Morphological and biometric characterisation of rare males and sexual dimorphism in parthenogenetic *Artemia* (Crustacea: Anostraca)

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The genus *Artemia* Leach, 1819 is a complex taxon with both sexual species and asexual populations. The asexual populations are considered as biological species "*Artemia parthenogenetica* Barigozzi, 1974" (BROWNE & BOWEN 1991). Since the reproductive mechanism of parthenogenetic *Artemia* is via parthenogenesis, males are rarly produced among these individuals. Therefore, they are introduced nowadays as "parthenogenetic *Artemia* populations" (ABATZOPOULOS et al. 2002), but sexual populations of *Artemia* have sexual reproduction and their offspring have an equal frequency of males and females.

We studied the morphological and biometric features of males and the sexual dimorphism in parthenogenetic populations of *Artemia* at Urmia Lake, Iran. The lake basin contains bisexual *Artemia* species: *A. urmiana* Günther, 1899 and parthenogenetic *Artemia* populations within Urmia Lake and other, parthenogenetic population from lagoons around Urmia Lake (ABATZOPOULOS et al. 2006; ASEM et al. 2009). Morphological studies show that two parthenogenetic *Artemia* from the Urmia Lake basin (costal lagoon and within the lake) can be attributed to two populations (ASEM et al. 2009).

For our study, the cyst samples of the parthenogenetic population of Urmia Lake have been taken from the *Artemia* and Aquatic Animal Institute, Urmia University, Iran. After hatching, nauplii were cultured at 80 ppt salinity under standard conditions in laboratory (AMAT et al. 2005). 30 mals were collected over five months, with less than 0.4% frequency and were compared with 30 females.

Generally, there are two main shapes for the frontal knob in bisexual species of *Artemia*: while *A. salina* (Linnaeus, 1758) is characterised by having a subconical frontal knob, the other species belonging to the genus *Artemia* have a subspherical frontal knob (MURA & BRECCIAROLI 2004). The morphological structure of frontal knob in the males of the parthenogenetic population

Table 1. Morphometric and meristic characters for males and females of *Artemia*. The table gives mean (mm) and Standard Deviation (S.D.).

	males	**females**	**significance**
Total length	8.01 (0.58)	9.09 (0.63)	p<0.01
Abdominal length	3.88 (0.36)	4.68 (0.28)	p<0.01
Head width	0.69 (0.05)	0.64 (0.07)	p<0.01
Distance between compound eyes	1.69 (0.12)	1.36 (0.06)	p<0.01
Diameter of right eye	0.39 (0.03)	0.24 (0.02)	p<0.01
Diameter of left eye	0.38 (0.03)	0.24 (0.02)	p<0.01
Length of right antenna	1.19 (0.09)	0.89 (0.07)	p<0.01
Length of left antenna	1.18 (0.10)	0.91 (0.06)	p<0.01
Length of furca (right)	0.34 (0.06)	0.27 (0.05)	p<0.01
Length of furca (left)	0.34 (0.06)	0.26 (0.05)	p<0.01
Length of telson	0.95 (0.07)	1.21 (0.19)	p<0.01
Number of setae per furca (right)	11.73 (1.91)	8.57 (1.61)	p<0.01
Number of setae per furca (left)	11.47 (2.11)	8.70 (1.34)	p<0.01

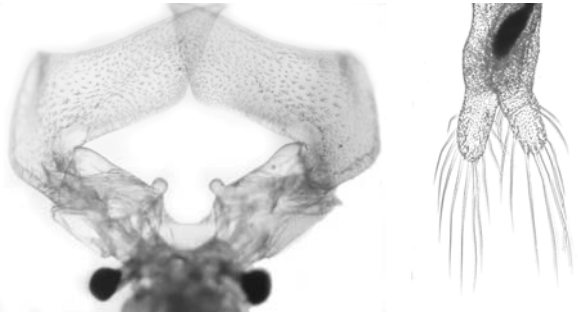

Fig. 1. The structure of frontal knob: subspherical shape (left) and furca: tow-lobed with many setae (right) in a parthenogenetic *Artemia* population from Urmia Lake.

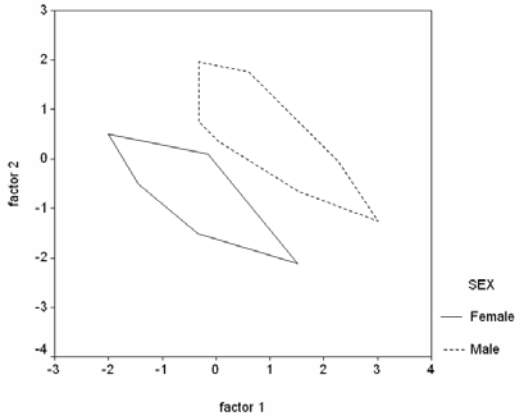

Fig. 2. Scatterplot of Principal Components Analysis in males and females of the parthenogenetic *Artemia* from Urmia Lake.

from Urmia Lake is recognised by its subspherical shape (Fig. 1a). The furca also appears to vary in its morphology, being two-lobed with many setae or rudimentary with few setae. Individuals of this population have a two lobed furca with many setae (Fig. 1b).

Twelve morphometric characters which are common between males and females were measured (ASEM & RASTEGAR-POUYANI 2007, see also ZHOU et al. 2003, CAMARGO et al. 2003, AMAT et al. 2005). The means of morphometric and meristic characters in males of parthenogenetic *Artemia* and their significant differences with females are shown in Table, 1 (t-Test, $p<0.01$). Principal Components Analysis shows that male and female groups are completely separated (Fig. 2). The first and second components show 66.45% and 14.56% of the total variation respectively; in total the two components show 81.02% of the variation. Discriminant Function Analysis confirms 100% of the original groupings.

Bisexual species of *Artemia* show Reversed Sexual Dimorphism (RSD) in that the female is significantly larger than the male (ASEM & RASTEGAR-POUYANI 2007). In most animals, the male is the larger sex, so dimorphism has been attributed to sexual selection for larger males and the competitive advantages which this confers on them during competition for females (ANDERSSON 1994). A size difference between sexes can be interpreted as a mating advantage because, so far as the *Artemia* breeding system is concerned, the female carries the male during copulation. For this reason the female needs a larg body for this mating

Procedure and for surviving the mating process. However parthenogenetic populations of *Artemia* have independent reproductive processes, without the males. But this result can prove that at less parthenogenetic population of *Artemia* from Urmia Lake has retained its ancestral and evolutionary characters because the parthenogenetic *Artemia* populations are new communities that have been separated from bisexual species of *Artemia* (BEARDMORE & ABREU-GROBOIS 1983, BAXEVANIS el al. 2006).

Acknowledgements. This study was funded by the *Artemia* and Aquatic Animals Research Institute of Urmia University, Iran.

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