Seasonal variations in abundance, biomass and ecological significance of microzooplankton in tropical coastal marine waters, South India

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- **Microzooplankton are the heterotrophic organisms whose size generally ranges between 20 µm and 200 µm.**

- **Microzooplankton communities include organisms belonging to the various systematic groups including small metazoan larval forms of both pelagic and sessile, sedentary and benthic organisms, besides a vast number of protozoan ciliates.**

Importance and ecological significance

- Microzooplankton are often constitute a significant component of the plankton community in many marine environments

- They are ubiquitous in distribution and abundant in the marine coastal, estuarine, brackish-water and freshwater lakes

- They are ecologically important group among marine zooplankton

- Because of small body size, they have higher weight- specific physiological rates such as feeding, respiration, excretion and growth rates than large metazoans

- Hence, they are important phytoplankton grazers by capable of exploiting pico- and nanoplankton, which are highly abundant in any marine coastal and estuarine systems

- However, these small size pico-and nanoplankton can not be utilized fully by the larger meso- and macrozooplankton

- Thus, microzooplankton are play an important link in transferring pico-and nanoplankton production to higher trophic levels, thus the loss of energy can be minimized while the energy transfer

- They are important regenerators and also they are the suitable food source for small, first feeding larvae of many shell and fin fishes

- Also they have link in the "microbial loop", which mediates crucial flow of energy and matter in the sea

- Further, the importance of microzooplankton has been well recognized by the Global Ocean Ecosystems Dynamics (GLOBEC) and Joint Global Ocean Flux Study (JGOFS) programs that they play a key role in the particle transformation and nutrient cycling in the oceans.

Table 1. Regional comparisons of system characteristics from dilution experiments. Data are distinguished among *Oceanic*, *Coastal* (overlying the continental shelf), and *Estuarine* (including coastal bays) habitats in the upper table and among *Tropical/Subtropical*, *Temperate/Sub-polar*, and *Polar* regions in the lower table. Mean values (± standard errors) are given for initial Chl *a*, phytoplankton growth rate (μ), grazing mortality (m), and percentage primary production grazed d^{-1}. Exp = number of experimental estimates averaged for the region, out of a total of 788.

	Exp (% total)	Chl *a* ($\mu g\ l^{-1}$)	μ (d^{-1})	m (d^{-1})	% PP grazed
Oceanic	510 (65%)	0.58 ± 0.03	0.59 ± 0.02	0.39 ± 0.01	69.6 ± 1.5
Coastal	142 (18%)	3.06 ± 0.53	0.67 ± 0.05	0.40 ± 0.04	59.9 ± 3.3
Estuarine	136 (17%)	13.0 ± 1.8	0.97 ± 0.07	0.53 ± 0.04	59.7 ± 2.7
Tropical	259 (33%)	1.01 ± 0.21	0.72 ± 0.02	0.50 ± 0.02	74.5 ± 2.0
Temperate	435 (55%)	5.18 ± 0.66	0.69 ± 0.03	0.41 ± 0.02	60.8 ± 1.8
Polar	94 (12%)	0.62 ± 0.06	0.44 ± 0.05	0.16 ± 0.01	59.2 ± 3.3

Table 2. Calculated estimates of microzooplankton secondary production ($MP_{2°}$) as a percentage of daily primary production. Calculations are based on the mean regional/habitat estimates of microzooplankton grazing on phytoplankton from Table 1 with assumed gross growth efficiencies (GGEs) of 30% and 40%.

	GGE = 0.3	GGE = 0.4
Oceanic	23.9	31.8
Coastal	21.0	28.0
Estuarine	20.9	27.9
Tropical	25.4	33.8
Temperate	21.2	28.3
Polar	20.8	27.7

Ref.: Landry and Calbet, ICES J. Mar. Sci.,2004, (61): 501-507

Why MZ communities ignored in early periods?

- their smaller size
- Lack of proper methodology for collection, preservation and difficulties in identification
- Lack of proper techniques for culturing of MZ

OBEJCTIVES

- ⇒ **to study the seasonal variations in abundance, biomass and estimated production rate of microzooplankton communities in tropical marine coastal waters, south India**

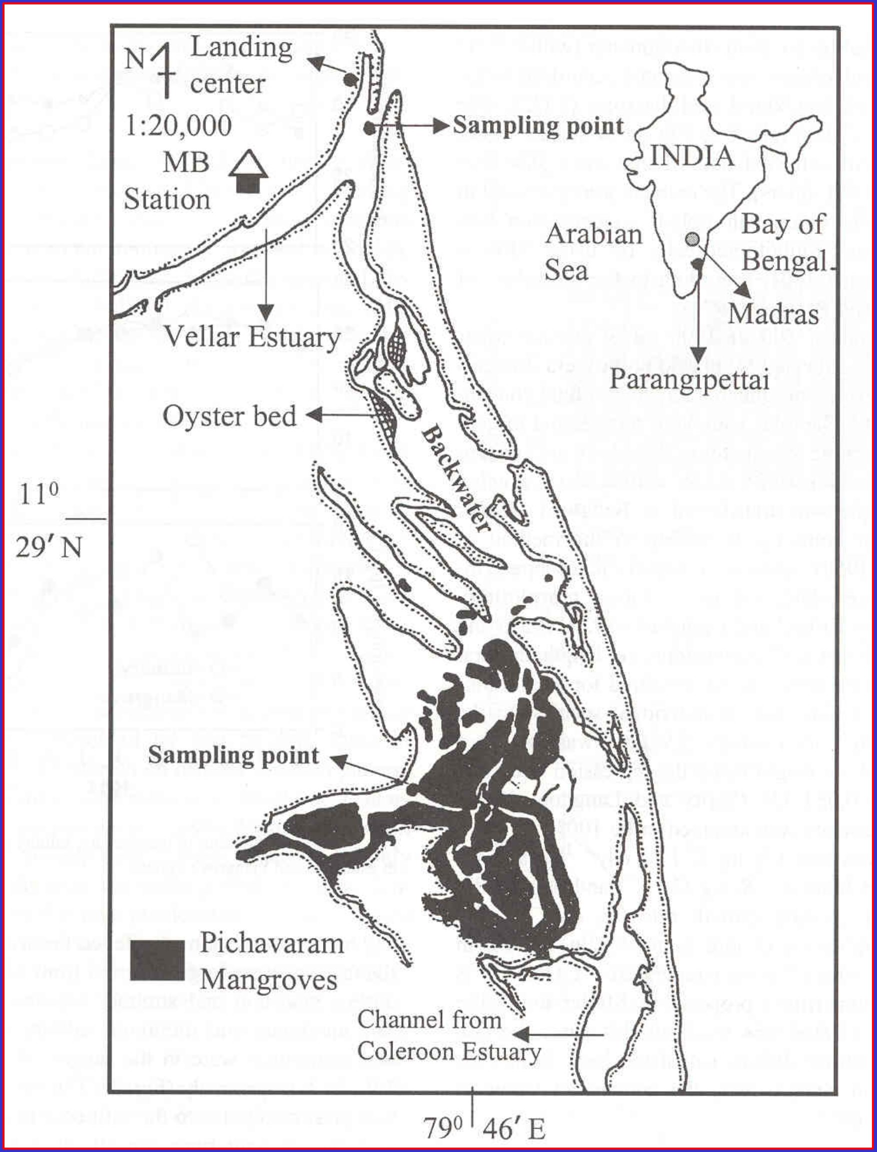
- ⇒ **to study the influence of environmental parameters on the abundance of microzooplankton**

- ⇒ **to assess the trophodynamic role of microzooplankton, with reference to phytoplankton grazers in natural environments**

- ⇒ **to document microzooplankton research and rich zooplankton diversity in order to emphasis the importance of India’s participation in the international research programs such as GLOBEC, LME, HAB and PICES**

Tropical Vellar Esturary

- ❖One of the most important productive tropical estuarine system at South India with a complexity of environmental conditions
- ❖Shallow in nature (average depth 2.5 m) and maximum depth 5.2 m
- ❖Based on salinity gradient, the estuary has been divided into 4 zones
- ❖Plankton rich ecosystem – 330 species of phytoplankton, 58 species of zooplankton were identified
- ❖The mixing proportions of seawater and fluviatile elements may be changed seasonally and the water temperature and salinity may also be influenced by the degree of mixing. Thus it providing an unique hydrographic and environmental conditions



Materials & Methods

Environmental Parameters

Temperature: Celsius thermometer
Dissolved Oxygen and Salinity: argentmetry method (Strickland & Parsons, 1972)

Chlorophyll *a*

Water samples were collected (500 ml)

↓

Filtered through Whatmann GF/C filter paper (0.4 µm) by using vacuum filter unit

↓

Extracts were prepared in 90% acetone

↓

Chlorophyll a concentration measured (Strickland & Parsons, 1972)

Rainfall - obtained from our Center Meteorological Unit, Chennai, INDIA

Microzooplankton Collection

Sedimentation method

500 – 1000 ml surface water sample were collected in a plastic bottle

↓

Samples immediately fixed with glutaraldehyde

↓

Kept refrigerated at ca. 3^{o}C in darkness until examination

↓

Samples were concentrated to a final volume of 25 ml

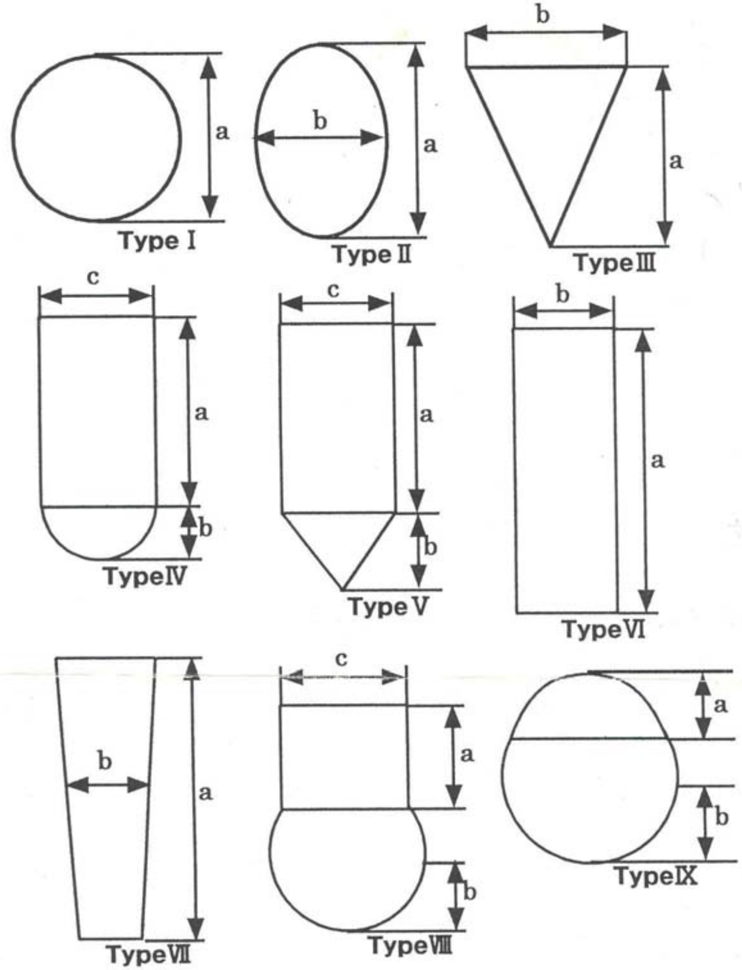
↓

From the concentrated sample, 10 ml was transferred to Sedgwick-Rafter for counting, according to the method of Utermohl (1958) under an inverted microscope

↓

Standard identification manuals are used for species level identification

Geometric configuration for calculating cell volume or Lorica volume of microzooplankton



Equations

Type I : $1/6\,\pi\, a^3$

Type II : $1/6\,\pi\, ab^2$

Type III : $1/12\,\pi\, ab^2$

Type IV : $\pi/12(3ac^2+b^3)$

Type V : $\pi/12(3ac^2+bc^2)$

Type VI, VII : $1/4\,\pi\, ab^2$

Type VIII : $\pi/4(ac^2+b^3)$

Type IX : $\pi/3(4a^3+3b^3)$

Microzooplankton groups based on geometric configuration to calculate cell volume and lorica volume

Type	Microzooplankton Group		
I	Naked ciliate		
II	Naked ciliate		
III	Naked ciliate		
IV	*Tintinnopsis lobiancoi*	*Tintinnopsis nana*	*Tintinnopsis tenuis*
V	*Tintinnopsis ampla*	*Tintinnopsis beroidea*	*Tintinnopsis kofoidi*
	Tintinnopsis radix	*Helicostomella longa*	*Helicostomella fusiformis*
	Helicostomella sp.	*Favella azorica*	*Favella ehrenbergii*
	Favella taraikaensis	*Codonella* sp.	
VI	*Tintinnidium* spp.		
VII	*Eutintinus rectus*	*Eutintinus lususundae*	*Eutintinus* sp.
VIII	*Tintinnopsis buchlii*	*Tintinnopsis direct*	*Steneosemella* sp.
IX	Rotifers		

Estimation of biomass, production rate and growth rate of microzooplankton

Biomass of naked ciliates:

- Cell volume (based geometric configuration)
- body carbon weight (using factor of 0.14 pg C μm^{-3} (Putt and Stoecker, 1989)
- ***Cn=0.14CV*** (Cn –body carbon weight (pg); CV cell volume (μm^{-3})

Tintinnids:

- Lorica volume (based geometric configuration)
- body carbon weight using the regression equation (Verity and Langdon, 1984)
- $C_t = 444.5 + 0.053$ LV (C_t body carbon weight (pg); LV Lorica volume (μm^{-3})

Tintinnids:

Cell volume was back calculated from their body carbon weight (using factor value of 0.14 pg C μm^3, that used in naked ciliates.

Copepod nauplii:

Regression equation that describes the composite relationship between specific growth rate and temperature (°C) was used: $g=0.057e^{0.069T}$ (Uye et al., 1996).

Ecological Seasons

In this tropical region, southwest and northeast monsoons are active and our coast (Tamil Nadu) gets the maximum rainfall during northeast monsoon from October to December.

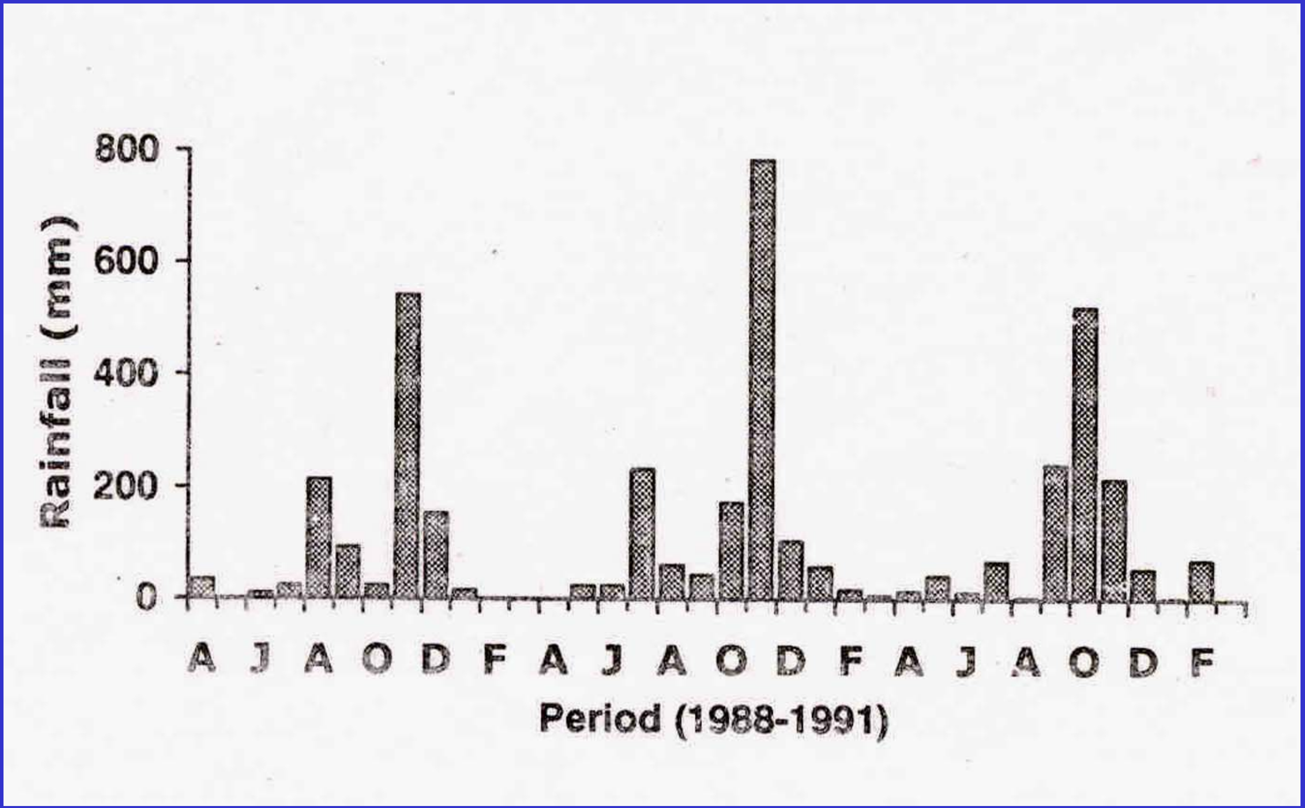
The remaining 9 months i.e. from January to September show warmer temperature and called as 'dry months'.

Accordingly, the year is divisible into 4 different seasons. They are as follows:-

Postmonsoon	**: January – March**
Summer	**: April – June**
Premonsoon	**: July – September**
Monsoon	**: October - December**

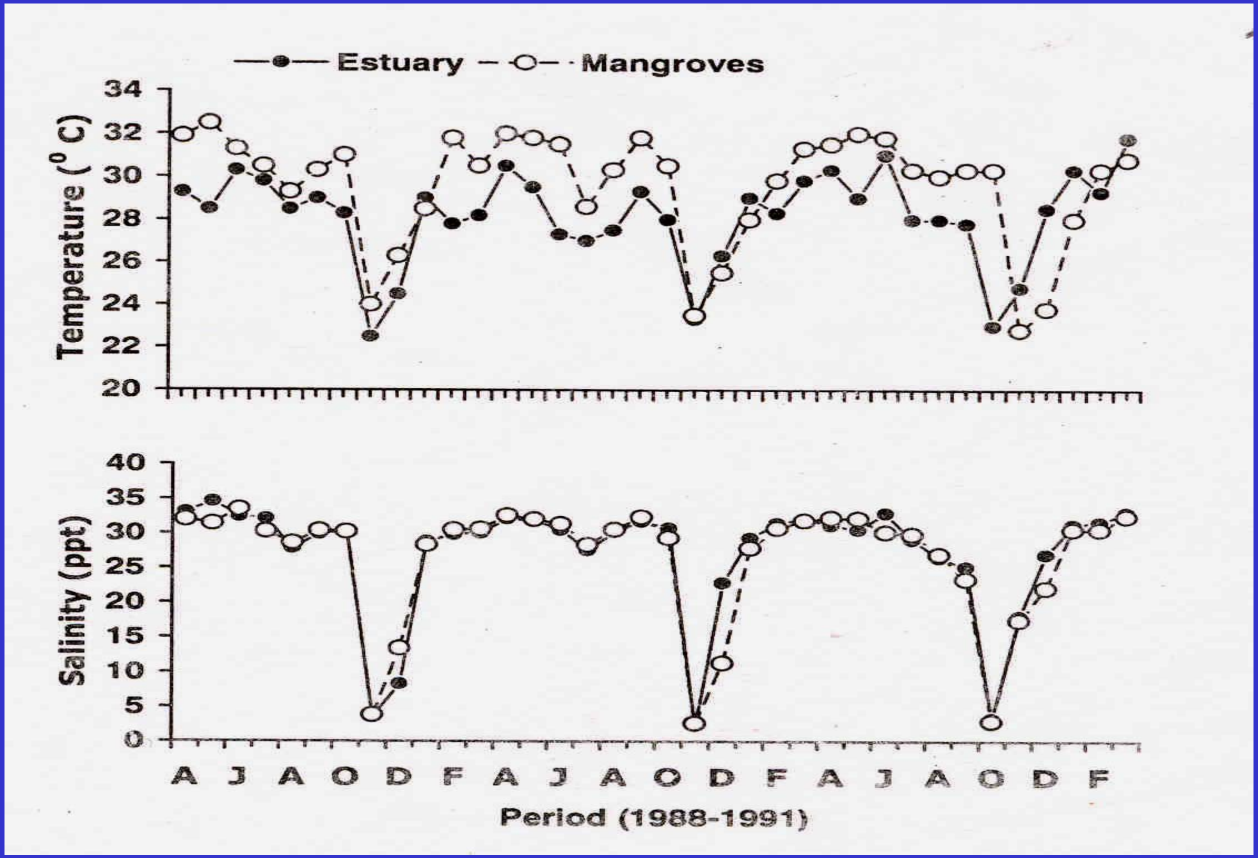
Results

Monthly rainfall in Parangipettai coastal region



- Annual precipitation is usually around 1,400 mm (±20%)
- We get rain totally 1000 mm during the rainy monsoon season (October –December) by active northeast monsoon

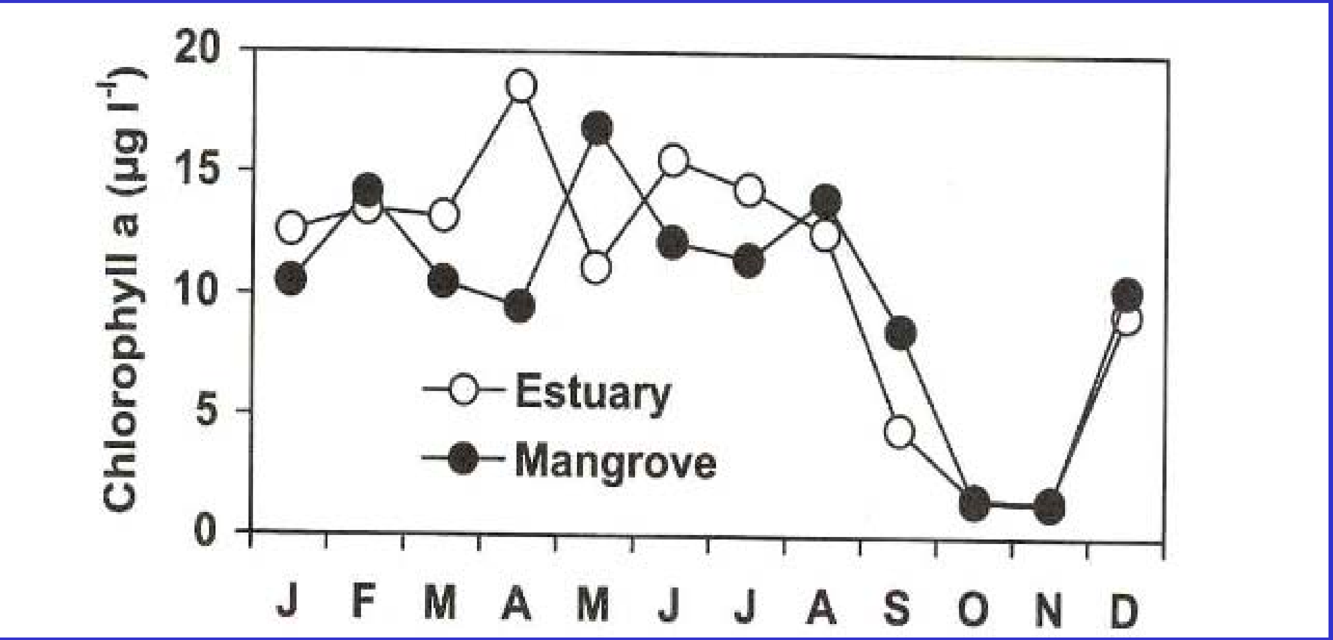
Seasonal variations in temperature and salinity in the tropical estuarine and mangrove system



❖Environmental parameters such as surface water temperature and salinity were highest in summer and lowest in monsoon months

❖Temperature varied from 22.5 to 31.8°C and salinity varied from 2.3 to 34.6 ppt

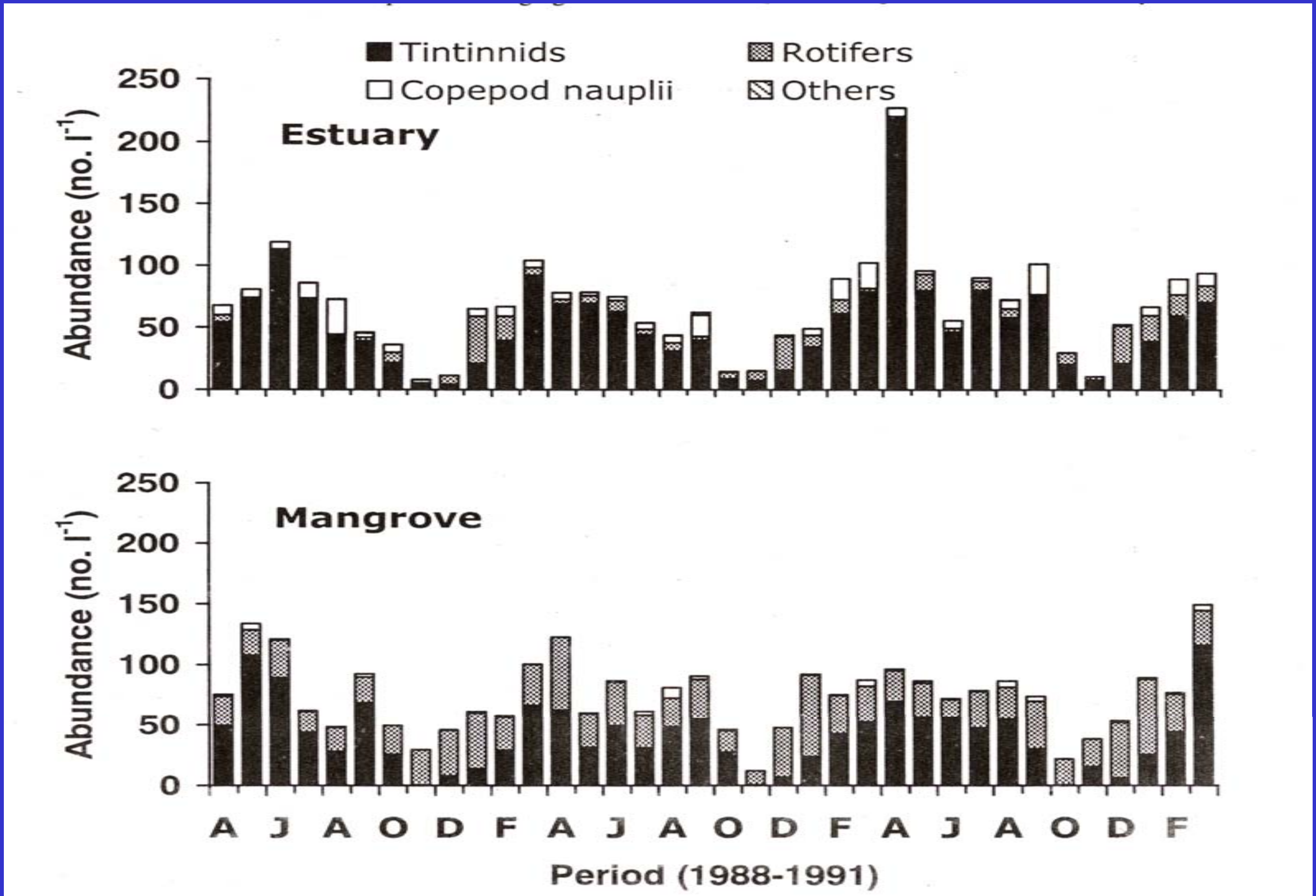
Seasonal variations in chlorophyll *a* concentration in estuarine and mangrove system



- Chlorophyll *a* concentration varied from 1.5 to 18.6 and 1.4 to 16.9 μg l^{-1} in estuarine and mangrove waters, respectively.

- Average chlorophyll *a* concentration were higher 3.2 fold (estuary) and 2.9 fold (mangrove) in summer compared to monsoon season

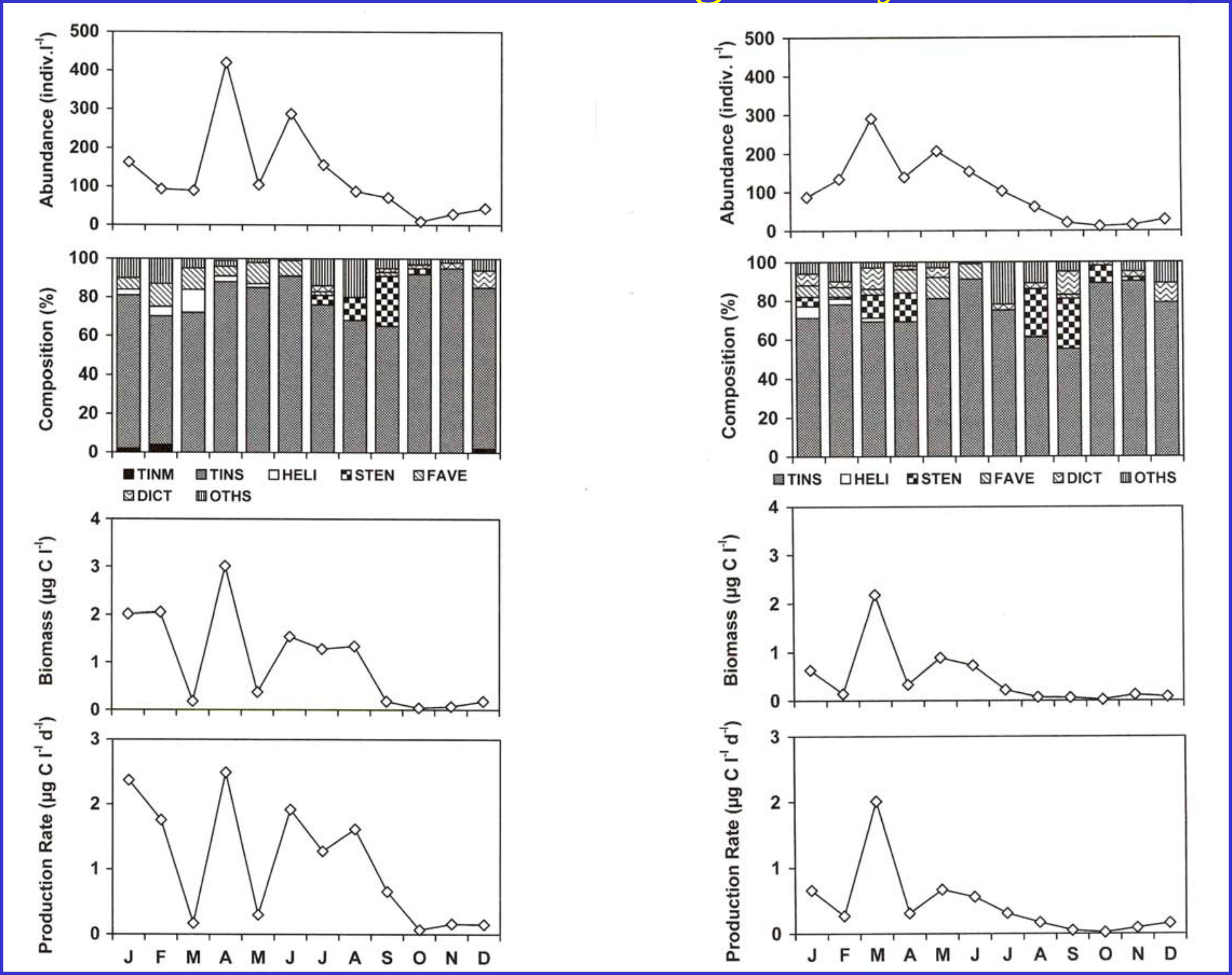
Seasonal variations in abundance of microzooplankton in tropical estuarine and mangrove system



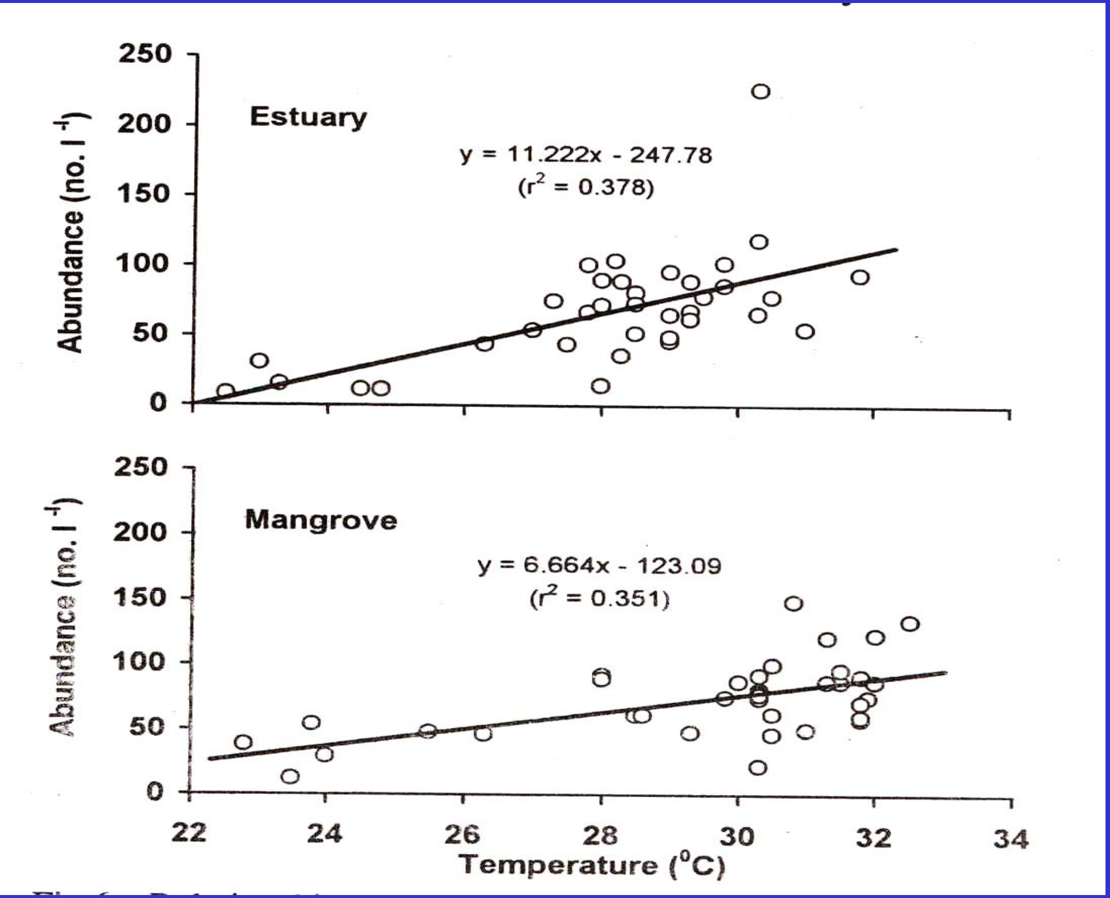
➢A total of 82 species of microzooplankton, consisting of naked ciliates, tintinnid ciliates, rotifers, copepod nauplii and early stages of mesozooplankton were identified.

➢The overall mean abundance (3.8 fold) was higher in summer than in monsoon season; tintinnids made larger contributions to the total abundance (overall mean:75%), followed, in order, by rotifers (12%), copepod nauplii (10%) and others (3%).

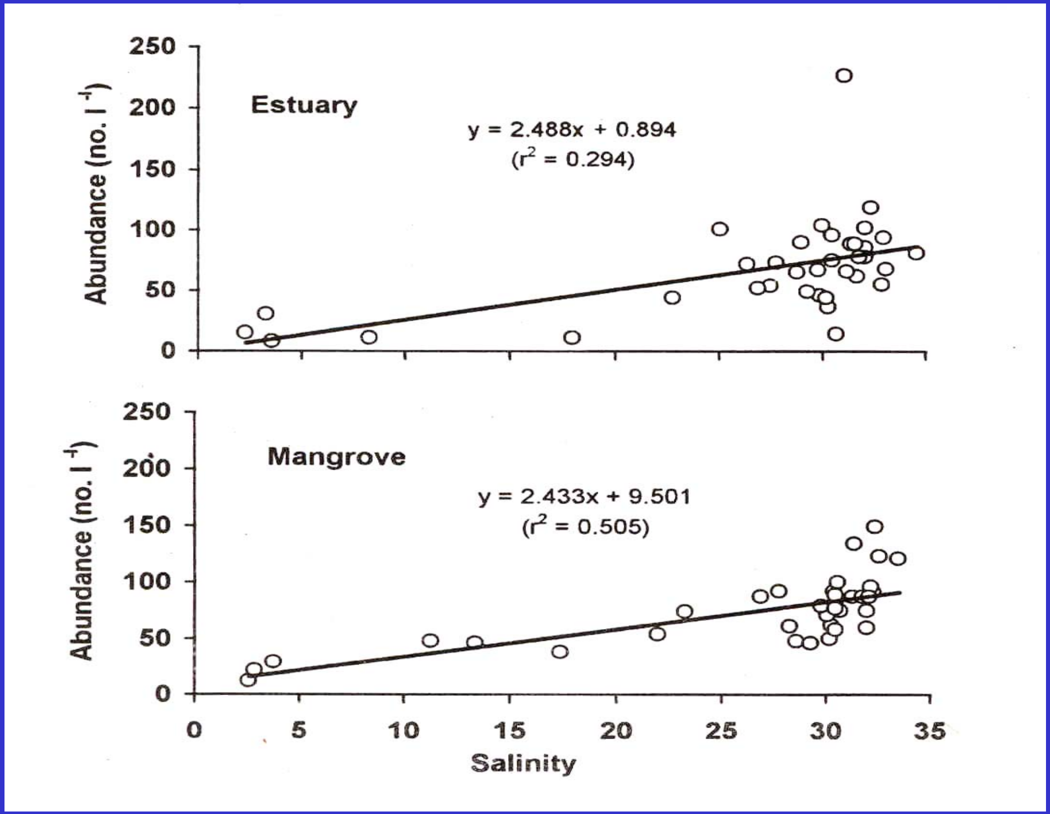
Seasonal variations in abundance, species composition, biomass and estimated production rates of tintinnids in estuarine and mangrove system



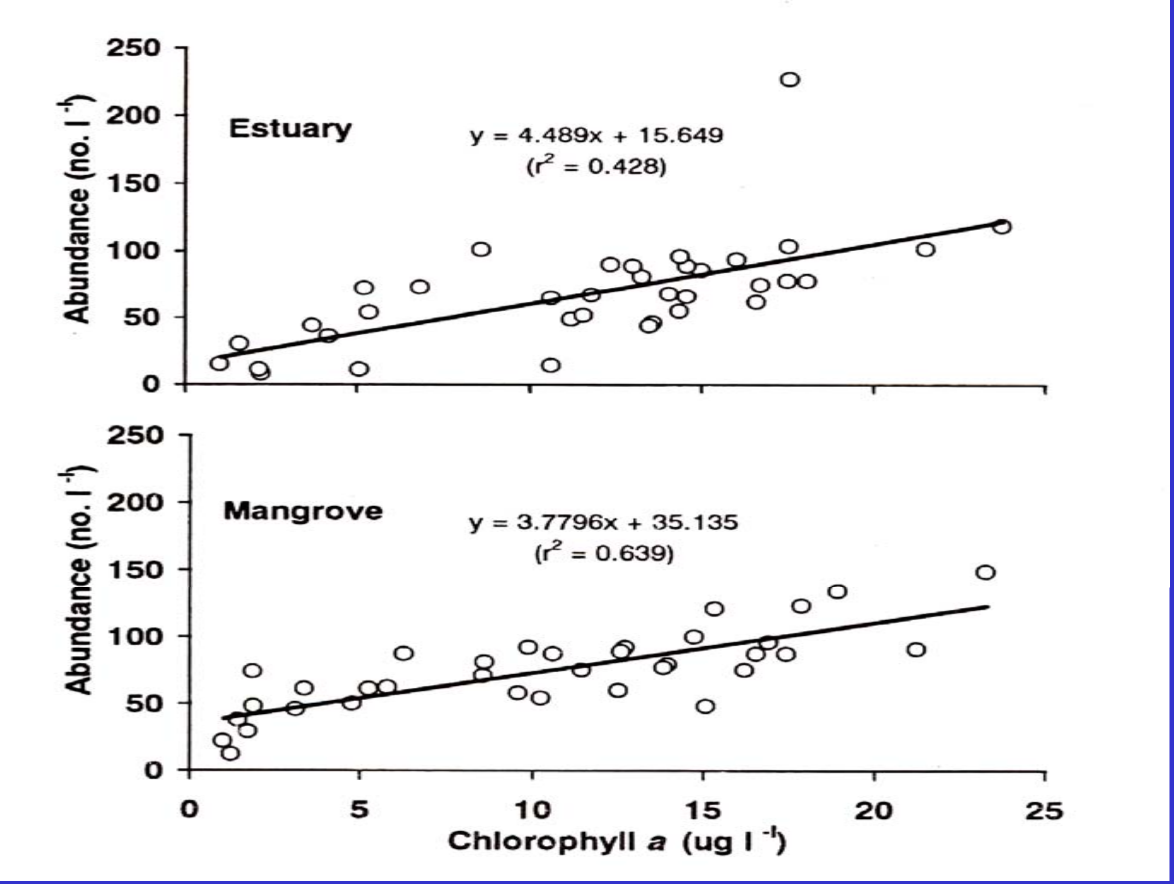
Relationship between abundance of MZ and water temperature in Estuarine and mangrove system



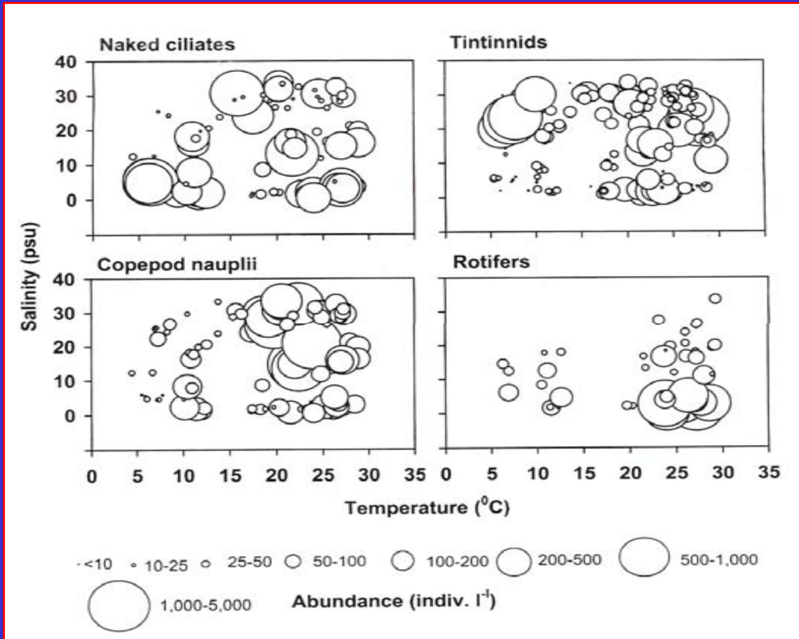
Relationship between abundance of MZ and salinity in Estuarine and mangrove system

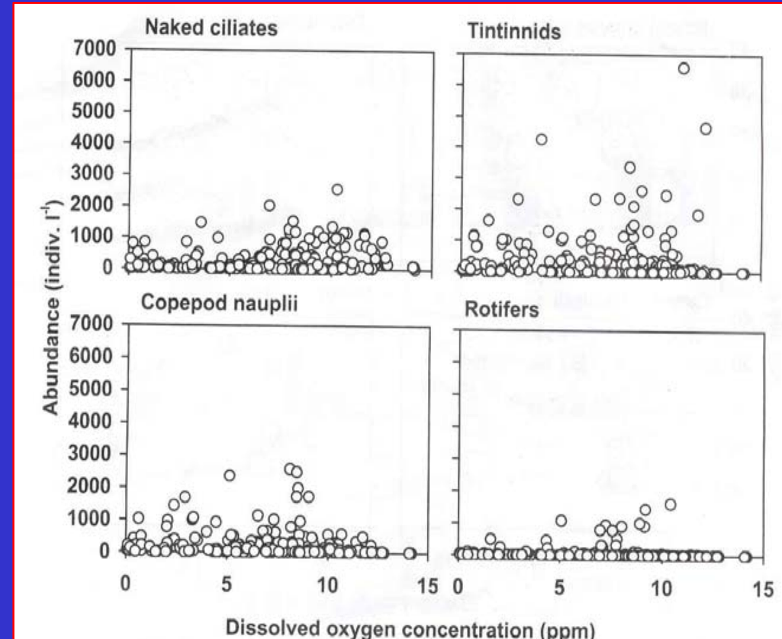


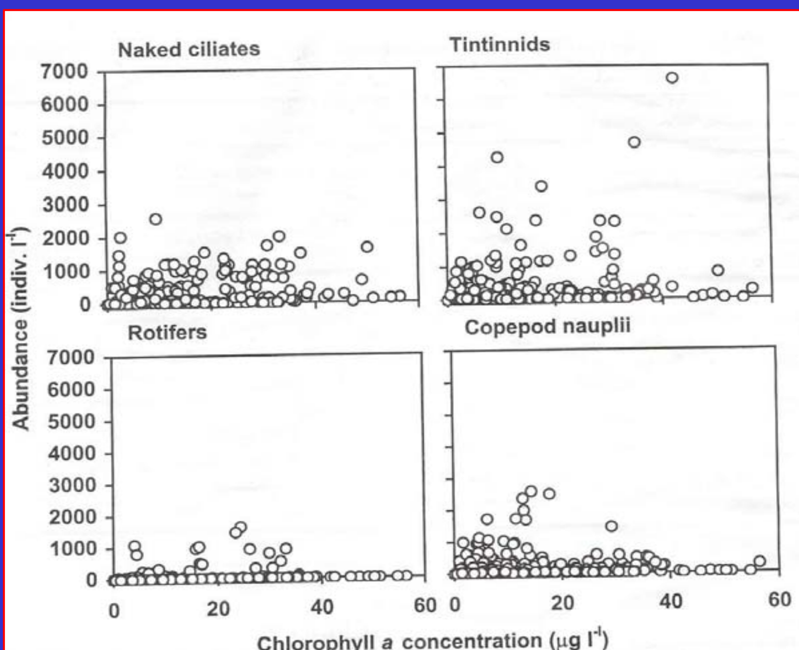
Relationship between abundance of MZ and chlorophyll *a* concentration in estuarine and mangrove system

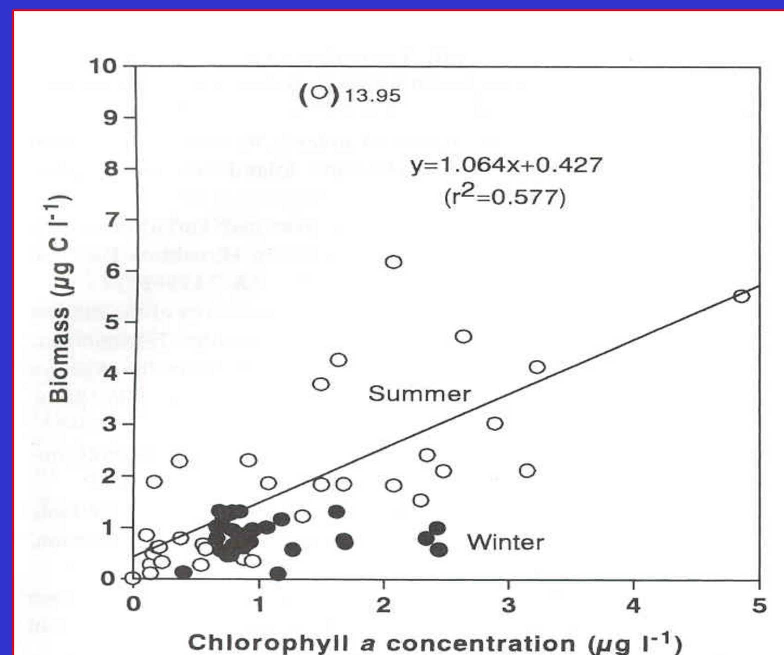


Influence of environmental parameters









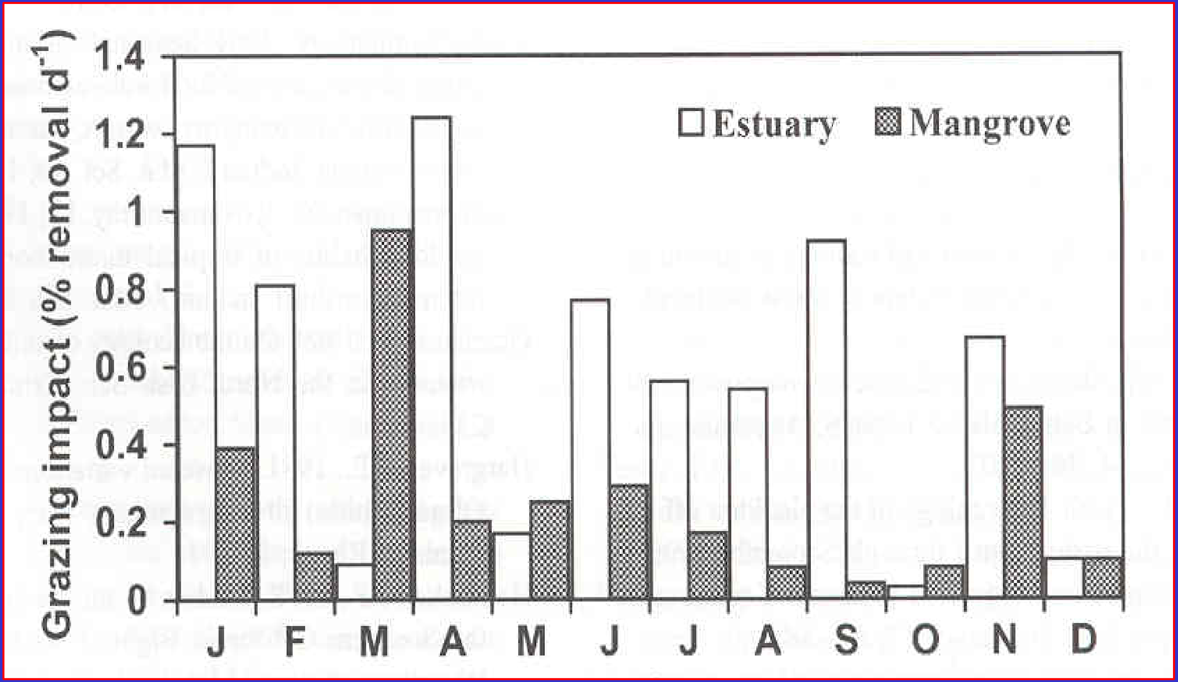
Trophodynamic role of microzooplankton

- Trophic significance of microzooplankton can be assessed by estimating their daily removal rate of phytoplankton biomass

- For phytoplankton biomass, it can be estimated from chlorophyll *a* concentration by using carbon:chlorophyll ratio of 40 (Parsons et.al., 1984)

- The required carbon (i.e food – phytoplankton) to meet the production of microzooplankton was estimated by assuming the gross growth efficiency - 0.4 for ciliated protozoan (Fenchel, 1987) and 0.3 for copepod nauplii (Ikeda and Motoda, 1978)

Seasonal variations in grazing impact of tintinnids as expressed by (%) removal of phytoplankton biomass per day in estuary and mangrove ecosystems, South India



CONCLUSIONS

❖ The taxonomic composition, abundance, biomass and estimated production rate of microzooplankton (MZ) varied seasonally due to temperature variations and salinity gradients

❖ There exists a tight coupling between the environmental parameters and abundance of MZ, hence the change of environmental variability during the non-monsoon and monsoon seasons not only affect the diversity and distribution pattern of MZ, it may also ultimately alter the feeding pattern and the trophic structure of the tropical Vellar estuarine system.

❖ The taxonomic composition of MZ between tropical and temperate waters are varied. Tintinnid ciliates are dominant group in tropical waters whereas naked ciliates are the abundant in temperate waters

- ❖Tintinnid species occurred in this tropical waters are closely associated with the species-specific environmental conditions that required to encystment or excystement.
- ❖Based upon the collective study of tintinnids (from 1975 to 2005) size categories and numerical abundance presumably indicated that tintinnids harbored in the estuarine and mangrove waters may be suitable food sources for first feeding fish larvae of many fishes.
- ❖Trophodynamic role of MZ demonstrated that they are the important grazers of phytoplankton biomass from the natural systems. Thus, tintinnid-based food web is changing remarkably due to characterized seasonal environmental conditions of the Vellar estuarine and mangrove systems.
- ❖Based upon the detailed study conducted in tropical as well as temperate waters supports the growing body of evidence that these smaller-size MZ are ubiquitous and play an important role as a trophic link between pico- and nanoplankton and meso-and macro-metazoan predators and fishes in range of marine environments.

- Intensive zooplankton research undertaken in tropical Vellar estuarine systems, South India richly contribute its impact globally towards the establishment of Asian Zooplankton Atlas

- Because of the zooplankton species diversity in Indian waters, India's participation has become eminent in international scenario.

Acknowledgement

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THANK YOU