



Species diversity and basic biology of Squids from Maharashtra waters, northwest coast of India

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ABSTRACT

Squid diversity was studied from Maharashtra waters during the period January 2000 - December 2017. Seven species were identified and they are *Uroteuthis (Photololigo) duvauceli* Orbigny, 1848; *Uroteuthis (Photololigo) edulis* Hoyle, 1885; *Loliolus (Loliolus) hardwickei* (Goodrich, 1886); *Uroteuthis (Photololigo) singhalensis* Ortmann, 1891; *Onychoteuthis banksii* (Leach, 1817); *Thysanoteuthis rhombus* Troschel, 1857 and *Symplectoteuthis oualaniensis* (Lesson, 1830). The estimated annual catch of squids by trawlers (all species combined) for the period 2000-2017 from NFW showed an increasing trend and the landings ranged from 1299.5 t (2002) to a peak of 8477 t (2017) and the corresponding catch rate ranged from 0.941 kg/hr (2002) to 3.966 kg/hr (2017).

Key words: Squids, Biodiversity, Biology, Fishery, Maharashtra.

INTRODUCTION

Squids are locally called as '*Makul*' in Maharashtra. Squids occur in the Oceans and Seas of the world and are pelagic, demersal or epibenthic (Roper *et al.*, 1984). There are about 80 species of cephalopods of commercial and scientific interest distributed in the Indian Seas (Silas, 1968). Almost the entire catch of squids is obtained as by-catch in trawl fishing all along the Indian coasts (continental shelf and oceanic region), while a small portion comes in targeted fishing such as hand-jigging (Nair, 1985).

Some of the most important squid markets are located in Asia. Extensive work has been carried out on squids along the Indian waters especially on the Indian squid, *Uroteuthis (Photololigo) duvauceli* and some of the major works carried out on squids are by Silas *et al.* (1985a,b), Silas *et al.* (1982) and Meiyappan *et al.* (1993) etc. Mohamed *et al.* (2009) gave an account on the exploitation of juvenile cephalopods from the Arabian Sea and Bay of Bengal including squids.

Sundaram (2009) gave an account on the various uses of cephalopods. Sundaram (2011b), Ramkumar *et al.* (2013) and Sugumar *et al.* (2015) gave an account on the fishery of cephalopods including squids from Maharashtra. Kuber (1987) gave an account on the cephalopods of Mumbai waters and Sundaram and Deshmukh (2011) described the emergence of squid jigging in India including Maharashtra. From the review of literature it seems there is no study on the diversity of squids from Maharashtra waters and therefore an attempt has been made to present the same. The major fish landing centres of Maharashtra such as New Ferry Wharf (NFW), Sassoon docks and Versova are situated in Mumbai and they account for nearly 60% of Maharashtra's fish landings (Annam and Sindhu, 2005), hence the species from these centres can be considered as representative of Maharashtra state.

MATERIAL AND METHODS

During the period January 2000 to December 2017, weekly visits were carried out to NFW and monthly visits were made to Sassoon docks and Versova landing centre. The specimens collected from these centres were brought to the laboratory for species identification based on the identification characters as described by Roper *et al.* (1984) and Silas *et al.* (1985c). Further biological analysis was also carried out and dorsal mantle length (DML) was measured using digital calipers (± 1 mm) and total body weight (TBW) by an electronic balance (± 0.01 g) after the specimens were dried on blotting paper. The measurements were taken as described in CMFRI manual (1995). As trawling was suspended from 10th June to 15th August, due to southwest monsoon and restrictions imposed by the government of Maharashtra, observations could not be collected for the month of July.

Squids are observed in trawl and *dol* catches in Maharashtra. *Dol* net is an indigenous fishing gear also called as bag net, used extensively in the northwest coast of India. The trawlers at NFW operate 70-80 km off northwest coast of Mumbai at a depth of 30-60 m. At Sassoon docks the fishing area extends up to Ratnagiri and the depth of operation extends from 20-90 m, but generally they carry out trawling in waters beyond 40 m. At Versova the trawlers operate in 20-40 m depth, parallel to coastline from Vasai in the north and Murud-Janjeera in the South. The *dol* nets

are operated along Mumbai harbor at the depths of 5-10 m (Mane and Sundaram, 2011). Catch and effort data for cuttlefishes from trawlers were obtained from the data files maintained by the Fishery Resources Assessment Division of Mumbai Research Centre of Central Marine Fisheries Research Institute.

500 specimens of *U. (P.) duvauceli*; 100-*U. (P.) edulis*; 25- *L. (L.) hardwickei*; 25-*U. (P.) singhalensis*; 25-*O. banksii*; 1-*T. rhombus*; and 5-*S. oualaniensis* were analysed. The length-weight relationship was obtained by the method of 'least squares' based on individual measurements. The relationship of DML and TBW was expressed as parabolic equation of the form, $W = a * L^b$. The stomach condition was analysed following Kore and Joshi (1975). The food items were in well-crushed and macerated condition; therefore, it was possible to categorise up to the level of groups only (such as fish). The Index of Preponderance was estimated as suggested by Natarajan and Jhingran (1961). The maturity studies were estimated following Silas (1985). The size at first maturity was estimated by King's (1995) method. To estimate the fecundity, ovaries were removed from the fresh specimens and a few drops of formalin (4%) were added and mixed with tissue to facilitate easy separation. Ova diameter measurements were made according to Prabhu (1956).

RESULTS AND DISCUSSION

With the increased exploitation and expansion of fishing grounds, new records of cephalopods are reported from various places all along the Indian coast. The estimated annual squid catch by trawl for the period 2000-2017 from NFW showed an increasing trend. Overall the catch of squids ranged from 1299.5 t (2002) to a high peak of 8477 t (2017) and the corresponding catch rate ranged from 0.941 kg/hr (2002) to 3.966 kg/hr (2017) (Fig 1). The annual catch was more or less uniform throughout the study period with not much fluctuation. However, in 2016 and 2017 the catch increased many folds, which could lead to over-exploitation. According to Nair *et al.* (1992), the seasons recognized for the cephalopod fishery are the pre-monsoon (February-May), the monsoon (June-August) and the post monsoon (September-January). The monthly abundance suggests that squid catches are very high during pre-monsoon seasons in Maharashtra i.e. during February-April with peak in March. Generally, in Mumbai waters

the abundance of squids is during pre-monsoon period (Kuber, 1987). Squids contribute 52.8% towards the total cephalopod catch in Maharashtra (CMFRI, 2013) and *L. duvauceli* with 90% dominates the squid fishery in Mumbai waters. The squid species available in Maharashtra waters are listed below according to their abundance.

***Uroteuthis (Photololigo) duvauceli* Orbigny, 1848**

U. (P.) duvauceli is commonly known as 'Indian squid' and locally known as 'Nal makul'. The mantle of *U. (P.) duvauceli* is relatively short and stout. The fins are rhombic and are just over 50% of mantle length. Tentacular clubs are extended and an oval photophore on each side of ink sac is observed. The body is pinkish white in colour in fresh condition. *U. (P.) duvauceli* is distributed in the Indo-Pacific: Indian Ocean periphery, including the Red Sea and the Arabian Sea, extending eastwards from Mozambique to the South China Sea and the Philippines Sea. *U. (P.) duvauceli* is a demersal and shallow water species ranging in depth between 30 to 170 m (Roper *et al.*, 1984).

In Maharashtra the species is observed in trawl catches at NFW, Sassoon docks and Versova throughout the year with peak landings during February-April. They are also caught by hand-jigging along Ratnagiri, Maharashtra (Sundaram and Sawant, 2013; Sundaram and Sawant, 2014). During

January'03 a large number of juveniles ranging in size between 25 mm to 49 mm were landed by trawlers at NFW (Sundaram and Sarang, 2004b). Environmental conditions influence the fish landings off Mumbai (Singh *et al.*, 2002) and mass spawning congregations of squids was observed at Versova during October'09 (Sundaram *et al.*, 2010; Sundaram and Deshmukh, 2010).

The DML of the species ranged from 30 to 320 mm in Mumbai waters. At Ratnagiri the maximum length of *U. (P.) duvauceli* caught by squid jigging was 327 mm (Sundaram and Sawant, 2013). According to Silas *et al.* (1985a), the maximum size of males along the east coast of India were 184 mm (at Kakinada) and 170 mm (at Madras) and the largest size attained along the west coast were higher being 285 mm (at Bombay) and 190 mm (at Cochin and Vizhinjam) and the largest female along east coast (Waltair) and on the west coast (at Cochin and Vizhinjam) measured 190 mm. It was observed that the species mainly fed on fish (72.2%), prawn (25.8%) and squid (1.9%). The sex-ratio was 1:0.90. Out of the specimens observed the percentage in different stages of maturity was indeterminant (0.7%), immature (7.6%), mature (73.2%) and spent (18.5%). The fecundity ranged between 1,080 to 15,570 and the ova diameter ranged between 0.5 – 1 mm.

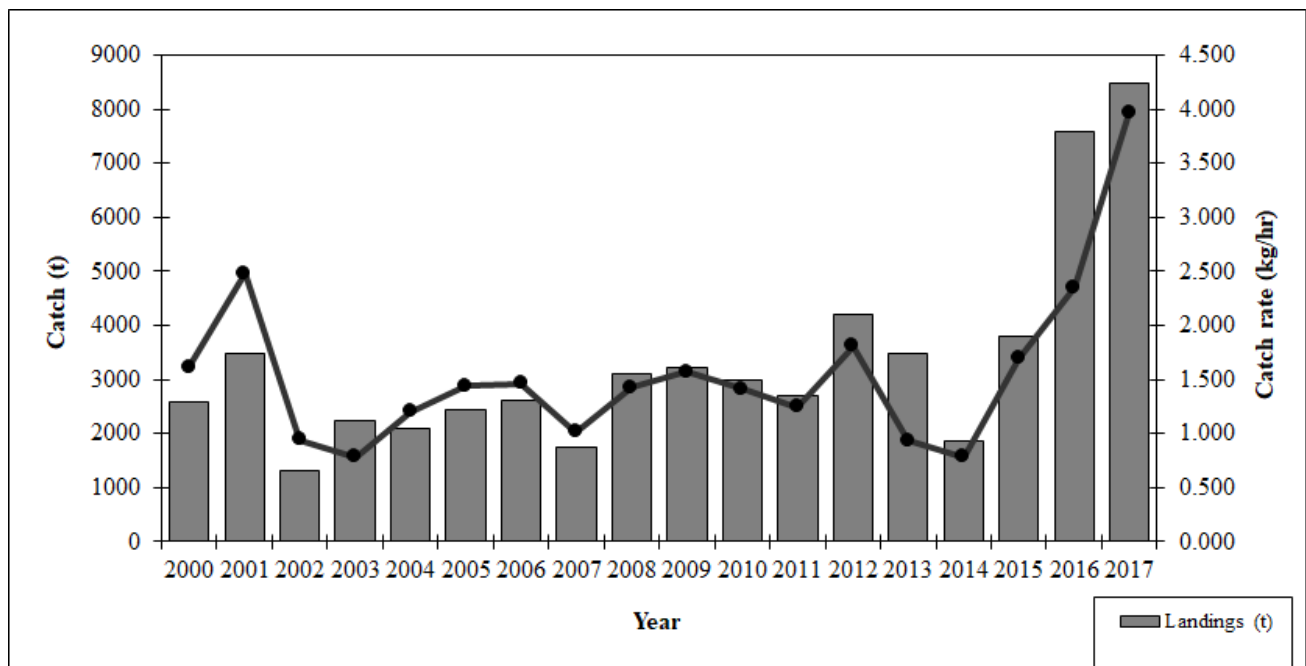


Fig. 1. Catch and catch rate of Squids by trawlers at New Ferry Wharf, Mumbai

Karnik and Chakraborty (2001) carried out morphometric studies on the species and Kuber and Deshmukh (1992) on the stock assessment from Mumbai waters. Sundaram *et al.* (2011) gave an account on the unusual heavy landings of the species at NFW. Sasikumar *et al.* (2017) estimated the legal minimum size for the species along Eastern Arabian Sea.

***Uroteuthis (Photololigo) edulis* Hoyle, 1885**

U. (P.) edulis is commonly known as 'Swordtip squid'. The mantle of *U. (P.) edulis* is moderately stout to elongate and mature males may be more slender (Okutani *et al.*, 1987). A cutaneous ridge on the ventral surface is generally present, but they are absent in the specimens collected from Mumbai, which was also not mentioned by Voss (1963), Adam (1973) and Jereb and Roper (2006) in their description of specimens from the Philippines, Red Sea and the Indian Ocean respectively. The fins are rhombic and their posterior margin slightly concave and also the fins become slightly longer than wide in adult specimens. Arms are moderately long forming about 25-45% of mantle length. The arm formula is variable - 3.4.2.1 or 4.3.2.1. Tentacular clubs are expanded with 30 to 40 sharp conical teeth on largest suckers. The gladius is long and moderately narrow. *U. (P.) edulis* morphologically resembles *U. (P.) duvauceli* and is distinguishable essentially by the arm sucker dentition. The Arm III sucker ring teeth of *U. (P.) duvauceli* is broad and square while in *U. (P.) edulis* they are distinct, longer and slender square (Sundaram and Mhadgut, 2013). *U. (P.) edulis* is distributed in the Western Pacific: Northern Australia, Philippine Islands and northern South China Sea to central Japan. It is a neritic species occurring in 30 to 170 m depth. It overwinters in deeper waters, migrating inshore in spring and summer forming large aggregations and spawning places on sandy bottoms in 30 to 40 m depth (Jereb and Roper, 2006).

In Maharashtra the species is observed in trawl netters at NFW and Sassoon Docks. They are observed in the catch almost throughout the year but during the period October – January they are more pronounced. The species entered the fishery in Mumbai waters probably from the year 2000 onwards but the catch was low. Over the years the landings increased in NFW and the peak landings were observed in 2011 (Sundaram, 2011a).

The DML of the species ranged from 59 to 251 mm (males 66- 251 mm and females 70 – 155 mm) with the corresponding weight ranging from 82 to 250 g. The females of this species are found to be smaller than the males. According to (Jereb and Roper, 2006) the maximum mantle length of *U. (P.) edulis* is 300 mm. Majority of the guts were in 'trace' and 'empty' condition and the food was finely macerated. The species seems to mainly feed on 'fish' (90%) followed by 'prawn' (10%). This species has a sex-ratio of 1:0.46. 68.7% of the specimens analysed for the maturity studies were 'spent' followed by 'mature' (31.3%). According to Natsukari and Tashiro (1991), the spawning season extends throughout the year, with three detectable peaks in spring, summer and autumn which also seems to be the case in Mumbai waters as spent specimens are found almost throughout the year. It was observed that *U. (P.) edulis* matured at a smaller size (70 mm) than *U. (P.) duvauceli* and the ova diameter of the species was also larger (up to 2 mm) than *U. (P.) duvauceli* and the fecundity ranged between 580 to 1,620.

***Loliolus (Loliolus) hardwickei* (Goodrich, 1886)**

L. (L.) hardwickei is commonly known as 'Investigator squid'. The body of *L. (L.) hardwickei* is conical shaped and have the greatest width at about the middle. The mantle is small and the midrib of the gladius is seen clearly through the skin mid-dorsally. The fins are large and broad and extend along more than 70% of the mantle length. The arms are rather short and sub-equal in length. The arm suckers are globular and arranged in two series. The tentacles are long and very thin and end in narrow clubs, which have small sub-equal suckers arranged in four rows. The body is transparent when fresh. Chromatophores are brown in colour and are distributed all over the body. *L. (L.) hardwickei* has a wide distribution, from the Northern Persian Gulf, The Indian and Burmese coasts and throughout Indonesia. This species is found in estuaries and shallow coastal waters to a maximum depth of 30 m (Lu *et al.*, 1985).

In Maharashtra the species is observed in *dol* nets at NFW, Sassoon Docks and Versova. They are observed in the catch almost throughout the year but during the period October – January they are more pronounced. However, during the monsoon months due to the ban on trawl net operations, *dol* netters operate extensively and hence the catch of this species is more during monsoon. It fetches better price during the

monsoon months, as there are no other cephalopod landings during this period (Sundaram and Sarang, 2004a). The DML of the species in Mumbai waters ranged from 20 to 45 mm. According to Silas *et al.* (1985c) the maximum mantle length of *L. (L.) hardwickei* is 55 mm. Females grow larger in size than the males. Gut analysis revealed that they predominantly feed on crustaceans such as *Acetes spp.*

***Uroteuthis (Photololigo) singhalensis* Ortmann, 1891**

U. (P.) singhalensis is commonly known as 'long barrel squid', also known as 'Arrow squid' locally. *U. (P.) singhalensis* has a long and posteriorly narrowing mantle to a sharp end. The anterior mid-dorsal projection is rounded at the tip. A very distinct longitudinal concentration of chromatopores is present mid ventrally on the mantle. Fins are large and rhombic in shape extending along more than 60-70% of the mantle length. Head is relatively stout and arms are rather short 20-30% of the mantle length. Tentacles are moderately long, slender and compressed. The clubs are short and the club suckers are arranged in four rows. The rings of the suckers bear 20-22 sharp curved teeth. The funnel is short, stout and placed in a deep furrow beneath the head. *U. (P.) singhalensis* is known to be distributed in Indo-Pacific region, eastern Arabian Sea, Bay of Bengal to South China Sea and Philippines waters. *U. (P.) singhalensis* is considered as a neritic, semipelagic species reported to occur at depths from 30-120 m (Roper *et al.*, 1984).

In Maharashtra the species is observed in trawl nets at NFW during September - October. The species occurred in considerable numbers in the year 2000 (Sundaram and Sarang, 2004a) and again in the year 2011. The DML of the species in Mumbai waters ranged from 180 to 260 mm. According to Silas *et al.* (1985c), the maximum mantle length recorded for this species is 150 mm for males and 310 mm for females. Gut analysis revealed that they predominantly feed on prawns and fish.

Mohamed and Nagaraja (1991) have reported similar *Uroteuthis sp* from Mangalore coast and the Occurrence of *Uroteuthis sp.* is very seasonal and is usually associated with the North flowing coastal current during November-December.

***Onychoteuthis banksii* (Leach, 1817)**

O. banksii is commonly known as 'Common club hook squid'. The mantle of *O. banksii* is robust and elongated. Fins are large, broad and the length of the fin is about 50% of the total mantle length. Tentacles and arms are longer with the tentacles as long as double the mantle length. Tentacular clubs are very distinct with 19 to 23 claws like hooks in two rows and no marginal rows of sucker. Gladius is visible as a dark line through the skin along midline of mantle. *O. banksii* is distributed world-wide in warm and temperate oceanic waters. It is known to be distributed from the surface to 150 m depth and to as deep as 800 m (Roper *et al.*, 1984).

In Maharashtra the species is observed in *dol* nets and also in small trawl netters operating up to a depth of 40 m. The occurrence of this species was observed off Mumbai during the period of March - June (Sundaram and Sarang, 2004a). According to Roper *et al.* (1984), the maximum DML recorded for this species is 300 mm. However, in Mumbai waters they are very small ranging in length from 20 - 40 mm. Abundance of larval stages is reported particularly from January to March in the Eastern Atlantic (Roper *et al.*, 1984). Gut analysis revealed that they predominantly feed on prawns. The bite of these squids is toxic and resembles a wasp sting in its effect Roper *et al.* (1984).

***Thysanoteuthis rhombus* Troschel, 1857**

T. rhombus is commonly known as 'Diamond back squid'. *T. rhombus* is an epipelagic oceanic species and is a very large and muscular squid. Mantle is thick and the shape of the fin is characteristically rhombic being very broad at the middle. Eyes are very big and prominent. The funnel mantle locking apparatus is typical. The funnel cartilage is fallen 'T' shaped consisting of an elongate and narrow longitudinal groove and a short and broad transverse groove emerging from the middle part. The suckers are small and arranged in four rows and the carpus is extended and the entire body is uniformly deep reddish brown colored. *T. rhombus* is a cosmopolitan pelagic oceanic species usually found in warm temperate waters throughout the world Oceans (Roper *et al.*, 1984).

In Maharashtra in January' 2007 at Sassoon docks, a single male specimen of *T. rhombus* was landed by trawler. The fishing was carried out at 60-70 m depth at a distance of 50-60 km of southwest coast towards Malvan (Sundaram *et al.*, 2007). The single specimen

brought to the laboratory measured 370 mm in DML and weighed 1.8 Kg. The Maximum size according to Roper *et al.* (1984) is 1000 mm and weighs 20 kg and they are common to size 600 mm. A single male specimen of *T. rhombus* with DML 327 mm was recorded in trawl at Veraval (Lipton, 1988). Mohammed *et al.* (2001) reported DML of 620 mm from Cochin waters. The gut was found to be empty. They generally feed on squids and small fishes (Woods *et al.*, 2003).

The species normally occur in small groups of two or more individuals swimming in the surface waters (Roper *et al.*, 1984). This species was recorded for the first time from the Indian Ocean by Fillipova (1968). According to Silas *et al.* (1985c), *T. rhombus* is among the important oceanic squids present in the Indian Ocean. Kasim *et al.* (1998) reported their occurrence from the Gulf of Mannar.

***Symplectoteuthis oualaniensis* (Lesson, 1830)**

S. oualaniensis is commonly known as 'Purple back flying squids'. *S. oualaniensis* has a very muscular mantle with muscular fins. Mantel and funnel are fused at locking cartilage. The arms are long and strong in the order of 3:2:4:1. The larger arm suckers are provided with 12 sharp teeth around the entire rim of the horny rings. The entire body is uniformly deep chestnut brown colored. *S. oualaniensis* is known to be distributed in the Indo specific, Indian Ocean and the Pacific Ocean. The species is generally found from the surface to probably 1000 m depth (Roper *et al.*, 1984).

In Maharashtra during October'2003 at Sassoon docks about 350 Kg of *S. oualaniensis* was landed. This species was caught by hook and lines, by using small fish pieces as baits. The hook size used was No.6 (approximately 3 inches) (Jadhav *et al.*, 2004). The maximum size according to Roper *et al.* (1984) is 350 mm but in the present observations the specimens ranged between 300 mm and 400 mm. A single specimen measuring 300 mm caught by drift net was earlier recorded off Mangrol, Saurashtra coast (Raje *et al.*, 1987). The gut was full with thoroughly macerated and pulpy food material, which could not be identified. The specimen was a female with the gonad in maturing stage.

This species is known to carry out diurnal vertical migration from the surface at night to deeper layers

during the day (Roper *et al.*, 1984). The distribution of the species in the Arabian Sea has been given by Filippova (1968) and Silas (1968). Mohamed *et al.* (2006) studied on the biology of this species from Indian waters.

Squids are known to make seasonal migrations, which are influenced by breeding activity. It seems that in all probability these species observed may have come to nearshore waters following many reasons one of them being breeding. The price of squids ranged between Rs.80-200/kg according to the size and species at the landing centre. Due to the abundant availability of squids and its high commercial importance, a detailed study on the distribution and population dynamics is essential for this resource from the Northwest coast of India in general and Maharashtra coast in particular. Fig 1 clearly indicates that the catch has increased over the years and eventually it would lead to over-exploitation.

Further studies on the fishery and biology of squids would prove useful to evolve effective management measures for judicious exploitation of these resources. Specimens of all the above mentioned species are deposited in the reference collection of Mumbai Research Centre of Central Marine Fisheries Research Institute for future reference.

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