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32. STUDIES ON THE CHAETOGNATHA OF THE INDIAN SEAS. PART IX. DIURNAL VERTICAL MIGRATION OF SOME SPECIES OF CHAETOGNATHA IN THE WATERS OFF VISAKHAPATNAM¹

INTRODUCTION

Diurnal vertical migration of the planktonic organisms in the surface layers of the sea is a well known phenomenon. The works of Michael (1919), Russel (1931), and others have confirmed the occurrence of vertical migration and they attribute this phenomenon mostly to the effect of light on the plankton. More recently Moore *et al.* (1953) and Owre (1960) have established some relationship between the vertical distribution and temperature.

The present observations on the vertical migration of Chaetognatha are based on the analysis of 94 samples of plankton collected at hourly intervals both from the surface and at different depths during the drifting cruises Nos. 2, 7, and 31 conducted in the waters off the Visakhapatnam coast. A Nansen-type of closing net was used for vertical hauls of plankton. In the following account the vertical distribution of 4 species of Chaetognatha, namely *Sagitta enflata* Grassi, *S. neglecta* Aida, *S. serratodentata* Krohn, and *Pterosagitta draco* Krohn, is described (see Parts I-VIII for other details of distribution in space and time).

¹ Formed part of the Doctoral thesis submitted by the author to the Andhra University.

TABLE I

VERTICAL DISTRIBUTION OF THE CHAETOGNATHA *Sagitta enflata*

(Summary of the data from Cruises No. 2, 7 and 31)

Cr. No.	Range in feet	DAY								NIGHT				
		6/7	8/9	10/11	12/13	14/15	16/17	18	19/20	21/22	23/0	1/2	3/4	5
2	surface	68	12	11	—	—	—	—	—	—	37	74	—	—
7	do.	—	141	11	*	—	*	—	—	—	—	—	—	—
31	do.	14	2	67	—	18	—	29	—	*	25	2	22	26
2	100/0	—	—	5	—	—	—	—	—	—	—	—	20	—
7	150/0	x	2	—	29	—	14	—	—	7	5	18	18	—
31	240/0	14	—	—	—	—	18	25	28	30	—	—	16	31
7	350/150	3	4	—	—	—	1	—	—	2	1	4	3	x
2	400/250	12	—	45	—	—	—	—	—	—	40	33	—	—
7	500/300	x	—	4	—	—	—	—	—	x	5	x	—	x
2	550/450	—	—	—	—	x	—	—	—	—	—	—	—	—

x indicates a haul in which this species was not found.

* indicates swarms

VERTICAL DISTRIBUTION

Sagitta enflata (Table I)

Michael (1911) describes this species as strictly epiplanktonic. According to Thiele (1938) the distribution of *S. enflata* is mostly confined to the upper zone, extending between 0-50 metres, and it might be present in waters below 400 metres. Owre (1960) has reported the occurrence of diurnal vertical migration for this species in the Florida current and found most of the forms occurring in the upper 200 metres.

Off the Waltair (Visakhapatnam) coast *S. enflata* is the most widely distributed of all the species of Chaetognatha. Most of the forms were collected in the upper 500 feet. A study of the Table I reveals the interesting fact that there is a gradual decrease (see average values) in numbers of this species with increase in depth both during the day and night.

S. neglecta (Table II)

This is next only to *S. enflata* in abundance on this coast. Michael (1911) found this form to be a typical surface-dwelling Chaetognath and he never obtained it in open or closed vertical nets off San Diego.

During Cruise No. 2, this species showed a distinct increase in number with depth during the day and surface concentrations in the night, while the reverse was the case in the material collected during the cruises No. 7 and 31. Like *S. enflata* this also is a surface-dwelling form and perhaps does not show any large scale vertical diurnal migration on this coast.

S. serratodentata (Table III)

Fowler (1906) considers this form to be surface-dwelling and also mesoplanktonic. Owre (1960) found this form oddly distributed like *Sagitta enflata* and *S. hexaptera* in the waters of the Florida current.

S. serratodentata occurs in these waters only from January to August and is considered as an indicator species of the northerly current flowing past this coast during the above period. From the data presented in Table III it shows a scattered distribution at different depths both during the day and night. However, the average values for the day and night during the cruise No. 7 indicate an instance of vertical diurnal migration. But in the material of the cruise No. 31 higher concentration of this species was found in the surface waters both during the day and night.

Pterosagitta draco (Table IV)

Fowler (1906) considers this form to be both neritic and oceanic. Burfield & Harvey (1926) found this form to be distinctly epiplanktonic

TABLE II
VERTICAL DISTRIBUTION OF THE CHAETOGNATHA *Sagitta neglecta*
(Summary of the data from Cruises No. 2, 7 and 31)

Cr. No.	Range in feet	DAY								NIGHT				
		6/7	8/9	10/11	12/13	14/15	16/17	18	19/20	21/22	23/0	1/2	3/4	5
2	surface	x	x	1	—	x	—	—	—	—	—	—	—	—
7	do.	—	x	x	*	—	*	—	—	—	—	—	—	—
31	do.	x	—	16	—	9	—	x	—	x	3	x	x	x
2	100/0	—	—	x	—	—	—	—	—	—	—	—	—	—
7	150/0	x	x	—	—	—	3	—	x	x	13	9	x	—
31	240/0	x	—	—	—	—	x	—	x	13	—	—	x	1
2	180/150	—	—	—	—	—	—	—	x	—	—	—	—	—
2	225/100	—	x	—	—	—	—	20	—	—	—	—	—	—
7	350/150	—	x	—	—	—	x	—	—	3	7	x	2	x
2	400/200	2	—	55	—	—	—	—	—	—	x	—	—	—
7	500/300	x	—	xx	—	—	—	—	—	x	x	—	—	2
2	550/450	—	—	—	—	3	—	—	—	—	—	—	—	—

Cr. No.	D A Y		N I G H T	
	No. of hauls	Range in feet	No. of hauls	Range in feet
2	6	surface	3	surface
	3	225/100	..	..
	3	400/200	3	450/250
	1	550/450	..	..
	4	surface	..	..
7	4	150/0	8	150/0
	3	300/0	..	..
	4	350/150	8	350/150
	2	500/300	4	500/300
	6	surface	8	surface
31	..	..	4	120/0
	4	240/0	6	240/0
	2	600/0	..	..

x indicates a haul in which this species was not found.

* indicates swarms

TABLE III
VERTICAL DISTRIBUTION OF THE CHAETOGNATHA *Sagitta serratodentata*
(Summary of the data from Cruises No. 2, 7 and 31)

Cr. No.	Range in feet	DAY								NIGHT				
		6/7	8/9	10/11	12/13	14/15	16/17	18	19/20	21/22	23/0	1/2	3/4	5
7	surface	—	x	x	x	—	x	—	—	—	—	—	—	—
31	do.	26	—	x	—	39	—	8	—	*	x	1	32	14
7	30/0	—	—	—	x	—	—	—	—	—	—	—	—	—
31	120/0	—	—	—	—	—	—	—	—	—	3	3	9	—
7	150/0	x	x	—	—	—	9	—	x	22	4	6	14	—
31	240/0	13	—	—	—	—	x	2	30	14	—	—	11	8
7	300/0	—	—	x	12	—	—	—	—	—	—	—	—	—
31	600/0	—	—	—	7	—	—	—	—	—	—	—	—	—
7	350/150	x	12	—	—	—	x	—	—	9	x	2	12	1
7	500/300	x	—	29	—	—	—	—	—	x	x	x	—	8

Cr. No.	DAY		NIGHT			
	No. of hauls	Range in feet	Total	No. of hauls	Range in feet	Total
7	4	surface	0	—	—	—
	4	150/0	9	8	150/0	46
	3	300/0	12	—	—	—
	4	350/150	12	8	350/150	24
	2	500/300	29	4	500/300	8
	6	surface	73	8	surface	*
31	—	—	—	4	120/0	15
	4	240/0	15	6	240/0	63
	2	600/0	17	—	—	—

x indicates a haul in which this species was not found

* indicates swarms

TABLE IV
VERTICAL DISTRIBUTION OF THE CHAETOGNATHA *Pterosagitta draco*
(Summary of the data from Cruises No. 2, 7, & 31)

Cr. No.	Range in feet	DAY							NIGHT					
		6/7	8/9	10/11	12/13	14/15	16/17	18	19/20	21/22	23/0	1/2	3/4	5
2	surface	x	x	x	—	x	—	—	—	—	x	x	—	—
7	do.	—	4	x	x	—	x	—	—	—	—	—	—	—
31	do.	15	—	x	—	10	—	x	—	4	2	x	5	2
2	200/0	—	—	x	—	—	—	—	—	x	—	x	—	—
7	150/0	x	x	—	—	—	6	—	x	1	3	x	9	—
31	240/0	19	—	—	—	—	6	10	16	x	—	—	5	12
31	120/0	—	—	—	—	—	—	—	—	—	3	3	2	—
2	180/150	—	—	—	—	—	—	—	—	—	—	2	—	—
2	220/100	—	x	—	3	—	—	2	—	—	—	—	—	—
7	350/150	3	4	—	—	1	—	—	—	5	3	7	z	4
2	400/200	1	—	7	—	—	6	—	—	—	13	10	—	—
2	500/300	—	—	—	—	x	—	—	—	—	—	—	—	—
7	500/300	x	—	3	—	—	—	—	—	2	x	2	—	x

Cr. No.	DAY		Total	NIGHT		Total
	No. of hauls	Range in feet		No. of hauls	Range in feet	
2	6	surface	0	3	surface	3
	3	225/100	5	1	180/150	2
	2	200/0	0	—	—	—
	3	400/200	14	3	450/250	23
	1	550/450	0	—	—	—
	4	surface	4	—	—	—
7	4	150/0	6	8	150/0	13
	3	300/0	5	—	—	—
	4	350/150	8	8	350/150	19
	2	500/300	3	4	500/300	4
	6	surface	25	8	surface	13
	4	240/0	35	6	240/0	33
31	—	—	—	4	120/0	8
	2	600/0	27	—	—	—

x indicates a haul in which this species was not found

and they obtained the majority of their specimens between 25-100 fathoms. Owre (1960) noted marked diurnal vertical migration both at Bermuda and Florida.

From a study of Table IV it is clear that *P. draco* is present mostly in the subsurface waters both during the day and night and no special concentration in the surface water is noticed at any time. As stated elsewhere (Satyanarayana Rao 1958b) the occurrence of this form is associated with up-welling on this coast.

SUMMARY

A total number of 94 hourly plankton samples taken from the surface and different depths in the waters off Visakhapatnam were analysed for studying the vertical distribution of some species of Chaetognatha.

The results indicate that *Sagitta enflata*, *S. neglecta*, and *S. serrato-dentata* are mostly surface-dwelling forms irrespective of night or day. *Pterosagitta draco* seems to be mostly confined to subsurface waters.

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DEPARTMENT OF ZOOLOGY,
ANDHRA UNIVERSITY,
WALTAIR,

T. S. SATYANARAYANA RAO¹

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¹ Present address: Indian Ocean Expedition, Council of Scientific & Industrial Research, Bombay 1-BR.

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