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SEASONAL ABUNDANCE AND DISTRIBUTION OF BOTTOM FAUNA OF THE CHILKA LAKE

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Abstract

The bottom fauna was studied month-wise during the period April 1963 to March 1964 from 31 sampling stations all over the Chilka Lake. The hydrological conditions, nature of bottom, transparency and vegetation of the lake are discussed in relation to distribution and abundance of benthos. The distribution of animals in different sectors from month to month showed the largest benthic population during October to December and minimum during monsoon period July to September. The microbenthos from the whole lake showed dominance of foraminifers and nematods whereas among macrobenthos molluscs (83%) were dominant followed by polychaete. The mean biomass from the whole lake was 13.57 gm/sq.m and the density 2,720 specimens/sq.m.

Introduction

The bottom fauna form a very important source of food for some groups of fishes and thus their distribution and abundance have received increased attention in recent years. The 'Fauna of the Chilka Lake' by Annandale and Kemp (1915, 1916), Sewell and Annandale (1922) and several other authors contain reference to benthos, hydrology, fish and fisheries of the lake. Recently Rajan (1971) has given an account of the benthic animal communities of the Chilka Lake, but this study pertains to one season only. The present investigation embodies a study of bottom fauna of the lake season-wise for the period April 1963 to March 1964 with special reference to the standing crop of macroscopic invertebrates in relation to salinity variation and fish production.

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Material and Methods

For quantitative studies of the bottom fauna, samples were taken from 27 stations along 7 transects in the main area of the lake and from 4 stations in the outer channel as shown in Fig. 1. Sector-wise location of stations were 3 transects and 9 stations in the southern sector and 2 transects and 9 stations in each of the central and northern sectors. The samples were taken at monthly intervals with the help of an Ekman dredge measuring 23 × 23 sq. cm (Sampling 529 sq. cm of bottom like a grab) as per procedure described by Welch (1952). Along with these collections, the depth, transparency, nature of bottom and presence or absence of vegetation were also noted for each station. After weighing the total sample of each dredge-haul it was stirred well and 908 gms (2 lbs) were removed and placed in a bottle. These samples were screened through Nos. 40 and 150 graded sieves for macro- and micro-organisms. The organisms from sieve No. 40 were picked up, counted and weighed. The sample from sieve No. 150 were preserved in four per cent formalin and later counted with a Sedwick-Rafter counting chamber. All the weights recorded were wet weights and the molluscs were weighed with their shells. The bottom organisms were expressed in no./sq. m of the bottom surface and the biomass expressed as gm/sq. m. The determination of transparency has been made by a secchi disk.

For estimating biomass the specimens of each group were sorted out and wet weights determined. After blotting out the excess of water, the samples were weighed to the nearest tenth of a milligram and then expressed in grams per sq. m of bottom surface.

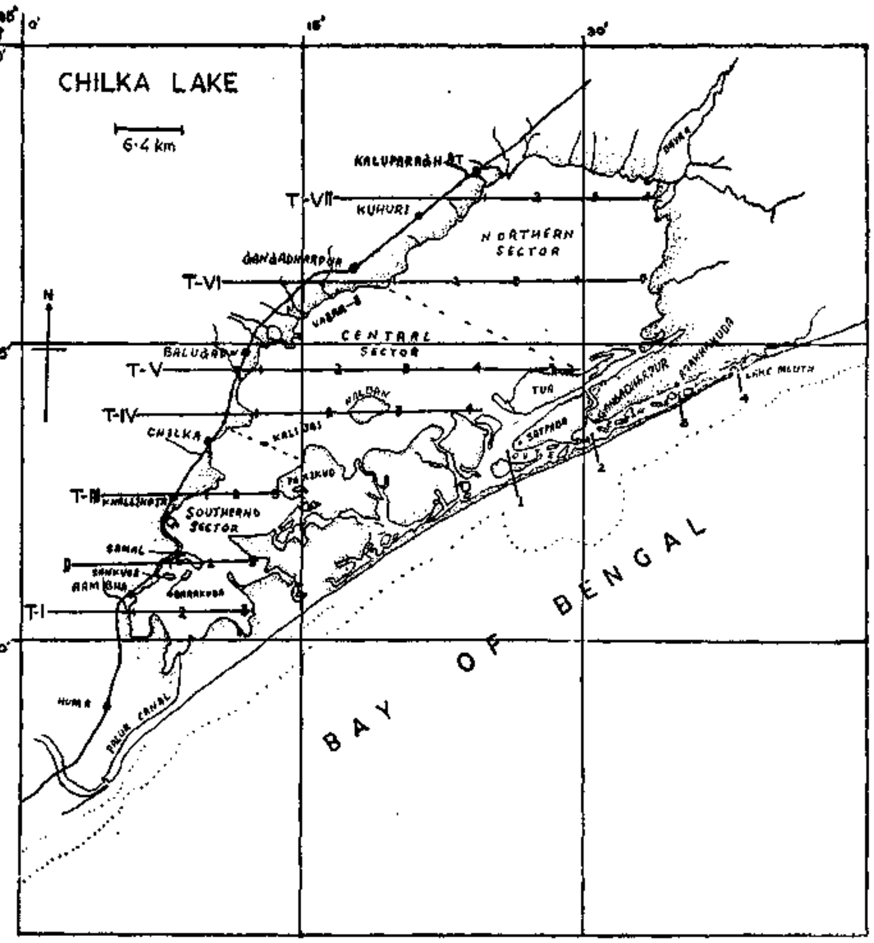

FIG. 1. Map of Chilka lake showing location of sampling stations in different sectors.

General Physical and Hydrological Conditions of the Lake

The Chilka Lake with an area of 1040 sq. km is the largest brackish water lake in India connected with the Bay of Bengal through a channel 29 km long and 365 metres wide. Based on the hydrological conditions the lake is arbitrarily divided into 4 sectors (Jhingran, 1963), (Fig. 1). The northern sector which is comparatively large, receives the discharge of flood water from the branches of Mahanadi river, which pushes the saline water out of the area and makes it almost fresh. The southern sector which is comparatively small does not show much variation of salinity from season to season. The central sector located between the above two presents physical and hydrological conditions intermediate between them. The outer channel connects the sea and the lake and here the tidal effect is always felt.

The nature of bottom as observed during the course of the present study shows that the entire northern sector consists of mud due to continued deposition of silt during floods. Similarly the middle portions of central and southern sectors also have muddy bottom. The western shore of the southern and central sectors is composed of clay with an admixture of sand and organic debris. The eastern shore of central and southern sectors consists of sandy bed. The bottom of the outer channel is sandy. The regions around islands like Kalijai, Barakuda, Sankuda, Samal and Vasra consist of gravels mixed with sand and clay.

As regards the depth of the water (Fig. 2) during April-June the level remains minimum but reaches the highest level during July-September. During the year of observation, the average water level for the whole lake showed a rise of about 50 cm over the minimum level of April-June. The water level gradually falls during October to December and January to March. In the outer channel the water level rises during July to September and also the rise is observed during high tide.

The transparency of water as seen from Fig. 2 shows that the lowest value (4 cm) has been recorded from the eastern shore of the northern sector during July to September period due to the influx of flood water and during April to June due to increased wave action as a result of heavy southern winds disturbing the shallow bottom. The highest value (100 cm) was seen during April to June in the southern sector because of the greater depth and less disturbance of bottom due to the presence of weeds. All along the western shore the comparatively high transparency was due to the presence of vegetation. In the outer channel the minimum values were observed during October to December when the flood water was passing through it and the low value in January to March was due to high concentration of planktonic organisms in the water.

The most important hydrological feature of the lake is salinity which changes from season to season and exerts some influence on the fauna. During the year of observation (Fig. 4) the salinity was low in the October-December period in the northern (0.31-0.54‰) and central sectors (1.87-3.57‰) and during September to December in the outer channel (2.09-4.39‰) due to ingress of flood water. High values of salinity were recorded during May-June in the northern sector (10.51-12.24‰), July-August in the central sector (11.16-11.76‰) and April-July in the outer channel (24.5-29.84‰). However, in the southern sector a value of (11.51-13.67‰) was observed during July-October when, with the influx of flood water from the northern end, part of the saline water gets pushed into this sector and there is no inlet from the sea at this end. The low value (6.83-7.58 ‰) in this sector was

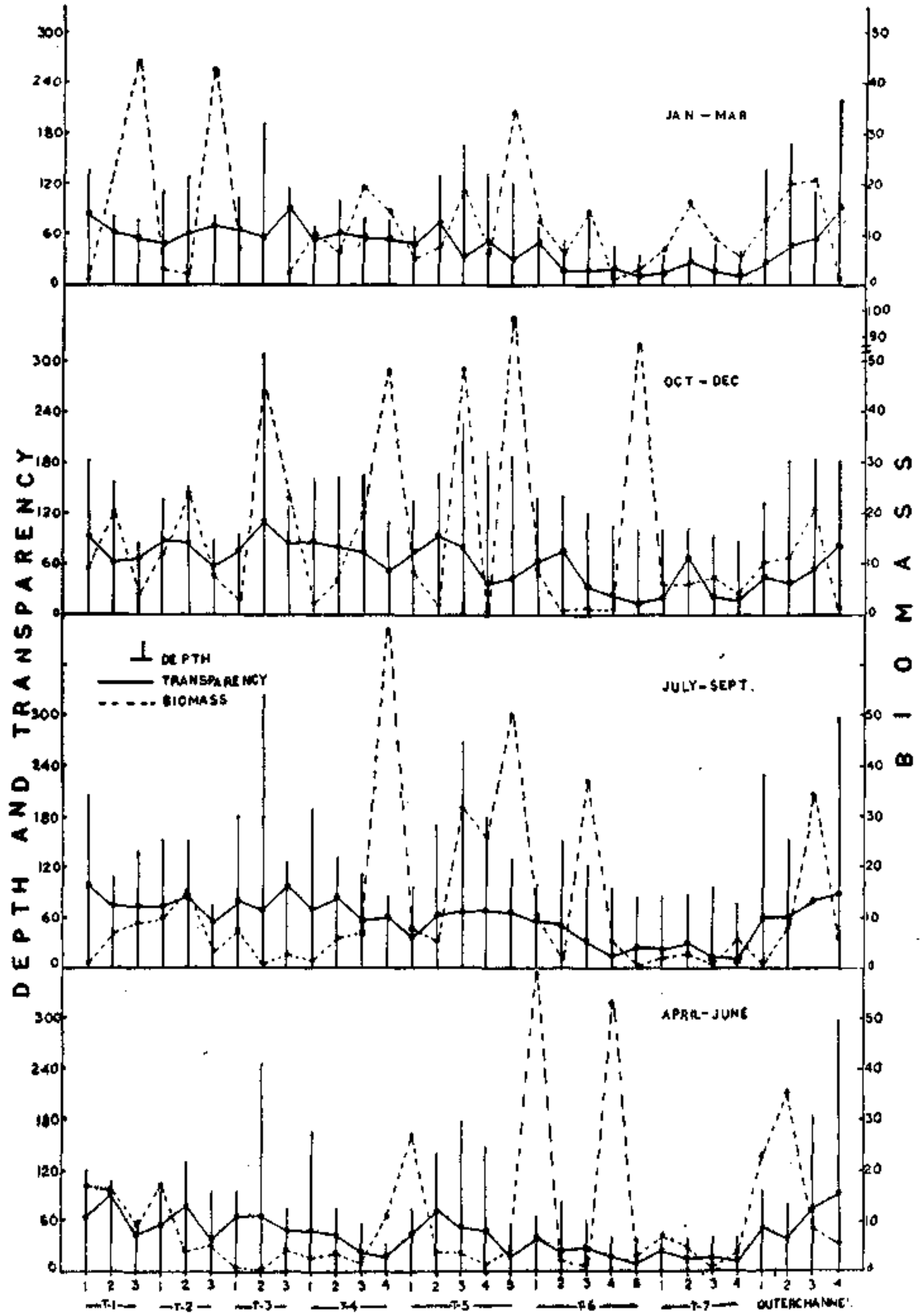

FIG. 2. Seasonal variation in mean depth, transparency and biomass in different stations during April 1963 to March 1964.

observed during November-December. The details of salinity variation are given by Sarkar (MS).

In considering the fauna it is important to know the vegetation which has a direct bearing on the distribution of many of the benthic forms. Biswas (1932) has given an account of the algal flora of the lake. Patnaik (MS) has given in detail the distribution of higher aquatic plants. Thus it was seen that the whole of western shore extending upto about 6 km in the northern sector and about 1 km in the southern sector have thick growth of vegetation. Similarly the eastern shore of southern and central sectors were also covered with vegetation. The rocks and boulders around islands which come in contact with water were covered with luxuriant growth of algae which harbour a number of animal forms. During the monsoon period many of the submerged weeds die and get uprooted due to heavy wind and consequent wave action. These dead weeds float on the surface in masses like rafts and were very often densely populated with amphipods, isopods and molluscs. These floating weeds may also be responsible for the distribution pattern of some benthic organisms. The outer channel in general was free from thick growth of vegetation.

Distribution of Benthos

The benthos are broadly classified here into microbenthos (those retained in sieve 150) and the macrobenthos (retained in sieve 40) based on the terminology of Mare (1942). All the organisms were treated in phylogenetic sequence. Wherever possible identifications were carried up to genus and species ; otherwise for purpose of abundance they were treated group-wise.

Foraminifera : They were distributed all over the lake with little monthly fluctuations (Table 1). The sectoral distribution shows that the foraminifers were abundant in the northern sector with maximum numbers in March and April and minimum during the flood season in July-September. In the central sector the largest numbers were noted during March and April and the lowest during June to August. The largest number recorded in September may be treated as an exception. The month to month figures in the southern sector, however, do not show much variation. In the outer channel comparatively low numbers were noted during September and October when the salinity was low due to flow of fresh water from the lake to the sea and larger numbers were seen during April to July when the salinity was high due to tidal flow. The highest number of 32,200/sq. m was recorded from the collection of station 4 of Transect VII in March 1964. Species of *Polystomella, Spirillina,* and *Rotalia* were most commonly present.

Nematoda : These were recorded throughout the year from all over the lake. They were more numerous during January to March in the northern sector and during July to September in the central sector (Table 1). In the southern sector the period of abundance was from January to March and in the outer channel from February to May. From the station-wise collections it was observed that they were more numerous in the collections from shallow regions where the bottom consists of detritus. These forms were so small and intermeshed with the bottom material that their small mass can be considered a part of the detritus available to bottom feeding organisms, especially fishes. The highest number of 1,32,037/sq. m was recorded from the station at Satpada in August 1963.

TABLE 1. *Monthly variation in the mean number of various groups of organisms expressed per square metre of bottom surface in different sectors*

Northern Sector

	April	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*March*
Foraminifera	221443	188363	192847	97785	98315	11356	130714	105352	100935	117473	153724	223768
Nematoda	6973	17001	10417	6590	27322	22750	18923	8079	532	30830	20730	36765
Rotifera	..	..	..	..	..	..	..	..	..	..	..	..
Polychaeta	231	263	235	136	25	68	798	251	..	385	126	302
Oligochaeta	..	..	..	..	..	..	51	..	..	..	..	..
Hirudinea	..	..	..	..	..	..	..	..	..	..	..	..
Cladocera	..	..	..	..	..	..	..	..	..	..	..	..
Ostracoda	..	8076	..	..	574	..	..	4143	..	1488	..	..
Copepoda	2682	..	..	2729	6607	3402	3615	1701	2019	11268	..	..
Cumacea	..	..	..	..	168	90	210	53	..	334	525	438
Isopoda	86	218	75	..	486	891	2215	297	463	149	1776	407
Amphipoda	124	101	27	..	40	161	191	258	3169	448	86	..
Crustacean nauplii	350	..	..	..	1377	..	850	..	..	..	..	..
Diptera larvae	..	..	..	..	..	..	..	..	207	28	178	208
Other insect larvae	..	..	..	..	..	..	..	..	..	..	36	38
Arachnida	..	..	..	..	..	..	..	..	..	..	..	..
Gastropoda	1043	2484	1016	157	1502	176	564	625	1023	350	1154	400
Pelecypoda	..	151	459	119	230	252	585	..	7482	153	180	45

Central Sector

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Foraminifera	133951	59690	22431	15521	24452	200507	26894	40185	55174	62062	64363	78007
Nematoda	16478	25709	9143	31999	17220	40610	10205	19985	8612	16120	8220	10844
Rotifera	..	..	..	..	..	5625	..	..	..	..	..	..
Polychaeta	230	262	252	1240	103	2630	4178	568	633	488	4868	335
Oligochaeta	..	..	..	..	..	..	..	..	..	9	9	45
Hirudinea	..	..	..	..	..	..	..	..	..	9	..	..
Cladocera	..	..	..	..	..	..	..	..	5316	..	..	..
Ostracoda	..	6906	10947	4165	..	425	..	..	..	38	38	131
Copepoda	4996	4039	7546	2338	1701	6581	9248	1067	11828	8089	10417	1948
Cumacea	..	..	..	..	..	39	282	..	..	..	126	..
Isopoda	111	9	..	38	69	64	128	227	122	134	425	182
Amphipoda	159	126	..	148	119	78	228	9	159	168	288	210
Crustacean nauplii	..	..	..	944	835	..	..	..	..	..	..	..
Diptera larvae	..	..	..	..	..	..	..	..	156	136	82	103
Other insect larvae	88	8	..	..	6	..	..	..	..	39	9	19
Arachnida	..	..	..	..	..	..	..	..	850	..	..	..
Gastropoda	1035	2602	1127	226	589	277	446	334	603	159	172	266
Pelecypoda	62	96	201	27	761	415	239	899	539	1080	147	..

Southern Sector

	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Foraminifera	14564	23068	13284	27868	22113	29873	24984	11481	25086	40717	24009	13502
Nematoda	18810	25833	6273	11659	25408	22750	21474	21262	10946	52518	27518	22970
Polychaeta	1647	283	23	314	252	733	235	492	692	507	379	1865
Oligochaeta	18	..	..	..	..	..	..	..	18	39	..	..
Ostracoda	3507	702	8547	11263	..	6590	..	..	9570	57	321	..
Copepoda	5848	7442	2337	4344	5209	3190	5839	6521	96	2870	4147	744
Cumacea	..	..	..	..	..	..	..	..	..	..	24	..
Isopoda	389	40	42	12	60	42	62	191	161	260	288	187
Amphipoda	32	4424	120	..	107	64	262	349	124	44	245	207
Crustacean nauplii	..	..	..	1260	7122	..	..	..	..	..	..	..
Decapoda	..	..	..	..	..	..	..	..	21	..	..	..
Diptera larvae	12	34	15	..	..	6	..	141	52	19	..	62
Arachnida	..	..	..	..	..	..	..	..	..	..	..	..
Coleoptera larvae	..	..	..	..	..	..	744	..	..	..	..	..
Stomatopoda	..	..	..	..	..	..	..	..	18	..	..	..
Gastropoda	859	1466	987	6669	937	539	2386	478	13	478	258	44
Pelecypoda	463	99	431	148	61	274	514	281	295	723	187	215

Outer Channel

	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Foraminifera	16743	24876	9807	18171	10877	3837	7654	8611	17317	15309	15309	12438
Nematoda	39228	30138	22462	17700	58845	23919	8611	11481	10046	..	22262	29980
Polychaeta	48	1172	5607	1952	1032	172	159	309	369	497	3075	3392
Oligochaeta	..	156	..	..	..	..	..	..	..	..	..	..
Ostracoda	..	..	..	..	..	..	..	..	..	..	..	..
Copepoda	20092	22004	13395	10046	16968	1747	9568	5741	5433	14032	12677	15549
Cumacea	..	..	..	..	..	24	..	51	..	316	23	..
Isopoda	1963	..	23	..	..	..	..	115	119	..	32	63
Amphipoda	..	120	..	..	..	45	..	..	51	240	172	230
Crustacean nauplii	..	..	..	7196	9568	..	..	..	..	..	..	..
Decapoda	201	..	..	..	..	..	25	50	..	..	..	30
Diptera larvae	48	..	15	..	..	..	..	..	102	..	..	..
Arachnida	..	..	..	..	..	..	..	9183	..	3421	..	2033
Coleoptera larvae	..	..	..	..	..	..	..	..	..	..	..	..
Stomatopoda	..	..	..	..	..	..	..	..	..	..	..	..
Gastropoda	19	19	..	57	..	..	38	99	19	..	30	..
Pelecypoda	153	38	394	151	354	584	38	1062	658	274	166	202

Rotifera : They were recorded very rarely and only during the monsoon period when along with flood water they may have entered the lake (Table 1). Only one species (*Brachionus* sp.) occurred forming the largest number of 61,234/sq. m from station 3 of Transect IV in September 1963.

Annelida : Among the annelids, the polychaetes were most abundantly found in the lake collections throughout the year. In the outer channel they were most numerous in occurrence partly accounted for by the larval ingress of some of the marine species at high tide. In the main area they were comparatively more in the central sector and taking station-wise collections they were more in the weed infested areas of the western shore. The largest number of 4,975/sq. m was recorded from the station at Satpada in March 1963. They were comparatively scarce in the northern sector probably due to low salinity and high turbidity. The most commonly occurring forms were *Nereis* spp., *Nephthys* sp. and *Fabricia* sp., from the main area of the lake and *Perinereis* sp., *Sternaspis* sp. from the outer channel.

The oligochaetes and hirudineans were recorded very rarely in the collections. The largest number of 631/sq. m of the former was recorded at Satpada in May and only 96/sq. m of the latter were from station 4 of Transect V in January 1964.

Cladocera : The cladocerans though present in the lake plankton were only recorded in one of the bottom collections at station 3 of Transect IV during December 1963.

Ostracoda : Considerable numbers of ostracods were recorded from all over the lake except the outer channel. In the northern sector they were recorded only in January, May, August and November and the highest number was during May. In the central sector large numbers have been recorded during May and June and low numbers during January to March. The largest number of 86,111/sq. m was recorded from station 2 of Transect II during December 1963. Only *Cypris* sp. was recorded. The ostracods form an important food item in the guts of some bottom feeding juvenile fishes such as *Gerres setifer*.

Copepoda : The maximum numbers of copepoda occurred in the collections from the outer channel and southern sector during April and May when the salinity was high. The low numbers recorded during September to December in the outer channel were due to low salinity as a result of outflow of flood water from the lake to sea through the channel. In the northern sector comparatively high figures noted during September and October was probably due to the settlement of some fresh water forms that have come in with the flood water. In the central sector comparatively high numbers were recorded during December to February and low numbers during July and August. The highest number from the lake bottom 38,272/sq. m have been recorded from station 2 of Transect V in June 1963. Some of the species recorded were bottom dwellers, but in shallow areas planktonic forms also occurred in the collections. Some of the frequently recorded forms were *Amphiascus* sp., *Pseudodiaptomus* spp., *Labidocera* sp., from the northern sector, *Acartiella* sp., *Pseudodiaptomus* spp., from the central sector, *Enhydrosoma* sp., *Nitocra* sp., *Acartia* sp., *Pseudodiaptomus* spp., from the southern sector and *Canuella* sp. and *Acartiella* sp. from the outer channel.

Cumacea : In the northern sector they were more abundant during January to March while their occurrence generally appeared to be sporadic particularly in the southern sector. Throughout the lake they were not recorded in the collections

TABLE 2. *Seasonal variation in the mean number of various gastropods and bivalves per square metre**

	Northern sector				Central sector				Southern sector				Outer channel			
	Apr.-June	July.-Sep.	Oct.-Dec.	Jan.-Mar.	Apr.-June.	July.-Sep.	Oct.-Dec.	Jan.-Mar.	Apr.-June.	July.-Sep.	Oct.-Dec.	Jan.-Mar.	Apr.-June.	July.-Sep.	Oct.-Dec.	Jan.-Mar.
Thais carnifera (Lam.)	—	—	—	—	7	20	—	—	7	17	—	8	—	—	—	—
Nassa Orissaensis Preston	38	7	5	—	45	31	7	—	79	65	27	—	13	19	52	10
Cerithidea fluviatilis (Potiez and Michaud)	—	6	—	—	—	—	—	—	17	18	—	5	—	—	—	—
Stenathyra spp.	1476	599	755	538	1527	310	454	199	928	2518	932	149	—	—	—	—
Nuculana sp.	—	—	19	18	9	3	—	—	60	—	—	89	—	—	—	—
Miscellaneous gastropods	—	—	42	79	—	—	—	—	13	97	—	9	—	—	—	—
Standella annandalei Preston	10	—	—	30	—	42	41	26	—	—	6	11	11	—	162	—
Theora opalina (Hinds)	76	98	13	111	108	152	82	27	33	24	639	84	113	233	13	44
Clementia annandalei Preston	—	57	59	—	—	102	100	23	—	6	6	—	64	87	13	—
Katelysia (Eumarcia) *Opima* (Gmelin)	—	—	—	—	—	11	—	—	—	—	—	—	—	—	—	—
Diplodonta (Felania) *annandalei* Preston	—	—	—	—	—	—	184	165	—	—	—	—	—	—	319	170
Modiola spp.	117	11	—	—	11	21	149	93	200	106	109	276	—	—	—	—
Solen spp.	—	—	—	—	—	44	—	4	—	—	13	—	—	—	—	—
Miscellaneous bivalves	—	35	2617	85	—	29	3	71	98	25	—	4	7	43	79	—

* The bivalves have been identified by the Zoological Survey of India.

during May to August. The maximum number of individuals (1971/sq.m) occurred at station 3 of Transect VII in March 1964 and the dominant form was *Iphinoe* sp.

Isopoda : The isopods were widely distributed in the lake and were observed to be dominant in the weed infested areas in the northern sector. The month to month variations show that they were comparatively fewer from April to July when the weeds were disturbed due to heavy southern wind, but gradual increase in their numbers occurred from August. In the central sector, they were present in fewer numbers during April-September from whence they started increasing in numbers with the luxuriant growth of weeds. In the southern sector they were less abundant during May-October when due to heavy wind and rain the weeds were detached and consequently there was disturbance in the habitat. In the outer channel they were encountered in large numbers during April and in other months they were either totally absent or very scarce probably on account of the unstable condition of the bottom due to the constant flow of tidal water and absence of rooted vegetation. Some species of *Cirolana* were observed to be predatory. On several occasions while operating gill nets at Satpada during night it was observed that these isopods appeared in swarms and entered the body cavity of the gilled fish and devoured the whole of flesh, leaving the skeleton and the skin. On one occasion in March 1963 while operating gill net at Satpada it was observed that a ray (*Trygon sephen*) of 1.5 metre length entangled at 10.00 p.m was completely eaten by these isopods by 6.00 a.m when the net was hauled. These forms were observed to be dominant in the southern sector, some parts of the central sector and at Satpada, especially in weed infested areas. Details of the predatory habits of this isopod have been dealt with elsewhere (Jhingran and Basu, MS ; Rajan, 1971). In the present collections *Cirolana* spp. have been recorded in considerable numbers but not proportionate to their presence as they may avoid the dredge. The other important forms recorded were *Calathura* spp. from the northern sector during August, September and January. In the central sector *Calathura* sp. were recorded exclusively from the eastern shore during August, September, November and December. Similarly *Sphaeroma* sp. and *Exosphaeroma* sp. were recorded from the eastern shore of the central sector during December. From the southern sector *Calathura* spp. were recorded during December, January and May, and *Synidotea* sp. during October and November. From the outer channel *Calathura* sp. were recorded during November and *Upogobia* sp. in February. The largest number 13,663/sq. m were recorded from station 4 of Transect VII in February 1964.

Amphipoda : The amphipod fauna in the lake was also rich and they were relatively more abundant in the southern sector, and highest number as recorded during May whereas in the central sector the period of greatest abundance was during December to April. In the northern sector they were comparatively more during September-January when there was good growth of weeds. In the outer channel they were recorded in considerable numbers during December-March period where ingress of the marine forms were likely. It was further observed that large numbers remain along with algal mass on stones and boulders in the lake and also on the weeds. When the dredge penetrates the vegetation, many specimens were carried to the bottom within the open jaws. These organisms, though not strictly benthic, are liable to be included in the counts. Also large number of them remain on the decaying vegetation thrown on the shore near water line. The highest number, 8,872/sq. m was recorded from station 2 of Transect I in May. Some of the forms collected were *Quadrivisio* sp., *Niphargus* sp., *Orchestia* sp. and *Talorchestia* sp.

Decapoda : The decapod fauna, especially prawns were very rich in the lake, but very few occurred in the dredge collections. Once in December 1963 at station 2 of Transect III, *Alpheus* sp. were recorded (208/sq. m).

Stomatopoda : Only *Squilla scorpio* was noted in the collections in station 2 of Transect III during December 1963.

Diptera larvae : The Diptera larvae comprising mainly chironomids were very few in the collections from all over the lake in different months. They were recorded during December to March only in the northern and central sectors (Table 1). But in the southern sector and outer channel they occurred irregularly in the samples. The highest number 1,072/sq. m was seen at station 2 of Transect VII in July. The other insect larvae collected from the northern and central sectors showed irregular distribution.

Miscellaneous forms : This category includes the Coleoptera and Arachnida collected very sparingly from the shallow areas of the southern sector in October and the central sector in December respectively.

Gastropoda : The gastropod fauna in the lake was very rich (Table 1). The maximum numbers were encountered from the northern and central sectors during April-June. In the southern sector comparatively higher numbers were recorded during May-August period. However, their distribution in the outer channel was scanty and irregular. The season-wise distribution of some of the common species (Table 2) shows that *Stenothyra* sp. was the dominant genus in the main area, being predominant during April-June in the northern and central sectors and during July-September in the southern sector when the salinity was high. They were completely absent from the outer channel probably because of lack of sheltered areas such as vegetation, pebbles and stones. The highest number 28,702/sq. m were recorded from station 2 of Transect II in July. *Thias carnifera* and *Cerithidea fluviatilis* had localised distribution, being restricted to the central and southern sectors and to the southern sector respectively. Except *Nassa orissaensis* other species of gastropods were absent in the outer channel collections.

Pelecypoda : These were widely distributed in the lake. In general the bivalves were recorded in comparatively large numbers during October-December period from all sectors. Large number of young bivalves were also noted during this period. *Theora opalina* was recorded from all over the lake in all seasons showing little fluctuation in number (Table 2). *Diplodonta annandalei* was restricted to October-March in the southern sector and the outer channel while *Solen* spp., *Katelysia opima*, *Clementia annandalei* and *Standella annandalei* were rare. *Modiola* sp. was widely distributed in the southern sector followed by the central sector but were only present during April-September in the northern sector and totally absent from the outer channel. *Modiola* spp. were observed to be present in much higher proportion than recorded here because they remain mostly on stones and boulders around islands that remain under water. The other unidentified bivalves showed maximum numbers in the collections of the northern sector during October-December period.

The Biomass

In the northern sector the total biomass showed four peaks in May, August, October and February (Fig. 3) whereas in the numerical curve for macrobenthos

TABLE 3. *Monthly variation in the mean weight in mg of various groups of organisms expressed per square metre of bottom surface*

Nor hern Sector

	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Polychaeta	595	951	1385	195	25	239	310	117	..	619	254	989
Oligochaeta	..	..	..	..	..	..	423	..	..	..	..	..
Hirudinea	..	..	..	..	..	..	..	..	..	..	..	..
Cumacea	..	..	..	..	82	44	106	25	..	166	262	218
Isopoda	153	270	61	..	580	776	1151	245	398	446	1998	314
Amphipoda	70	136	15	..	27	161	115	195	25	340	170	..
Diptera larvae	..	..	..	..	..	..	..	..	1677	159	1882	392
Other insect larvae	..	..	..	..	..	..	..	..	..	..	36	119
Gastropoda	6800	14790	3350	662	3193	306	3562	1062	1913	607	2064	3083
Pelecypoda	..	15458	249	1297	11873	2560	31161	..	99	2658	3518	4252

Southern Sector

	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Polychaeta	7005	1150	38	111	348	861	404	421	795	532	591	290
Oligochaeta	510	..	..	..	..	..	..	..	315	477	..	..
Cumacea	..	..	..	..	..	..	..	..	..	..	12	..
Isopoda	884	40	90	12	255	135	172	7326	308	454	1372	364
Amphipoda	134	184	99	..	49	38	138	297	75	84	270	192
Decapoda	..	..	..	..	..	..	..	..	9348	..	..	..
Stomatopoda	..	..	..	..	..	..	..	..	3444	..	..	..
Diptera larvae	34	129	27	..	..	24	..	197	63	19 *	..	107
Gastropoda	5722	5001	3253	12331	2221	1234	4154	1482	1276	1047	3723	189
Pelecypoda	1945	777	1358	464	467	1940	10414	6165	2351	26526	1776	3024

Central Sector

	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Polychaeta	408	966	486	258	313	641	1821	216	369	842	598	828
Oligochaeta	..	..	..	..	..	..	..	..	..	264	264	282
Hirudinea	..	..	..	..	..	..	..	..	..	264	..	..
Cumacea	..	..	..	..	..	18	140	..	..	..	63	..
Isopoda	111	9	..	73	132	155	186	332	4060	763	693	344
Amphipoda	132	150	..	178	140	63	258	9	159	170	362	398
Diptera larvae	25	..	..	..	..	..	..	..	126	241	350	402
Other insect larvae	97	65	..	..	24	..	..	..	..	31	4	10
Gastropoda	2124	8405	2701	576	4571	15943	818	716	1592	159	497	520
Pelecypoda	1711	1184	1227	3936	31985	23791	11007	30368	28870	19119	11238	..

Outer Channel

	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Polychaeta	48	1984	224	96	392	448	618	717	219	215	131	2788
Oligochaeta	..	2106	..	..	..	..	..	..	..	..	..	..
Cumacea	..	..	..	..	..	12	..	24	..	157	11	..
Isopoda	241	..	23	..	..	..	..	115	2462	..	34	35
Amphipoda	..	99	..	..	..	24	..	..	24	172	128	178
Decapoda	20091	..	..	..	..	..	1148	1606	..	..	..	630
Stomatopoda	..	..	..	..	..	..	..	..	..	..	..	..
Diptera larvae	48	..	360	..	..	..	..	..	126	..	..	..
Gastropoda	1527	96	..	5856	..	..	..	11893	1913	..	1578	..
Pelecypoda	287	1913	25907	14352	4305	10782	..	8659	3236	12270	14352	8898

an additional prominent peak was observed in December. The biomass of molluscs alone was dominant (Fig. 3) throughout, but the biomass of other animal groups

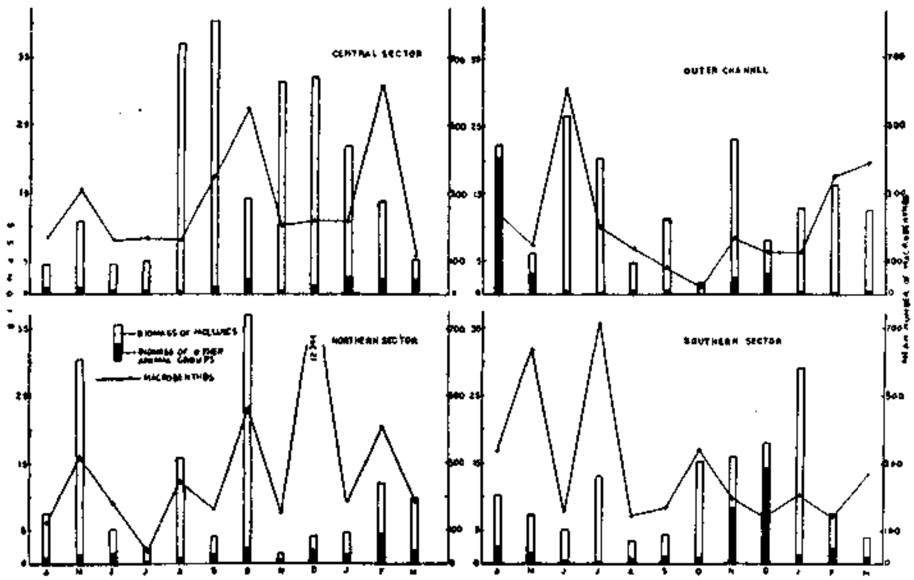

Fig. 3. Comparison of the monthly distribution of macrobenthos numbers and biomass in respect of molluscs alone and other animal groups together, in different sectors.

showed a rise from December to March due to sudden appearance of dipteran larvae (Table 3). As seen in Figure 4 the biomass showed a direct relationship with salinity except in October. In this sector the total production does not show any clearcut relationship with biomass. The average value for the whole year is 11.125 gm/sq. m of which molluscs alone constitute 86.3%. The season-wise fluctuation of biomass at the various stations (Fig. 2) shows that in this sector the relationship with depth and transparency was irregular.

In the central sector the peaks of total biomass occurred (Fig. 3) in May, September and December whereas the numerical abundance for macrobenthos was observed in May, October and February. The biomass in respect of polychaete were high in October, isopods in December, gastropods in September and bivalves in August (Table 3). As in the northern sector, the molluscs were dominant throughout but other animal groups showed a rise from December to March mostly due to the appearance of dipteran larvae and oligochaetes (Table 3). The total biomass and salinity showed a near direct relationship in most of the months whereas the relationship with total production was indistinct (Fig. 4). The production of total biomass on an average for the whole year (April 1963 to March 1964) was 18.279 gm/sq. m of which molluscs alone constituted 92.6%. The seasonal distribution of biomass station-wise did not show any regular relationship with depth or transparency (Fig. 2).

In the southern sector, the peaks of total biomass were observed (Fig. 4) in April, July and January whereas the numerical curve showed peaks in May, July, October and January. While biomass in respect of polychaete and gastropods were

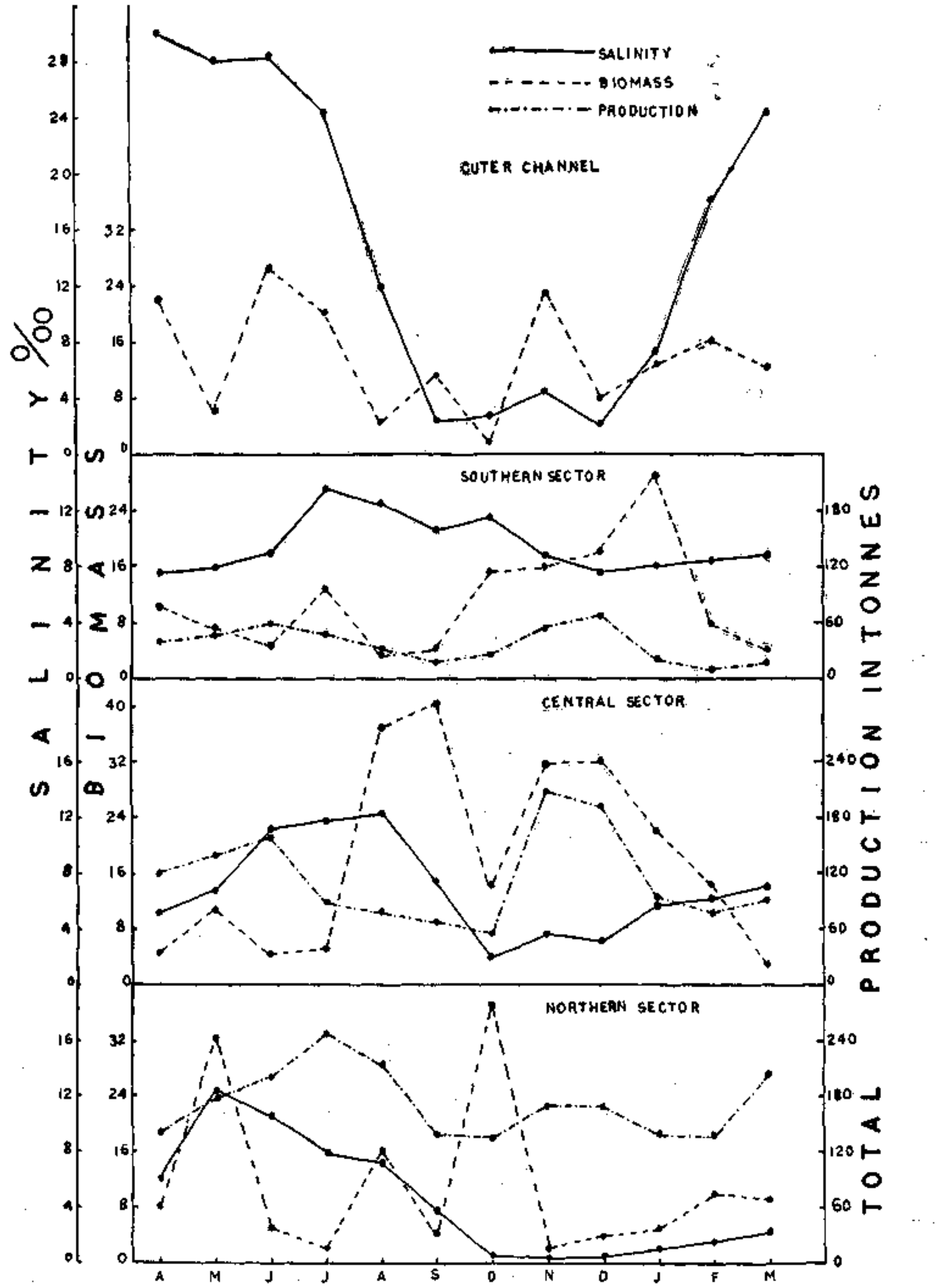

FIG. 4. Monthly variation of biomass, salinity and total production in different sectors during April 1963 to March 1964.

high in April, the peak in July was caused mostly by gastropods and that in January by pelecypods (Table 3). In this sector the salinity curve (Fig. 3) showed a somewhat direct relationship with biomass throughout except during February and March whereas the relationship with total fish production was not clear. The total biomass on an average was 11.088 gm/sq. m and molluscs formed 74.3%. Molluscs were dominant in all the months except in November when isopods predominated and in December when the decapods and stomatopods were more. As in the northern and central sectors the relationship of total biomass (Fig. 2) with depth or transparency was irregular.

In the outer channel sector the peaks of total biomass were observed in April, June, September, November and February (Fig. 4) and the numerical curve also showed peaks in the same months except in September. The peak in April was mostly due to decapods and that in June, September and February due to bivalves whereas the November peak was due to gastropods. The total biomass on an average for the whole year (April 1963-March 1964) from this sector was 13.796 gm/sq. m of which molluscs constituted 77.7% and other animal groups 22.3%. As observed in Fig. 4 the relationship between biomass and salinity was direct and figures of total production were not available for comparison from this sector. In this sector where the bottom is mostly sandy and there is regular tidal flow the station-wise depth and transparency (Fig. 2) showed both direct and indirect relationship with biomass in different seasons and station 4 which is at the lake mouth was poor in respect of biomass throughout.

Discussion

Most of the work on bottom biota pertain to their bathymetric distribution. However, in a lake such as Chilka where most of the water areas come within two metres depth (Fig. 2), the depth of water is not likely to influence the distribution of benthos though same areas of the central sector, southern sector and outer channel have a depth range of 2 to 3 metres. On the other hand it was seen that areas with vegetation were distinctly richer in terms of either number or weight of organisms than open water areas as indicated by Wohlschlag (1950) for a marl lake. Taking the lake as a whole the largest benthic populations occurred between October and December but the fauna decreased to a minimum during the monsoon period, July and August.

It was further observed that taking the lake as a whole, among microbenthos Foraminifera were the most dominant numerically followed by nematodes and copepods and among macrobenthos molluscs and polychaete dominated in that order. In terms of estimated biomass for the whole lake the molluscs comprised 83%. Rajan (MS) has shown that the percentage occurrence of molluscs used as food by 23 species of fishes examined from Chilka, was 78.2%. The present author while examining the guts of 2 Chilka perches *Gerres setifer* and *Sparus sarba* has observed that molluscs contribute 31% and 17% respectively. Thus it is evident that molluscs play a very important role in the food chain of certain lake fishes as one of the major food items.

The variations in salinity has some impact on biomass though not showing direct correlation. The figures of total fish production from the lake do not show any direct relationship with bottom biomass sector-wise. However, taking the production figures of fishes which mostly feed on bottom biota some relationship of seasonal fluctuation and sectoral abundance can be obtained.

In terms of annual mean standing crop (wet weight) of bottom fauna the central sector is comparatively richer showing 182.79 kg/ha. followed by the outer channel 137.96 kg/ha., the northern sector 111.25 kg/ha., and the southern sector 110.88 kg/ha. The figure for the whole lake was 135.72 kg/ha. Some of the available comparable figures are that of Parvin Lake 582 kg/ha. (Buscemi, 1961); Weber and Nebish Lakes 73-147 and 122 kg/ha. respectively (Juday, 1942); Connecticut and New York Lake district 10-348 kg/ha. (Deevey, 1941) and north German Lake district 20-200 kg/ha. (Landbeck, 1936). Townes (1938) considers a natural lake yielding 300 kg/ha. of bottom fauna to be 'at least normally rich' when compared to this standard Chilka Lake appear to be rather poor.

From the lake the average number of macroscopic bottom fauna recorded is 2,720/sq. m. Thienemann (1925), has classified a lake bed producing 1,000 animals or less per m^2 as oligotrophic, one producing above 2,000/sq. m as eutrophic and one producing a number between the above two as mesotrophic. Basing on this classification which takes into account benthic productivity alone Chilka may be described as an eutrophic lake.

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