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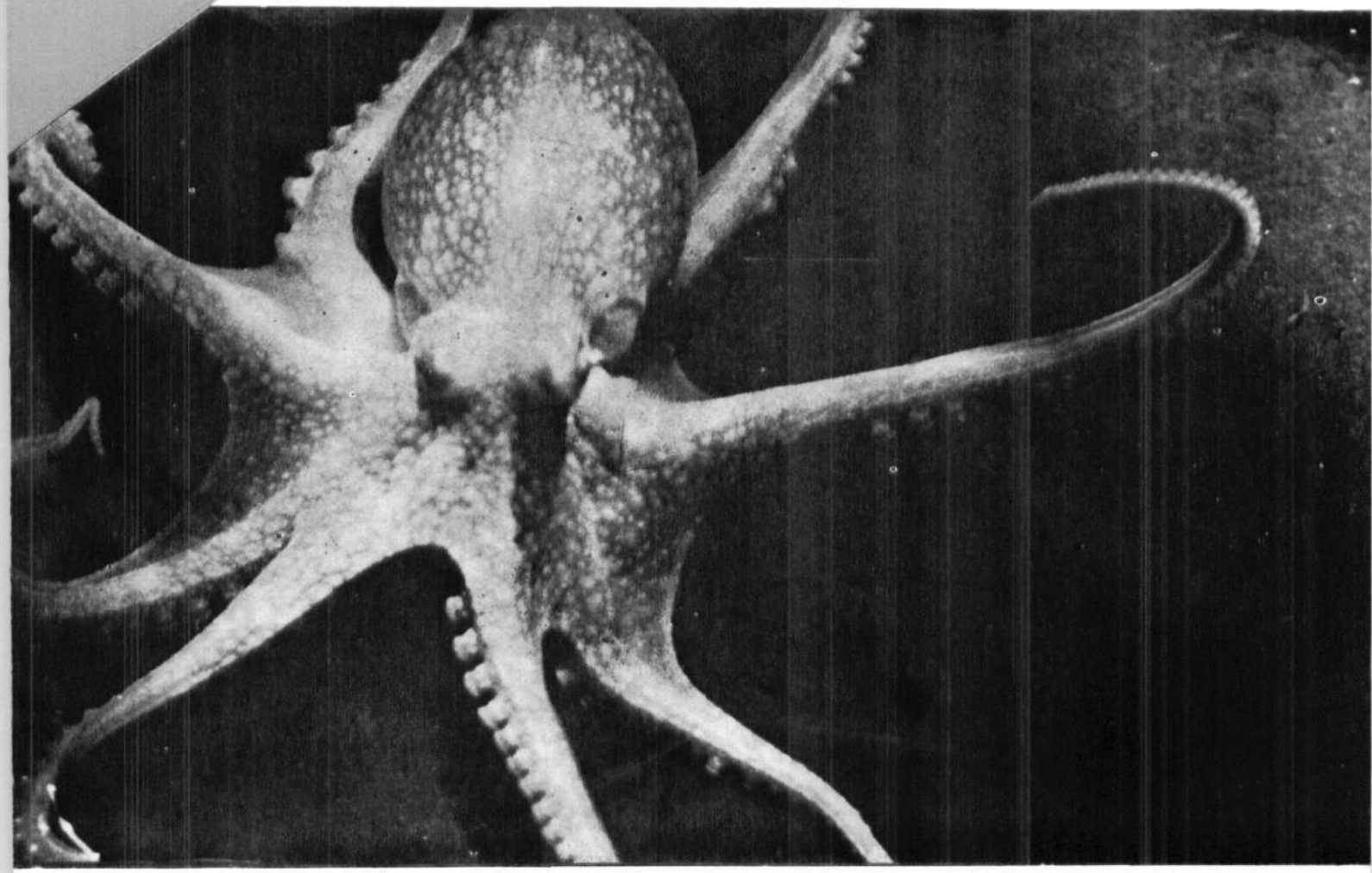

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RESUME OF THE WORK ON CEPHALOPODS OF THE INDIAN OCEAN

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ABSTRACT

The available literature on the cephalopods of the Indian Ocean with particular reference to those of the Indian Seas has been reviewed under five sections : systematics and distribution, biology, ecology, fishery and resources, and utilization.

INTRODUCTION

The cephalopods of the Indian Ocean have not received as much attention as the other shellfishes and finfishes. Information that is available on the cephalopods is confined mainly to faunistic records and taxonomic studies, besides some isolated accounts on the biology and natural history. With the realisation of their importance as a potential marine resource, concerted attention is now being paid to the study of the biology and ecology as an essential pre-requisite for their better utilization.

The scope of this brief review is to elucidate as much literature as possible on the cephalopods of the Indian Ocean, with particular stress on that in regard to the species of the Indian EEZ. This is not intended to be a complete literature review, but to highlight all essential aspects concerning systematics and distribution, biology, ecology, fishery and resources, and their utilisation.

SYSTEMATICS AND DISTRIBUTION

Noteworthy works on the cephalopods of the Indian Ocean are those of Chun (1910, 1915), Wülker (1920) Robson (1924a, 1924b, 1929, 1932), Massy (1927), Adam (1934, 1938, 1939a, 1939b, 1939c, 1939d, 1954, 1960, 1979), Thore (1945) and Adam and Rees (1966). Among several works dealing with cephalopods of the Atlantic and Pacific Oceans, mention is made of many Indian Ocean species also by Verrill (1881, 1882), Hoyle (1886), Berry (1912), Pfeffer (1912), Sasaki (1929), Pickford (1946, 1949a, 1949b, 1952, 1959), Voss (1956, 1963), Roper (1966) and Roper *et al.*, (1984). The important works pertaining to the cephalopods of the Indian Seas, Sri Lanka and Maldive Archipelago are by Ortmann (1891), Goodrich (1896), Massy (1916), Hoyle (1905), Robson (1921), Winckworth (1926, 1936), Rao (1954) and Silas (1968).

Velain (1877) has recorded the deep sea squid *Architeuthis sancti-pauli* from St. Paul Island in the southern Indian Ocean. Hoyle (1885a, 1885b, 1885c, 1885d, 1885e, 1886, 1904a, 1904b, 1905, 1907a, 1907b), has given an exhaustive account of many cephalopod collections from the H. M. S. Challenger Expedition, the specimens collected by Prof. Herdman from Sri Lanka in 1902, and the cephalopods of the Laccadive and Maldive Archipelagos. Robson's (1921, 1924a, 1924b, 1926a, 1926b, 1929, 1932) works also include cephalopods of many parts of the Indian Ocean. Winckworth (1926, 1936) has reported on the cephalopods around Sri Lanka and described *Sepia prashadi* from Madras waters.

Goodrich (1896), based on the collection of cephalopods in the Indian Museum, has described 18 species of decapods and 10 species of octopods, of which 11 were new species. Subsequently Massy (1916) has described 43 species in detail with morphometric measurements of many of them ; *Sepia arabica* has been described as a new species. Most of these cephalopods were taken in the INVESTIGATOR Expedition off the Indian and Burmese coasts at depths of 9 m to 1,723 m. In a major revision of nomenclature of many of the cephalopods in the Indian Museum, Adam (1939b) has redescribed 53 species under 23 genera. These and some

unidentified species number 65 till that time. Gravely (1941) identified six species of cuttlefish under the family Sepiidae from shells (cuttlebone) washed ashore along the Madras beach. Satyamurthi (1956) described three sepiids and two loliginids from Krusadai Island. Moses (1948, 1949) published preliminary reports on the cephalopods *Loligo*, *Enoploteuthis*, *Sepia*, *Sepiola*, *Octopus* and shells of *Spirula* and *Nautilus* in the erstwhile Baroda State.

Sasaki's (1929) monograph of the dibranchiate cephalopods, though mainly of the Japanese and adjacent water species, includes cephalopods that are also distributed in the Indian Ocean. Based on the collection of cephalopods of the ALBATROSS Expedition in the Philippine Islands, Voss (1963) has described 46 species, among them many occurring in the Indian Ocean. The classical review of the family Sepiidae by Adam and Rees (1966) includes many Indian Ocean species. Adam (1979) has given a detailed systematic account of many species of sepiids of west Australian waters in the Southeast Indian Ocean.

Pickford (1959) has mapped 15 known records of the deep water octopod *Vampyroteuthis infernalis* from the Indian Ocean collected by the INVESTIGATOR, DANA, DISCOVERY and GALATHEA Expeditions. Adam's (1965) redescription of two sepiids from the Indian Ocean, viz. *Sepia recurvirostra* and *Sepia brevimana*, was followed by Burgess's (1967) record of a new species of squid, *Loliolus rhomboidalis*, from Bay of Bengal collected by R. V. ANTON BRUUN during the International Indian Ocean Expedition. Maes (1967) has collected shells of *Nautilus pompilius* from the Cocos-Keeling Islands in the Indian Ocean ; *Sepioteuthis lessoniana*, *Octopus cyanea* and an unidentified species of *Octopus* also were recorded from these islands. Clarke's (1966) monumental review of the systematics and ecology of oceanic squids includes about fifty species which are distributed in the Indian Ocean ; this work deals with the distribution, eggs, larvae, juveniles, growth, maturity, egg-laying, food, predators as well as economic uses of many of the species.

A great and long-felt need in compiling a list bringing together all the known cephalopods of the Indian Ocean has been fulfilled by Silas (1968), who has catalogued 201 species, including the dibranchiate cephalopods collected by him from the west coast of India and the Laccadive Sea during the cruises of R. V. VARUNA. This work gives the synonyms, distribution and references for the taxonomic discussion of each species. This also extends the distributional records of five oegopsid squids and one octopod to the Arabian and Lakshadweep Seas.

Filippova (1968) has reported on the extensive collection of cephalopods made by the research vessels VITYAZ, ACADEMICIAN KNIPOVITCH and SOVETSKAJA ROSSIA from the Indian Ocean upto 41° S. Of these collections, eight species are recorded for the first time from the Indian Ocean. A clear latitudinal zonality in the distribution of the ommastrephid squids is established : while *Symplectoteuthis oualaniensis* inhabits the tropical waters within 20° S, *Onmastrephes bartrami*, together with *Todarodes sagittatus angolensis* occur in the areas between 20° S and 37° S, and further southwards upto 41° S the third species becomes dominant.

Oommen (1966, 1967, 1971, 1973, 1975, 1976, 1977a) has recorded many cephalopods of the families Sepiolidae (one species), Loliginidae (two species), Opisthoteuthidae (one species), Octopodidae (five species), and Argonautidae (one species) from the Arabian Sea. Of these, *Opisthoteuthis philippi* is a new species collected from a depth of 275-365 m off Alleppey on the southwest coast of India and this is the third species of *Opisthoteuthis*, the other two being *Opisthoteuthis extensa* collected off Sumatra and *Opisthoteuthis medusoides* obtained off East Africa (Thiele, 1915). Of the five species of Octopodidae, *Octopus varunae*, *Berrya keralensis* and *Berrya annae* are new species described by Oommen. He has also recorded the octopod *Argonauta argo* for the first time from the Arabian Sea (Oommen, 1980).

Sarvesan (1969a) has listed 33 species of cephalopods under 9 families in the Reference Collection Museum of the Central Marine Fisheries Research Institute. Okutani (1970, 1973a) has described three species of squids (*Sepioteuthis lessoniana*, *Doryteuthis singhalensis* and *Symplectoteuthis oualaniensis*) from the Seychelles Bank in the Indian Ocean, and made a preliminary note of the planktonic cephalopods belonging to the oegopsid families Enoploteuthidae, Brachioteuthidae and Cranchiidae, collected during the International Indian Ocean Expedition. Chandra Mohan and Rao (1978) have recorded the occurrence of *Sepiela oweniana* off Visakhapatnam.

The cephalopods of the Red Sea and the Gulf of Aqaba have been reviewed by Adam (1959, 1960). In a subsequent work he (Adam, 1973) has enumerated 23 species, 6 of which where reported from the area for the first time. Mienis (1978) has recorded two species of *Argonauta* and one species of *Spirula* from the Red Sea. Voss (1962, 1967) has reported on the bathypelagic and other cephalopods of South Africa. Pickford (1974) has discussed the taxonomic status of *Cistopus indicus*, a common Indo-Malayan species of

octopod. Again, Adam (1975) has described a new species of ommastrephid squid, *Todarodes filippovae*, from the Indian Ocean. Sanjeeva Raj and Kalyani (1971) have recorded the squid *Euprymna morsei* from Madras coast, together with a redescription of the species. Based on the plankton collections of the International Indian Ocean Expedition, Aravindakshan and Saktivel (1973) have broadly indicated the areas of occurrence and abundance of planktonic cephalopods in the Indian Ocean. Sarvesan (1976) has extended the distributional record of the cuttlefish *Sepia trygonina* by describing it from the Gulf of Mannar. Rao (1977) has given the faunistic distribution of cephalopods of Digha Coast, Bay of Bengal. Ray (1937) recorded *Loligo duvaucelii* from Burma for the first time, and Imber (1978) described a new species, *Gonatus phoebetriae*, from an Indian Ocean Island. Taki (1981) has given a catalogue of the cephalopods of Wakayama Prefecture, which includes many species that are also distributed in the Indian Ocean.

Biology

In his pioneering work on the biology of the Palk Bay squid *Sepioteuthis arctipinnis* (=*Sepioteuthis lessoniana*), Rao (1954) has studied the growth and longevity, length-weight relationship, age and size at sexual maturity, food and feeding habits, and spawning. Alagarswami (1966) has described its egg clusters, egg capsule, egg and the newly hatched young ones. Rahaman (1968, 1980) has studied the gonad and hepatic indices, sexual maturation and spawning of this squid and also of the cuttlefish *Sepia aculeata*. Karnekamp (1979) reported on the shell growth and aberrent shape of the shell of *Sepia gibba* from the Red Sea. Some biological aspects such as age and growth, length-weight relationship, stages of maturity and food and feeding habits of the cuttlefish *Sepiella inermis* of Mandapam area on the southeast coast of India were studied by Unnithan (1982).

Nagabhushanam (1968a, 1968b) has reviewed the studies on the physiology of chromatophores in cephalopods and on the neurosecretion in cephalopods as well as other molluscs. The calcium, strontium and radium contents of the cuttlebone of *Sepia* have been estimated by Rao and Viswanathan (1968). Pandit and Magar (1972) and Suryanarayan and Alexander (1980) have estimated the chemical composition of some cephalopods from Indian waters.

The spawning grounds of the cuttlefish *Sepia pharaonis* have been located off Orissa and Visakhapatnam coasts (FAO UN, 1961). Sarvesan (1969b) has observed the breeding behaviour and hatching process of *Octopus dollfusi*. Sivalingam and Pillai (1980) have discussed the breeding season and hatching of the squid *Sepioteuthis arctipinnis* and the hatching of the cuttlefish *Sepia aculeata*.

Oommen (1977b) has given a detailed account of the functional morphology and food and feeding of the squid *Loligo duvaucelii* and the cuttlefishes *Sepia aculeata* and *Sepiella inermis* collected off the west coast of India. He has further noticed cannibalism in some of the species. Kore and Joshi (1975) also observed cannibalism in *Loligo duvaucelii*. Jothinayagam (1981) has studied the seasonal abundance, sex ratio, maturity stages and food habits of *Sepiella inermis* of the Madras coast.

Ecology

In the ' Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Mannar ', Herdman (1903-1906) has mentioned that the octopods are abundant in some of the pearl banks of Tuticorin and that they are well-known to live at the expense of oysters and mussels. Mahadevan and Nair (1967, 1974) have found that the octopod *Polypus* (=*Octopus*) sp. inhabits the pits and crevices in the pearl banks of Gulf of Mannar, and sometimes it haunts the empty shell of oysters ; it is often seen opening the shell of live pearl oysters to eat the flesh, and is considered as one of the predators of pearl oyster. Sarvesan (1974) also mentions that *Octopus herdmani* preys upon pearl oysters, and that another small poisonous octopod is dangerous because of its bite, rendering it unsuitable for use as food or bait.

Tampi (1959) has recorded that in the salt water lagoons of Mandapam the young ones of the squid *Sepioteuthis arctipinnis*, and occasionally *Loligo* sp., occur early in the year when the water level is high.

Gopalakrishnan (1970), while studying the shore ecology of Okha on the northwest coast of India, has noticed *Octopus* sp. and *Sepia* sp. in the midlittoral reef region, hiding in rock crevices and submerged pools ; he has also observed a large number of cuttlebones washed ashore.

In the ' Report on Cruise of the R. V. SHOYO MARU in the North Arabian Sea Survey ', it has been recorded that the oceanic squid *Symplectoteuthis oualaniensis* seems to avoid the upwelling areas ; it sinks in the low-oxygen layer, in day time but moves to the oxygen-saturated upper layers at night for feeding (Fishery Agency of Japan, 1976, 1977 ; Yamanaka *et al.*, 1976). Silas (1969a) records that during the exploratory fishing by R. V. VARUNA, schools of *Symplectoteuthis oualа-*

niensis have been attracted by light towards the ship at night and were found to feed on planktonic organisms. Filippova (1968) draws a parallel between this oceanic squid and the tropical epipelagic fishes in their ecology. For both the sub-tropical convergence (18°S to 20°S) seems to be the southern boundary of distribution in the Indian Ocean. She also remarks on the association between the pelagic octopod *Argonauta hians* and the pleiston organisms such as *Velella*, and between the young of another pelagic octopod *Tremoctopus violaceus* and *Physalia*.

There are very few records of parasites on cephalopods. Kalavati *et al.* (1977, 1978) have recorded a microsporidian parasite, *Steinhausis spraguei*, and a mesozoan parasite, *Dicyemmennea coromandelensis*, from the cuttlefish *Sepia elliptica* collected from Bay of Bengal. Belyaeva (1979) mentions about some squids of the Indian Ocean as the intermediate hosts of helminth parasites. A new parasite species, *Aggregata kudoi* was recorded from *Sepia* sp. by Narasimhamurti (1979). A new species of a dicyemid mesozoan parasite under a new genus, *Dodecadicyema loligoi*, has been recorded by Kalavati and Narasimhamurti (1980) from the renal appendages of *Loligo* sp.

The cephalopods are prey of a great variety of fishes, cetaceans and cephalopods themselves. The literature on this prey-predator relationship is rich in that there are numerous references to cephalopods as one of the items of food of many marine fishes. Often the identification of the prey cephalopods to the species or genus level is not possible, and in most references they have been mentioned as cephalopods, squids, cuttlefish, and sometimes as *Loligo*, *Sepia* and *Octopus*. Okada (1933) has observed a single specimen of *Spirula* in the stomach of a yellowfin tuna from Sumatra. According to Mimura *et al.* (1963), octopods formed 46.1% of the food of the yellowfin tuna around 10°S in the East Indian Ocean, and 15.9% in the area around 20°S. Talbot and Penrith (1963) found that *Loligo reynaudi* and *Abralia gilchristi* formed part of the food of *Thunnus alalunga*, *Thunnus albacares* and *Histioteuthis bonellina*; *Loligo reynaudi* was noticed in the stomach of *Thunnus obesus*, and various species of squids in the food of *Thunnus thynnus orientalis*. In the stomach contents of the little tuna *Euthynnus affinis* collected from the East African waters, squids were found to occur as part of the food (Williams, 1963). Okutani and Suzuki (1975) have noticed the bathypelagic *Spirula spirula* and the epipelagic *Argonauta bottgeri* in the stomach of a single yellowfin tuna taken off the southern coast of Sri Lanka.

Williams (1964, 1967) has found the following fishes caught in long lines off East Africa to feed on cephalopods: *Carcharhinus amblyrhynchus*, *Thunnus albacares*, *Thunnus alalunga*, *Euthynnus affinis*, *Tetrapterus audax*, *Istiophorus gladius*, *Acanthocybium solandri* and *Alepisaurus ferrox*. They formed upto 44% of the stomach contents. Mienis (1977) has observed squid in the stomach contents of the deep water shark *Iago omanensis* from the Arabian Sea.

Many workers have recorded cephalopods in the stomach contents of scombroid fishes of the Indian Seas. Raju (1964) has observed that cephalopods formed 21.8% by volume of the food of the skipjack caught in pole and line off Minicoy, Lakshadweep, and that in the stomachs of this fish below the size of 400 mm (TL) there were no cephalopods, between 401 mm and 550 mm they formed 19.4%, between 551 mm and 700 mm 25.2%, and above 700 mm, 37.8%. Silas (1963) mentions about squids as a food item of the dog-tooth tuna *Gymnosarda unicolor*. Kumaran (1964) has recorded that *Sepioteuthis* sp. and *Loligo* sp. formed food of *Euthynnus affinis affinis* collected from Vizhinjam (upto 56.5%) and larger individuals of *Auxis thazard* and *Auxis thynnoides* (upto 22.7%). Squids and *Octopus* formed substantial portion (upto 75% by volume) of the stomach contents of *Katsuwonus pelamis* of the Laccadive Sea (Raju 1964). Rao (1964) has observed cephalopods in the food of adult *Scomberomorus guttatus* landed at Lawson's Bay, Waltair.

Among threadfins, the adult *Polynemus indicus* has been found to have fed on *Sepia* and *Octopus* by Karekar and Bal (1958), and *Polynemus heptadactylus* on *Sepia* sp. by Kagwade (1969).

James (1967) has observed young of *Sepia* and *Octopus* in the stomach contents of ribbon fishes collected from the Palk Bay and Gulf of Mannar. Cuttlefish remains have been noticed by Sivaprakasam (1967) in the food of *Parastromateus niger* at Veraval on the Northwest coast of India. Suseelan and Nair (1969) have found cephalopods to form part of the food of many demersal fishes of Bomaby coast: *Pseudosciaena diacanthus*, *Otolithoides brunneus*, *Otolithus rubex*, *Johnius dussamieri*, *Johnius axillaris*, *Pomadasys hasta*, *Muraenesox talabonoides* and *Arius thalassinus*. The 'ghol' *Pseudosclaena diacanthus* of Bombay waters (Rao, 1968), the catfish *Tachysurus thalassinus* of Waltair coast (Mojumder, 1969), *Pomadasys hasta* of Bombay and Gujarat coasts (Deshmukh, 1973), the deep sea shark *Haleolurus hispidus*, *Eridancis radcliffei* and *Iago omanensis* collected from a depth of 150-200 fathoms (273-364 m) off the southeast coast of India (Nair and Appukuttan, 1973), the juveniles of the flatfish *Psettodes erumei* and the eel *Muraenesox cinereus* of Portonovo coast (Devadoss and Pillai, 1973, 1979), the flat fishes

Psettodes erumei and *Pseudorhombus arsius* of the same coast (Natarajan and Natarajan, 1980), the juveniles (42-53 cm) of *Otolithoides brunneus* of Bombay waters (Jayaprakash, 1974), the torpedo travelly *Megalaspis cordyla* of Vizhinjam coast (Sreenivasan, 1974), the carangid *Decapterus dayi* of the same coast (George *et al.*, 1976) and the catfish *Tachysurus tenuispinis* collected in trawl nets off Visakhapatnam (Mojumder and Dan, 1979) have been reported to have consumed cephalopods as food.

Rabindranath (1966) has recorded cephalopods in the stomach contents of *Rastrelliger kanagurta, Decapterus russelli, Auxis thazard, Otolithus argentius, Caranx crumenophthalmus, Selaroides leptolepis, Selar kalla Sphyraena acutipinnis, Indocybium guttatum, Cybium commersoni, Saurida tumbil, Chirocentrus dorab,* and *Nemipterus furcosus* collected mostly from Trivandrum coast and partly from Quilon and Cochin coasts of Kerala. Cephalopods formed 2.7% of the gut contents of the 'velameen' *Pristipomoides argurogammicus* taken off the southwest coast of India (Oommen, 1976).

Thus it will be seen that cephalopods form an important forage for several species of fishes and a very significant constituent of the food of tunas and billfishes.

Cephalopods, especially squids, are a very favourite food of sperm whales. According to Matthews (1938), cephalopods formed part of the food of sperm whales caught off Southeastern Africa, and Hollis (1939) recorded octopods as well as squid species of the genera *Moroteuthis, Histioteuthis, Stenoteuthis* and *Architeuthis* from the stomachs of sperm whales from west and northwest Australian waters. Based on a large number of beaks collected from the stomachs of sperm whales caught off Durban (South Africa), Albany (Western Australia) and the yellowfin tuna *Thunnus albacares* caught off East Africa, Clarke (1977) reported that many species of squids belonging to the families Histioteuthidae, Cycloteuthidae, Ommastrephidae, Pholidoteuthidae, Octopoteuthidae and Cranchiidae formed food of sperm whales and Enoploteuthidae and Ommastrphidae that of tunas. He has also made a rough estimate of the total weight of cepahlopods consumed by sperm whales in a year and briefly mentioned about their importance in the ecology of the oceans. In regard to the Indian waters, Silas *et al.*, (1985) have recorded that *Chiroteuthis* formed part of food of the sperm whale *Physeter macrocephalus* stranded on the east coast of India.

Fishery and Resources

Hornell (1917), in his account of the edible molluscs of Madras Presidency, states that the cephalopod fishery was then restricted to the Palk Bay, where the squid *Loligo* (= *Sepioteuthis lessoniana*) was caught in a special type of shore seine, locally called 'ola valai', (upto 5,000 squids in a single haul), and in a type of hand jig operated in the shallow areas. He also makes mention of the commercially important cephalopods of South India in general (Hornell, 1922, 1951). Rao's (1954) account of the Palk Bay squid describes the fishing methods adopted in this region and also gives the fishing seasons. Krishnamurthi (1957) also records that these squids are taken in shore seines in the Palk Bay area where they come to shallow waters for depositing their eggs among seaweeds. Light fishing experiments were conducted in the Gulf of Mannar, and squids along with clupeoids and half-beaks formed the main catch (CMFRI, 1957). Chellappa (1959) has given an account of the light fishing experiments conducted in the same area with the aid of a 'kelong' and a 300-candle power kerosene petromax lamp, in which squids were one of the important items of the catch. Jones (1968) lists the edible cephalopods of India and briefly mentions about their importance as an incidental catch in the marine fish landings. Rao (1958, 1969a, 1969b, 1973) mentions the important species of cephalopods that are obtained in the fish landings in India, and refers to the Palk Bay and Gulf of Mannar squid and octopod fishery, pointing to the need to develop the fishery not only as a source of food but also to prevent young shoaling fishes from being preyed upon by squids. Passing mention of this localised fishery is also made in a review of the fishery resources of India (CSIR, 1962). Prasad and Nair (1973) also refer to the seasonal squid fishery in the Palk Bay and Gulf of Mannar.

Giving a preliminary account of the fisheries of Vizhinjam, Nair (1958) records the catch of *Sepia* for 1950-'54. Radhakrishnan (1973) recognises Vizhinjam area as an important centre of cephalopod landings. Jayabalan and Ramamurthi (1977) give a brief account of the fishery and relative abundance of cephalopods at Portonovo. Varghese (1981), discussing the present status of small-scale fisheries in Lakshadweep, gives the landings data of *Octopus* spp. for the period 1973-77. Rayudu and Chandramohan (1982) briefly mention about the cephalopod fishery of Visakhapatnam.

Many workers have recorded cephalopods in the catches taken in trawl fishing in the various parts of the seas around India. Tholasilingam *et al.* (1968) record the squid catches obtained in exploratory trawl fishing conducted in depths of 274-474 m off Alleppey. Rao and Dorairaj (1968) have indicated the productive areas for cephalopods off Goa, and from the catch/

hour data they have also estimated the potential yield of the area. Bapat *et al.* (1972) have observed cuttlefish in the trawl catches of Karwar. In the northwestern part of the Bay of Bengal squids were caught in exploratory trawl fishing on the continental shelf area at a depth of 15-128 m (Sekharan *et al.*, 1973). In Kakinada region they formed 0.95% to 1.22% of the total demersal fish catch (Muthu *et al.*, 1975; Narasimham *et al.*, 1979). In the trawl surveys off Visakhapatnam during 1972-78 by the Fishery Survey of India (previously, Exploratory Fisheries Project), cephalopods contributed 1.2% of the total catch (CMFRI, 1980).

The trawl survey conducted by M.T. MURAENA in area between 15°N and 24°N off the northwest coast of India during 1977 revealed the occurrence of cephalopods which formed 0.2% of the total trawl catch (Bapat *et al.*, 1982). *Sepia aculeata, Sepia pharaonis* and *Loligo duvaucelii* constituted the bulk of the catch.

The UNDP/FAO Pelagic Fishery Project surveys on the southwest coast of India has revealed the occurrence of cephalopods in normal to good quantities (UNDP/FAO, 1974a, 1974b, 1976a, 1976b, 1976c, 1976d, 1977). In pelagic trawling squids formed upto 34% in Quilon-Kanyakumari and Gulf of Mannar areas, upto 50% in Quilon-Mangalore area and upto 25% in Mangalore-Ratnagiri area. In bottom trawling also they formed upto 50% of the total catch in the southern areas. There is also mention of the traditional coastal fishery of Trivandrum, locally called 'nonnavu' fishery, in which post-larval and early juvenile stages of various fishes together with young cephalopods and sergestids are caught. The trawlers of the Fishery Survey of India have surveyed areas off Bombay and Gujarat coasts, off Kerala and the Wadge Bank on the southwest coast, and these surveys revealed good concentration of squids and cuttlefishes (EFP, 1979a, 1979b, 1979c, 1982; Sulochanan and John, 1982).

The importance of the oceanic squids as a potential resource has been pointed out by Silas (1969b), stressing the need to exploit them by India. In a detailed report on the exploratory fishing by R. V. VARUNA and other vessels in the neritic deep waters and the upper continental slope (75-450 m) between 8°N and 14°N on the southwest coast of India, Silas (1969a) has recorded that cephalopods formed a major group in the trawl catches. The drift net fishing surveys conducted between 7°-15°N and 71°-78°E revealed the occurrence and abundance of the oceanic squid *Symplectoteuthis oualaniensis*; its concentrations were noticed beyond 180 m depth off Trivandrum-Cochin area, and off Calicut upto 14°N and also in deeper waters between 10°-12°N and 72°-73°E. The deep water octopod *Berrya keralensis* has been recorded in small quantities in trawl catches from continental slope at 200-350 m depth off Kerala coast, and *Sepia* spp. at 75-350 m from the same area.

Silas *et al.* (1976) drew attention to the importance of cephalopods as a potential resource, at present obtained as a bye-catch and earlier discarded at sea owing to lack of local demand and to prevent contamination of fish and shrimp catches with their ink. These authors have also stressed the need to exploit the commercially important squid and cuttlefish resources including the oceanic squid *Symplectoteuthis oualaniensis.*

Hida and Pereyra (1966) have recorded cephalopods in the catches taken in bottom trawling by ANTON BRUUN in 1963 from Thailand, Andaman Islands, Burma, Bangladesh, India, Pakistan, Oman and Arabia. Druzhinin (1972) has recorded squids in the trawl catches from southern Burmese waters in the Bay of Bengal. According to Zupanovic and Mohiuddin (1973), *Sepia* sp. and *Loligo* sp. were obtained from a depth of 46-123 m and *Octopus* sp. from 80-125 m in trawl survey in the northeastern Arabian Sea off Pakistan. The Norwegian vessel, R/V Dr. FRIDTJOF NANSEN, which surveyed North Arabian Sea, has frequently taken the oceanic squid *Symplectoteuthis oualaniensis* in such quantities as 8 kg at 21°57'N, 62° 41'E and 58 kg at 23° 37'N, 59° 22'E. (Institute of Marine Research, 1975). The Fishery Agency of Japan (1976, 1977) and Yamanaka *et al.* (1976) report that one of the most important findings during the cruise of R. V. SHOYO MARU in the North Arabian Sea Survey to assess the pelagic fish stocks is the occurrence of the potential pelagic squid *Symplectoteuthis oualaniensis* (23-50 cm) taken in jig fishing from wide areas in the North Arabian Sea and central portion of the South Arabian Sea. Sanders and Bouhlel (1981, 1983) have conducted experiments to determine the mesh selection properties of trawl cod ends of various mesh sizes involving alternate haul method for the exploitation of the cuttlefish *Sepia pharaonis* in the PDR Yemen.

Dayaratne (1978) has studied the cuttlefish catches from the Wadge Bank trawl fishery. The species (*Sepia pharaonis*) in the range of 10-36 cm was taken at depths of 33-69 m from the area.

Sarvesan (1974) has briefly reviewed the fishing methods by which cephalopods are caught in India. These include fishing with shore seines, boat seines hooks and lines, hand lines, trawl nets and shore trap, for octopods.

In India cephalopods form nearly 4% of the total bye-catch in the shrimp fisheries, the States of Maharashtra, Gujarat and Kerala accounting for the substantial portion of the catch (CMFRI, 1981). Silas *et al.* (1982) have briefly dealt with the magnitude of cephalopod landings in India (11,335 tonnes in 1980) and constituent states and the prospects for increasing production.

Regarding the potential cephalopod resources of the Indian Ocean, our information is very limited. Gulland (1970) estimates it to be over several hundreds of thousands of tonnes. Voss (1973) puts the potential at 500,000 tonnes and Tussing (1974), recognising cephalopods as one of the categories which forms a resource, also gives about the same estimate. Still another proposition is 200,000 tonnes (Anon, 1977).

Belyaev (1962) observed that cephalopod beaks are abundant in the sediment in the northwestern part of the Indian Ocean, upto a maximum 15,000 beaks/m^2. According to Zuev and Nesis (1971) this abundant distribution of beaks and the hydrographical conditions like upwelling are clear indications of the rich cephalopod resources in the pelagic zone of the Arabian Sea. Based on Soviet investigations in the northwestern part of the Indian Ocean, Zuev (1971) has identified *Loligo duvaucelii, Loligo edulis, Loligo* sp., *Symplectoteuthis oualaniensis* and *Sepia pharaonis* as occurring in commercial quantities and also suggested some potential regions. Druzhinin (1973), giving an account of the fishery resources of the Gulf of Aden, estimates a potential of 10,500 tonnes for this area, which Voss (1973) considers an underestimate. Discussing the present condition of the exploitation and the latent stock of the cephalopod resources of the world, Okutani (1973b) suggests *Sepia pharaonis* and *Symplectoteuthis oulaniensis* as the latent species in the western Indian Ocean and *Sepia* spp. and *Nototodarus sloani* in the eastern Indian Ocean. From the catch and effort data in respect of trawlers operated by Japan, PDR Yemen and U.S.S.R. in the Arabian Sea off the coasts of Yemen, he states that the maximum sustainable yield of cuttlefish in this region might be about 6,500 tonnes, and with the present level of fishing effort the recent fishery has been operating at around the optimum level. Payne (1978) is of the opinion that the stocks of cephalopods are widely distributed in the Arabian Sea, and that the commercial harvest of cuttlefish is taking place southwest of the Arabian Peninsula. Sanders (1979) has made some preliminary stock assessment studies of the cuttlefish *Sepia pharaonis* taken off the coast of PDR Yemen. Based on the catch and effort data for *Sepia pharaonis* (forming 95% of the cephalopod fishery) and three other Sepiids taken during 1967-1980 Sato and Hatanaka (1983) have estimated the MSY of cuttlefish off PDR Yemen as 8,500 tonnes with an effort of 1,200 standard days.

George *et al.* (1977) have estimated that the cephalopod potential of the Indian Economic Zone would be of the order of 180,000 tonnes ; of this 55% would be the contribution from the upper east coast, 11% from the lower east coast, 20% from the southwest coast, 11% from the northwest coast and the remaining 3% from the Laccadive Sea.

For the student reader we would refer a recent book ' Marine Fisheries ' by Bal and Rao (1984) which summarizes some aspects of cephalopods and their fisheries in India along with other marine fishery resources of the country.

Apart from the above mentioned references on the fishery and resources of cephalopods of the Indian Ocean, the ' Advances in Assessment of world Cephalopod Resources ' (FAO Fisheries Technical Report 231 edited by Caddy (1983) contains some papers dealing with stock assessment of cephalopods. Chikuni (1983) discusses the present status of the cephalopod fishery, potential yield of the neritic species and the problems involved in the future development in the Indo-Pacific region. Worms (1983) reviews the cephalopod fisheries of the north and northwest Indian Ocean among other geographic areas.

Utilization

Except for some periodic reports on cephalopods as an item of the export trade, given by various maritime countries, and for a few stray references to cephalopod products and their marketing in the context of localised fisheries, the literature on their utilization is very scanty. In Hornell's (1917) account on the edible molluscs of Madras Presidency, it was mentioned that the cephalopods were of economic importance in the Palk Bay area both as food and as an item (cuttlebone) of export. Rao (1954) has briefly dealt with the processing of the Palk Bay squid for local market and Mukundan (1968) has referred to the use of the ink of *Sepia* by artists. The several ways of utilization of cephalopods have been mentioned by Sarvesan (1974).

There are many references to cephalopods as an effective bait in the hooks and line fishery (Jones, 1968 ; Sarvesan, 1974 ; Silas and Pillai, 1982 ; Rajagopal *et al.* 1977 ; 1982). According to Silas and Pillai (1982), squids (*Loligo* spp.) are one of the most important baits in the tuna longline fishery ; they have also given the catch

data of the southern bluefin, albacore, bigeye and yellowfin taken in squid-baited longlines by the Japanese during 1965-81.

Sreenivasan (1962) has dealt with the bacterial discolouration of squids. Padmanabhan (1970) has discussed the prospects of developing cephalopods into fishery products for internal and export trade and has given the methods of processing and preservation. Sastry and Srikar (1982) have studied the changes in total nitrogen, salt-soluble and water-soluble proteins, non-protein nitrogen and total free amino acids of the cuttlefish *Sepia aculeata* preserved in ice at 0°C over a 14 day period of storage.

Abdulla and Idrus (1978), dealing with the fish processing industry of Peninsular Malaysia, give the quantity of cuttlefish products of the country for 1976. Menon (1978) mentions that frozen squids and cuttlefish are among over 37 major items of marine products exported from India. According to Venkataraman and Devadasan (1978), the increase in the export of cephalopod products fetches good returns to the fishermen of India, and according to Yeoh and Merian (1978), squids and cuttlefish are among the traditionally processed marine products in the processing industry of Malaysia. Santhanakrishnan (1982a, 1982b, 1982c) has listed the cephalopod products which have potential export market and has given the methods of drying the squid and preparing it for export. In a series of periodic publications, the Marine Products Export Development Authority, Government of India, are giving all the relevant data in regard to the export of cephalopods from India. Particular mention must be made of a special feature on the quality requirements and methods of processing squids and cuttlefish for export (Indian Seafoods, July-December, 1976). Shenoy (1985) has briefly described the method for processing dried squid which has a potential export market in Japan.

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