Reproductive Characteristics of Four *Artemia* Populations with Different Geographical Origin Fed on a Halophylic Unicellular Algae: *Dunaliella tertiolecta*

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Abstract

This study was conducted to investigate reproductive characteristics of four *Artemia* populations (*A. urmiana*, *A. franciscana*, Pakistan and Turkmenistan strains) cultured under the identical laboratory condition and fed on a unicellular alga. Cysts were hatched by standard methods and the nauplii from the populations were cultured in laboratory condition using 80 g/l salinity, 25±1ºC with photoperiod (12L: 12D). *Dunalliella tertiolecta* fed to all *Artemia* populations. To determine the reproductive characteristics, 30 pairs of adult *Artemia* of each population were randomly placed in 50ml conical falcons so that each conical falcon contains a pair of *Artemia*. The number of cysts and nauplii in each falcon were counted daily. All data were analysed using SPSS, one way ANOVA. The results showed that in all *Artemia* populations, the daily nauplii production were higher than cyst production. Also, during reproductive period, A. *franciscana* had the highest cyst production (639±105) and *A. urmiana* had the highest nauplii production (78.5±7). The highest and the lowest birth rate were related to A. *franciscana* (1225±193) and Turkmenistan strain (362±29), respectively. Therefore, it is suggested that *A. urmiana* and A. *franciscana* were perefered species for cysts production. Turkmenistan strain was not recommended for production plans, due to low cysts and nauplii production.

Key words: *Artemia*, Reproduction, *Dunaliella tertiolecta*, Geographical origin.

Introduction

Artemia as a live food has a high nutritional value for larval rearing of the most marine fishes (Sorgeloos et al., 2001) and shelfish species (Leger et al., 1986; Bengetson et al., 1991; Sorgeloos et al., 1998). *Artemia* is used to feed aquatic animals in different types as decapsulated cysts, early hatched nauplii, juvenile, adult, dry and frozen (Bengtson et al.,1991). *Artemia* genus consists of bisexual and parthenogenetic strains. *Artemia* has two types of reproduction, namely ovi-viviparous and oviparous depending on environmental conditions (Liang and Macrae, 1999; Jackson and Clegg, 1996). Nauplii production occurs in suitable culture conditions, while cyst production occurs in improper condition. Factors such as age of mother, photoperiod, salinity and oxygen and water temperature interfere in controlling reproductive

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mode. In *Artemia* strains the differences in genetic tendencies of females, determines the time of viviparous or cyst production pattern of reproduction. Bisexual reproduction is effective to maintain genetic diversities between individuals of a population that cause live potentials and dispersal in different habitats and enhance development rate in environment change. Parthenogenesis has the advantage of rapid production (Hafezieh, 2003). Lavens and Sorgeloos (1996) mentioned the most effective factor on *Artemia* cyst production as selection of suitable culture strain based on their growth, reproduction and tolerance level into temperature and salinity. In fact, native strain of the region that enjoys maximum growth and reproductive potential should be selected. Usually, strains with smaller size cyst and nauplii production is preferred to cyst production and strains with rapid growth and nauplii producers would be selected for biomass production (Tackaert and Sorgeloos, 1992). Ahmadi (2003) mentioned that population density influenced the cyst production of earthen pond cultured *Artemia* and regarding that parthenogenetic strain has a higher level of heterozygotic level compared to bisexual one, suggesting that parthenogenetic strain should be used to cyst production and *Artemia urmiana* bisexual strain used for biomass production (Ahmadi, 2003). The aim of this study was to compare the growth and cyst production and live birth rate in various geographical *Artemia* strains and determining the best species for production plans.

Materials and Methods

Bisexual strains of *A. urmiana* and *A. franciscana* and parthenogenetic *Artemia* of Pakistan and Turkmenistan were cultured under standard condition in 4 treatments, each consisted of 4 replicates, feeding *Dunaliella tertiolecta*. *Artemia* were cultured in 120× 53× 31 cm aquariums. After a 20 days of culture period in bisexual species when males began to catch females and in parthenogenetic ones when the signs of ovarian development were observed, 30 pairs of each species were isolated and added to 50 ml conical falcons where each conical falcon bore a pair of *Artemia* of the studied species. Females with oocystes migration into uterus considered as adult (Triantaphyllidis et al., 1995). Culture period continued as they live. During reproduction period, *Artemia* fed with *D. tertiolecta* according to Coutteau et al., (1984). During the test period in bisexual species, active swimming males replaced with dead males (Browne et al., 1988). All cysts and nauplii of each falcon were counted daily. Reproductive characteristics including number of birth rate, cyst production, nauplii production , spawners , birth rate per spawner were determined daily for each *Artemia* population until day 28 (Browne et al., 1998). All data were analyzed using ANOVA – SPSS software (Triantaphyllidis et al., 1995; Sokal and Rohlf, 1981) and means were compared by Tukey test.

Results

The results showed that there were no difference in nauplii production in 4 *Artemia* strains ($p>0.05$). There was a significant difference in *A. urmiana* and *A. franciscana* compared to Turkmenistan strain ($p< 0.05$) and no significant difference among other species ($p> 0.05$) in cyst production and total fecundity. There was a significant difference in Turkmenistan strain and other strains in daily nauplii produc-

tion ($p< 0.05$). *A. urmiana* and *A. franciscana* showed a significant difference compared to Pakistan and Turkmenistan *Artemia* in daily cyst production and daily cyst production of each spawner ($p< 0.05$). Also, *A. urmiana* and *A. franciscana* showed a significant difference compared to Turkamanestan *Artemia* in daily fecundity of each spawner ($p< 0.05$).

The mean of reproductive parameters in different *Artemia* populations were shown in Table 1 and Figures 1-4.

Table 1. Mean of reproductive parameters of *A. urmiana*, *A. franciscana*, Pakistan and Turkmenistan populations

Artemia population Parameter	*A. urmiana*	*A. franciscana*	Pakistan	Turkmenistan
Total birth rate	1208±182[a*]	1225±193[a]	715±74[ab]	362±29[b]
Total cyst production	619±91[a]	639±105[a]	342±40[b]	220±16[b]
Total nauplii production	589±134[a]	587±141[a]	373±48[ab]	141±18[b]
Mean daily cyst production	59.6±5.7[a]	61±6[a]	28.2±2.3 [b]	24.2±1.5[b]
Mean daily nauplii production	78.5±7[a]	66±8[a]	64±6.6[a]	29±2.4[b]
Number of daily cyst producer spawners	11.1±1.4 [a]	10.9±1.5[a]	13.4±1.5 [a]	9.3±0.5 [a]
Number of daily nauplii producer spawners	6.8±1.6[a]	7.8±1.6[a]	5.6±0.6 [a]	4.6±0.4[a]
Daily fecundity of each spawner	25.1±3.7[a]	25.5±4[a]	14.9±1.5[ab]	7.5±1[b]
Total cyst production of each spawner	361±36[a]	372±26 [a]	199±23[b]	129±9[b]
Total nauplii production of each spawner	343±35[a]	342±28[a]	217±32 [b]	82±9[c]
Total birth of each spawner		715±21[a]	417±28[b]	211±9[c]

Significant differences were determined by ANOVA ($p<0.05$).
*Different superscript letters in a row show significance and similar letters in a row show non-significance.

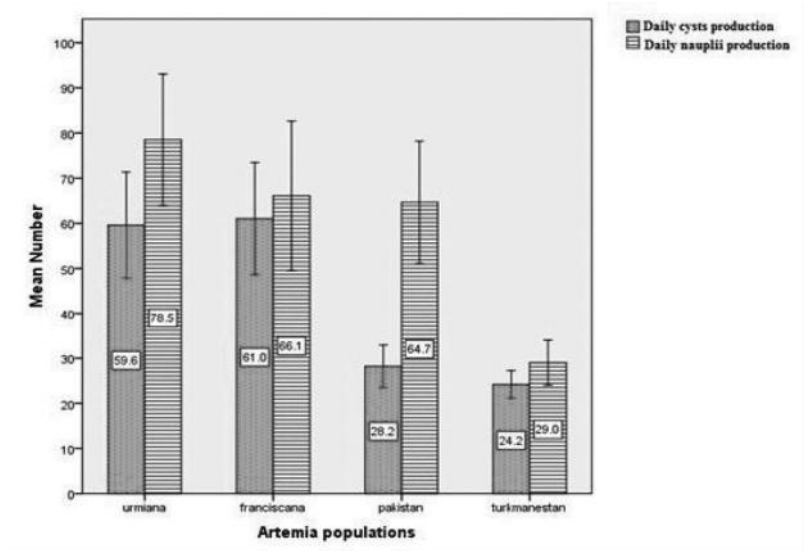

Fig. 1. Comparing the daily cyst and nauplii production rate among different *Artemia* populations

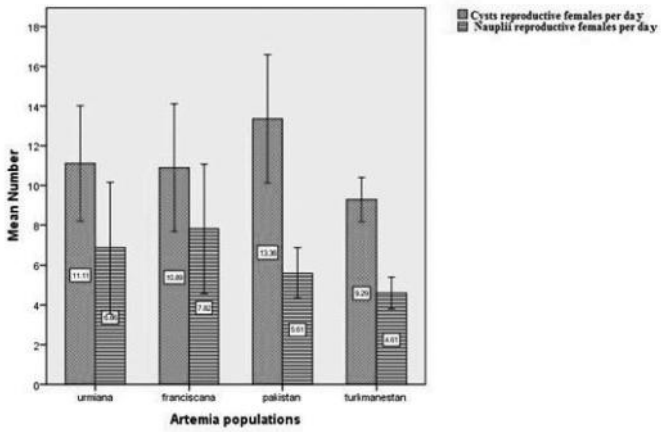

Fig. 2. Comparing daily cyst and nauplii producer spawners among different *Artemia* populations

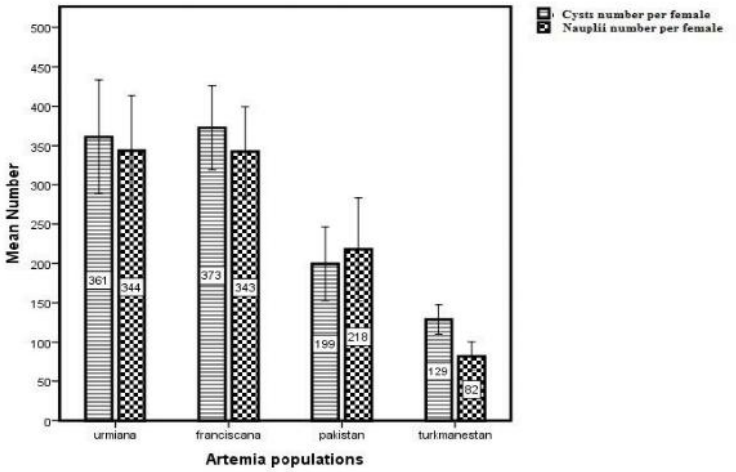

Fig. 3. comparing the total cyst and nauplii production of spawners from different *Artemia* populations

Artemia populations were shown in Table 1 and Figures 1-4.

In all *Artemia* populations, the mean daily nauplii production were higher than the mean daily cyst production. That *A. franciscana* had the highest daily cyst production and *A. urmiana* had the highest daily nauplii production. Also, the lowest daily cyst and nauplii production was observed in Torkamanestan population (Fig. 1).

In all *Artemia* daily spawner populations, the number of nauplii producers was higher than cyst producers and the Pakistan *Artemia* had the highest daily cyst producers and *A. franciscana* had the highest nauplii producers.

Figure 3 shows that during reproduction period, each spawner of *A. urmiana*, *A. franciscana* and Turkmenistan had the highest cysts production and each spawner of Pakistan *Artemia* had the highest nauplii production among their populations. Totally, each spawner of *A. franciscana* had the highest and each Turkmenistan *Artemia* had the lowest birth and fecundity. During reproductive period, *A. urmiana*, *A. franciscana* and Turkmenistan had the highest cysts number and Pakistan strain had the highest nauplii production in their populations. *A. franciscana* and *A. urmiana* had the highest cyst and nau-

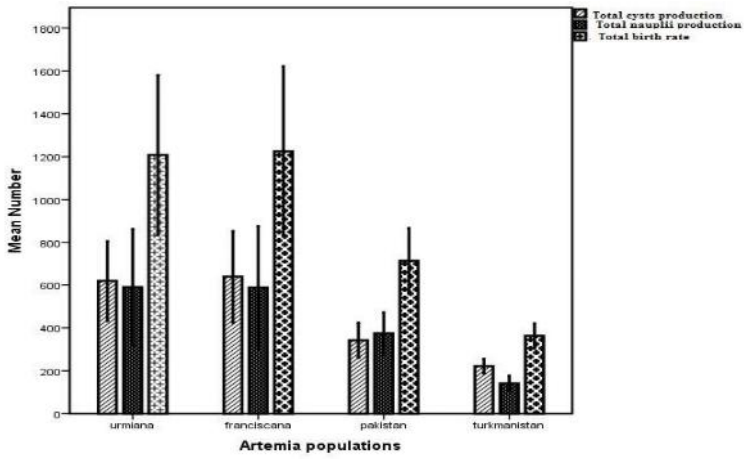

Fig. 4. Total cysts and nauplii production and total birth rate of four *Artemia* population

plii production compared to other strains. The highest and the lowest birth rate were belonged to *A. franciscana* and Turkmenistan *Artemia*, respectively (Fig. 4). Most of researchers have studied the reproductive characteristics and life cycle of bisexual and parthenogenetic *Artemia* populations of different geographical regions (e.g. Triantaphyllidis et al.,1995; Browne and Wanigasekera, 2000; Abatzopoulos et al., 2003; El- Bermawi et al., 2004; Baxevanis et al., 2004).

Triantaphyllidis et al., (1995) reported that the number of total offspring (cyst and nauplii), number of offspring at each birth (cyst and nauplii production) and the number of birth rate from each *Artemia* spawner was significantly higher in *A. franciscana* than Tanggu partenogenetic *Artemia*. But comparing bisexual *Artemia* from Egypt with parthenogenetic strains had a converse result (Baxevanis et al., 2004). Also, the percentage of nauplii production in bisexual Eygept *Artemia* and *A. franciscana* were significantly higher than parthenogenetic *Artemia*. Gajardo et al. (2002) suggested that *Artemia* strains with higher heterogygotic level was more suitable for cyst production. Also, Ahmadi (2003) mentioned that *A. urmiana* cyst production such as *A. franciscana* is under the genetic control and depends on heterozygotic level of studied species. Sorgeloos and Lavens (1996) mentioned that the most important factor affecting the cyst production of *A. urmiana* was the selection of appropriate cultured species, which should be based on scientific data of any kind regarding growth, especially reproduction. In fact, for breeding, we choose the species of each region that has the maximum growth and the maximum reproductive capacity in the heat and salinity regime of that area. In examining the results, there was no correlation between the number of breeding times and the reproductive model (cyst or nauplii production) of *Artemia* species with each other during the reproductive days, and each *Artemia* had specific features of that strain for birth, that depends on the genetic diversity of the *Artemia* population that was the same as Triantaphyllidis et al. (1995), Baxevanis et al. (2004), Guajardo et al. (2002). Regarding that total nauplii production has not significant difference in *Artemia* strains, and bisexual *A. urmiana* and *A. franciscana* have a significant difference than

Turkmenistan parthenogenetic *Artemia* in cyst production and number of offspring, that *A. franciscana* enjoys the highest birth rate of offspring and Turkmenistan parthenogenetic *Artemia* had the least birth rate that corresponds to Triantaphyllidis et al. (1995), Guajardo et al. (2002) and Ahmadi (2003).

A. urmiana, *A. franciscana* and Torkamanestan have enjoyed the highest cyst production within their own populations, while Pakistan parthenogenetic *Artemia* had enjoyed the most nauplii production within its own population the same as Triantaphyllidis et al. (1995) and Baxevanis et al. (2004) mentioned heterogenetic characteristics and intra population differences of each species. The results from each *Artemia* spawner, revealed that each *A. franciscana* and Turkmenistan has the most and the least birth rate and the most intra population cyst production were due to *A. urmiana*, *A. franciscana* and Torkamanestan population. Pakistan *Artemia* spawner had the highest nauplii production that was the same as Triantaphyllidis et al., (1995), Guajardo et al. (2002) and Ahmadi (2003). They mentioned the cyst production of bisexual *A. urmiana* and *A. franciscana* were higher and under genetic control but this results are incontrast with Baxevanis et al. (2004).

As bisexual *A. urmiana* and *A. franciscana* have a significant difference in total number of offspring, number of birth rate, and number of offspring from each birth than other species ($p>0.05$), therefore, bisexual *Artemia* has a different reproductive characteristics than parthenogenetic *Artemia* that was the same as El-Bermawi et al. (2004) and Baxevanis et al., (2004) that distinguished bisexual and parthenogenetic *Artemia* species of Egypt according to reproductive characteristics. As Turkmenistan *Artemia* has a significant difference in total number of offspring, number of birth rate, and number of offspring in each birth, than other species ($p< 0.05$), it can be mentioned that this *Artemia* has a different reproduction characteristics as Browne et al. (2002), reported that reproductive characteristics of *Artemia* have greatly influenced by environmental factors. *Artemia* populations situated far apart each other biotopes, live in different environmental conditions is according to Triantaphyllid et al. (1995), Browne and Wanigaseker (2000), Abatzopoulos et al. (2003), El-Bermawi et al. (2004) , Baxevanis et al. (2004). They proved that most *Artemia* populations show different responses based on their survival, growth and reproductive characteristics. Therefore, each strain based on high heterogenetic characteristics and population differences, may reflect the best accommodation at the resident strain of the area. On the other hand, cyst production of bisexual *Artemia* is under genetic control and depends on its heterozygoty level and the culture of each species has adapts with growth, reproductive pattern, reproductive characteristics and tolerable level of organism regarding to salinity and temperature of culture environment. Therefore, in order to select a species, the growth adaptation, breeding model, reproductive characteristics and living standards should be considered in relation to the salinity and temperature of the breeding place in order to select the best priority. Also, in choosing a species, the region's aquaculture should be directly linked with the use of *Artemia*. If, due to the diet of aquatic animals, the need for small naples, it is necessary to choose a species of *Ar-*

temia, which produces small nauplii and cysts, than other species, or if it requires biomass of *Artemia* in the aquaculture of the area, There should be a species of *Artemia* that has the power to grow, and grow better with the predominance of nauplii production, to be selected for *Artemia*. Therefore, if the goal of *Artemia* cultivation is to produce daily live mass, Pakistani parthognagmatic *Artemia* is more suitable than other species, because it has the most nauplii production within its population, although in the breeding season, *A. urmiana* and *A. franciscana* have more in breeding and reproduction. If the goal of the *Artemia* breeding is the production of cysts, it is recommended to breed *A. urmiana* and *A. franciscana* species. Turkmenistan's *Artemia* is not recommended for reproduction because of poor nauplii and cyst production and poor growth.

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