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THE DISTRIBUTION OF GONOSTOMATID FISHES IN THE WESTERN INDIAN OCEAN [1,2]

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ABSTRACT

Seventeen species of gonostomatid fishes, exclusive of the genus *Cyclothone*, were taken on cruises 3 (10°N to 45°S along 60°E) and 6 (18°N to 40°S along 65°E) of the R/V *ANTON BRUUN* during the International Indian Ocean Expedition. *Bonapartia pedaliota, Danaphos oculatus, Gonostoma atlanticum*, and *Woodsia* sp., were found mainly in the Indian Equatorial Water Mass, and did not enter the oxygen-poor water of the Arabian Sea. *Gonostoma bathyphilum, Photichthys argenteus, Vinciguerria attenuata*, and *Vinciguerria poweriae* had their centers of abundance in the Indian Central Water Mass. *Gonostoma elongatum, Ichthyococcus ovatus, Valenciennellus tripunctulatus*, and *Vinciguerria nimbaria* were encountered throughout both water masses. Of these four species, only *Valenciennellus* does not enter the Arabian Sea. *Margrethia obtusirostra, Ichthyococcus elongatus, I. irregularis, Diplophos taenia*, and *Diplophos* sp., were taken but rarely; all seem rather restricted in their ranges. There is good correspondence, although by no means complete, between the kinds of patterns species exhibit in the Indian Ocean and the kinds they exhibit in the much-better-known North Atlantic.

INTRODUCTION

Two cruises of the R/V *ANTON BRUUN* during the International Indian Ocean Expedition (IIOE) were devoted to midwater trawling with a 10-foot Isaacs-Kidd midwater trawl (IKMT). Both were north-south transects in the western part of the ocean running from the Arabian Sea south to at least the Subtropical Convergence. Cruise 3, in August-September 1963, was along the meridian 60°E; Cruise 6, in May-July, 1964, was along 65°E. The broad coverage of these two cruises geographically (Fig. 1) and with respect to season and depth produced samples which probably reflect the nature of the mesopelagic fauna in the western part of the Indian Ocean very well. Complete station data have been published in two final cruise reports (Anonymous 1965, 1965 a); the trawldata have been republished in a more readily useable form by Nafpaktitis and Nafpaktitis (1969).

The fishes from Cruises 3 and 6 were sent to the Woods Hole Oceanographic Institution where they were sorted to family. The family lots, in turn, were relayed to specialists for final identification. Much of this material has been reported. The most important groups dealt with to date are the Myctophidae (Nafpaktitis and Nafpaktitis, 1969), the Stomiatidae (Gibbs, 1969), and the Chauliodontidae (Gibbs and Hurwitz, 1967). We report here the fishes of the second most abundant group in the collections, the Gonostomatidae (excluding *Cyclothone*).

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Both the hydrography and the productivity of the western Indian Ocean have been investigated recently (Ivanenkov and Gubin, 1960; Ryther *et. al.*, 1966). These two comprehensive studies provide the background for the summary of conditions between 200 and 1000 metres which follows. Superimposed on the plot of station positions (Fig. 1) are some of the major hydrographic features of the western Indian Ocean.

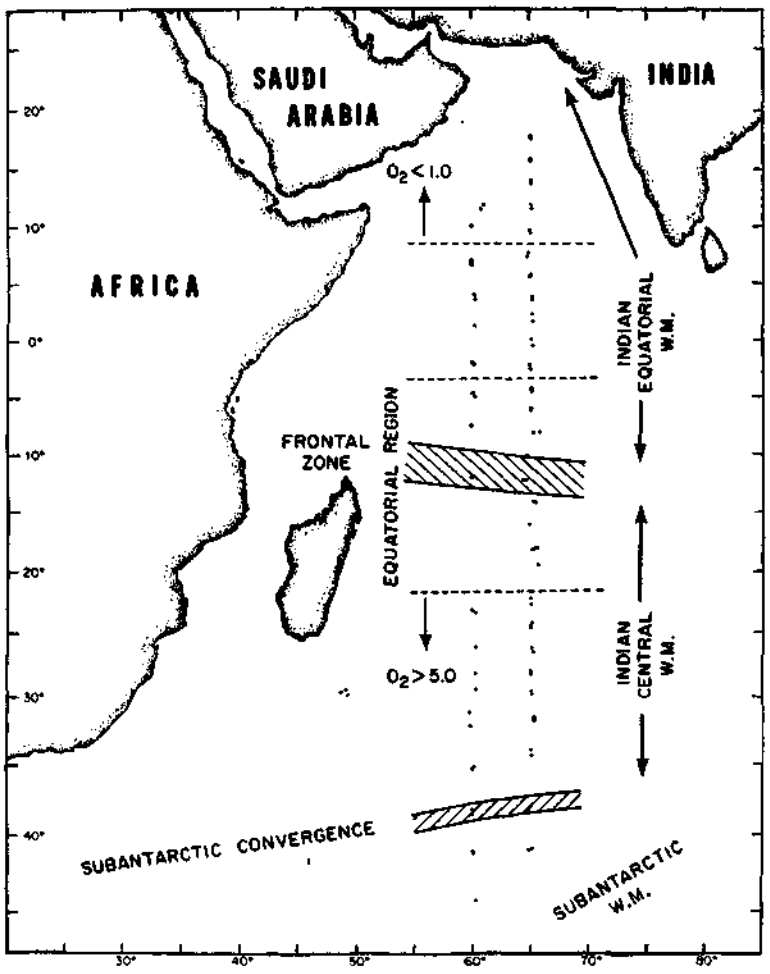

Fig. 1. Midwater trawl station positions of *ANTON BRUUN* cruises 3 and 6. The major hydrographic features of the western Indian Ocean are indicated.

The Indian Equatorial Water Mass dominates the northern part of this ocean, and extends to about 10°S. Except in localized areas of upwelling, its productivity is fairly low, ranging from perhaps 0.50 to (mostly) less than 0.10 gm C/m²/day. At about 10°S the Indian Equatorial water meets the Indian Central Water Mass in a broad Frontal Zone. In this boundary region productivity is somewhat higher, in the range 0.26-0.50 gm C/m²/day. In the Indian Central water, which extends south to the Subantarctic Convergence between 35° and 40°S, the productivity is very low, less than 0.10 gm C/m²/day.

The northernmost part of the Indian Ocean, the Arabian Sea, is characterized by very low oxygen levels, less than 1.0 ml/liter to as far south as 10°N. South of 20°S there is an abundance of oxygen with levels exceeding 5.0 ml/liter.

The Equatorial Region, centered roughly about the Frontal Zone and extending from 4°S to 20°S, is defined on the basis of the shoaling of the 10°C isotherm-which lies above 500 m in this area.

Seventeen species of gonostomatid fishes, exclusive of those in the genus *Cyclothone*, were taken by the *ANTON BRUUN*. Two of these, in the genera *Diplophos* and *Woodsia*, belong to new species being described by Robert J. Lavensberg of the Los Angeles County Museum. In the list of species below, the first number is the number of specimens, and the number in parentheses is the number of stations at which the species occurred. The species taken were:

28 (14)	*Bonapartia pedaliota* Goode and Bean, 1896
101 (20)	*Danaphos oculatus* (Garman, 1899)
21 (10)	*Diplophos taenia* Günther, 1873
2 (2)	*Diplophos* sp. nov.
223 (25)	*Gonostoma atlanticum* Norman, 1930
26 (11)	*Gonostoma bathyphilum* (Vaillant, 1888)
66 (28)	*Gonostoma elongatum* Günther, 1878
1 (1)	*Ichthyococcus elongatus* Imai, 1941
3 (3)	*Ichthyococcus irregularis* Rechnitzer and Böhlke, 1958
12 (11)	*Ichthyococcus ovatus* (Cocco, 1838)
3 (3)	*Margrethia obtusirostra* Jespersen and Tåning, 1919
96 (16)	*Photichthys argenteus* Hutton, 1872
72 (27)	*Valenciennellus tripunctulatus* Jordan and Evermann, 1895
53 (19)	*Vinciguerria attenuata* (Cocco, 1838)
306 (36)	*Vinciguerria nimbaria* (Jordan and Williams, 1895)
25 (9)	*Vinciguerria poweriae* (Cocco, 1838)
5 (5)	*Woodsia* sp. nov.

A complete list of species with stations, number of specimens at each station, and range of standard lengths at each station is available on request from the authors.

No specimens of *Triplophos hemingi* (McArdle, 1901) were captured, although the German *METEOR*, during the IIOE, took one specimen in the Arabian Sea at about 11° 24′ N, 74°36′E (Kotthaus, 1967). Likewise, the *ANTON BRUUN* took no *Polymetme corythaeola* (Alcock, 1898), a species known from the Andaman Sea and Gulf of Aden to Zanzibar. Almost all specimens of *Triplophos* and *Polymetme* have been taken in bottom trawls, however, and both are considered to be benthic rather than mesopelagic fishes (Grey, 1964). The *METEOR* specimen of *Triplophos* is unusual in that it was taken in an IKMT.

Four species were found only between 10°N and 15°S (Fig. 2). The pattern of these four (*Bonapartia pedaliota, Danaphos oculatus, Gonostoma atlanticum,* and *Woodsia* sp.) — here termed "equatorial" — corresponds well with the distribution of the Indian Equatorial Water Mass. None of these four species entered the oxygen-poor water of the Arabian Sea.

Four other species (*Gonostoma bathyphilum, Photichthys argenteus, Vinciguerria attenuata,* and *Vinciguerria poweriae*) had their centers of abundance in the Indian Central Water Mass (Fig. 3). This distribution pattern, less rigorous in its

definition than the "equatorial" pattern, we term "central." Three of the species were found also in subantarctic waters; only *V. poweriae* was not. *V. poweriae* was uncommon and occurred only rarely in the Equatorial Region. The distribution of both *Vinciguerria* species extended northward into Indian Equatorial waters, and there was even one record of *V. attenuata* from the Arabian Sea.

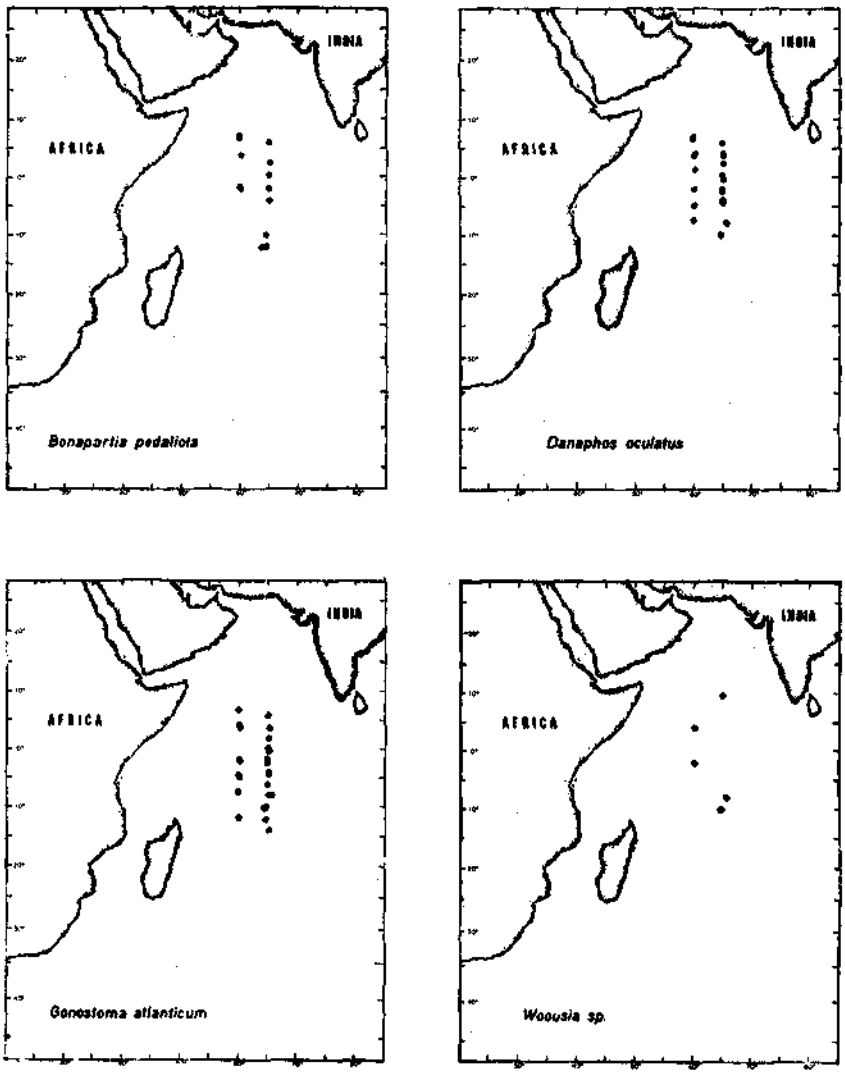

Fig. 2. Species found mainly in the Indian Equatorial Water Mass.

Figure 4 shows the "widespread" pattern. The four species (*Gonostoma elongatum, Ichthyococcus ovatus, Valenciennellus tripunctualatus,* and *Vinciguerria nimbaria*) were encountered for the most part throughout both transects. *Valenciennellus* and *I. ovatus* did not enter the oxygen-poor water to the north, as did

V. nimbaria and *G. elongatum*. Of the four species, only *V. nimbaria* did not occur south of the Equatorial Region.

Five species (*Margrethia obtusirostra, Ichthyococcus elongatus, I. irregularis, Diplophos taenia* and *Diplophos* sp.) were "restricted" in their distribution patterns (Figs. 4 & 5). *Margrethia* was taken only along the northern edge of the Equatorial

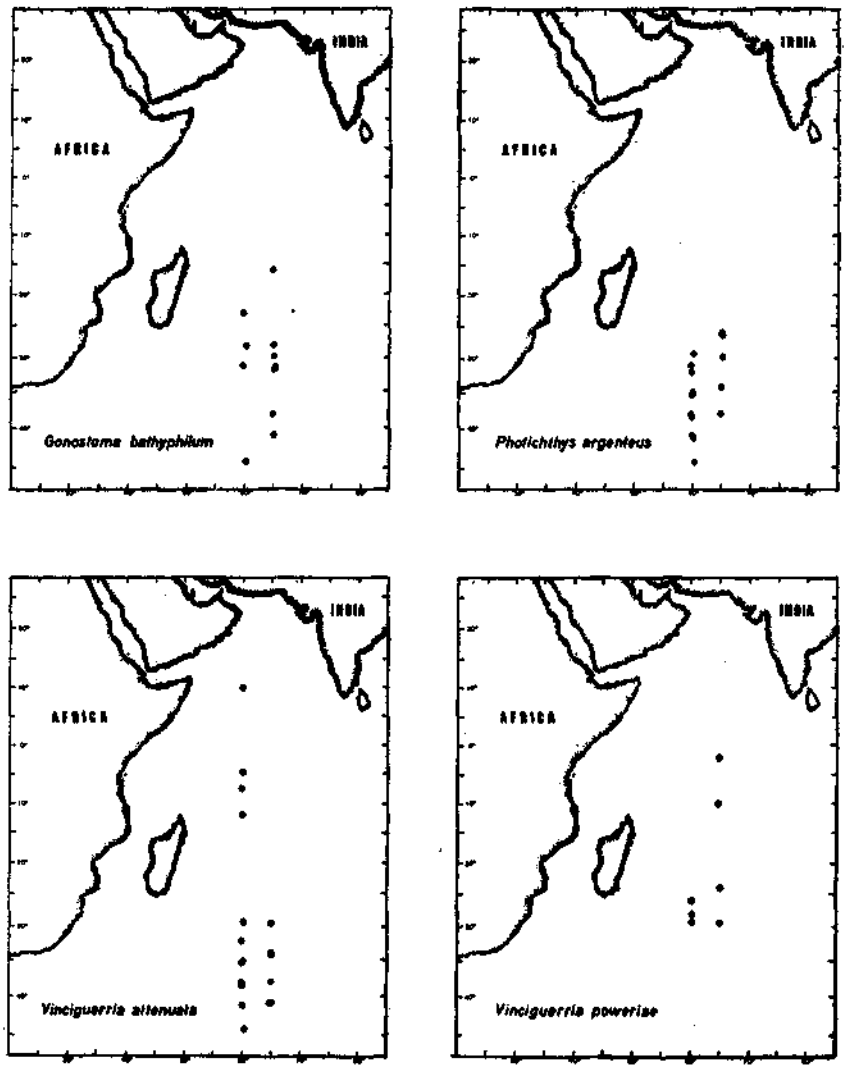

Fig. 3. Species found mainly in the Indian Central Water Mass.

Region in the Indian Equatorial water. *Diplophos taenia* occurred in both Indian Equatorial and Indian Central water, but only in the low productivity water of the Equatorial Region. *Ichthyococcus elongatus* and *Diplophos* sp. were found only south of the Subantarctic Convergence. *Ichthyococcus irregularis* was taken only north of 5° N.

DISCUSSION

It would be premature, on the basis of the distribution patterns shown in one family of midwater fishes, to draw broad conclusions concerning the zoogeography of the western Indian Ocean. We have run *"CHAIN-17"* faunal analyses (Backus *et. al.*, 1965, 1969) on our gonostomatid data and on myctophid data derived

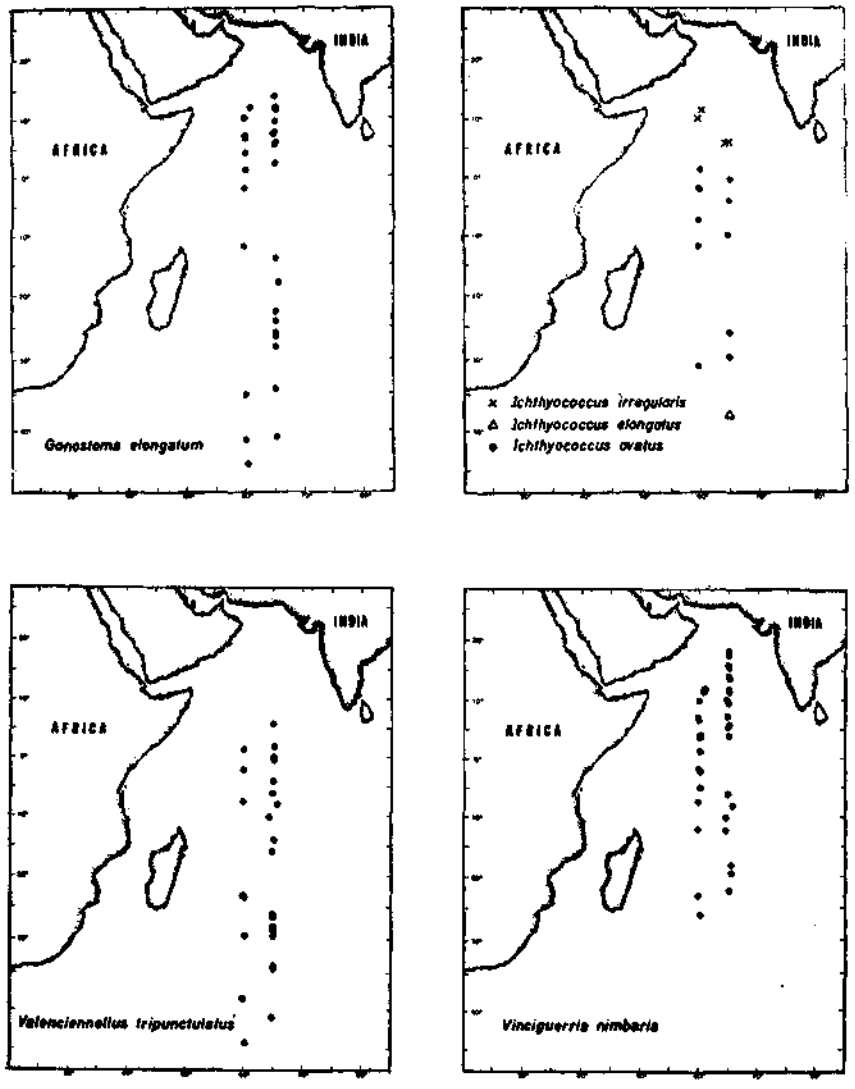

Fig. 4. Species throughout both transects. Included also are the restricted captures of *Ichthyococcus irregularis* and *I. elongatus*.

from Nafpaktitis and Nafpaktitis (1969). The results of these analyses on the two families are in general agreement with one another. Both indicate that the most significant faunal break along the transects occurs approximately at the Frontal Zone where the Indian Equatorial and Central Water Masses meet. Secondary

breaks are suggested at the northern edge of the Equatorial Region and at the entrance to the Arabian Sea.

Of more interest is a comparison of the distribution patterns of gonostomatid species in the Indian Ocean with their patterns in the North Atlantic (Backus *et. al.*, 1970).

Of the four "equatorial species, neither *Danaphos oculatus* nor *Woodsia* sp. occur in the North Atlantic. *Gonostoma atlaticum* exemplifies the "tropical" distribution in the scheme of Backus *et. al.* (1970). Thus, its distribution in the Indian Ocean is very like its distribution in the North Atlantic. *Bonapartia pedaliota,* on the other hand, has very different types of distribution in the two oceans. It is considered widespread in the North Atlantic, having been taken throughout the equatorial and western parts of that ocean.

Gonostoma bathyphilum, although it occurs in the Atlantic, was taken too rarely by Backus *et. al.* (1970) for assignment to a distribution pattern, and *Photichthys argenteus* does not occur in the Atlantic. The other two "central" species, *Vinciguerria attenuata* and *V. poweriae,* have similar distributions in the Indian and Atlantic Oceans. Both were included by Backus *et.al.* (1970) in a group of essentially northern temperate species with their southern limit in the Gulf of Mexico ("northern pattern 3").

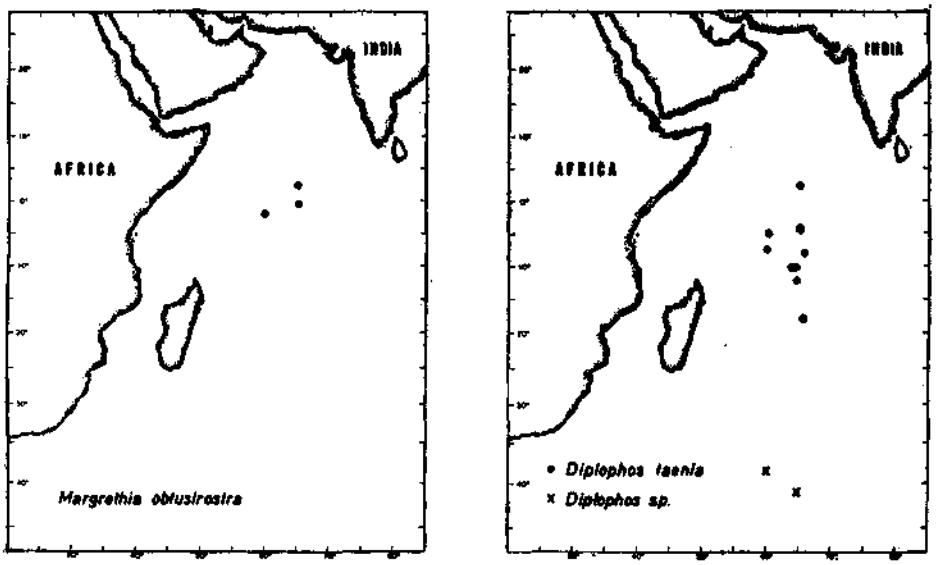

Fig. 5. Species restricted in their distribution patterns.

The "widespread" species *Ichthyococcus ovatus* and *Valenciennellus tripunctulatus* are also widespread in the North Atlantic. *Gonostoma elongatum* and *Vinciguerria nimbaria,* however, were considered, with reservations, to be "tropical" (Backus *et. al.*, 1970).

Margrethia obtusirostra and *Diplophos taenia,* "restricted" species, occur in the North Atlantic but were not taken in sufficient number by Backus *et. al.* (1970) to be assigned patterns. Both *Ichthyococcus elongatus* and *I. irregularis* do not occur in the North Atlantic.

Thus, of the eight species for which sufficient comparative data is available, five appear to be consistent in their patterns in both oceans. Our "equatorial" then is equated with the "tropical" of Backus *et. al.* (1970), "central" with "northern 3," and "widespread" with "widespread."

Three species show wide disparities in their distribution patterns. *Bonapartia pedaliota* is "widespread" in the Atlantic but "tropical" in the Indian Ocean. *Gonostoma elongatum* and *Vinciguerria nimbaria* are "tropical" in the Atlantic but "widespread" in the Indian Ocean. The last two species, in the Indian Ocean, are unique in their occurrence in abundance in the oxygen-poor water of the Arabian Sea. The causes of these disparities are not apparent. Scrutiny of the life histories of the three species involved could provide some insight into the particular factors which limit midwater distributions.

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