African Journal of Basic & Applied Sciences 4 (6): 216-220, 2012
ISSN 2079-2034

DOI: 10.5829/idosi.ajbas.2012.4.6.1936

Effect of Temperature on the Egg Production and Hatching Success of *Sinodiaptomus (Rhinediaptomus) Indicus* (Calanoida: Copepoda)

[1]B. Dilshad Begum, [2]G. Dharani and [3]K. Altaff

[1]Department of Zoology, Justice Basheer Ahmed Sayeed College for Women, Teynampet, Chennai-600 018, India
[2]National Institute of Ocean Technology, Pallikaranai, Chennai-600 100, India
[3]Department of Zoology, The New College, Royapettah, Chennai-600 014, India

Abstract: Effect of temperature on the egg production and hatching success were investigated in the laboratory reared *Sinodiaptomus (Rhinediaptomus) indicus* at 26, 28, 30 and 32°C under standard feeding conditions. The percentage of ovisac producing females increased as the temperature decreased. Similarly the metasome volume decreased as the temperature increases. The ovisac volume decreased and also observed to contain less numbers of eggs as the temperature increased among the four temperatures tested except for a slight increment in the second clutches in the 26°C temperature. Interestingly the embryonic development rate and hatching success was high in higher temperature, however the female ceased to produce third successive clutches of eggs in 30°C and 32°C. The results of the present study on *S. (R). indicus* indicates that the optimum temperature for maximum numbers of egg production were in between 26°C and 28°C.

Key words: Freshwater calanoid copepod · Culture temperature · Egg production and hatching

INTRODUCTION

Copepods are the most dominant and numerically abundant crustaceans and form an important link between phytoplankton and higher trophic levels in most of the aquatic ecosystems. Copepods such as calanoids are particularly suitable for laboratory studies, as they have a wide distribution, short life cycle and easy to maintain in laboratory conditions. Besides that the presence of various developmental stages and easy to harvest from the culture at any time makes them more suitable as test animal for experimental purposes. Studies on egg production and the factors regulating the reproduction and abundance of calanoids have formed the basis for a number of investigations. The egg production rate of individual female of the crustaceans is a function of temperature, food conditions, stage of the ovulation cycle, body size and age [1]. Among various factors, temperature, food availability and reproductive condition of the female are considered to be most important influencing factors in egg production [2]. Effect of temperature on egg production in calanoids has been reported by a number of investigators [3 - 12]. More than 90% of the variations in growth rate of copepods is related to temperature [13]. The growth rate of *Acartia tonsa*, was reported to be lesser at 15°C when compared with 25°C [14]. Synergistic effect of various factors on egg production in calanoids was reported by number of authors [15-17].

The present trend in copepodology research is towards utilizing copepods as a live feed in aquaculture [18]. Studies are also being increasingly focused on unraveling the various endogenous and exogenous factors controlling the life history of calonoid copepods [19]. The effect of water temperature on fecundity and hatchinghas been well investigated in marine calanoids such as *Acartia* species [20-22]. However, reports on the temperature effect on egg production and hatching success in tropical fresh water calanoids are sparse [23]. Therefore, the present work was aimed to study the effect of temperature on egg maturation leading to clutch formation and embryonic development of egg in the egg sac leading to hatching in the freshwater calanoid copepod *Sinodiaptomus (Rhinediaptomus) indicus* in the laboratory conditions.

Corresponding Author: G. Dharani, National Institute of Ocean Technology, Pallikaranai, Chennai-600 100, India.
E-mail: gdharani@yahoo.com.

MATERIALS AND METHODS

Laboratory reared fifth copepodite *Sinodiaptomus (Rhinediaptomus) indicus* were isolated under binocular dissection microscope and maintained in beakers containing 1000 ml of filtered pond water in four different temperatures *viz* 26, 28, 30 and 32°C±0.5°C in temperature controlled incubators. The experimental animals were exposed to a cool white fluorescent tube light with a light intensity of 60 lux at 12 hrs intervals. The copepodites were fed with a mixture of algae *Chlorella* sp. and Brewery yeast *Saccharomysis* sp. during the whole experimental period. Twelve sets of experimental containers each with 15 male + 15 female 6^{th} copepodites. were maintained at each experimental temperature. The presence of ovigerous females were recorded after 24 hours. The ovisac was allowed to hatch and the number of eggs hatched and the nauplii were counted under microscope. Three batches of copepods from each temperature were slowly narcotized and fixed in five percent formalin. From these animals, the parameters such as the number of eggs in ovisac, ovisac diameter, egg diameter, female metasome length and width were measured under microscope using pre calibrated ocular micrometer. The metasome and egg sac volumes were calculated following the standard formula to calculate the volume of cylinder. The experiments were continued until the copepods produce second and third clutches of egg. Statistical analysis such as single variant ANOVA and correlation coefficient of metasome volume with egg sac and number of eggs were made using standard statistical package.

RESULTS AND DISCUSSION

Sinodiaptomus (Rhinediaptomus) indicus is one of the most common calanoid copepod in fresh water bodies of Tamil Nadu and often reported to co-occur with *Heliodiaptomus vidus* and *Neodiaptomus physalipus* [23]. Calanoid copepods and their larvae form a major component in freshwater zooplankton and constitute an important food resource for larval fin and shellfishes. Experimental studies on fecundity in relation to food, temperature and other environmental factors are important steps in developing suitable methodology for laboratory culture of live feed organisms. The results of the experimental studies on the fecundity of *S. (R.) indicus* at different temperatures show definite influence of temperature on egg production. The percentage of *S. (R.) indicus* producing ovisac was not significantly different among the four different temperatures tested,. The ovisac production decreased with increasing temperature. In lower temperature the percentage of ovisac production increased significantly from the first clutch to the serial third clutch whereas the same decreased significantly at higher temperature. At 28°C and 30°C temperatures the females failed to produce the third batch of ovisacs. The clutch size of *S. (R.) indicus* decreased significantly as the temperature increased, (ANOVA>0.05). Maximum of 16, 19 and 21eggs were recorded in the first, second and third serial clutches in 26°C (Table-1). Similar observations were reported by [24] in *Acartia tsuensis*. Though there is no significant difference among the serial of clutches, a reduction in egg production was recorded in the second clutch in all temperatures tested.

The metasome volume decreases as the temperature increases in *S. (R.) indicus*. Interestingly at 26 and 28°C the metasome volume moderately increased in the third clutch. Similar correlation between the prosome length and clutch size was reported in *E. norvegica* [25]. The ovisac volume decreased as the temperature increased in all four temperatures tested whereas the same increased in the second serial clutches in the 26°C temperature in *S. (R.) indicus*. Metasome volume and ovisac volume are the direct function of egg production, as the temperature increases the metasome volume decreased, the female produced less numbers of eggs there by the ovisac volume also decreases. Reduction of metasome volume is a function of physiological response to elevated temperate, as it is evident by the occurrence of large calanoids in temperate water and small calanoid in tropical waters [26]. The reduction of ovisac volume is function of the number of eggs laid in the ovisac because the ovisac are elastic membrane secreted by the oviductal gland of the female [27] and it expands according to the number of eggs that are extruded into it during egg laying. In the present study the female produced less numbers of eggs in elevated temperature in contrary to high fecundity reported for tropical calanoids [23]. The reduction of egg production in *S. (R.) indicus* elevated temperature is not clear, it may be due to the temperature induced stress on the reproducing females [28] or the synergistic effect of factors like temperature, food and light as suggested by [1, 5].

The egg diameter was significantly less in 26°C when compared to the other temperature in all of the serial clutches, where as the egg diameter were marginally higher in the second clutch among the serial clutches and across the temperatures tested. The hatching success of the eggs in the ovisac of *S. (R.) indicus* increased

Table 1: Effect of temperature on the egg production of *Sinodiaptomus (Rhinediaptomus) indicus*

Parameters	26°C	28°C	30°C	32°C
I - Clutch				
Ovigerous females (%)	65	75	60	50
Hatching success (%)	83	95	94	100
Clutch size (Nos.)	16±5	18 ^{T4}±6	18 ^{T4}±4	12±3
Egg diameter (mm)	0.097±0.007	0.090±0.007	0.090 0.005±	0.099±0.006
Metasome volume (mm^3)	0.053±0.005	0.056±0.001	0.053±0.006	0.052±0.012
Ovisac volume (mm^3)	0.013±0.002	0.014 ^{T4}±0.004	0.012±0.004	0.010±0.003
II - Clutch				
Ovigerous females (%)	64	85	25	17
Hatching success (%)	94	100	100	100
Clutch size (Nos.)	19±2	15±5	15±3	13±3
Egg diameter (mm)	0.102^{T3}±0.006	0.092±0.003	0.099 ^{T3}±0.008	0.100±0.001
Metasome volume (mm^3)	0.050±0.005	0.054±0.017	0.058±0.004	0.047±0.004
Ovisac volume (mm^3)	0.032 ^{T4}±0.001	0.012 ^{T4}±0.003	0.013 ^{T4}±0.001	0.007±0.002
III - Clutch				
Ovigerous females (%)	60	77	-	-
Hatching success (%)	95	100	-	-
Clutch size (Nos.)	21^{ab}±5	17±2	-	-
Egg diameter (mm)	0.097±0.007	0.093±0.004	-	-
Metasome volume (mm^3)	0.060 ^{ab}±0.003	0.058±0.004	-	-
Ovisac volume (mm^3)	0.017 ^{ab}±0.002	0.013±0.000	-	-

^{a} =Significant when compared with clutch –I, ^{b}= Significant when compared with clutch –II, Significant when compared with clutch –III. ^{T1}=Significant when compared with 26°C, ^{T2}=Significant when compared with 28°C, ^{T3}=Significant when compared with 30°C, ^{T4}=Significant when compared with 32°C

significantly as the temperature increased in all clutches. Though, hatching success of the eggs was higher at 28°, 30° and 32°C there was significant decrease in the clutch size as the temperature increased and subsequently the female ceased to produce the third batches of ovisac in elevated temperature (30 and 32°C). Similar decrease in egg production with increase in temperature above the optimum has been reported in *Psudocalanus* sp. Determining life history parameters of copepods such as embryonic and post embryonic development times, growth, survival and egg production rates under various environmental conditions in the laboratory were consider as important parameters for comprehending in-situ population dynamics and production of copepods for live feed purpose [4, 8, 29-31]. Taking into consideration, the parameters such as percentage of occurrence of ovigerous females, clutch size and egg diameter, it is evident that in the present study, 26°C followed by 28°C appeared to be the optimum temperature for maximum fecundity of *S.(R.) indicus*. Generally, copepods are found abundantly in small freshwater ponds, pools and temporary water bodies where the surface water temperature ranges between 28° and 30°C, however maximum numbers of copepods were recorded in surface zooplankton samples in early hours of morning and late evenings, suggesting that the copepods avoid excess temperatures and bright sun light. During the bright day light and increased surface water temperature the copepods tends to stay close to the bottom of pond where temperature ranges from 26-28°C. Overall, the water temperature at which *S.(R.) indicus* showed high fecundity and hatching success was recorded consistently at around 26°C. This temperature corresponds to that fresh water pond temperature from July to September when the species is reported to occur abundantly with maximum ovigerous females [23]. As observed earlier, in many species of calanoids [3, 32] the results of the present study also indicates that the optimum temperature for higher fecundity of *S. (R.) indicus* is 26°C and 28°C, providing further evidence that temperature influenced egg maturation and embryonic development in the freshwater calanoid copepod *Sinodiaptomus (Rhinediaptomus) indicus*.

ACKNOWLEDGEMENTS

The authors are grateful to Prof. T. Subramonium, (Retd.) Head Dept of Zoology, University of Madras, Chennai and Dr. M. Vijayakumaran, (Retd.) Principle Scientist, Central Marine Fisheries Research Institute, Chennai for critically reviewing the manuscript.

REFERENCE

1. Pandian, T.J., 1994. Arthropoda-Crustacea: In K.G.A. Adiyodi and R.G. Adiyodi (eds) Reproductive biology of invertebrates. Oxford-IBH Publishing Co. Pvt. Ltd., New Delhi, VI part B, pp: 39-166.
2. Subramoniam, T., 1997. Some aspects of reproductive ecology of a mole crab Emerita asiatica Milne Edwards. J. Exp. Mar. Biol. Ecol., 36(3): 259-268.
3. Corkett, C.J. and E.J. Zillioux, 1975. Studies on the effect of temperature on the egg laying of three species of calanoid copepods in the laboratory. Bull. Plankton. Soc. Jpn., 21(2): 77-86.
4. Uye, S.I., 1981. Fecundity studies of neritic calanoid copepods, Acartia clause giesbrecht and A. steueri smirnon: A simple empirical model of daily egg production. J. Exp. Mar. Biol. Ecol., 50: 255-271.
5. Williamson, C.E. and N.M. Butler, 1987. Temperature food and mate limitation of copepods reproductive rates separating the effects of multiple hypotheses. J. Plankton Res., 9(5): 821-836.
6. Peterson, W.T. and S.J. Painting, 1990. Developmental rates of the copepods Calanus australis and Calanoides carinatus in the laboratory, with discussion of methods used for calculation of development time. J. Plankton Res., 12: 283-293.
7. Chow-Fraser and E.J. Maly, 1991. Factor governing clutch size in two species of diaptomus (Copopoda: Calanoida), Can. J. Fish. and Aquat. Sci., 48: 364-370.
8. Ban Syuhei, 1994. Effect of temperature and food concentration on postembryonic development, egg production and adult body size of calanoid copepod Eurytemora affinis. J. Plankton Res., 16: 721-735.
9. Kim, W.S., 1995. The Effect of Temperature on the Egg Production Rates of Acartia tonsa (Calanoid copepod) in Long Island Sound. Ocean Research, 17(1): 1-7.
10. Castro-Longoria, E., 2003. Egg production and hatching success of four Acartia species under different temperature and salinity regimes. J. Crustacean Biology, 23(2): 289-299.
11. Bonnet, D., R.P. Harris, L. Yebra, F. Guilhaumon, D.V.P. Conway and A.G. Hirst, 2009. Temperature effects on Calanus helgolandicus (Copepoda: Calanoida) development time and egg production. J. Plankton Res., 3(1): 31-44.
12. Benni W. Hansen, Guillaume Drillet, Angelique kozmér, Kirsten V. Madsen, Morten F. Pedersen and Thomas F. Sørensen, 2010. Temperature effects on copepod egg hatching: does acclimatization matter. J. Plankton Res., 32(3): 305-315.
13. Huntley, M.E. and M.D.G. Lopez, 1992. Temperature-dependent production of marine copepods: a global synthesis. Am. Nat, (140): 201-242.
14. Richmond, C., N.H. Marcus, S. Sedlacek, G.A. Miller and C. Oppert, 2006. Hypoxia and seasonal temperature: Short-term effects and long-term implications for Acartia tonsa Dana. J. Exp. Mar. Biol. and Ecol., 328(2): 177-196.
15. Woodward, I.O. and R.W.G. White, 1981. Effects of temperature and food on the fecundity and egg development rates of Boechella symmetrica sars (Copepoda: Calanoida). Aust. J. Mar. Freshwater Research, 32(6): 997-1002.
16. Watras, C.J., 1983. Reproductive cycles in diaptomid copepods effects: Effects of temperature, photo cycle and species on reproductive potential. Can. J. Fish. Aquat. Sci., 40: 1607-1630.
17. Jamieson, C.D. and C. Burns, 1988. The effect of temperature and food on copepodite development, growth and reproduction in three species of Boechella (Copepoda: Calanoida) Hydrobiologica, 164: 235-257.
18. Uye, S., 2005. A brief review of mass culture of copepods used for fish food in Japanese mariculture and a proposed plan to use high biomass natural population of brackish water copepods. In: Copepods in Aquaculture (Ed. By C. S. Lee, P.J. O' Bryen and N.H. Marcus), Blackwell Publishing Ltd, Oxford, UK., pp: 75-89.
19. Grégory Beaugr and Frédéric Ibanez, 2004. Monitoring marine plankton ecosystems. II: Long-term changes in North Sea calanoidcopepods in relation to hydro-climatic variability. Mar. Ecol. Prog. Ser., 284: 35-47.
20. Landry, M.R., 1978. Population dynamics and production of a planktonic marine copepod, Acartia clausi, in a small temperate lagoon on San Juan Island, Washington. International Review of Hydrobiology, 63: 77-119.
21. Johnson, J.K., 1980. Effects of temperature and salinity on production and hatching of dormant eggs of Acartia californiensis (Copepoda) in an Oregon estuary. Fish. Bull., 77: 567-584.
22. Raquel Jiménez-Melero, Barbara Santer and Francisco Guerrero, 2005. Embryonic and naupliar development of Eudiaptomus gracilis and Eudiaptomus graciloides at different temperatures: comments on individual variability. J. Plankton Res., 27: 1175-1187.

23. Dharani, G., 1998. Reproductive biology and culture of freshwater plankton Sinodiaptomus (Rhinediaptomus) indicus Kiefer (Calanoida: Copepoda). Ph. D Thesis submitted to the University of Madras.
24. Takahashi, T. and A. Ohno, 1996. The Temperature Effect on the Development of Calanoid Copepod, Acartia tsuensis, with some comments to Morphogenesis. J. Oceanography, 52: 125-137.
25. Hopkins, C.C.E., 1977. The relationship between maternal body size and clutch size, development time and egg mortality in Euchaeta norvegicai (Copepoda: Calanoida) from Loch Etiva, Scotland. J. Mar. Biol. Ass., 57: 723-733.
26. Mauchline, J., 1998. The Biology of Calanoid Copepods. Adv. Mar. Biol., 33: 1-710.
27. Altaff, K. and M.R. Chandran, 1994. Oviductal gland of planktonic copepod Helidiaptomus vidus (Gurney) a new report. Curr. Sci, 66(1): 81-83.
28. Vidal, J., 1980. Physico-ecology of zooplankton: Effects of phytoplankton concentration, temperature and body size on the growth rate of Calanus pacificus and Psudocalanus sp. Mar. Biol., 56: 111-134.
29. Corkett, C. and I.A. McLaren, 1969. Egg production and oil storage by the copepod psudocalanus in the laboratory. J. Exp. Mar. Biol. Ecol., 3(1): 90-105.
30. Runge, J.A., 1984. Egg production rates of Calanus finmarhicus in the sea of Nova Scotia. Arch. Hydro. Biol., 21: 33-40.
31. Vengadeshperumal, N., P. Damotharan, M. Rajkumar, P. Perumal, S. Vijayalakshmi and T. Balasubramanian, 2010. Laboratory Culture and Biochemical Characterization of the Calanoid Copepod, Acartia southwelli Sewell, 1914 and Acartia centrura Giesbrecht, 1889. Adv. Biol. Res., 4(2): 97-107.
32. McLarene, I.A., 1965. Some relationships between temperature and egg size, body size, development rate and fecundity of copepods, Psudocalanus. Limnology Ocenogaraphy, 10: 528-538.