

A PRELIMINARY REPORT ON THE BIOMASS OF CHAETOGNATHS IN THE INDIAN OCEAN COMPARING THE SOUTH-WEST AND NORTH-EAST MONSOON PERIODS

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The data for the present paper have been derived from the analysis of 1276 standard samples of plankton collected during the International Indian Ocean Expedition (1962-65). At the Indian Ocean Biological Centre fractions (3-5 ml) of the samples were sorted and the total number of chaetognaths in the samples were then computed. The average number of chaetognaths for all samples from each 5° Marsden Square is separately estimated for the south-west and north-east monsoon periods. The period mid-April to mid-October (SW monsoon) shows a comparatively higher density of chaetognaths for all areas except the eastern half of the Arabian Sea. In both the periods the areas of highest density are in the western part of the Arabian Sea. The region 40°-60°E between the equator and the northern limit of the ocean is richest in Chaetognaths during both seasons.

INTRODUCTION

Chaetognaths are extremely abundant in the sea and constitute an important part of the marine plankton. There is a substantial amount of published information about the distribution and systematics of Chaetognaths of other oceans but comparatively little on chaetognaths of the Indian Ocean. Mention may be made of the systematic account of chaetognatha of Indian coastal waters by George (1952), of Tokioka's publications (1955-1956) on Chaetognaths of the north-eastern and central areas of the Indian Ocean, of the publications of Rao (1958) and Rao and Ganapati (1958) on chaetognaths of the Bay of Bengal and lastly of the work of Alvarino (1964b) on chaetognaths of the "Monsoon Expedition" of the *Argo* during 1960-61. The *Siboga* (Fowler 1906), *Gazelle* (Ritter-Zahony 1909), *Sealark* (Burfield 1926) and *Snellius* (Schilp 1941) expeditions covered only parts of the Indian Ocean. The International Indian Ocean Expedition has, however, achieved a much wider coverage.

The majority of chaetognath species live in warm waters but it is not necessarily anticipated that their greatest abundance would be found in the tropical and subtropical zones. They occur from the surface to depths below 1000 m. Some species are restricted to one geographical region, whereas others are cosmopolitan in distribution. A total of about 52 species is widely accepted for the six pelagic genera (Alvarino 1965). Nearly 28 species have been heretofore recorded from the Indian Ocean. Taxonomic studies on the chaetognaths of the International Indian Ocean Expedition Collections are only just beginning but as a provisional estimate it may be said that at least 22 species occur in these collections. As most of the samples are from 200-0 m depth, mesoplanktonic chaetognaths (200-1000 m, Alvarino 1964a) are not expected to comprise a significant part of the material. In this pre-

liminary presentation, the chaetognath component of the plankton would be treated as a whole leaving the distribution of individual species to be studied separately.

MATERIAL AND METHODS

The data presented in this paper have been derived from the analysis of 1276 standard samples collected during the International Indian Ocean Expedition (1962-65). Standard samples are those obtained by a vertical haul of the Indian Ocean Standard Net from approximately 200 m depth to the surface. Samples obtained from shoal water are considered as standard if the depth of haul and depth of water are in close agreement. At the Indian Ocean Biological Centre, fractions (3 to 5 ml) of the samples were sorted and the total number of chaetognaths, as well as numbers of individuals in all major taxa, were computed for each sample. The average number of chaetognaths for all samples from each 5° Marsden square is separately estimated for each of two six-month seasons, that is, the south-west monsoon (taken as 16th April to 15 October) and the north-east monsoon (taken as 16th October to 15th April). For mapping, the contour intervals were chosen so as to reduce the effect of patchiness and at the same time provide five population density ranges. In figures 2 and 3, each 5°-square with a dot in the centre represents a square for which data are available. The figures 2 and 3 give a general picture of the biomass of chaetognaths in the Indian Ocean. The distribution of population density is illustrated for the south-west and north-east monsoon periods.

DISCUSSION

Mean values for day-time and night-time densities (Table I), were calculated for ten randomly chosen 5°-squares, for each of the two seasons. These averages show that there is no significant difference between day and night in the estimated abundance of chaetognaths in the standard samples.

The period mid-April to mid-October shows a comparatively higher density of chaetognaths for all areas except the eastern part of the Arabian Sea and the south-western quadrant of the Ocean. (In the latter region, however, the mean values

TABLE I

5°-Square	SW Monsoon		NE Monsoon	
	Day	Night	Day	Night
331—1	1790(2)*	2166(3)	3954(8)	2953(8)
032—2	4769(5)	3569(6)	2874(5)	5357(6)
067—1	2627(6)	2130(12)	4004(11)	4053(4)
067—4	3158(9)	2312(5)	3146(2)	3899(2)
102—2	577(3)	187(7)	1191(14)	1373(15)
065—3	792(16)	684(9)	1265(8)	1293(5)
029—4	4905(2)	2176(4)	2490(8)	2910(4)
064—4	4254(7)	2841(12)	1899(8)	1687(3)
027—4	1574(8)	1894(7)	1784(4)	1254(4)
327—1	630(2)	1594(3)	2708(1)	1264(3)
Average	2508	2055	2532	2404

*Numbers in brackets indicate number of collections in each 5°-square.

for the two seasons are nearly equal). In both periods the areas of highest density are the western part of the Arabian Sea, including waters of the Somalia region. Values for the average number of chaetognaths in all standard samples from different geographical regions are as follows:

Area	16th April- 15th October	16th October- 15th April
Western Arabian Sea (W of 65° E, N of 5° S)	3107	2544
Eastern Arabian Sea (65-80° E, N of 5° S)	1287	1480
Arabian Sea (above two regions combined)	2369	2166
Bay of Bengal (E of 80° W, N of 5°)	2502	1859
SW quarter of the Indian Ocean (W of 80° E, S of 5° S)	693	715
SE quarter of the Indian Ocean (E of 80° W, S of 5° S)	773	495

East-west (Fig. 1a) and north-south (Fig. 1b) plots of the average number of chaetognaths for all standard samples, are drawn according to 10 increments of longitude and latitude respectively. These show diagrammatically that the region 40°-60°E between the equator and the northern limit of the ocean is richest in chaetognaths during both seasons. Lowest values are at the eastern and western sides of the southern half of the ocean.

For the south-west monsoon there is a maximum peak between 50° E and 60° E and a lesser peak between 80° E and 100° E. Similarly for the north-east monsoon the maximum is between 40° E and 50° E and a lesser one between 80° and 90° E, but the peaks are observed to be shifted a little to the west. It is interesting to note that the north-east monsoon shows a comparatively higher density peak in the Arabian sea and the peak in the Bay of Bengal in the north-east monsoon period is the least prominent of all.

Along the north-south axis it is observed there is an almost uniform rate of decrease in density as we proceed from the north to the south up to 45° south, which is the limit of the HIOE sampling. This is particularly true south of the equator with the values for population density being somewhat lower for the north-east monsoon than for the south-west monsoon in almost all the south latitudes. North of the equator the major peaks for the two seasons occur. But whereas for the north-east monsoon period, the single peak density is observed between 10° N and 20° N, with lower but nearly equal values for the belts both above (20° to 30° N) and below it (0° to 10° N), the exact opposite is observed for the south-west monsoon period, with two peaks, nearly equal to each other occurring between 20° to 30° N and again between 0° to 10° N, with a considerably lower value in the intermediate belt, 10° to 20° N.

The surface salinity is at a minimum near the equator, reaches a maximum in about latitude 20° N and 20° S again decreases toward high latitudes (Sverdrup *et al.* 1942). A majority of chaetognaths appear to show a preference for high salinity and high temperature. Rao and Ganapati (1958), after a study of the distribution of chaetognaths of the Visakhapatnam coast in relation to the salinity and tempera-

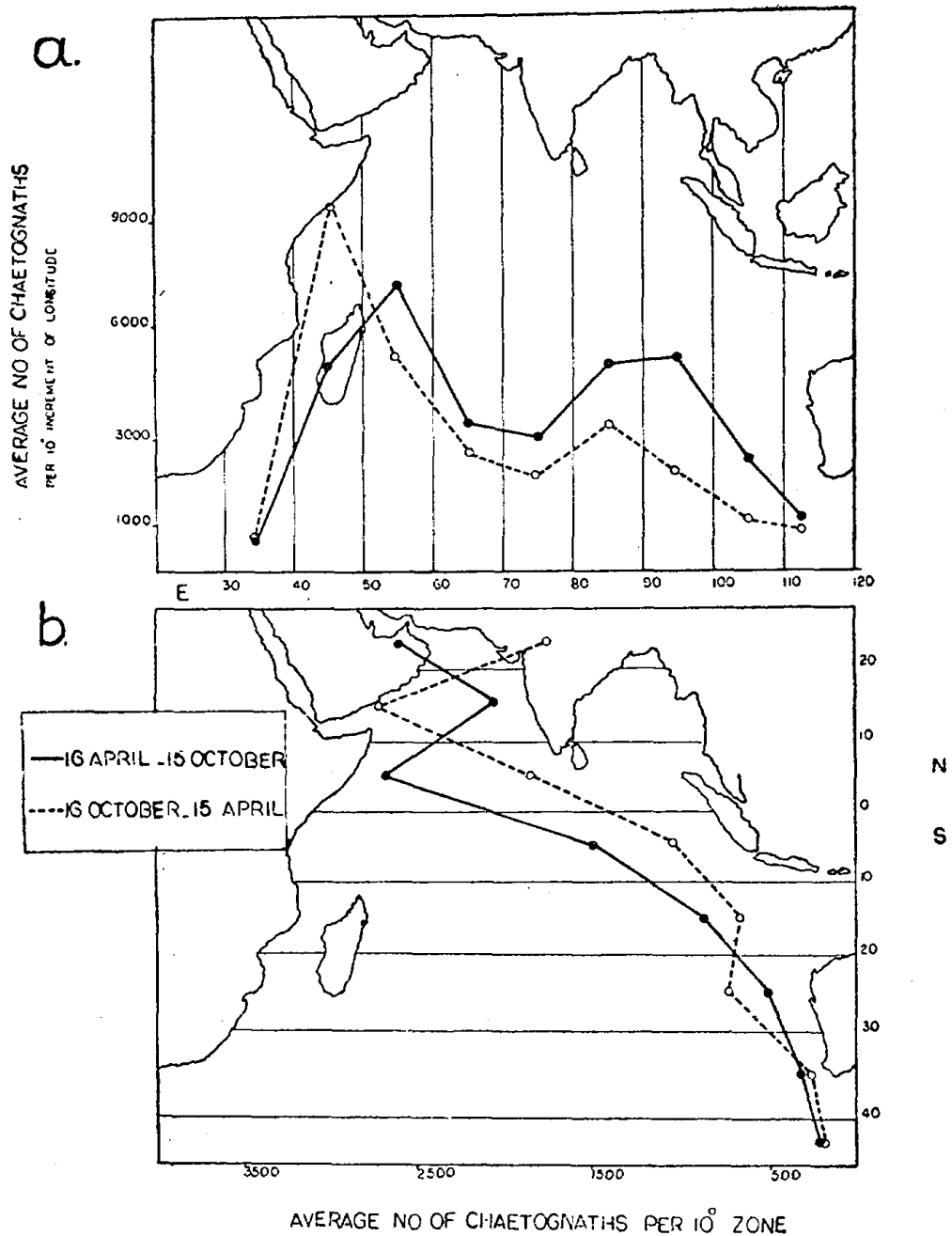


FIG. 1. Average number of chaetognaths beneath 1m², 0-200 m depth, plotted against (a) longitude, and (b) latitude.

ture, concluded that, apart from *Sagitta enflata* and *Krohnitta pacifica*, the species show aversion to low salinity and temperature. This may account, in part, for the highest density of chaetognaths in the zone 0-20° N. Doubtless, the enrichment process prevailing along the coasts of tropical east Africa and the Asian land mass are also contributing factors. During the south-west monsoon, the highest density

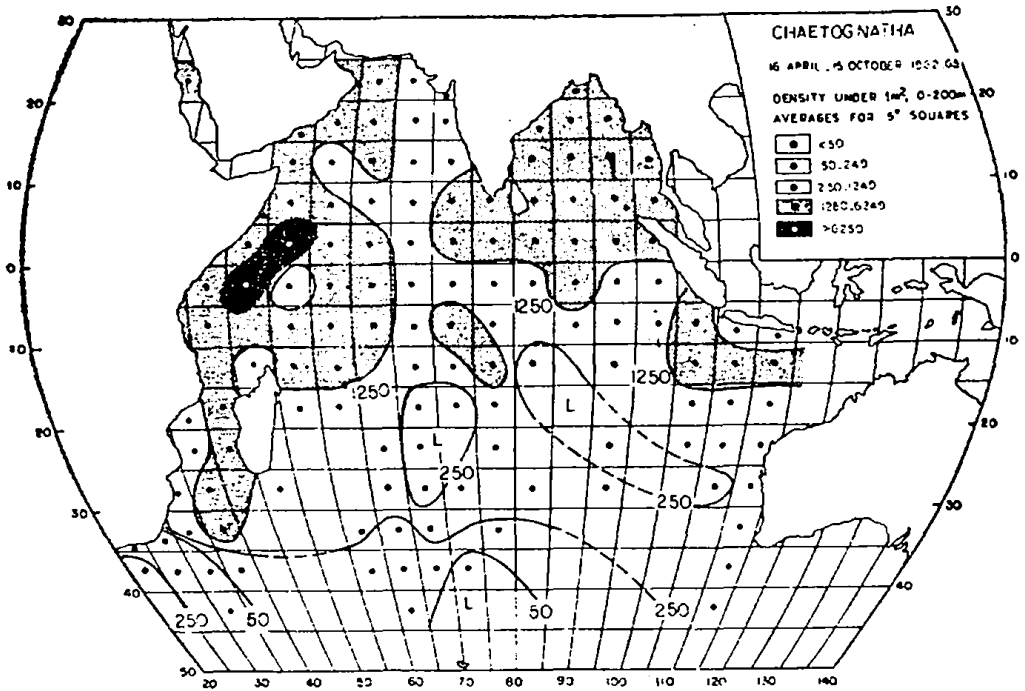


FIG. 2. Population densities of chaetognaths April-October. Dots indicate squares for which data are available. L indicates areas of low density.

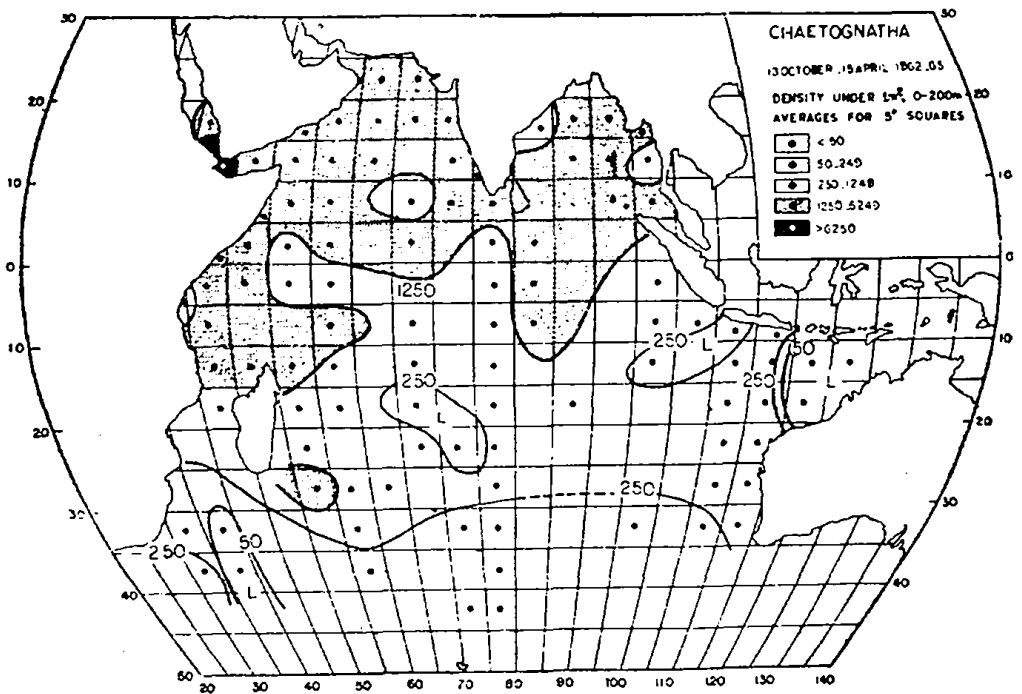


FIG. 3. Population densities of chaetognaths October-April. Dots indicate squares for which data are available. L indicates areas of low density.

is near the Somalia region (Fig. 2). On the western margins of the ocean where the prevailing seasonal winds carry the surface waters away from the coast, an overturn of the upper layers takes place. During the same season the westerly North Equatorial Current disappears and is replaced by the Monsoon Current which flows from the west to east. Along the African coast the current is then directed north from lat. 10° S. Water deriving in part from the Equatorial Current crosses the equator and considerable upwelling takes place off the Somali coast (Sverdrup *et al.* 1942). During upwelling the nutrient content of the surface water increases and this results in an increase in primary production which in turn accelerates the secondary production. It is noteworthy, however, that the 5° -squares showing population maxima during April-October were *not* adjacent to the African coast, but at some distance from it. This suggests that chaetognaths, as a whole, develop and aggregate optimally along the fringe of the enriched area. During the period October to April (Fig. 3) an equatorial maximum east of Africa was not noted, but high population densities occurred throughout the northern part of the Indian Ocean. Highest densities were at the mouth of the Red Sea.

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