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Myctophid fishery along the Kerala coast with emphasis on population characteristics and biology of the headlight fish, *Diaphus watasei* Jordan & Starks, 1904

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ABSTRACT

Myctophids form bycatch in deep sea shrimp trawls with an annual average catch of 2668 t during 2009 - 2011 in Kerala coast. Fishery occurred almost round the year with peak during November - February. Fishery and biology of the dominant species, *Diaphus watasei* was monitored. Peak spawning and recruitment of the species was during January-August. Growth parameters L_∞ and K are estimated as 15.06 cm and 0.8 per year respectively. These values indicate that the species growth is relatively fast. Natural mortality estimate (M) is 1.21, total mortality (Z) 1.68 and fishing mortality (F) 0.47. The exploitation rate (E) is low being 0.279. These indicate that the stock is at its initial stage of exploitation and there is large scope for enhancing their commercial exploitation. The stock abundance, biomass and distribution of the resource need to be assessed. These factors have to be taken into consideration while planning for exploitation of myctophids in future.

Keywords: Exploitation rate, *Diaphus watasei,* Growth, Mortality, Myctophids

Introduction

Myctophids are the most ubiquitous fishes in the world oceans with the total biomass estimated being 600 million t (Hulley, 1994). They are also called as lanternfishes owing to the presence of photophores on the ventral, lateral and head regions of the body. Myctophiformes includes two families namely myctophidae and neoscopiliade. Myctophids are small to medium sized (3-35cm) mesopelagic fishes with compressed body, large eyes, large jaws and terminal mouth. Genus *Diaphus* are commonly called as head light fish due to the presence of secondary photophores on the head. The Indian Ocean harbours a rich fauna of lanternfishes both in number and biomass (GjØsaeter and Kawaguchi, 1980). GLOBEC (1993) estimated 100 million t of myctophids from the Arabian Sea. Wide occurrence of *Diaphus* spp. from the eastern and north-eastern Arabian Sea has been reported (FAO, 1997; Balu and Menon, 2006). A study carried out by the Central Marine Fisheries Research Institute during 1997 - 2002, estimated a biomass of 100,000 t of myctophids along the Indian EEZ of Arabian Sea, dominated by *Diaphus* sp. (Balu and Menon, 2006).

Finfishes constitute a sizable portion of the deep-sea shrimp trawl bycatch, which demands only very low price and are often discarded in the sea at the time of catch. Along the south-west coast of India, lantern fish (order, myctophiformes) forms a major portion (20-35%) of the bycatch in the deep sea shrimp trawls (Bineesh *et al*., 2009). These fishes, when landed are mostly used for fishmeal or manure production.

Blindheim *et al*. (1975) reported a large concentration of myctophids along certain parts of the south-west coast of India and stated that they had been commercially exploited at certain localities. There is only limited information on the commercial exploitation of lanternfishes. Fishermen in Suruga Bay, central Japan used *Diaphus* spp. as food (Kubota, 1982). Commercial fishery for *Diaphus coeruleus* and *Gymnoscopelus nicholski* (edible species) in the south-west Indian Ocean and southern Atlantic began in 1977 and catch by former USSR countries reached 51,680 t in 1992, after which the fishery ceased due to decrease in catch. Despite this, the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR) still permits Total Allowable Catch (TAC) of 2,00,000 t for this resource from the area under its jurisdiction. Industrial purse seine fishery for *Lampanyctodes hectoris* was developed in South African waters and closed in the mid 1980s due to processing difficulties caused by the high oil content in the fish (FAO, 1997). Lanternfishes are harvested commercially only off South Africa and in the sub-antarctic (Nafpaktitis *et al*., 1977; Hulley, 1994).

Though *Diaphus watasei* formed the dominant component of the lanternfish catch, their biological and population characteristics are least studied. The present

study aimed to gather scientific information on the above aspects of *D. watasei*.

Materials and methods

Data on effort, catch and species composition of myctophids were collected at weekly intervals from commercial deep-sea shrimp trawlers operated from Kollam and Kochi coasts during 2009 - 2011. Biology, length and weight composition of the common species, *D. watasei* in the landings were studied. Reproductive and feeding biology of 1481 specimens within the size range of 4.26 – 14.32 cm standard length (SL) were recorded. Standard length of the fish was used in all studies, unless otherwise mentioned. Length-weight relationship was determined by the method of least squares using the logarithmic forms of the exponential equation $W = aL^b$, where W=weight (g), L=length (cm) and 'a' and 'b' are constants (Pauly, 1983). The correlation coefficient was determined to know the degree of association of the two variables. The variation between the regression coefficients (b) in male and female was tested using ANACOVA (Analysis of covariance). Food and feeding was studied following the method proposed by Natarajan and Jhingran (1961). Monthly length frequency data for the period was used for the estimation of von Bertalanffy growth parameters L_∞ and K by ICLARM's FiSAT software (Gayanilo *et al*., 1997). Age at zero length (t_o) was estimated as in Bertalanffy (1934) and size at first capture (L_c) as in Pauly (1984). Natural mortality (M) was estimated using Pauly's empirical formula (Pauly, 1980). Total mortality (Z) and exploitation rate (E) were estimated from the catch curve as per Pauly (1983) and exploitation ratio (U) from the relation $U = F/Z * (I-e^{-Z})$; where, F is the fishing mortality. Optimum age of exploitation was estimated following Krishnankutty and Qasim (1968).

Results

Fishery and fishing area

Myctophids form bycatch in the deep sea shrimp trawlers. The operation area was between off Kollam and off Kasargode, along the south-west coast of India ($8^0$20' - $12^0$38'N; $74^0$20' - $76^0$25'E). Fishing was carried out during day time at depths of 270-500 m. Annually an average of 2667 t of myctophids were landed during the study period 2009 - 2011 (Table 1; Fig. 1). Catch rate was estimated as 6.3 - 9.5 kg h^{-1} with an average of 7.9 kg h^{-1}. Fishery occurred year-round with peak fishing during November and February.

Catch comprised of five species *viz*., *Diaphus watasei* (74.23%), *Neoscopilus microchir* (20.57%), *Benthosema fibulatum* (1.94%), *Diaphus garmani* (1.69%) and *Myctophum obtusirostre* (1.58%) (Fig. 2). *D. watasei* and *N. microchir* were available round the year whereas, other species occurred only seasonally. *D. watasei* was found to be dominant among the myctophids.

Table 1. Estimated catch of myctophids (t) from the deep sea shrimp trawlers off Kerala during 2009-11

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2009	391.96	443.58	189.57	153.39	120.26	0	0	15.22	65.62	265.73	393.25	382.09	2420.67
2010	440.54	433.36	145.59	171.93	8.54	0	0	21.66	157.24	354.11	456.50	420.07	2610.01
2011	432.53	479.73	213.20	162.68	180.85	0	0	18.53	73.80	272.13	486.90	408.16	2972.27
Average	421.68	452.22	182.79	162.67	103.22	0	0	18.47	98.89	297.32	445.55	403.44	2667.65

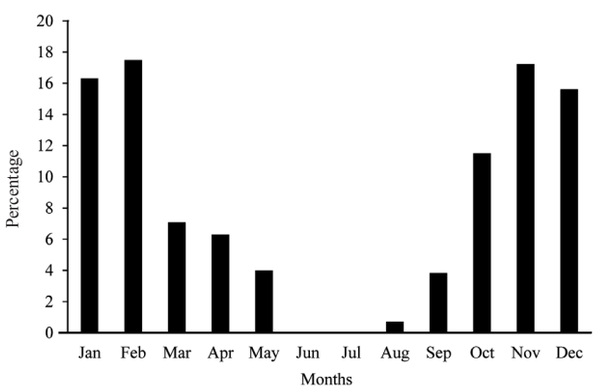

Fig. 1. Seasonal pattern in the myctophid catch by deep sea shrimp trawlers during 2009-11

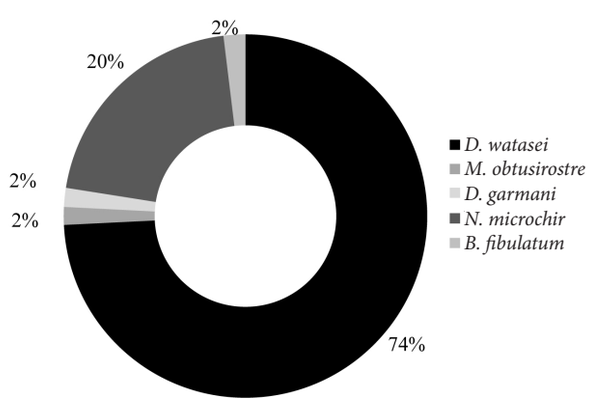

Fig. 2. Species composition of myctophids

Size composition and length-weight relationship of Diaphus watasei

Catch was supported by fishes ranging in size 4.26-14.32 cm, with a mean of 9.56 cm and weight ranged from 1.03 to 37.83 g, with a mean of 12.37 g. The length-weight relationships derived are:

Males : Log W = 0.013912+2.953861* Log L (r = 0.848153)

Females : Log W = 0.010052+3.063181* Log L (r = 0.957939)

Pooled : Log W = 0.011442+3.023246* Log L (r = 0.908653)

The length-weight relationship differed significantly between males and females of the species (ANCOVA, p=0.005). The co-efficient indicate that the species follow an isometric growth pattern.

Size composition of other species

B. fibulatum, D. garmani and *M. obtusirostre* were in the size range of 1.5 - 9 cm, with short and deep body. *N. microchir*, which belongs to the family neoscopilidae had a size range of 4 - 19 cm, with elongate and slightly compressed body.

Population parameters of Diaphus watasei

Growth and age

Estimates of growth parameters, L_∞ and K by FiSAT were 15.06 cm and 0.8 per year respectively. Age of the species at zero length (t_o) was estimated as -0.0284 years. The estimated K value is relatively small indicating relatively longer life span. They were estimated to attain 9, 12, 13.5 and 14.5 cm respectively by the end of 1st, 2nd, 3rd and 4th years (Fig. 3). It will take more than 3.5 years to reach the L_{max} (14.5 cm).

Size at first capture (L_c) of *D. watasei* in trawl was estimated as 7.92 cm and optimum size of exploitation (L_{opt}) as 9.1 cm. Age corresponding to size at first capture estimated was 9 months and age at optimum exploitation is one year.

Maturity and spawning

The catch was dominated by adults (51.05%), the rest being sub-adults. Mature and spent fishes dominated the catch during January, May and August (44, 43 and 68% of the catch respectively). During other seasons, occurrence of matured and spent fishes is relatively low, indicating January-August as the peak spawning season for the species along the Kerala coast.

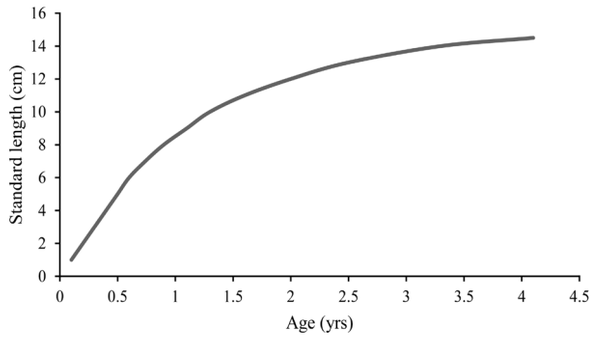

Fig. 3. Growth curve of *D. watasei*

Mature specimens were observed from 5.5 cm size onwards, but size at first maturity on logistic curve was 10.12 cm (Fig. 4). Age of the fish at this size is 1.4 years, indicating that they attain sexual maturity and spawn after one year growth.

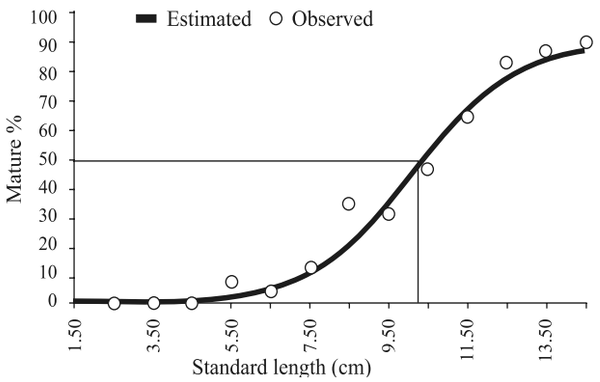

Fig. 4. Logistic curve for determining size at maturity of *D. watasei*

Fecundity

Relative fecundity (fecundity per gram body weight) of the fish determined by examining gravid gonads (stage V and VI) ranged between 542 and 1442 with a mean of 850.

Feeding habit and prey

Gut observation indicated that myctophids are carnivorous in feeding habit. Food was constituted by deep sea prawns, deep sea squids, small mesopelagic fishes and foraminiferans. Crustaceans constituted 68% followed by cephalopods (21%), fishes (5%) and other miscellaneous organisms (6%).

Predators

D. watasei was observed in the guts of yellowfin tuna *(Thunnus albacares), Chauliodus solani, Psenopsis cyanea, Neoepinnula orientalis, Chlorophthalmus bicornis* and *Priacanthus hamrur.*

Stock, mortality and exploitation rate

Total stock from the point of fishery was estimated as 8676 – 9779 t with an average of 9270 t. Estimate of total mortality (Z) in the population during the period was 1.68, natural mortality (M) being 1.21 and fishing mortality (F) 0.47. Exploitation rate was very low being 0.279. Total loss from the population due to fishing is only 28% and that by natural causes is 72%.

Discussion

Myctophids, dominated by *D. watasei* form only an incidental catch in deep sea shrimp trawls. Earlier studies show that *D. watasei* is a good source of protein, fat and PUFA, hence it could well be a potential source of alternative protein and fat for future (Manju *et al*., 2011). At present, there are no buyers for the resource, except the fish meal industry. Their enormous biomass may make them suitable for much greater commercial exploitation in future (Nafpaktitis *et al*., 1977; Hulley, 1994). An understanding of the biology and population parameters of the component species is very essential for development of fishery sustainable exploitation strategy in future.

Length-weight relationship of *D. watasei* indicated isometric growth whereas, Vipin *et al*. (2001) reported isometric growth in females and positive allometric growth in males. Estimate of the size at maturity was larger than the size at first capture and optimum size of exploitation, but since the exploitation rate is very low, there is no immediate threat to the stock. Low values for estimates of fishing mortality and exploitation rates indicate that removal from the stock by fishing was only nominal from the present fishing grounds. The results indicate that the stock is almost at virgin state and remains grossly underexploited. Since the extent of distribution and abundance of the stock in the ecosystem remains to be ascertained, sustainable yield could not be estimated. Generally non-conventional and non-target resources are under low fishing pressure and have low values for exploitation rates (Abdussamad *et al*., 2011). The database developed from the present study will form primary information on the population characteristics of the species. Hence, detailed studies are required to arrive at conclusive estimates for stock as well as potential yield of the resource, which are essential for management of the resource.

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References

Abdussamad, E. M., Joshi, K. K., Balasubramaniam, T. S., Beni, N., Habeeb Mohamed, O. M. M. J. and Jeyabalan, K. 2011. Snake mackerel fishery of the Tuticorin coast of Gulf of Mannar with emphasis on population characteristics of the sackfish, *Neoepinnula orientalis* (Gilchrist & von Bonde 1924). *Indian J. Fish.,* 58 (3): 9-12

Balu, S. and Menon, N. G. 2006. Lantern fish - a potential deep sea resource. *Marine Ecosystem, ENVIS*, 5(1): 3 - 5.

Bertalanffy, L. V. 1934. Unter suchungen uber die Gesetzlichkeiten des waswasdestums I. Allgemeine Grundlagen der Theorie. *Roux Arch. Entwicklungsmech. Org.,* 131: 613-653.

Bineesh, K. K., Manju Sebastine, Akhilesh, K. V., Rajool Shanis, C. P., Hashim, M., Pillai, N. G. K. and Ganga, U. 2009. Diversity of mesopelagic fishes in the deep-sea prawn trawlers from south-west coast of India with notes on myctophids. *Book of Abstracts, 20th All India Congress of Zoology.* Cental Institute of Fisheries Education, Mumbai, p. 167.

Blindheim, J., Chakraborthy, D. and Menon, M. D. 1975. The pelagic fishery resources off the south-west coast of India. In: Shankar, J. V., Sen, D. P., Rao, P. B. R., Potty, V. H., Ranganath, K. A., Rao, B. S. N. and Sastry, M.V. (Eds.), *fish processing industry in India*. Cental Food Technology Research Institute, Mysore, p. 3 - 11.

FAO 1997. Review of the state of world fishery resources: marine fisheries. *FAO Fisheries Circular No. 920*., Rome, FAO, 173 pp.

GjØsaeter, J. and Kawaguchi, K. 1980. A review of the world resources of mesopelagic fish. *FAO Fish. Tech. Pap*., 193: 151 pp.

Gayanilo, Jr. F. C., Sparre, P. and Pauly, D. 1997. The FAO-ICLARM stock assessment tools (FiSAT) user's guide. *FAO computerised information series: fisheries.* FAO, Rome, Italy.

GLOBEC (Global Ocean Ecosystem Dynamics) 1993. *Implementation plan and workshop report for U. S. GLOBEC Studies in the Arabian Sea.* Report No. 3, Scientific steering committee coordinating Office, USA, 89 pp.

Hulley, P. A. 1994. Lanternfishes. In: Paxton, J. R. and Eschmeyer, W. N. (Eds.), *Encyclopedia of fishes*. Academic Press, San Diego, p. 127-128.

Krishnan Kutty, M. and Qasim, S. Z. 1968. The estimation of optimum age of exploitation and potential yield in fish populations. *J. Cons. Perm. Int. Explor. Mer.,* 32 (2): 249-255.

Kubota, T. 1982. Food of lanternfishes in Suruga Bay, Central Japan. In: Melteff, B. R. and Neve, R. A. (Eds.), *Proc. North Pacific Aquaculture Symposium.* University of Alaska, p. 275 - 283.

Manju, S., Chakraborty, K., Bineesh, K. K., Pillai, N. G. K., Abdussamad, E. M. and Vijayan, K. K. 2011. Proximate composition and fatty acid profile of myctophid (*Diaphus watasei* Jordan & Starks, 1904) from the Arabian Sea. *Indian J. Fish*., 58 (1): 103-107.

Nafpaktitis, B. G., Backus, R. H., Craddock, J. E., Haedrich, R. L., Robinson, B. H. and Karnella, C. 1977. Family myctophidae. In: Gibbs Jr. R. H. (Ed.), *Fishes of the Western North Atlantic*. *Mem. Sears Found. Mar. Res*., 1. Pt. 7.

Natarajan, A. V. and Jhingran, V. G. 1961. Index of preponderance method of grading the food element in the stomach analysis of fishes. *Indian J. Fish*., 8: 54-59.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. *FAO. Fish. Circular,* No. 729, FIRM/ 129: 54 pp.

Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. *FAO. Fish. Tech. Paper,* 234: 1-52.

Pauly, D. 1984. Length converted catch curves: A powerful tool for fisheries research in the tropics (Part II). *Fishbyte*, 2 (1): 17-19.

Vipin, P. M., Pradeep, K., Renju Ravi, Jose Fernandez, T., Remesan, M. P., Madhu, V. R. and Boopendranath, M. R. 2011. First estimate of the length–weight relationship of *Diaphus watasei* Jordan and Starks, 1904 caught off the south-west cast of India. *Asian Fish. Sci.,* 24 : 453-455.

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