



## *The Scientific Temper*

VOL-IX, NO.1&2; JANUARY-JULY, 2018

ISSN 0976 8653, E ISSN 2231 6396

UGC SR NO 2535; JR NO. 47226

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# **GROWTH AND REPRODUCTION OF *Daphnia carinata* IN LOW AND HIGH DENSITY CULTURE UNDER LABORATORY CONDITIONS**

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## **ABSTRACT**

The effect of population density on the *Daphnia carinata* individuals were investigated at two different densities with similar food medium. There is no difference in age at first reproduction, low-significant changes in carapace length and the number of neonates produced after 15 days to AFR, however, egg diapauses only visible in high density cultures. These findings suggest that high population density depresses both growth in adult instars and parthenogenesis to induce ephippial egg under enriched culture medium.

**Key words:** crowding effect, *Daphnia*, growth, reproduction, parthenogenesis

## **INTRODUCTION**

The cladocerans are thriving in freshwater ecosystem. The population dynamics of *Daphnia* under field study reveals a striking transition from a low density spring population with a large brood size to a high density summer population with frequent low egg production (Kerfoot et al, 1985). There past studies (Hebert, 1978; Burns, 1995) also concluded that small brood size in a high population was resulted with limited food supply. In laboratory conditions, a similar relationship has been observed

(Kleiven et al, 1992). However, some studies have been shown that growth and reproduction in daphniids to be affected by high population densities or by addition of water from crowded cultures, even under sufficient food concentrations. (Hebert, 1978; Burns, 1995).

There have been no studies on the effect of high population density on the growth and reproduction of cladocerans. In the present study, *Daphnia carinata* individuals were reared at two different densities in the laboratory to examine the

crowding effect on their growth and reproduction under enriched medium conditions. During the experimentation, parameters like somatic growth from hatching to adulthood, days of first reproduction and number of neonates produced by the individuals were monitored.

#### METHODS AND MATERIALS

*Daphnia carinata* clone was established by a single female isolated from the culture maintained in the zoology department laboratory with used water collected from nearby pond filtered through a glass-fibre filter. The stock cultures were maintained on *Scenedesmus spinosus* with  $>5 \times 10^5$  cells  $\text{ml}^{-1}$  at  $20^\circ\text{C}$  grown on the medium (Ichimura, 1971) at similar temperature. The cells from 7 day old culture were washed with filtered pond water and then cell concentration was calculated prior to addition in the experimental cultures.

The series of experiments for low and high population densities (1 and 20 individuals in  $50 \text{ ml}^{-1}$ ) respectively were made at  $20^\circ\text{C}$  temperature and 12 hour sunshine day within the range ((e.g. up to  $1000 \text{ indiv. l}^{-1}$ ) that can be observed in natural environments (Barker and Hebert, 1990) and have been used for laboratory studies (Urabe, 1988). In the low density experiment, a neonate born within a 24 hour period in the stock culture and 20 neonates for high density experiment of similar stock were placed in 50 ml jar with 50 ml filtered pond water with food alga at  $10^5$  cells  $\text{ml}^{-1}$  and  $5 \times 10^5$  cells  $\text{ml}^{-1}$  respectively. The lowest food concentration for maximum egg production can be maintained by *Daphnia* of 2-mm length is at about  $2.4 \times 10^4$  cells  $\text{ml}^{-1}$  of *Chlamydomonas* (Lampert and Schober, 1980).

The growth and reproduction of the cladocerans in both density cultures were monitored at 24 hour intervals. The animal was placed on a slide to measure carpace length with an optical micrometer attached to a microscope. The number of newly born neonates or ephippial eggs was also counted until 15 days after first reproduction and carpace length was measured over a period of 25 days. There are 20 and 10 replicates were used respectively for low and high density cultures.

#### RESULTS AND DISCUSSIONS

The animals about 7 days to mature in both conditions and no significant differences was observed in age at first reproduction (AFR) under the different density cultures (Table 1).

Table 1: Reproductive performance on 15 days AFR at each population density

Reproductive performance	Density Indiv. (50ml)-1		
	2	20	t- Value
AFR (days)	$8.15 \pm 1.01$	$8.72 \pm 1.25$	-1.45
Neonates (Female)-1	$69 \pm 11.40$	$30 \pm 6.30$	11.63
Ephippial eggs (Female)-1	NF	$1.0 \pm 0.10$	-

The similar body size in juveniles and AFR between the both densities suggests that growth and maturation of *Daphnia carinata* neonates are not affected by the population density in culture medium. The gross pattern of the increase in carpace length of the cladocerans was similar under both density conditions, however, the significant higher carpace length in high density than low density venue observed up to 10 days of period (t-test,  $p < 0.05$ ) (Figure 1).

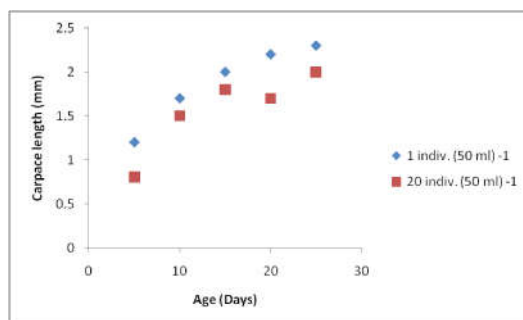
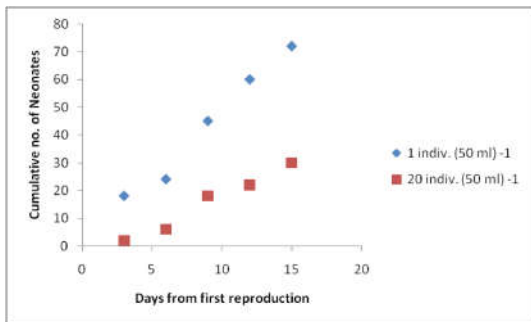
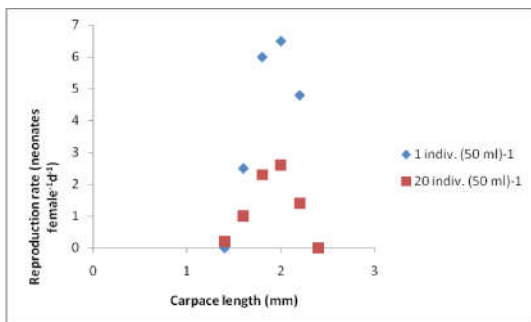


Figure 1: Carpace length of *Daphnia carinata* at culture densities.

The mean cumulative number of neonates increased with age and reached about  $72 \text{ indiv. female}^{-1}$  after 15 days in comparison of  $20 \text{ individual female}^{-1}$  under the high density condition (Table 1, Figure 2). Although smaller adults produced a small number of neonates and larger ones were more productive in both conditions, two to three fold more neonates were produced in low density compared to those produced by the same sized female in the high density experiment (Figure 3).



**Figure 2: Prediction after first reproduction and cladoceran population.**



**Figure 3: Carapace length and reproduction rate in cladoceran population.**

The ephippia were found only in the high density condition (Table 1) and cumulative numbers of ephippia produced during the 15 days varied among replicates ranged from 0 to 9. This high variability might affect the number of produced neonates with several protective membranes over brood chamber during production of ephippial eggs and probable hindrance in egg production.

## DISCUSSIONS

Urabe (1988) has been shown that growth and maturity in *Daphnia* to be affected by food concentration, but both cultures in this study would be under similar nutrition at least during the juvenile instars. Growth in the adult instars was slightly depressed in the high density condition even under excess quantity of food. This implies that the crowding effect on growth in *Daphnia carinata*

could ontogenetically changes and probably related to egg production.

The number of produced neonates by females with similar carapace length was lower in the high density culture. The reproductive rates of cladocerans are affected by temperature (Bottrell, 1975), food concentration (Urabe, 1988; Vijverberg, 1976) and population density (Barker and Hebert, 1990). There was no change in temperature and photoperiod, and the food concentration was sufficient. Therefore, high daphniid population density only has depressed the production of neonates. The past study as crowded *Daphnia pulex* at  $270 \text{ indiv l}^{-1}$  fed more slowly than at  $30 \text{ indiv l}^{-1}$  (Hebert, 1978) and similar study for 30 hours with reduced feeding (Lampert and Schober, 1980) suggesting that crowding might be able to change growth and reproductive patterns also reduce metabolic rate and/or assimilation efficiency in *Daphnia* resulted in reduced reproduction in the case of high population density.

There was weak correlation between the number of neonates and ephippia among replicates (Spearman's rank correlation test,  $\hat{A} = -0.45$ ,  $p = 0.08$ ) and thus the number of neonates would not have been significantly affected by ephippial egg production in the present study. Previous studies have implied combined density-dependent factors as starvation, limited food or short photoperiod with high population density (Matveev, 1993). The present study suggesting that *Daphnia carinata* individuals may produce diapause eggs in high density conditions even under enriched food medium and a normal photoperiod. The species-specific differences in daphniid response to population density may depend on their body size and small sized depends may be more sensitive in the same condition.

## ACKNOWLEDGEMENTS

I appreciate immense role of Dr Ashok Kumar (Ex-Dean, Jai Prakash University Chapra) for review of manuscript and instructions which were needful to shape this study and Principal, Vidya Bhawan Mahila Mahavidyalay, Siwan (Bihar) for kind support during research period.

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