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Frequencies of Occurrences and Abundance of Both the Sexes of *Temora Discaudata* and their Developmental Stages Based on Seven International Cruises Undertaken in the Indian Ocean

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Abstract.- The specimens examined were from 141 stations, covered by seven international ships which participated in the International Indian Ocean Expedition (IIOE). These specimens were identified to species, *Temora discaudata*. Its adults and developmental stages, copepodite III-V of both sexes have been identified. Their frequencies of occurrences and abundance in different geographical regions based on the specimen sent to us by the Indian Ocean Biological Centre (IOBC), Cochin, India is attempted.

Keywords: *Temora discaudata*, Copepodites, Indian Ocean.

INTRODUCTION

A large-scale oceanographic study of the Indian Ocean was first considered in 1957. Later the Scientific Committee on Oceanic Research (SCOR) developed an exploratory program and allowed individual scientists of various countries to carry out their own specialized programs of interest. To facilitate joint as well as individual specialized programs the SCOR appointed Mr. Robert Snider (U.S.A.) as its International Indian Ocean Expedition (IIOE) co-ordinator to assist in finalizing scientific, inter-governmental, and administrative problems. This program evolved into a large international enterprise under the umbrella of UNESCO with the establishment of the Intergovernmental Oceanographic Commission (IOC) in Paris. Ship operating countries include Australia, France, Federal Republic of Germany, India, Indonesia, Japan, Pakistan, Portugal, Republic of South Africa, Thailand, USSR, United Kingdom (U.K.) and United States of America (U.S.A.). Other participants were Burma, Ceylon, China, Ethiopia, Israel, Italy, Malagasy Republic, Federation of Malaya, Mauritius, and Sudan. It was decided to establish an international zooplankton-sorting Centre in Cochin, India, following an agreement between UNESCO and India. The zooplankton samples collected by the participant country from any location of the Indian Ocean were deposited in the sorting center headed by Dr. V. Nansen of Denmark appointed by UNESCO. The specimens sorted here were sent to many scientists of various countries for further study. The specimens sorted out from the selected sub-sample (aliquot) of Temoridae were sent to the Center of Excellence in Marine Biology, Pakistan. An attempt is being made to see the frequencies of occurrences, abundance per haul of the same species, sexes, adults and copepodite stages III-V (C3-C5). These were based on the unidentified specimens sent to us from selected samples of Anton Brunn (AB), Argo Lusiad (Lu), Diamantina (DM), Discovery (Di), Meteor (ME, our previously published data partly used for comparison), Oshoromaru (OS) and Vitiaz (Vi) cruises. The compilation of present work has been delayed for various reasons including the deputation of Dr. S.M. Haq to IOC, Paris and elsewhere to whom the material was sent, now it has been worked out and compiled for publication.

MATERIALS AND METHODS

The present study is based on the specimens collected on board the seven international ships belonging to countries such as United States, Anton Brunn (AB) and Argo Lusiad (Lu); Australia, Diamantina (DM); United Kingdom, Discovery (Di); Germany, Meteor (ME); Japan, Oshoro Maru

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(OS); the then Soviet Union, Vitiaz (Vi). The cruise track of these ships during the IIOE is shown in Figures 2-9. The collected samples were first deposited in the IOBC Cochin, India, for sorting and identification upto familial level. Later the specimens were distributed to various countries for further studies. We were selected for the further study and distribution of the specimens of the family Temoridae in the region (Fig. 1) based on the samples collected by a net of 1m diameter at the mouth which was towed oblique from mostly about 200 m to the surface or so. A typical sample represents the straining of about 400 to 500 m^3 of water per haul. Routine examination of these samples ranging from 2 % to 10 % of the total catch was made. These selected specimens of different ships and cruises based on aliquot (sub-sample) from various localities and depths (mostly 200 m), after further identification were calculated to total sample (100 % sample). For some technical reasons we are, hesitantly, presenting our counts to per haul (nos. / haul) instead of 100 or 1000 m^3. Hopefully, the results of different cruises would be comparable to some extent including published results of Meteor (Ali-Khan and Ali-Khan, 2002).

In the present study, the specimens from 141 stations of the said ships; AB (35), Lu (24), DM (05), Di (18), ME (41), OS (11), Vi (07) have been further identified to the genus *Temora*, and its species *discaudata*, the Adult females as (AF), adult males (AM). The developmental stages as copepodite III (C3), copepodite IV (C4) and copepodite V (C5). Their frequency of occurrences and abundance in different geographical regions are attempted with some reservations as mentioned before. Supporting figures are also given.

RESULTS

The number of specimens per haul (per sample) varied greatly, from 01 to 2520 (ME station 145). Figure 10 shows dominance of 1-10 class for the ships AB, Lu, OS, Di and Vi, respectively. Whereas the dominance of largest class (>100 - class) was found on 19 occupancies of ME. Zero in Fig. 10 does not mean the absence from the region at all, but indicates its absence in the sample taken. The co-occurrence of other species can not be commented since the sorted specimens of only genus *Temora* were supplied to us for the present study.

A generalized picture of the region can be obtained by reviewing published literature, Rao (1973, Table 5) in his preliminary study, as one can expect, mentions the dominating abundance of copepoda which ranged from 69.4 % in March to 75.53 % in October averaging 75.59 % of the total sample. A very minor fraction of this group is comprised of Calanoida and still further minor fraction was of Family Temoridae. A very minute fraction of this was of the Genus *Temora* and of species *discaudata*.

The total numbers of 14981 specimens from 141 stations were collected. The regions of collection and the numbers of stations varied greatly from 05 to 41 stations and the numbers of specimens from 01 to 2520 (ME station 145). The Figure 11 shows the relative abundance and frequency of occurrence of *T. discaudata* taken on seven international ships. The largest percentage was taken on Meteor (65.36 % on 41 stations) and the lowest percentages were noted for Diamantina (0.84 % on 05 stations) and Oshoromaru (0.83 % on 11 stations). The medium percentages were noted for other ships. The tracks of ships, location of stations allow us to assume wider distribution of this species in the Indian Ocean. The highest abundance was found in NE-Monsoon period, in the coastal areas of Somalia where summer upwelled water prevails and resulted in high standing crop of phytoplankton (Ali-Khan and Ali-Khan, 2002). The specimen (adult and copepodite stages of either sex) found absent does not prove that they do not occur there.

Figure 12 shows the average numbers of female adults and their copepodite stages III-V (C3 to C5) per haul. Usually the number of adult females were higher (AB, Lu, Dm, Di ships) to highest (ME ship) and the competitors were generally the copepodite V (C5). The collections of Vi ship was an exception to this observation where the C4 were found abundant but the abundance of adults and C5 were more or less the same. Similarly, Figure 13 has been drawn for male average number of specimens per haul. At a glance it appears that the adult males were always

Fig. 1. Location of biological stations, all IIOE, cruises.

Figs. 2-9. Cruise tracks of various international ships during IIOE. Symbols of ships and positions of sampling are given. (Courtesy of IOBC, Cochin (India).

Fig. 10. Distribution of numbers of *T. discaudata* per station. (Approximate volume of water strained was 400-500 m^3 per haul). 0 = no specimen.

Fig. 11. Frequency of occurrence and relative abundance of *T. discaudata* (both sexes and their stages combined) on some stations of few cruises of IIOE based on the specimens supplied by the IOBC, Cochin (India)

dominating their other developmental stages and again the competitors are C5 with an exception to ME and Vi collections where C4 seems to be the competitors of adults. It appears that time of change from C5 to adults is very short (minimum). The absence of C3 males does not seem to be accidental. Because of their minute sizes and relatively larger mesh size of the collecting net it is just possible that they might have filtered out with water and do not offer a correct picture of their abundance comparable to their later stages in the region.

DISCUSSION

The unique circulation in the northern Indian Ocean is reversal of direction and flow twice a year, due to seasonal changes in monsoons (Dietrich 1973; Wyrtki 1971). The monsoon gyres flow, counter clockwise in November to March (NE-monsoon) and clockwise in summer monsoon (October to April) as discussed in detail by Wyrtki (1973).

More numbers of specimen were noted in the northern Arabian Sea as compared to other parts of the Indian Ocean. One of the reasons could possibly be due to the pattern of circulation, which causes intense upwelling in several places (Wyrtki, 1973). Another outcome of the IIOE was the discovery of the highest primary production in the Arabian Sea as compared to the other seas and oceans in the SW-monsoon. In turn the condition promises high secondary production. It seems convincing that the current pattern during the NE-monsoon leads to the accumulation of planktonic organism in the several smaller areas in the Arabian Sea. Fleminger and Hülsemann (1973) mentioned that the " warm water epiplanktonic copepods have two distributional patterns; those species which occur near the latitudes of subtropical covergences (about 40^0 S) or beyond tend to be circumglobal whereas those species which are limited to within 20^0N or30^0N latitude tends to show regional provincialism. The lower numbers of our specimen taken in other parts of the Indian Ocean especially from the southern part, on one hand, might probably be due to relatively colder water, as our species is a warm water species. On the other hand the sampling in those areas was found haphazard, scattered and inadequate. The adult and copepodite stages of either sex if shown absent in figures do not prove that they are not found there or in adjacent waters.

Fleminger and Hülsemann (1973) assumed that *T. discaudata* replaces *T. stylifera* in the Indian Ocean and Pacific Oceans. According to them "it is polytypic and shows morphological and geographical discontinuities paralleling the two *Temora* species above. The Indian Ocean and Pacific Ocean populations appear to enjoy genetic continuity in that diagnostic features are similar and relatively constant through out the two oceans." The same diagnostic feature in the Atlantic is also constant but significantly different in certain details.

Fig, 12. Average numbers of male and female *T. discaudata* on seven international cruises of IIOE, (cruise symbols as in Figures 2-9). 0 = no specimen.

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