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THE EFFECTS OF FOOD ON GROWTH, LIFE SPAN AND REPRODUCTION OF A CLADOCERAN ZOOPLANKTER, *CERIODAPHNIA CORNUTA* (SARS).

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ABSTRACT

The effects of food concentration on the growth, brood size, fecundity and life span of a cladoceran zooplankter, *Ceriodaphnia cornuta* (Sars) have been studied under ordinary laboratory conditions (temperature 25 ± 3° C). Six different food regimes ranging from distilled water to highly enriched medium were tested. Starvation affected considerably and animals could not survive for more than 24 hours. The molting, instar duration, growth and reproductive rates were lowered and life span shortened in diluted medium. The growth and reproductive rates were the highest in the medium containing moderate quantity of food and not much differences were noticed in these parameters with very high food level.

INTRODUCTION

Enormous amount of literature is available on the effects of food quality and quantity on various parameters affecting life and behaviour of daphnids both, in laboratory and under natural conditions from temperate regions (Ingle *et al.* 1937, Banta *et al.* 1939, Ryther 1954, Richman 1958, Regler 1961, Hall 1964, Hall *et al.* 1970, Buikema 1973, Vijverberg 1976). At the same time, there is an apparant lack of information on this subject from tropical regions, specially from India.

The present paper reports the results of laboratory studies carried out on the effects of food on instar duration, growth rate, survival, life span, reproductive rate and fecundity of an important cladoceran zooplankter, *Ceriodaphnia cornuta* (Sars). This species occurs abundantly in the ponds of this region and contributes significantly to the total cladoceran population.

MATERIALS AND METHODS

All experiments were carried out under laboratory conditions (temperature 25 ± 3° C). Stock culture of *C. cornuta* was maintained in laboratory in large enamel bowls. In order to avoid any genetic differences, the entire culture was raised gradually from a single parthenogenetic female obtained from nature, so that all animals belonged to the same clone. Details of culture procedure of cladocera have been described in a separate communication (Khan 1983). Culture was maintained in water collected from a near by pond (Monohar Das pond) and filtered through

No. 25 bolting cloth net so as to remove all zooplankton but allow all algae, protozoa, bacteria and detritus to pass through.

Water was changed thrice a week. Overcrowding was never allowed and when number of individuals increased in a bowl, they were removed and put in another bowl.

To study the effects of food quantity, the following 6 food regimes were tested, following Vijverberg (1976) with some modifications :

Food regime I. Pond water filtered through No. 25 bolting cloth plankton net. Only zooplankton and larger particles were removed but protozoa, algae and detritus remained. This will be referred to as pond water.

Food regime II. The water of food regime I filtered through 0.6 μ filter paper.

Food regime III. Pond water (Food regime I) with additional 100 algal cell/ml.

Food regime IV. Pond water with additional 1000 algal cell/ml.

Food regime V. Pond water with additional 10,000 algal cell/ml.

Food regime VI. Double distilled water.

Since algal culture was not possible in the laboratory, algae were collected from Monohar Das pond in the following manner. Care was taken, while collecting, to avoid the bloom of blue green algae as far as possible. A large quantity of pond water was filtered through 0.6 μ filter paper (as for food regime II). The algae collected on filter paper were washed in a small quantity of water and their concentration (cells/ml) was determined as for general phytoplankton counting. Then calculated volumes of algal concentration was added with the help of a wide mouth pipette to various petri dishes according to the quantity of water present and food level desired. Though this was a crude substitute of pure algal culture, for comparative effects of different food concentrations this gave satisfactory results.

Experiments were conducted by placing newly emerged neonates in small petri dishes containing 80 ml of test media. Examination of petri dishes was done daily and observations on molting, size increase, number of young ones produced etc. were recorded. Test medium was also changed at the time of examination. At least 10 replicates for each test medium were maintained at a time. The entire experiment was repeated three times and means were calculated. Statistical analysis was carried out following Bailey (1959).

Results

Growth

The effects of food concentration on growth rate was assessed by comparing the size attained by animals grown in different food regimes. In ordinary pond water (Food regime I), the animals were found to pass through 18 instars (3 preadults and 15 adults) and attained a mean length of 0.70 mm in the total life span of 20 days (Table 1).

In food regime VI (distilled water), animals could not survive for more than 24 hours (mean 20.5 hours) and therefore no comparison could be made with others.

TABLE 1. Number of instars, mean size and life span of *C. cornuta* in different food regimes

Parameters	Food regime I	Food regime II	Food regime III	Food regime IV	Food regime V	Food regime VI
Mean maximum length (mm)	0.70	0.57	0.72	0.77	0.76	0.21
Mean life span (days)	20	14	20	22	23	1
Number of Instars						
a— preadult	3	5	3	3	3	—
b— adult	15	8	15	18	19	—

In food regime II (filtered through 0.6 μ filter paper), the growth and molting was considerably delayed than in food regime I or any other level studied. Though the animals were able to survive upto the age of 14 days, only 13 moltings (Table 1) took place and final length attained at the end of life was 0.57 mm, as compared to 0.70 mm in food regime I.

regime I and III. However, considerable differences were evident in the growth of animals in food regimes III and IV, but not much differences could be detected between regimes IV and V. In fact the mean growth rate and maximum size attained by the animals in food regime V were slightly lower than the animals in regime IV. The differences in the lengths of animals of same age

TABLE 2. Significance test of the differences in length and brood size of *C. cornuta* grown under different food regimes

Source	Length			Brood size		
	D.F.	't' value	Probability	D.F.	't' value	Probability
Food regimes I and II	19	9.11	less than 0.001	19	8.50	less than 0.001
Food regimes II and III	19	1.81	more than 0.005	19	1.70	more than 0.005
Food regimes III and IV	19	6.82	less than 0.001	19	6.50	less than 0.001
Food regimes IV and V	19	2.01	more than 0.005	19	1.89	more than 0.005

From Figure 1 it is evident that the size of individuals increased with increasing food concentrations. Whereas, the growth rate in food regime II was lower than food regime I, very little variation existed between food

but of different food regimes were statistically tested by 't' test (Table 2). Differences were significant at 1% level between food regimes I and II, III and IV, while values between I and III, IV and V were not significant.

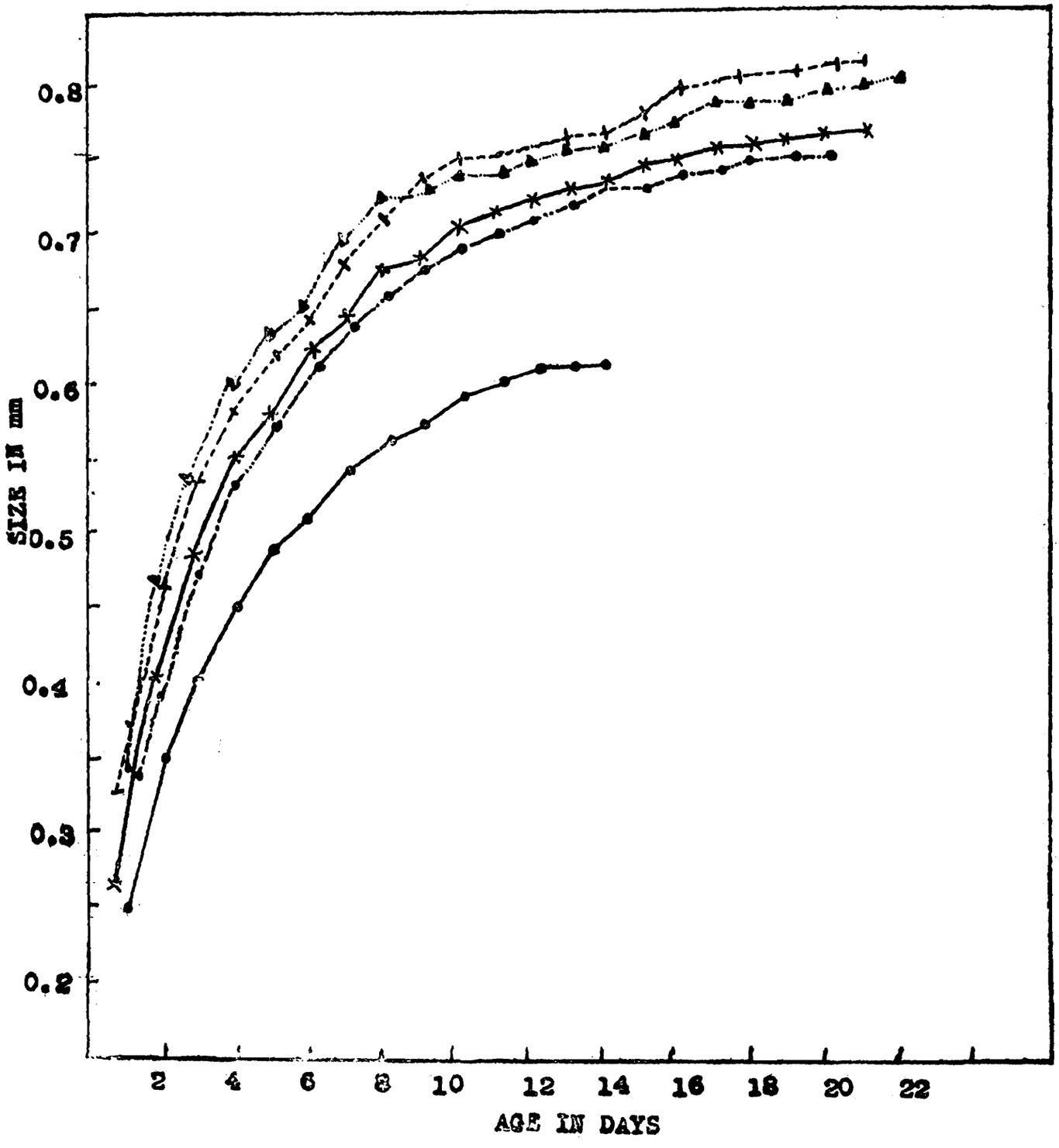

Fig. 1. Relationship between size and age at different food regimes.

Reproduction

The effects of food quantity on brood size (egg/brood) in relation to length is shown in Figure 2. In all the sets of experiments, the brood size increased gradually with increasing size upto certain point after which it either decreased or remained constant. In normal pond water (Food regime I), the brood size varied between 2.2, produced by the 4th instar females, to 10.0 produced by the 16th instar females (Table 1).

In food regime II, the egg production was low and the maximum bood size observed was 4 in the largest (0.57 mm) and the oldest (14 days) female. The tests of significance in different food regimes gave similar results as for the effects on growth (Table 2).

The differences were more striking,

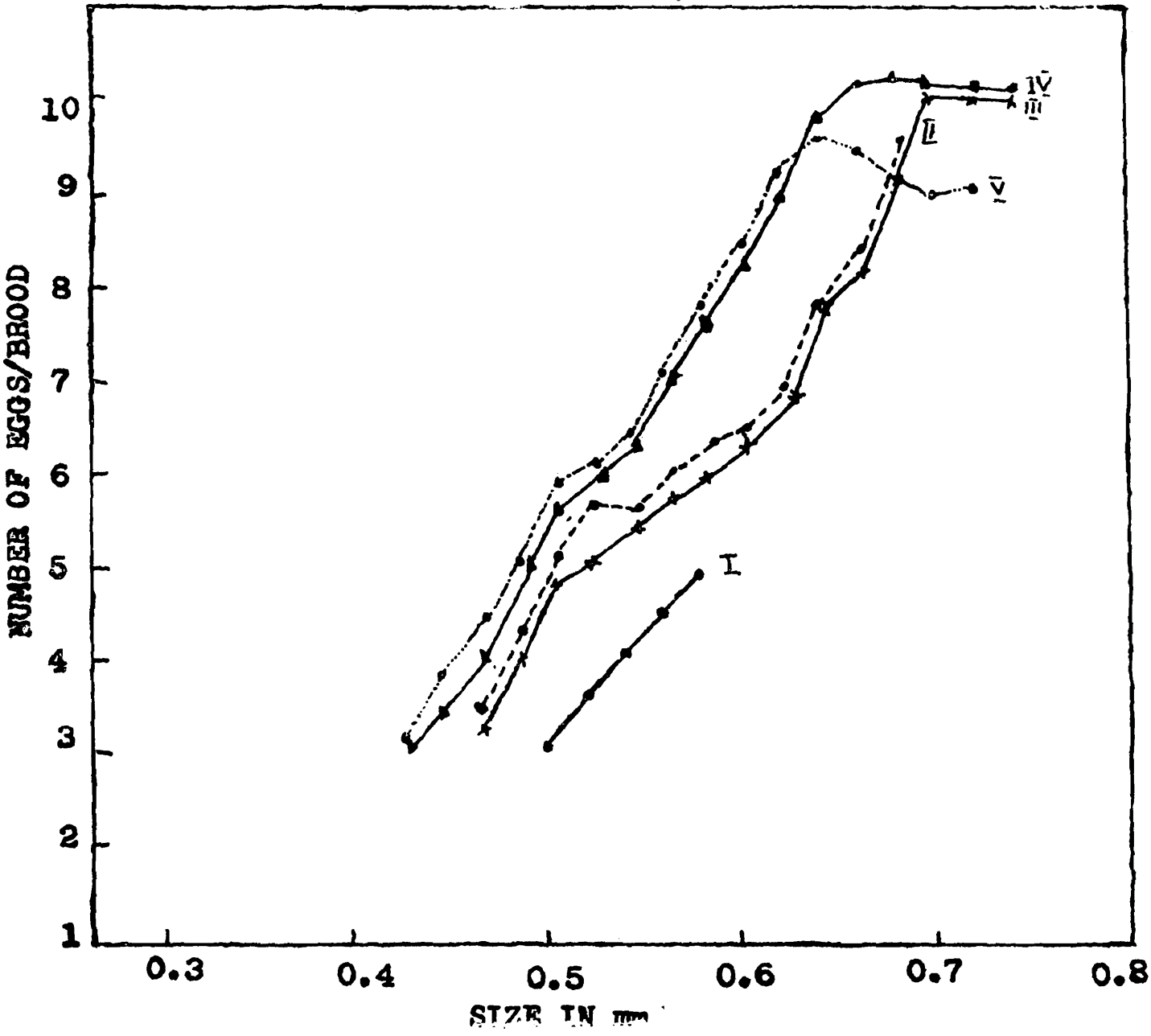

Fig. 2. Relationship between size and brood size at different food regimes.

when the total egg produced by a female in the life span was compared. Fecundity increased with increasing food concentrations. The fecundity of animals in food regime II was very low as compared to other food regimes (Figure 3).

Physiological Longivity

The mean total life span of individuals grown in diffenent food regimes differred (Table 1). Like all other parameters, the total life span of the animals in food regime II was only 14 days as compared to 20 days in food regime I. Highest life span was observed in the animals of food regimes V.

Discussion

The effect of food on size, reproductive rate and life span was essentially similar to those reported by other workers (Brooks 1946, Ingle *et al.* 1937, Ryther 1954, Green 1956, Vijverberg 1976) in the respect that these increased with increasing food levels. Complete starvation was fatal to animals and

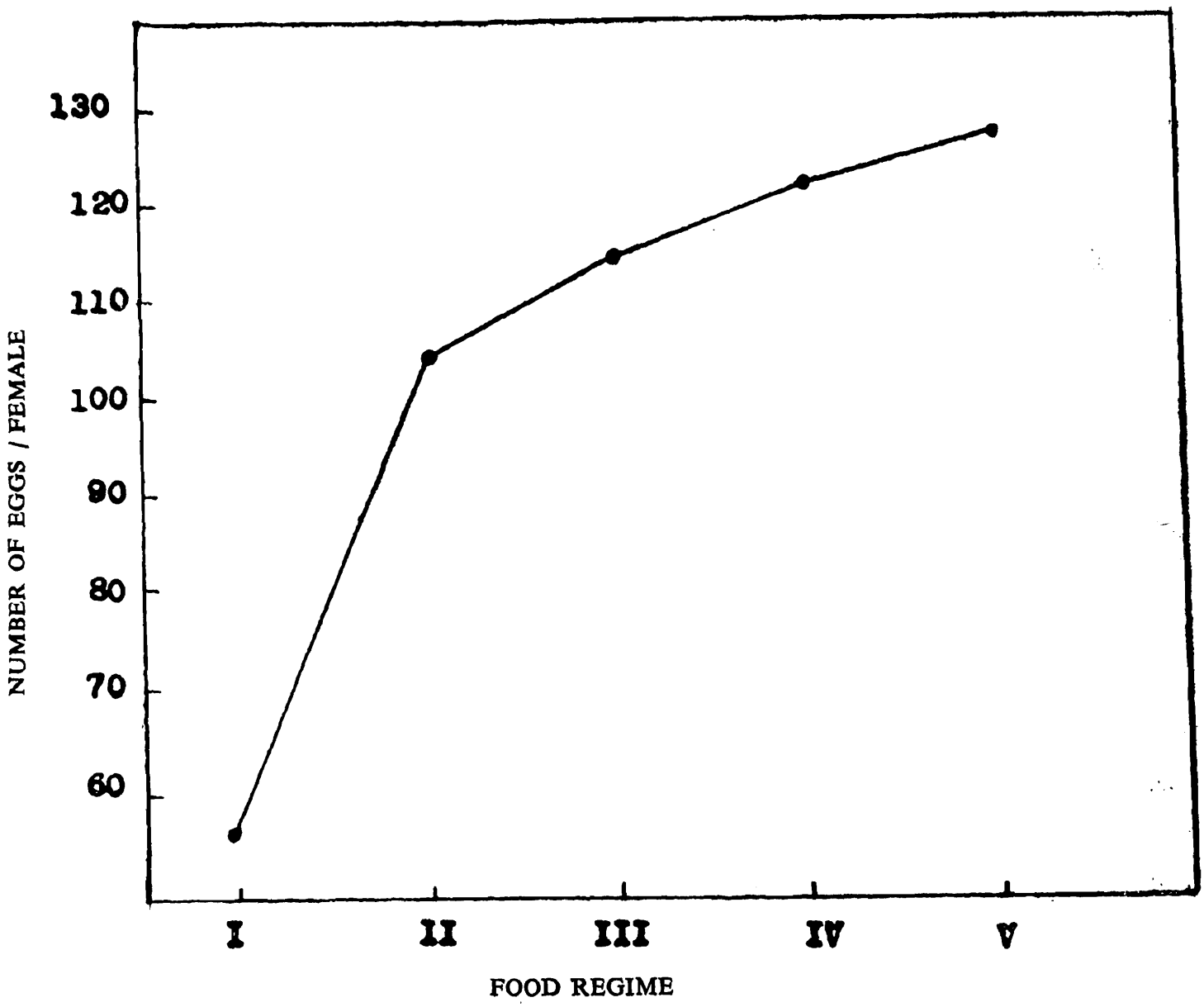

Fig. 3. Total number of eggs produced by a female at different food regimes.

they could not servive after 24 hours. These results support the observations of Dehn (1930) who found that *Daphnia magna* could not survive for more than 12 hours in bacteriologically filtered water. However this is contrary to the observations reported by Staurt *et al.* (1931) in case of *Moina macropa* which could survive for four days in distilled water.

The conditions in food regime II, which was filtered through 0.6 μ filter paper were unique, neither completely devoid of food nor with sufficient food and probably represented a dilute medium. Many smaller organic particles can pass through filter paper. Some species of daphnids have been found to grow and reproduce, though in a restricted way, in such media (Gellis and Clarke 1935, Vijverberg 1976).

The insignificant differences between growth and reproductive rates of animals in food regime I and III, where the difference was only additional 100 cells/ml, was probably due to the very little amount of extra food.

The significant difference in life parameters of the animals in food regime III and IV, where the quantity of extra food added was 10 times, revealed that a moderate supply of food could be favourable. However, the insignificant differences in the growth and reproductive rates and life span of animals in food regime IV and V showed that very high concentrations of food did not necessarily result in the enormous increase in the growth or reproductive potential of the animals. Hall (1964) also found no effect on the longivity of *Daphnia galeata mendotae* when the food was over 64 fold range. Vijverberg (1976) also found insignificant differences in the growth rate of *Daphnia hyalina* at very high food concentrations.

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