BULLETIN OF MARINE SCIENCE, 49(1–2): 186–198, 1991

ON THE DISTRIBUTION OF PELAGIC CEPHALOPODS IN THE ARABIAN SEA

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ABSTRACT

From April to June of 1987 R/V METEOR collected zooplankton and micronekton samples in the northeastern part of the Arabian Sea. One hundred and fifty-seven cephalopod specimens were captured by oblique IKMT hauls through water depths from 1,000 to 0 m and identified to the lowest possible taxon. Thirteen species of nine families were recorded. The majority of the specimens were early life stages of pelagic oceanic species. The cranchiid squid *Liocranchia reinhardti* was the dominant form (108 specimens) followed by the enoploteuthid squids *Abraliopsis lineata* (22) and *Abralia marisarabica* (9). Size-frequency compositions and maps of the geographical distribution are compiled for the most abundant species. The data reveal a tropical cephalopod fauna and will improve the poor knowledge on the distribution patterns of pelagic cephalopods in the Indian Ocean.

In 1987, a cruise was conducted aboard the German research vessel METEOR in the northern Indian Ocean as part of the long-range investigations on interactions and interrelationships of abiotic and biotic processes in the sea.

One of the principal objectives of the expedition was a detailed investigation of the large and small scale, as well as short- and long-term spatial variability of the pelagic ecosystem in various regions of the Arabian Sea. Therefore, an extensive sampling program on phytoplankton and zooplankton was carried out. Besides these collections young fish, shrimps and cephalopods were captured with midwater trawls to describe their biogeography and to ascertain their influences as potential predators on the zooplankton. What follows is a report on the cephalopods from these midwater trawl samples.

Special attention was focused on the cephalopod fauna, which in the Indian Ocean is much more poorly known than those in the Pacific and Atlantic Oceans. Chun's (1910) report on the cephalopod collection of the VALDIVIA expedition still comprises the most comprehensive information on cephalopods from the Indian Ocean. However, it deals exclusively with the oceanic squids. Silas (1968) reported on the VARUNA collections from off the west coast of India and compiled a catalogue of all cephalopod species so far known from the Indian Ocean. Aravindakshan and Sakthivel (1973) described the location of cephalopod nurseries in the Indian Ocean. Their data, however, which are based on the vast collections from the International Indian Ocean Expedition, give no information on species composition and biogeography.

Besides these basic studies, more recently a number of publications appeared which give more detailed information on single species or report on small collections of cephalopods from the tropical Indian Ocean (Filippova, 1968; Nesis, 1970; 1974; Okutani, 1970; 1983). However, the role of commercially exploitable cephalopod stocks in the oceanic parts of the Indian Ocean has not been clarified, and thus more comprehensive studies are still needed.

MATERIALS AND METHODS

The cephalopods were collected on two oceanographic station-transects in the northeastern part of the Arabian Sea from April to June 1987 during cruise 5 of R/V METEOR in the Indian Ocean (Fig. 1). All samples were obtained by an enlarged Isaacs Kidd midwater trawl (IKMT) with a mouth opening of 2.5 × 4 m and a mesh size of 4.5 mm. The standard double oblique haul reached from 0

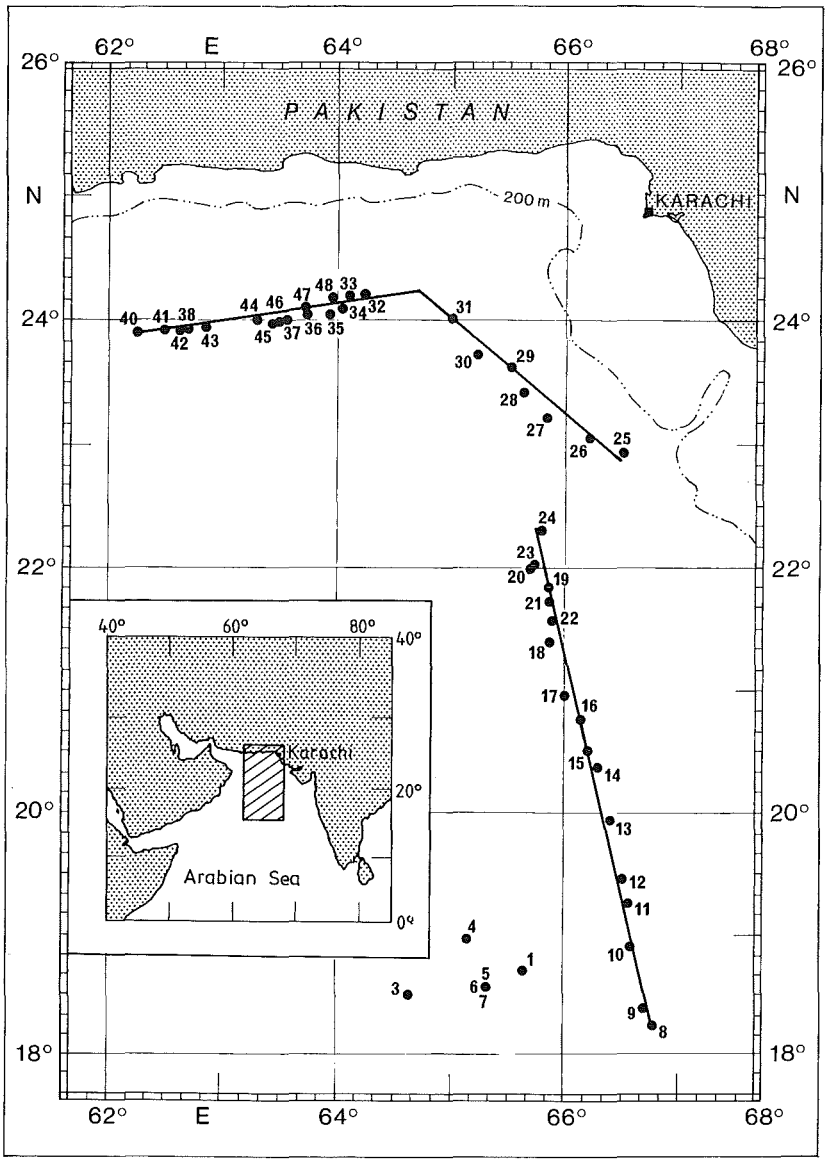

Figure 1. IKMT stations of the R/V METEOR cruise 5 in the Arabian Sea, April to June 1987.

to 1,000 to 0 m. Thus, a bias due to diel vertical migration was considered to be widely excluded. In shallower regions near to the shelf slope off Pakistan the hauls were carried out close to the sea floor. Shooting and hauling speed of the trawl varied between 0.3 and 0.6 $m \cdot s^{-1}$ while the vessel was steaming with approximately 2.5 knots. Altogether 46 IKMT-hauls were carried out in the open water of the northeastern Arabian Sea. They were arranged in two station-transects parallel to the coasts of Pakistan and India and covered a region between 24° and 18°N latitude and 62° and 67°E longitude (Fig. 1). A detailed compilation of station data, the work at sea, and first results are included in the cruise report (Nellen et al., 1988).

Samples were stored in 4% buffered formalin. Cephalopods were sorted from the samples in the home laboratory, identified, measured and transferred into 70% ethyl alcohol.

Physical oceanographic data that were determined for the time of sampling, were obtained from

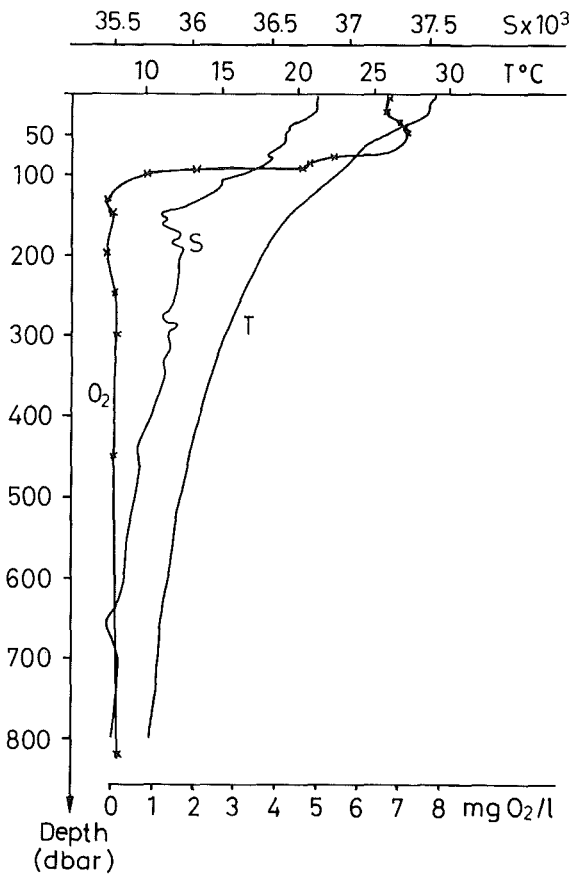

Figure 2. Typical depth profiles of temperature (T°C), salinity, (S × 10^3), and oxygen (mg O_2·liter) in the central Arabian Sea during the R/V METEOR cruise 5.

temperature and conductivity recordings during the zooplankton hauls with a modified MOCNESS (Multiple Opening/Closing Net and Environmental Sensing System; Wiebe et al., 1976). They provided profiles of temperature and salinity in the investigated area. Dissolved oxygen was measured from water samples in about 10-m intervals down to 300 m depth as well as from 450 and 820 m depth. (Waller, unpubl.).

RESULTS AND DISCUSSION

Hydrography.—The dominant physical features of the Indian Ocean which affect the distribution of marine flora and fauna have been summarized by Dietrich (1973), Wyrtki (1973), and more recently by Angel (1984). Typical vertical profiles of temperature, salinity and dissolved oxygen for the northeastern Arabian Sea as obtained during the METEOR expedition in 1987 are shown in Figure 2. A warm ($T > 28°C$) and saline ($S > 36.7 \cdot 10^{-3}$) surface layer extends to a depth of about 30 m. Below the thermocline, in approximately 30 to 40 m, temperature and salinity values decrease steadily with increasing depth. At 800 m depth the temperature has dropped to approximately 10°C and salinity to $S = 35.5 \cdot 10^{-3}$. Oxygen concentrations, however, are high in the surface layer (7 mg O_2·liter) and decrease sharply below 80 m to minimum values of less than 0.5 mg O_2·liter between 150

Table 1. Cephalopods identified from IKMT-samples in the Arabian Sea, April/May 1987

Taxon	Specimens (No.)
Abralia marisarabica	9
Abraliopsis lineata	22
Ancistrocheirus alessandrini	4
Enoploteuthidae indet.	1
Ctenopteryx sicula	1
Bathyteuthis bacidifera	3
Chiroteuthis picteti	1
Onychoteuthis banksii complex	1
Sthenoteuthis oualaniensis	5
Ommastrephidae indet.	1
Liocranchia reinhardti	105
Japetella diaphana	2
Octopodidae indet.	2
Total	157

and 800 m (Fig. 2) indicating the extensive oxygen depleted layer in the NW Indian Ocean.

Systematics and Distribution. — Twenty seven of the 46 IKMT hauls were positive for cephalopods and yielded a total of 157 specimens. The most southern station (St. 8; Fig. 1) produced the richest catch with 59 specimens. On all other stations cephalopods appeared only in low numbers. Thirteen different taxa were identified from our collection (Table 1). They belong to nine families which are treated separately in the following description of species distribution and size frequencies.

Family Enoploteuthidae. — *ABRALIA MARISARABICA.* Nine paralarval and juvenile specimens between 3.9 and 23.9 mm dorsal mantle length (ML) occurred in the samples. The length frequency composition is shown in Figure 3. Although the morphological differentiation is not clear at such immature stages, the species could be identified according to the type description given by Okutani (1983) and the illustrated key of Nesis (1988). They were separated from a closely related species, *Abralia andamanica* by the illustrations given by Voss (1963) and the examination of *Abralia andamanica* specimens in the collection of the National Museum of Natural History in Washington, D.C.

Abralia marisarabica appeared in the northern part of the investigated area, north of 21°N (Fig. 4), which is in concordance with the type locality at 24°48′N, 63°20′E (Okutani, 1983). Silas (1968), however, only found *Abralia andamanica* in his collections west of the coast off India (7° to 14°N); and Nesis (1986) only describes one specimen of *Abralia marisarabica,* but 24 specimens of *Abralia andamanica* from the seamounts in the western Indian Ocean.

ABRALIOPSIS LINEATA. Twenty two juvenile and adult specimens (ML = 11.5–28.9 mm), several in very good condition, were found in the collection (Fig. 5). Some of them are now under closer examination to re-describe this species. *Abraliopsis lineata* could easily be identified by its very distinctive photophore patterns on the head and mantle. The distinction from the genus *Abralia* was also very evident by the appearance of three big photophores at the tips of the fourth arms, which is a characteristic feature of the genus *Abraliopsis.* Moreover, the ratios fin length/dorsal mantle length and fin width/dorsal mantle length were

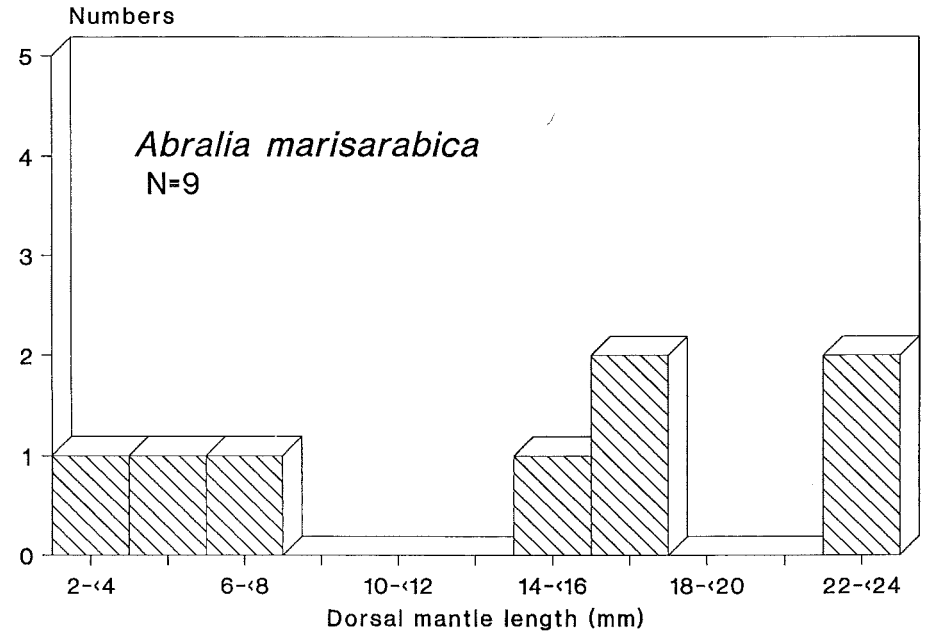

Figure 3. *Abralia marisarabica*: Length frequency composition as obtained from IKMT samples in the Arabian Sea, April to June 1987.

good criteria to distinguish *Abralia marisarabica* from *Abraliopsis lineata* in our samples (Figs. 6, 7).

The geographical distribution is shown in Figure 4. In contrast to *Abralia marisarabica* this species tends to occur more in the southern region of the north-eastern Arabian Sea. *Abraliopsis lineata* occurred in the collection of Nesis (1986) only once; it was absent in the VARUNA samples (Silas 1968).

ANCISTROCHEIRUS ALESSANDRINI. Only four paralarval and juvenile specimens (mantle lengths 9.2, 9.6, 18.5, and 42.0 mm) were identified as this species. They were captured at St. 9 (18°25′N, 66°39′E; 2 specimens), St. 18 (21°24′N, 65°56′E), and St. 44 (24°04′N, 63°19′E). This species has been recorded from a number of samples in all tropical oceans of the world (Okutani, 1974). It is also a common component of the cephalopod fauna in the oceanic Indian Ocean (Silas, 1968; Nesis, 1986) and can easily be distinguished from other enoploteuthids by its gelatinous body.

ENOPLOTEUTHIDAE GEN. ET SP. INDET. St. 28 (23°32′N, 65°30′E) revealed a specimen which could not be further identified. It is a paralarva of approximately 4.0 mm mantle length which lacks any features to be determined more accurately.

Family Ctenopterygidae.—The collection contained only one specimen of *Ctenopteryx sicula* with a dorsal mantle length of 12.0 mm. This species can be clearly identified by its typical fins which are supported by muscular ribs. The animal was captured at St. 46 (24°05′N, 63°29′E) in a shallower region on the shelf off Pakistan. *Ctenopteryx sicula* is a common component of tropical and subtropical seas, and was previously found in the Arabian Sea (Nesis, 1974; 1986).

Family Bathyteuthidae.—Roper (1969) has given a comprehensive study on systematics and zoogeography of this group. We encountered three specimens which

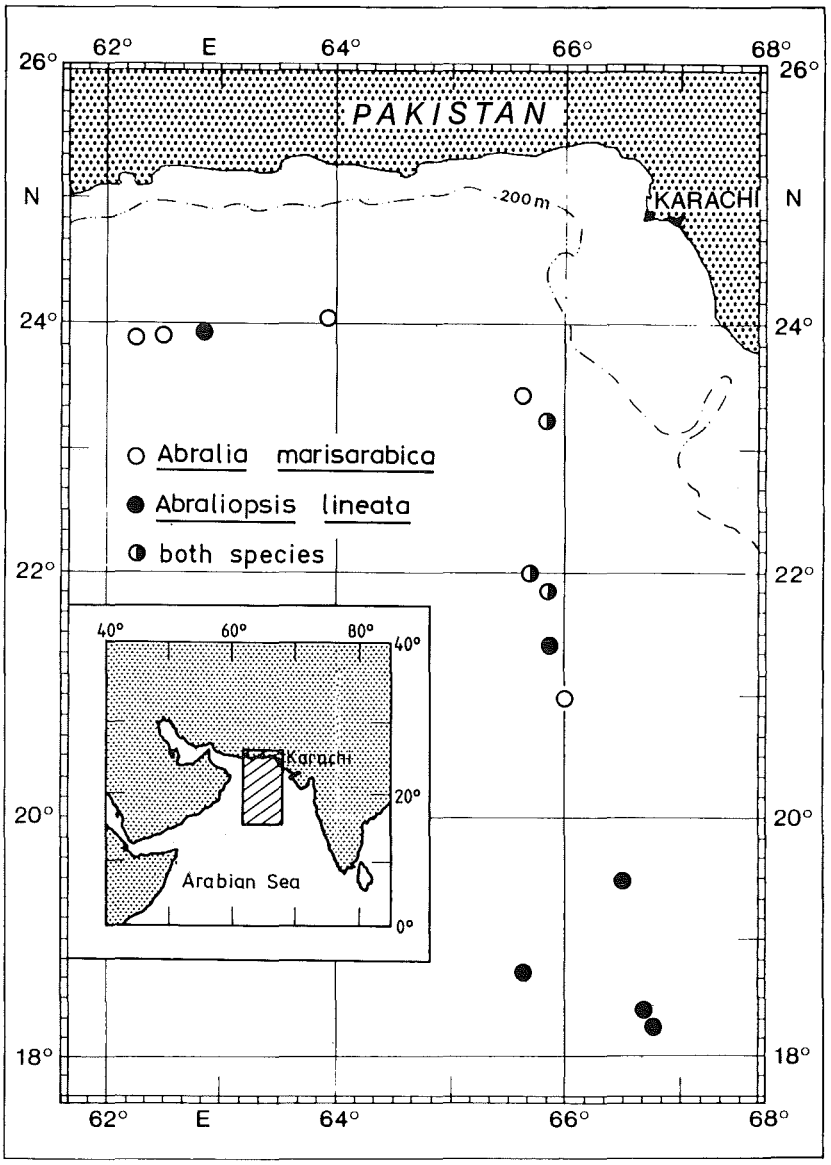

Figure 4. *Abralia marisarabica, Abraliopsis lineata*: Geographical distribution in the Arabian Sea according to IKMT samples from April to June 1987.

were identified as *Bathyteuthis bacidifera.* The mantle lengths were 25.5, 27.0, and 30.8 mm, respectively. They occurred in the most southern range at St. 8, 9, and 10, respectively. The species is characterized by a deep maroon color which makes it easily distinguishable from all other species in the collection. Its distribution has been described by a number of authors; it is also known from oxygen depleted deep waters of the tropical Pacific (Roper, 1969). Nesis (1985; 1986) characterized it as an Indopacific and Equator mesopelagic/bathypelagic species.

Family Chiroteuthidae.—Only the head of one specimen belonging to this family

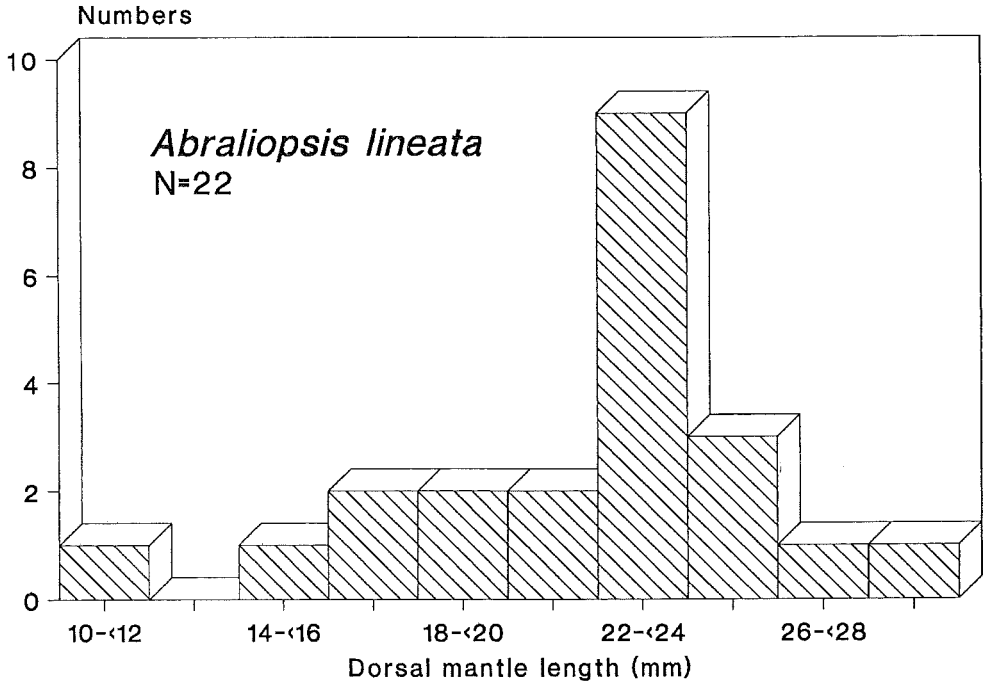

Figure 5. *Abraliopsis lineata*: Length frequency composition as obtained from IKMT samples in the Arabian Sea, April to June 1987.

was found at St. 24 (22°16′N, 65°44′E). Despite its poor condition, it could be identified as *Chiroteuthis picteti* by the characters given in the identification key of Nesis (1988). The species is common in the deep water of the tropical parts of the Indopacific (Nesis, 1986; 1988).

Family Onychoteuthidae.—At St. 8 (18°14′N, 66°47′E) a juvenile specimen (dorsal mantle length 9.0 mm) was caught which belongs to the species complex *Onychoteuthis banksii*. The species could be identified by four already well developed hooks on the tentacular clubs, the distinct chromatophore pattern on the dorsal side of the mantle, and the sharp point of the gladius at the posterior end of the mantle.

The *Onychoteuthis banksii* complex is mainly epipelagic and is caught in the warm waters of all oceans (Roper et al., 1984; Nesis, 1988).

Family Ommastrephidae.—*STHENOTEUTHIS OUALANIENSIS*. Five specimens (ML = 5.2–19.2 mm) belonging to this species were collected in the IKMT samples. The animals were captured at St. 18 (21°24′N, 65°56′E; 4 specimens) and at St. 26 (23°02′N, 66°12′E). Both are locations close to the shelf slope off NW-India. The species diagnoses of larval ommastrephids by Harman and Young (1985) were used for identification. Accordingly, the specimens were identified as *Stenoteuthis oualaniensis* because of the occurrence of a pair of photophores between intestine and digestive gland. The smaller specimens showed the typical pattern of proboscis suckers: the two lateral suckers are moderately enlarged compared to the six medial suckers. Among the specimens were some animals with funnel and mantle components of the locking apparatus already fused together which is a characteristic feature of this species.

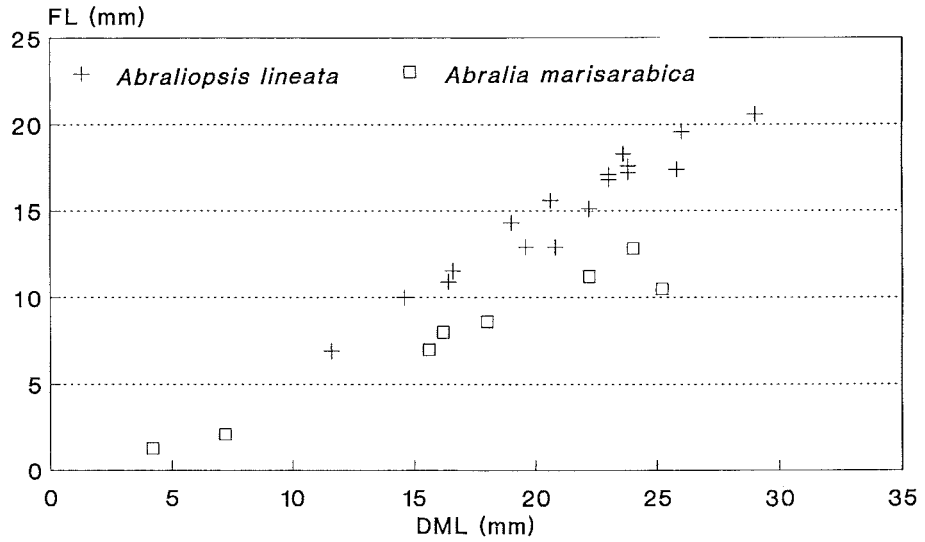

Figure 6. *Abralia marisarabica, Abraliopsis lineata*: Scatter diagram of dorsal mantle length vs. fin length.

Sthenoteuthis oualaniensis is a common ommastrephid squid in the whole Indo-Pacific region (Roper et al., 1984). There are indications of large concentrations in the Gulf of Aden and the Arabian Sea (Silas et al., 1982) which make it an interesting target species for a possible commercial fishery in the northwestern Indian Ocean.

This species is one of the most abundant paralarval squids in the zooplankton collections (MOCNESS samples) of the R/V METEOR expedition where it was identified by detailed scanning electron micrographs (unpubl.).

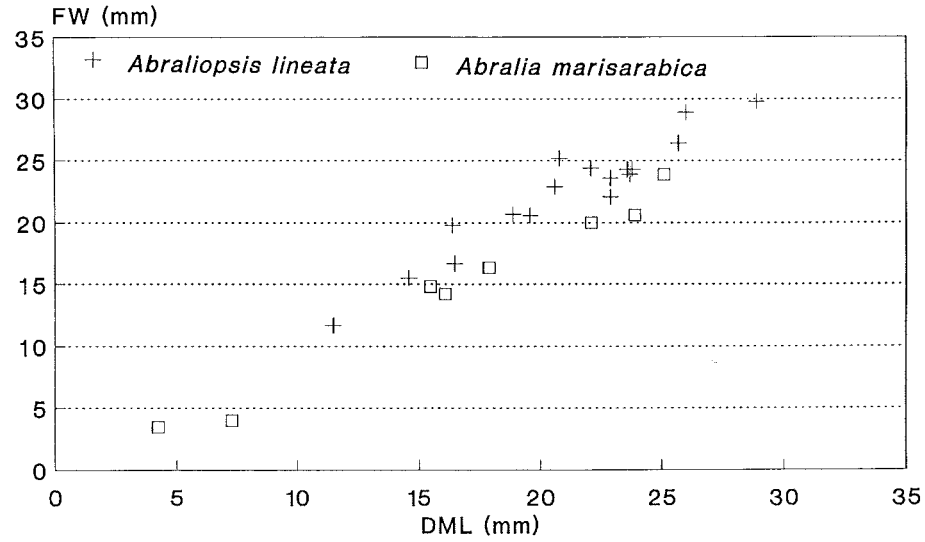

Figure 7. *Abralia marisarabica, Abraliopsis lineata*: Scatter diagram of dorsal mantle length vs. fin width.

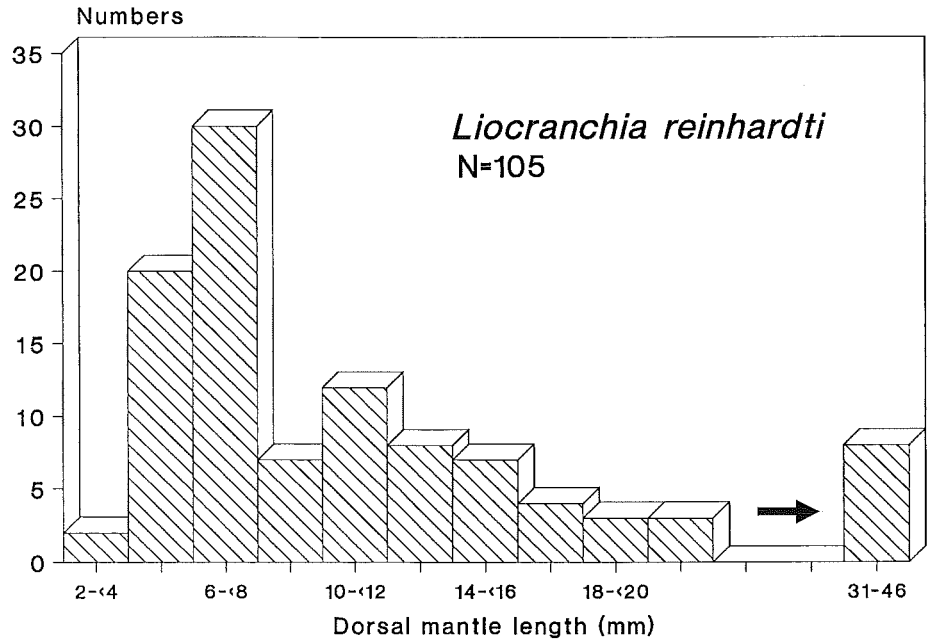

Figure 8. *Liocranchia reinhardti*: Length frequency composition as obtained from IKMT samples in the Arabian Sea, April to June 1987.

Ommastrephidae gen. et sp. indet. We found one paralarval specimen (rhynchoteuthion larvae, ML = 5.6 mm) at St. 12 (19°23'N, 66°31'E). According to the illustrated identification key for some early life stages of ommastrephids (Harman and Young, 1985) our specimen can be tentatively identified as belonging to the genus *Hyaloteuthis*: There is only a weak pattern of chromatophores on the mantle, and only a single prominent photophore between intestine and digestive gland can be recognized. However, further examination of this specimen is necessary to confirm a more detailed identification.

Family Cranchiidae.—*Liocranchia reinhardti* was the only cranchiid species in our collection, but it was by far the most abundant cephalopod captured. The length frequency composition of the 105 collected specimens is shown in Figure 8. The species is characterized by two V-shaped cartilaginous stripes on the anterior part of the ventral mantle side (Fig. 9). These stripes bear a number of pointed tubercles (5 to 7) and are coequal in length. Additionally there is a median dorsal line which is also partly covered by cartilaginous tubercles in varying numbers. These striking features distinguish *Liocranchia reinhartdti* clearly from all other cranchiids.

All of our specimens had a small, but very distinct gelatinous appendage covering the eyes (Fig. 9). This peculiar character, which we do not believe is an effect of preservation, is not shown in the figures of *Liocranchia reinhardti* given by Chun (1910), Okutani (1974) and Voss (1980).

Liocranchia reinhardti is a cosmopolitan meso-bathypelagic species that is common and numerous in all tropical seas (Clarke, 1966; Okutani, 1974; Voss, 1980; Nesis, 1988). It was reported several times from the Indian Ocean (Chun, 1910; Silas, 1968; Nesis, 1986) and occurred at 18 stations during the METEOR expedition

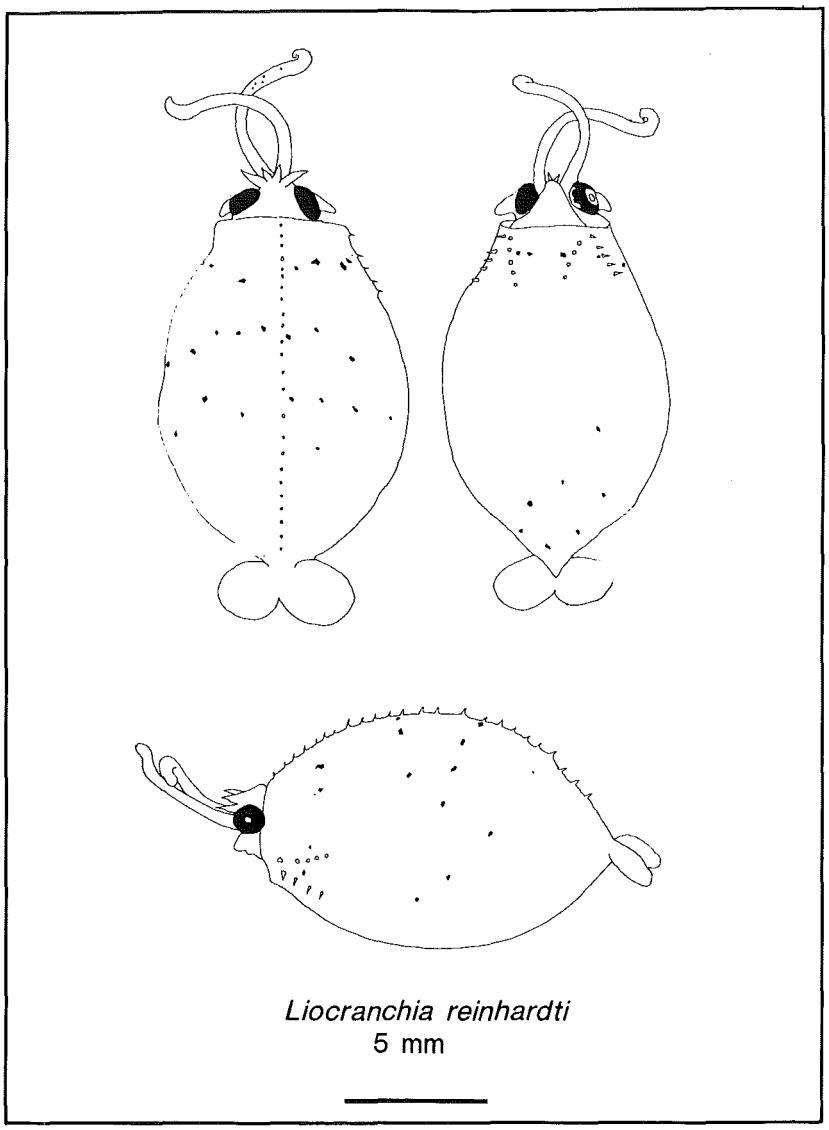

Figure 9. *Liocranchia reinhardti*: Paralarval specimen from central Arabian Sea, 12.2 mm DML. Dorsal, ventral, and lateral view.

(Fig. 10). The richest catch with 53 specimens was obtained at the southernmost station (St. 8; 18°14′N, 66°47′E).

Family Bolitaenidae.—Two specimens with mantle lengths of 6.0 and 8.0 mm, respectively, were caught at St. 8 and identified as *Japetella diaphana*. The specimens are in poor condition, but showed the characteristic features as described in the identification key of Nesis (1988).

Japetella diaphana is a typical inhabitant of the bathypelagic zones in all tropical oceans (Nesis, 1985). It was already reported from the Arabian Sea by Silas (1968) and Nesis (1986).

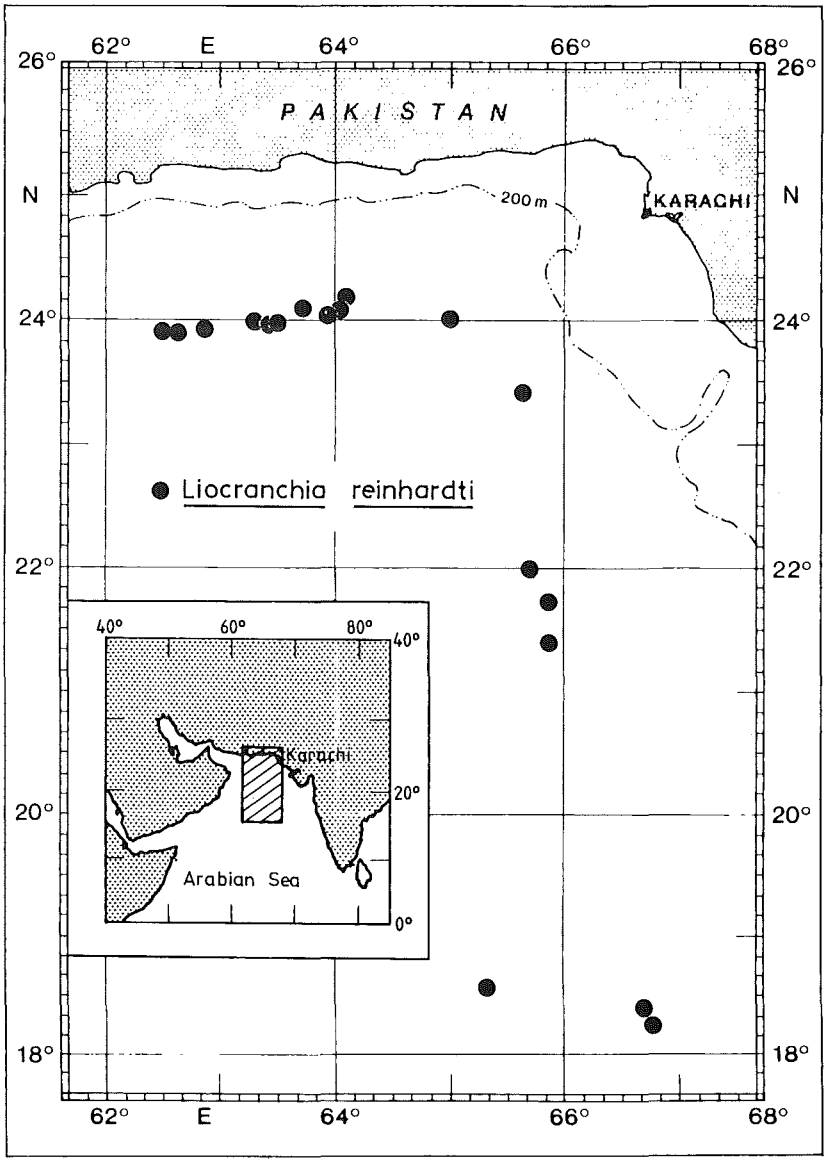

Figure 10. *Liocranchia reinhardti*: Geographical distribution in the Arabian Sea according IKMT samples from April to June 1987.

Family Octopodidae.—Two specimens of this family were found at shallower stations in the northern range of the investigated area (St. 33; 46). The mantle lengths are approximately 3 and 4 mm, respectively. Nothing can be said about correct genus or species name of these specimens.

Conclusions

Although the present work describes only a comparatively small collection of cephalopods, the data reveal new information on the distribution of pelagic squids

in the northeastern Arabian Sea. This is especially important, because based on the samples of the International Indian Ocean Expedition the Arabian Sea was one of the richest regions for cephalopods in the Indian Ocean (Aravindakshan and Sakthivel, 1973).

Species abundances (individuals per 1,000 m^3) as usually given for zooplankton species from net samples were not calculated, because the numbers of cephalopod specimens caught by the IKMT were too low. One reason for these low numbers is the high mobility of cephalopods which allows them to escape successfully most conventional sampling gears. This is particularly evident for the juvenile and adult stages of onychoteuthids and ommastrephids. On the other hand, these very strong swimmers may be an important fishery resource in wide parts of the Arabian Sea. However, in most parts of the Indian Ocean the cephalopod fauna is still poorly described, and nearly nothing is known about the biology of the various species. Thus, much basic work on cephalopod biology is still needed, before any effective method for harvesting the cephalopod resources shall be worked out (Silas et al., 1982).

Acknowledgments

We are very grateful to Dr. J. Kinzer from the Institut für Meereskunde, Kiel, for the valuable cephalopod collection he left in our hands. The first author expresses his special thanks to Professors G. L. and N. Voss, Rosenstiel School of Marine and Atmospheric Science, and to Dr. C. F. E. Roper and M. Sweeney, National Museum of Natural History, for the excellent introduction into cephalopod taxonomy, and to Professor R. E. Young, University of Hawaii, for the encouragement and great help in getting started with the puzzling work on cephalopod paralarvae. Professor T. Okutani, University of Tokyo, kindly identified the *Abraliopsis lineata* specimens. This research was funded by the Bundesministerium für Forschung und Technologie grant MFE 05408 and the Deutsche Forschungsgemeinschaft grant Ne 99/21-1.

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DATE ACCEPTED: December 10, 1990.

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