Zooplankton of the pond Moat

Zooplankton form the next higher trophic level after the phytoplankton, the primary producers of organic matter, and are their immediate consumers (Ruttner, 1963). In a lake or pond, a close relationship therefore exists between the two communities (Hardy and Gunther, 1935; Pennington, 1941; Anderson, Comita and Engstrom-Heg, 1955; Comita and Anderson, 1959 and Edmondson, 1962). The study of the zooplankton community, is accordingly important in the understanding of the secondary production in lakes and ponds. From the point of view of fisheries biology, they are more so important in being the major food of many economically important fishes.

Limnological investigations on the zooplankton of the temperate lakes are many and cover almost every aspect of their life (Coker, 1933; Pennak, 1944, 1955, 1957; Aycock, 1942; Hoshi, 1949, 1957 a; Baldi, Cavalli, Pirocchi and Tonolli, 1949; Comita and Edmondson, 1953; Ravera, 1954; Elster, 1954; Slobodkin, 1954, 1959; Edmondson, 1955; Comita, 1956; Eichhorn; 1957 and Edmondson, 1960 etc.). Literature on the zooplankton of Indian waters in comparison is very meagre (Upadhaya, 1963, 1964; Sreenivasan, 1964; Sarkar and Rai, 1964; Chacko and Krishnamurthy, 1954; Kiefer, 1939; Brehm, 1953; Sehgal, 1966; Edmondson, 1934; Hater, 1937; Arora, 1962, 1963). The present investigations were, therefore, undertaken to evaluate the dynamics of the zooplankton populations in the ponds.

Methods:

Samples were collected from open areas of the ponds by filtering 10 litres of water with a 270-mesh sieve (pore size 30 u). The individuals in 1 ml. of the concentrate were counted in a Sedgewick-Rafter counting cell. The results obtained were subsequently converted in terms of numbers/L. Identifications of the species were made by referring to standard works (Ward and Whipple, 1963; Kiefer, 1939; Brehm, 1953; etc).Nauplier and Copepodid stages were identified with the help of the works of Rylov (1963) and Comita and Tommordahl (1960). As the ponds water mix regularly, the vertical population distribution is supposed to be uniform (Hutner, 1963) and the samples taken are good representatives of the standing population.

List of the zooplankton species in the ponds:

PROTOZOA:

Diffugia species, *Diffugia corona*, *Arcella* species, *Verticella* species.

ROTIFERA:

Platyias species, *Monostyla* species, *Polyarthra remata*, *Filinia* species, *Brachionus falcatus*, *Brachionus calyciflorus*.

Pallas, *Keratella tropica*.

CLADOCERAN:

Daphnia species.

CALANOIDA:

Heliodiaptomus viduus Gurney.

CYCLOPOIDA:

Thermocyclops hyalinus (Rehberg).

Zooplankton populations in the ponds:

The results of the observation on the seasonal changes in the zooplankton population in the ponds, are illustrated in Figure 1. It would appear that the pattern of seasonal variation of the population in all the ponds is uniform and is bimodal (from the monsoon of 1964 to monsoon of 1965). The first period of increase extends from September, 1964 to October, 1964 and the second from March, 1965 to July, 1965. The populations are observed to decline in the winter months of January and February (Fig.1). Maximum productivity is obtained in the months of May and June, 1965.

Chau Tal is found to support the largest zooplankton population among all the four ponds while in the ponds Achal Tal and Noomaish Tal, the populations are smaller. In the pond Moat, the population abundance occupies an intermediate position. Phytoplankton productivity of the four ponds is also similar

(Chapter V).

Seasonal changes in zooplankton populations in the ponds follow closely the changes in phytoplankton in the ponds (Figs. 1 and 2) which shows that besides many other factors (Hazelwood and Parker, 1961) food supply has an important bearing on the zooplankton production in the ponds. This has also been observed in other investigations (Hardy and Gunther , 1935; Pennington, 1941 and Comita and Anderson, 1959). The greater summer populations of the ponds are most likely supported by the phytoflagellates which are abundant in the summer months (Ruttner, 1963).

Composition of the zooplankton of the pond Moat:

Seasonal changes observed in the zooplankton composition of the pond Moat, are illustrated in Figure 1. The two dominant groups are the rotifers and Cyclopoida. The rotifer group is composed of three species -- *Brachionus calyciflorus* Pallas, *Brachionus falcatus* and *Keratella valga* var. tropica while the Cyclopoida is represented by only one species -- *Thermocyclops hyalinus* (Rehberg). The cyclopoid population, is abundant in all the seasons, except in the months of October, 1964, March and June, 1965 when the rotifers as a group are more abundant (Fig. 1). By species composition, *Thermocyclops hyalinus* (Rehberg) is the predominant zooplankton of the pond. Daphnia and *Heliodiaptomus viduus* Gurney, form only a minor part of the zooplankton. The former is comparatively abundant in the months of March, June and August (Fig. 1) while the latter is found to be present in maximum numbers in the monsoon season -- from July to September. Similar was the zooplankton composition in other ponds.

The composition of the zooplankton community in the ponds is much different than that met with in big lakes (Pennak, 1957)and the insignificance of the Diaptomids among the zooplankton is another peculiarity of the ponds.

Rotifer populations in the ponds: Results of observations on the four abundant species in the pond Moat, three major species -- *Brachionus calyciflorus* Pallas, *Brachionus falcatus* and *Keratella valga* var. tropica and one minor species, Asplanchana sps., are illustrated in Fig. 2. The figure also shows the relation of the changes in individual populations to the changes in the phytoplankton of the pond and its surface water temperature.

The pattern of change in all the species is bimodal (from monsoon of 1964 to monsoon of 1965). In case of the species *Brachionus calyciflorus* and *Brachionus falcatus*, the first period of abundance is from October to November, 1964 while the first increase in the population of the species *Keratella valga* var. tropica, occurs in the months of November and December, 1964. The second period of abundance of all the species extends from April to June, 1966 (Fig. 2). The species *Brachionus calyciflorus* shows the maximum numbers in individual samplings but the population of the species *Brachionus falcatus* is more stable and extends for a longer period. Asplanchana sps. also occured in fairly good numbers and is found to increase before there occurs the abundance of other species (Fig. 2).

The periods of abundance of the species,-- *Brachionus calyciflorus* and *Brachionus falcatus*, coincide with the algal increases in the pond (Fig. 2) and correlation between their numbers and that of the phytoplankton crop (as H.P.U./L) is found to be significant (*Brachionus calyciflorus* and phytoplankton, $n = 26$, $r = 0.35$, $P = 0.1$; B. *falcatus* and phytoplankton, $n = 26$, $r = 0.391$, $P > .05$). The same is, however, not true for the population of the species *K. valga* var tropica ($n = 26$, $r = 0.26$, $P > .1$). The maximum abundance is observed in between the temperature range 20° to $30^{\circ}C$ and there is a marked susceptibility to the lower temperature ranges (Fig. 2).

The first abundance in the population of the rotifer *K. tropica* occurs with the decline in the population of the other two species (Fig. 2). The reasons of this are not very clear but it seems likely that this is due to competition for space and food. This species is also more tolerant to lower temperatures than the other two species (Fig. 2) and is able to build a stable population soon after their decline.

The numbers of the eggs of the three species, observed in the samples in the various months were also counted and the results of the countings are illustrated in Fig. 2. The difference in the shape of the eggs of the two Brachionus species made the identifications easy. Useful informations on the reproductive potential of the rotifer populations have been derived from these observations (Edmondson, 1960). In the present investigations, the maximum egg ratio (eggs/female, Edmondson, 1960) in the populations of the species Brachionus and Brachionus falcatus are observed in the months of September, 1964 and April, 1966, whereafter a major increase in their population is observed. In Keratella valga var. tropica, the ratio is maximum in October, 1964 and April, 1966, the former time being different from that of other two species for the reason that its population comes late in the pre-winter period.

Usually one egg was found attached to one female and the greater numbers of eggs got detached during sieving. Only sometimes, the females were found carrying more than one egg, upto six, but this was excluded in exceptions. Individuals of the Asplanchana sps. were found carrying embryos but no attempt was made to sort out these individuals in countings.

Arora (1963) comments that the species of the Brachionus recorded in the present work, are more abundant in moderately polluted waters and this is true for the present work also (Chapter III). It also confirms that these species prefer very alkaline waters and they can be regarded as indicators of highly alkaline, productive and supersaturated waters.

Thermocyclops hyalinus population in the pond Moat:

There is comparatively much paucity of literature on the biology of the Cyclopoids for the dominance of the Diaptomids in the big lakes has attracted so far the attention of the investigators. The biology of the three cyclopoids in western lake Erie was worked out by Andrews (1953) and that gives a good estimate of the trends in the populations of this group. There is perhaps no such work from Indian waters.

The results of the observations on the biology of the species are illustrated in Fig. 3. The nauplier stages are found to be abundant in all months except the months of January and February, 1966, when the temperature of the pond is lower than 16°C. This shows that the hatching of the eggs is delayed in these months. The peaks of abundance of the five nauplier stages follow each other closely (Fig. 3) and there is a difference of numbers among all the stages. The first two stages are more abundant while the numbers of the fourth and fifth stages are low. This probably shows that there is either very rapid development through these stages or there is higher mortality during these phases. It is likely that both the reasons hold good.

Copepodite stages were encountered in all months but their numbers were much lower in the months of January and

February, 1965. The first copepodite stage was less abundant than other stages and this shows that there was quick molting at this stage. The numbers of the second and third follow each other. The fourth copepodid stage was comparatively more abundant during the post-winter period.

The fifth copepodid stages were abundant during the months of November and December, 1964, and April, May and June, 1965, and the same pattern of abundance was met with in case of adults (Fig. 3). The ratio of the males to females is given in Table 1. The females out number the males in all seasons. From 60 to 70% of the adult females were found carrying egg sacs. Based on this and taking in view the seasonal variation in the population structure of the species, it can safely be concluded that the breeding of the species in this pond is polycyclic (Rylov, 1963).

Population changes of the species show good agreement with the changes in the phytoplankton and water temperature of the pond (Fig. 3). As temperature has been found to govern the phytoplankton changes (Chapter V), it is clear that abundance of the species in the pond is largely governed by temperature changes of the pond water -- both directly and indirectly.

The results also show that the species is not very successful in the pre-winter period as it is in the post-winter period. This is most likely due to the suitability of warmer water to the species and the abundant food that is present in the pond during this period. Computations of the mortality rate show that the first decline in the population during the period 16th to 30th December, 1964, is very rapid (mortality rate, 4.0 adults/L/day), slows down a little in the first half of January, 1966 (mortality rate, 2.0 adults/L/day), comes to minimum in the second half of January (0.66/L/day) and then increases again in the first half of February, 1966 (2.66/L/day).

Calanoids and Cladocerans in the pond Moat:

These two groups which form most of the animal plankton mass in bigger lakes (Ruttner, 1963) seem to have been eliminated by the dominance of rotifers and cyclopoida. They were present, however, in all seasons.

Adult Diaptomus individuals were met with only in the summer months of April to July. After the monsoon flooding of the pond, copepodid stages and nauplii formed the majority of the population. Isolated individuals were encountered till the next summer. Most of the females were carrying eggs and the males were only few.

Caldocerans occured in patches, mostly in region E and F of the pond where the wind action was minimal. In other open ponds, they were mostly present in still corners. Many individuals were observed carrying embryos in the summer months.

Factors affecting zooplankton production in the ponds:

Many attempts have been made to correlate the zooplankton production with other variables in the pond system, but among all temperature and food have been found to be of utmost importance to zooplankton production (Hazelwood and Parker, 1961). Their relation with algal production in the ponds or lakes also otherwise means that most of the physical, chemical and biological factors which govern algal production, also influence zooplankton production. The effect of the inter-species and intraspecies com-petition is also there (Hazelwood and Parker, 1961) and this adds more to the complexity of the problem.

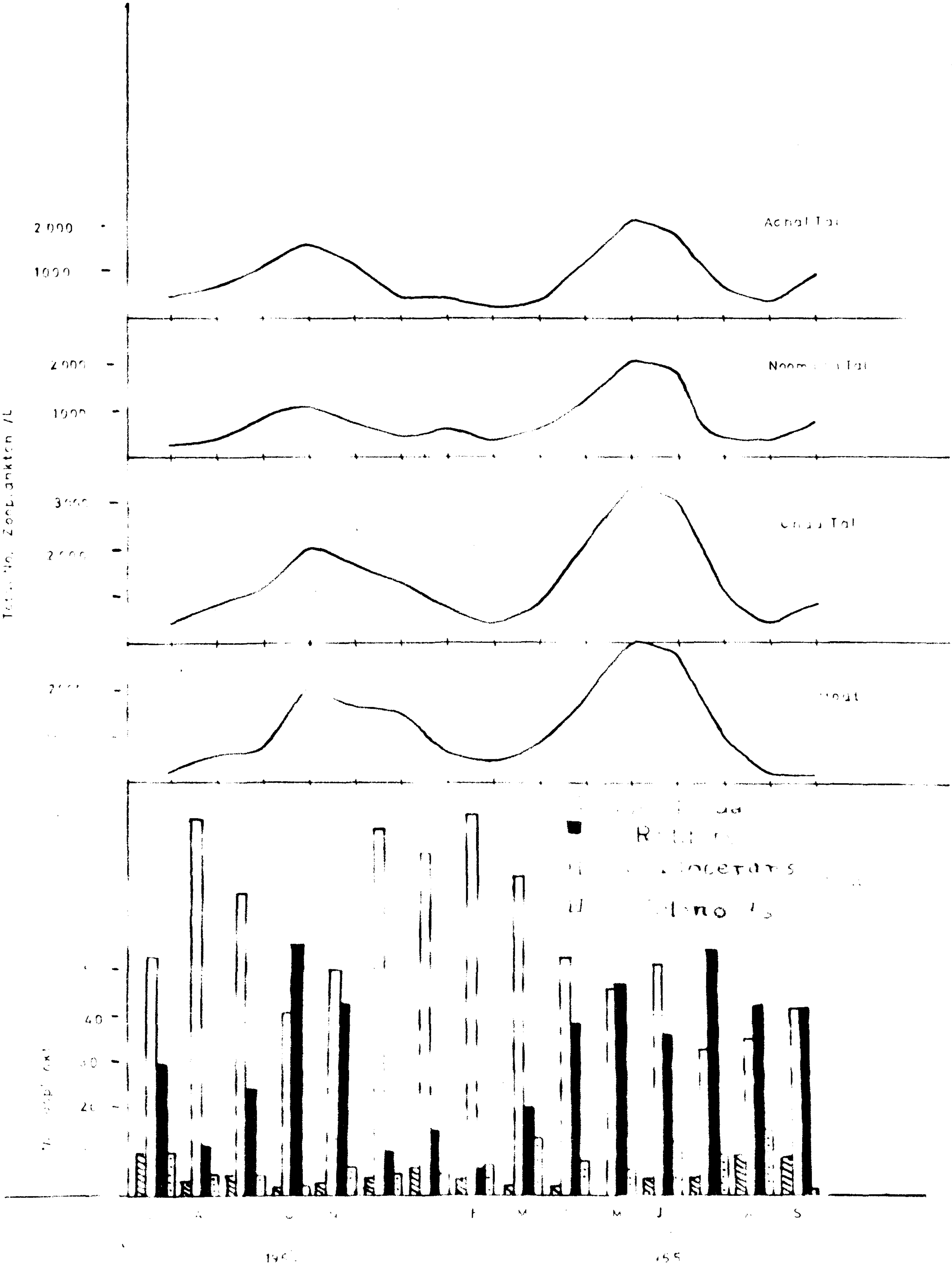
Temperature and phytoplankton production have also been found to be the major factors controlling zooplankton production in these ponds (Figs. 2 and 3). Maximum production is obtained in the pond which supports the maximum phytoplankton in all seasons. The maxima in zooplankton is also observed in those periods when the algal production is also maximum (Figs. 2 and 3). Temperature influences the population as to its abundance, e.g., the rotifer and cyclopoids populations are found to decline in the colder winter months and the species tolerant of the lower ranges (Fig. 2) persist after the others have dwindled in numbers.

Table - 1

Sex ratio in *Thermocyclops hyalinus*

Date	Adult	Cv
1.10.1964	4.0	2.0
1.11.1964	5.0	1.5
15.11.1964	4.0	2.7
15.12.1964	9.0	3.2
1.1.1965	1.5	1.4
15.1.1965	3.0	3.0
15.2.1965	3.0	4.0
1.4.1965	2.3	5.3
15.4.1965	2.2	3.0
1.5.1965	1.54	2.4
15.6.1965	4.7	6.0
15.7.1965	3.66	6.0

Figure I : seasonal variations in the total zooplankton numbers in the ponds and the % group composition of the zodplankton of the pond Moat in the different months.



2 000
1000
Achal Tal
2 000
Noom
Tal
3000
2000
Tal
R
ocerans
A
M
F
M
M
J
S
40
20

Figure 2 : changes in rotifer populations of the pond Moat and the relative changes in the phytoplankton production in terms of H.P.U./L and the temperature of the pond water.

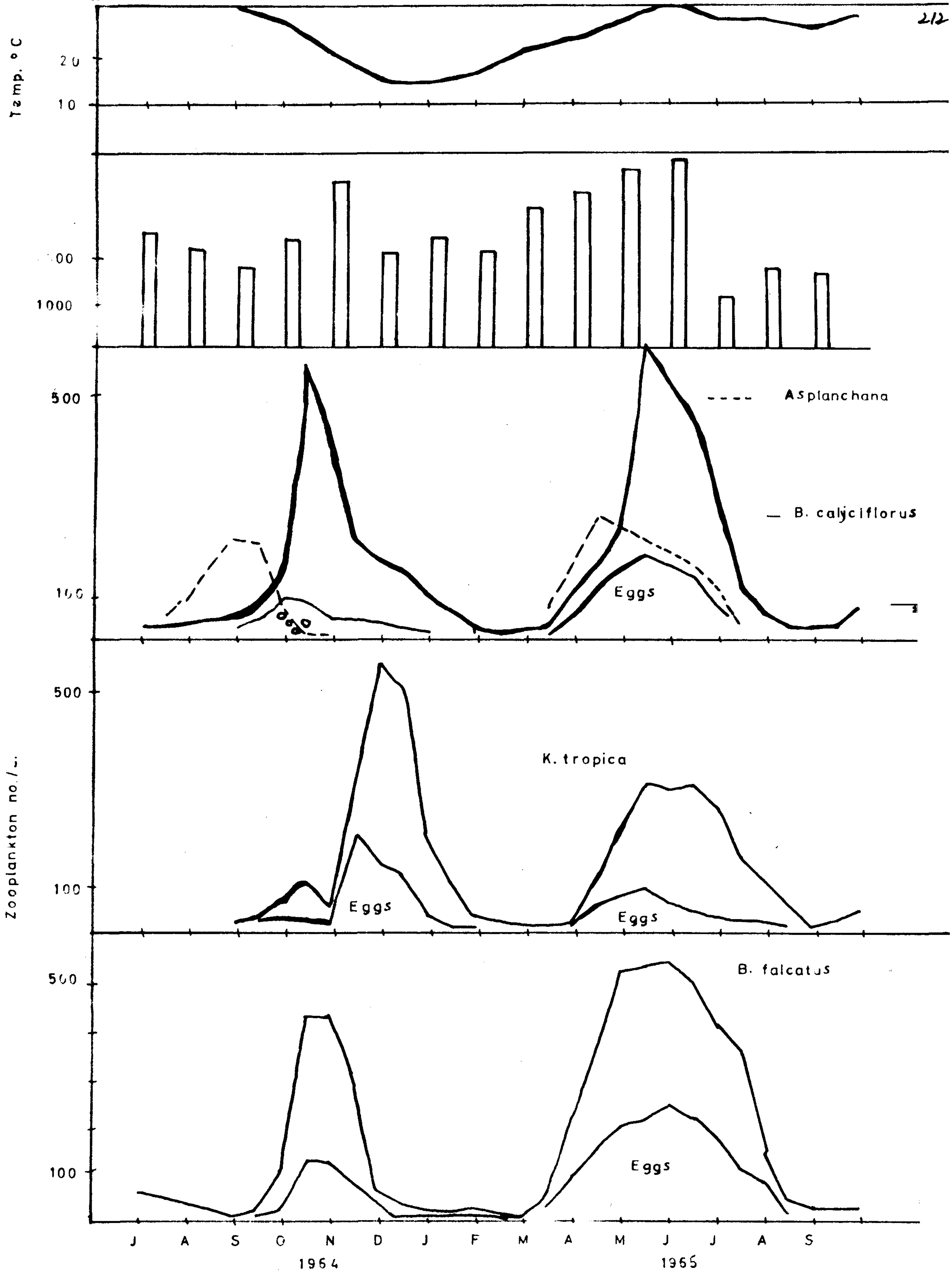
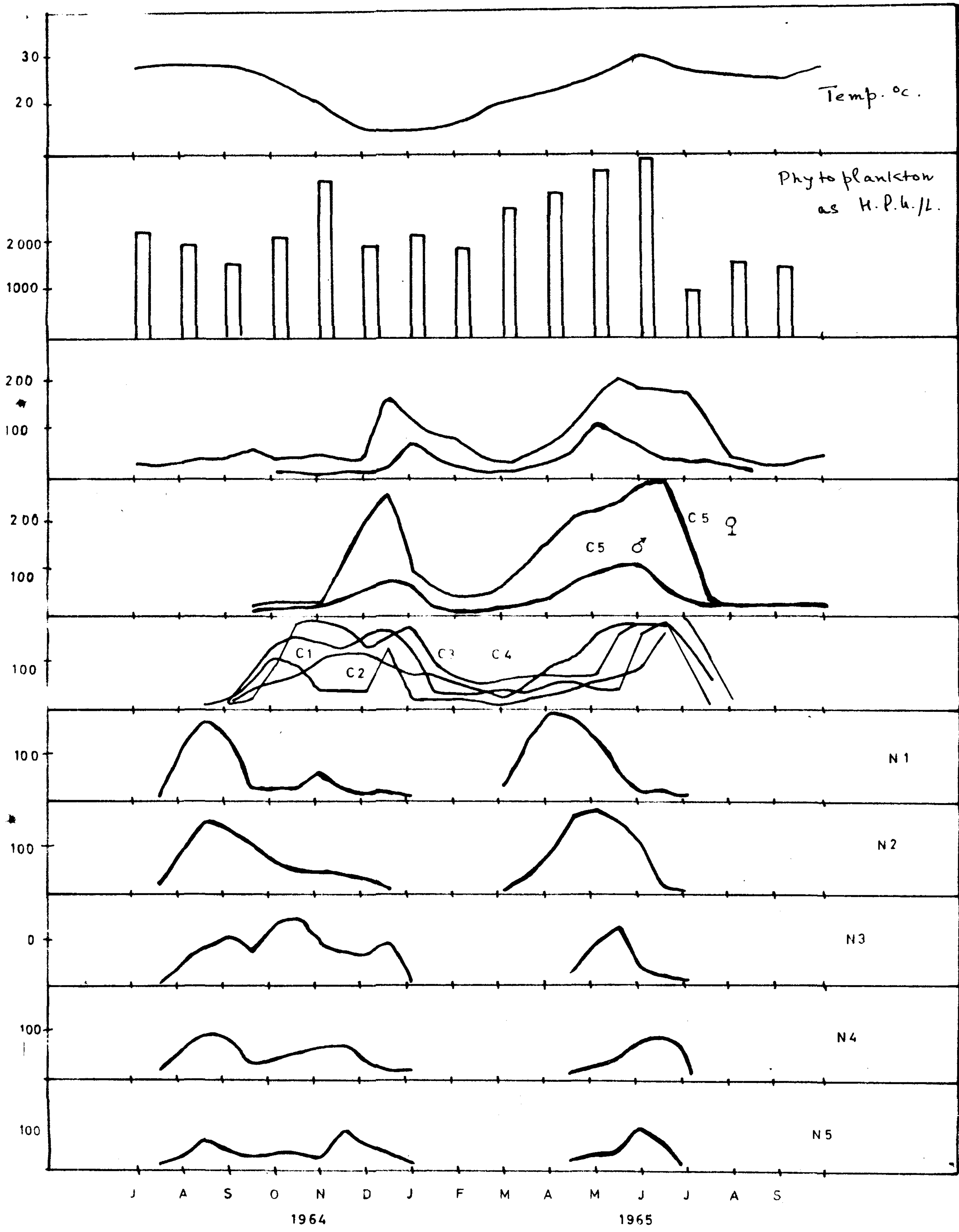

Temp. °C
20
10
00
1000
500
100
Asplanchana
B. calyciflorus
Eggs
egg
500
100
K. tropica
Eggs
Eggs
Zooplankton no./l
500
100
B. falcatus
Eggs
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
1964
1965

Figure 3 : seasonal variations in the population of the cyclopoid *Thermocyclops hyalinus* and the related cahnges in phytoplankton production in the pond (Moat) and the water temperature.



30
20
Temp. °c.
Phytoplankton as H.P.h./L.
2000
1000
200
100
200
100
C5 ♀
C5 ♂
100
C1
C2
C3
C4
100
N1
100
N2
0
N3
100
N4
100
N5
J A S O N D J F M A M J J A S
1964
1965