Age, growth and mortality studies of Indian squid, *Uroteuthis (Photololigo) duvauceli* (d’ Orbigny) along Ratnagiri Coast of Maharashtra, India

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The study on the growth and mortality of Indian squid *Uroteuthis duvauceli* was carried out based on the length frequency data collected during February 2012 to January 2013. Using ELEFAN, the asymptotic length (*L*∞) and growth coefficient (K) were estimated as 376 mm and 0.95 yr⁻¹ respectively. Using the von Bertalanffy’s Growth Formula (VBGF), it is seen that *L. duvauceli* attain 233, 324 and 355 mm at the end of 1st – 3rd years respectively. The total, natural and fishing mortalities were 4.5, 1.82 and 2.68 yr⁻¹ respectively. The *Lc*₅₀ was found to be 107 mm. The exploitation rate (U) and exploitation ratio (E) was calculated 0.53 and 0.54 respectively. The value of *E* max in the present study is lower than exploitation ratio E of 0.54. This indicates that to maximize the yield per recruit from *L. duvauceli* the efforts may be reduced from the present E of 0.54 to 0.5 to sustain the stock.

**Key words:** Indian squid, *Uroteuthis duvauceli*, growth, mortality, stock assessment

Introduction

The Indian squid *Uroteuthis duvauceli* is the one of the commercial important cephalopod species found along Indian coast. This species is distributed in the Indo-Pacific neritic waters from Mozambique to South China Sea and Philippine up to Taiwan. It occurs up to a depth of 120 m or even beyond but the most of the stock is found in depths of about 50 m to 60 m.¹ The production of cephalopods during the year 2012 in India was 1, 90,322 tonnes among which squid *U. duvauceli* contributes 92,241 tonnes which is more than 48% in cephalopod landings of India. The annual catch of cephalopods by trawlers in Maharashtra state was 15, 658 tonnes forming 11.0% of the total fish landings in the state in 2012. Along the northwest coast, *U. duvauceli* with 60% dominated trawl landings of cephalopods². In India, cephalopods are principally caught by bottom trawlers operating up to 100m depth zones. Most of the catch is brought in as by-catch from the shrimp and fish trawls employed by the trawlers³.

Reports are available on growth and mortality studies of Indian squid, *U. duvauceli* on Indian coast by ⁴,⁵,⁶,⁷,⁸,⁹,¹⁰ and ¹¹,¹² from Thailand waters. As no report from Ratnagiri is available for this species, a study was conducted on growth, mortality and stock assessment of this species.

Material and Methods

The catch and efforts data was collected weekly from the commercial catches from Mirkarwada landing centre (16.98° N, 73.3° E) of Ratnagiri during February 2012 to January 2013. A total of 1059 fish specimen were measured. The total length (DML) was measured to the nearest millimeter. The length frequency data were grouped into 10 mm class interval, then raised & pooled month wise.¹³ Employing ELEFAN of FiSAT computer programme ¹⁴,¹⁵, the asymptotic length (*L*∞) and growth coefficient (K) was determined. The total instantaneous mortality (Z) was calculated by length-converted catch curve ¹⁶,¹⁷. Natural mortality coefficient (M) was estimated by using Cushing’s method (1968)¹⁸.

\[ M= \left(1/T_{max} – 1\right) \ln \left(100/1\right) \]

(Where *T* max is maximum age attained by species)

The fishing mortality (F) was arrived by subtracting M from Z.

The exploitation rate (U) is calculated as \( U = \left(\frac{F}{Z}\right) * (1 - e^{-z}) \) and exploitation ratio (E) by \( \frac{F}{Z} \) ¹⁹.

The length frequency data was pooled and by backward extrapolation of catch curve, the
The relative yield/recruit was estimated from the relative yield/recruit model of 19 & 20 was represented by the equation:

\[(\frac{Y}{R})' = E^* \frac{U^{M/K}}{1 - \left(\frac{U}{1 + m} + \frac{3U^2}{1 + 2m} - \frac{U^3}{1 + 3m}\right)}\]

where \(E = \frac{F}{Z}\) the exploitation ratio or the fraction of deaths caused by fishing:

\[m = \frac{K}{Z}\]

\(U = 1 - \frac{L_c}{L_\infty}\) the fraction of growth to be completed after entry into the exploited phase, \((\frac{Y}{R})'\) is considered a fraction of \(U\) and \(E\) and the only parameters is \(M/K\). Using different value of \(E\) on the X-axis and various sizes at first capture \(L_c/L_\infty\) ratios on Y-axis, the isovalues of relative yield per recruit were plotted to generate the yield isopleth diagram.

**Results**

In the present study, the growth parameters \(L_\infty\) and \(K\) were estimated 376 mm and 0.95/year respectively by ELEFAN-I employing FiSAT programme (Fig. 1).

The \(t_e\) was estimated by VBGF plot was \((-0.0567)\) yr. Using the von Bertalanffy’s Growth Formula (VBGF), it is seen that \(L. duvauceli\) attain 233, 324 and 355 mm at the end of I\(^{st}\) – III\(^{rd}\) years respectively. The maximum size recorded during the period of study was 332 mm, at which the estimated age is 2.258 years. The \(t_{max}\) was estimated by employing inverse von Bertalanffy’s growth formula was 3.1578 years taking the largest squid observed in the catch.

The value of total mortality (\(Z\)) obtained from length converted catch curve is 4.50 (Fig. 2). The natural mortality coefficient (\(M\)) was estimated by Cushing’s method gave estimates of \(M\) as 2.10. The annual fishing mortality coefficient (\(F\)) was estimated as 2.40 for \(U. duvauceli\).

The length at which 50% of the squid became vulnerable to the gear was found to 107 mm (Fig. 3).

The exploitation rate (\(U\)) calculated as 0.53 and exploitation ratio (\(E\)) was 0.54 for \(U. duvauceli\). Relative yield / Biomass per recruit shows \(E_{max}\) at 0.519, \(E_{50}\) at 0.299 and \(E_{10}\) at 0.410. The values of \(L_c/L_\infty\) and \(M/K\) taken for estimation of \(Y/R\) and \(B/R\) are as 0.290 and 1.92 respectively (Fig. 4).

**Fig.1- Growth curve fitted by ELEFAN method**

The exploitation rate (\(U\)) calculated as 0.53 and exploitation ratio (\(E\)) was 0.54 for \(U. duvauceli\). Relative yield / Biomass per recruit shows \(E_{max}\) at 0.519, \(E_{50}\) at 0.299 and \(E_{10}\) at 0.410. The values of \(L_c/L_\infty\) and \(M/K\) taken for estimation of \(Y/R\) and \(B/R\) are as 0.290 and 1.92 respectively (Fig. 4).

**Fig.2- Length converted catch curve for estimation of Z**

**Fig.3- Probability of capture of \(U. duvauceli\)**

**Fig.4- Relative yield per recruit and relative biomass per recruit of \(U. duvauceli\)**
Discussion

By employing ELEFAN, $L_\infty$ and $K$ were estimated as 376 mm and 0.95 per year respectively. In present study the length data of both males and females have been pooled and therefore the present estimates are an average for both the sexes. Thomas and Kizhakudan\(^9\) based on the analysis of length frequency data, reported the estimates of $L_\infty$ and $K$ to be 303 mm and 0.98 per year respectively. In present study the length data for both the sexes were estimated as 376 mm and 0.95 per year by Karnik et al.\(^8\). While Chakraborty et al.\(^7\) estimated the values of $L_\infty$ and $K$ as 323 mm and 0.449 per year. From Mangalore coast the $L_\infty$ and $K$ of *L. duvauceli* have been estimated as 343 mm and 1.43 per year by Mohamed & Rao\(^6\). From Gulf of Thailand Supongpan\(^10\) reported the $L_\infty$ and $K$ value to be 266 mm and 0.86 per year respectively. It has been reported that the females of squids grow at a faster rate, but males reach to a larger size (Silas et al.,\(^4\), Meiyappan et al.,\(^3\) , Mohamed et al.,\(^1\)). Asymptotic length ($L_\infty$) obtained in the present study is on higher side compared to most obtained by earlier workers except Karnik et al.,\(^8\). Higher $K$ value conforms to most of the earlier reports. In present study, $t_0$ was estimated by employing VBGF plot to be $-0.0567$ year. Karnik et al.,\(^8\), estimated $t_0$ for *L. duvauceli* as -0.0033 years from Mumbai waters. While Supongpan et al.\(^11\) estimated the value of $t_0$ for *L. duvauceli* in Gulf of Thailand was 0. $t_0$ often has a small negative value as conformed by the present study.

The present study indicated that *L. duvauceli* attain size of 233, 324, and 355 mm dorsal mantle length at the end of I to III year respectively. Maximum size recorded during the period of study was 332 mm at which the estimated age is 2.3072 years. The $t_{\text{max}}$ value is estimated to be 3.10 years. Thomas and Kizhakudan\(^9\) reported the length at age for *L. duvauceli* along the Gujarat coast of India as 189, 260, 287 mm at the end of $I^{\text{th}}$ to $III^{\text{rd}}$ year respectively. He further stated $t_{\text{max}}$ value as 3.06 years. Karnik et al.,\(^8\), reported the length at age for *L. duvauceli* along the Mumbai waters as 221, 315, 355, and 372 mm at the end of $I^{\text{th}}$ to $IV^{\text{th}}$ year of its life span respectively. Also the $t_{\text{max}}$ value was estimated as 3.53 years. The growth of *L. duvauceli* indicated in the present study is almost similar to that reported by Karnik et al.,\(^8\). Thomas and Kizhakudan\(^9\) reported the values of $Z$, $M$ and $F$ to be 3.94, 1.74 and 2.20 respectively. Karnik et al.,\(^8\), reported the values of $Z$, $M$ and $F$ at 4.29, 1.82 and 2.47 respectively. Natural mortality ($M$) of 1.82 is more or less same to that reported by above workers and is within the range obtained for this species from India (Meiyappan et al.,\(^3\)). Total mortality coefficient ($Z$) is higher than reported by Karnik et al.,\(^8\), and Thomas and Kizhakudan\(^9\). This can be attributed to increased exploitation of the species along the Ratnagiri coast.

The length at first capture was estimated to be 107 mm. This size is less in relation to the maximum size of 332 mm reported in the study while it is more than minimum size at first maturity of 86 mm. Fishing intensity should be slightly reduced, so that size at first capture doesn’t approaches size at first maturity.

In the present study, the exploitation rate (E) of 0.59 is more or less same to 0.56 (Thomas and Kizhakudan\(^9\)) and 0.57 as reported by Karnik et al.,\(^8\). Present exploitation rate shows that the resource is exploited above the optimum level and the effort has to be reduced for sustaining the resource for long term exploitation.

By employing the relative yield / Biomass per recruit model, the value of Exploitation, $E_{\text{max}}$ was estimated at 0.519. Thomas and Kizhakudan\(^9\) reported the value of $E_{\text{max}}$ for *L. duvauceli* to be 0.44 from Saurashtra coast. While Karnik et al.,\(^8\), reported $E_{\text{max}}$ of 0.49 for *L. duvauceli* by employing relative yield per recruit analysis from Mumbai waters. Value of $E_{\text{max}}$ in the present study is lower than exploitation ratio $E$.  


of 0.60 calculated on the basis of ratio of $F/Z$. This indicates that to maximize the yield per recruit from *L. duvauceli* the efforts may be reduced from the present $E_o$ of 0.60 to 0.5 to sustain the stock.

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