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Myctophid discards from deep sea shrimp trawlers operating off south-west coast of Kerala

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Total bycatch and discards of deep sea shrimp trawlers operating from Sakthikulangara and Neendakara harbours in Kollam District during the period 2009-10 has been estimated as 11,488 t and it is about 58% of the total catch. Major part of the discarded fishes belongs to mesopelagic group which has the largest resource potential in the Arabian Sea. More than 98% of the bycatch was discarded at sea. Contribution of myctophids in the total discards is about 32%. Eight species of myctophids belonging to the genus *Diaphus* (*Diaphus watasei, D. luetkeni, D. dumerilli, D. hudsoni and D. effulgens*), *Myctophum* (*Myctophum spinosum* and *M. obtusirostre*) and *Benthosema* (*Benthosema fibulatum*) were identified and quantified from the samples.

[Keywords: bycatch, discards, mesopelagic fishes, myctophids]

Introduction

Along southwest coast of India, deep sea shrimps are one of the commercially important species and accounts for a major portion of the landings. Average deep sea penaeid shrimp catch from Quilon Bank, landed at Sakthikulangara has been estimated at 4,693 t and non-penaeid shrimps at 2,769 t during the period 2009-10[1]. A study has reported the average discards of mechanised trawlers in Kerala as 4,29,074 t during 2008[2]. Longer deep sea fishing trips tend to discard non-commercial species of fishes and shrimps due to shortage of storage space. Myctophids are the major components in the bycatch of deep sea shrimp trawlers operating off Kerala[3-5].

Distribution and abundance of myctophids in the Indian Ocean region have been studied by several authors[6-11]. Studies conducted on the DSL of EEZ of India during 1985-1986 have shown that it shifts vertically from depths of 200–540 m during day to the surface during night. The common fishes recorded in the DSL were myctophids which formed about 17% of the total fish biomass and consisted of the genera *Diaphus, Myctophum* and *Benthosema*[12]. Myctophids consisted of 31% of the total fish biomass of the DSL in the Eastern Arabian Sea and the common genera represented were *Diaphus, Lampanyctus, Diogenichthys, Hygophum, Symbolophorus, Bolinichthys, Benthosema* and *Myctophum*[13]. A study has reported a total of 28 species of myctophids from the DSL of Indian EEZ of Arabian Sea[14]. A recent review of the existing information on distribution of myctophids in Indian Ocean has reported 137 species belonging to 28 genera[15]. Studies on the biochemical composition of various species of myctophid fishes reported that these fishes are good source of most of the essential nutrients and have the potential for product development. Proximate composition of myctophids shows high level of protein ranging from 11.3 to 15.7% and the fat content from 4.9 to 28.5% [16, 17].

A study of the myctophid bycatch in the deep sea shrimp trawlers operating off south west coast of Kerala was undertaken in order to find out species characteristics useful for development of harvesting strategies for myctophids.

Materials and Methods

A year round survey was undertaken to collect data regarding the landings and bycatch of deep sea shrimp trawlers operating from Sakthikulangara and Neendakara fishing harbours in Kollam, during 2009-2010. The deep sea shrimp trawlers generally operated between 08°00' N - 09°07' N lat and 74°00' E - 75°58' E long (300 to 400 m depth), off the south-west coast of India. The fishing ground lying between Kollam and Alappuzha, popularly

known as Quilon Bank, is a rich ground for deep sea shrimps and lobsters[18].

Details of landed catch of deep sea trawlers were collected from auctioneers dealing with catches of deep sea trawlers. Monthly landings were computed from the average daily landings per fishing unit, the number of fishing units in operation and the actual fishing days for each month. Details of catch-discard ratio, area and depth of operation, duration of fishing trip and actual fishing hours were collected from the crew of the deep sea shrimp trawlers operating from these harbours, using pre-tested questionnaires. Bycatch discards was estimated based on the quantity of shrimp landings and the mean catch-discard ratio, realised by the deep sea trawlers. Random samples of 30-60 kg from the catch meant to be discarded were brought to the shore in styroform boxes in iced condition, by special arrangement with the crew, periodically. These samples were used for identification and analysis of the discarded species. The fishes were identified up to species level based on identification keys[19, 20] and online species identification database[21]. Morphometric characters used for the species identification were position of photophores such as Anterior anal (AOa), Posterior anal (AOp), Supra-anal (SAO), Pre-caudal (Prc), Posterio-lateral (Pol), Dorso-nasal (Dn), Ventro-nasal (Vn), Anterio-orbital (Ant), Sub-orbital (So), Ventral (VO), Supra-pectoral (PLO), Anal organs (AO) and Lateral line (LL); fin rays in Dorsal (D), Anal (A) and Pectoral (P) fins; Gill rackers (GR); Body depth (BD); and Standard length (SL).

Results

Deep sea shrimp trawling has started in Kerala since 1999 and the catch mainly comprised of *Heterocarpus* spp. According to the Department of Fisheries, Govt. of Kerala, about 1,158 trawlers are operating from Sakthikulangara and Neendakara fishing harbours consisting of about 761 wooden and 397 steel trawlers. The size of these trawlers ranged between 9.1 m and 20.0 m L_{OA}. Most trawlers were equipped with marine diesel engines of 175 to 411 hp. Among these vessels, around 300 to 400 vessels were mainly targeting deep sea shrimps. Deep sea shrimp trawl nets with a head rope length of 32.4 m, with mesh size ranging from 50 to 30 mm in the net body and 26 mm in the codend were used in fishing operations. The crew size varied from six to ten and the duration of fishing trip varied from 5 to 6 days.

The exploited deep sea shrimp catch in the study area during the period of 2009-10 was estimated as 7,880 t (Fig. 1). The fishing season for deep sea shrimps was observed to extend from September to May and the peak season was from October to December. Highest landings of deep sea shrimps (1,420 t) was observed during the month of October, with a catch rate of 41.67 kg h^{-1} and the lowest landings was recorded during the month of March, during the period of deep sea shrimp trawling operations. There was no landings during trawl ban period from 15 June to 31 July and during the month of August when trawlers prefer to operate in coastal waters.

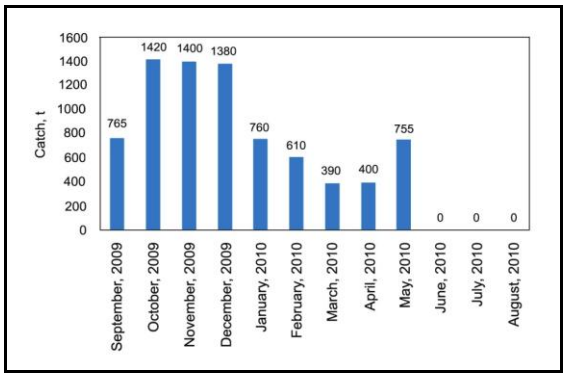

Fig. 1- Monthly landings of deep sea shrimps at Sakthikulangara and Neendakara during 2009-10

Deep sea shrimp trawler catch was constituted by 39% of deep sea shrimps and 61% of bycatch which included myctophids and were discarded. Percentage contribution of deep sea shrimp and bycatch species to the total catch is given in the Fig. 2. Total bycatch during the period was estimated as 11,488 t with a catch rate of 62.1 kg h^{-1}, during the peak season. Myctophids constituted about 32% (3,676 t) of the bycatch discards, with the catch rate of 19.87 kg h^{-1}, during the period of study (Fig. 2).

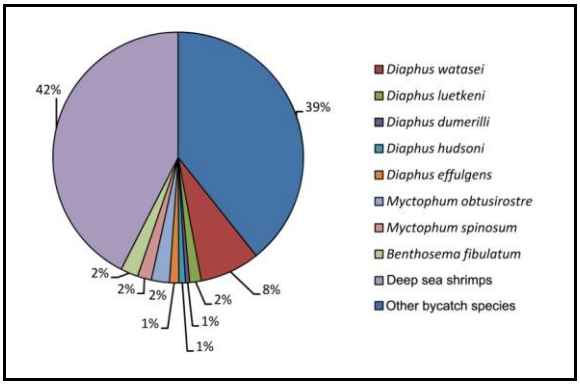

Fig. 2 - Percentage contribution of myctophid species to the total catch

Percentage contribution of different myctophid species to the total bycatch is given in the Fig. 3. Myctophids and other species found in the deep sea shrimp trawl bycatch are listed in the Table 1.

Table 1- Myctophids and other species found in the deep sea shrimp trawl bycatch

Family	Species
Fishes	
Acropomatidae	*Synagrops bellus*
Acropomatidae	*Synagrops philippinensis*
Alepocephalidae	*Alepocephalus australis*
Berycidae	*Beryx splendens*
Bothidae	*Chascanopsetta lugubris*
Champsodontidae	*Champsodon capensis*
Chaunacidae	*Chaunax fimbriatus*
Chlorophthalmidae	*Chlorophthalmus acutifrons*
Cynoglossidae	*Symphurus strictus*
Gempylidae	*Neoepinnula orientalis*
Gempylidae	*Nealotus tripes*
Gempylidae	*Promethichthys prometheus*
Gempylidae	*Ruvettus pretiosus*
Gonostomatidae	*Triplophus hemingi*
Percophidae	*Bembrops caudimacula*
Platycephalidae	*Thysanophrys* sp.
Lophiidae	*Lophiodes endoi*
Lophiidae	*Lophiodes mutilus*
Lophiidae	*Lophius vomerinus*
Macrouridae	*Coelorinchus matamua*
Macrouridae	*Hymenocephalus italicus*
Macrouridae	*Coryphaenoides acrolepis*
Myctophidae	*Diaphus watasei*
Myctophidae	*Diaphus luetkeni*
Myctophidae	*Diaphus dumerilli*
Myctophidae	*Diaphus hudsoni*
Myctophidae	*Diaphus effulgens*
Myctophidae	*Myctophum obtusirostre*
Myctophidae	*Myctophum spinosum*
Myctophidae	*Benthosema fibulatum*
Neoscopiledae	*Neoscopelus microchir*
Nomidae	*Psenes arafurensis*
Nomeidae	*Cubiceps paradoxus*
Ogcocephalidae	*Halieutaea coccinea*
Ophidiidae	*Neobythites monocellatus*
Parazenidae	*Cyttopsis rosea*
Phosichthyidae	*Polymetme thaeocoryla*
Sternoptychidae	*Argyropelecus aculeatus*
Stomiidae	*Astronesthes martensii*
Triacanthodidae	*Macrorhamphosodes platycheilus*
Trachichthyidae	*Hoplostethus* sp.
Zeidae	*Zenopsis conchifer*
Elasmobranches	
Proscylliidae	*Eridacnis radcliffei*
Etmopteridae	*Etmopterus* sp.
Crabs	
Portunidae	*Charybdis smithii*
Oregoniidae	*Chionoecetes opilio*

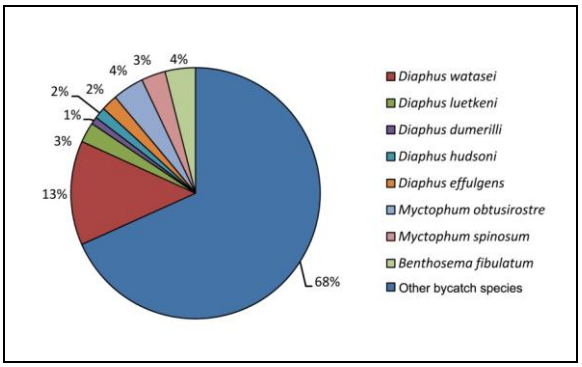

Fig. 3 - Percentage contribution of myctophid species to the total bycatch

Eight species of myctophids belonging to the genus *Diaphus* (*Diaphus watasei*, *D. luetkeni*, *D. dumerilli*, *D. hudsoni* and *D. effulgens*), *Myctophum* (*Myctophum spinosum* and *M. obtusirostre*) and *Benthosema* (*B. fibulatum*) were identified from the samples (Fig. 4).

Discussion

Deep sea shrimp fishery off southwest coast is mainly constituted by *Aristeus alcocki*, *Heterocarpus woodmasoni*, *Heterocarpus gibbosus*, *Solenocera* spp. and *Plesionika ensis*. Average catch rate of 9.3 kg h^{-1} for deep sea penaeid shrimps and 13.7 kg h^{-1} for non-penaeid shrimps, have been reported from Quilon Bank, during 2009-10. Taxonomical characters of different myctophid species found in bycatch during the present study are discussed below.

Diaphus watasei (Jordan and Starks, 1904)

The size range of males and females were 12-16.5 cm TL and 10-15.6 cm TL, respectively. PLO nearer upper base of P than LL; SAO3 and Pol three photophore-diameters or more below LL. Dn smaller than nasal rosette. Ant present. Vn extending dorsally to make contact with Dn. AOa1 elevated. So absent. Luminous scale at PLO smaller. SAO series almost in a straight line. D 14-15; A 14-15; P 11; GR (4-6)+(13-15); AO (6-7)+(5- 6)

Diaphus luetkeni (Brauer, 1904)

The total length of *Diaphus luetkeni* ranged between 7.5-8.8 cm in male and 7.0-8.2 cm in female. Vn very long, extending along most of ventral border of eye, its dorsal margin with small, round, bud-like projections. SAO1 on

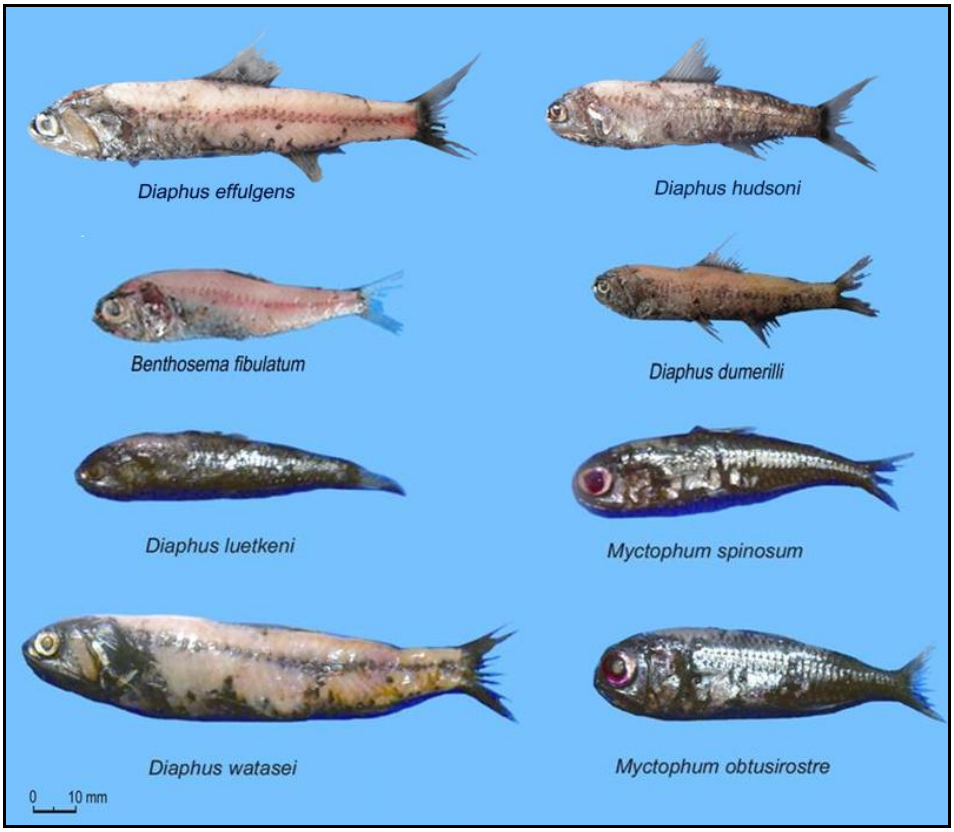

Fig. 4 - Myctophid species identified from the bycatch of deep sea shrimp trawlers

same level with, or only slightly higher than VO5; maxilla extends more than diameter of eye past orbit. Vn widely separated from Dn, confined to ventral or anteroventral aspect of orbit but connected to Dn by a strand of dark tissue along front margin of orbit it. D 15-17; A 14-16; P 11-12; GR (6-7)+(14-26); AO (5-7)+(4-6).

Diaphus dumerilli (Bleeker, 1856)

The standard length of *Diaphus dumerilli* is 8.7 cm in male. Vn round and small, half the size of general body photophore, completely separated from Dn and located at ventral margin of orbit on, slightly in advance of, vertical through front margin of pupil; about 1-2 photophore-diameters below LL; SAO series markedly angulate. D 14-15; A 14-15; P 11-12; GR (7-9) +(16-18) : AO (6-7)+(4-6).

Diaphus hudsoni (Zubrigg and Scott, 1976)

The standard length of *Diaphus hudsoni* is 8.4 cm. Prc separated from AOp, so that distance Prc1- Prc3 equal to or shorter than AOp- Prc1 interspace; C peduncle normal; anterior margin of lower GR of 1st arch fleshy. Total GR 22-28; luminous scale at PLO mottled. D 13-15; A 12-14; P 10-12; GR (7-9)+(15-19); AO (4-6)+(4-6).

Diaphus effulgens (Goode and Bean, 1896)

The standard length of *Diaphus effulgens* is 15 cm (male/unsexed). Head much longer than it is deep. SAO3 and Pol 1.5-3.0 photophore – diameters below LL. At least 1 pair of sexually dimorphic, luminous glands on head; 5 PO; 5 VO; SAO series curved to strongly angulate; AO series divided into AOa and AOp; AOa1 usually elevated, sometimes level; 1 Pol, sometimes continuous with AOa; 4 Prc. Supracaudal and infracaudal luminous glands absent; usually a luminous scale at PLO. Total GR 17-22. D 15-17; A 15-16; P 11-13; GR: South Atlantic (5-7)+(13-14); GR: Indian Ocean (5-6)+(12-14); AO (5-7)+(4-6). Total GR 17-22. Myctophum spinosum (Steindachner, 1867)

The total length of *Myctophum spinosum* ranged between 7.5-8.8 cm in males and 7-7.4 cm in females. Ctenoid scales along A base with 1-3 strong, posteriorly directed spines; Pol well in advance of vertical at origin of adipose fin; posterodorsal margin of operculum serrate GR (5-6)+(13-15), total 18-21. Total GR 18-25; SAO series straight or only slightly curved. Body scales ctenoid. Prc2 more than 1 photophore-diameter below LL. Prc1-Prc2 interspace about 1/2 AOp-Prc1 interspace. Body

elongate, BD about 4 times in SL. D 13-14; A 18-19; P 14-15; GR (5-6)+(13-15); AO (6-8)+(5-7).

Myctophum obtusirostre (Taning, 1928)

The total length of *Myctophum obtusirostre* ranged between 7.8-8.8 cm in males and 7-7.6 cm in females. Body elongate, BD about 4 times in SL. Prc2 more than 1 photophore-diameter below LL; Prc1-Prc2 interspace about 1/2 AOp-Prc1 interspace. Body scales cycloid. Posterodorsal margin of operculum evenly rounded, with serrations. Pol on or slightly behind vertical at origin of adipose fin; AO (7-8)+(2-5), total 10-12. D 12-14; A 18-19; P 17-20; GR (6-7)+(16-19); AO (7-8)+(2-5).

Benthosema fibulatum (Gilbert and Cramer, 1897)

The total length of *Benthosema fibulatum* ranged between 5-8 cm in male and 5.5-8.8 cm in female. Dorsal spines (total): 0 - 0; Dorsal soft rays (total): 12 - 14; Anal spines: 0; Anal soft rays: 18 – 20; Vertebrae: 31 – 32. Anal organs 10-11; mature males have large 3 to 5 translucent supracaudal gland and smaller infracaudal gland; mature females have small supracaudal gland and much smaller infracaudal patches. D 12-14; A 18-20; P 14-17; GR (6-7)+(13-15); AO (5-6)+(4-5).

Among myctophids, *Diaphus watasei* was the most dominant species in the bycatch which contributed 13% to the total bycatch. *D. luetkeni* (3%), *D. dumerilli* (1%) *D. hudsoni* (2%), *D. effulgens* (2%), *Myctophum obtusirostre* (4%), *M. spinosum* (3%) and *Benthosema fibulatum* (4%) are also contributing to the total bycatch.

Other bycatch species associated with myctophids catch of deep sea shrimp trawlers collected from Kollam were also identified. Discarded items include finfishes, crabs, gastropods, shrimps, cephalopods, stomatopods, squid eggs, juvenile shrimps and snakes. 45 species of fishes and 2 species of crabs were identified from the bycatch of deep sea shrimp trawlers landed at Sakthikulangara and Neendakara harbour during the period of study.

Conclusion

As myctophids contribute a major quantity in the discards of deep sea shrimp trawlers, more attention is required to utilize this resource effectively through the production of meal, oil, mince, hydrolysate, silage, etc., in the face of increasing demand for fish based products. The presence of myctophids in discards to the extent of 32%, indicate the potential of the species for future expansion in capture fisheries. Information generated under this study on associated species in shrimp trawl bycatch will be useful for developing bycatch reduction strategies.

Acknowledgment

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