EFFECTS OF DIFFERENT SALINITIES ON MATURATION PERIOD OF *ACARTIA CLAUSI* COPEPOD OF CASPIAN SEA

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EFEKTI RAZLIČITOG SALINITETA NA SAZREVANJA KOPEPODE *ACARTIA CLAUSI* IZ KASPIJSKOG MORA

Abstract

The present study was conducted to evaluate the effects of salinity on maturation rate of *Acartia clausi* which is a copepod in Caspian Sea. The experiment was done during March to April 2007 and the referred zooplankton was collected from southern coast of Caspian Sea via plankton net. The gathered zooplankton was introduced to culture tanks for mass production. Afterwards *Acartia clausi* nauplius was isolated from tanks and transferred to four different salinities (07, 13, 18, 24psu) with three replicates in separate glass dishes in order to obtain growth and maturation. An equal mixture of *Isochrasis galbana* and *Chaetoceros sp*. alga were used for nauplii daily feeding.

Statistic analysis indicated significant differences among the salinity treatments in the time of maturation ($p<0.05$). However, maturation period in salinities of 7, 13, 18 and 24psu was prolonged to 285.6, 268.8, 288 and 396 hours respectively. In addition, the results of Duncans averages comparison test showed that the 13psu salinity caused the lowest time for the maturation of 50% of the population, and this salinity obtained the first rank (a) among other salinity groups.

Key word: *Acartia clausi, Copepod, nauplius, zooplankton*

INTRODUCTION

Copepods are primary consumers in the oceans which have crucial effect on transferring the carbon of phytoplankton to higher trophic levels (Mckinnon et al., 2003). Also they are the most numerous crustaceans among zooplankton community [(Knueky

et al., 2005) and (Schipp et al., 1999)]. Copepods, especially their nauplii, are natural prey items for fish larvae ([Chesney, 2005] and (Chen et al., 2006), typically make up fifty percent or more of their stomach contents (Camus and Zeng, 2008). This makes copepods possible attractive candidates to use as live food for commercial larviculture in hatcheries (Shamsudin et al., 1997) and (Knucky et al., 2005). Three orders of planktonic copepods are important in aquaculture: 1) Calanoida, which have been the copepods that was most successful in colonizing both marine and fresh water environments (Schipp et al., 1991). 2) Cyclopodia and 3) Harpacticoida, which are mostly parasitic (endo or ectoparasites) and due of their bigger size, they have the less importance in aquaculture (Damgaard & Davenport, 1994). Some calanoid species, belonging to the *Acartia* genus are important in aquaculture because of their suitable size for feeding of marine larvae (Mckinnon et al., 2003) and (Toledo et al., 1999).

Life cycle of *Acartia clausi* starts from eggs hatching into nauplius larvae, which consist of a head with a small tail, but no thorax or true abdomen (Almeda et al., 2010). The nauplius moults six times (which lasts for approximately 3.2 days) before emerging as a "copepodid larva"(Calliari et al., 2008). This stage resembles the adult, but has a simple unsegmented abdomen and only three pairs of thoracic limbs (Almeda et al., 2010). After five molting, which lasts around 4.95 days for males and 5.23 days for females, the copepod finally takes on the adult form (Calliari et al., 2008). The difference between male and female is displayed by formation of "fifth leg" which is coarse and circular in males and sharp in females (Mckinnon et al., 2003).

Salinity is one of the most important environmental parameters effecting the seasonal and spatial distribution of the planktonic copepod *Acartia clausi* in the wild (Miller and Marcus, 1994). However, this parameter can also be relatively easily manipulated in aquaculture hatcheries, where mass culture of copepods is desirable in means of providing live prey for culture animals (Milione and Zeng, 2007). *Acartia clausi* is naturally adapted to sudden shift in temperature and salinity, thereby making it suitable for rearing fish species whose larvae occur in either estuarine or oceanic environments (Mckinnon et al., 2003, [Camus and Zeng, 2008). The effects of salinity on productivity of calanoid copepods has shown well, so that it has clear effects on egg production, egg hatching rates ([Hall and Burns, 2002] and [Peck and Holste, 2006]), as well as on nauplii growth for various calanoid copepod species (Chinnery and Williams, 2004). But, to date, no published information is available on the optimum salinity condition to obtain minimum time for maturation of this species which is an important subject in commercial marine larviculture.

MATERIALS AND METHODS

In order to determine the effects of salinity on maturation period of copepod *Acartia clausi*, a random experiment were set up with 4 salinity treatments (7, 13, 18 and 24psu) and 3 replicates. Twelve 800 cc glass dishes were used as experimental plots. In addition, a plankton net (with 100µm mesh size) which was stretched via a boat across Khazaradad port in southern cost of Caspian Sea has been used for collecting copepods. Sampling was done in surface water for 2-3 hours and samples were transferred to laboratory in 1 litter dishes.

In order to purify the mentioned species, the contents of plankton net were diluted in test tubes with filtered sea water. Recognizing and separating the males and females was done by using microscope (Nikon-E-200) and micropipette. Then the adult copep-

ods (one pair of male and female) were presented to individual Petri dishes with a little amount of seawater.

Throughout the experiment period, *A. clausi* was fed with equal mixed *Isochrysis galbana* and *Chaetoceros sp* alga which were cultured purely in Gillard media culture. 25000-30000 alga cellules/cc of media culture was suitable for feeding *A. clausi*. Microscope and Neobar lam were utilized for daily alga counting. The photoperiod was 12h light: 1050 Lx 12 h dark cycle with 1050 Lx light intensity. Salinity and pH were 12-13psu and 7.5-8.5 respectively. During the period, egg production and hatching were accomplished and nauplii were randomly captured by using a fine-tipped pipette for transferring into the 20 litter mass culture tanks.

Various salinity treatments were obtained by either diluting the Caspian Sea water or adding sea salt it. The copepods used in this experiment were gradually acclimated to the various salinities by changing 2.5psu every 12 h until the required salinity levels were reached. 40%-50% of water was exchanged daily using a siphon through out a 38 µm filter.

After appearing the "fifth leg" in copepods, the number of adult females was recorded daily. In addition, the elapsed time for maturation of 50% of copepod communities in each treatment has been determined. Data for maturation rate in different salinity treatments were analyzed by one way ANOVA in order to determine differences. The Duncan's multiple comparison test was used to compare the adults number averages among different treatments. The linear regression model for maturation on the basis of elapsed time was analyzed by utilizing SPSS soft ware, version 11. Results were presented as mean ± standard error (SE).

RESULTS

The elapsed times until maturation in all treatments is shown in table 1. The maturation times for 50% of copepod population in salinity levels 7, 13, 18 and 24psu, resulted in 285.6, 268.8, 288 and 396 hours respectively. Regarding to table 2, the salinity level of 13psu (treatment no.2) caused the lowest maturation time among other salinity treatments.

Table 1. The average number of adult copepods in 4 salinity treatments considering time

Day		9*th*	10*th*	11*th*	12*th*	13*th*	14*th*	15*th*	16*th*	17*th*	18*th*	19*th*
Average number of adults in salinity level	*7psu*	0	0	7.5	3	0	0	0.5	0.5	0.5	0.5	0
	13psu	1	1	12	o.5	0	0	0.5	4	0	0	0
	18psu	0	15.67	32.67	19	10.67	16.67	28.33	0	0	0	0
	24psu	0	0	0	0	0	0.3	0.7	1	18.3	2.3	0.3

Table 2. The results of variance analyzes and Duncan's test on maturation time in different salinities

Examined factor	The average in salinity treatments				*fs*
	7psu	*13psu*	*18psu*	*24psu*	
Maturation time of 50% of *A.clausi* communities (hour)	285.6 ^{ab}	268.8 ^{a}	288 ^{ab}	369 ^{ab}	5.487*

*Significant differences in the level of 0.05

As it is seen in table 1, salinity treatments caused significant differences (P<0.05) on the maturation period of 50 percent of *A. clausi* population. Across the wide range of salinity treatments from 7psu to 24psu, the lowest maturation time (268.8 h) was recorded at 13psu and the highest time (369 h) at 24psu. Therefore the salinity of 13psu obtained the first rank among other 4 treatments.

The figures 1 to 4 display the liner regression diagrams between salinity and time of maturation in 50% of copepod population.

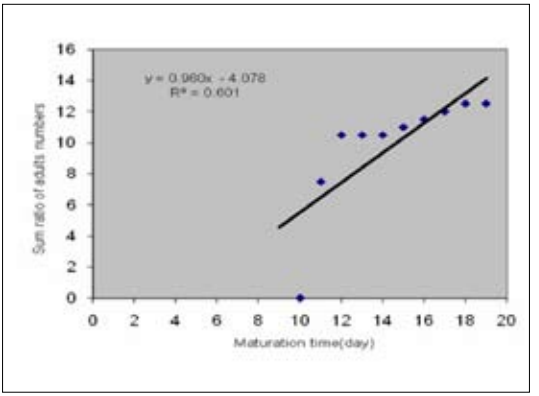

Figure 1. Diagram of maturation for 50% of population in 7psu treatment

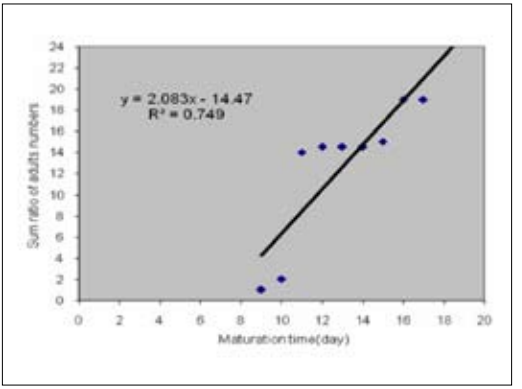

Figure 2. Digram of maturation for 50% of population in 13psu treatment

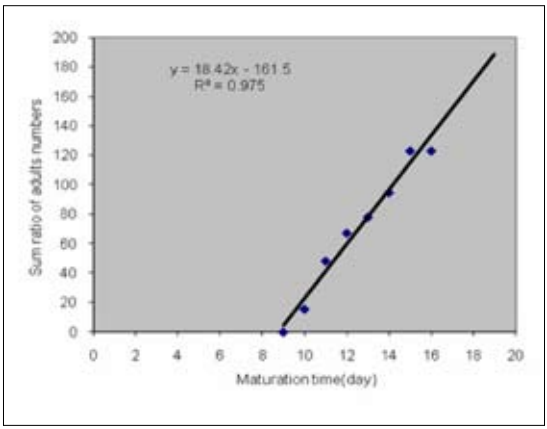

Figure 3. Diagram of maturation for 50% of population in 18psu treatment

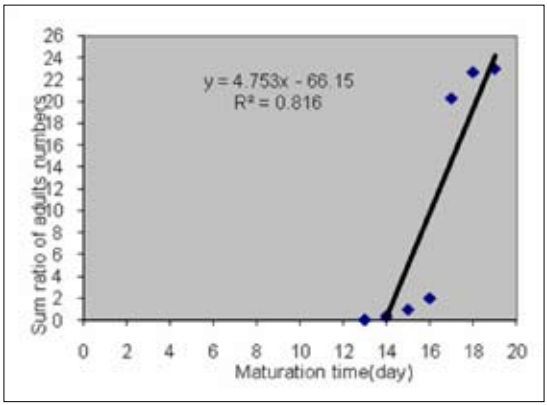

Figure 4. Diagram of maturation for 50% of population in 24psu treatment

As it could be seen from the figures 1 to 4, 13psu salinity has had more appropriate effect on maturation rate of *A.clausi* population

DISCUSSION

Under natural conditions, Calanoida copepods are often well adapted to cope with seasonal salinity fluctuation ([Miller and Marcus, 1994], [Engel and Hirche, 2004] and [Camus and Zeng, 2008]). Species found in estuarine habitats in particular have broad tolerance ranges for this parameter ([Castro and Longoria, 2003] and [Chinnery and Williams, 2007]). This is a useful attribute for aquaculture, as live food for fish larvae will be alive and available in water under various salinity conditions that are suitable for the fish larvae culture (Camus and Zeng, 2008).

For aquaculture purpose, maximizing copepod productivity in the least period is important and salinity conditions used for culturing are likely to provide productivity. For example, previous studies have shown that the highest copepod productivity was observed in the ratio 13- 28psu salinity ([Damgaard et al., 1994] and [Hall et al., 2002]). In

addition, it has been stated that copepod survival in 9psu was notably more than 35psu (Cerretto, 1994) and maturation period in18-27 psu was considerably lower than in 9 psu salinity (Calliai et al., 2008). Meanwhile, present study was designed to focus on the salinity which causes the minimum time for maturation and was not reported until now (table2). Nevertheless, in this experiment, cannibalism was not monitored and therefore its effects on maturation time were unknown. We considered this approach (salinity) more pertinent to the ultimate goal of copepod culture for aquaculture.

The findings of this study have indicated that the salinity has had negligible effects on nauplii production and 17.1+-2.6 nauplii were produced in all treatments every day.

Given that *A. clausi* is generally considered a euryhaline species, as it is commonly found in coastal and estuarine waters ([Uye, 1985] and [Mckinnon et al., 2003]), some flexibility is expected in its ability to tolerate salinity changes. The results of this study demonstrated that maturation time decreased significantly at 13psu salinity and most matured copepods were observed at the 11^{th} and 15^{th} days (fig.2). At lower salinities, the most maturation occurred at the 12^{th} and 20^{th} days (fig.1). However, the higher salinity does not determine specific period for the most maturation (fig.3, 4). In summary it seems that in high salinity levels specially 18 and 24psu, the effect of time on maturation is more important than salinity (fig.3, 4). Meanwhile, the maximum maturation in lower salinity levels is more dependent to salinity rather than time. However this is something that needs more study in future. At the same time the results of this study demonstrate that, while *A. clausi* could survive in wide salinity ranges; this factor has strong impacts on the maturation trend of this species. This study clearly was done in order to identify the optimal salinity conditions for *A. clausi* culturing, which seems to be applicable in commercial scales. Based on the finding of this experiment, to achieve maximum productivity of *A. clausi* for aquaculture purposes, the species should be farmed in 13psu salinity.

ACKNOWLEDGMENT

We should thank from aquaculture laboratory responsible of Mazandaran University for providing facilities in order to do this experiment.

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