

Biogeographical Change in the Latitudinal Boundary of a Bisubtropical Pteropod *Styliola subula* (QUOY et GAIMARD) in the Indian Ocean

M. SAKTHIVEL

The geographical distribution and relative abundance of the bisubtropical pteropod *Styliola subula* is given in Fig. 1. This species has a wide range of distribution from 10° N to 40° S and is very rare or absent in the Indian Ocean north of 10° N and south

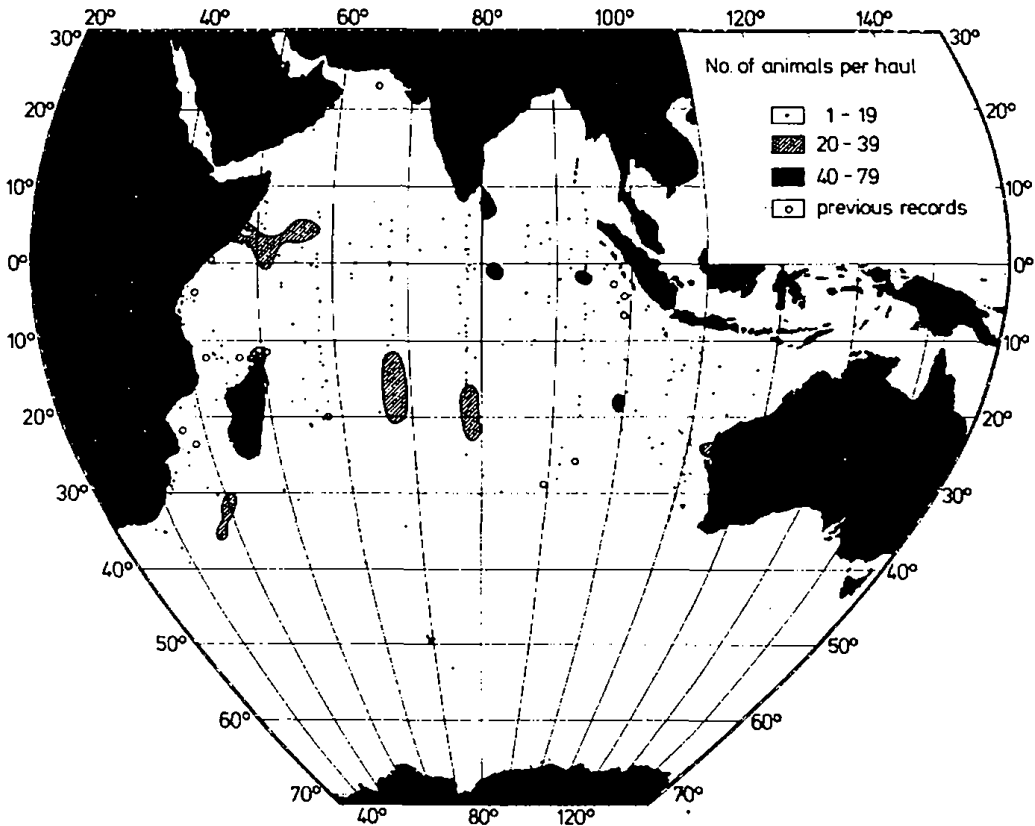


Fig. 1. Distribution of *Styliola subula* in the Indian Ocean

of 40° S. The sparse occurrence of this species between 5° N and 10° N, and 30° S and 40° S is noticed in the present study. There were 579 collections from north of 10° N: except for a single record of a single specimen from AB 175 at 17° 26' N and 56° 57' E, none of them contained this species. Therefore, the extreme scarcity of *S. subula* in the

northern part of the Arabian Sea is borne out by previous and present findings. There were also 268 zooplankton collections from north of 10°N in the Bay of Bengal, none of which contained this species. The southern boundary of *S. subula* in the South Indian Ocean further supports previous findings in all 3 oceans. Clearly, the boundary of subtropical convergence which runs for the most part between 38°S and 40°S acts as a thermal barrier to the distribution of *S. subula* further south than 40°S .

S. subula is more common between 5°N and 30°S , especially in the subtropical gyre, the Mozambique Channel and along 110°E in the Indian Ocean. It is abundant off the Somali coast, and in 2 isolated patches in the eastern equatorial area and another at

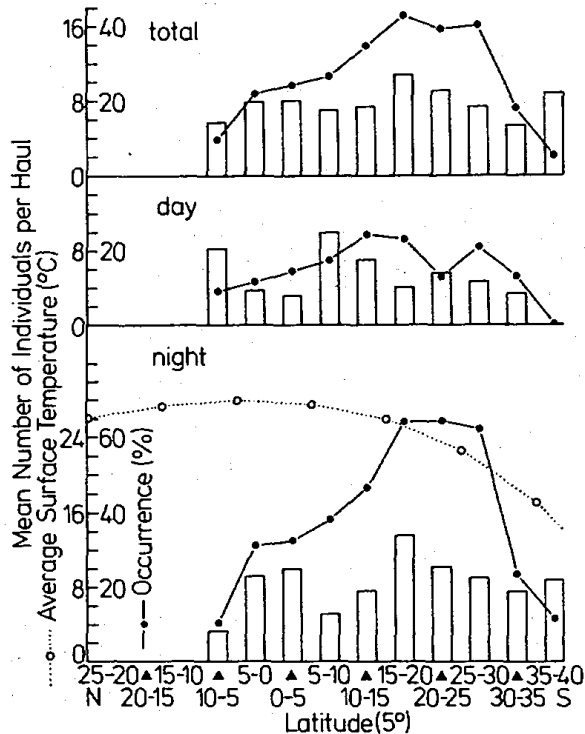


Fig. 2. Latitudinal and diurnal variation of the occurrence of *Styliola subula* in the Indian Ocean

19°S and 100°E , also in the areas between 66°E and 80°E , and 10°S and 25°S (Fig. 1). The 3 larger areas of abundance are known to have mild climatic conditions.

Even though the area of abundance near the Somali coast is very close to the Equator, it is subject to upwelling which reduces the temperature to the subtropical level. The other 2 large areas are between 10° and 25°S . The availability of adequate food in association with mild climate must provide a suitable habitat for the breeding and spawning of this species.

From the records of *S. subula* in the IIOE collections an attempt was made to evaluate the latitudinal variation in the occurrence of this species. The percentage occurrence at each 5° interval was calculated by dividing the number of records by the number of collections. The abundance in the form of arithmetic mean at each 5° interval was estimated by dividing the total number of individuals by the number of records. As this

species is subject to marked diurnal fluctuations in abundance, 3 graphs were prepared (Fig. 2) based on day, night and total distribution to minimize any error in the estimation of abundance.

Fig. 2 shows that the latitudinal variation in occurrence of *S. subula* is almost uniform. This species is absent in the northern latitudes (except for a single record) between 25° N and 10° N and sparse (10%) between 10° N and 5° N, rising to 22% between 5° N and the Equator. From the Equator to 15° S there is a gradual increase in percentage occurrence (22 to 35%) with the peak (40%) between 15° S and 20° S and maintaining more or less the same percentage up to 30° S. Between 30° S and 35° S there is a sudden decrease to 18% with a further reduction (5%) beyond 35° S and total disappearance beyond 40° S. The peak percentage occurrence between 15° and 30° S indicates clearly that *S. subula* flourishes in the subtropical zone rather than in the tropical zone of the Indian Ocean. The unique feature in the distribution of *S. subula* is the change in occurrence with latitude. The absence of this species in the northern latitudes and its continuous occurrence from 10° N to 40° S suggests a possible change in the bisubtropical distribution of a subtropical species in a unipolar ocean.

The diurnal variation of *S. subula* is clearly seen in Fig. 2. A distinct rise in percentage occurrence is observed during the night, especially between 5° N and 30° S. The largest difference in the percentage between day and night is found between 15° S and 30° S. This diurnal variation is attributed to the position of the sun at different latitudes in different months of the year, the intensity of light, the transparency of water and other local environmental conditions which determine the vertical division of the hydrosphere into photic, dysphotic and aphotic zones.

From the present state of knowledge of the hydrography of the Indian Ocean it is really difficult to define the exact barrier to the distribution of *S. subula* in the northern part of the north Indian Ocean. It is probably due to the combination of several factors caused by the land barrier in the north.

With regard to surface salinity, the waters of the Bay of Bengal are less saline than the waters of the Arabian Sea. The average values are 30–33‰ for the Bay of Bengal and 34–37‰ for the Arabian Sea (PANIKKAR and JAYARAMAN, 1966). Salinity increases from north to south in the Bay of Bengal and decreases from north to south in the Arabian Sea (GALLAGHER, 1966). As RAMPAL (1966) has observed, this species as a stenohaline form is avoiding the area of high salinity (38‰) in the Mediterranean, the water mass with low salinity and high temperature in the northern Bay of Bengal and the water mass of high salinity and high temperature in the northern Arabian Sea, might possibly act as hydrological barrier for the distribution of *S. subula*. The unique subsurface O₂ minimum (0.5 ml l⁻¹) found north of 8° N might also be a major reason for the absence of this species in the northern part of the Indian Ocean.

In support of the relict theory of bipolarity, MEISENHEIMER (1905) traced the various stages in the migration of pteropods. He believed that the pteropods originally spread evenly from the Equator to the north and south without any gap. The next step was moving away from the warmest water on either side of the Equator. He quotes *S. subula* and *Cavolinia gibbosa* as examples of this migration from the Equator because they are rare in the equatorial zone and abundant in the subtropical zone. The gradual increase in the percentage occurrence of *S. subula* from equatorial to subtropical latitudes in the Indian Ocean supports this hypothesis, even though this species still occurs in the

equatorial zone. As the Pacific and Atlantic provide 2 subtropical zones one on either side of the Equator, *S. subula* could easily have migrated from the warmer zone of the Equator to the cooler zone of the subtropical latitudes. This is almost evident from the paucity in the distribution of *S. subula* in the equatorial Pacific and Atlantic. In the Indian Ocean, for lack of a subtropical zone in the northern hemisphere, this species can migrate only towards the subtropical zone of the South Indian Ocean. This may account for the persistence of *S. subula* in the equatorial zone.

A similar phenomenon has been observed in the distribution of euphausiids in the Indian Ocean. Three species of euphausiids, *Euphausia brevis*, *E. mutica* and *E. recurva*, have centres of distribution in the subtropical latitudes of the North and South Pacific but are absent in the equatorial water mass. BRINTON (1962) has called this type of distribution biantitropical. BAKER (1965) says that *E. brevis* and probably *E. mutica* have a continuous distribution from the subtropics to the southern Bay of Bengal, while *E. recurva* has a northerly restricted distribution in the partially enclosed Indian Ocean.

From the present study it is difficult to explain the tropical submergence of *S. subula* in the northern part of the Indian Ocean as only 4 deep hauls (400 m to 880 m) were available. Tropical submergence is normally reported for a cold-water surface-living form inhabiting the deeper zone in the tropical latitudes (e.g. *Eukrohnia hamata*). Here the temperature forms the major factor of distribution. As *S. subula* is mainly a surface-living form, tolerating even the high temperature of the equatorial zone in the Indian Ocean, tropical submergence based on temperature would hardly apply to this species.