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Effect of Tide on the Variability of Zooplankton in the Nearshore Waters of Thal, Maharashtra

S N GAJBHIYE, VIJAYALAKSHMI R NAIR, L KRISHNAKUMARI & B N DESAI
National Institute of Oceanography, Regional Centre, Versova, Bombay 400061

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Quantitative and qualitative difference in zooplankton in relation to the tide were studied along 3 transects located off Thal during Feb. 1980 to Jan. 1981. Variation in zooplankton biomass for the flood and ebb period were 2 to 96 and 2 to 134 ml.(100 $m^3)^{-1}$ respectively. In general, there was shoreward increase in zooplankton during the flood period and a reverse trend during the ebb period. Biomass for the ebb period [av. 23 ml.(100 $m^3)^{-1}$] was relatively more than the flood period [av. 21 ml.(100 $m^3)^{-1}$] and this feature was more prevalent at stations close to the shore. The topography of the area and prevailing current pattern exert profound influence on the distribution of zooplankton. Difference in the representation of common groups of zooplankton for the flood and ebb periods was distinct. Copepods and decapods sustained higher population during the ebb period. Groups like chaetognaths and molluscs were caught in appreciable numbers during the flood period.

Being passive drifters, zooplankton are bound to be influenced by the high and low tide conditions. Depending on the prevailing tide, organisms may be carried towards the shore or away from the shore. There are some conflicting reports on the effect of tides on the distribution of zooplankton from estuaries and nearshore waters of India[1-5]. Tidal influence is more pronounced in the nearshore waters and hence 3 transects off Thal were investigated for evaluating the influence of tide on zooplankton.

Materials and Methods

Details of study area, sampling locations and methods, and the prevailing physico-chemical characteristics of the waters off Thal are same as reported[6]. Collections were made from Feb. 1980 to Jan. 1981 during spring period. Each sampling was of 5 min duration covering both ebb and flood conditions. During the neap period samples were collected along the middle transect only. Because of the rough weather from June-Aug. sampling could not be done for both the tides.

Results

Zooplankton biomass and total population— Variation in zooplankton biomass and population for different stations covering both the tides are given in Table 1. Along the southern transect biomass for the flood and ebb conditions varied at a rate of 3-64 and 5-85 ml.(100 $m^3)^{-1}$ respectively. Populations along the southern transect for the flood and ebb periods were 63-1826 and 55-2926.m^{-3} respectively. During the premonsoon period (Feb.-May) higher biomass values were equally spread over the ebb and flood periods, while after the monsoon flood period often sustained higher biomass of zooplankton. However, when mean values at different stations were considered standing stock of zooplankton was invariably more for the ebb period (Table 1). Average values of zooplankton biomass for the entire period of study for the ebb and flood periods were 0.25 and 0.2 ml.m^{-3} respectively. At times zooplankton biomass greatly increased towards the shore during the flood period while a reverse pattern was observed for the ebb period. High population of zooplankton was not always associated with high biomass.

Along the middle transect during the ebb and flood period zooplankton biomass varied at a rate of 2-134 and 4-73 ml.(100 $m^3)^{-1}$ respectively. The population for the ebb (68-2799.m^{-3}) and the flood (76-4299.m^{-3}) indicated very wide fluctuations. During the premonsoon period higher biomass was more often recorded for the flood period. However, the mean value for biomass was more for the ebb period except at st M 1 (Table 1). When the entire period was considered, biomass for the ebb was 0.21 ml.m^{-3} and that of flood period was 0.2 ml.m^{-3}. Often there was shoreward increase in zooplankton biomass during the flood period.

Pattern of zooplankton distribution for the ebb and flood periods in the northern transect was different from that of the other 2 transects. Variations in zooplankton biomass for ebb and flood periods were 2-85 and 3-98 ml.(100 $m^3)^{-1}$ respectively. Population densities respectively for ebb and flood conditions were 36-2333 and 125-3640.m^{-3}. During Feb. to May, ebb period more often sustained higher biomass than the flood period and the pattern was reversed after the monsoon. When mean biomass for the entire period was considered, invariably flood period sustained

Table 1—Zooplankton Biomass (ml.m $^{-3}$) during the Ebb (E) and Flood (F) Periods Along the Southern (S) Middle (M) and Northern (N) Transects

[Values given in parentheses are total population counts (n.m $^{-3}$)]

	Stations					
	S1		S2		S3	
	E	F	E	F	E	F
Feb. '80	—	0.29	0.09	0.22	0.07	0.04
	—	(409)	(73)	(336)	(141)	(260)
March	—	0.09	0.09	0.03	0.23	0.03
	—	(215)	(219)	(176)	(466)	(288)
April	0.08	0.14	0.10	0.13	0.10	0.47
	(180)	(387)	(605)	(380)	(705)	(325)
May	0.13	0.09	0.09	0.10	0.12	0.06
	(100)	(94)	(375)	(329)	(345)	(359)
June	—	0.11	0.24	—	0.19	—
	—	(168)	(438)	—	(190)	—
July	—	0.16	—	0.25	—	0.39
	—	(256)	—	(1090)	—	(1072)
Aug.	0.32	—	0.42	—	0.47	—
	(187)	—	(2346)	—	(359)	—
Sept.	0.08	0.11	0.10	0.06	0.05	0.08
	(55)	(288)	(509)	(63)	(269)	(102)
Oct.	0.51	0.16	0.79	0.23	0.44	0.18
	(380)	(341)	(2926)	(833)	(2063)	(603)
Nov.	0.85	0.43	0.56	0.61	0.43	0.04
	(379)	(689)	(1960)	(1357)	(825)	(254)
Dec.	0.22	0.46	0.07	0.21	—	0.17
	(493)	(1826)	(82)	(421)	—	(140)
Jan. '81	0.06	0.057	0.10	0.11	0.11	0.17
	(233)	(316)	(231)	(368)	(505)	(29)
	M1		M2		M3	
	E	F	E	F	E	F
Feb. '80	0.22	0.23	0.19	0.17	0.05	0.31
	(94)	(240)	(522)	(838)	(166)	(980)
March	0.11	0.13	0.12	0.04	0.11	0.07
	(128)	(191)	(471)	(691)	(273)	(127)
April	0.09	0.16	0.05	0.09	0.04	0.12
	(107)	(229)	(111)	(170)	(212)	(277)
May	0.13	0.13	0.04	0.05	0.03	0.07
	(229)	(204)	(358)	(362)	(75)	(131)
June	—	0.14	0.09	—	0.35	—
	—	(380)	(471)	—	(272)	—
July	—	0.35	—	0.27	—	0.20
	—	(1160)	—	(1033)	—	(1043)
Aug.	—	0.16	—	0.22	—	0.26
	—	(265)	—	(322)	—	(1128)
Sept.	0.13	0.04	0.07	0.16	0.02	0.20
	(740)	(151)	(91)	(76)	(68)	(459)
Oct.	0.17	0.20	0.36	0.52	0.63	0.45
	(759)	(506)	(1789)	(2878)	(2698)	(1385)
Nov.	0.25	0.75	1.34	0.37	0.70	0.28
	(387)	(301)	(2799)	(575)	(842)	(4299)
Dec.	0.17	0.14	0.13	0.17	0.11	0.13
	(536)	(451)	(104)	(196)	(426)	(293)
Jan. '81	0.11	0.18	0.09	0.06	0.13	0.10
	(426)	(901)	(521)	(396)	(162)	(342)

Contd

Table 1—Zooplankton Biomass (ml.m^{-3}) during the Ebb (E) and Flood (F) Periods Along the Southern (S) Middle (M) and Northern (N) Transects —*Contd*

[Values given in parentheses are total population counts (n.m^{-3})]

	Stations					
	N1		N2		N3	
	E	F	E	F	E	F
Feb. '80	0.08	0.1	0.12	0.07	0.11	0.1
	(205)	(202)	(401)	(261)	(1480)	(1320)
March	0.13	0.08	0.16	0.12	0.15	0.14
	(307)	(196)	(1411)	(297)	(594)	(291)
April	0.20	0.16	0.06	0.12	0.12	0.18
	(1080)	(1040)	(601)	(409)	(257)	(233)
May	0.02	0.03	0.024	0.017	0.05	0.01
	(314)	(1030)	(481)	(419)	(257)	(187)
June	0.07	—	0.11	—	0.14	—
	(116)	—	(269)	—	(301)	—
July	—	0.11	—	0.42	—	0.49
	—	(641)	—	(1494)	—	(891)
Aug.	1.41	—	—	0.98	—	0.85
	(566)	—	—	(912)	—	(1207)
Sept.	0.19	0.15	0.11	0.28	0.21	0.06
	(68)	(184)	(36)	(364)	(68)	(709)
Oct.	0.42	0.65	0.43	0.65	0.62	0.96
	(1919)	(673)	(889)	(2065)	(2307)	(579)
Nov.	0.66	0.52	0.85	0.54	0.60	0.89
	(456)	(435)	(2333)	(588)	(1250)	(2861)
Dec.	0.226	0.231	0.14	0.21	0.03	0.17
	(886)	(263)	(187)	(125)	(205)	(156)
Jan. '81	0.15	0.06	0.16	0.14	0.11	0.14
	(484)	(455)	(784)	(1137)	(177)	(418)

higher biomass than the other. The difference was more conspicuous at sts 1 and 3. Average for the entire transect was 0.22 ml.m^{-3} for the ebb and 0.26 ml.m^{-3} for the flood. During the ebb period there was a tendency for zooplankton to congregate towards the offshore area.

Influence of spring and neap tides on the disposition of zooplankton is given in Table 2. During the flood period of neap and spring from Feb. to May, usually spring tide sustained higher biomass. The pattern was reversed after the monsoon (Sept.-Jan.) and higher biomass values were recorded in the neap period. Spatial distribution of zooplankton biomass for the ebb period of spring and neap also indicated a similar trend (Table 2). In the nearshore (sts 1 and 2) mean biomass values for the ebb and flood conditions were 24 and 21.8 ml.(100 m^3)$^{-1}$.

Zooplankton composition—Ebb and flood period: Percentage composition of different groups of zooplankton along the 3 transects are given in Figs 1 and 2. Copepods formed the major part of the total zooplankton. The percentage incidence of the group decreased towards the end of the postmonsoon period (Dec. 1980 to Jan.'81). In general, copepod population was more during the ebb tide than the flood period. Eventhough decapods were represented in all the transects their percentage of incidence varied at different stations. Usually when records of decapod population was high at st 1 their representation became low at sts 2 and 3. On the contrary when density of decapods was low at st 1 higher population of this group was observed at sts 2 and 3. Difference in the distribution of decapods for the ebb and flood showed that relatively high percentage of decapods were caught during the ebb condition.

Chaetognaths were represented throughout the period of study. A major peak for this group was recorded soon after the peak monsoon period (Sept.-Oct.). Variation in the total population of chaetognaths for ebb and flood periods was more prevalent at sts 1 and 2. High density of chaetognaths was usually observed for the flood period. Siphonophores were recorded in appreciable quantity only during Jan. at sts 2 and 3 and population difference associated with the tides was not discernible.

Molluscs were represented by gastropods and lamellibranchiates. Two peaks in the abundance of molluscs were observed, a major one in Dec./Jan. and a lesser peak during April/May. Their representation was almost nil during Jan.-July. Numerical density of

Table 2—Zooplankton Biomass (ml.m $^{-3}$) during Flood and Ebb Periods of Spring (S) and Neap (N) along Middle Transect

[Values given in parentheses are total population counts (n.m $^{-3}$)]

	Stations					
	M1		M2		M3	
	S	N	S	N	S	N
	Flood period					
Feb. '80	0.22	0.17	0.17	0.03	0.31	0.12
	(240)	(343)	(832)	(617)	(980)	(635)
March	0.13	0.03	0.04	0.07	0.04	0.09
	(191)	(99)	(691)	(104)	(127)	(141)
April	0.16	0.12	0.09	0.05	0.12	0.04
	(229)	(161)	(170)	(245)	(277)	(534)
May	0.13	0.02	0.05	0.04	0.07	0.04
	(404)	(4)	(662)	(314)	(631)	(10)
Sept.	0.04	0.23	0.17	0.14	0.20	0.33
	(151)	(371)	(76)	(462)	(459)	(1043)
Oct.	0.2	0.82	0.52	0.82	0.45	0.50
	(506)	(3363)	(2878)	(5674)	(1385)	(2394)
Nov.	0.75	0.42	0.37	0.64	0.28	1.24
	(301)	(195)	(575)	(588)	(4299)	(881)
Dec.	0.14	0.27	0.17	0.23	0.13	0.19
	(451)	(281)	(196)	(567)	(293)	(252)
Jan. '81	0.18	0.13	0.06	0.06	0.10	0.09
	(901)	(357)	(396)	(378)	(342)	(137)
	Ebb period					
Feb. '80	0.23	0.07	0.19	0.14	0.05	0.06
	(94)	(155)	(522)	(1047)	(165)	(222)
March	0.11	0.01	0.12	0.11	0.15	0.04
	(128)	(111)	(471)	(273)	(273)	(110)
April	0.09	0.08	0.05	0.05	0.04	0.13
	(107)	(102)	(111)	(276)	(212)	(1979)
May	0.13	0.01	0.04	0.01	0.03	0.01
	(364)	(14)	(360)	(168)	(175)	(1)
Sept.	0.13	0.18	0.07	0.32	0.02	0.30
	(740)	(707)	(91)	(927)	(68)	(847)
Oct.	0.17	0.78	0.36	0.32	0.63	0.23
	(759)	(5730)	(1789)	(1069)	(2698)	(2171)
Nov.	0.25	0.56	1.34	0.66	0.70	0.38
	(387)	(129)	(2799)	(99)	(70)	(844)
Dec.	0.17	0.11	0.13	0.19	0.11	0.16
	(536)	(393)	(104)	(337)	(426)	(280)
Jan. '81	0.11	0.9	0.09	0.47	0.13	0.20
	(426)	(311)	(521)	(602)	(62)	(1090)

molluscs increased from st 1 to st 3. Compared to ebb period, flood sustained higher density for molluscs.

Fish eggs and larvae were occasionally recorded in the area with maximum abundance in Sept. Relatively higher incidence of the group was obtained at sts 1 and 2.

Groups like hydromedusae, ctenophores, cirripede nauplii, ostracods, stomatopod larvae, polychaetes, amphipods, mysids, isopods, and appendicularians were occasional inhabitants of the area. Since their incidence was individually negligible, total percentage incidence was given as other groups. Among these hydromedusae and ctenophores were more common and they were continuously represented in the samples from Oct. to Jan. Medusae and ctenophores were absent during the monsoon period (June to Aug.). Foraminiferans, pteropods and cephalopod larvae were very rarely recorded at the offshore area (st 3).

Spring and neap period: Percentage incidence of various groups of zooplankton for the flood and ebb period at different stations along the middle transect are given in Fig.3. Copepod population at M_1 was more during the spring premonsoon period (Feb.-May) while from Sept.-Jan. the recorded values were higher for the neap. The pattern of distribution of copepods was less pronounced at sts M_2 and M_3.

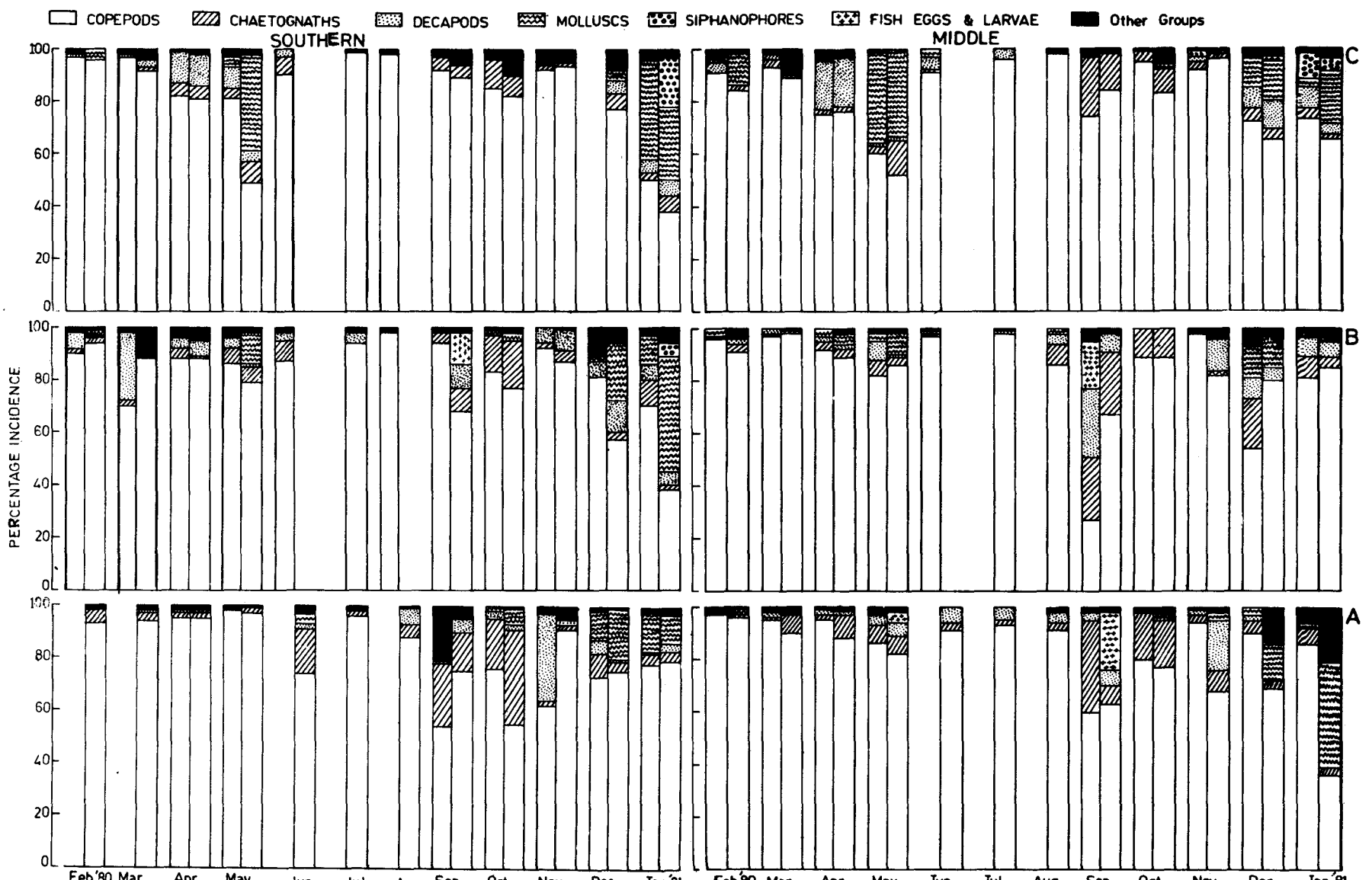

Fig. 1—Percentage incidence of different groups of zooplankton at different stations of southern and middle transects during Feb. 1980 to Jan. 1981 [For each month the first bar represents ebb period and the second the flood period. A,B and C denote respectively sts 1,2 and 3]

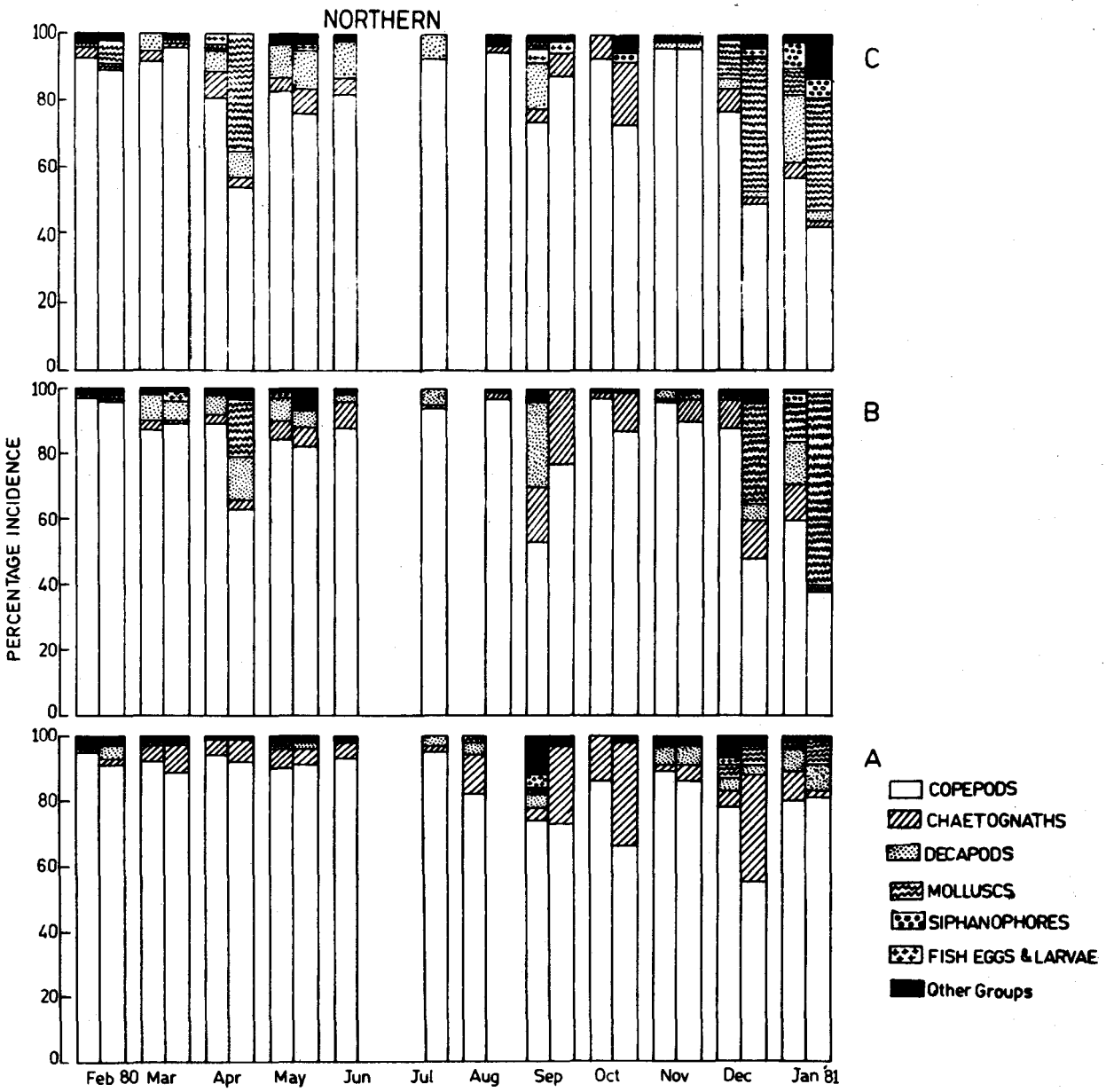

Fig. 2—Percentage incidence of different groups of zooplankton at different stations of northern transect (other details as in Fig.1)

However, when the entire period of observation was taken into consideration at sts M_1 and M_3 population of copepods was more for spring and ebb periods respectively. At sts M_1 and M_2 numerical density of decapods was high for the neap period than the spring. In general, chaetognaths and molluscs were caught in higher numbers during the spring period. Incidence of fish eggs and larvae were more for the neap period. Records of ctenophores, medusae, ostracods and cladocerans were confined to the neap period.

Discussion

Previous reports on the influence of tide on zooplankton from Indian seas[1-5] indicate that tide may or may not have its impact on the distribution of zooplankton. During the postmonsoon period in the Cochin backwaters, the variations in zooplankton biomass appear to be partly influenced by the diel rhythm of plankters, and the incoming tides contribute to their increase during day time[2]. However, Madhupratap and Rao[4] could not find any significant effect of tides on zooplankton component in the Cochin backwaters. Tidal flow seems to influence the larval ingression of decapods into Mandovi and Zuari estuaries with peak during high tide[3]. Variations in zooplankton biomass and species of copepods correlated with tide had already been reported[7].

The present investigation indicates variability in the

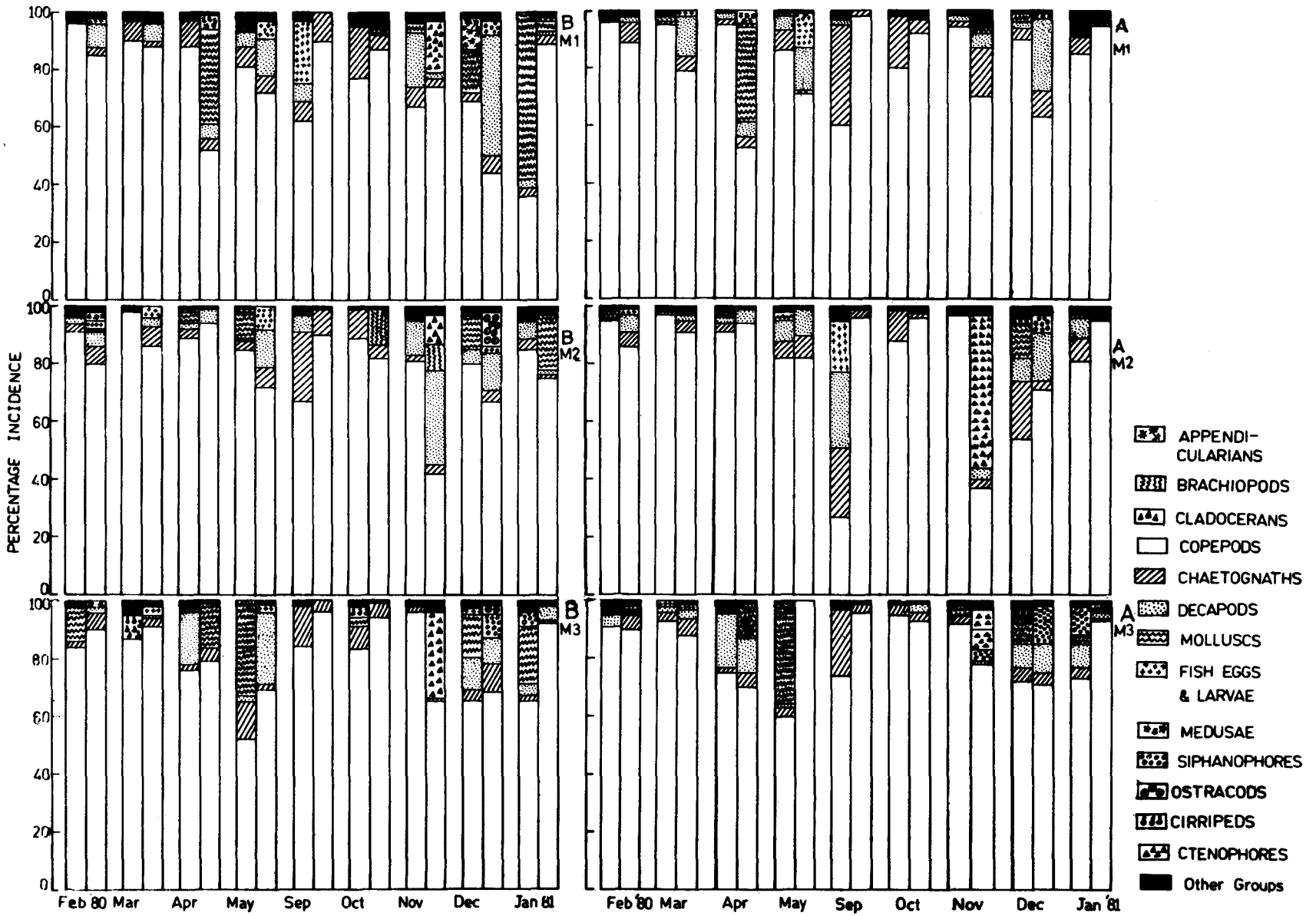

Fig. 3 – Variation in the incidence of different groups of zooplankton at sts M1, M2 and M3 during the ebb (A) and flood (B) periods of spring and neap. (For each month the first bar represents spring and second the neap)

disposition of zooplankton under different tidal conditions. The range of fluctuation in biomass for the flood and ebb period were 2 to 96 and 2 to 134 ml.(100 $m^3)^{-1}$ respectively. The mean biomass for the entire period covering the nearshore area, (sts 1 and 2) indicated slightly higher biomass for the ebb period [23 ml.(100 $m^3)^{-1}$] than the flood period [21 ml.(100 $m^3)^{-1}$]. In general, there was shoreward increase in zooplankton biomass during the flood period and a reverse trend during the ebb period. Studies on the current from this area reveals that the shoreward component was stronger during the flood tide and the offshore component during the ebb tide[8]. Difference in the representation of common groups of zooplankton during the flood and ebb period was prevalent in the nearshore area (sts 1 and 2). Percentage incidence of copepods and decapods were more for the ebb period. Chaetognaths and molluscs showed better representation for the flood period. Group diversity of zooplankton gradually increased from nearshore to offshore station.

The overall picture on zooplankton distribution indicates the effect of the prevailing tide. Along the southern and middle transects the ebb conditions sustained higher standing stock of zooplankton than the flood period. This feature was more prevalent in the nearshore stations (sts 1 and 2) than the offshore station (st 3). However, in the northern transect higher biomass was obtained during the flood than the ebb period. This appears to be the effect of the prevailing circulation pattern of the area. The proximity of the 2 islands and the complexity of the sea bed profiles modified the circulation pattern of this region resulting in circulation cells with onshore curvature[8]. This limiting factor would result in flooding of water in the southern section of the survey area, whereas to the north of the islands flooding water has a large unhindered expanse of the sea for the transportation. This pattern of circulation was directly reflected on the recorded biomass for the ebb and flood periods of the different transects. Along the south and middle area the piled up water must have contributed to the relatively high biomass for the ebb period. Towards the north outgoing stream carried the zooplankton to a vast expanse resulting in low biomass of zooplankton for the ebb period.

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