

## Neuston composition in central Arabian Sea

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Composition of neuston in the Arabian Sea (lat. 16-19°N, long. 60-72°E) was studied. The standing stock ranged between 1.5 and 49.3 ml (100 m<sup>2</sup>)<sup>-1</sup>. Copepoda was generally the dominant group, forming on an average 50.5% of the total organisms. But at some stations where the biomass was high, aggregation of the mysid *Siriella gracilis* was observed. The copepods *Undinula vulgaris*, *Acrocalanus gibber*, *Bestiola similis*, *Euchaeta rimana*, *Paracalanus* spp, *Labidocera* spp, *Oncaea* spp and *Corycaeus* spp commonly occurred in the surface layer. Chaetognaths were dominated by *Sagitta enflata* and decapod Crustacea by *Lucifer typus*. Many other taxonomical groups were also present, but in small numbers. Significant variations were not observed in the biomass and the commonly occurring species of copepods between day and night. Surface temperature at the southwest leg of the study area was relatively low (<28°C) and incidentally recorded high biomass values.

Considerable data on zooplankton distribution and secondary productivity of the Indian Ocean have been collected through many oceanographic expeditions and cruises<sup>1-9</sup>. However, neuston which is an interesting group of organisms occupying the uppermost layer of the pelagic realm has not been studied. This is the first attempt in this direction wherein the neuston composition and diversity in the central Arabian Sea have been investigated.

### Materials and Methods

Samples were collected on board *ORV Sagar Kanya* (1-10 October 1983) along 19 stations in central Arabian Sea (Fig. 1) using a neuston net (David/Hempel model 200, 30 × 15 cm net bag, 300 μm mesh width) towed for 15-20 min at 2 kn speed. Since it was visually observed that the uppermost microlayer hardly had any neustonic organisms during day time, samples collected just below the surface by the lower net were only used in the present study. Biomass was estimated as displacement volume and computed to unit area from speed of tow and duration of haul. Various taxa of zooplankton were sorted from aliquots. Copepods, chaetognaths, decapods, mysids and cladocerans were mostly identified up

to species. Amphipods were identified only up to family. Surface water salinity and temperature values were taken from the data collected using the CTD system (Keil-Multi Sonde). Terminology for differentiating the ecological categories of neuston was adopted from Zeitsev<sup>10</sup> and Hempel and Weikert<sup>11</sup>.

### Results

**Hydrography**—The study was conducted immediately after the southwest monsoon period. The surface salinity values were within the oceanic range met in the Arabian Sea (35.8-36.7 × 10<sup>-3</sup>). The surface water temperature ranged between 27.2° and 28.6°C and was <28°C in the southwest region occupied by sts 140-150 (Fig. 1).

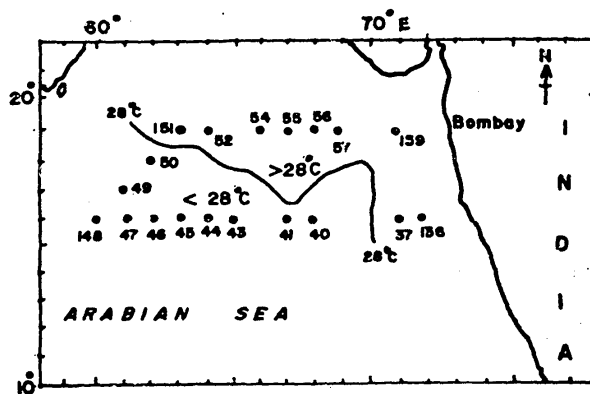


Fig. 1 – Station locations and surface water temperature

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**Neuston standing stock**—It ranged between 1.5 and 49.3 ml (100 m<sup>2</sup>)<sup>-1</sup> (Fig. 2). The highest biomass was recorded at st 149 followed by sts 150, 146 and 155 [46.2, 35.6 and 30.5 ml (100 m<sup>2</sup>)<sup>-1</sup>]. Large aggregations of mysids and copepods were mainly responsible for the high biomass (Fig. 3, Table 1). Mean biomass for day and night was 13.7 and 15.1 ml (100 m<sup>2</sup>)<sup>-1</sup>. Copepods dominated the collections numerically except at sts 137 and 155. At sts 146 and 149, chaetognaths also contributed substantially to the biomass (Fig. 4). Maximum number of organisms, however, was observed at st 150 [23340 (100 m<sup>2</sup>)<sup>-1</sup>]. Biomass did not show significant difference between day and night ( $P > 0.05$ ).

**Species composition**—Copepoda: On an average, 50.5% of the total neuston count was formed by this group. The contribution, however, varied from 3.2 (st 155) to 89.3% (st 156). About 35 species belonging to 22 genera were represented in the collections. Of these, the calanoid *Undinula vulgaris* was the most abundant species forming 9.79% of the total copepod population. It occurred at 14 stations with a maximum density of 1314 (100 m<sup>2</sup>)<sup>-1</sup> at st 150. *Canthocalanus pauper* (6.65%), *Eucalanus crassus* (6.4%), *Bestiola similis* (5.56%) and *Acrocalanus gibber* (4.24%) were the other abundant species. Species belonging to the genera *Paracalanus* (15%) and *Labidocera* (7.79%), *Oncaea* (6.96%) and *Corycaeus* (3.87%) also contributed significantly to the total population. Table 1 shows the individual contribution of these species at various stations. The percentage contribution of the important families of calanoids is presented in Fig. 5. Student's *t* test performed on the above listed species did not indicate

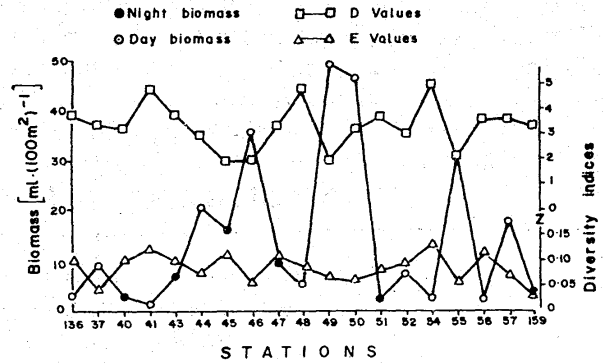


Fig. 2—Biomass distribution and species diversity indices at different stations

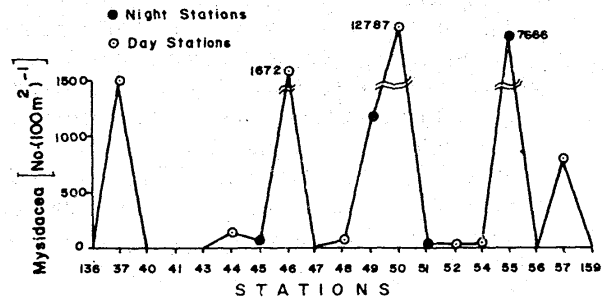


Fig. 3—Abundance of mysids (*Sagitta gracilis*) at different stations (peak values represent actual numbers)

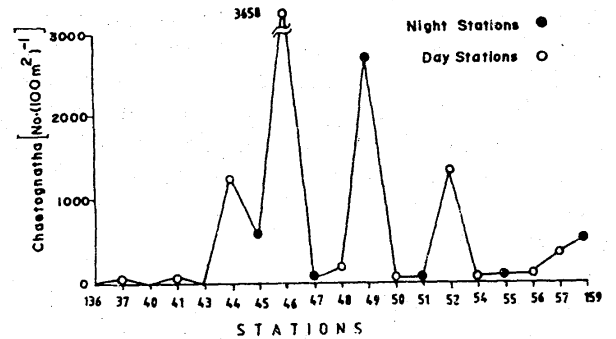


Fig. 4—Abundance of chaetognaths at different stations

Table 1—Percentage contribution of important copepods to total copepods at different stations

Species	Stations																		
	136	37	40	41	43	44	45	46	47	48	49	50	51	52	54	55	56	57	159
<i>Undinula vulgaris</i> (Dana)	33	17	35	18	10	2	13	3	11	14	6	10	—	19	13	39	7	6	—
<i>Canthocalanus pauper</i> (Giesbrecht)	—	9	—	—	—	—	—	14	—	23	23	20	—	—	—	—	—	—	10
<i>Acrocalanus gibber</i> Giesbrecht	8	—	65	—	34	5	—	6	—	9	9	10	—	—	—	—	4	2	7
<i>Bestiola similis</i> (Sewell)	14	—	—	—	—	10	—	11	—	—	—	—	—	29	—	—	9	5	28
<i>Paracalanus</i> spp.	—	—	—	13	—	51	13	6	48	—	10	10	16	6	13	6	16	11	12
<i>Labidocera</i> spp.	9	17	—	32	19	—	—	8	7	5	14	10	8	3	62	6	36	5	8
<i>Eucalanus crassus</i> Giesbrecht	—	—	—	13	—	—	—	—	11	—	—	—	4	13	—	—	5	—	5
<i>Oncaea</i> spp.	—	—	—	5	—	15	25	6	—	14	3	—	—	6	—	—	13	19	13
Other copepods	36	57	—	19	37	17	49	46	23	35	35	40	72	24	12	49	10	52	17

significant differences in their abundances between day and night ( $P > 0.05$ ). Family Pontellidae had the maximum number of species, forming  $> 13\%$  of total copepods (Fig. 5). Candaciids were fairly well represented with *Candacia pachydactyla* contributing the major share (4.34%).

**Chaetognatha:** Chaetognaths occurred at 16 stations (Fig. 4). Seven species belonging to 2 genera were observed in the microlayer. The percentage occurrence of 4 common species viz *Sagitta enflata*, *S. robusta*, *S. pacifica* and *S. bedoti* are shown in Fig. 6. Among them, *S. enflata* was the dominant species (81.8%) with the maximum density of  $2442 (100 \text{ m}^2)^{-1}$  at st 146. *S. robusta* which was next in abundance recorded  $932 (100 \text{ m}^2)^{-1}$  at this station. The other species present in the collections were *S. bipunctata*, *S. neglecta* and *Krohnitta pacifica*.

**Decapoda:** Although widely distributed (Fig. 7), they were less common in the surface layer. Larval stages of *Acetes indicus*, *Sergestes*

*orientalis*, *S. robustus*. *Trachypenaeus curvirostris*; *Alpheus* spp, brachyura and stomatopods were represented in the collections. However, adults and larvae of the sergestids *Lucifer hansenii* and *L. typus* formed the major share (71.6%) of the total decapods, the latter species by far the most abundant (Fig. 8).

**Mysidacea:** The mysids collected from the surface layer (Fig. 3) belonged to a single species *Siriella gracilis*. Males, females and juveniles were present. As mentioned above, their aggregations at some stations resulted in high biomass especially at sts 150 and 155 [ $12787$  and  $7636 (100 \text{ m}^2)^{-1}$ ].

**Amphipoda:** This group was frequent in the neuston. It was present in 12 out of 19 stations, but mostly in low numbers. A notable exception was st 146 where their contribution to the total was 29.1%. They belonged to the families Phoxocephalidae, Gammaridae, Hyperiididae and Lycaeidae, with phoxocephalids outnumbering the others.

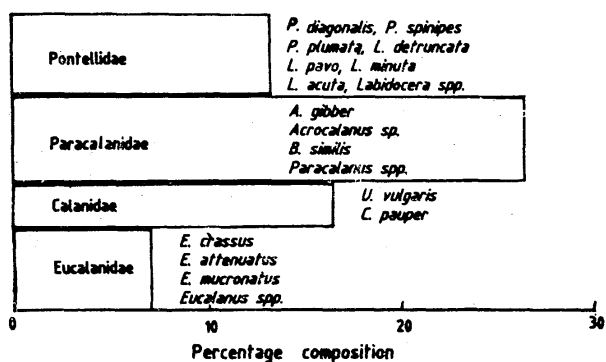


Fig. 5 – Percentage composition of important calanoid families to the total copepods and the respective species assemblage

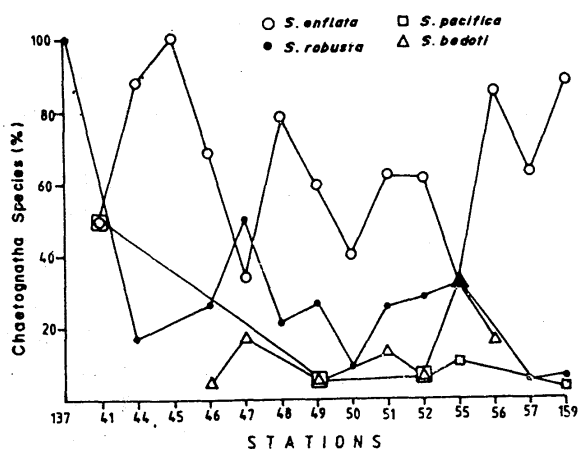


Fig. 6 – Percentage occurrence of dominant species of chaetognaths

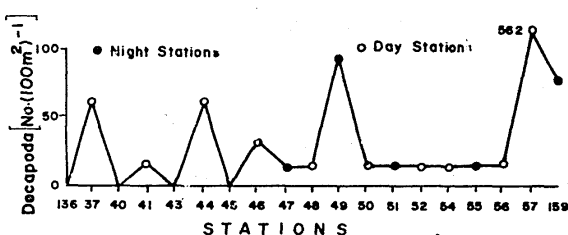


Fig. 7 – Abundance of decapods at different stations

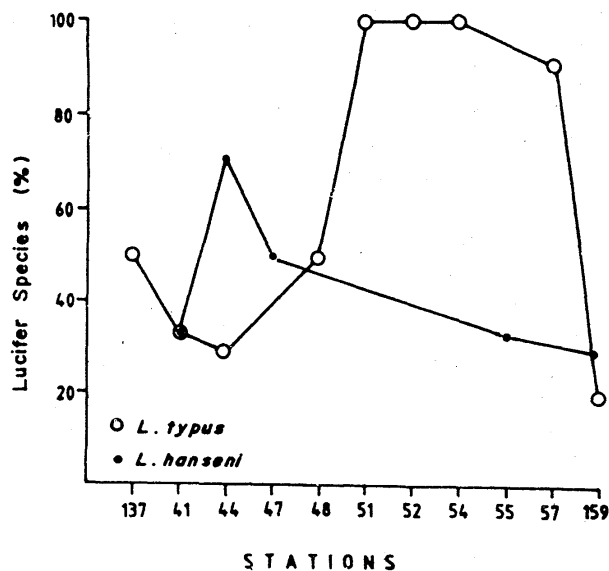


Fig. 8 – Percentage occurrence of *Lucifer* species

**Other groups:** Other groups constituting the neuston in this study were foraminiferans, radiolarians, hydromedusae, siphonophores, cladocerans, ostracods, isopods, euphausiids, *Halobates*, polychaetes, pteropods, young molluscs, appendicularians, fish eggs and fish larvae. Of these, only appendicularians, fish eggs and fish larvae were collected from a majority of the stations though in small numbers.

**Species diversity**—The diversity indices were calculated for the neuston population (Fig. 2). While the species richness<sup>12</sup> (D) was not very high, the evenness<sup>13</sup> (E) was inversely related to the biomass.

### Discussion

The surface water temperature was relatively low (<28°C) along the southwest part of the investigated area (Fig. 1). Decrease in surface temperature towards the western Arabian Sea is the result of a greater response to the preceding monsoon winds and as such the reminiscence of surface cooling is still felt in this area<sup>14</sup>. Incidentally, the stations located in this area recorded high biomass values. However, the nature of influence of the prevailing temperature structure on the standing stock could not be ascertained. Nonetheless, seasonal variations in neuston species abundance following shift in surface temperature has been reported from the north-eastern Atlantic Ocean<sup>11</sup>.

The low abundance of pleustonic community in the present study, which otherwise may form a permanent component of the uppermost microhorizon, can probably be attributed to the fact that the collections were made just below the surface layer. In the subtropical waters of the north-eastern Atlantic Ocean, however, it has been observed that a large number of species concentrate in the lower layers rather than in the immediate surface layer<sup>11</sup>. A similar picture could be envisaged in the tropical oceans also where the organisms, other than euneuston, would tend to aggregate in the lower layers especially during day time to avoid high light intensity and in fact such situations with almost negligible standing stock from the upper layer during day time has been observed from the Arabian Sea<sup>15</sup>. This would explain why in the present study the upper net collections were very poor in neuston community during day time.

It is interesting that no striking diurnal difference occurred in the biomass. However, Zaitsev<sup>10</sup>, Hempel and Weikert<sup>11</sup> and Holdway and Maddock<sup>16</sup> have observed high biomass in

the uppermost layer in the subtropical and temperate oceanic waters during night time which was mainly caused by the migration of facultative and pseudoneustonic organisms. The lack of day and night biomass difference in this study suggests that in the tropical waters even if there is an upward movement of zooplankton from the immediate lower layers during night hours, there may also be a nearly equal replenishment from layers below this thereby making the diurnal differences in biomass nonsignificant. Since there is no data available on the diel migration of zooplankton in the surface layers of this area, it is not possible to comment more on it.

Only a few species of the commonly occurring epipelagic calanoid copepods<sup>17</sup> were found to inhabit the neuston realm during the present investigation. The calanoids belonged mostly to the families Eucalanidae, Calanidae, Paracalanidae and Pontellidae (Fig. 5). Some of the species presently encountered have been recognised as surface dwellers<sup>18</sup>. The calanids *U. vulgaris* and *C. pauper*, which are often dominant in the epipelagic copepod populations of the Indian neritic and oceanic waters<sup>17</sup> formed >16% of the total copepods of the surface layer. Of the several species of Eucalanidae recorded from the Indian coastal waters, only 3 species were represented in this study. Members belonging to Paracalanidae were abundant. They included *B. similis*, *A. gibber* and *Paracalanus* spp, which together formed 24.9% of the neustonic copepods. Family Pontellidae is generally considered as epiplanktonic and the genera *Pontella* and *Labidocera* include several surface dwelling species<sup>10,18</sup>. This observation was found to be true in the present study too. The lone member of the families Acartiidae and Euchaetidae represented in this study was respectively *Acartia amboinensis* and *Euchaeta rimana*, both in small numbers. Thus it becomes clear that the copepod population in the neustonic realm of the central Arabian Sea was dominated by a few families of calanoids and the majority of the epipelagic species does not appear to inhabit this domain.

The chaetognath population in the neuston was composed of only 7 species belonging to 2 genera as against 13 species reported in the zooplankton of the western Indian Ocean<sup>19</sup>. Nair and Rao<sup>20</sup> have recognised the presence of 19 species of chaetognaths belonging to 5 genera in the zooplankton of the Arabian Sea collected during the International Indian Ocean Expedition of which 15 are epiplanktonic. Thus many common species of chaetognaths also do not appear to

occupy the surface layer. However, the general dominance of *S. enflata* among the chaetognath population observed in the Arabian Sea<sup>20</sup> was found to be true also in the case of neuston where its contribution was 81.8% of the total chaetognaths.

The epipelagic mysid *S. gracilis*, an Indo-Pacific warm water species<sup>18</sup> has strongly weighed the composition of the neuston standing stock at a few stations. Species belonging to the genus *Siriella* are common only at night time in the neuston of the subtropical Atlantic Ocean<sup>11</sup>. On the contrary, in the central Arabian Sea their abundance was noticed during both day and night and the highest number occurred during day time [ $12787 (100 \text{ m}^2)^{-1}$  at st 150]. The decapod crustacean larvae, on the other hand, were less common in the samples although at some stations adults of *L. typus* and *L. hanseni* were relatively abundant. This study has shown that the larval decapod crustaceans form only a minor component in the neuston of the central Arabian Sea. In contrast, Locke and Corey<sup>21</sup> observed diurnal abundance of decapods in the neuston of the Bay of Fundy.

Species diversity indices were low compared to the values obtained for zooplankton of the western Bay of Bengal<sup>8</sup>. This is understandable because only a few common epipelagic species of zooplankton occurred in the neuston. The diversity index values were further low where aggregations of mysids, copepods and chaetognaths occurred. The low evenness index (E) obtained for st 150 (0.0609) and other stations having high biomass values clearly indicates that it is inversely related to biomass and numerical abundance.

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