

## STUDIES ON THE ESTUARINE COPEPODS OF INDIA

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### ABSTRACT

This paper embodies a discussion on the pelagic copepods, especially the calanoids inhabiting, as transitory or permanent residents, the estuaries in India. Out of the 67 species of calanoids recorded from the estuarine waters of India, 36 species occur in the backwaters around Cochin. The occurrence, distribution and seasonal abundance of these species in the estuarine system around Cochin is dealt with. In addition, the influence of the physico-chemical properties of the environment on the spatial and temporal distribution of these species is also discussed.

### INTRODUCTION

IN comparison with the considerable amount of knowledge gained on the studies of the biology of the estuarine plankton in higher latitudes, practically little is known about the biological aspects of the planktonic elements in the estuaries of the tropics. As pointed out by Sewell (1934) the brackishwater area 'forms one of the main highways by which certain constituent elements of the marine fauna of the Indian Seas encroach on and finally establish themselves in freshwater'. Panikkar and Aiyar (1937) opined that the studies concerning the biology of animal life in the brackish-water is interesting as we find here an intimate association of the animals of the Sea, backwater and freshwater for life in a common habitat. In the present communication specific attention has been given to the study of calanoid copepods because of the interest that some species such as those belonging to the families Centropagidae, Pseudodiaptomidae and Acartiidae hold as transitory forms or permanent residents in the overlapping environmental conditions.

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### RESUME OF EARLIER WORKS ON ESTUARINE COPEPODS OF INDIA

Earlier works on Copepoda of the estuaries in India are confined to the descriptions of species or records of their occurrence in different areas. Little work has been done on the ecology of estuarine copepods.

A faunistic list of calanoid copepods of Salt lakes and the associated estuarine system of Calcutta including the Hoogly river estuary was presented by Sewell (1934). Subsequently, Dutta *et al.* (1954) studied the planktonic fauna and the seasonal variations in the occurrence of copepods of the Salt lakes.

Sewell (1919, 1924) reported on the copepod fauna of Chilka lake and more recently Devasundaram and Roy (1954) have discussed briefly the occurrence and

seasonal variations of the copepods in the plankton of the Chilka lake for the period 1950-51.

There are brief references to Copepoda in the accounts on the brackishwater fauna of Adayar and other estuarine areas around Madras, by Panikkar and Aiyar (1937), Krishnaswamy (1953), and Chacko *et al.* (1953).

Sewell (1919) described a new copepod from the Cochin Backwater. The first attempt of making a systematic study and ecology of the planktonic copepods of the Cochin Backwater was made by George (1958). Wellershaus (1969, 1970) has given a detailed treatment of the taxonomy of some of the copepods of the estuarine system around Cochin. Pillai (1970) while giving a list of the Pseudodiaptomidae of the Cochin Backwater has also described a new species of the genus *Pseudodiaptomus* Herrick.

The following authors also have contributed to our knowledge of the copepods inhabiting brackishwaters of India : Brehm (1953), Desai and Bal (1961), Kasthurirangan (1963), Kiefer (1928, 1935 and 1936), Lindberg (1940, 1947 and 1950), Sewell (1948, 1956) and Ummerkutty (1960). All the above studies have either recorded or described a total of 62 species of calanoid copepods from different estuaries in India as follows :

#### LIST OF CALANOID COPEPODS RECORDED FROM DIFFERENT ESTUARIES IN INDIA

[Faunal composition is indicated by (×) mark. Single (×) indicates occurrence of species in different environments, double (××) indicate their primary preference to different saline conditions. An (\*) denotes species recorded from Cochin Backwater.]

	<i>Limnetic</i> ( $<\pm$ 0.5‰)	<i>Mixo- haline</i> (0.5- 30.0‰)	<i>Euhaline</i> (30.0- $\pm$ 40.0‰)
<b>Family CALANIDAE</b>			
*1. <i>Canthocalanus pauper</i> (Giesbrecht), 1888	—	×	××
<b>Family EUCALANIDAE</b>			
*2. <i>Eucalanus crassus</i> Giesbrecht, 1888	.. —	×	××
<b>Family PARACALANIDAE</b>			
3. <i>Paracalanus dubia</i> Sewell, 1912	.. —	××	×
*4. <i>P. crassirostris</i> Dahl, 1893 f. <i>cochinensis</i> Wellershaus, 1969	.. —	×	××
*5. <i>P. aculeatus</i> Giesbrecht, 1888 f. <i>major</i> Sewell, 1929	.. —	×	××
*6. <i>Acrocalanus similis</i> Sewell, 1914	.. —	××	×
*7. <i>A. monachus</i> Giesbrecht, 1888	.. —	×	××
8. <i>A. inermis</i> Sewell, 1912	.. —	××	×

		Limnetic ( $<\pm$ 0.5‰)	Mixo- haline (0.5- 30.0‰)	Euhaline (30.0- $\pm$ 40.0‰)
<b>Family CENTROPAGIDAE</b>				
*9.	<i>Centropages alcocki</i> Sewell, 1912	.. —	××	×
*10.	<i>C. furcatus</i> (Dana), 1849	.. —	×	××
*11.	<i>C. orsinii</i> Giesbrecht, 1889	.. —	×	××
*12.	<i>C. trispinosus</i> Sewell, 1914	.. —	×	××
*13.	<i>C. tenuiremis</i> Thompson & Scott, 1903	.. —	×	××
*14.	<i>Isias tropica</i> Sewell, 1924	.. —	××	×
<b>Family DIAPTOMIDAE</b>				
15.	<i>Phyllodiaptomus blanci</i> (di Gurne), 1896	××	—	—
*16.	<i>Heliodiaptomus cinctus</i> (Gurney), 1907	××	×	—
17.	<i>H. contortus</i> (Gurney), 1907	.. ××	×	—
18.	<i>H. viduus</i> (Gurney), 1907	.. ××	—	—
19.	<i>H. pulcher</i> (Gurney), 1907	.. ××	—	—
20.	<i>Tropodiaptomus orientalis</i> (Brady), 1886	××	—	—
*21.	<i>T. nielsenii</i> Brehm, 1953	.. ××	×	—
22.	<i>Sinodiaptomus indicus</i> (Sewell), 1934	.. ××	—	—
*23.	<i>Allodiaptomus mirabilipes</i> Kiefer, 1936	.. ××	×	—
24.	<i>Neodiaptomus strigilipes</i> (Gurney), 1907	.. ××	—	—
<b>Family PSEUDODIAPTOMIDAE</b>				
*25.	<i>Pseudodiaptomus annandalei</i> Sewell, 1919	—	××	×
26.	<i>P. binghami</i> Sewell, 1912	.. —	××	×
*27.	<i>P. binghami malayalus</i> Wellershaus, 1969	—	××	—
*28.	<i>P. jonesi</i> Pillai, 1970	.. —	××	×
*29.	<i>P. ardjuna</i> Brehm, 1953	.. —	×	××
30.	<i>P. dubia</i> Kiefer, 1936 (= <i>P. annandalei</i> Sewell)	.. —	××	×
31.	<i>P. aurivillii</i> Cleve, 1901	.. —	××	×
*32.	<i>P. serricaudatus</i> (T. Scott), 1894	.. —	×	××
*33.	<i>P. tollingerae</i> Sewell, 1919	.. ×	××	—
34.	<i>P. hickmani</i> Sewell, 1932	.. —	××	×
35.	<i>P. lobipes</i> Gurney, 1907	.. ×	××	—
*36.	<i>P. mertoni</i> Fruchtl, 1923	.. —	×	××
<b>Family TEMORIDAE</b>				
*37.	<i>Temora turbinata</i> (Dana), 1849	.. —	×	××
38.	<i>T. stylifera</i> (Dana), 1849	.. —	×	××
<b>Family CANDACIIDAE</b>				
*39.	<i>Candacia bradyi</i> A. Scott, 1902	.. —	×	××

		Limnetic ( $< \pm$ 0.5‰)	Mixo- haline 0.5- 30.0‰)	Euhaline (30.0- $\pm 40.0$ ‰)
Family PONTELLIDAE				
*40.	<i>Calanopia elliptica</i> (Dana), 1849 ..	—	×	×
*41.	<i>Labidocera pectinata</i> Thompson & Scott, 1903 ..	—	×	×
*42.	<i>L. pavo</i> Giesbrecht, 1889 ..	—	×	×
43.	<i>L. gangetica</i> Sewell, 1934 ..	—	×	×
44.	<i>L. kroyeri</i> Brady var. <i>nov?</i> Krishna-swamy, 1953 ..	—	×	×
*45.	<i>L. kroyeri</i> var. <i>gallensis</i> Thompson & Scott, 1903 ..	—	×	×
46.	<i>Pontella andersoni</i> Sewell, 1912 ..	—	×	×
*47.	<i>P. danae</i> Giesbrecht, 1889 var. <i>ceylonica</i> Thompson & Scott, 1903 ..	—	×	×
Family ACARTIIDAE				
*48.	<i>Acartia (Odontacartia) centrura</i> Giesbrecht, 1889 ..	—	×	×
*49.	<i>A. (O.) spinicauda</i> Giesbrecht, 1889 ..	—	×	×
*50.	<i>A. (O.) erythraea</i> Giesbrecht, 1889 ..	—	×	×
*51.	<i>A. (Acanthacartia) chilkaensis</i> Sewell, 1919 ..	—	×	—
*52.	<i>A. (A.) plumosa</i> T. Scott, 1894 <sup>1</sup> ..	—	×	×
*53.	<i>A. (Euacartia) southwelli</i> Sewell, 1914 ..	—	×	—
*54.	<i>A. (Odontacartia) pacifica</i> Steuer, 1915 ..	—	×	×
*55.	<i>A. sp.</i> <sup>2</sup> ..	—	×	×
*56.	<i>Acartiella keralensis</i> Wellershaus, 1969 ..	—	×	—
*57.	<i>A. gravelyi</i> Sewell, 1919 ..	—	×	×
58.	<i>A. major</i> Sewell, 1919 ..	—	×	×
59.	<i>A. minor</i> Sewell, 1919 ..	—	×	×
*60.	<i>A. sewelli</i> Steuer, 1934 ..	—	×	—
61.	<i>A. tortaniformis</i> Sewell, 1912 ..	×	×	—
Family TORTANIDAE				
*62.	<i>Tortanus (Tortanus) forcipatus</i> (Giesbrecht), 1892 ..	—	×	×

<sup>1</sup> Recorded also by Abraham, S. (1970 : *Curr. Sci.*, 39 (5) : 115-116).

<sup>2</sup> Described as *Acartia biloba* by Abraham, S. (1970 : *Crustaceana*, 18 (1) : 49-54).

## OBSERVATIONS ON CALANOID COPEPODS OF COCHIN BACKWATER

The hydrography of the Cochin Backwater has been studied by George (1958), George and Kartha (1963), Ramamirthm and Jayaraman (1963), Nair (1967), Cherian (1967), Qasim *et al.* (1969) and Qasim and Gopinathan (1969). All the above studies have shown that the hydrographic parameters are adapted to an annual rhythm showing sharp changes during the monsoon months with the onset of rain. According to the trend of salinity of the surface waters of this area, there appears to be three distinct periods in any year : (1) a period of low salinity from June to September, (2) a period of gradual rise in surface salinity from October to January and (3) a pre-monsoon period from February to May when the channel surface contains waters with salinity comparable to that of the inshore waters of Arabian Sea.

Monthly variations of salinity and temperature observed for the period of the present investigation are given in Figure 1b. The zooplankton abundance at the fixed station (Fig. 1a) was associated with the changes in the salinity and thus could be related to the monsoon cycle. Maximum standing crop occurred during the period of high salinity when its constituents become similar to that of the adjacent neritic waters. Low volumes were found to occur during July to September when the salinity of the surface water reaches minimum values due mainly to the large influx of freshwater. However, as shown by Qasim and Gopinathan (1969) the tidal influence on the salinity is quite considerable in the backwaters. The pronounced tidal flushing throughout the year due to the connection of the backwaters with the Arabian Sea results in the influx from time to time of many marine forms into the estuary. This incursion into backwaters of marine fauna is conspicuous during the months of high surface salinity but during monsoon months with the influx of freshwater many marine organisms disappear from the surface stratum.

## SEASONAL DISTRIBUTION AND FLUCTUATION OF CALANOID COPEPODS

Quantitative and qualitative estimations of calanoid copepods of Cochin Backwater have been made from plankton samples collected by 50 cm conical net of mesh size 0.33 mm along surface during July, 1968 to July, 1969 from a fixed station (Fig. 1a). Total estimates for 1,000 m<sup>3</sup> of water filtered have been calculated and monthly averages are plotted for the same period. A total of 38 species representing 21 genera and 11 families of calanoid copepods were encountered in the samples collected. Investigations on 13 species belonging to 6 families of calanoid copepods have been carried out to understand their distribution in the backwaters in time. Two distinct peaks were observed, one during November and the other during February (Fig. 1c). George (1958) opined that considering copepods as a whole 'the variations in the abundance have not clearly shown any relationship with the variations in the salinity, their maxima and minima having occurred during the periods of both low and high salinities'. However, based on the observed peaks in the occurrence of calanoids it would appear that copepod biomass is higher in backwaters during the periods of increase in temperature and salinity.

The species-wise analysis dealt with below comprise those species that are numerically abundant (Fig. 3).

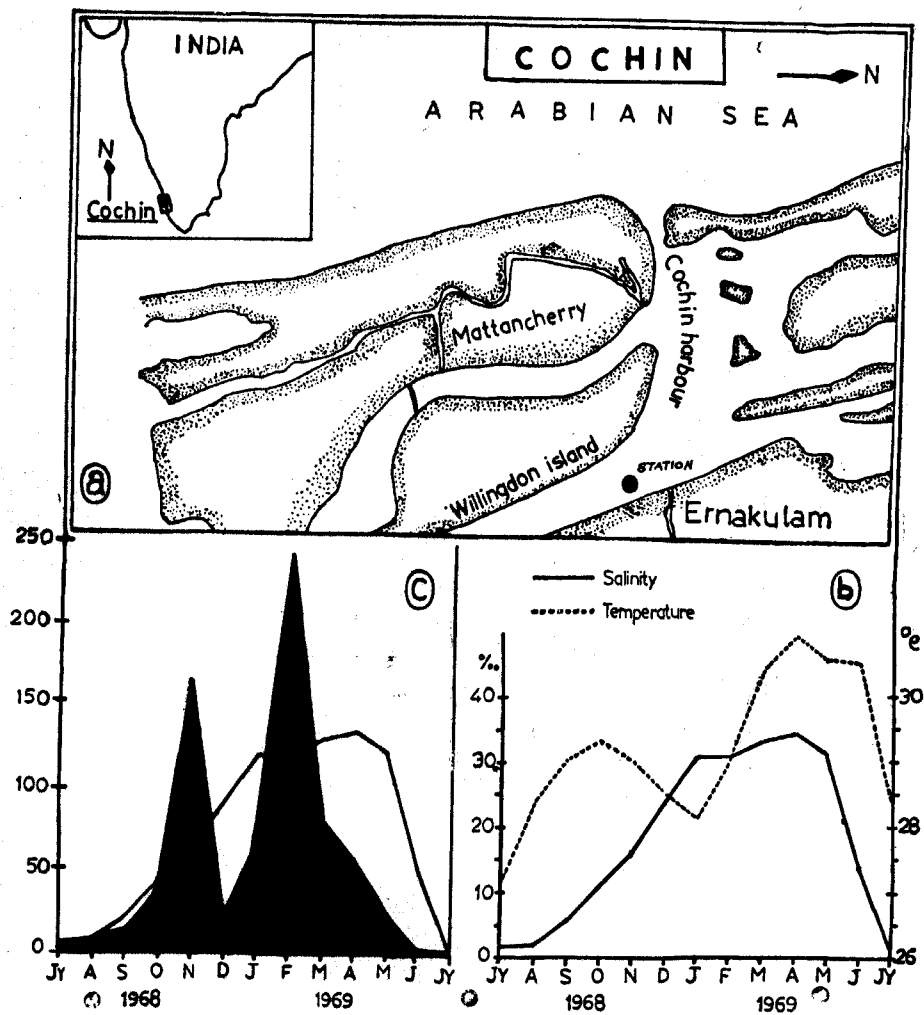


FIG. 1a. Map showing the station position in Cochin Backwater where observations were made. b. Fluctuation in salinity and temperature for the period July, 1968 to July, 1969. c. Monthly fluctuation in composition (Combined) of 13 species of calanoid copepods in the Backwaters during July, 1968 to July, 1969 in relation to the fluctuations in salinity.

#### Family Centropagidae :

*Centropages furcatus* (Dana) : (Fig. 3 a, b) A predominantly marine species. Present in the collection from November to May with a peak in February. During January, females were observed to carry spermatophores attached to the genital segment by coupler sheath. Different stages of copepodites were present from November to April.

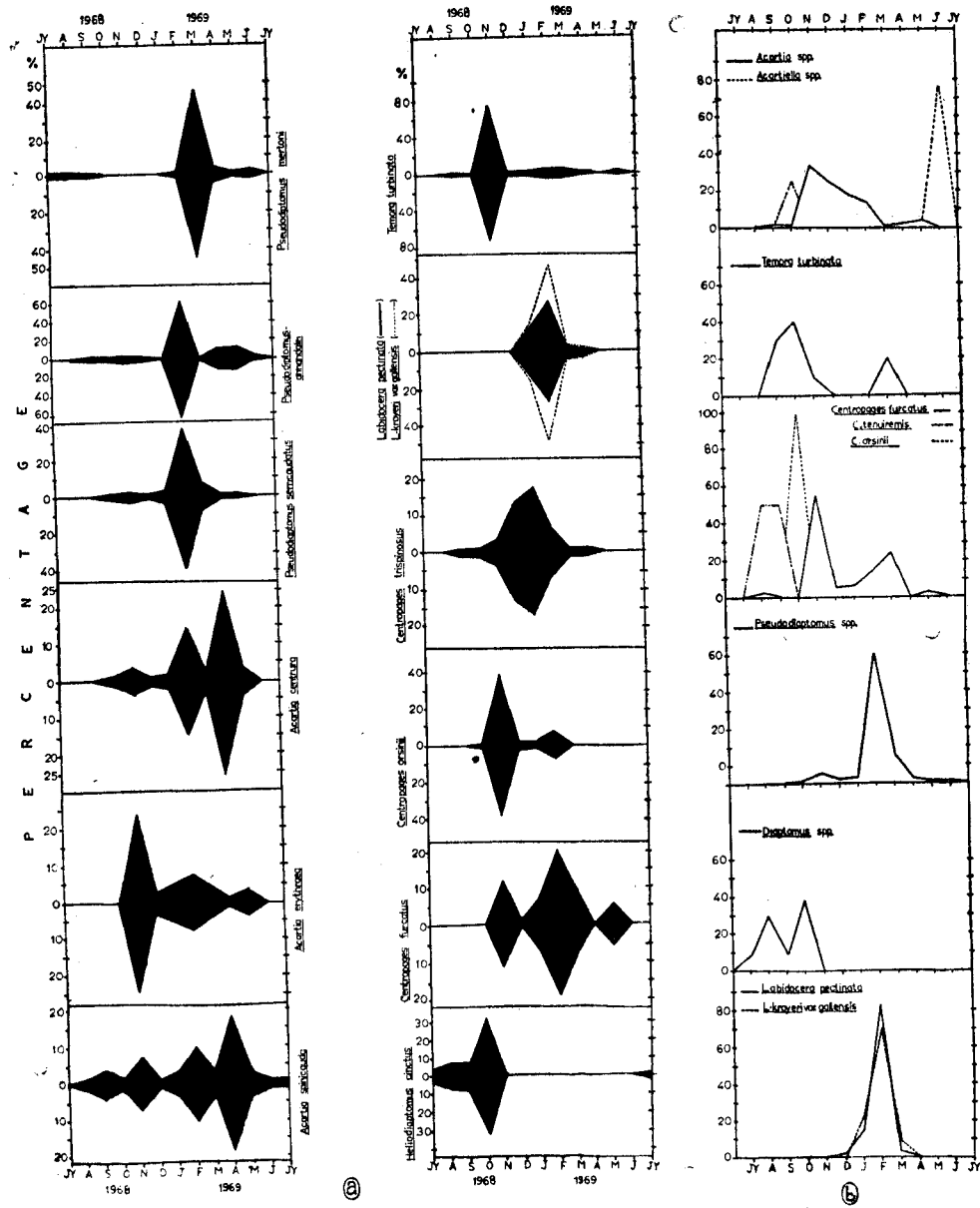


FIG. 3. Relative percentages, by counts, of 13 numerically abundant calanoid copepods in Cochin Backwater during the period of July, 1968 to July, 1969 (a=Adults, b=Copepodites)

*Centropages orsinii* Giesbrecht : (Fig. 3 a, b) Present from October to February with a peak in November. Several copepodites were present in November and females bearing spermatophores were observed during January and February.

*Centropages trispinosus* Sewell: (Fig. 3 a) Occurred in the plankton from September to April with a peak in January. Different copepodite stages were observed in December and January.

Family *Diaptomidae* :

*Heliodiaptomus cinctus* (Gurney): (Fig. 3a, b) A predominantly freshwater species, occurred in the collection from July to October with a peak period in October. Late copepodites were observed along with the adults during this period.

Family *Pseudodiaptomidae* :

*Pseudodiaptomus serricaudatus* (T. Scott): (Fig. 3a) Occurred in the collection from October to May with a peak in February. Late copepodites and adult females carrying eggs were present in the collections in January.

*Pseudodiaptomus annandalei* Sewell: (Fig. 3a) Occurred more or less throughout the year from September to June with a peak in February. Egg carrying females were observed in November and February.

*Pseudodiaptomus mertoni* Fruchtl: (Fig. 3a) Occurred twice during the period of observation, from July to September (peak in August) and from February to June (peak in March). During March copepodites were present along with the adults.

Family *Temoridae* :

*Temora turbinata* (Dana): (Fig. 3a) Present in the collections from September to June with a peak in November. During September, late copepodites were found along with adults.

Family *Pontellidae* :

*Labidocera pectinata* Thompson and Scott, and *L. kroyeri* var. *gallensis* Thompson and Scott: (Fig. 3a, b) Both are typical marine species and occurred during the periods of high salinity from January to April, registering a peak in February. Females of both these species bearing coupler sheath and spermatophores were observed in the collections during January and February. Different copepodite stages of these species occurred from January to April.

Family *Acartiidae* :

*Acartia spinicauda* Giesbrecht: (Fig. 3a) Present in the collections throughout the year from August to July, with a peak in April.

*Acartia centrura* Giesbrecht: (Fig. 3a) Present from October to May with a peak in April.

*Acartia erythraea* Giesbrecht: (Fig. 3a) Occurred in the collections from November to May registering a peak in November.

A study of the distribution patterns of various species that are recorded from the backwaters and the range of salinity within which each species in the collection has been found to exist shows that many species are having limited distribution,



particularly the marine element, in the estuary (Fig. 2). No decisive conclusion could be drawn on the tolerance of these species to different salinity gradients as only limited data is available.

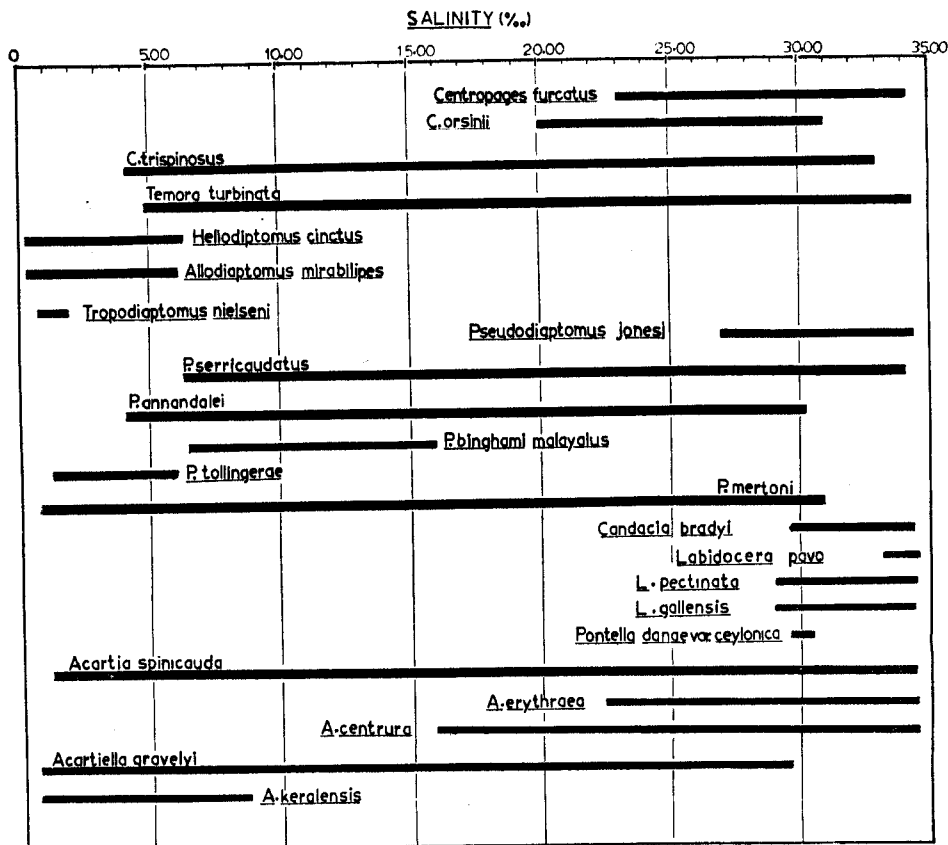


FIG. 2. Observed salinity ranges of 23 species of calanoid copepods found in the Backwaters.

A general survey of the collections show that many species such as *Centropages furcatus* (Dana), *Pseudodiaptomus jonesi* Pillai, *P. serricaudatus* (T. Scott), *Temora turbinata* (Dana), *Acartiella* spp. and *Acartia* spp. were breeding in the backwaters. It is also noted that typically marine species such as *Labidocera pectinata* Thompson and Scott, *Labidocera kroyeri* var. *gallensis* Thompson and Scott, and the fresh water species *Heliodiaptomus cinctus* (Gurney), evincing fortuitous distribution in the backwater areas were also found to carry eggs and spermatophores during the periods of incursion into brackishwaters. It would appear from the data presented earlier that the main breeding season for these 13 dominant species is from November to March. Further studies on the biology of estuarine copepods are in progress for understanding the breeding cycles of different species of copepods and the number and longevity of the broods.

The present investigations as well as the works by earlier authors (Sewell, 1956 ; George, 1958) show that the calanoid copepods of the families Pseudodiaptomidæ and Acartiidæ offer good examples of spatial distribution in relation to different ecological conditions. Gradations of distribution from marine to freshwater conditions are evinced by different species of the above families as indicated below :

## MARINE TO FRESHWATER

<i>Acartia southwelli</i>			
<i>A. erythraea</i>		<i>A. chilkaensis</i>	
<i>A. spinicauda</i>		<i>Acartiella minor</i>	<i>Acartiella tortani-</i>
<i>A. centrura</i>	<i>A. plumosa</i>	<i>A. major</i>	<i>formis</i>
<i>Pseudodiaptomus</i>	<i>Acartiella</i>	<i>P. tollingeræ</i>	<i>P. lobipes</i>
<i>serricaudatus</i>	<i>gravelyi</i>	<i>P. binghami-</i>	FRESHWATER
<i>P. mertoni</i>	<i>A. keralensis</i>	<i>malayalus</i>	
<i>P. aurivillii</i>	<i>P. annandalei</i>	BRACKISH &	
<i>P. hickmani</i>	<i>P. binghami</i>	FRESHWATER	
<i>P. ardjuna</i>			
<i>P. jonesi</i>	BRACKISH		
MARINE & BRACKISH			

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