

DISTRIBUTION OF PELAGIC TUNICATES IN THE WESTERN PART OF THE BAY OF BENGAL

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ABSTRACT

A total of thirty-three species and two varieties of pelagic tunicates are reported from the western part of the Bay of Bengal. The influence of the prevailing water movements, temperature and salinity on the distribution of pelagic tunicates at the surface and in the subsurface is considered. The suitability of *Oikopleura intermedia*, *Fritillaria borealis* f. *sargassi*, *Fritillaria pellucida*, *Thalia democratica* var. *orientalis* and the western-Pacific form of *Thalia democratica* as indicators of water movements is suggested.

INTRODUCTION

THE plankton organisms, whose powers of movement are feeble are at the mercy of the currents and they can be taken as indicators of water movements. The periodic physico-chemical fluctuations in the seas around India, subjected to the two monsoon winds and currents have a pronounced effect on the plankton organisms. The individuals that are adapted to certain temperature and salinity conditions in one season may find themselves existing under totally different conditions during another period of the year. The wide fluctuations in the physico-chemical conditions in the Bay of Bengal are a result of the unique meteorological conditions that are associated with the south-west and the north-east monsoons. They not only reverse the circulation pattern of the water with the season but also provide the heavy rainfall which dilutes the waters of the Bay of Bengal.

Sewell (1926) and Nair (1949) made reports on the seasonal distribution of Thaliacea in the Bay of Bengal. It was indicated that the distribution was by no means uniform and that a very clear seasonal periodicity in their occurrence was noticeable in the surface waters. Ganapati and Bhavanarayana (1958) made some preliminary observations on the occurrence of pelagic tunicates in relation to the current patterns and the prevailing temperature and salinity characteristics in the Bay of Bengal.

A study on the occurrence of pelagic tunicates in the western part of the Bay of Bengal was undertaken with a view to study the distribution of the group in relation to the water movements and their associated temperature and salinity structure at different levels in the sea.

MATERIAL AND METHODS

The plankton samples collected from a fixed station at about 20 m. line in the Bay of Bengal off Visakhapatnam coast in Lawson's Bay during 1956-61 were analysed for pelagic tunicates. The plankton samples collected from about 750 stations during the first fifty-two oceanographic cruises conducted by the Andhra University during the years 1952-57 were also analysed and the pelagic tunicates identified. The cruises were made from October to May and the area off Visakhapatnam was repeatedly traversed during the oceanographic cruise programme.

The horizontal plankton tows were made with a net of 1.8 m. length and 0.6 m. diameter made of fine bolting silk (with no flow-meter attached and with approximately 22 meshes per cm.) was used. To the cod end of the net a 500 ml. capacity collector with a stop-cock was tied. A number of samples were also collected from specific depth ranges by means of a plankton net provided with a closing device.

Rough numerical estimates were made and letters were employed only to denote the presence of pelagic tunicates within certain numerical ranges. They are:

Rare

$$(R) = 1-5$$

Frequent

$$(F) = 5-20$$

Common

$$(C) = 20-100$$

per sample of roughly 500 ml.

HYDROGRAPHY OF THE AREA

The surface currents off the east coast of India are north-easterly during January-May and south-westerly during October-December period.

Hydrography of the western part of the Bay of Bengal has received considerable attention (Sewell, 1929, 1932; La Fond, 1954, 1957, 1958; Ganapati

et al., 1956; Ganapati and Satyanarayana Rao, 1959; and Banse, 1960). The annual range of temperature is about 25–29° C. The temperature goes down from about 27.5° C. during October to about 25.0° C. during December. From January onwards there is a gradual increase in temperature which is due to the reversal of the surface current pattern from North–South to South–North bringing in warm equatorial Indian Ocean waters into the Bay. The upwelling of the deeper, cooler water takes place during March–May period. However, the high temperature values (about 27.5° C. to 28.5° C.) during this period suggest an overwhelming effect of summer heating over the upwelled waters. The sudden lowering in salinity during October–November period is due to the prevailing south-westerly current which brings in large volumes of highly diluted water from the major rivers north of Visakhapatnam which are full after the south–west monsoon. The salinity gradually rises from December onwards when there is a reversal of the current pattern in a northerly direction bringing into the Bay the highly saline equatorial waters. The high salinity values (about 34.5‰) during the March–May period is also due to the upwelling of the deeper waters during this period.

During October–November period the surface water mass is the Northern Dilute Water (σ_t = less than 19). The water mass prevailing during January–May period is largely the Southern Bay of Bengal Water (σ_t = 21–22). During March–May period the Upwell Water (σ_t = 22–23) also comes up to the surface through upwelling of the deeper waters (La Fond, 1958).

LIST OF PELAGIC TUNICATES RECORDED FROM THE AREA

A total number of thirty-three species and two varieties of pelagic tunicates were recorded during the present investigation. They are:

Oikopleura longicauda, *Oikopleura fusiformis*, *Oikopleura dioica*, *Oikopleura rufescens*, *Oikopleura albicans*, *Oikopleura cophocerca*, *Oikopleura intermedia*, *Megalocercus huxleyi*, *Pelagopleura gracilis*, *Stegosoma magnum*, *Fritillaria formica*, *Fritillaria haplostoma*, *Fritillaria borealis* f. *sargassi*, *Fritillaria pellucida*, *Fritillaria abjornseni*, *Fritillaria fraudax*, *Appendicularia sicula*, *Dolioletta gegenbauri*, *Doliolum denticulatum*, *Doliolum mulleri* var. *krohni*, *Cyclosalpa pinnata*, *Brooksia rostrata*, *Ritteriella amboinensis*, *Ritteriella picteti*, *Metcalfina hexagona*, *Iasis zonaria*, *Thalía democratica*, *Thalía democratica* var. *orientalis*, *Pegea confoederata*, *Traustedtia multitentaculata*, *Salpa fusiformis*, *Salpa maxima*, *Salpa cylindrica* and *Pyrosoma atlanticum*.

SEASONAL DISTRIBUTION OF PELAGIC TUNICATES

During the period January–May the north-easterly current prevails in the western part of the Bay of Bengal and the south-westerly current prevails during the period October–December. The fluctuations in the distribution of pelagic tunicates during these two periods is described here.

Horizontal distribution (Table I).—*Oikopleura rufescens*, *Stegosoma magnum*, *Pelagopleura gracilis*, *Fritillaria haplostoma*, *Fritillaria abjornseni* and *Iasis zonaria* were frequent or common during the period January–May. The other species recorded during this period, viz., *Oikopleura albicans*, *Oikopleura cophocerca*, *Megalocercus huxleyi*, *Fritillaria formica*, *Cyclosalpa pinnata*, *Brooksia rostrata*, *Ritteriella amboinensis*, *Pegea confoederata*, *Salpa fusiformis*, *Salpa maxima* and *Salpa cylindrica*, were common only during March–April period. *Fritillaria pellucida* was common from March till May.

From October till November *Oikopleura cophocerca*, *Oikopleura albicans*, *Megalocercus huxleyi*, *Fritillaria formica*, *Cyclosalpa pinnata*, *Brooksia rostrata*, *Ritteriella amboinensis*, *Pegea confoederata*, *Salpa fusiformis*, *Salpa maxima* and *Salpa cylindrica* were frequent or common. During this period *Oikopleura rufescens*, *Stegosoma magnum*, *Pelagopleura gracilis*, *Fritillaria haplostoma*, *Fritillaria abjornseni* and *Iasis zonaria* were rare.

Oikopleura longicauda, *Oikopleura fusiformis*, *Oikopleura dioica*, *Doliolum* spp. and *Thalia democratica* were common during both the current periods.

Oikopleura intermedia and *Fritillaria borealis* f. *sargassi* were recorded during January–May period but not during the other period, i.e., October–November.

December is the transition period when the north-east monsoon retreats and the south-west monsoon is gradually established. There is winter cooling of the surface waters. The pelagic tunicate fauna was sparse during this month.

Appendicularia sicula, *Thalia democratica* var. *orientalis*, *Traustedtia multitentaculata* and phorozoid of *Doliolum mulleri* var. *krohni* were recorded during December, January, February and March respectively. The western-pacific form of *Thalia democratica* was recorded during December at the head of the Bay and during February and March in the area off the east coast of India (Table II).

TABLE I
Seasonal distribution of some pelagic tunicates

Name of the species	Month								
	O	N	D	J	F	M	A	M	
<i>Oikopleura albicans</i>	..	C	C	R	—	R	C	C	—
<i>Oikopleura cophocerca</i>	..	C	C	R	—	R	C	C	—
<i>Oikopleura rufescens</i>	..	R	R	R	F	C	C	C	C
<i>Oikopleura intermedia</i>	..	—	—	—	R	C	C	C	—
<i>Megalocercus huxleyi</i>	..	C	C	R	—	R	C	C	—
<i>Pelagopleura gracilis</i>	..	R	R	—	F	C	C	C	C
<i>Stegosoma magnum</i>	..	R	R	—	F	C	C	C	—
<i>Fritillaria formica</i>	..	C	C	R	R	R	C	C	F
<i>Fritillaria abjornseni</i>	..	R	R	R	F	C	C	C	—
<i>Fritillaria haplostoma</i>	..	R	R	R	C	C	C	C	C
<i>Fritillaria borealis f. sargassi</i>	..	—	—	—	C	C	C	C	F
<i>Fritillaria pellucida</i>	..	—	—	—	—	—	C	C	C
<i>Cyclosalpa pinnata</i>	..	C	C	R	—	R	C	C	—
<i>Ritteriella amboinensis</i>	..	C	C	R	—	R	C	C	—
<i>Ritteriella picteti</i>	..	C	C	—	—	—	C	—	—
<i>Brookis rostrata</i>	..	C	F	R	R	F	C	C	—
<i>Iasis zonaria</i>	..	—	R	R	F	C	C	C	—
<i>Pegea confoederata</i>	..	C	C	R	—	R	C	C	—
<i>Salpa fusiformis</i>	..	C	F	R	—	R	C	C	F
<i>Salpa maxima</i>	..	C	C	F	R	R	C	C	F
<i>Salpa cylindrica</i>	..	C	F	F	R	R	C	C	F
<i>Appendicularia sicula</i>	..	—	—	R	—	—	—	—	—
<i>Thalia democratica var. orientalis</i>	..	—	—	—	C	—	—	—	—
<i>Traustedtia multitentaculata</i>	..	—	—	—	—	F	—	—	—
Phorozoid of <i>Doliolum mulleri f. krohni</i>	..	—	—	—	—	—	R	—	—

R = Rare

F = Frequent

C = Common

Distribution in relation to depth (Table III).—During the period from January–February *Oikopleura rufescens*, *Stegosoma magnum*, *Pelagopleura gracilis*, *Fritillaria haplostoma* and *Fritillaria abjornseni* were common between 0 and 45 m. *Fritillaria borealis f. sargassi* was also recorded during this period from 0–45 m. and was common.

TABLE II

Occurrence of the western-pacific form of Thalia democratica

Period	Nature of collection surface/depth (m.)	Position	
		Lat. °N.	Long. °E.
December ..	Surface	18 52·0'	85 05·0'
.. ..	Surface	20 56·0'	89 19·0'
.. ..	76–195	19 13·5'	85 29·5'
February ..	Surface	17 08·1'	83 25·0'
.. ..	Surface	17 38·5'	83 21·2'
.. ..	Surface	17 39·2'	83 19·2'
.. ..	0–90	17 26·6'	83 37·8'
.. ..	45–90	17 26·6'	83 37·8'
March ..	Surface	11 24·0'	80 56·0'
.. ..	Surface	17 38·8'	83 19·5'
.. ..	Surface	17 51·0'	83 08·7'
.. ..	0–54	17 26·6'	83 33·1'

During the period from October–November *Oikopleura cophocerca*, *Oikopleura albicans*, *Megalocercus huxleyi*, *Fritillaria formica*, *Ritteriella amboinensis*, *Brooksia rostrata*, *Pegea confoederata*, *Salpa fusiformis*, *Salpa maxima*, *Salpa cylindrica* and *Cyclosalpa pinnata* were frequent or common between 0 and 76 m. During the same period *Oikopleura rufescens*, *Stego-*

TABLE III
Distribution of pelagic tunicates in relation to depth

Period	Depth range (m.)	Name of the species	Abundance
October– November	0– 76	<i>Oikopleura rufescens</i>	Rare
		<i>Fritillaria haplostoma</i>	”
		<i>Fritillaria abjornseni</i>	”
		<i>Oikopleura cophocerca</i>	Frequent or
		<i>Oikopleura albicans</i>	Common
		<i>Megalocercus huxleyi</i>	”
		<i>Fritillaria formica</i>	”
		<i>Ritteriella amboinensis</i>	”
		<i>Brooksia rostrata</i>	”
		<i>Pegea confoederata</i>	”
		<i>Salpa fusiformis</i>	”
		<i>Salpa maxima</i>	”
		<i>Salpa cylindrica</i>	”
		<i>Cyclosalpa pinnata</i>	”
..	76–167	<i>Iasis zonaria</i>	Rare
		<i>Oikopleura rufescens</i>	Common
		<i>Stegosoma magnum</i>	”
		<i>Pelagopleura gracilis</i>	”
		<i>Fritillaria haplostoma</i>	”
		<i>Fritillaria abjornseni</i>	”
December	0–36	<i>Megalocercus huxleyi</i>	Rare
		<i>Brooksia rostrata</i>	”
		<i>Salpa fusiformis</i>	”
		<i>Salpa maxima</i>	”
		<i>Cyclosalpa pinnata</i>	”
	<i>Oikopleura albicans</i>	Frequent	
	<i>Oikopleura rufescens</i>	”	
	<i>Fritillaria formica</i>	”	
	<i>Fritillaria abjornseni</i>	”	
	..	76–198	<i>Iasis zonaria</i>
<i>Salpa fusiformis</i>			”
<i>Oikopleura rufescens</i>			Frequent
<i>Stegosoma magnum</i>			”

TABLE III (Contd.)

Period	Depth range (m.)	Name of the Species	Abundance
January-February..	0- 45	<i>Oikopleura cophocerca</i>	Rare
		<i>Oikopleura albicans</i>	"
		<i>Megalocercus huxleyi</i>	"
		<i>Fritillaria formica</i>	"
		<i>Ritteriella amboinensis</i>	"
		<i>Cyclosalpa pinnata</i>	"
		<i>Oikopleura rufescens</i>	Common
		<i>Stegosoma magnum</i>	"
		<i>Pelagopleura gracilis</i>	"
		<i>Fritillaria haplostoma</i>	"
		<i>Fritillaria abjornseni</i>	"
		<i>Fritillaria borealis f. sargassi</i>	"
--	45- 90	<i>Oikopleura cophocerca</i>	Rare
		<i>Fritillaria formica</i>	"
		<i>Brooksia rostrata</i>	"
January-February...	45- 90	<i>Ritteriella amboinensis</i>	Rare
		<i>Pegea confoederata</i>	"
		<i>Cyclosalpa pinnata</i>	"
		<i>Oikopleura albicans</i>	Frequent or
		<i>Pelagopleura gracilis</i>	Common
		<i>Fritillaria haplostoma</i>	"
		<i>Fritillaria pellucida</i>	"
		<i>Iasis zonaria</i>	"
		<i>Salpa maxima</i>	"
		<i>Salpa cylindrica</i>	"
--	90-182	<i>Fritillaria formica</i>	Rare
		<i>Pegea confoederata</i>	"
		<i>Salpa maxima</i>	"
		<i>Salpa fusiformis</i>	Frequent
March-April	0- 90	<i>Oikopleura cophocerca</i>	Frequent or
		<i>Oikopleura albicans</i>	Common
		<i>Oikopleura rufescens</i>	"

TABLE III (Contd.)

Period	Depth range (m.)	Name of the Species	Abundance
March-April	0- 90	<i>Megalocercus huxleyi</i>	Frequent or Common
		<i>Stegosoma magnum</i>	
		<i>Pelagopleura gracilis</i>	"
		<i>Fritillaria formica</i>	"
		<i>Fritillaria haplostoma</i>	"
		<i>Fritillaria abjornseni</i>	"
		<i>Fritillaria borealis f. sargassi</i>	"
		<i>Fritillaria pellucida</i>	"
		<i>Brooksia rostrata</i>	"
		<i>Pegea confoederata</i>	"
		<i>Iasis zonaria</i>	"
		<i>Salpa fusiformis</i>	"
		<i>Salpa maxima</i>	"
		<i>Salpa cylindrica</i>	"
<i>Cyclosalpa pinnata</i>	"		

soma magnum, *Pelagopleura gracilis*, *Fritillaria haplostoma* and *Fritillaria abjornseni* were common from 76-167 m.

A rich pelagic tunicate fauna was recorded during the period from March till April. This is the period of pronounced upwelling off the east coast of India. It was during this period that *Fritillaria pellucida* was recorded from 0-90 m.

Some pelagic tunicates were recorded from a few stations and their depth distribution is mentioned under Table IV.

REMARKS

In the western part of the Bay of Bengal *Oikopleura longicauda*, *Oikopleura fusiformis*, *Oikopleura dioica*, *Doliolum* spp. and *Thalia democratica* were common throughout the period of study. The wide distribution of the above forms has also been reported by previous workers from different parts of the world (Neumann, 1906; Aida, 1907; Tokioka, 1937; Sewell, 1953; Furnestin, 1957, 1960; Fraser, 1962 and Forneris, 1965).

TABLE IV

Depth distribution of some pelagic tunicates

Name of the species	Period	Depth (m.)	Position	
			Lat. °N.	Long. °E.
<i>Oikopleura intermedia</i>	.. December	0- 12	17 41.5'	83 30.0'
	February	45-150	17 26.6'	83 37.8'
<i>Fritillaria fraudax</i>	.. February	45- 90	17 26.6'	83 37.8'
<i>Metcalfinia hexagona</i>	90-150	17 26.6'	83 37.8'
<i>Traustedtia multitentaculata</i>	.. December	76-167	18 52.0'	85 05.0'
	February	90-150	17 26.6'	83 37.8'
<i>Ritteriella picteti</i>	.. November	9- 45	15 38.7'	80 21.4'
	February	90-150	17 26.6'	83 37.8'
	..	90-182	21 01.0'	89 14.0'
Tetrazoid colony of <i>Pyrosoma atlanticum</i>	..	0- 24	17 29.5'	83 29.0'

Two peaks in the occurrence of pelagic tunicates were observed, one during the October–November period and the other during the March–April period. Nair (1949) observed Thaliacea to be abundant during March and August. Sewell (1953) noticed salps in abundance during two periods in the tropical waters, the first extending from August to October and the second from January–April.

The horizontal and vertical distribution of pelagic tunicates is influenced by the seasonal changes in the water movements and their associated temperature and salinity structure. During October–November, the south-westerly current is fully established and the surface waters are considerably diluted owing to a large influx of freshwater from the north. During this period, *Oikopleura rufescens*, *Stegosoma magnum*, *Fritillaria haplostoma*, *Fritillaria abjornseni*, *Pelagopleura gracilis* and *Iasis zonaria* were rare at the surface. During the same period there is a large vertical gradient in salinity (Ganapati *et al.*, 1956) in the surface layers and these forms (excepting *Iasis zonaria*) were common between 76 and 167 m. *Iasis zonaria* was, however, rare in

this level. From January to May there is a gradual increase in temperature and salinity at the surface owing to an incursion of the warm, highly saline oceanic waters. The vertical gradient in salinity becomes negligible during this part of the year. It was during this period that the above-mentioned oceanic species were frequent or common at the surface and at the different levels below the surface. The other forms, viz., *Oikopleura albicans*, *Oikopleura cophocerca*, *Megalocercus huxleyi*, *Fritillaria formica*, *Cyclosalpa pinnata*, *Ritteriella amboinensis*, *Pegea confederata*, *Brooksia rostrata* and *Salpa* spp. were encountered in large numbers during the periods October–November and again from March–April. These forms are able to tolerate wide fluctuations in temperature and salinity and they may therefore be considered as neritic species. The pelagic tunicate fauna was rich during March–April coinciding with the period of pronounced upwelling of the subsurface waters. Similar correlations between the seasonal abundance of certain pelagic tunicates and the temperature, salinity conditions of the waters in the different parts of the world have been made earlier (Apstein, 1905; Farran, 1906; Sewell, 1926; 1953; Russell and Colman, 1935; Fraser, 1949; Nair, 1949; Ganapati and Bhavanarayana, 1958; Berner, 1960; Bary, 1960 and Berner and Reid, 1961).

The present study suggests the suitability of some pelagic tunicates as indicators of water movements in the western part of the Bay of Bengal. The western-pacific form of *Thalia democratica*, was recorded at the head of the Bay of Bengal in December and in the area off the east coast of India during February and March. It is possible that this form enters the Bay of Bengal from the western-Pacific Ocean through the prevailing strong westerly drift in December. In January a clock-wise circulation is established at the head of the Bay which widens out in the succeeding months February, March and April when the current pattern along the east coast is in a northerly direction. The movements of this form closely follow the movements of the surface waters in the above months and accounts for its presence in the area off the east coast during February–March period. The presence of the oceanic forms, *Oikopleura intermedia*, *Fritillaria borealis* f. *sargassi* and *Thalia democratica* var. *orientalis* during January suggests an incursion of the waters from the Indian Ocean which is well known to support a rich pelagic tunicate fauna (Herdman, 1888, 1906; Apstein, 1906; Lohmann, 1914, 1931, 1933; Neumann, 1906, 1913; and Tokioka, 1955, 1956, 1960). The appearance of *Fritillaria pellucida* at the surface during March coincides with the period of intense upwelling of the subsurface layers.

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