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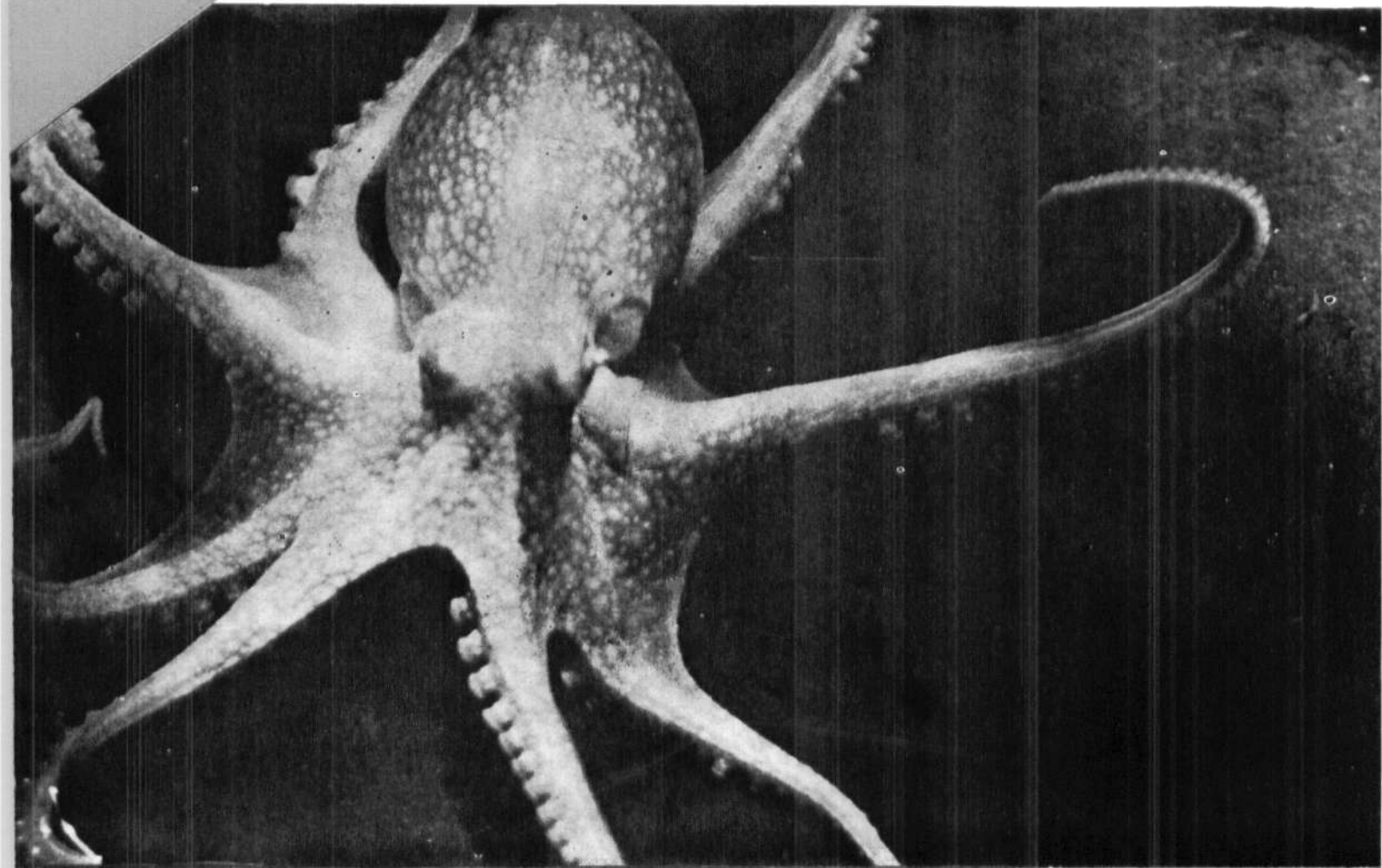
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CEPHALOPOD BIONOMICS, FISHERIES AND RESOURCES OF THE EXCLUSIVE ECONOMIC ZONE OF INDIA

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OCEANIC SQUIDS

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ABSTRACT

The various species of oceanic squids distributed in the Indian Ocean especially in the Exclusive Economic Zone of India and adjacent waters and their importance from the point of view of exploitation are discussed. The need for conducting experimental fishing and use of suitable fishing and drift net fishing for developing a fishery for oceanic squids is emphasized.

INTRODUCTION

The oceanic squids are comprised of the Oegopsida, which are distinguished by the presence of an opening (slit) in the corneal membrane exposing the lens of the eye to the surrounding medium. Excepting a very few, e.g., *Todarodes pacificus* and *Illex illecebrosus*, almost all oceanic squids spend their entire life span in the open ocean.

There are about 200 species of oceanic squids belonging to 28 families known to occur in the world oceans (Worms, 1983). Our knowledge about the oceanic cephalopods of Indian Ocean is through the works of Clarke (1966), Filippova (1968) and Silas (1968, 1969 a, 1969 b and Silas *et al.* (1976). A comprehensive list of species of cephalopods known from the Indian Ocean has been given by Silas (1968). In that work, sixty nine species of oceanic squids representing forty three genera of thirteen families are reported from this region. Many of the oegopsid squids and a few other cephalopod species are considered to form stocks which have been hitherto unexploited in the Indian Ocean and the seas around India. Some of the commercially important squids are known to abound in our Exclusive Economic Zone and contiguous areas. Upto now no quantitative estimates have been made of the available resources. However, the exploratory works and planktological investigations carried out in the past

indicate that extensive resources exist especially in the North Arabian Sea, off west coast of India and in the oceanic waters of the Bay of Bengal. We have some idea of the general distribution of many of these oceanic squids and their juveniles. The report by Filippova (1968) based on the large collections of cephalopods made from a total of 190 stations in Indian Ocean by R/V VITYAZ (1959-67), R/V ACADEMICIAN KNIPOVITCH (1966) and by the Factory Ship SOVETSKAYA ROSSIA (1966-67) throws more light on the occurrence of some of these species in the different areas of the Indian Ocean up to 41°S. Silas (1969) has presented the results of the investigations made during cruises of R.V. VARUNA on the distribution and abundance of cephalopod larvae, juveniles and adults belonging to the families Loliginidae, Enoploteuthidae, Bathyteuthidae, Histioteuthidae, Ommastrephidae and Cranchidae. Based on the observations made, the distributional charts with information on the seasonal cycles of abundance pertaining to *Abralia andamanica*, *Abraliopsis gilchristi*, *Rhyncoteuthis* larvae of *Symplectoteuthis oualaniensis*, *Doratopsis* stage of *Chiroteuthis* sp., *Liocranchia* spp. and *Thelidoteuthis alessandrini* have been given.

Studies on the distribution and relative abundance in time and space of cephalopod juveniles in general have been made by Aravindakshan and Sakhivel (1973).

The studies were based on plankton collections obtained from a wide area during the International Indian Ocean Expedition from the Bay of Bengal, Somalia Sea, North Arabian Sea and East Arabian sea. A comparison of occurrence of cephalopod juveniles in different areas showed that they are abundant in the Bay of Bengal, Andaman Sea, southwest off Sri Lanka, off Kutch, South Arabian Coast, parts of Somali Coast, certain isolated areas along equatorial zone and southern area off South African Coast. Seasonal variations in the abundance of cephalopod juveniles with peak abundance during southwest monsoon period in the Bay of Bengal (April-September) were observed in these areas. In the North Arabian Sea, the major peak (was noticed in November and December followed by a minor peak in June and July. The general pattern observed is that juveniles are more abundant along the South Arabian Coast during the northeast monsoon period than in other months whereas their abundance is during southwest monsoon period in the Bay of Bengal (Aravindakshan and Sakthivel, 1973).

Prevalence of similar conditions has been reported along the west coast of India (Silas, 1969). The larvae of cephalopods were in greater abundance during the periods April-July and November-December in the Wadge Bank off Cape Comorin and between Quilon and Cochin.

It is interesting to note that of all the areas explored in the Indian Ocean, greater abundance of cephalopod larvae and juveniles were recorded in the Bay of Bengal area, in the Wadge Bank off Cape Comorin and areas off Kutch in the northwest coast of India.

Although a number of species occur in oceanic waters, many owing to their small size and unfavourable consistency of their body, are not suitable for human consumption but are important as forage to tunas, billfishes and toothed whales. Only a few species of oceanic squids are commercially and potentially important and they belong to the families Ommastrephidae, Histioteuthidae, Lepidoteuthidae, Onychoteuthidae, Veranyidae, Gonatidae and Cranchiidae (Voss, 1973). A list of selected oceanic species of cephalopods distributed in Indian ocean based on the work of Silas (1968) and Filippova (1968) is given here (Table 1). Of these, the members of the family Ommastrephidae are by far the most important because many species of this family are already exploited in commercial fisheries by some countries particularly in the Pacific and Atlantic waters.

TABLE 1. *Oceanic Species of Cephalopods of importance distributed in the Indian Ocean Region (Silas, 1968)*

| | |
|--------|---|
| Family | Lycoteuthidae Pfeffer <i>Lycoteuthis diadema</i> (Chun) |
| Family | Enoploteuthidae Pfeffer <i>Enoploteuthis dubia</i> Adam <i>Abralia andamanica</i> Goodrich <i>A. steindachneri</i> Weindl <i>A. renschi</i> Grimpe <i>A. lucens</i> Voss <i>A. armata</i> (Quoy and Gaimard) <i>A. sparcki</i> Grimpe <i>Abraliopsis gilchristi</i> (Robson) <i>A. morrisii</i> (Verany) <i>A. hoylei</i> (Pfeffer) <i>A. lineata</i> (Goodrich) <i>Ancistrocheirus lesueurii</i> (Orbigny) <i>Thelioteuthis alessandrini</i> (Verany) <i>Pterygoteuthis giardi</i> Fischer |
| Family | Octopoteuthidae Berry <i>Octopoteuthis sicula</i> (Ruppell) <i>Taningia danae</i> Joubin |
| Family | Onychoteuthidae Gray <i>Onychoteuthis banksii</i> (Leach) <i>Onychia carribea</i> LeSueur <i>Moroteuthis lonnbergii</i> Ishikawa and Wakiya <i>M. robsoni</i> Adam <i>M. robusta</i> (Verrill) |
| Family | Lepidoteuthidae <i>Tetronychoteuthis dussumieri</i> (Orbigny) |
| Family | Architeuthidae <i>Architeuthis sancti-pauli</i> Velan <i>Architeuthis</i> sp. Clarke |
| Family | Histioteuthidae Verrill <i>Histioteuthis bonnellii</i> Ferussac <i>Calliteuthis hoylei</i> (Goodrich) <i>Calliteuthis reversa</i> Verrill <i>C. miranda</i> Berry <i>C. japonica</i> (Massy) <i>Histiochromus chuni</i> Pfeffer |
| Family | Bathyteuthidae Pfeffer <i>Bathyteuthis abyssicola</i> Hoyle |
| Family | Ctenopterygidae Grimpe <i>Ctenopteryx sicula</i> (Verany) |

- Family Brachioteuthidae Pfeffer
Brachioteuthis riisei (Steenstrup)
B. picta Chun
- Family Ommastrephidae Steenstrup
Illex coindetii (Verany)
Todarodes eblanae (Ball)
T. sagittatus (Lamarck)
T. pacificus Steenstrup
Nototodarus sloanii (Gray)
N. gouldi (McCoy)
Ommastrephes bartrami (LeSueur)
Symplectoteuthis oualaniensis (Lesson)
S. luminosa Sasaki
- Family Thysanoteuthidae Keferstein
Thysanoteuthis rhombus Troschel
- Family Chiroteuthidae Gray
Chiroteuthis imperator Chun
C. macrosoma Goodrich
C. pellucida Goodrich
- Family Mastigoteuthidae Verrill
Mastigoteuthis cordiformis Chun
M. glaukopsis Chun
- Family Grimalditeuthidae Pfeffer
Grimalditeuthis bonplandi (Verany)
- Family Cranchiidae prosch
Cranchia scabra Leach
Leachia cyclura Lesueur
L. eschschollzii (Rathke)
Liocranchia gardineri Robson
L. reinhardti (Steenstrup)
L. valdiviae Chun
L. intermedia Robson
Pyrgosis pacificus (Issel)
P. rhynchophorus Rochebrune
Sandalops melancholicus Chun
Megalocranchia abyssicola (Goodrich)
M. maxtma Pfeffer
Anamalocranchia impensis Robson
Hensenioteuthis joubinii Pfeffer
Gallteuthis armata Joubin
Corynomma speculator Chun
Toxeuma belone Chun
Taonidium chumi (Pfeffer)

Among the important oceanic squids in the Indian Ocean which are either presently exploited or exploitable, mention must be made of *Symplectoteuthis oualaniensis*, *Ommastrephes bartrami*, *Thysanoteuthis rhombus*, *Onychoteuthis banksii* and *Notatodarus sloani*. Our knowledge about the resources of these species

as to their biological and ecological aspects is scanty. The available information on these species is mainly based on their distribution in the Pacific Ocean and surveys carried out in the Indian Ocean as they are beginning to be exploited commercially by Japan and a few other countries following full exploitation of the stocks of the common Japanese squid *Todarodes pacificus*. *Notatodarus sloani* and *N. gouldi* support good fisheries in Australian waters.

Symplectoteuthis oualaniensis (Lesson)

This is a widely distributed Indo-Pacific oceanic squid, recorded from Oualan Islands (Clarke, 1966) and subsequently reported from Red Sea, Arabian Sea, Laccadive Sea, Coast of Sri Lanka, Bay of Bengal, off Natal, South Africa, East Africa, Cocos Islands and West coast of Australia in the Indian Ocean. In the Pacific Ocean this species is distributed widely from Japan, Taiwan, Philippines, South Sea and up to west coast of South and Central America (Silas, 1968; Okutani, 1982). A detailed numerical taxonomic study has been made by Wormuth (1976) on the oceanic squid family Ommastrephidae.

S. oualaniensis is a large-sized ommastrephid which is most abundant and appears to be restricted to northern and central parts of Indian ocean approximately up to 20°S. The southern boundary of *S. oualaniensis* coincides with the zone of subtropical convergence and the area is situated in the limits of the tropical waters (Filippova 1968). Such distributional pattern has also been observed for tropical zooplankton and epipelagic fishes (Parin, 1967). In the Pacific Ocean *S. oualaniensis* has been found to be distributed in the regions further north of 20°N (Wormuth, 1976).

The biology and ecology of this oceanic squid is now better known as compared to the other ommastrephids of the Pacific Ocean. Our knowledge about *S. oualaniensis* is from the works of Clarke (1966), Silas (1968), Voss (1973), Roper and Young (1975), Filippova (1968), Wormuth (1976) and Okutani (1977). Apart from these, the recent exploratory surveys conducted in the northern Arabian Sea, off Pakistan and in the South give additional information on this species (Fishery Agency of Japan, 1975; Yamanaka, 1976).

The *Rhynchoteuthis* larvae of *S. oualaniensis* were abundant in plankton collections obtained during the exploratory cruises of R/V VARUNA (Silas, 1969) in the Arabian Sea particularly within the areas between Lat. 7°N-17°N and Long 70°E-78°E beyond the continental shelf or beyond 200 m. depth off Mangalore, Calicut,

Quilon, in the Wadge bank and off the east coast of India. Their seasonal distribution indicates that though *Rhynchoteuthis* larvae are present almost throughout the year excepting June and August, there are two periods of peak abundance in March to May and November—December. This distribution pattern of the larvae of *S. oualaniensis* suggests that spawning may also take place within the Exclusive Economic Zone of India. However, further exploratory surveys are needed in this direction to assess the larval abundance and recruitment in this area. Apart from the larvae in the plankton, squids were also captured frequently in drift nets, and very often 15 to 20 specimens were obtained per operation. They were also often attracted towards the light from the research vessel when working hydrographic stations during night (Silas, 1969). *Symplectoteuthis oualaniensis* exhibits positive phototaxis and is of aggressive nature. This species is commercially caught by hooks and lines with light at night in the waters around Okinawa to Taiwan (Tung, *et al.*, 1973; Okutani and Tung, 1978; Okutani, 1980; Caddy, 1983). It is reported that *S. oualaniensis* usually forms small schools consisting of about thirty individuals of nearly the same size, most likely to avoid cannibalism (Wormuth, 1976).

Information on predators of *S. oualaniensis* is limited. A number of predatory fishes are believed to feed extensively on squids. According to Wormuth (1976) *Coryphaena hippurus* and *Gempylus serpens* and several species of tuna (Alverson, 1963) feed on *S. oualaniensis*. Apart from these fishes, some of the sea birds of Christmas Island in the Pacific Ocean, viz. *Phaethon rubricauda*, *Puffinus nativitatis*, *Pterodroma alba*, *Sterna muscata*, *Anous stolidus*, *A. tenuirostris*, *Gygis alba* and *Procelsterna cerulea* (Ashmole and Ashmole, 1967) also feed on this species. In addition to these the Sooty tern and Brown Noddy are also known to feed on *Symplectoteuthis oualaniensis*, (Brown, 1973).

S. oualaniensis appears to feed on small fishes and occasionally on other squids. The stomachs of this squid examined for food items included amphipods, megalopa larvae, small shrimps, stomatopod larvae crab zoea, large copepods, euphausiids, enoploteuthid squids and predominantly fishes. Most of the small crustaceans and other organisms would have come from the stomachs of the fishes consumed by *S. oualaniensis* (Young, 1975). These squids are occasionally seen actively preying upon small fishes, mostly Myctophids (lantern fishes), seizing the prey with tentacles and bite just behind the head, severing the backbone. In Hawaiian waters, the prey species of this squid included *Stolephorus purpureus*, *Exocoetus*

voltans, *Oxyporhamphus micropterus*, *Ceretoscopelus*, *Vinciguerria*, *Hygophum* spp., *Diaphus* spp. and *Myctophum* spp. (Wormuth, 1976). Other squids frequently found in the stomachs of *S. oualaniensis* were *Onychoteuthis banksii* and *Hyaloteuthis pelagica*.

EXPLORATORY FISHING IN THE ARABIAN SEA BY JAPANESE VESSELS

The recent exploratory surveys conducted by R/V SHOYA MARU of the Fishery Agency of Japan to assess the Pelagic fishes and squid stocks in the North Arabian Sea, off Pakistan (Fishery Agency, 1976) and in the South Arabian Sea in the oceanic waters (Fishery Agency, 1977) provide some important and basic information on the distribution, behaviour, biology and environmental aspects of this squid. During the survey a most significant stock of *Symplectoteuthis oualaniensis* was discovered in the North Arabian Sea. The surveys were conducted by the FAO with the co-operation of I.O.P. in 1975-76 and 1976-77. Besides the oceanographic data, biological surveys have been conducted along with visual observations, trolling and sampling of eggs and larvae. Midwater handline, bottom handline, bottom long line, midwater trawl and bottom trawl gears were also employed. In mid-water handline, bottom handline and midwater trawling, squids (*S. oualaniensis*) were obtained both in the North Arabian Sea and in the Southern areas.

In midwater handline test operations totally 130 squids, ranging in size from 12 to 36 cm and 75 to 137.5 gm in weight were obtained from 19 stations out of 33 stations scattered throughout the survey area (Fishery Agency of Japan, 1977). In an earlier survey during 1976, also considerable numbers of *S. oualaniensis* were noticed in the North Arabian Sea off Pakistan distributed around the upwelling areas.

The most significant finding during the above exploratory fishing was the discovery of these squids in dense concentrations recorded in the acoustic surveys. Analysis of these data obtained from 1975 to 1977 indicate that the squids mostly occur at depths of 120 to 200 m and below in day time. These squids appear to make vertical migration descending in the day time to low oxygen layer of 0.18 ml to 0.3 ml/l and moving to oxygen saturated upper layer at night for feeding when they are taken easily in jigs.

S. oualaniensis is not at present exploited in Indian waters or in any part of Indian Ocean. The stock in the Pacific is subjected to commercial exploitation along with other species of oceanic squids off Okinawa

(Japan) and Taiwan (Okutani, 1977). Some aspects of the fishery biology of this species have been investigated on the populations around Taiwan. There appears to be three seasonal subpopulations differing in size-maturity relationship (Tung *et al.*, 1973 ; Tung, 1976) in Taiwanese waters.

Ommastrephes bartrami (LeSueur)

This oceanic ommastrephid squid is known from the tropical and warm temperate waters of the Indo-Pacific and the Mediterranean (Clarke, 1966 ; Silas, 1968). The species has been recorded from Indian Ocean by Pfeffer (1912) ; from South Africa and Chagos Islands by Robson (1921) and by Filippova (1968) from the subtropical region of Indian ocean between Lat. 23° and 37°S and Long. 60° and 113°E. Wormuth (1976) has recorded it from several localities in the northern and southern Pacific Ocean.

This species is mainly distributed in the surface layers in the warm oceanic environment and seems to be abundant in the northern and southern limits of Indian and Pacific oceans (Okutani, 1977). *Ommastrephes bartrami*, in general appearance has similarity with other ommastrephids such as *Symplectoteuthis oualaniensis*. The former is a very large sized oceanic squid sometimes growing to 40-50 cm in mantle length and 2 to 3 kg in weight. It possesses subcutaneous photophores on the ventral side of the mantle, head and centrolateral and ventral arms. Information on the biology, life-history and ecology of this species is limited. Some information on the ecology and age and growth of *O. bartrami* in Japanese waters are given by Ishii (1977) and Murata and Ishii (1977). *O. bartrami* like other oceanic squids, has been observed to form schools, and the size of the school usually tends to decrease as the size of individual squid increases. Large individuals measuring about 50 cm in mantle length appear to be solitary (Wormuth 1976). *O. bartrami*, like other ommastrephids, is a very strong and rapid swimmer, often being reported to leap out of water. Hence it is known as the 'flying squid' (Clarke, 1966). It has also been observed at times gliding above the surface of the ocean during daytime (Araya, 1954).

Although there was no commercial exploitation of *O. bartrami* until recently, a beginning has been made in the capture of the species in good quantities since 1968. It has become the main target species of jig fishery in north Japan (Okutani, 1977 ; Murata, 1977). According to Okutani (1977) about 27,000 tons to 90,000 tons of *O. bartrami* were landed during 1974 to 1976 at Hokkaido and North East Honshu. Most of

the catches were exploited in the Northwest Pacific off Northeast Honshu and Hokkaido along with *Todarodes pacificus*. An initial investigation made on the oceanic squids by Japan mainly in the area 152°E and 40°N45°N since 1968 to 1976 indicates an estimated potential of 150,000 to 600,000 tons which represents only a part of the total population that came within the survey area (Okutani, 1977). Similar estimates on the stocks in the Indian Ocean region are not available and the potential existing in the area is not known. The distribution of *Ommastrephes bartrami* in commercial quantities in the Southern Indian Ocean in the waters around Australia and New Zealand has been indicated by the capture of good quantities of the squid by the Taiwanese research vessel *HAI KUNG* with surface gill net which is one of the effective gears for oceanic squids (Collins and Dunning, 1981).

Some aspects of the biology and ecology of *O. bartrami* caught in the jigging experiments in the Pacific off northern Japan during 1968-76 are given by Murata and Ishii (1977). Generally, the female squids obtained were larger in size than males and the size difference between the sexes increased with increasing age. Squids measuring 36 cm and above in mantle length were found to be females. The males appear to mature prior to females when they attain a length of 31 cm in mantle size and 15-20 g in testis weight, whereas the females grow up to 40 cm in size and 20-50 g in ovary weight. The investigations carried out from 1968 to 1976 showed that there were two distinct groups in the *O. bartrami* population in the Pacific off North Japan which are distinctly different in growth pattern ; one group was found to be large-sized whereas the other was a small-sized one. The average monthly growth in mantle length attained by the former group was 3-4 cm in June-October, 1-2 cm in October-December and 0.5-1 cm in December-February and in the small-sized group 2-3 cm in June-December and 1-2 cm in December-February. It was also observed that the main spawning season of squids of both the groups was January to May. The life span of *O. bartrami* was estimated to be about one year.

Prey and predators

The stomachs of *O. bartrami* obtained in New Zealand waters which were examined were full of fishes belonging to the genera *Hygophum*, *Symbolophorus*, *Lampanyctus*, *Nansenia*, *Scopelosaurus* and *Centrobranchus*. They are also found to be cannibalistic and include squids in their diet (Wormuth, 1976). The main predator of *O. bartrami* seems to be the sperm whale *Physeter catodon* (Kawakami, 1976).

Thysanoteuthis rhombus Troschel

This oceanic squid is a cosmopolitan pelagic species usually found in warm water areas of the world oceans. This is the only known species of the genus *Thysanoteuthis* and normally occurs in small groups of two or more individuals swimming in the surface waters. Adults commonly grow to a large size of about 60 cm in mantle length (Okutani, 1977). According to Roper *et al.* (1984) the maximum size attained by this species is about 100 cm with a body weight of 20 kg. Sausage-like gelatinous floating eggmass 16-17 cm in length and 15-20 cm in diameter with two rows of embryos and early stage larvae of *T. rhombus* have been described by Sanzo (1929) from the Mediterranean Sea and recently by Misaki and Okutani (1976) from Japanese coast. This species was first recorded from the Mediterranean Sea and subsequently from North and South Atlantic near the Cape of Good Hope (Bernard, 1947), Algoa Bay (Bruggen, 1962), in the Pacific Ocean off Japan (Sasaki, 1929); China and the Bor Islands (Nishimura, 1964) and from the Indian ocean for the first time by Filippova (1968). More details of distribution of this species in Atlantic and Pacific are given by Voss and Eradman (1959).

This squid has been subjected to commercial exploitation only in recent years in Japan. The fishery for *Thysanoteuthis rhombus* according to Okutani (1977) was initiated in 1962, in Hyogo Prefecture, Japan. They are usually taken in small quantities by jigging from boats while drifting, but in recent years they are captured in single jigs connected to a drifting float (Nazumi, 1975). The catch statistics for this species for Huogo Pr fecture (Okutani, 1977) show that in certain years they were landed in good quantities, with annual catches of about 500 to 600 tons. The annual catches fluctuated highly from about 2 to 620 tons during 1962-74.

Thysanoteuthis rhombus has been recorded by Filippova (1968) from Indian Ocean from 9 stations

scattered in the western, central and eastern parts. On one occasion, a juvenile was also obtained, which indicates that the spawning of this species takes place in the area surveyed. This thus appears to be a potentially important species.

Onychoteuthis banksii (Leach)

This is a cosmopolitan species distributed in warm and temperate oceanic waters and considered to be common from surface waters upto 150 m depth (Clarke, 1966; Filippova, 1968). It may also be found in deep waters of 800 m (Roper *et al.*, 1984). In Indian Ocean this has been recorded from a number of places (Pfeffer, 1912; Rees, 1949) the east Indies (Pfeffer, 1912) Philippines (Pfeffer, 1912; Voss, 1956, 1963) Formosa (Pfeffer, 1912, Sasaki, 1929), east Australia (Gould, 1852; Braizier, 1892; Cotton and Godfrey, (1940; Allen, 1945) and Goodrich (1896). This is a moderate sized oceanic squid reaching a mantle length of about 30 cm. This species, known as 'Clubhook squid' is often caught in dipnets but there is not much information of its biology.

While the cephalopods in the neritic areas are exploited by India to some extent by traditional gears, there is no exploitation of the oceanic squids of different species in the oceanic waters off India. For fishing the oceanic squids distributed in the high seas, the development of suitable types of mechanised vessels capable of appropriate capture methods such as jigging, light fishing and drift gill net fishing is necessary. Great advances have been made by Japan in fishing techniques for oceanic squids. What is needed is a major effort at experimental fishing in the oceanic areas by adoption of fishing techniques known to be efficient for the capture of oceanic squids. We feel that training of our manpower under Japanese expertise will be essential for developing a major fisheries for oceanic squids in our EEZ and contiguous high seas.

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