PROCEEDINGS OF THE SYMPOSIUM ON COASTAL AQUACULTURE

Held at Cochin

From January 12 to 18, 1980

PART 4: CULTURE OF OTHER ORGANISMS, ENVIRONMENTAL STUDIES, TRAINING, EXTENSION AND LEGAL ASPECTS

(Issued in December 1986)

MARINE BIOLOGICAL ASSOCIATION OF INDIA

POST BOX NO. 1023, COCHIN-682 031, INDIA

Price : Rs. 400.00

SYMPOSIUM SERIES 6

Abbreviation

Proc. Symp. Coastal Aquaculture, Pt. 4.

PRINTED IN INDIA BY A. D. THOMAS STEPHEN AT THE DIOCESAN PRESS, MADRAS 7 AND PUBLISHED BY E. G. SILAS ON BEHALF OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, COCHIN-682 031

Proc. Symp. Coastal Aquaculture, 1986, **4**: 1275-1280

PRODUCTION OF COPEPODS IN AN OUTDOOR CULTURE TANK

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ABSTRACT

Production of copepods in a 3000 litre capacity outdoor mass culture tank has been studied by periodical sampling. The culture was maintained by fertilizing the filtered sea water using cowdung, groundnut oil cake, Super Phosphate and Urea in the ratio 80 : 10 : 1 : 1 to enhance the phytoplankton production and thereby that of the grazers. The change in the hydrological parameters due to evaporation, or dilution due to rain has been correlated to the trend in the production of the species belonging to the genera *Cyclops*, *Oithona* and *Pseudodiaptomus*.

The species *Pseudodiaptomus annandalei* Sewell, dominated in the culture system and reached its maximum density of 22,000 per litre at 28‰ salinity. The utilization of copepods, copepodites and nauplii in rearing crustacean and fish larvae has been discussed.

INTRODUCTION

COPEPODS serves as an important link in the marine food chain. The mass culture of these organisms assumes an added importance in intensive aquaculture practices involving rearing of larval stages of fishes and crustaceans. Much attention has been focused in recent years on culturing copepods under controlled conditions since they form an inevitable live feed for fish and crustacean larvae.

Various workers have attempted to mass culture different species of copepods. However, the technology for the mass culture and production of copepoda for aquaculture has not yet been established on a global basis. Most of the available work are limited to the studies on the life history and biology of copepoda. Jacobs (1961), Mullin and Brooks (1967) and Kahan (1979) report small scale experimental culture of copepods. Zillioux (1969) is the first to describe a continuous culture system for planktonic copepods using synthetic sea water in 100 l capacity tanks. While discussing the problems associated with the culture of marine copepods Gonzalez *et al.* (1972) opined that one of the major problems encountered in obtaining dependable cultures of copepods for laboratory studies appears to be that of finding a suitable medium. Using artificial sea water, the culture rarely exceeded 100 l capacity. Kitajima (1973) based on his experiments opined that the harpacticoid copepod *Tigriopus japanicus* is the most promising copepod for mass culture. The potentiality of the copepod *Nitocra spinipus* was pointed out by Abraham and Gopalan (1975) and Gopalan (1977). Goswami (1977) suggested that *Laophante setosa* can be easily reared and maintained since the adult can tolerate wide fluctuations in temperature and salinity. Ikeda (1973) indicated that small sized neritic or brackishwater copepods are easy to rear artificially as compared with those of large sized species in the open seas. Hirata *et al.* (1979) polycultured the rotifer *Brachionus plicatilis* and the harpacticoid copepod *Tigriopus japonicus* in 500 l capacity tanks using a feed back system.

Heinle (1970) was the first to study the population dynamics of exploited cultures of calanoid

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copepods. Based on the culture experiments on *Oithona* spp. Thompson and Easterson (1977) estimated the production of Oithonids in the estuarine wateis of Cochin for a period of one year. During the present investigation, the population characteristics of three species of copepods *viz. Pseudodiaptomus annandalei* Sewell *Oithona hebes* Giesbrecht and *Cyclops* sp. reared in 3000 litre capacity outdoor culture tank has been studied in relation to hydrological conditions. The production rate has been estimated for *P. annandalei.*

The authors are grateful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute, Cochin for his keen interest in this work and for constant encouragement.

Material and Methods

The culture was maintained in 3000 1 capacity out-door culture tank. The water was fertilized using cowdung, groundnut oil cake, Super Phosphate and urea in the ratio 30 : 10 : 1 : 1 to enhance the phytoplankton production and thereby the copepods. The water was continuously aerated. Weekly collections were obtained by stirring the water and an alliquot of 1 litre sample was collected during the months of May to August in the year 1979. The collections were preserved in 5% formaldehyde. The counts were made for the adults, copepodites and nauplii separately for the three species. Along with each sampling, measurements of salinity temperature and oxygen were also made.

The duration of development of *P. annandalei* was determined by maintaining a culture of gravid females under laboratory conditions. During this period they were fed with a mixed culture of phytoplankton. The time taken from hatching of the egg to the development of Copepodite-1 was taken as the duration for naupliar development and the duration from Copepodite-1 to the development of Copepodite VI (*i.e.* adult) was taken as the life span of copepodite stage.

Hydrological Features

The hydrological conditions in the culture tank were greatly influenced by evaporation in the sun or dilution due to rain (Fig. 1).

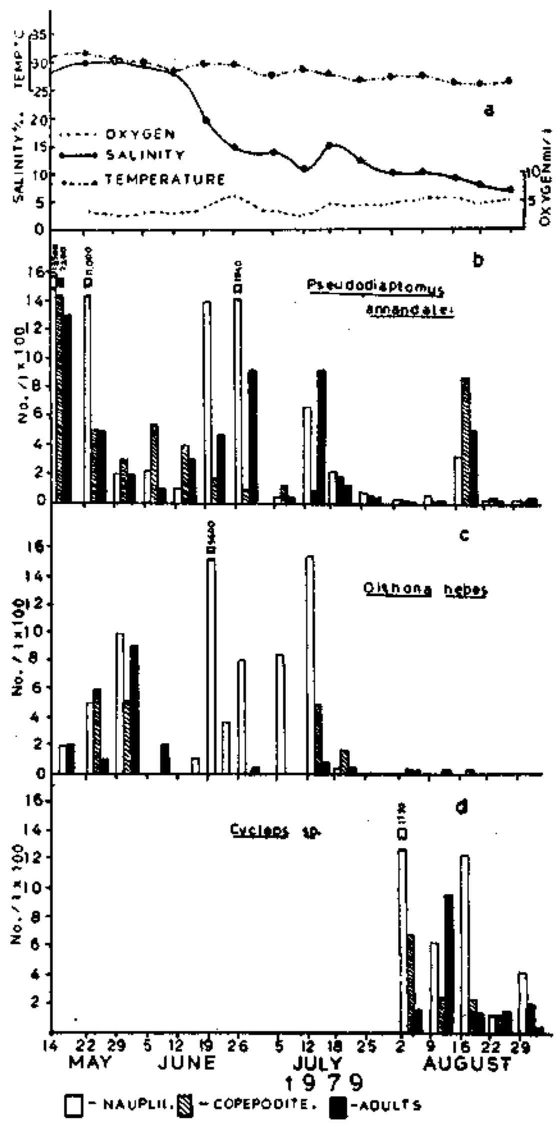

Fig. 1 a. Salinity (‰), Oxygen (ml/l) and Temperature (°C) in the mass culture tank ; b. Population density (No/l) of *Pseudodiaptomus annandelei* ; c. Population density (No/l) of *Oithona hebes* and d. Population density (No/l) of *Cyclops* sp.

The temperature of water varied from 26.1 to 31.0°C. A gradual decrease in temperature during the period of observation was mainly due to the onset of southwest monsoon. The salinity varied between 6.75 to 30.0/‰. The decrease of salinity was due to dilution by rain during the observation period. However, the salinity fluctuated and showed an upward trend due to evaporation during the middle of July. The dissolved oxygen varied between 2.6 to 5.7 ml/l. Though the increase in dissolved oxygen was mainly due to the bloom of phytoplankters, there was not much fluctuation since the culture was constantly aerated.

where B=number moulted per day; E= number of developing individuals of a particular stage per litre; and D=mean duration of development.

The instantaneous birth rate (b) was calculated using the formula:

$$b = ln\ (l + B) \qquad (2)$$

The instantaneous population growth rate (r) was calculated using the expression:

$$r = \frac{ln\ N_t - ln\ N_o}{T} \qquad (3)$$

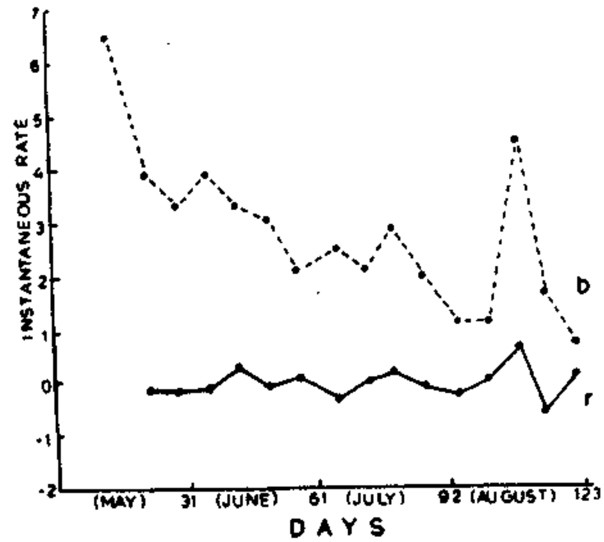

FIG. 2. Instantaneous birth rate (b) and population growth curve (r).

RESULTS AND DISCUSSION

Production of P. annandalei

To estimate the production of *P. annandalei*, the model proposed by Edmondson (1960, 1971) and applied by Thompson and Easterson (1977) has been followed in principle. The natality of the copepods was calculated by using the formula:

$$B = \frac{E}{C} \qquad (1)$$

where N_o=initial population size; N_t=the size of the population in the following sample; and T=the time interval in between the sampling.

The instantaneous mortality rate (d) was calculated by the expression:

$$d = b - r \qquad (4)$$

The production of copepods (P) was calculated from the natality rate for the said period

TABLE 1. *Calculated production of* Pseudodiaptomus annandalei *during the months of May-August in* 1979

Date	Nauplii (No./l)	Days*	Natality of Copepodites (No./l/day)	Copepodites (No./l)	Days*	Copepods (No./l)	Natality of Copepods (No./l/day)	Instantaneous birth rate	Population growth	Mortality	Production (No./l)	
				E	D	N	B	b	r	d	Pno	Pno/l/day
14-5-1979	13,500	7	1,929	7,200	11	1,300	655	6.49	—	—	—	—
22-5-1979	11,000	7	1,571	500	11	500	46	3.85	—0.12	—3.97	5,48,100	68,513
29-5-1979	200	7	29	300	11	200	27	3.33	—0.13	—3.46	6,650	950
5-6-1979	220	7	31	550	11	100	50	3.93	—0.10	—4.03	3,450	493
12-6-1979	100	7	14	400	11	300	36	3.31	+0.30	+3.01	2,800	400
19-6-1979	1,400	7	200	160	11	480	15	2.77	—0.08	—2.85	8,190	1,170
26-6-1979	1,840	7	263	80	11	920	7	2.08	+0.09	+1.99	5,600	800
5-7-1979	40	7	6	120	11	40	11	2.48	—0.35	—3.83	1,920	213
12-7-1979	760	7	109	80	11	44	7	2.08	+0.01	+2.07	168	24
18-7-1979	320	7	46	180	11	120	16	2.83	+0.17	+2.66	738	123
25-7-1979	80	7	11	60	11	40	6	1.95	—0.16	—2.11	800	114
2-8-1979	30	7	4	18	11	6	2	1.09	—0.24	—1.33	92	12
9-8-1979	58	7	8	17	11	6	2	1.09	0.00	+1.09	12	2
16-8-1979	315	7	45	870	11	501	79	4.38	+0.63	+3.75	19,520	2,789
22-8-1979	20	7	3	40	11	12	4	1.61	—0.62	—2.23	19,238	3,206
29-8-1979	20	7	3	10	11	26	1	0.69	+0.11	+0.58	114	16

* Duration of development.

(t) using the equation proposed by Galkovskaya (1971):

$$P=B_t \tfrac{1}{2}(N_o+N_t) \qquad (5)$$

The calculated daily production of *P. annandalei* has been given in Table 1.

The instantaneous birth rate curve (b) shows wide fluctuations and is always positive (Fig. 2). However, there is a gradual decrease from 6.49 to 0.69 during the period of observation. The population growth curve (r) is more negative and is almost parallel with the

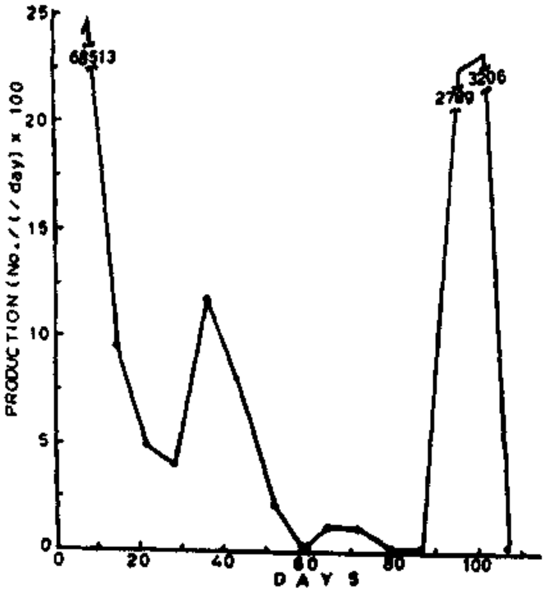

FIG. 3. Production of *P. annandalei* (No/l/day).

instantaneous birth rate from June onwards. This evidences constant mortality operating in the culture system. This may also be related to the hydrological condition of the culture system wherein the salinity decreased with the onset of southwest monsoon. The population growth curve without violent fluctuations shows high order of stability during the period of observation.

The mean daily production for *P. annandalei* varied between 68,513 to 2/litre (Fig. 3). The production decreased with the decrease in salinity. The fluctuations in *P. annandalei* population is not due to lack of food. As it was a closed culture system the water was regularly fertilized for stimulating phytoplankton bloom. There was not much change in the temperature, though there was a decrease with the onset of southwest monsoon. The *P. annandalei* population peak coincided with the period of dilution and recovery of the culture medium and as such salinity acted as the controlling factor.

With the decrease in salinity from 15‰ onwards the *Oithona hebes* population also decreased and the disappearance of this species in the culture tank was noted when the salinity decreased below 9.93‰. The appearance of the copepod *Cyclops sp.* coincide with the decrease of salinity in the culture medium and reached its maximum abundance at 9.93‰. The population succession in the culture tank was mainly due to the change in the salinity.

Lebour (1919 a, b) reported copepods as the most common food of nearly all very young fishes and Blaxter (1965) concurred. Larvae of Atlantic herring *Clupea harengus* reared in the laboratory, selected copepod nauplii and copepodites as food (Rosenthal, 1969). Blaxter (1969) implied that copepod nauplii were the food of laboratory reared pilchard, *Sardina pilchardus* larvae, based upon an examination of the composition of wild plankton offered as food and from the analyses of stomach contents of larvae collected at sea. Detwyler and Houde (1970) also found that copepod nauplii and copepodites were suitable as food for larval and adult fishes. Hirata (1977) cultivated zooplankton for fundamental research as well as for prawn seed production. Yamasaki (1977) personal communication opined that Harpacticoid copepod *Tisbe sp.*, showed potential as a substitute to *Artemia* or *Brachionus* which is used as food for fin fish and crustaceans secondary to *Artemia*.

Because copepods are universally accepted as food by fin fishes and crustaceans, development technique for mass culture of these organisms would greatly benefit rearing of larval fish.

References

Abraham, S. and U. K. Gopalan 1975. Growth of an estuarine harpacticoid copepod *Nitocra spinipes* Boeck cultured in the laboratory. *Bull. Dept. Mar. Sci. Univ. Cochin*, **7** : 309-318.

Blaxter, J. H. S. 1965. The feeding of herring larvae and their ecology in relation to feeding. *Rep. Calif. food Oceanic Fish Invest.*, **10** : 79-88.

——— 1969. Rearing herring larvae to metamorphosis and beyond. *J. Mar. Biol. Ass. U.K.*, **48** : 17-28.

Detwyler, R. and E. D. Houde 1970. Food selection by laboratory reared larvae of the scaled sardine *Herengula pensacolae* (Pisces, Clupeidae) and the bay anchovy *Anchoa mitchilli* (Pisces, Engraulidae). *Mar. Biol.*, **17** : 214-222.

Edmondson, W. T. 1960. Reproductive rates of rotifers in natural populations. *Mem. Inst. Ital. Idrobiol.*, **12** : 21-77.

——— 1971. Reproductive rate determined indirectly from egg ratio. *In* : Edmondson W. T. and Winberg G. G. (Eds.) *A manual on methods for the assessment of secondary productivity in fresh waters.* Blaskwell, Oxford pp. 165-169.

Golkovskaya, G. A. 1971. The production of planktonic rotatoria. *In* : Winberg. G. G. (Ed.) Anne Duncan (Trsl.). *Methods for the estimation of production of aquatic animals.* Academic press, London, pp. 123-128.

Gonzalez, J. G., P. P. Yevich, J. H. Gentile and N. F. Lackie 19v2. Problems associated with culture of marine copepods. *Culture of Marine Invertebrate Animals.* Smith, Walter L. and M. H. Charley, N. Y., pp. 199-207.

Gopalan, U. K. 1977. Experimental mass culture of a Harpacticoid copepod *Nitocra spinipes* Boeck. *Proc. Symp. Warm water Zoopl. Spl. Publ.* UNESCO/NIO ; pp. 558-562.

Goswami, S. C. 1977. Laboratory culture of a Harpacticoid copepod *Laophonte setosa* (Boeck). *Ibid.*, pp. 563-570.

Hirata, H. 1977. Zooplankton cultivation and prawn seed production in an artificial ecosystem. *Helgolander wiss. Meeresunters*, **30** : 230-242.

———, S. Yamasaki, S. Kodowaki, I. Hirata, and K. Mae 1979. Marine Zooplankton culture in a feed back system. *European Mariculture Society, Special Publication*, **4** : 377-388.

Ikeda, T. 1973. On the criteria to select copepod species for mass culture. *Bull. Plankton Soc. Japan*, **20** (1) : 41-46.

Jacobs, J. 1961. Laboratory cultivation of the marine copepod *Pseudodiaptomus caronatus* Williams. *Limnol. Oceanogr.*, **6** : 443-446.

Kahan, D. 1979. Vegetables as food for marine harpacticoid copepods. *Aquaculture*, **16** : 345-350.

Ketajima, C. 1973. Experimental trials on mass culture of copepods. *Bull. Plankton Soc., Japan*, **20** : 54-60.

Lebour, M. V. 1919 a. Feeding habits of some young fish. *J. Mar. Biol. Ass. U.K.*, **12** : 9-21.

——— 1919 b. The food of post-larval fishes No. 2 (1918). *Ibid.*, : 261-324.

Mullin, M. M. and E. R. Brooks, 1967. Laboratory culture, growth rate, and feeding behaviour of a planktonic marine copepod. *Limnol. Oceanogr.*, **12** : 657-666.

Thompson Martin, P. K. and D. C. V. Easterson 1977. Dynamics of cyclopoid copepod population in a tropical estuary. *Proc. Symp. Warm water zoopl. Spl. Publ.* UNESCO/NIO, pp. 486-496.

Yamasaki, S. 1977. A preliminary study of some factors involved in mass culture of the Harpacticoid copepod *Tisbe* sp., and evaluation of the copepod's effectivity as food for milk fish fry. *Unpub. MS.* (Personal communication).

Zillioux, E. J. 1969. A continuous recirculation culture medium for planktonic copepods. *Mar. Biol.*, **4** : 215-218.