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Growth rate comparison of two bisexual species of *Artemia*: *Artemia franciscana* (Kellogg, 1906) Mexico and *Artemia urmiana* (Günther, 1899) Lake Urmia, Iran.

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ABSTRACT

This study is aimed to find out possible differences or similarities of growth rates of two bisexual species of *Artemia* from Mexico and Iran. Through the obtained results, the suitable strain of *Artemia* will be introduced for possible application in aquaculture industry.. An amount of 0.5 g of *Artemia* cysts from each population was hatched and inoculated into 200L plastic beaker with 160L (60 gL^{-1} salinity), pH 8-10 and a temperature of 26 ± 2°C. Each third day, animals were fed with 50mL of rice bran, 1 L *Tetraselmis* sp. microalgae (500,000 cel mL^{-1}), for 21 days. Each third day, total body length of animals was measured for each population. A tendency curve analysis was performed for growth values. Absolute growth rate (AGR), instantaneous growth rate (IGR) were obtained for comparison between populations. CCI population showed significant differences (P<0.05) with other *Artemia* populations. *A. urmiana* population did not show any significant differences with ZAC, LSLP and TEX populations. The knowledge of growth rate of different species of *Artemia* which is cultivated in the same temperature, salinity, food type and food concentration, are of a great importance for understanding of growth development. There is a little information regarding to know growth rate responses among different populations of *Artemia*. This information is valuable for making predictions of *Artemia* size and biomass production of different populations of *Artemia* for commercial application in aquaculture industry.

Key words: *Artemia urmiana*, *Artemia franciscana*, Growth rates, absolute growth rate, instantaneous growth rate.

INTRODUCTION

The genus *Artemia* comprises a complex of sibling species and superspecies defined by a criterion of reproductive isolation (Browne and Bowen 1991). A group named “New World” species is composed of *Artemia franciscana* Kellogg, 1906 (North, Central and South America), *Artemia persimilis* Piccinelli & Prosdocimi, 1968 (Argentina) and *Artemia monica* Verrill, 1869 (USA). Another group named “Old World” species is represented by *Artemia salina* (Linnaeus, 1758) (Mediterranean basis), *Artemia urmiana* Günther, 1900 (Lake Urmia, Iran), *Artemia sinica* Cai, 1989 (China and neighboring countries), *Artemia tibetiana* Abatzopoulos, *et al.*, 1998 (Tibet`s high Plateau), Artemia sp. Pilla and Beardmore 1994 (Kazakhstan) and parthenogenetic lineages which are distributed in the Old World, i.e., *A. parthenogenetica* (Abatzopoulos et al. 2002).

These brine shrimp organisms are largely distributed in inland and coastal hypersaline body waters (Triantaphyllidis *et al.* 1998, Castro *et al.* 2000, Van Stappen 2002, El-Bermawi *et al.* 2004). *Artemia* may inhabit chloride, sulphate or carbonate waters and combinations of more than two anions (Bowen et al. 1985, Lenz *et al*. 1987). Artemia are among a few organisms which adapted to survive in a very diverse living conditions, including salinities as low as 10g/L (Abatzopoulos *et al.* 2006a; Abatzopoulos *et al.* 2006b) and as high as 340g/L (Post and Youssef 1977).

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There are handful information concerning to survival and growth rate characteristics of bisexual and parthenogenetic populations cultivated in different salinities (Vanhaecke *et al.* 1984, Browne *et al.* 1984, Wear *et al.* 1986, Browne *et al.* 1991, Triantaphyllidis *et al.* 1995, Triantaphyllidis *et al.* 1997a, Triantaphyllidis *et al.* 1997b, Browne and Wanigasekera 2000, Abatzopoulos *et al.* 2003, Baxevanis *et al*. 2004, Castro 2004, El-Bermawi *et al.* 2004, Abatzopoulos *et al.* 2006b, Agh *et al.* 2008), owing to dropping rate of cyst harvesting from Great Salt Lake, Utah, USA from 1977 (Lavens and Sorgeloos, 2000), the needs for alternative resources have been extensively intensified. This is understood especially in inland saline lakes which have a natural source of *Artemia* and can be used for commercial exploitation.

The aim of the present study is to make a comparison of growth rates of two bisexual species *Artemia* from inland saline water. Through the present study we are able 1) to find differences or similarity of growth rate from each population and 2) to choose *Artemia* strain for possible application in aquaculture industry.

MATERIAL Y METODOS

Sampling localities

This study was conducted at Live Food Production Laboratory of Autonoma Metropolitana Xochimilco University, Mexico. Artemia population with their partial localities on the map and geographical coordinates are litsed in Table 1 and Fig. 1.

Experimental conditions

An amount of 0.5 g of *Artemia* cysts from each population was hydrated for one hour in tap water and decapsulated with hypochlorite sodium solution to remove the external cyst shell (Castro *et al.* 2001). Mexican and Iranian populations were hatched in a 4L plastic beaker with 35gL^{-1} salinity, pH 8-10, temperature of 23 ± 2°C with continuous illumination and aeration.

Nauplii collected for each population were inoculated into 200L plastic beaker with 160L (60 gL^{-1} salinity), pH 8-10 and a temperature of 26 ± 2°C. Each third day, the organisms were fed with 50 mL of rice bran (100 gL^{-1} solution) and every day with a 1 L *Tetraselmis* sp. microalgae (500,000 cel mL^{-1}). The organisms were maintained at these conditions during 21 days.

Each third day, total length body of organisms was measured for each population (Fig.2).

A database in Excel 2010 was constructed to obtain mean values and standard deviation for total body length of each population (Tatsuoka 1970, Kachigan 1991). A tendency curve analysis was performed for growth values of each population using Excel 2010 program.

Table 1. Sampling localities and geographical coordinates of *Artemia* populations examined in the study.

Species	Localities	Country	Geographical coordinates
Artemia urmiana	Lake Urmia	Iran	37°36´ N 45°30´E
Artemia franciscana	Cuatro Cienegas de Carranza, Coahuila (CCI)	Mexico	26°56´N 102°05´W
Artemia franciscana	Santo Domingo, Zacatecas (ZAC)	Mexico	23°19´N 101°43´W
Artemia franciscana	Las Salinas de Hidalgo, San Luis Potosí (LSLP)	Mexico	22°37´N 101°43´W
Artemia franciscana	Texcoco, state of Mexico (TEX)	Mexico	19°33´N 99°00´W

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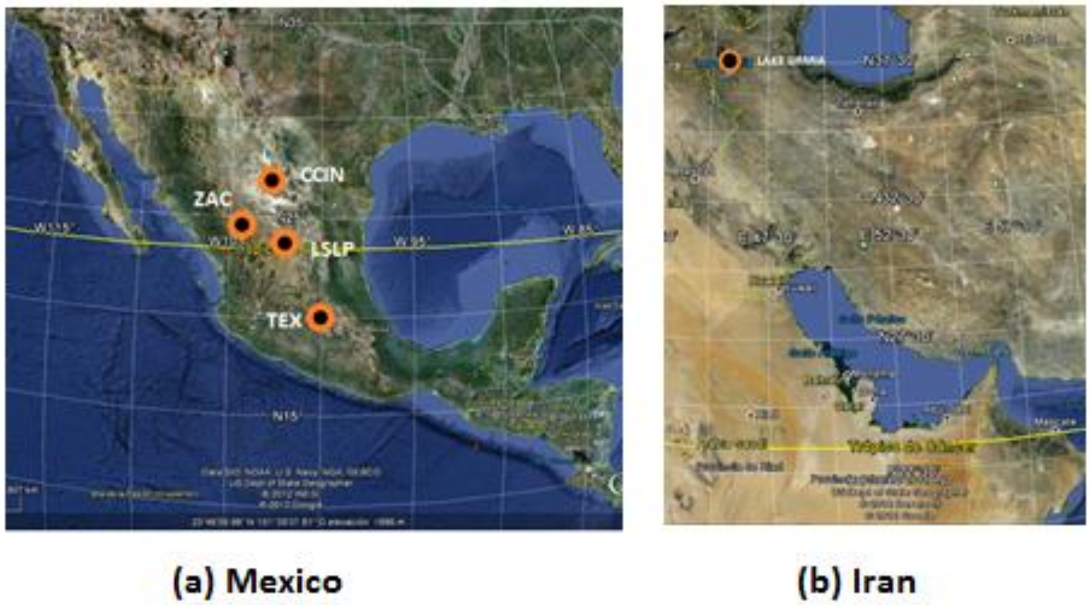

Fig.1. Map sites of *Artemia* populations from Mexico and Iran.

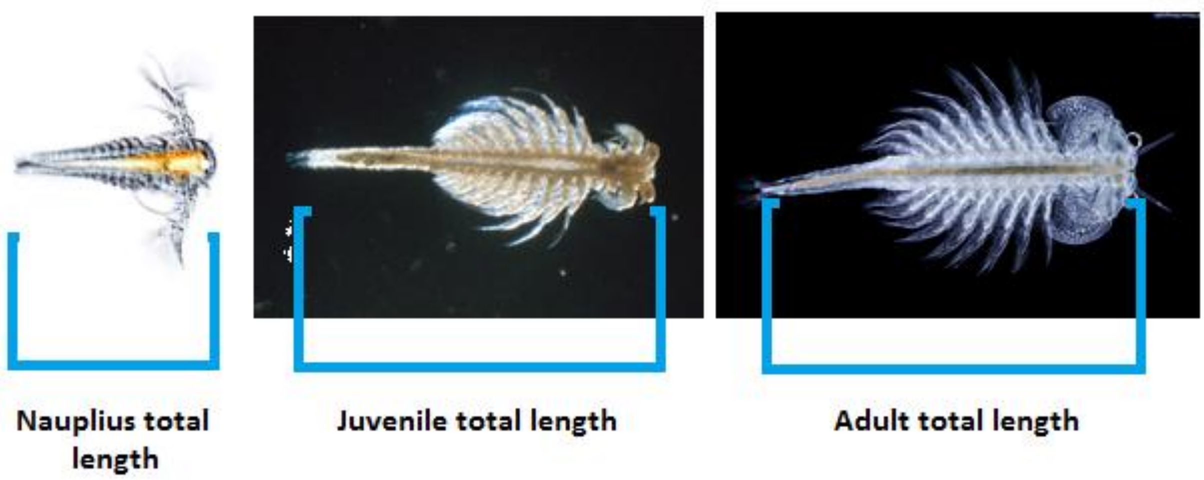

Fig.2. Diagram of total body length biometry considered in the experiment.

Absolute growth rate (AGR) was obtained using the following formula (Wooton 1991):

$$\text{Absolute growth rate} = \frac{\text{Lenght}_{\text{finnal}} - \text{Lenght}_{\text{initial}}}{\text{Time}_{\text{finnal}} - \text{Time}_{\text{initial}}}$$

Instantaneous growth rate (IGR) was obtained using the following formula (Soriano y Hernandez 2002):

$$\text{Instantaneous growth rate} = \frac{\text{LN Lenght}_{\text{finnal}} - \text{LN Length}_{\text{initial}}}{\text{Time}_{\text{finnal}} - \text{Time}_{\text{initial}})} \text{ x } 100$$

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RESULTS

The mean values of total body length with standard deviation are shown in Table 2. After 21 days culturing period, CCI population showed a significant difference (P<0.05) compare to other inland water populations. *A. urmiana* did not show any significant differences with ZAC, LSLP and TEX *Artemia* populations.

The tendency curve analyses are depicted in Fig.3. The best curve tendency used to explain *Artemia* growth rate for all populations was a logarithmic curve.

Total body length and growth rates values are summarized in Table 3. CCI population showed significant differences (P<0.05) with other *Artemia* populations. *A. urmiana* population did not show any significant differences with ZAC, LSLP and TEX populations.

DISCUSSION

Many studies of different species of *Artemia* indicate differences in survival, growth and reproductive patterns characteristics (Castro *et al.* 2011). Triantaphyllidis *et al.* (1995), El-Bermawi *et al.* (2004), Agh *et al.* (2008) and Castro *et al.* (2011), reported that growth rates in brine shrimp *Artemia* is inversely proportional to salinity and each *Artemia* strain has different response to salt concentration. In this case, salinity was maintained at $60gL^{-1}$ during all experiments to eliminate this physic-chemical variable in the growth rate values from each population. This can be observed clearly in the growth rate values, i.e. AGR and IGR did not show any differences in millimeters and percentage values. The best growth value is observed in Cuatro Cienegas population which is actually because of bigger size of nauplius rather than the rest *Artemia* populations. The bigger nauplius size increased at the same rate in millimeters and percentage in the same culture medium, which consequently gave bigger adult organisms.

Forster and Hirst (2012), confirmed that adult size is an effect a product of growth rate (increase in size and weight per time) and the possible differences can show at final life stages and the time taken to reach this mature stage (Stillweel and Fox 2005).

Considering to feeding rate, *Artemia* was considered a continuous, non-selective, obligate phagotrophic filter feeding organism (Evjemo and Olsen, 1999), which ingested food using larval antennae in star development stage, but during post-embryonic development the feeding function is gradually taken over by multifunctional thoracopods (Evjemo and Olsen, 1999). These morphological structures changes at same rate in all these populations which was the reason they can increase their body size at the same rate. The food was not a variable factor, because the same concentration was incorporated to culture medium of *Artemia*, considered the same energy transfer in all experiments.

Another variable factor which could have effect on growth rate of *Artemia* populations was temperature. Sorgeloos *et al.* (1986) mentioned that for most *Artemia* species the optimum temperate range were 25-30°C. Temperature value in this experiment was kept at (26±2°C). Figueiredo *et al.* (2009), and Anger (2001), mentioned that temperature has been recognized as a key environmental factor influencing crustacean development and growth. The growth rate increased with temperature, which may be explained by metabolic acceleration and consequently greater moult frequency. The growth rate also increases with salinity, but the literature agrees that temperature regulates *Artemia* growth much more than salinity (Narciso 2000).

Another variable factor that can be modified the results must be the microalgae species. The digestibility and the nutritional value of the algae will also affect the growth rate potential of these organisms (Evjemo and Olsen 1999). These authors mentioned that it is necessary to maintain stable microalgae type, concentration of microalgae and density of organisms which also maintained in this experiment in order to avoid changes in growth rate. They mentioned growth rate in *Artemia franciscana* populations decrease when they are in pre-adult stages (5.2-5.8 mm), but they show the same growth curve. In this experiment, we can observe the same

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Table 2. Mean values (±S.D.) of total body length values of *Artemia* populations studied.

Sampling	*Artemia* populations studied				
	Cuatro Cienegas	Santo Domingo, Zacatecas	Las Salinas, San Luis Potosí	Texoco, State of Mexico	Lake Urmia, Irán
0	0.468[a]	0.430[b]	0.425[b]	0.423[b]	0.469[b]
D.S.	±0.013	±0.010	±0.007	±0.018	±0.012
3	2.039	1.868	1.837	1.825	1.835
D.S.	±0.121	±0.114	±0.148	±0.167	±0.117
6	5.310	4.864	4.784	4.750	3.771
D.S.	±0.162	±0.287	±0.257	±0.120	±0.485
9	5.536	5.071	4.987	4.952	5.172
D.S.	±0.136	±0.139	±0.232	±0.118	±0.912
12	7.932	7.266	7.146	7.096	7.605
D.S.	±0.143	±0.273	±0.271	0.270	±0.726
15	9.864	9.036	8.885	8.822	8.968
D.S.	±0.099	±0.103	±0.126	±0.137	±0.062
18	11.166	10.227	10.057	9.985	10.175
D.S.	±0.165	±0.144	±0.099	±0.116	±0.104
21	12.175[a]	11.152[b]	10.966[b]	10.888[b]	11.110[b]
D.S.	±0.094	±0.065	±0.078	±0.110	±0.118

Note: Same letters in the row, shows no significant differences (P<0.05)

Table 3. Total body length and growth rates values of *Artemia* populations.

Artemia populations	Total body length (mm)	Absolute growth rate (AGR) (mm)	Instantaneous growth rate (IGR) (%)
Lake Urmia, Iran	10.64	0.507	11.261
Cuatro Cienegas, Coahuila	11.71	0.557	11.715
Santo Domingo, Zacatecas	10.72	0.511	11.297
Las Salinas, San Luis Potosí	10.54	0.502	11.215
Texcoco, State of Mexico	10.64	0.507	11.261

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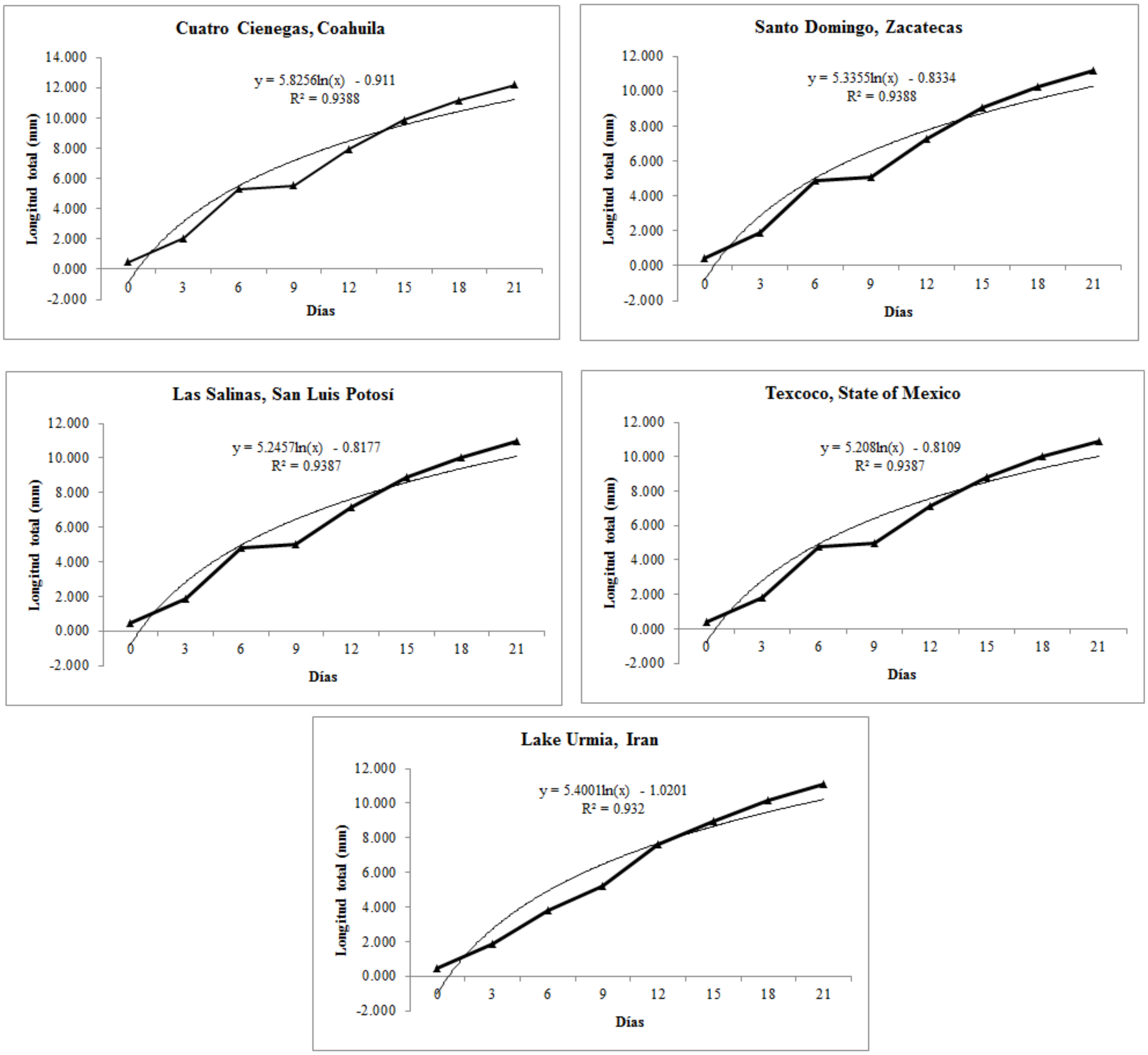

Fig.3. Curve tendency analysis of growth values of *Artemia* populations studied.

rate growth value not only with *A. franciscana* but also with *A. urmiana* species.

Sayg (2004) mentioned that geographical isolations of populations in specific biotopes with different temperature and salinity conditions can result in different tolerance ranges for each *Artemia* strains and their different responses can be attributed to local adaptation, but considered the same variable conditions for all studied populations. It is important to obtain the same negative or positive growth response and compare the biometry rate results.

The knowledge of growth rate of different species of *Artemia* which is cultivated in the same temperature, salinity, food type and food concentration, are of a great importance for understanding of growth development. There is a little information regarding to know growth rate responses among different populations of *Artemia*. This information is valuable for making predictions

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of *Artemia* size and biomass production of different populations of *Artemia* for commercial application in aquaculture industry.

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