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Life Cycle Characteristics of Six *Artemia* Populations from Iran

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Abstract: The present study was conducted to achieve the life cycle characteristics of six *Artemia* populations (one bisexual and five parthenogenetic) from Iran. The cysts of parthenogenetic strains were collected from Maharlu, Incheh, Varmal and Qom salt lakes and Lagoons at the periphery of Lake Urmia. Cysts of the bisexual *Artemia urmiana* were collected from the Lake Urmia. All cysts strains were hatched using the standard procedures and the nauplii from all populations were reared at 80 g L^{-1} at laboratory conditions. Survival and total length of the *Artemia* were measured on days 8, 11, 14, 17, 20 and 23 of culture. Randomly selected adult animals were studied for eight reproductive and four life span characteristics. The findings showed that parthenogenetic *Artemia* from Maharlu, Incheh lakes and from Lagoons at the vicinity of the Lake Urmia had significantly highest ($p<0.05$) values of survival rate (73 and 62.8%, respectively) compared to bisexual *A. urmiana* and parthenogenetic strains from Qom and Varmal lakes (49.6, 29.2 and 23.2%). No significant differences were observed in all growth strain populations when cultured under similar laboratory conditions. *Artemia* populations from Maharlu, Qom lakes and from Lagoons in many occasions had significantly highest ($p<0.05$) reproductive values compared to other three populations including the bisexual *A. urmiana*. The results showed the highest heterogeneity and intrapopulation variations among parthenogenetic population strains.

Key words: *Artemia*, Iran, survival, growth, reproduction, life span

INTRODUCTION

Artemia can be found in a great variety of habitats in terms of anionic water composition (Lenz, 1987; Browne *et al*., 1988), altitude (Abatzopoulos *et al*., 1998; Triantaphyllidis *et al*., 1998; Van Stappen, 2002) and climatic conditions, from humid-sub humid to arid (Vanhaecke *et al*., 1987).

Many studies have been carried out on growth, survival, reproductive and life span characteristics of *Artemia* populations from different parts of the world cultured under standardized laboratory conditions (Browne *et al*., 1984; Wear and Haslett, 1986; Gajardo *et al*., 1998; Lotfi, 2001; Abatzopoulos *et al*., 2003; Triantaphyllidis *et al*., 1995; Browne and Wanigasekera, 2000; El-Bermawi, 2003; Baxevanis *et al*., 2004). Most of these studies confirm that different ecological conditions such as salinity and temperature have major influence on reproductive characteristics of *Artemia*.

Historical overview of *Artemia* populations from Iran is discussed in detail by Abatzopoulos *et al*. (2006). Until recently only 3-4 populations of *Artemia* were reported from Iran (Vanhaecke *et al*., 1987; Triantaphyllidis *et al*., 1998). It was only as a result of recent surveys by Agh *et al*. (2001, 2002, 2007), Van Stappen (2002) and Abatzopoulos *et al*. (2006) that occurrence of *Artemia* from many new geographic locations from Iran were reported. All these populations except *Artemia urmiana* from Urmia Lake are parthenogenetic populations. Considerable differences were observed in their habitats in terms of ionic composition, temperature, altitude and climatic conditions (Abatzopoulos *et al*., 2006).

The life cycle of these different *Artemia* populations from Iran has not been documented so far. This research reports on a study on growth, survival, reproductive and life span characteristics of five inland parthenogenetic and one inland bisexual *Artemia* population from Iran. The main aim of this study is to present data on further characterization of *Artemia* populations from Iran, based on their growth and survival patterns and also on their reproductive and life span characteristics.

MATERIALS AND METHODS

Strains studied: The *Artemia* populations studied were from 6 different geographic regions of Iran including the bisexual *A. urmiana* from Lake Urmia (North West) and five inland parthenogenetic populations: the lagoons at the vicinity of Lake Urmia, Incheh Lake (North East), Qom Salt Lake (central region), Maharlu lake (South) and Varmal lake (South East).

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Culture experiments: Cysts of *Artemia* were collected from each lake and lagoon and were hatched under standard conditions (Sorgeloos *et al*., 1986). From each population 400 newly hatched larvae were transferred into separate 1 L cones containing 800 mL of 80 g L^{-1} brine water in four replicates. They were cultured under controlled standard conditions using *Dunaliella tertiolecta* and Lansy PZ as food. Growth and survival were determined at each water renewal on days 8, 11, 14, 17, 20 and 23. As soon as males started to clasp females (in case of bisexual *A. urmiana*) or parthenogenetic females showed signs of ovarian development, 30 randomly collected couples or parthenogenetic females were removed from each population's mass culture and placed in 50 mL cylindroconical falcon tubes to begin the isolated culture. Females were considered mature when migration of the oocytes into the uterus was observed (Triantaphyllidis *et al*., 1995).

Clonal cultures continued as long as the female *Artemia* were alive. In the falcon tubes containing bisexual *A. urmiana* dead males were immediately replaced with actively swimming males during the experiment (Browne *et al*., 1988). The falcon tubes were checked every day for the production of cysts or nauplii, which were counted and recorded separately. Finally the reproductive characteristics (brood size, total number of offspring, number of nauplii, number of cysts, offspring in each reproduction, offspring/day during the reproductive period, brood intervals and percentage of encystment) and the life span characteristics (pre-reproductive period, reproductive period, post-reproductive period and life span) were determined for each population according to Browne *et al*. (1984, 1988). The results were statistically analyzed using SPSS (version 14) analysis of variance (ANOVA) (Sokal and Rohlf, 1981; Triantaphyllidis *et al*., 1995) and the averages were compared using Tukey test. The results of reproductive and life span characteristics were also processed with discriminant function analysis (Kachigan, 1986; Hontoria and Amat, 1992a, b; Triantaphyllidis *et al*., 1995; Abatzopoulos *et al*., 2003).

RESULTS

Survival and growth: Survival results after 23 days of experiment demonstrate significant differences ($p<0.05$) when different populations are cultured under similar laboratory conditions (Fig. 1). The asexual *Artemia* (MAH) had significantly higher survival (73%) compared to the sexual URM and other asexual populations. Two other asexual populations (INC and LAG) also had significantly higher survival in comparison to URM

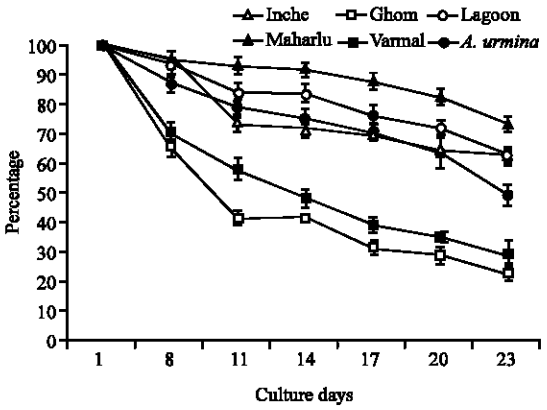

Fig. 1: Survival of *Artemia* populations from Iran

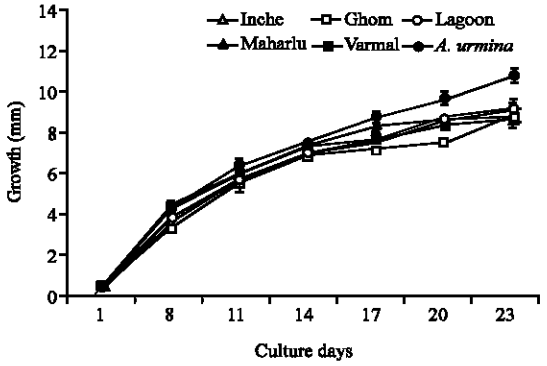

Fig. 2: Growth of the *Artemia* populations cultured at laboratory condition

($p<0.05$). Results showed that parthenogenetic strains when cultured under standardized conditions performed differently. MAH, INC (62.8%) and LAG (62.8%) populations had significantly higher survival in comparison to QOM (23.2%) and VAR (29.2%) after 23 days (Fig. 1, $p<0.05$).

The sexual URM had significantly higher growth in comparison to the parthenogenetic strains ($p<0.05$) throughout the growth period. The recorded maximum total length of URM was significantly bigger than this of the parthenogenetic strains (URM: 11.67 mm while for the parthenogenetic strains it was less than 10 mm). Asexual populations exhibited significant differences in the growth among them ($p<0.05$). Maximum and minimum total length for these strains was 9.98 and 9.32 mm, respectively. Among the parthenogenetic populations LAG had significantly higher growth followed by MAH. VAR had the lowest growth, significantly lower than all populations studied (Fig. 2, $p<0.05$).

Table 1: Mean of various reproductive and life span characteristics for six *Artemia* populations from Iran (standard deviations in parenthesis)

Parameters	Incheh	Qom	Lagoon	Maharlu	Varmal	Urmia
No. of offspring	256.1±279.5^{b}	576.1±567.5^{a}	429.0±382.9^{a}	214.1±104.6^{b}	213.1±117.7^{b}	194.3±130.6^{b}
No. of nauplii	197.8±198.4^{ab}	290.5±359.6^{a}	263.6±237.7^{a}	55.8±72.9^{c}	133.1±87.4^{bc}	96.3±70.3^{bc}
No. of cysts	58.2±100.4^{d}	285.6±317.2^{a}	165.4±182^{bc}	188.3±103.7^{b}	80.6±49.9^{cd}	97.9±99.7^{cd}
No. of offspring per brood	50.1±18.5^{b}	75.2±41.4^{a}	53.6±22.9^{b}	44.0±10.0^{b}	47.0±17.2^{b}	47.5±18.7^{b}
No. of offspring per day	12.6±5.2^{bc}	16.0±5.9^{a}	14.0±4.8^{ab}	9.6±4.5^{e}	10.3±3.1^{de}	10.7±4.9^{de}
Brood	4.5±2.7^{bc}	6.2±4.5^{ab}	7.3±4.5^{a}	5.5±2.1^{bc}	4.1±1.4^{d}	3.7±2.0^{d}
Days between broods	5.4±1.2^{c}	6.7±3.2^{ab}	4.8±1.3^{c}	6.5±2.0^{b}	5.1±0.5^{c}	7.7±2.8^{a}
Percent offspring encysted	23.3±19.9^{e}	58.4±34.7^{b}	37.0±27.6^{cd}	79.1±23.9^{a}	37.0±27.6^{cd}	43.6±32.8^{c}
Pre reproductive period	20.0±2.1^{d}	21.6±2.9^{bc}	22.0±1.2^{b}	28.4±2.5^{a}	20.5±2.1^{cd}	21.5±1.8^{bc}
Reproductive period	19.2±11.0^{b}	35.2±26.1^{a}	31.9±21.6^{a}	28.6±10.8^{ab}	19.7±7.6^{b}	26.6±14.1^{ab}
Post reproductive period	1.2±1.7^{b}	1.4±3.2^{b}	0.8±1.6^{b}	11.9±13.8^{a}	2.1±0.6^{b}	1.2±2.0^{b}
Life span	39.8±11.8^{d}	54.5±27.1^{b}	52.9±21.6^{bc}	67.9±23.2^{a}	42.3±8.0^{d}	43.3±16.6^{cd}

Significant differences were determined by ANOVA test ($p<0.05$), Values in each row that share the same superscripts are not significantly different

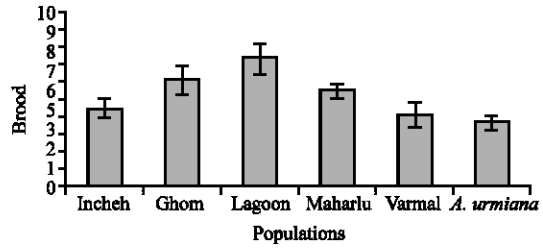

Fig. 3: No. of broods in the Iranian populations of *Artemia*

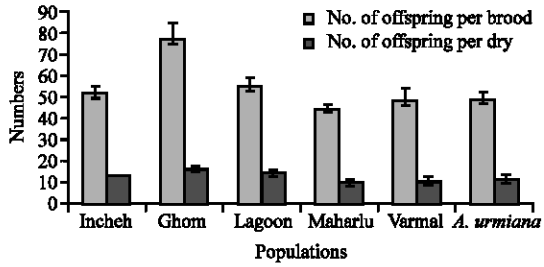

Fig. 4: No. of offspring per brood and No. of offspring per day in the Iranian populations of *Artemia*

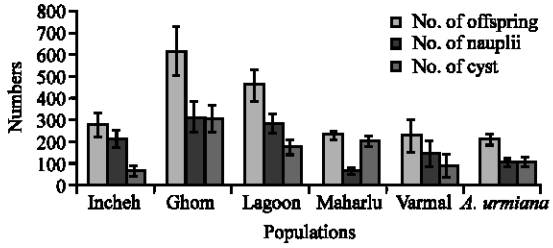

Fig. 5: Total No. of offspring, No. of nauplii and No. of cysts produced by the Iranian populations of *Artemia*

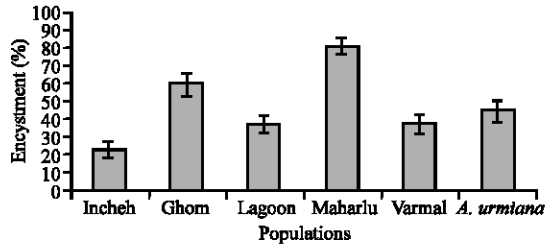

Fig. 6: Percentage of encystment in Iranian populations of *Artemia*

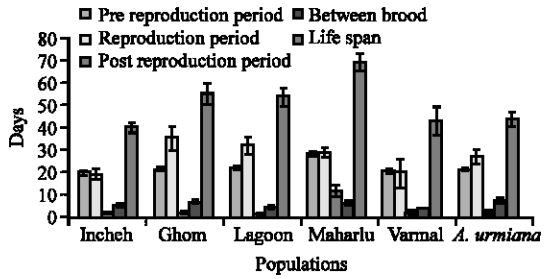

Fig. 7: Life span characteristics of the Iranian populations of *Artemia*

Reproductive and life span characteristics: Statistical analysis using ANOVA indicated that significant differences exist among the different populations in most of the characters studied (Table 1). It was revealed that the sexual URM had lowest values in total number of offspring and number of broods in comparison to all asexual strains (Fig. 3, 4). QOM and LAG strains had significantly higher values in the total offspring and nauplii production than other asexual strains and the sexual URM (Fig. 5, $p<0.05$). QOM strain had the highest number of cyst production, offspring per day and offspring per brood (Fig. 4, 5). URM had significantly longer intervals between broods (7.7 days) than the asexual strains, showing its slower reproducing capacity in comparison to parthenogenetic populations (Fig. 7). Minimum intervals between two consecutive broods were observed in LAG strain (4.8 days). MAH strain produced significantly higher percentage of encysted embryos (79.07%) in comparison to all strains studied, followed by QOM strain (58.39%) (Fig. 6, $p<0.05$).

MAH showed significantly longer pre-reproduction and life span periods ($p<0.05$) in comparison to all other

Table 2: Discriminant analysis of the reproductive and life span parameters of female *Artemia* populations. Classification functions produced by discriminant analysis for each population

	Classification function coefficients for each population					
Variables	Incheh	Qom	Lagoon	Maharlu	Varmal	Urmia
No. of offspring per brood	0.154	0.074	0.137	0.151	0.190	0.118
No. of offspring per day	2.649	2.970	2.826	2.538	2.151	2.992
No. of broods per female	9.785	8.670	10.878	9.828	8.390	9.098
Time interval in-between broods (in days)	7.348	8.013	7.777	7.453	6.183	7.987
Encystment rate (%)	-0.068	-0.028	-0.052	-0.014	-0.023	-0.054
Total No. of offspring per female	-0.103	-0.095	-0.110	-0.116	-0.096	-0.113
Number of cysts	0.028	0.033	0.031	0.041	0.024	0.033
Pre-reproductive period	4.959	5.236	5.402	7.141	5.111	5.451
Reproductive period	-0.524	-0.378	-0.540	-0.370	-0.351	-0.240
Post-reproductive period	-0.424	-0.399	-0.443	-0.100	-0.326	-0.457
Total life span	0.167	0.151	0.163	0.142	0.132	0.164
(Constant)	-100.486	-113.029	-117.771	-157.851	-92.085	-118.617

Table 3: Standardized coefficients produced by discriminant analysis for canonical variables. Eigenvalues and Cumulative percentages are presented

	Standardized coefficients for canonical variables				
Variables	Root 1	Root 2	Root 3	Root 4	Root 5
No. of offspring per brood	0.028	-0.907	0.128	-0.065	-0.084
No. of offspring per day	-0.086	1.468	0.503	-0.659	0.206
No. of broods per female	0.302	0.304	3.311	0.505	0.347
Time interval in-between broods (in days)	0.075	1.298	0.552	-0.440	0.443
Encystment rate (%)	0.178	-0.072	-0.420	0.373	-0.608
Total No. of offspring per female	-0.947	-0.196	-2.095	2.298	0.426
No. of cysts	0.418	0.483	0.157	-0.140	0.512
Pre-reproductive period	0.893	0.037	0.120	-0.028	0.090
Reproductive period	0.234	0.166	-1.600	-1.827	-1.880
Post-reproductive period	0.389	-0.263	-0.235	0.316	0.349
Total life span	-0.050	0.133	0.207	-0.159	0.282
Eigenvalues	3.295	0.796	0.523	0.262	0.069
Cumulative (%)	66.600	82.700	93.300	98.600	100.000

Table 4: Classification results of discriminant analysis showing the percentages of populations classified in each group. The percent of grouped cases correctly classified is 70.60%

		Predicted group membership						
Group	Habitat	Incheh	Qom	Lagoon	Maharlu	Varmal	Urmia	Total
Original count	Incheh	21.0	1.0	2.0	0.0	5.0	1.0	30.0
	Qom	7.0	17.0	2.0	0.0	2.0	2.0	30.0
	Lagoon	5.0	2.0	14.0	0.0	4.0	5.0	30.0
	Maharlu	0.0	0.0	0.0	29.0	0.0	1.0	30.0
	Varmal	4.0	0.0	0.0	0.0	26.0	0.0	30.0
	Urmia	6.0	1.0	0.0	0.0	3.0	20.0	30.0
Percent	Incheh	70.0	3.3	6.7	0.0	16.7	3.3	100.0
	Qom	23.3	56.7	6.7	0.0	6.7	6.7	100.0
	Lagoon	16.7	6.7	46.7	0.0	13.3	16.7	100.0
	Maharlu	0.0	0.0	0.0	96.7	0.0	3.3	100.0
	Varmal	13.3	0.0	0.0	0.0	86.7	0.0	100.0
	Urmia	20.0	3.3	0.0	0.0	10.0	66.7	100.0
Total predictability				70.6%				

populations. INC and VAR demonstrated shortest pre-reproduction period significantly less than other populations except *A. urmiana*. Maximum and minimum reproduction period was observed in QOM and INC, respectively. But only QOM and LAG strains were significantly different from INC and VAR. MAH lived for an average of 11.9 days after its last production showing significantly longer post reproduction period in comparison to other strains ($p<0.05$). MAH strain had longest life span (67.9 days), significantly longer than any other population, followed by QOM and LAG strains ($p<0.05$). Sexual URM lived for 43.3 days, significantly shorter than MAH and QOM strains (Fig. 7).

Discriminant analysis based on the origin of each population as a separation criterion resulted in 70.90% separation of original groups. However this analysis could separate the sexual *A. urmiana* only by 66.7% predictability from the parthenogenetic populations. The predictability value for MAH strain was 96.7%, but the respective values for the other four parthenogenetic populations ranged from 46.7 to 86.7% (Table 2-4). Figure 8 shows the discriminant analysis

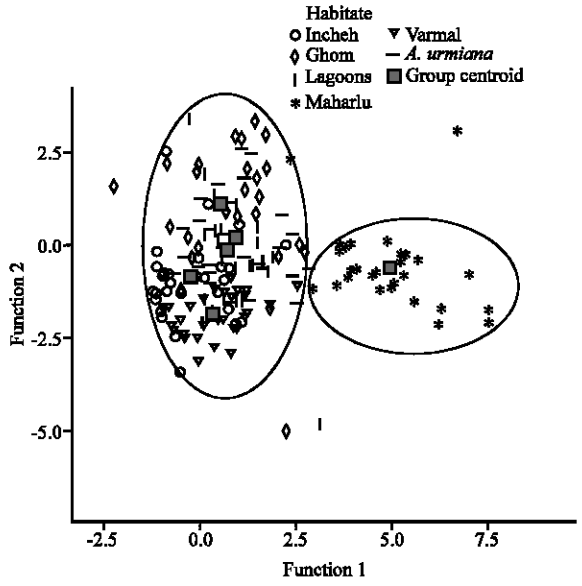

Fig. 8: The discriminant analysis (canonical scores) based on reproductive and life span characteristics and using the origin of each population as a separation criterion

based on the 2 out of 5 roots that were produced. The MAH population is clustered separately from other populations suggesting its significantly different reproductive and life span characteristics. Sexual URM was clustered together with VAR, LAG and QOM populations, while INC strain was placed in a separate group.

DISCUSSION

Survival and growth: There are a number of studies on laboratory culture of *Artemia* at 80±20 g L^{-1} showing that most *Artemia* grow and reproduce well in this range of salinity (Pador, 1995; Triantaphyllidis *et al*., 1995; Browne and Wanigasekara, 2000; Abatzopoulos *et al*., 2003; El-Bermawi *et al*., 2004; Baxevanis *et al*., 2004). These studies proved that most *Artemia* populations demonstrated different responses with regard to survival, growth and reproductive characteristics at the same salinity. According to Vanhaecke and Sorgeloos (1989), who compared survival and growth of *Artemia* larvae in 25 geographical strains, bisexual strains had significantly higher survival and growth compared to asexual populations. However, Gilchrist (1960) reported that a parthenogenetic *Artemia* from La Palme (France) grew faster than a bisexual strain from San Diego (California, USA). El-Bermawi *et al*. (2004) reported that the bisexual population from Wadi El-Natrun of Egypt had higher survival compared to the parthenogenetic strains when cultured at 80 g L^{-1} without any significant differences in their growth.

Triantaphyllidis *et al*. (1995) reported that the survival of parthenogenetic *Artemia* obtained from Tanggu China and bisexual *A. franciscana* had no significant differences when grown at 60 and 100 g L^{-1}. Whereas, parthenogenetic population demonstrated significantly higher growth compared to *A. franciscana*.

Browne and Wanigasekara (2000) found significant differences in the survivorship of bisexual *Artemia* (*A. franciscana*, *A. salina*, *A. sinica* and *A. persimilis*) and *A. parthenogenetica* from Italy cultured at different combinations of salinity and temperature. Their findings confirmed that in terms of survival, there is no one optimal temperature-salinity combination with each species having a different optimum.

In this experiments the survival of the Iranian bisexual population, *A. urmiana*, exhibited considerable differences with the parthenogenetic populations. *A. urmiana* had significantly higher survival compared to VAR and QOM, but at the same time significantly lower than LAG, MAH and INC populations ($p<0.05$). But in terms of growth, the sexual URM grew significantly faster than the asexual strains. Significant differences were recorded in both survival and growth among the parthenogenetic strains too.

There is no data available on the survival and growth of *Artemia* populations from Iran, but in comparison with results obtained by other researchers on *Artemia* populations from other geographic locations, our findings are in agreement with a number of literature observations: strain differences in survival and growth can not be ascribed to the mode of reproduction. It seems that each population has its own optimal environmental conditions for growth and better survival. The culture condition that is considered standard for rearing *Artemia* may be optimal for some strains, but not for others. Moreover our study provides further evidence that growth and survival of *Artemia* are strain-dependent.

Reproductive and life span characteristics: Many researchers have studied reproductive and life span characteristics of parthenogenetic and bisexual *Artemia* populations from different geographic locations (Gilchrist, 1960; Dana and Lenz, 1986; Triantaphyllidis *et al*., 1995; Browne and Wanigasekara, 2000; Abatzopoulos *et al*., 2003; El-Bermawi *et al*., 2004; Baxevanis *et al*., 2004). Triantaphyllidis *et al*. (1995) who compared the reproductive and lifespan characteristics of Tanggu parthenogenetic *Artemia* and *A. franciscana* from San

Francisco Bay reported no significant differences in pre-reproductive period between them. Baxevanis *et al.* (2004) also did not find any statistical difference in this parameter between the parthenogenetic and bisexual strains from Egypt.

A. franciscana from San Francisco Bay had significantly longer reproductive period than Tanggu parthenogenetic *Artemia* (Triantaphyllidis *et al.*, 1995) but the Egyptian bisexual *Artemia* had a significantly shorter reproductive period (12.3 days) in comparison to the parthenogenetic *Artemia* (23.2-27.6 days). Abatzopoulos *et al.* (2003) found still a shorter reproductive period (21.8 days) in the parthenogenetic population of Megalon Embolon saltworks from Greece when cultured in similar conditions.

Triantaphyllidis *et al.* (1995) did not find any significant differences in the total life span of *A. franciscana* and parthenogenetic *Artemia* from Tanggu. Similarly the Egyptian bisexual population also did not exhibit any significant differences in total life span with 2 out of 3 asexual strains (El-Bermawi, 2003; Baxevanis *et al.*, 2004).

Total number of offspring, offspring per brood and number of brood per female were significantly higher in *A. franciscana* when compared with Tanggu parthenogenetic *Artemia* (Triantaphyllidis *et al.*, 1995). But Egyptian bisexual *Artemia* produced significantly less offspring and had lesser number of offspring per female per brood and fewer broods per female in comparison to the parthenogenetic strains (Baxevanis *et al.*, 2004). Percentage of offspring encysted was significantly high both in *A. franciscana* and in Egyptian bisexual *Artemia* compared to the asexual *Artemia*.

Triantaphyllidis *et al.* (1995) claimed that high standard deviations observed for reproduction and lifespan characteristics of the bisexual *A. franciscana* presumably reflects the presence of high heterogeneity and intrapopulation variance, whereas much lower variance levels for the Tanggu parthenogenetic population are expressed due to their lower genetic diversity compared to the bisexual species. But Baxevanis *et al.* (2004) found higher standard deviations among Egyptian parthenogenetic populations in comparison to the bisexual species.

In this study, INC and VAR had shortest maturation time significantly different from other populations including the bisexual *A. urmiana* ($p<0.05$). But however no significant differences were observed in pre-reproductive period between *A. urmiana* and parthenogenetic populations from QOM, LAG and VAR. Parthenogenetic *Artemia* from MAH had a significantly longer maturation time in comparison to all populations studied ($p<0.05$), proving that pre-reproductive period is an individual characteristic for each strain, regardless of their reproductive mode. We found no significant differences in reproductive period of the bisexual *A. urmiana* and the parthenogenetic strains. But significant differences were found among the parthenogens themselves with regard to this characteristic. QOM and LAG strains had significantly longer reproductive period compared to INC and VAR populations ($p<0.05$). Moreover the bisexual *A. urmiana* demonstrated a significantly shorter life span compared to MAH and QOM populations, but no significant differences were observed with the same parameter in INC, LAG and VAR strains. Therefore it could be assumed that the life span characteristics are strain-specific for the Iranian populations of *Artemia*.

In this experiment, the bisexual *A. urmiana* had least number of offspring compared to parthenogenetic strains from Iran, significantly less than that in QOM and LAG populations ($p<0.05$). It was also found that the number of broods in URM was significantly lower in comparison to the asexual strains except from that in VAR strain. No significant differences were found in the number of offspring per brood among most Iranian strains except for MAH population that was highly significant from others. Moreover the percentage of *A. urmiana* producing encysted embryos was significantly lower than QOM and MAH populations and only significantly higher than the INC strain. Comparison of the parthenogenetic populations revealed no significant differences in the majority of the characters assayed between INC and VAR on one hand and QOM and LAG on the other.

In this study, we found high standard deviations in Iranian parthenogenetic strains compared to the bisexual *A. urmiana* in most of the reproductive characters, indicating that some other parameters like culture conditions and ionic differences of the culture medium might be important in determining this high standard deviation rather than the genetic diversity. This is in agreement with findings of Baxevanis *et al.* (2004) with Egyptian parthenogenetic strains but does not support findings of Triantaphyllidis *et al.* (1995) and Browne and Hoops (1990).

We also tried to define possible grouping of six *Artemia* populations based on reproductive characteristics. Based on the reproductive parameters studied, discrimination models resulted in total predictability of 70.60%. The sexual URM showed significantly higher values not even in a single reproductive and life span characteristics when compared

to the asexual populations. On the contrary, the asexual MAH strain showed significant differences from URM and other parthenogenetic populations in 5 out of 12 reproductive and life span characteristics ($p<0.05$). The reproductive parameters that contributed to the discrimination of the MAH from URM and other asexual strains were the pre-reproductive period; post-reproductive period; total life span; number of offspring per day and percent offspring encysted. The first four variables were significantly higher and the fifth variable was significantly lower compared to all populations studied ($p<0.05$). Present results are different from findings of El-Bermawi (2003) and Baxevanis *et al.* (2004) who could statistically discriminate an Egyptian sexual strain from asexual strains of Egypt based on reproductive and life span characteristics. According to present findings sexual URM was grouped close to asexual strains from QOM, LAG and VAR habitats. This reveals that based on reproductive and life span characteristics, sexual URM is not much different from the Iranian parthenogenetic populations of *Artemia*.

These findings show that bisexuality is not always a determining factor for better reproductive and life span characteristics for a population of *Artemia*, but we should look into more favourable culture conditions in order to have a higher reproductive result with asexual strains of *Artemia*. The studied populations of *Artemia* live in biotopes far away from each other with considerably different environmental conditions. Our results are therefore in agreement with Browne *et al.* (2002) who reported that reproductive characteristics of *Artemia* are highly influenced by the environmental components.

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