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Fecundity in Relation to Different Types of Feed Composition in *Sinodiaptomus (Rhinediaptomus) indicus* (Copepoda : Calanoida)

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Laboratory experiments were conducted to study the effect of starvation and different food types (dry yeast, *Spirulina* powder and wild algae) on egg production in Sinodiaptomus (*Rhinediaptomus*) *indicus*. Studies to assess egg production in relation to varying feed combinations showed that highest percentage of females producing ovisacs with maximum number of eggs per ovisac were obtained in algae and algae + yeast feed combination. Yeast-fed females produced eggs with highest diameter. Wild ovigerous and laboratory starved females showed highest ovisac diameter. Results were statistically analysed and discussed in comparison with values obtained for natural population.

Key Words : **Fecundity, Tropical Copepod, Feed**

Introduction

Mass culture of plankton is gaining importance in aquaculture practices. Increasing attention is being focussed on this aspect as they form a vital link in the aquatic food chain. Planktonic copepods have high nutritive value because of their protein content (Rajendran 1973, Altaff & Chandran 1988, 1989), essential amino acids and PUFA (Kraul et al, 1991 and 1993) which greatly enhance their value as live feed in aquaculture.

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Studies on egg production in relation to varying environmental parameters in Calanoid copepods may help to assess their suitability for mass culture. The condition of the female, temperature and food are the most important factors influencing egg production. Temperature directly influences egg production (McLaren 1965, Corkett & Zillioux 1975, Saint - Jean & Pagano 1984, Williamson & Butler 1987).

Watras and Haney (1980) and Ianora and Dicarlo (1988) described the reproductive condition of female copepods as light (non-gravid) and dark (gravid) in relation to starvation and feeding. Egg production in relation to starvation, quality and quantity of food had been studied earlier (Aboudebs & Nival 1983. Hirche 1989, Ianora et al. 1989; Sheriff, 1991). Pandian (1994) has reviewed egg production in various groups of crustaceans including a few marine calanoids, but there is no report on egg production in tropical freshwater calanoid copepods.

Further, in contrast to numerous reports on the reproductive biology of temperate calanoid copepods, studies on tropical freshwater species are very meagre (Rangareddy & Devi 1985, 1989, 1990, Altaff 1990, Sheriff & Altaff 1993). *Sinodiaptomus (Rhinediaptomus) indicus* is a dominant zooplankton commonly occurring in the various freshwater bodies of South India. Considering its potential as live feed, an attempt is made to evaluate egg production in relation to different types of feed.

Materials and Methods

Sinodiaptomus (Rhinediaptomus) indicus was collected from the fish pond of the hydrobiological station at Chetput and Nanganallur pond, Madras. A part of the sample was narcotised immediately using 20% alcohol and preserved in 5% formaldehyde. The rest were transported to the laboratory in large bottles within an hour of collection. The live specimens were left in one litre glass bottles for a day to àcclimatize them to laboratory conditions.

Experiments were conducted to assess the egg production in *S. (R) indicus* in the natural medium, under conditions of starvation and when fed on different food items like algae from wild (Predominantly *Oscillatoria, Spirulina* and *Chlorella*, commercially prepared dry Spirulina powder and dry yeast (Baker's yeast granules) and combination of these three food media i.e. Spirulina + yeast, Spirulina + algae and algae + yeast (50% each by volume).

The ovigerous females from preserved specimens were separated, the ovisac was carefully detached from the urosome and its diameter was measured using micrometer and clutch size (number of eggs per ovisac) was also determined by counting the eggs. The diameter of the individual eggs, metasome length, width of corresponding female producing ovisac were also measured using micrometer.

Ten actively swimming adult males and females were introduced into the plankton chamber (150 ml) and maintained at the prevailing temperature (30 ± 2°C). No food was added. Daily observations were made to note the occurrence of ovisac. The experiment was followed for four days and repeated for six batches of ten males and females in each bach. Other observations with regard to ovisac and egg diameter, clutch size, metasome length and width were also recorded. The experiment was then repeated in a similar manner by adding excess of individual and mixed feed as already mentioned.

The recorded data were then subjected to statistical analysis. The Mean, Standard deviation and Ranges for ovisac diameter, clutch size and egg diameter were calculated. The one way analysis of variance was adopted to find if there was any significant difference between different food media with respect to number of eggs produced, ovisac and egg diameter. The Duncan's multiple range test was applied to find which food media was significantly different with regard to fecundity. The correlation technique was applied to find out if there was any association between the length of metasome and number of eggs and the volume of metasome and volume of ovisac. Student's T test was applied to find out any significant difference between the food media in relation to egg diameter.

Results

Egg production in *Sinodiaptomus (Rhinediaptomus) indicus* showed some interesting variations under different feeding regimes. Significantly high percentage of females produced ovisac when fed on algae (90%) followed by those fed on algae + yeast (83.3%), algae + *Spirulina* (66.7%), yeast (58.3%), yeast + *Spirulin* (53.3%) and *Spirulina* (51.7%). Among the starved females only 6.7% produced ovisac (table 1).

The mean diameter of the ovisac produced by the wild and starved females was significantly larger than that produced by those fed on algae + yeast (0.303 mm), algae (0.301 mm), algae + *Spirulina* (0.293 mm), yeast (0.29 mm) yeast + (*Spirulina*) (0.29 mm) and *Spirulina* (0.285 mm) in descending order (table 2).

Table 1 *Ovisac production in Sinodiaptomus (Rhinediaptomus) indicus in different food media*

Food medium	Total females (No.)	Females producing ovisac (No.)	Females producing ovisac(%)
Starved	60	4	6.66
Algae	60	54[abcde]	90
Yeast	60	35[a]	58.33
Spirulina	60	31[a]	51.66
Spirulina + Yeast	30	16[a]	53.33
Spirulina + Algae	30	20[a]	66.66
Yeast + Algae	30	25[abcd]	83.33

[a]Significant when compared with starvation
[b]significant when compared with Spirulina
[c]significant when compared with Spirulina + yeast
[d]significant when compared with yeast
[e]significant when compared with Spirulina + algae

Yeast fed animals produced eggs of significantly large mean diameter (0.158 mm) followed by those produced by wild females and algae fed females (0.093 mm). Females fed on *Spirulina, Spirulina* + algae and *Spirulina* + yeast produced eggs of smaller mean diameter (0.09 mm) while the starved females produced smallest eggs (mean diameter 0.88 mm) (table 2).

Mean clutch size of yeast + algae fed females was significantly high (10.36). Clutch size of females fed with other types of food showed a decreasing trend - algae + *Spirulina* (9.68), *Spirulina* + yeast (9.5), natural medium and starved (9.06), yeast (8.4) and *Spirulina* (7.58) (table 2).

Metasome length and egg number in females fed with yeast and yeast + algae was significantly correlated (at $P < 0.05$). There was no significant correlation in the remaining types of feed and also in the wild and starved females (table 3). Metasome volume and clutch volume showed significant correlation in the case of females fed with yeast and yeast + algae (at $P < 0.001$) while there was no significance in other types of feed (table 4).

Discussion

The significant difference in ovisac production in fed and starved females of *S. (R). indicus* may be attributed to the fact that feeding enhances the development of oocytes while starvation results in lower fecundity. Similar result had been reported

Table 2 *Ovisac diameter, Clutch size and Egg diameter in Sinodiaptomus (Rhinediaptomus) indicus in different food media*

Food medium	Ovisac diameter				Clutch size			Egg diameter			
	No. of observations	M (mm)	SD	R (mm)	M	SD	R	No. of observations	M (mm)	SD	R (mm)
Natural medium	30	0.311[eda]	0.033	0.369-0.241	9.06	1.36	12- 6	272	0.093[f]	0.021	0.113-0.071
Starved	4	0.311	0.033	0.369-0.241	9.06	1.36	12-6	27	0.088[f]	0.009	0.099-0.071
Algae	54	0.301	0.048	0.355-0.022	10.20	1.99	16-6	528	0.093[f]	0.008	0.113-0.071
Yeast	35	0.290[e]	0.024	0.369-0.025	8.40	1.74	12-6	296	0.158	0.235	0.994-0.085
Spirulina	31	0.285[e]	0.021	0.324-0.256	7.58	1.59	11-6	235	0.092[f]	0.008	0.113-0.071
Spirulina + Yeast	16	0.290	0.038	0.369-0.249	9.50	2.42	15-9	152	0.092[f]	0.007	0.113-0.085
Spirulina + Algae	19	0.293	0.025	0.369-0.269	9.68	1.41	12-5	184	0.092[f]	0.008	0.113-0.085
Algae + Yeast	25	0.303	0.035	0.361-0.256	10.36	1.80	14-6	259	0.090[f]	0.007	0.113-0.071

M, Mean; SD, Standard Deviation; R, Range

[a]significant when compared with algae; [b]significant when compared with Spirulina + yeast;
[c]significant when compared with Spirulina + algae; [d]significant when compared with yeast + algae;
[e]significant when compared with natural medium; [f]significant when compared with yeast;

Table 3 *Relationship between metasome length and clutch size in* ***Sinodiaptomus (Rhinediaptomus) indicus*** *in different food media*

Food medium	No. of observations	Metasome length			Clutch size		
		M	SD	R	M	SD	R
Natural medium	30	0.831	0.024	0.852-0.781	9.07	1.36	12-6
Starved	4	0.841	0.013	0.852-0.824	6.75	0.96	8-6
Algae	54	0.835	0.021	0.866-0.781	10.20	1.99	16-6
Yeast	35	0.828	0.022	0.852-0.781	8.43*	1.74	12-6
Spirulina	31	0.829	0.023	0.866-0.781	7.58	1.59	11-6
Spirulina + Yeast	16	0.825	0.021	0.852-0.781	9.50	2.42	15-6
Spirulina + Algae	19	0.830	0.019	0.852-0.781	9.68	1.42	12-7
Algae + Yeast	25	0.830	0.028	0.086-0.781	10.36*	1.80	14-8

M, Mean; SD, Standard Deviation; R, Range;
*Significant ($P < 0.01$) compared to metasome length

Table 4 *Relationship between metasome volume and clutch volume in* ***Sinodiaptomus (Rhinediaptomus) indicus*** *in different food media*

Food medium	No. of observations	Metasome volume			Clutch volume		
		M	SD	R	M	SD	R
Natural medium	30	0.044	0.008	0.059-0.027	0.016	0.005	0.026-0.007
Starved	4	0.051	0.004	0.054-0.046	0.009	0.002	0.012-0.006
Algae	54	0.049	0.009	0.046-0.030	0.015*	0.004	0.018-0.006
Yeast	35	0.046	0.007	0.059-0.032	0.013	0.004	0.026-0.008
Spirulina	31	0.046	0.008	0.059-0.031	0.012	0.003	0.017-0.008
Spirulina + Yeast	16	0.048	0.006	0.058-0.035	0.014	0.006	0.026-0.007
Spirulina + Algae	19	0.048	0.010	0.080-0.031	0.013	0.004	0.026-0.010
Algae + Yeast	25	0.045	0.008	0.054-0.031	0.015**	0.005	0.026-0.008

M, Mean; SD, Standard Deviation; R, Range

*Significant at ($P < 0.01$) compared to metasome volume, **Significant at ($P < 0.001$) compared to metasome volume earlier for *Pseudocalanus moultani* (Jonasdottir 1989). The availability or lack of food affected the development of ovary or gential tract in *Temora stylifera* (Razouls et al. 1986). Interestingly in crustaceans, interruption of food supply leads to regression of ovarian tissue while resumption of feeding renews ovarian development (Pandian 1994).

Very few starved females produced ovisac on the first day which suggests that oocytes must have completed their growth prior to starvation. The close similarity between diameter of ovisac and egg and clutch size of starved and wild females supports this inference. The other possibility is the utilization of reserve food material which is unlikely, as only a very small number of starved females produced ovisac. Continued starvation resulted in decreased clutch size, increased interclutch period and cessation of egg production. Similar observations were reported in *Calanus hyperboreus* (Conover 1967) and *C. glacialis* (Hirche 1989).]

Higher percentage of females producing ovisac when fed on algae compared to other types of feed may be due to familiarity of the food in its natural habitat as well as the good correlation between particle size and mouth size of the animal (Altaff & Chandran 1995). Occurrence of algae as suspension in the medium may also facilitate better utilisation of this food. Next to algae alone, algae + yeast combination showed higher percentage of females producing ovisac. Lower fecundity in yeast fed females may be due to its artificial nature, however the higher egg diameter obtained may be due to smaller particle size of this feed. Poor fecundity in *Spirulina* fed females may be the result of its dry nature and availability for feeding in the suspended state for a limited period of time. Higher fecundity in algae fed animals (under laboratory condition) is comparison to natural medium may be due to factors such as easier and greater availability of feed, consequent incorporation of nutrient precursors for reproduction and absence of predation and interspecific competition.

Hopkins (1977) studied correlation between prosome length and clutch size in *Euchaeta norvegica* and observed variations in egg production. This could perhaps be due to various environmental factors which may alter the relative number of eggs produced (Pandian 1994). Food is an important factor as is evident from the present study. Statistical analysis of correlation between metasome length and clutch size and metasome volume and clutch volume in *S. (R.) indicus* shows significance (at $P < 0.01$) for metasome length and at $P < 0.001$ for metasome volume for yeast, algae and algae + yeast fed animals.

The present study clearly indicates that in general, highest fecundity is obtained in algae, algae + yeast fed animals. The other types of feed like yeast, *Spirulina* (powder), *Spirulina* + yeast and *Spirulina* + algae are less effective from fecundity point of view. Thus algae, algae + yeast may serve as the most suitable feed for mass culture of this species. However, there may be varying degree of interaction between the nature of food, its availability, reproductive condition of the female and other environmental parameter producing a synergistic effect on egg production (Woodward & White 1981, Watras 1983, Jamieson & Burns 1988). Further studies on egg production with reference to mono and polyculture algae and different physicochemical factors may help in the mass culture of this species for its utilisation as a economical and protein rich live feed for commercially important fishes and prawn larvae.

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