2. REVIEW OF LITERATURE

The members of the family Nemipteridae commonly known as threadfin breams, whiptail breams, monocle breams, dwarf monocle and coral breams constitute about 64 species. They inhabit in the shallow coral reef to deeper shelf areas living in the demersal regions ranging from sandy to muddy bottoms. These fishes may remain solitary or form schools in the sea and exhibit no territorial preference (Russell, 1990a).

The available literatures suggest that most of the studies on nemipterids are limited to the commonly occurring species. The distribution of the nemipterids is patchy, with the exception of *Nemipterus japonicus*, *N. zysron*, *Parascolopsis eriomma* and *Scolopsis vosmeri*. Therefore, the biological information is also patchy, and most of the works are from southeast Asian countries bordering west pacific region.

Most of the works on nemipterids from our coasts are on their taxonomy, distribution and utilisation using advanced processing technology. Though some biological studies have been carried out on the threadfin breams like *N. japonicus*, *N. mesoprion*, *N. delagoae*, *N. tolu* and *N. peronii*, most of them are confined to the species from the east coast, south west coast and north west coast. Thus the information is patchy with gaps especially with respect to the population from the central west coast. Moreover, in some cases the very validity of their identification is
doubtful due to the in-built uncertainties and fluidity in taxonomic characters adopted for the group.

2.1. Taxonomy

The members of the family Nemipteridae are all marine belonging to order Perciformes. They belong to super family Sparoidea, which includes other families like Sparidae (porgies), Lethrinidae (emperor fishes) and Centracanthidae (picarels). Akazaki (1962) and Johnson (1980) have discussed relationship of the sparoid fishes. Johnson (op.cit.) is of the opinion that nemipertids are more closely related to lethrinids than any other sparoides. Some of the recent works (Jordan, 1923; Berg, 1940; Gosline, 1971; Lindbergh, 1971; Greenwood et al., 1974; Nelson, 1984 and 1994) have reduced the variations in the general classification of the fishes. In the most commonly followed classification, the threadfin breams belong to Super Class: Teleostomi; Class: Osteichthyes; Sub Class: Actinoptrygii; Order: Perciformes; Sub Order: Percoidei; Super Family: Sparoidea; Family: Nemipteridae. The generic name Nemipterus was given by Swainson (1839), while Günther (1859) gave the name Synagris.

Threadfin breams in Indian waters were first documented by Day (1875-77) under genus Synagris Günther (family: Percidae), which were earlier placed under a different genus Dentex Cuvier and Valenciennes. Munro (1955) recorded only 4 species from the Gulf of Mannar and Sri
Lanka and placed them under family Nemipteridae of Suborder Percoidei and order Perciformes. Talwar and Kacker (1984) listed 8 species of Genus *Nemipterus* and 17 species of Genus *Scolopsis* under the family Nemipteridae.

Nelson (1994) described 62 species of nemipterids under four Genera Viz. *Nemipterus* (Swainson), *Scolopsis* (Cuvier) *Parascolopsis* (Cuvier) *Pentapodus* (Quay and Gaimard) and Scaevius (Whitley). *Pentapodus* was placed under nemipterids following Johnson (1975, 1980), though formerly it was isolated in a separate family Pentapodidae. Weber and Beaufort (1936) placed all the species occurring in Indo-Australian Archipelago under sub-family Nemiptirinae. They included Genera 1) *Scolopsis* Cuvier, 2) *Gnathodentex* Bleeker, 3) *Monotaxis* Bennett 4) *Nemipterus* Swainson, 5) *Pentapodus* Cuvier and Valenciennes, 6) *Gymnocranius* Klunzinger and 7) *Symphorus* Günther. Under Genus *Scolopsis* they described 16 species and under Genus *Nemipterus* 20 species.

**Taxonomy**

Nemipterids are considered to be one of the taxonomically difficult groups. Fowler (1904, 1931, 1933 and 1943), Weber and Beaufort (1936) and Akazaki (1959 and 1962) previously reviewed taxonomic status of these fishes. Nevertheless, the confusion continues. Fowler (1972) has reported 7 species under genus *Nemipterus* from the Chinese waters. The
reviews of *Nemipterus* species of Thailand (Wongratana, 1972, 1974), Taiwan (Lee, 1986) and western Indian Ocean (Russell, 1986) have attempted to solve some of the taxonomic problems. In spite of these efforts, identification and systematics of these fishes is full of confusion. Many species of nemipterids are similar in morphology, hence colour differences separate the taxa (Eggleston, 1973) making the identification of preserved specimen difficult. The descriptions of species under family Nemipteridae were revised to reduce the confusion in identification, and the work is still in progress. Hence, the FAO species catalogue for the nemipterid species of the world (Russell, 1990a) which is a product of on going revision of the family Nemipteridae is not complete (Russell personal communication).

Russell (1991a) described a new species *N. thosaporni* previously identified as *N. marginatus*. In addition, he re-described *N. marginatus* (Val.), *N. mesoprion* (Bleeker) and *N. nematopus* (Bleeker) from west pacific region and Southern Japan to Indonesia. Russell (1991b) established the validity of *N. furcosus* (val.) which was hitherto wrongly identified as *N. peronii* (Val.) and re-described as a senior Synonym of *N. tolu* (Val.).

The nemipterids from Indian waters so far recorded are placed under genera *Nemipterus* (Swainson), *Scolopsis* (Cuvier), and *Parascolopsis*
(Boulenger). The species of these genera recorded from Indian waters are given below.

**Species of the genus *Nemipterus* recorded from Indian waters.**


   Synonyms: *Dentex blochii* Bleeker (1851c); *Synagris japonicus* Day 1875-77 in Day (1889); *Nemipterus japonicus* (Bloch) in Talwar and Kacker (1984)


   Synonyms: *Synagris bleekeri* (Day, 1875 - 77) in Day (1889); *Nemipterus mulloides* Smith (1939)(Preoccupied); *Nemipterus delagoae* Smith (1941); *N. delagoae* in Fisher and Bianchi (1984) *Nemipterus bleekeri* (Day, 1875-77) in Talwar and Kacker (1984); mostly reported as *N. bleekeri* in Indian waters. Reported as *N. delagoae* (Smith) of Quillon, south west coast of India by Rajagopalan *et al.*, (1975), from Waltair by Rao & Rao (1981b) and along Cochin waters by John and Hameed (1983).
3. *Nemipterus marginatus* (Valenciennes, 1830) *Dentex marginatus*


Reported first time in India by Shameem and Rao (1997) as *Nemipterus marginatus* (Valenciennes, 1830)

4. *Nemipterus nematophorus* (Bleeker, 1853) *Nemipterus nematophorus*


Synonyms: - *Dentex tolu* Valenciennes in C. and V. (1830b); *Synagris tolu* (Day, 1875); *Dentex Mulloides* Bleeker (1852); reported as *Nemipterus tolu* Valenciennes in Talwar and Kacker (1984). *N. peronii*, (Valenciennes, 1830) was reported from Tuticorin waters (Rao & Rao, 1986a) and along Cochin waters John and Hameed (1983).


7. *Nemipterus randalli* Russell (1986): *Nemipterus randalli* Russell, 1986, *Senckenberg. Biol.* 67: 23, fig. 2 (Persian Gulf; Red Sea; Gulf of Aden; Zanzibar; Seychelles; Madagascar; Pakistan; India). This species was described by Russell while reviewing the Nemipterid fishes of the world. There is no general agreement on this description. According to him the fishes hitherto recorded as *N. mesoprion* (Bleeker, 1853) in Indian waters are wrongly identified so. Mishra and Krishnan (1992) have recorded *N. randalli* from Andaman waters.

Russell (1986) the species occurring in west cost of India is *Nemipterus randalli.*


**Species of the genus *Parascolopsis* recorded from Indian waters**


3. *Parascolopsis townsendi* (Boulenger, 1901): *Parascolopsis townsendi*


The taxonomic status of the members of genus *Scolopsis* Cuvier (1815) occurring in Indian waters was first dealt by Rao and Rao (1981a) who placed them under *Scolopsis* Cuvier, 1815, which included the species of *Parascolopsis* also.

**Species of the genus *Scolopsis* recorded from Indian waters**


Representatives of Genus *Pentapodus* (Quoy and Gaimard, 1824) are mostly found in the West Pacific region (Russell, 1990a), their distribution in Indian waters is yet to be recorded.
The genus *Scaevius* Whitley, 1947 is represented by a single species *Scaevius mili* (Bory de Saint- Vincent, 1823) in the northwestern Australian waters; and is not known from Indian waters.

### 2.2. Length-weight relationship and relative condition factor

The length-weight relationships of different species of nemipterids from waters around India and other parts of the world are available. In Indian waters, Krishnamoorthi (1971) observed that a single equation was not possible as there was significant difference in the regression equations of males and females of *N. japonicus*. He gave the equation for males as $W = 0.001752 L^{2.0769}$ and for females, $W = 0.0000183 L^{2.9423}$. Vinci and Nair (1974) gave common length-weight relationship of *N. japonicus* along Kerala coast as $\log W = -5.4793 + 2.8487 \log L$. They also suggested that the regression equation of both sexes of the species of Kerala, differed from that of Andhra and Orissa due to difference in stock.

The length-weight relationship of *N. mesoprion* of Kakinada region was worked out by Murty (1981) in the form of a common equation, $\log W = -4.650901 + 2.877071 \log L$. Murty (1984) observed that difference of the regression coefficients between sexes in the case of *N. japonicus* of Kakinada region was significant. He derived the equation for male, $\log W = -3.65045 + 2.43025 \log L$ and for female, $\log W = -4.78137 + 2.95688 \log L$. In fishes with lengths lesser than 155 mm, the $K_n$ value for males was
always higher than that for females. For *N. mesoprion* in Chennai region the length-weight equation for males was log W = -4.7926 + 2.9692 log L and for females was log W = 3.0602 + 2.1570 log L which differed significantly (Vivekanandan and James, 1984). Acharya and Dwivedi (1980-81) have worked out the length-weight relationship of *N. japonicus* from the Bombay region as log W = -4.4516 + 2.8069 log L for males and log W = -5.0034 + 3.0634 log L for females. In *N. japonicus* from the trawl of grounds of Chennai the length-weight relationship among males and females did not differ significantly. The pooled equation was log W = -4.8665 + 2.9661 log L (Vivekanandan and James, 1984).

Lee (1973) gave length-weight equation for *N. japonicus* from Hong Kong region as $W = 0.0176 \times L^{3.0246}$ for males and $W = 0.0147 \times L^{3.0939}$ for females. Hoda (1976) found that among the *N. japonicus* of Pakistan coast the length-weight relationship between sexes did not differ significantly and proposed a combined equation, log W = -6.875413 + 3.090598 log L. He also computed the condition 'K' for both the sexes. Gopal and Vivekanandan (1991) have reported that the length-weight relationship between sexes of *N. japonicus* of Veraval region did not differ significantly. The combined equation proposed by them was log W = -4.2570 + 2.7488 log L. Along the Kochi region (John and Hameed, 1994) the length-weight relationship for *N. japonicus* was log W = -4.3794 + 2.7831 log L and that
for females was $\log W = -4.8315 + 2.9881 \log L$. The regression equation for males of *N. mesoprion* was $\log W = -4.4430 + 2.7983 \log L$ and for females was $\log W = -4.6385 + 2.8873 \log L$. For both the species, the exponent value 'b' for males and females was less than 3. The regression equations between sexes differed significantly among *N. japonicus* but among *N. mesoprion*, difference was not significant. Hence they proposed a combined equation $\log W = -4.5641 + 2.8163 \log L$ for *N. mesoprion*. Raje (1996) found that there was no significant difference in length-weight relation between males and females of *N. mesoprion* from Veraval region. Therefore the combined equation was $\log W = -10.7134 + 2.9124 \log L$. He also reported that the peak condition of females was up to March and that for males upto April. Length-weight relation for *N. japonicus* along Kuwait waters (Samuel, 1990) was $\log W = 0.02448 + 2.78952 \log L$ for males and $\log W = 0.01123 + 3.0399 \log L$ for females. The $K_n$ value had 3 peaks suggesting two spawning periods.

Madanmohan and Velayudhan (1984) observed that in the case of *N. delagoae* from Vizhinjam Kerala, the equation for males was $\log W = -4.894391 + 2.969385 \log L$ and for females, $\log W = -4.675841 + 2.881551 \log L$. The difference between the regression equations for males and females was not significant. Therefore the combined equation derived by them was $\log W = -4.891125 + 2.972582 \log L$. 
2.3. Food and feeding

Most of the earlier studies on the food and feeding habits of nemipterids were of generalized/gross nature and did not provide details. In the first ever report (Anon, 1960) the most common food items of *N. japonicus* obtained from the southern part of the Indian coast were recorded as prawns, polychaetes and small fish. Food habits of *N. japonicus* from trawl catches along Mangalore shore did not differ between seasons (Kuthalingam, 1965), but differed among those caught from different depths. The food of the fish from 10-20 m depth mainly consisted of *Metapenaeus dobsonii* and *Parapaenopsis stylifera* along with polychaetes, foraminiferans, and fishes. Among them the prawn *M. dobsonii* (35%) dominated. In slightly deeper waters of 20-30 m depth, *Parapaenopsis stylifera* formed the bulk (40%) of the food. At 30-40 m depth, besides crustaceans teleosts were included in the diet while at 40-50 m, cannibalism was observed. George et al. (1968) reported that *N. japonicus* off Kochi consumed crustaceans, predominantly amphipods. They were considered to be active predators possibly by sight (Krishnamoorthi, 1971), feeding substantially on crustaceans, molluscs, annelids and echinoderms. *N. japonicus* from shallow waters were reported to feed on mostly prawns and those from deeper waters on fish and crabs (Vivekanandam, 1990). *Squilla*, crab prawns, teleosts, cephalopods,
amphipods, polychaetes, were encountered in the order dominance in the gut of *N. japonicus* caught off Visakhapatnam (Rao and Rao, 1991). Their feeding intensity was recorded to be the highest between March to November and lowest during December and February. Off Bombay coast (Acharya *et al.*, 1994) also the *N. japonicus* were found to feed on bottom mainly on crustaceans, fishes polychaetes and salps.

Rao (1989) observed that the food of *N. mesoprion* from the Andhra coast was mainly crustaceans such as young prawns, crabs and squilla and so also teleosts. Along Gujarat coast, *N. mesoprion* was found to feed on crustaceans, fishes, molluscs and annelids in the order of preference (Raje, 1996).

The *N. delagoae* off Tutukkudi fed predominately on fishes, prawns and crabs (Hamsa *et al.*, 1994). They also fed on brittle star, cuttle fishes, gastropods, bivalves, squilla, polychaetes, alphids, isopods and amphipodes. *N. delagoae* (Smith) from Vizinjam (Madanmohan and Velayudhan, 1984) consumed crustaceans (74.5%) mainly prawns, crabs and *Squilla*. They also fed on fishes such as *Stolephorus* sp., *Saurida*, *Trichiurus* sp., *Platycephalus* sp., *Thryssa* and molluscs, such as *Octopus*, *Sepia* and mussels.

*N. bathybius, N. japonicus, N. virgatus* from Hong Kong waters (Eggleston, 1972) were reported to be active predators feeding during day
time and hunting by sight. Adults among them fed mainly on crustaceans, fishes and cephalopods. Range of food items narrowed down as they grew and the prey size increased. Cephalopods crustaceans, polychaetes and lamellibranchs formed the bulk of the diet of *N. virgatus*, *N. bathybius* and *N. japonicus* respectively. The *Nemipterus tolu* of the South China Sea was an active carnivore, day light feeder, feeding on fishes, crustaceans, molluscs and polychaetes. Stomach contents of bigger fish varied less than that of smaller fish (Said *et al.*, 1983). *N. japonicus* of Daya Bay, China fed mainly on benthos and small zooplankton (Zhuang, 1990). Feeding of *N. peronii*, along northwest Australia was observed to be during day (Sainsbury and Whitelaw, 1984). *N. furcosus* from gulf of Carpentaria, Australia showed seasonal differences in food habits (Salini *et al.* 1994). In a related species *N. nemurus* from South-China Sea, crustaceans dominated the food composition (Daud and Taha, 1986).

### 2.4 Reproduction

The first ever report on the reproduction of nemipterids from Indian waters was on that of *N. japonicus* (Anon, 1960). They were reported to begin to attain maturity from September and move to deeper waters beyond 50m along Mangalore coast after attainment of sexual maturity (Kuthalingam, 1965). He also suggested that breeding took place during January or February. According to Krishnamoorthi (1971), *N. japonicus*
along the east coast spawns for the first time on attainment of 160 to 179 mm total length, and second time on attainment of 222 mm total length. In *N. japonicus* additional growth of upper region of caudal fin in males, nearly one and half time more than that of females was treated as secondary sexual character (Nammalwar, 1973). Along the east coast, *N. japonicus* was found to breed twice a year - December – February and June – July, and the fishes ranging in total length from 132 to 209 mm had a fecundity of 10.5 to 80.8 thousand (Dan, 1977). Along Kakinada, *N. japonicus* was observed to be a fractional spawner releasing the ova in two batches during the protracted spawning season extending from August to April. The species at Kakinada attained first maturity when they were 125 mm long and had a fecundity of 23,094 to 1,39,160 while in the size range of 134 to 199 mm (Murty, 1984). Off Mumbai, *N. japonicus* spawned from August to November with a peak during October (Acharya and Dwivedi, 1980-81). The occurrence of low catch of running *N. japonicus* along Kuwait in deeper waters through out the year (Samuel, 1986) suggests that they also move to deeper waters for breeding as observed along Mangalore coast. Gonadal maturation in *N. japonicus* off Visakhapatnam (Rao and Rao, 1991) is between August and October. Further, *N. japonicus* with ripe ovaries were observed off the coast of Visakhapatnam from January to April, wherein the males outnumbered the females. Along Madras coast
(Vivekanandan and James, 1986) *N. japonicus* matured at 145 mm total length and had an extended spawning period from June to March with a peak between December to March. Acharya (1990) recorded July to December as the breeding season off Mumbai coast with a peak during November to December. Vivekanandan (1990) observed that mature females of *N. japonicus* were in a larger number in deeper waters of Tamil Nadu and South Andhra Pradesh.

*N. mesoprion* were found to attain sexual maturity when 100 mm long, and were recorded to be fractional spawners releasing ova in two batches during a single spawning season extending from December to April (Murty, 1981). The males outnumbered the females in *N. mesoprion* landed at Visakhapatnam (Rao, 1989). Along Veraval, the sex ratio for *N. mesoprion* was 2.57:1 (Raje, 1996). The females of the fishes attained first maturity at 134 mm and the fecundity ranged from 50,344 to 64,369 in fishes of size ranging from 104 to 198 mm. They are also known to spawn from September to March with a first peak in September and second peak in November-December.

Sex ratio, maturity and spawning season for *N. delagoae* off Mumbai were recorded by Muthiah and Pillai (1979). The females achieved first maturity when they were 135 mm long. The sex ratio was 1:1.01 and the fecundity ranged from 5,578 to 93,948 with a high correlation with length,
body weight and weight of gonad. Along Vizhinjam these fishes spawned twice a year with a peak during September to June (Madanmohan and Velayudhan, 1986). The size at first maturity was between 164 to 170 mm, and the annual fecundity ranged from 86,184 to 4,97,230, which increased with increase in both length as well as weight.

The histological examinations of gonads of *Scolopsis monogramma*, *S. taeniopterus*, *S. bilineatus* exhibited protogynus hermaphroditism (Young and Martin, 1985). In *N. peronii* and *Pentapodus porous*, the evidence suggested the occurrence of hermaphroditism. They observed that the size related skewness in *S. monogramma*, *S. taeniopterus* and *S. bilineatus* was a result of protogynus hermaphroditism and not sexually differentiated growth rates. *N. peronii* of northwest shelf of Australia was found to have ripe eggs throughout the year, the proportion of ripe eggs was highest in November and December (Sainsbury and Whitelaw, 1984). The *N. tolu* from the trawl grounds of the South China Sea was found to have two prolonged spawning periods one from November to February and another starting from May/June (Said et al., 1983). Along Hong Kong waters, Eggleston (1972) studied the spawning habits of three species *N. japonicus*, *N. virgatus* and *N. bathybius*. Spawning of *N. virgatus* was around the islands in the northern part of South China Sea (Zhang and Lee, 1980). While surveying the ichthyoplanktons of Daya Bay, China, Wang (1990) observed
a large number of eggs of *N. virgatus* and *N. japonicus*, abundance of which decreased during summer. He also carried out studies on the hatching and larval development of these fishes. In the northern part of south China sea, spawning season of *N. virgatus* was observed to be from April to June (Zhang, 1986).

2.5 Age, growth, stock and population dynamics

Age and growth details of fish form an important input for stock assessment studies. In the earliest recorded work on growth, the Japanese threadfin bream *N. japonicus* had the modal size of 120 – 130 mm in September-December which advanced to 140 mm by January- March (Anon, 1960). Along South Sea coast, Israel (Ben -Tuvia, 1968) *N. japonicus* measuring up to 130 mm were of '0'-year class and those measuring 170 mm were of one-year class.

In *N. virgatus* of the South China Sea, males grew faster than females (Eggleston, 1970) resulting in size difference between them. At Visakhapatnam, *N. japonicus* is reported to grow to an average size of 150 mm, 210 mm, 240 mm at the end of 1st, 2nd and 3rd years respectively (Krishnamoorthi, 1971). Eggleston (1972) suggested that growth curves for males and females of Nemipterids should be plotted separately as the growth rate of male and females of *N. Virgatus, N. bathybius* and *N. japonicus* differed. Males and females of *N. japonicus* caught by Hong Kong
vessels were found to have maximum length of 311 mm and 357 mm and maximum age of 7 and 8 years respectively (Lee, 1973). Krishnamoorthi (1974) observed size differences between the sexes of *N. japonicus* along Visakhapatnam, the females being generally smaller. Krishnamoorthi (1976) worked out yield per recruit in weight \((Y_w/R)\) and in number \((Y_n/R)\) for the stocks of *N. japonicus* off Andhra Pradesh coast and opined that the stocks were under exploited, as the rate of exploitation \('E'\) was only 0.3. In *N. vigratus* off Persian Gulf and Arabian Sea the formation of growth check was once a year which is considered to be associated with spawning (Nekrasov, 1979). Age determination using the otolith of *N. virgatus* was carried out by Kao and Liu (1979), wherein a single growth check was noticed by May in the population from South China Sea and by June in that from East China Sea. They observed that males grew faster. The parameters of von- Bertalanffy's growth formula (VBGF) in East China Sea were \(L_\infty = 31.26\) cm, \(K = 0.3216, t_o = -0.8998\) for females and \(L_\infty = 41.37\) cm \(K = 0.3026, t_o = -0.2663\) for males. For fishes in South China Sea, females had \(L_\infty = 27.98\) cm, \(K = 0.4404, t_o = -0.8135\) and males had, \(L_\infty = 34.18\) cm, \(K = 0.4474, t_o = -0.2016\). 

In Indian waters, Acharya and Dwivedi (1980-81) observed difference in the growth rates among males and females of *N. japonicus* along Mumbai coast. They further observed that *N. japonicus* on an average grows at the
rate of 12.91 mm per month and attains a size of 155 mm in the first year and later, grows at a rate of 5 mm per month and attains a size of 211.5 mm in the second year. *N. Japonicus* attained a length 136 mm, 186 mm and 230 mm by the end of 1st, 2nd and 3rd year respectively along the Kerala coast (Vinci, 1982). *N. mesoprion* along Kakinada attained 140 mm, 185 mm, and 205 mm at the end of 1st, 2nd and 3rd year respectively (Murty, 1981). The values of VBGF obtained by him were \( L_\infty = 219 \text{ mm}, K = 0.83248 \) and \( t_0 = -0.256198 \). *N. japonicus* along Kakinada coast had an estimated total mortality \( (Z) \) of 1.86, fishing mortality \( (F) \) of 0.72, natural mortality \( (M) \) of 1.14 and the exploitation rate \( (U) \) of 0.33 (Murty, 1983). The estimated total annual stock was 1181 tons. The yield per recruit \( (Y/R) \) curve showed that the Fishing mortality \( 'F' \) could be increased from 0.72 to 1.75. These fishes attained 185 mm, 255 mm, 285 mm on completion of first, second and third year respectively (Murty, 1984), and their growth parameters were \( L_\infty = 314 \text{ mm}, K = 0.75142, t_0 = -0.173909 \) Year. The growth of males and females differed significantly in the case of *N. peronii* from north west coast of Australia (Sainsbury and Whitelaw, 1984). Along the Madras coast *N. japonicus* had \( L_\infty \) of 305 mm, \( K = 1.004, t_0 = 0.2257 Y, M = 2.5254 \) and \( F = 0.4599 \). The annual stock (2300 tons) and standing crop (731 tons) were higher than the estimated landings which suggested that increased effort can be put for increasing the total
production (Vivekanandan and James, 1986). The growth checks on the scales of *N. japonicus* landed at Visakhapatnam were biannual, one during January – March when feeding was poor and another during August – October due to gonadal maturation and spawning (Rao and Rao, 1986b). The maximum age of fish in the commercial landings estimated by them by using the scales was three years.

Growth and mortality parameters observed for *N. japonicus* of Kakinada trawl ground were, $K = 0.52$ per Year, $L_\infty = 339$ mm, $t_0 = -0.16$ Year, $M = 1.11$, $F = 1.53$, $Z = 2.64$ (Murty, 1987a). The estimated length at first capture ($L_c$) of the fish was 120 mm and he recommended for an increased effort ($F$). The average recommended $F$ for *N. japonicus* and *N. mesoprion* along Kakinada was 1.95 and 2.7 respectively (Murty, 1987b). Using two different methods John (1987) obtained values of $L_\infty = 303$ mm, 326 mm; $K = 0.4$ and $t_0 = 0.7$ Year for *N. japonicus* along Kerala coast. At an estimated value of $Z = 1.37$ per Year, the maximum sustainable yield (MSY) of nemipterids above 80 mm along Kerala coast was 27000 t, slightly higher than the catch level of the period. According to Devaraj and Gulati (1988), *N. japonicus* from Mumbai region attained an average length of 150 mm, 250 mm and 280 mm in 1st, 2nd and 3rd year respectively. Their estimated average annual yield of 6600 tons at $F = 0.3504$ for 1983-84 was far less than the MSY level of 11,887 tons available from the inshore
waters. The average standing stock of *N. japonicus* along Gujarat was 419634 tons, Maharastra 64555 tons and Karnataka 38,621 tons. Along Mangalore regions the estimated \( L_\infty \) was 33 cm, \( K = 1.0 \text{ yr}^{-1} \), \( M=1.87 \) and \( Z = 5.65 \) with the \( E \) of 0.68. (Zacharia, 1998).

Along the Malaysian waters *N. japonicus* had \( L_\infty = 314 \text{ mm} \), \( K = 0.55 \) per Year, \( Z = 3.72 \), \( M = 1.21 \), \( F = 2.51 \) (Isa, 1986). Along Bangladesh (Khan and Mustafa, 1989), *N. japonicus* had \( L_\infty = 20.14 \text{ cm} \) and \( K = 1.06 \) per Year and the rate of exploitation was estimated to be 0.47. The *N. mesoprion* landed at Visakhapatnam measuring 70-140 mm in length were found to grow at the rate of 10 mm per month (Rao, 1989). The growth parameters of *N. japonicus* for males and female was given by Samuel (1990) as \( L_\infty = 303, 265 \text{ mm} \); \( K = 0.542, 0.595; t_0 = 0.19, 0.03 \) respectively. He also observed that the males grew faster than females. Along the northern Arabian Sea the stock parameters of *N. japonicus* were studied by Iqbal (1991a), using length based stock assessment technique, ELEFAN. Three species along east coast viz. *N. mesoprion*, *N. tolu* and *N. delagoae* had \( K \) values of 1.080, 0.828 and 0.761 respectively and the corresponding \( L_\infty \) Values were 207 mm, 282 mm and 271 mm respectively (Vivekanandan, 1991). Murty *et al.*, (1992a) recorded increase of Threadfin landings from 22247 tons (1980-83) to 48100 tons (1984-88) with a maximum landing of 60000 tons during 1986.
Estimated growth parameters from length data of *N. delagoae* landed at Tutukkudi were, $L_\infty = 362$ mm and $K = 1.0586$ per year and $t_o = 0.007$ year (Hamsa *et al.*, 1994). They also found that the average annual total mortality coefficient $Z$ for the species by trawl net was 3.29, with natural mortality coefficient ($M$) 1.625. Yield per recruitment ($Y_r$) indicated that the fishing mortality ($F = 1.665$) was below $F_{\text{max}}$ for age at first capture ($t_o$) of 0.4687 years. The recorded $M/K$ ratio was 1.535. The estimated VBGF parameters for *N. japonicus* of Bangladesh region using ELEFAN technique were $L_\infty = 245$ mm and $K = 0.94$; and the natural mortality coefficient $M = 1.81$ and $F = 1.58$ (Mustafa, 1994). Along the north west Coast of India *N. japonicus* from Mumbai region grew to 193, 281 and 322 mm at the end of 1st, 2nd and 3rd year (Chakraborty, 1995). The VBGF parameters were $L_\infty = 356$ mm, $K = 0.75576$, $t_o = 0.03358254$. The total, natural and fishing mortality were respectively 3.58, 1.53 and 2.03, while the exploitation rate and exploitation ratios were 0.54 and 0.56. Compared to the yield of 1645 tons during the study period under reference, estimated total stock and standing stocks were 3047 tons and 810 tons respectively.

2.6. Distribution and fishery

The members of the family Nemipteridae are marine, distributed along the Indo-Pacific regions. Most species of the genus *Nemipterus* inhabit muddy and sandy bottom in coastal inshore as well as offshore
shelf waters, some in depths ranging up to 300 m. The species of *Parascolopsis* occur in mud or sand bottom, but are mainly in deeper waters up to a depth of 400 m. Species of *Scolopsis* and *Scaevius* inhabit relatively shallow waters on muddy or sandy bottom closer to coral reefs. *Pentapodus* are benthic, free swimming in regions closer to reefs. The threadfin breams (*Nemipterus* spp.), whiptail breams (*Pentapodus* spp.), monocle breams (*Scolopsis* spp.) and the dwarf monocle breams (*Parascolopsis* spp.), constitute multi species catch of the trawl gear. The monocle breams and the dwarf monocle breams are of little importance in fishery. The *Scolopsis* spp. is caught for aquarium trade, the *Parascolopsis* spp. are occasionally caught by the fishermen along with other deep-water resources. The whiptail breams are of artisan fisheries, occasionally taken by recreational fisheries. Only the members of genus *Nemipterus* come in the multi-species catch, often two or three species caught together.

2.6.1. Global distribution and the fishery

The distribution of the members of family Nemipteridae are limited to tropical and sub tropical Indo-West Pacific region. There is no record of their occurrence in Eastern Pacific. The report of their occurrence in Atlantic was an error, and that at Mediterranean Sea is yet to be confirmed (Russell, 1990a). The three genera: *Nemipterus, Scolopsis* and *Parascolopsis* are widely distributed throughout the Indo-West Pacific
region. Whereas the genus *Pentapodus* is restricted to west Pacific. The genus *Scaevius* is endemic to northern Australia. The landings of nemipterids are not systematically reported, hence the landing statistics of these fishes are inadequate. According to the catch statistics compiled by FAO, the fishing area 71 lands the highest quantity followed by areas 61 and 57.

Zupanovic and Mohiuddin (1976) reported abundance of *N. japonicus* along the northeastern Arabian Sea in the 50-125 m depth zone. Nemipterids formed 5.3% of demersal community in the Malaysian shallow waters (Chan and Liew 1986). In the Malaysian EEZ, nemipterid species formed one of the important by-catch (Mohamed 1986). In another study 9.7% of the overall catch of demersal survey yielded threadfins constituting eight species, (Said *et al.*, 1986) of which *N. nemurus* was most abundant. This group was second in abundance after Lutjanidae (Mohamed *et al.*, 1986). Along South China Sea, the Nemipterids formed the third largest commercially important resource (Mohsin *et al.*, 1987). Threadfins formed a small resource along Arabian Gulf (El-Sedfy *et al.*, 1987). Along Pakistan waters, *N. metopias* formed one of the important constituents of trawl catch during the northeast monsoon period (Iqbal, 1991b).
2.6.2 Distribution and Fishery along the Indian Coast

Nemipterids were identified for the first time in India by Day (1878) who also recorded their distribution. Banse (1959) observed that, off Kochi, *N. japonicus* were available when the oxygen content was above 0.25 to 0.50 mIlL$^{-1}$. *N. japonicus* were first reported from the southern coast (Anon, 1960) and later along Mangalore coast (Kuthalingam, 1965). Krishnamoorthi (1973) observed that the peak abundance of *N. japonicus* along Andhra coast was from January to April coinciding with the upwelling period. Silas *et al.* (1976) reported existence of the rich nemipterid resource on the continental shelf beyond 50 m depth, especially in the 75-100 m belt, often-forming 75% of the trawl catches along different parts of the Indian coast. Along Kakinada, they were found to form about 9.7% of total trawl catch (Muthu *et al.*, 1977). Murty (1984) recorded that 50% of nemipterid landings at Kakinada was constituted by *N. japonicus*, followed by *N. mesoprion*, *N. tolu*, and *N. luteus*. *N. japonicus* are found all along the Indian coast including Andaman waters. Nemipterids was one of the important resources available for exploitation during the 1980's (Joseph, 1986). At Sassoon Dock, Mumbai, which is one of the major landing centers of northwest coast, the landing of threadfins started during 1970's (Pillai, 1986). These were projected as one of the important resources from the deep-water region (Sudarsan *et al.*, 1988). *N. japonicus*
and *N. mesoprion* were the two dominant species representing the threadfin breams in the trawl catch in the region. Dwarf monocle bream (*Parascolopsis*) was also caught with the threadfin breams in the deeper waters in small quantity. Vivekanandan (1990) reported that *N. japonicus* were dominant in shallow waters while *N. mesoprion* (*N. randalli?*) was dominant in the deeper waters. Reuben *et al.*, (1989), while assessing the demersal resource between 1961-1985, along northeast coast of India observed that threadfin breams were under exploited in the region. Nair and Jayaprakash (1986) observed that *N. mesoprion* and *N. japonicus* were dominant in the catch from 35-40 m depth off Kochi during monsoon. Kasim *et al.*, (1988), based on the landing figures reported that threadfin breams formed 50% of the perch resources. In the trawling grounds at 10-80 m depth between Lat.17° and 18° N. along the east coast of India the nemipterids formed about 14.7% of the catch (Shastry and Chandrasekhar, 1986). Landing along Waltair comprised of *N. mesoprion* measuring 70 to 140 mm (Rao, 1989). Along the Karnataka coast, major part of demersal resource consisted of threadfin breams (Biradar, 1987). Murty *et al.* (1992) observed that *N. japonicus* and *N. mesoprion* formed two important species in the fishery along Kerala State. Sudarsan (1993) opined that quantitatively nemipterids were one of the most important marine resources of India. The results of survey conducted on board FORV Sagar
Sampada (Kunjipalu, 1990; Nair and Reghu, 1990; Nair et al., 1996; Sivakami, 1990; Panicker et al., 1993; Bensam et al., 1996, and Menon et al., 1996) also revealed the abundance of Nemipterids in the deep waters along our coast, especially in the southwest sector.