet and set a simple index to identify sexes for all specimens. Previous investigations have surveyed maximum roughly one-third of these characters and no reported index.

MATERIALS AND METHODS

According to distribution of this species in the north of Iran, 130 specimens were collected from 14 stations (Fig. 1) such as Sijoval, Mohammad-Abad, Imer, AqQala, Voshmgir dam, Anbar-Olum, Gharasu, Niazabad, Kordkuy, Khanbebin, Kalaleh, Galikesh, Maraveh Tappeh and Gonbad Kavus in aquatic habitats including rivers, ponds, pools and fish farms in Golestan Province. As the species have hibernation in winter, specimens were collected in spring, summer and fall during 2016-2017 by hand and net. The turtles were transported alive to the laboratory in the Golestan University and then morphometric characters were measured using digital caliper to the nearest 0.1 mm (Figs. 2, 3, 4 and 5) based on some references (Terentev & Chernov 1949; Perälä, 2001) Quantitative data was recorded including 25 characters (Table 1) and their weights were measured using electronic weighing scale. Sexes were determined using visual observation of morphological characters. All specimens were finally returned to their habitats. Statistical analyses were carried out using Excel and SPSS (version 22) and also paleontological statistics (PAST) (version 3.14) software to study sexual dimorphism in males and females. Results were considered significant at $P < 0.001$.

Fig. 1. Fourteen collecting stations of specimens in Golestan Province.

Normal distributions of the characters were tested by Shapiro-Wilk separately for males and females. Significance of differences between sexes in mean value of the parametric characters was tested by t-student test. Sexual differences in nonparametric characters were tested by Mann-Whitney U test. Multivariate analysis of variances (MANOVA) were performed for comparing mean vectors of sexes.

An explorative principle component analysis (PCA) based on correlation matrix extraction was performed to explore patterns of co-variation in the data matrix and its relationships with sexual dimorphism. The stepwise discriminant analysis with cross-validation was carried out to examine validation of grouping the specimens by their sexes and extract the most discriminative character(s) between sexes.

Table 1. Measurements and conventional abbreviations used in this study.

Symbol parameter	Definition	Explanation
SCL_1	Minimum straight carapace length	From anterior edge of nuchal scute to the external end of suture between supra-caudal scutes
SCL_2	Maximum straight carapace length	From anterior edge of nuchal scute to the most posteriorly projecting point of supra-caudal scutes
SCW	Straight carapace width	Greatest width of carapace
CH	Carapace height	Maximum carapace height
PL_1	Minimum plastron $length_1$	From anterior of seam between the gular scutes to the end of seam between the anal scutes
PL_2	Maximum plastron $length_2$	From anterior edge of gular scutes to the most posteriorly projecting point of anal scutes
TL_1	$Taillength_1$	From posterior edge of seam between the anal scutes to anterior edge of cloaca
TL_2	$Taillength_2$	From anterior edge of cloaca to tip of tail (complete tail)
W	Weight	Weight of specimens (gram)
GSL	Gular seam length	Gular seam length in straight line
GU-w	Width of gulars	Maximum gular scutes width
HSL	Humeral seam length	Humeral seam length in straight line
PSL	Pectoral seam length	Pectoral seam length in straight line
AbSL	Abdominal seam length	Abdominal seam length in straight line
FSL	Femoral seam length	Femoral seam length in straight line
AnSL	Anal seam length	Anal seam length in straight line
FASW	Straight width of femuro-anal suture	Maximum straight width of femuro-anal suture
PFLW	Plastralfore lobe width	Straight width of humeral-pectoral suture
PHLW	Plastralhind lobe width	Straight width of femuro-anal suture
RBrL	Right bridge length	Minimum length of bridge between the right dorsal and ventral shell
LBrL	Left bridge length	Minimum length of bridge between the left dorsal and ventral shell
ASO-h	Anterior shell opening height	Inner height of anterior shell opening parallel to median axis
NL	Nuchal length	Maximum nuchal scute length
NW	Nuchal width	Maximum nuchal scute width
SUP-a	Anterior width of supracaudalscutes	Maximum anterior width of supracaudalscutes

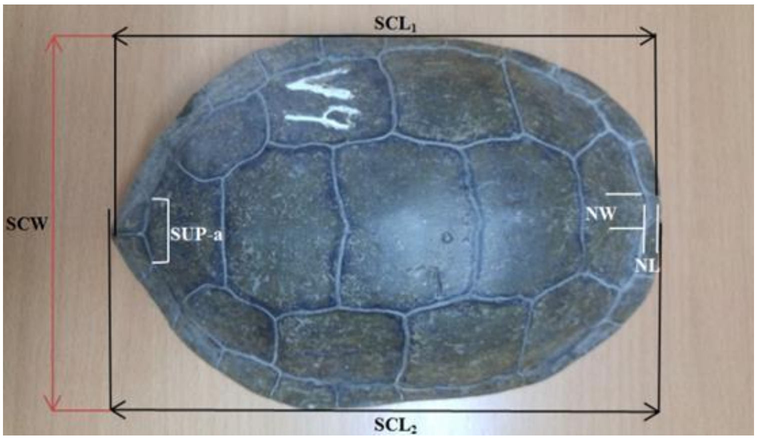

Fig. 2. Measured parameters of carapace.

Fig. 3. Maximum carapace height (CH).

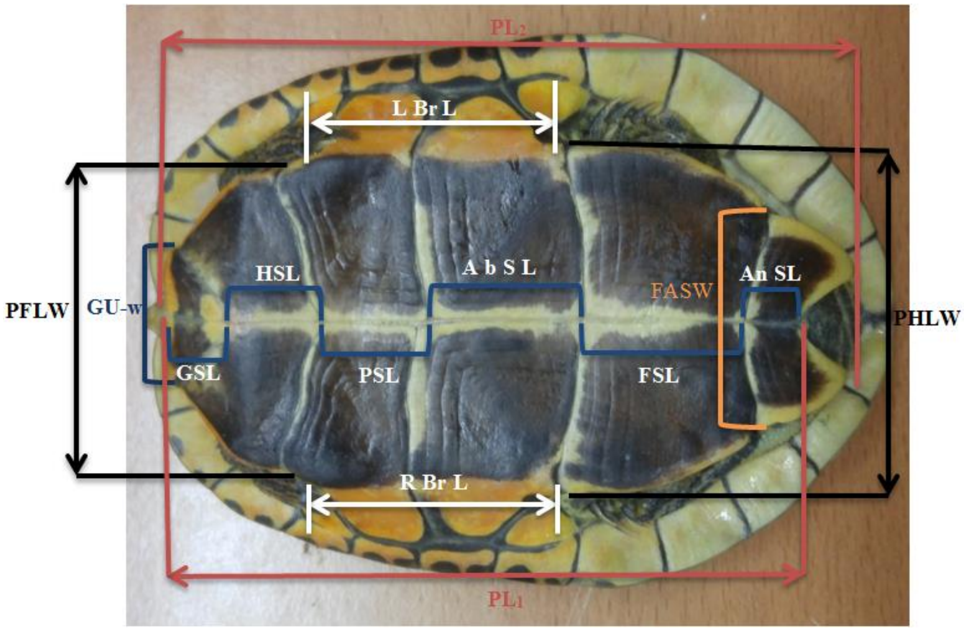

Fig. 4. Measured parameters of plastron.

Note: If the left and right scute are different in length, as is the case here, then take the mid for placing the caliper.

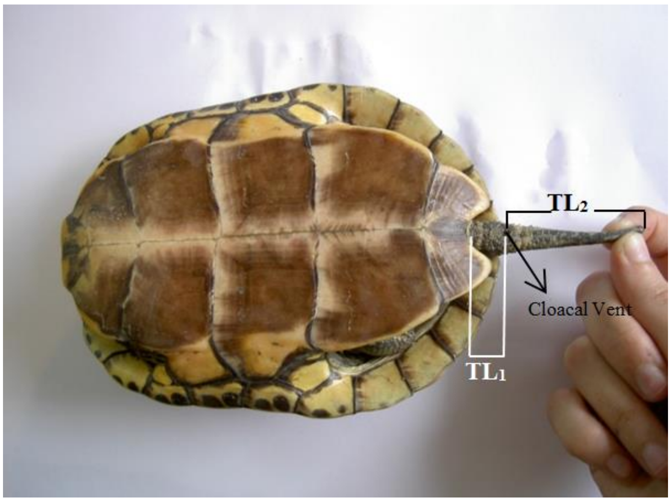

Fig. 5. Measured parameters of tail length.

RESULTS

The carapace of Caspian pond turtles, was relatively flat, having two supra-caudal scutes; Their fingers and toes had swimming membranes, and also five and four claws, respectively. Plastron lacks mobility, with axillary and inguinal scutes. The bridge between the dorsal and ventral shells was bony. The skin of this turtle was dark olive green in color and had rows of longitudinal yellow stripes around of head and neck. The ends of anal scutes were to be pointed. The presence of a plastral concavity located at the abdominal and femoral scutes was indicative of males in this species; this is due to the ease of mating. As an adaptation for copulation, male turtles also had longer, thicker tails with the cloacal vent located more distally as compared to females. In this study, sex ratio of males to females was nearly 1: 1.

Results of mean, minimum, maximum and standard deviation (SD) of characters in males and females are presented in Table 2, and also ratios of some parameters in Table 3.

All morphometric characters showed normal distribution ($P > 0.001$) except for weight in females ($p = 0.001$). Four characters (W, PL_1, PFLW and PHLW) did not show normal distribution in males ($P<0.001$).

In the parametric compare mean analysis, mean values of characters TL_1 ($p < 0.000$), AnSL ($p < 0.005$) and TL_2 ($p < 0.005$) were significantly different between the sexes. None of the four nonparametric characters showed significant differences between males and females ($p> 0.66$). Characters with higher mean values in male than in female included: Tl_1 (56%), SCL_1 and SCL_2 (6.5%), FASW (4.8%), CH (4.5%), GU-w (7%) and lower mean values included: AnSL (12.7%), W (7.8%), PSL (8.5%) and RBrL (7.6%).

Mean vectors of characters differed significantly between sexes ($F = 16.7$; $p < 0.000$).The first four component of principle analysis represented over 95% of variances. The first component exhibiting a high positive correlation with all the characters, showed variation in overall sizes of the specimens, while the second one showed sexual dimorphism in size (Fig. 6).

Characters TL_1, ASO-h exhibited a higher positive correlation with second component (Correlations 8.26 and 0.106, respectively) whereas AnSL, PSL and RBrL showed negative correlation (correlations 0.36, 0.18 and 0.14 respectively). Linear discriminant analysis (LDA) with stepwise data reduction extracted one significant function (Eigen value = 4.38; Wilks' Lambda = 0.186; $p < 0.000$) that classified 98.4% of cases to the correct memberships with cross-validation (Table 4), whereas the discriminant function grouped all the membership correctly but based on posterior probabilities of membership two specimens showed a doubtful grouping with $p = 0.47$ and 0.58 (Fig. 7). Included characters were PL_2, RBrL and TL_1. The most discriminative characters were TL_1, AnSL, ASO-h, PSL, RBrL, SCL_1 and SCL_2. The ratio TL_2 to TL_1 is simple grouping index to determine sex of the specimens with mean value nearly 1.2 for males and 3 for females in 63% of specimens (n = 81) which have complete tail tips. The index score for these specimens is: males < 2.13 = TL_2/TL_1 = 2.21 <females. 49 specimens (37%) had incomplete tail tips (no data for character TL_2), thus we found also an alternative index, the ratio of TL_1 to RBrL. The index determined sex of the specimens with 100% confident on all specimens (n = 127) with following sores: Females < 0.46 = TL_1/RBrL = 0.50 < males.

Table 2. Values are Min-Max (mean ± SD) of characteristics in males and females.

Parameters (mm)	**Males (n = 67)**	**Females (n = 63)**
SCL_1	79.27-229.48 (155.37 ± 43.01)	55.79-235.32 (145.57 ± 50.94)
SCL_2	80.66-230.16 (156.72 ± 42.93)	56.96-236.84 (147.02 ± 50.76)
SCW	64.83-153.24 (112.53 ± 27.54)	45.5-162.76 (107.14 ± 32.64)
CH	28.68-93.00 (56.86 ± 17.90)	12.4-110.64 (57.02 ± 24.12)
PL_1	67.17-178.96 (124.18 ± 32.64)	46.84-205 (125.78 ± 44.54)
PL_2	72.42-195.92 (136.46 ± 35.54)	50.52-219.94 (136.45 ± 47.59)
TL_1	16.3-52.22 (34.21 ± 9.42)	6.54-29.21(15.84 ± 5.93)
TL_2	19.68-53.92 (40.52 ± 6.81)	26.78-74.22 (47.57 ± 12.73)
W	69-1318 (541.27 ± 378.70)	23.93-1856 (590.36 ± 525.58)
GSL	8.57-25.82 (16.50 ± 4.70)	5.61-26.76 (16.66 ± 5.83)
GU-w	16.76-41.65 (29.24 ± 7.33)	12.36-43.61 (27.81 ± 8.63)
HSL	8.51-23.97 (15.88 ± 5.58)	6.07-24.41 (15.89 ± 4.86)
PSL	10.76-30.46 (19.53 ± 5.58)	6.62-36.85 (21.37 ± 8.27)
AbSL	15.62-60.24 (31.90 ± 10.06)	9.26-58.84 (32.01 ± 13.73)
FSL	16.84-44.62 (28.46 ± 7.19)	10.16-44.91 (27.462 ± 9.50)
AnSL	7.01-18.88 (11.14 ± 2.56)	3.84-19.86 (12.64 ± 3.82)
FASW	23.99-65.5 (42.37 ± 10.58)	14.84-64.13 (41.03 ± 13.69)
PFLW	35.29-81.36 (59.39 ± 15.28)	23.45-97.65 (60.06 ± 20.71)
PHLW	38.94-99.25 (70.23 ± 19.13)	26.33-109.51 (69.91 ± 24.41)
RBrL	25.58-69.23 (46.58 ± 12.64)	17.4-83.88 (50.20 ± 18.92)
LBrL	26.66-69.79 (47.20 ± 12.52)	17.9-83.55 (50.27 ± 83.55)
ASO-h	13.18-31.67 (21.95 ± 5.34)	9.35-36.79 (20.90 ± 6.06)
NL	6.22-13.53 (10.31 ± 2.04)	4.48-13.84 (9.82 ± 2.35)
NW	7.12-14.46 (10.40 ± 1.78)	5.39-16.15 (10.23 ± 2.31)
SUP-a	11.89-28.92 (19.65 ± 4.36)	7.34-34.68 (19.54 ± 5.85)

MIN = Minimum
MAX = Maximum
SD = Standard Deviation

Table 3. Min-Max (mean ± SD) of seven ratios calculated in males and females.

Ratios	Males (n = 67)	Females (n = 63)
SCL_1/PL_1	1.08-1.32 (1.24 ± 0.03)	1.06-1.26 (1.16 ± 0.03)
SCL_2/PL_2	1.01-1.32 (1.15 ± 0.04)	1.01-1.15 (1.08 ± 0.03)
SCL_1/TL_2	2.28-7.55 (3.72 ± 0.92)	2.30-4.34 (2.93 ± 0.46)
SCL_2/TL_2	2.33-7.59 (3.76 ± 0.91)	2.34-4.78 (3.06 ± 0.62)
SCL_2/CH	2.28- 3.55 (2.79 ± 0.22)	2.05-8.78 (2.87 ± 1.11)
SCL_2/SCW	1.24-2.60 (1.40 ± 0.16)	1.20-1.47 (1.35 ± 0.07)
FASW/AnSL	2.95 – 5.89 (3.78 ± 0.54)	2.65 - 4.13 (3.23 ± 0.40)

Min = Minimum
Max = Maximum
SD = Standard Deviation

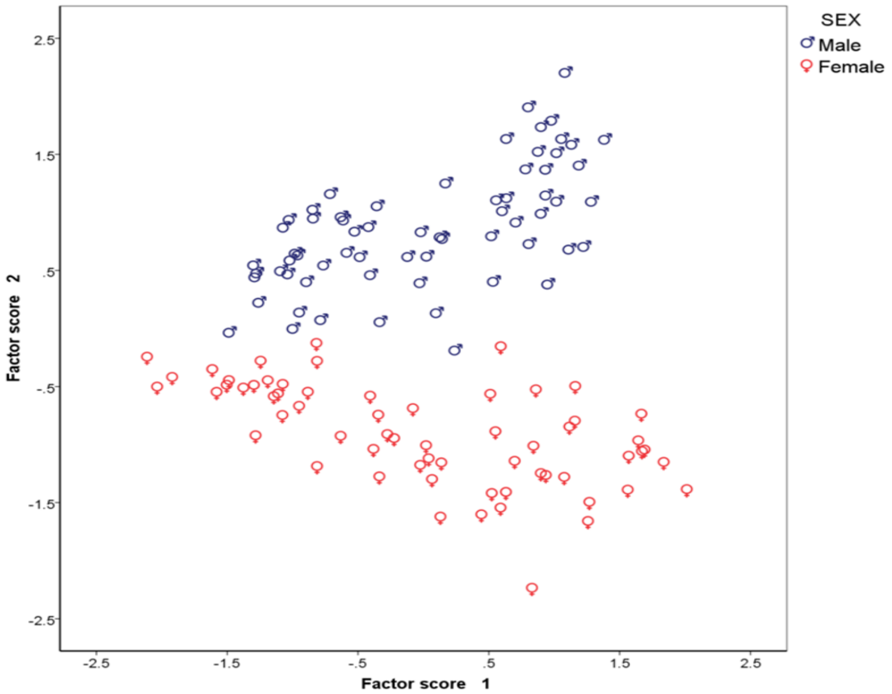

Fig. 6. Scatter plot of Caspian pond turtles based on first two components.

Table. 4. Grouping results of Linear Discriminant Analysis (LDA) of Caspian pond turtle.

		SEX	Predicted Group Membership: Male	Predicted Group Membership: Female	Total
Original[a]	Count	Male	64	1	65
		Female	0	62	62
	%	Male	98.5	1.5	100.0
		Female	.0	100.0	100.0
Cross-validated[b,c]	Count	Male	63	2	65
		Female	0	62	62
	%	Male	96.9	3.1	100.0
		Female	.0	100.0	100.0

a. 99.2% of original grouped cases correctly classified.
b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.
c. 98.4% of cross-validated grouped cases correctly classified.

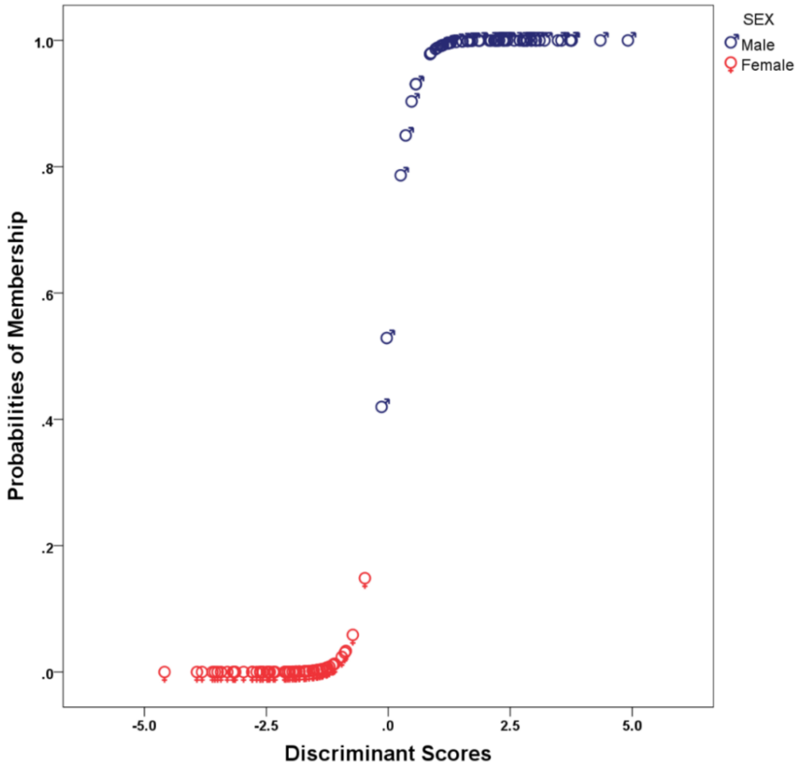

Fig. 7. Scatter plot of specimens based on LDA score and posterior probability of memberships.

DISCUSSION

Sexual dimorphism is common in reptiles; males and females differ in multiple characters (Butler & Losos 2002; Bayrakci & Ayaz 2014; Moura *et al.* 2015), mainly in size and color variation according to the sex. These aspects are known among testudines (Berry & Shine 1980; Gibbons & Greene 1990; Brito *et al.* 2009). In addition to location of vent on the tail and the presence of a plastral concavity located at the abdominal and femoral scutes in males, tail length measurements are commonly greater for males than females. Males have longer tails and wider anal width, presumably for the positioning of the penis during copulation (McRae *et al.* 1981; Gibbons & Lovich 1990; Leuteritz & Ganz 2013). In addition, tail length measurement has also been associated with the selection of the best males for mating (Vogt 1980). Males with longer tails have more success in the mating process (Moll 1980; Moura *et al.* 2015). The Caspian pond turtle has anal notch in posterior of plastron. A larger anal notch in female *G. polyphemus* has been attributed to aiding in breeding and allowing for the passage of large eggs (McRae *et al.* 1981; Smith 1999). Sex ratio in populations normally diverge from 1:1 (Gibbons 1990; Forero-Medina *et al.* 2007). Sex ratio of male to female is in the present study (1:1), is different from the results of Hojjati *et al.* (2005) (1:3) and from the population in southwest of Iran (1: 8) (Karimpour *et al.* 2011), but similar to Kami *et al.* (2012). Among the regulating factors of sex ratio, there are a difference of mortality between sexes, different ages of sexual maturity and the sexual determination for temperature (Gibbons 1990). Aquatic turtles exhibit environmentally temperature-dependent sex determination. The usual temperature of its body is below the threshold temperature in which sex ratio is 1:1; It leads to development of males and if temperature rises above the threshold temperature, females would develop. The threshold is varied for different turtle species (Hojjati *et al.* 2005).

The sexual dimorphism is to be related with variable reproductive aspects as well as energy resource for breeding in females and also male combat (Gibbons 1990). In turtles, the reproductive cycle seems to be synchronized with abiotic variables, especially air temperature and precipitation levels (Rueda-Almonacid *et al.* 2007; Schneider *et al.* 2011; Rodrigues & Silva 2014). According to Gibbons and Lovich (1990), sexual size dimorphism (SSD) may be the result of a trade-off between the benefits of early maturity (increased mating leading to increased reproductive output) and the negative environmental consequences of small body size (Brophy 2006). In the present study, mean maximum straight carapace length (SCL_2) were found to be 156.72 and 147.08 mm in males and females respectively. This result is different from the results of Kami *et al*. (2012) who reported these characters to be 147.54 and 158.13 mm in males and females respectively. Our results revealed that the female body size was smaller than that of male which may be the result of increased risk of predation, desiccation, and thermal stress. Berry & Shine (1980) showed that in species with male combat, or forcible insemination, males are often as large, or larger, than females. In male-male interaction, several of these involved behaviors are very similar to those displayed during mating (i.e., sniffing, circling, biting, ramming, lifting, and mounting) (Leuteritz *et al*. 2005).

Kami *et al.* (2012) found that the female body size was larger than that of male, which may be the result of importance of fecundity as a factor influencing body size in female turtles (Gibbons *et al.* 1982; Brophy 2006). Slightly smaller males were observed once mating them with larger females (Leuteritz & Ravolanaivo 2005). It is unlikely that a significantly smaller male turtle could successfully copulate with a larger female because of the physical strength needed to restrain her and their sheer size disparity (Leuteritz & Ganz 2013).

In the present study, the ratio of TL_2 to TL_1 seems to be a simple grouping index to determine sex of the specimens with mean value almost 1.2 in male and 3 in female, similar to those reported by Kami *et al.* (2012). Hojjati *et al.* (2005) reported the ratio of TL_2 to TL_1 with mean value to be almost 2 in male and 3.6 in female. The ratio of TL_1 to RBrL is also an alternative index in the present study, but has not been investigated in previous studies. Some authors (review in Gibbons & Lovich 1990) have suggested that SSD is a result of ecological forces or natural selection. The most frequently cited ecological cause is probably competitive displacement (Brown & Wilson 1956; Dunham *et al.* 1979). It seems that the ecological differences between the sexes, rather than the ecological factors being the cause of SSD, are simply consequences of sexually-selected dimorphism. In summary, the SSD pattern exhibited by *M. caspica* may be the result of a combination of selective pressures (Gibbons & Lovich 1990; Brophy 2006).

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بررسی دوشکلی جنسی و صفات اندازشی لاک‌پشت خزری *Mauremys caspica* (Testudines : Geoemydidae)دراستان گلستان، جنوب شرقی دریای خزر

یازرلو م.، کمی ح.ق.*، باقریان‌یزدی الف.

گروه زیست‌شناسی، دانشکده علوم، دانشگاه گلستان، گرگان، ایران

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چکیده

لاک‌پشت خزری (*Mauremys caspica*) از لاک‌پشتان آبزی متعلق به خانواده Geoemydidae است. دراین پژوهش، ۱۳۰ نمونه (۶۷ نر و ۶۳ ماده) از زیستگاه‌های آبی مختلف در استان گلستان با کمک دست و تور جمع‌آوری شد. صفات اندازشی به وسیله کولیس دیجیتال و وزن با ترازوی دیجیتال اندازه‌گیری شد. نتایج نشان داد که پوست بدن لاک‌پشتان خزری، زیتونی تیره و دارای خطوط موازی زرد رنگ است. لاک پشتی آنها نسبتاً تخت، پل بین لاک پشتی و شکمی استخوانی، انتهای سپرهای مخرجی نوک تیز است. انگشتان دست‌ها و پاها واجد پرده شناست. جنسیت آنها از روی موقعیت مخرج قابل تشخیص است. نسبت فراوانی جنس نر به ماده تقریباً ۱ به ۱ به دست آمد؛ میانگین حداکثر طول مستقیم لاک پشتی (SCL_2) در نر و ماده به ترتیب ۲۳۰/۱۶ -۸۰/۶۶(۴۲/۹۳ ± ۱۵۶/۷۲) و۲۳۶/۸۴ -۵۶/۹۶ (۵۰/۷۵ ± ۱۴۷/۰۲) میلی‌متر، نسبتSCL_2 به حداکثر طول لاک شکمی (PL_2) در نرها ۱/۳۲-۱/۰۱ (۰/۰۴ ± ۱/۱۵) و در ماده‌ها ۱/۱۵ -۱/۰۱ (۰/۰۳ ± ۱/۰۸)، نسبت SCL_2 به عرض مستقیم لاک پشتی (SCW) در نرها ۲/۶۰ -۱/۲۴ (۰/۱۶ ± ۱/۴۰)و در ماده‌ها ۱/۴۷ -۱/۲۰ (۰/۰۷ ± ۱/۳۵) ، نسبت SCL_2 به ارتفاع لاک پشتی (CH) در نرها ۳/۵۵-۲/۲۸ (۰/۲۲ ± ۲/۷۹) و در ماده‌ها ۸/۷۸-۲/۰۵(۱/۱۱ ± ۲/۸۷)، نسبت SCL_2 به طول دم TL_2)(در نرها ۷/۵۹-۲/۳۳(۰/۹۱ ± ۳/۷۶)و ماده‌ها ۴/۷۸-۲/۳۴ (۰/۶۲ ± ۳/۰۶)،نسبت درز طول اتصال رانی- مخرجی (FASW) به درز بین دو سپر مخرجی (AnSL) در نرها ۵/۸۹-۲/۹۵ (۰/۵۴ ± ۳/۷۸)و در ماده‌ها ۴/۱۳-۲/۶۵ (۰/۴۰ ± ۳/۲۳). نسبت TL_2 بهTL_1 و TL_1 به RBrL شاخص‌های مهم برای تشخیص جنسیت به حساب می آیند.

*مولف مسئول