Available online at: www.mbai.org.in
doi: 10.6024/jmbai.2013.55.2.01638-10

Age, growth and maturity of brown stripe snapper *Lutjanus vitta* (Quoy & Gaimard, 1824) from southwest coast of India

S. Ramachandran*, D.M. Ali and Benjamin C. Varghese
Fishery Survey of India, Kochangadi, P.B.No.853, Kochi - 682 005, Kerala, India.

*Correspondence e-mail: marine_ramc@yahoo.co.in

Received: 02 Jul 2010, Accepted: 03 Dec 2013, Published: 15 Jan 2014

Original Article

Abstract

Growth, mortality, length-weight relationship, maturity and spawning of *Lutjanus vitta* were studied based on samples collected from 30 and 80 m depths along the southwest coast of India during October 1999 - December 2009. The von Bertalanffy growth equation was derived as $L_t = 32.5\ (1\text{-}e^{-0.66\ (t\ -\ 0.014)})$ during the year 2000; changes in these parameters during 2003-04 and 2007-08 are discussed in this paper. The length-at-age was 12.3±1.36 cm, 18.9± 1.67 cm, 24.72± 1.58 cm, 28.9±0.98 cm and 31.5±0.94 cm in the I, II, III, IV and V year respectively. The annual natural, fishing and total mortality rates were 1.33, 0.85 and 2.18 respectively. The exploitation ratio (E) was 0.39, which indicates that this species is not under heavy fishing pressure. Recruitment was peak in March. Length-weight relationship was estimated for males and females, and later for the pooled data as $W= 0.00000139\ L^{2.983}$. The relative condition factor (K_n) does not vary significantly among the size groups but the seasonal condition factor (K_s) is comparatively lower in the smaller size group. Higher gonado-somatic index (GSI) was seen during August - December. The length-at-first maturity was 15.8 cm for female and 14.5 cm for male. During October and November, the one-year age group (12.5cm (♂) and 14 cm (♀)) appeared in the spawning grounds and extended the spawning activity by performing batch fecundity. The relative fecundity ranged between 2,22,016 ± 28,543 and 5,21,482 ± 67,044 eggs/fish.

Keywords: *Lutjanus vitta, population dynamics, spawning, fecundity, age and growth.*

Introduction

Snappers (Family Lutjanidae) are one of the highly valued resources along the southwest coast of India and are caught by trawlers, bottom-set liner and other craft from rocky, coral grounds of 30 - 100 m depth. During 2008 the average landings of snappers was 8,580 t in India, which constituted 3.4% to the total perch landing (CMFRI, 2009). *Lutjanus vitta* is a medium-sized shoaling demersal fish inhabiting 30 - 100 m depth in Wadge Bank and contiguous waters. Publications on this species in India are mostly restricted to commercial catch statistics (Chacko and Rajendran, 1955; Alagaraja *et al*., 1994; James *et al*., 1994) and gear selectivity (Hamsa and Kasim, 1994; Sam Bennet and Arumugam, 1994). Davis and West (1992, 1993) and Newman *et al.* (2000) have carried out biological studies on this species from northwest Australian coast. The main objectives of the present study are to estimate population parameters, maturity, spawning season and fecundity of *L. vitta*, which will be helpful for generating management models for the sustainable exploitation of this species.

Material and methods

Monthly samples of *L. vitta* were collected during October 1999 - December 2009 from the southwest coast (Lat.7°

41.77′ and 8° 24.76′) from depth range of 30-80 m during the exploratory surveys of the vessel *Matsya Varshini* of Fishery Survey of India, using expo model bottom trawl (45.6 m; cod end mesh size: 30 mm). The total length and weight of the fish were measured to the nearest 1 mm and 0.5 g accuracy. Length-weight relationship was calculated by least square method using the formula of W= a x L^b and its logarithmic form Log W = Log a+ b Log L. The relative condition factor (K_n) was calculated from the equation K_n = W/w, where W= estimated weight and w = calculated weight (Le Cren, 1951). The seasonal condition factor (K_s) was estimated following the standard formula K_s = w/L3 *100 (Hile, 1936) (as the Growth coefficient is indicated in this text as 'K' for population parameter, the seasonal condition factor actually referred by 'K' in the pertinent literatures is hereby modified and cited as 'K_s'). For determining the spawning season, the GSI (gonado-somatic index) was estimated from weight of gonad/body weight X 100 (June, 1953). Size-at-maturity was considered as the smallest length at which 50% of the fish in the sample had yolked or ripe stage ovaries (Hunter *et al.*, 1986) maturity ogive was drawn on the scatter plots for estimating length at first maturity. Eight ovaries in different stages of maturity were examined histologically to explain batch spawning. For histological studies, small pieces of different regions of gonad were taken and fixed in Bouins's fluid. Transverse section at 10 μm were made and stained with haematoxylin and eosin and observed under the trinocular microscope (Lobomed - CXR ii - magnification of 10x, 40x and 100x of objective lens). The fecundity was determined using the gravimetric method to count numbers of hydrated but unovulated oocytes in weighed subsamples of formalin-fixed ovaries (Hunter *et al.*, 1986). Each subsample consisted of a wedge of tissue extending from the periphery to the lumen of the ovary.

The length range of *L. vitta* recorded during the study period (1999-2008) was between 9 cm and 31.8 cm. Male: 11-30.6 cm; weight 95-376 g; n = 208; for female: 12.9-31.8 cm; weight 106-460 g; n = 395; pooled specimens: 9-31.8 cm; weight: 10-460 g; n = 656, including immature; n = 53). For estimating the population parameters, samples collected during October 1999 to September 2001 were utilized. The length range during this period was between 12 and 31 cm. However, during 2008 one specimen of 31.8 cm total length and few samples of 9 cm total length were collected and incorporated to the available data during 2008. Due to discontinuous data availability on biology of *L. vitta* after 2001, the available data (2003-04 and 2007-08) were utilized for estimating the population parameters, fecundity, maturity stages and GSI. Population parameters were estimated by length frequency based computer program ELEFAN as suggested by Pauly and David (1981) and Saeger and Gayanilo (1986). The natural mortality , M was estimated using the empirical relationship of Pauly (1980). The length-at-age 0 was estimated using the following formula t_0 = a - (loge. Lmax)/ -(b) and the 'a' and 'b' were estimated as constant (Bal and Rao, 1984) from the length-at-age (L_t) data derived from the Battacharya method (Battacharya, 1967). Fishing mortality, F was estimated by subtracting M from Z, the exploitation rate, E was computed from E = F/Z (Gulland, 1971).

Results and discussion

Length-weight relationship: The length-weight relationship of male *L. vitta* was log W = -1.6798 + 2.892 log L (r = 0.849); the relationship for female was log W = -1.965 + 3.062 log L (r = 0.956). As the slopes in the relationship were tested using ANCOVA and were not significantly different ($P > 0.05$) between sexes, the data of two sexes (n = 603) and immature specimen (n = 53) were pooled and thus the length-weight relationship was: log W = -1.859 + 2.983 log L (r = 0.985) and its exponential form was W = 0.0139 $L^{2.983}$. The unchanging body form and specific gravity of a fish are supposed to yield a regression coefficient (b) value of 3, where fish exhibits isometric growth. The b (2.983) value of *L. vitta* was subjected to 't' test, which revealed that this species exhibited isometric growth since its 'b' value did not significantly differ from theoretical value of 3.

Condition factor-growth relationship: The relative condition factor (K_n) and seasonal condition factor (K_s) were estimated for different length group from 9 cm to 31.8 cm. Fig. 1a, shows that the seasonal condition factor (K_s) was comparatively lower in the Ist year age group of 10-13 cm size. The K_s increased in the subsequent size group (14-18 cm) which is predicted to be second year age group and attained first maturity during this period and also been recruited into the fishing ground. Based on the present observation it is opined that the specimens attained first maturity were more healthy and robust than the smaller young ones and subsequent larger adults. It is an established fact that the K_s would be determined by the feeding intensity and reproduction (Nair *et al.*, 1983). The higher value of K_s in the largest size group was reported in other teleost (Fawzy and Soliman 1984; Hamsa *et al.*, 1994; Ramachandran *et al.*, 2004). In some species higher condition factor was reported in smaller animals than the larger size groups (Nair *et al.*, 1983; Ramachandran and Philip, 2010).

The mean value of relative condition factor (K_n) did not show much variation among the size group (Fig.1b), which may be because *L. vitta* follow the cubic law strongly for its length weight relationship (b=2.98). According to Nair *et al.* (1983) if the fish does not obey the cubic law in it's length weight relationship, the relative condition factor (K_n) could

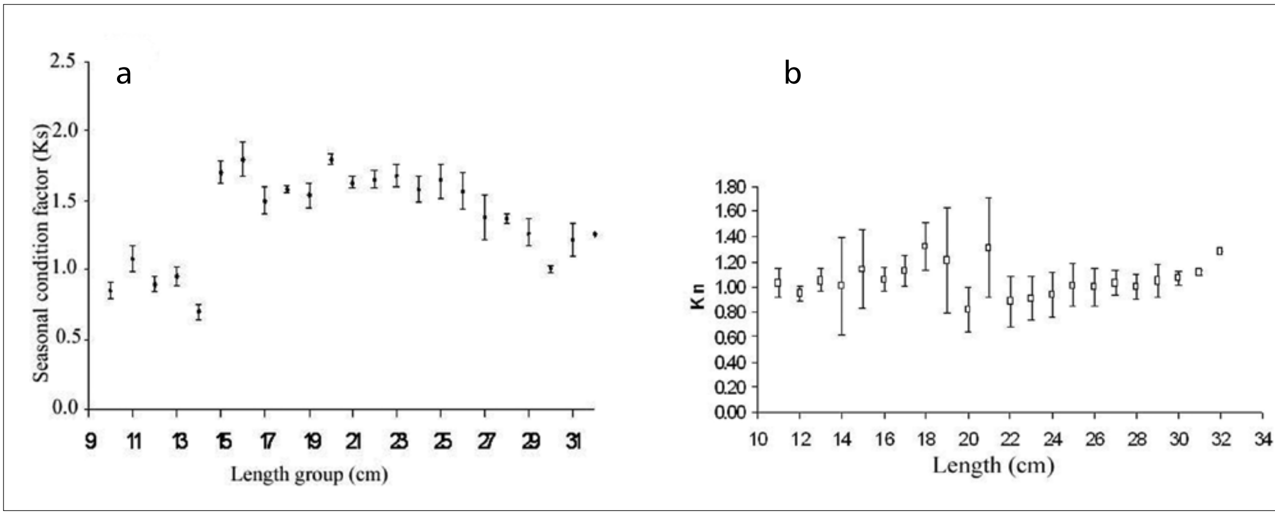

Fig. 1. Variation of condition factors in different size groups of *L. vitta*

be calculated to understand the well being, feeding intensity, maturation and spawning. The present observation revealed that the K_n values of different size groups not differed significantly and been overlapped among various size groups. The near unity in relative condition factor (K_n) among the size groups may also be due to its protracted spawning habit or factors other than spawning (Zacharia and Jayabalan, 2007). However Weatherley (1972) suggested that the seasonal condition factor (K_s) would not yield near unity for all ages of a particular species whereas relative condition factor (K_n) could derive near unity among group of fishes and different population (stock) and with age of a species, which is close propinquity with the present observation.

Seasonal variation of condition factors: Seasonal variation of condition factors of *L. vitta* were analysed to understand the relationship between the condition of fish and maturity by comparing with gonado somatic Index (GSI). The condition factors (K_s and K_n) of female specimens were only considered for comparing with the GSI of similar length group in a year (Fig. 2a-2c). The seasonal variation of K_n during different months indicated (Fig.2a) that *L. vitta* showed parallel trend of K_n with GSI (Fig. 2c), similar observations were reported in other teleosts by Le Cren (1951); Nair *et al.* (1983). Qasim (1957) suggested that the hiking and waning of the condition factor could be probably due to the building up or loss of reserves of the fish.

The K_s showed lower value during peak spawning period (October to December) and an increasing trend during January to August (Fig. 2b), which indicated that the K_s is directly following the energy transfer for gonadal recrudescence and gametogenisis (González & Oyarzún, 2002). Similarly, Nair *et al.* (1983) also reported inverse relation between seasonal

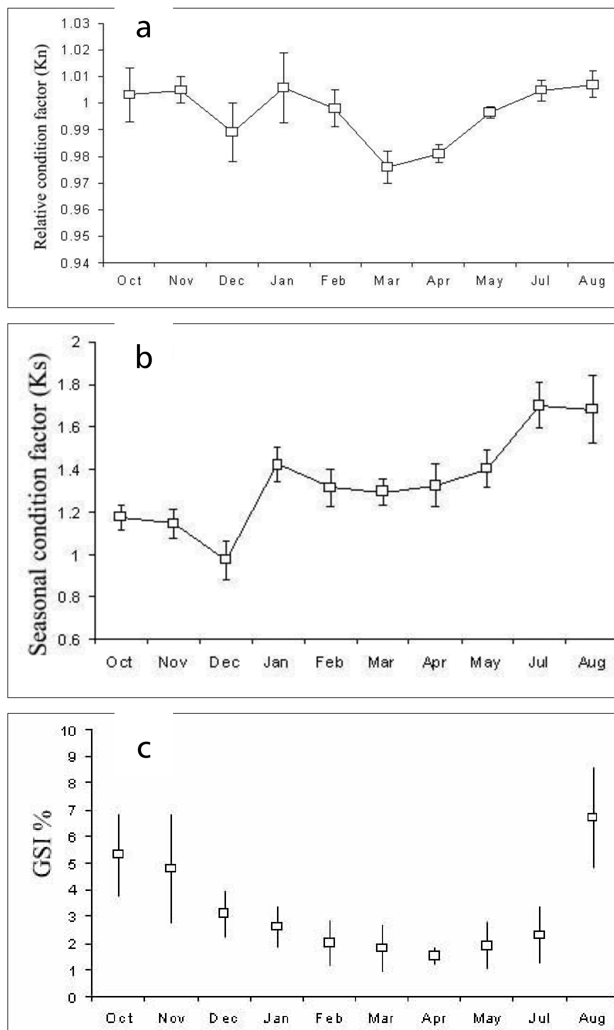

Fig.2. Seasonal variation and relationship of (c) Gonado Somatic Index and condition factors (b-K_s , a-K_n) of *L. vitta.*

condition factor (K_s) and GSI during spawning period in perchlet. Moreover Hickling (1945) found low and high value of K_s before and after spawning, which was further explained by him as due to availability and intake of food during post spawning. Generally the condition factors are negatively correlated to degree of ripening / spawning cycle (Maddock & Burton 1999).

Length at first maturity: Data on mature specimens of smallest length group, which had ripe stage ovaries from August to December, were included for estimating size at first maturity analysis (Fig. 3). The smallest specimen having hydrated oocyte (ripe) was 13.5 cm TL, which occurred during October 2003 and November 2007-08. However the estimated length at first maturity of female *L. vitta* was 14.5 cm whereas it was 15.8 cm in female (Fig. 3). The male specimens of 12 cm size group with fully mature gonad occurred during November (only during 2008 and 2009), whereas this condition continuing up to January in 2001 and December in 2009. As the data were discontinuous, year-wise comparison was not possible. Hence the data during 2001 was updated with that of subsequent year on new length group, which was not available in the previous year. The smallest size at which *L. vitta* attained first maturity was 14.2 cm FL from Australian waters (Davis and West, 1993), which is close to the present observation 15.8 cm TL. However Davis and West (1992, 1993) derived L_{50} for *L. vitta* as 15.2cm (FL), in the present study it was 15.8 cm TL.

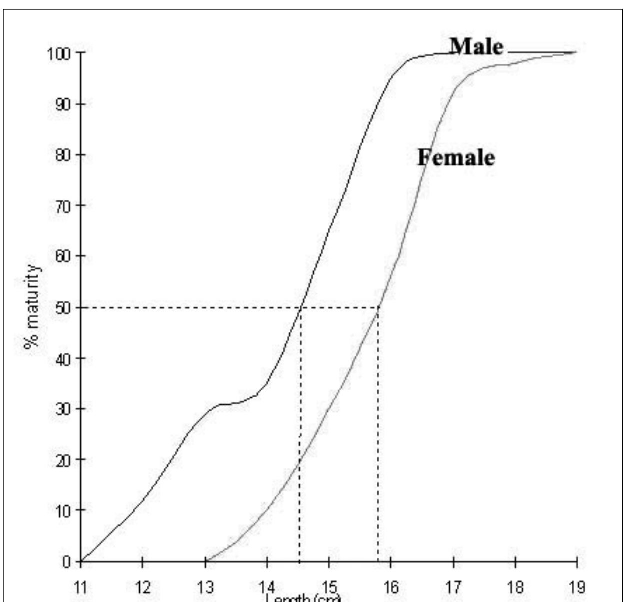

Fig. 3. Length at 50% maturity of *L.vitta*

Spawning and recruitment ground: The mature specimens occurred during September - November with hydrated oocyte, whereas, the post spawners occurred during December in the shallow water (30-40m) along with juvenile (4-6 cm TL) from the area between Lat. 8°40'N to 8°52' and Long. 76°38' to 76°28'E. The juveniles of *L. vitta* have occurred in this area during December along with juveniles of other Lutjanid species (*Pinjalo pinjalo* and *Lutjanus seba*). Analyses of seasonal sex ratio revealed that there was higher proportion of males during spawning season (October - December) than pre-spawning season (Fig. 4). This may indicate that, the males move on to the spawning grounds prior to the females as hypothesized by McKenzie (1940) and Chrzan (1950). The arrival of males prior to female in the spawning area is common among many fish species (Green *et al.*, 1966; Noltie and Keenleyside, 1987; Eckmann, 1991; Ridgway *et al.*, 1991).

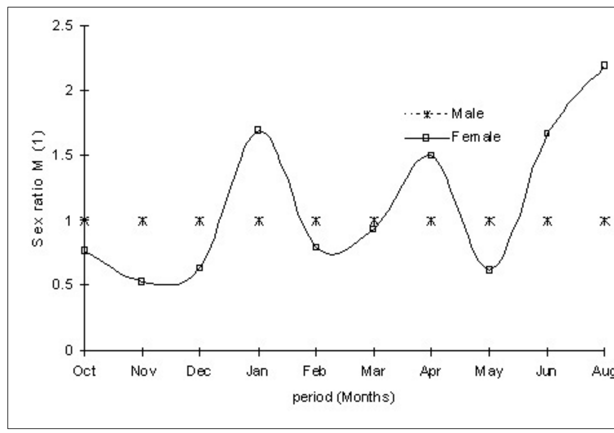

Fig. 4. Seasonal variation of sex ratio of *L.vitta*

Ovarian development: The oocyte development in *L. vitta* based on histological studies is as follows (Fig. 5a-5d).

Early maturing or Perinucleolus stage: This is a primary growth stage; in this stage it does not contain yolk. Ovary transparent, cylindrical, ova small (≤0.08 mm diameter) with visible nucleus.

Maturing: Darker and increases in size; nucleolus appear on the periphery of the nucleus; carticle alviole form circle between nucleus and zona (lumen) (Fig. 5a).

Early nuclear migratory stage: Nucleus migrates out from the center; the volume increases (≤ 0.5mm); fat vesicles occupies center. Small fat vesicle aggregated and form large vesicle (Fig. 5b).

Ripe: Late nucleus migratory stage / hydrated oocyte stage; enlarged oocyte (≤ 0.9mm); nucleus apparent at the periphery

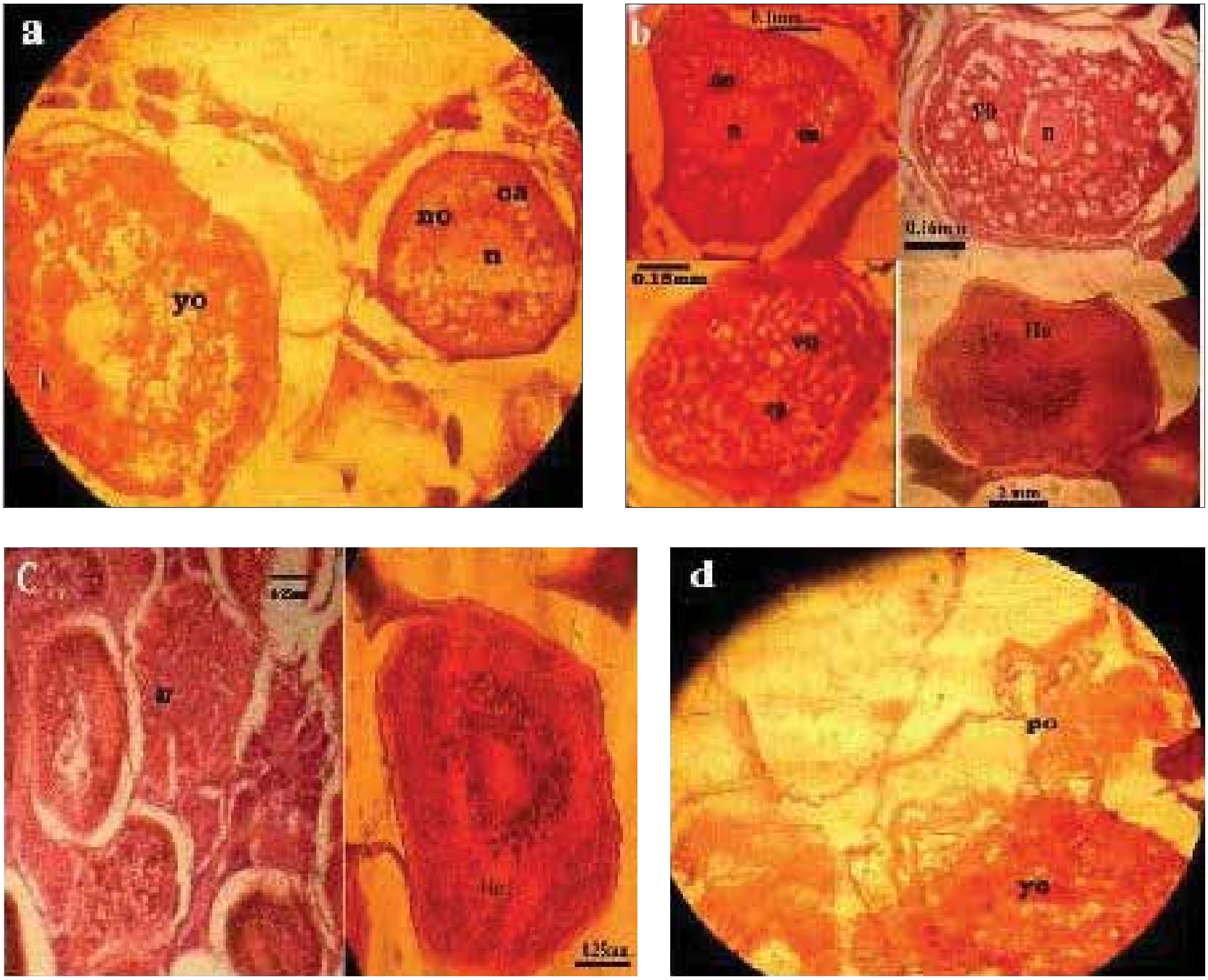

Fig. 5. a-d; Microphotomicrograph of histological section of ovary of L. vitta showing different stages of maturity. ar – atretic oocyte; ca - cartical alveoli; Ho- hydrated oocyte; n- neucleus; no- nucleolus; og- oil globule; po - postovulatary follicle; vo- vitelogenic oocyte;; yo-yolk,

of the oocyte, yolk vesicles coalesce together and form a translucent mass (Fig. 5c).

Spent / partially spent: Early postovulatory follicle appears; the lumen of the follicle collapses (Fig. 5d).

Spawning season: The main spawning season appears to be September - December. However presence of hydrated oocytes upto February indicated that the spawning season is protracted. The mean GSI peaked in August - October and then declined gradually, reaching its lowest value in March (Fig. 2c). There was a marked and significant deference in mean GSI during August - December which shows that spawning strength is not uniform during the spawning period as gonads of individual fish were depleted by successive batch spawning (Davis and West 1993). The pattern of oocyte development is asynchronous and *L. vitta* is a multiple spawner (Davis and West,1993). The number of spawnings cannot be established from modes in the size-frequency distribution of oocyte (Hunter and Goldberg, 1980). However Davis and West (1993) reported that an individual *L. vitta* could spawn nearly 150 times in a year. The present study revealed that the mean ova diameter (MOD) of hydrated eggs are almost equally distributed in the gonad (MOD of anterior part of gonad: 0.645 ± 0.09mm; middle part: 0.631 ± 0.08mm; posterior part: 0.65 ± 0.119mm). However, different stages of ova (0.11mm-0.81mm) were seen in the gonad during the spawning season (Fig. 6). In general during the spawning season male dominance was observed in several fish species (Mc Kenzie 1940; Ridgway *et al.*, 1991; Morgan and Trippel, 1996). In the present observation it is clearly seen that the proportion of male is higher during actively spawning season (October-December) than post spawning and pre-spawning months except during January (Fig. 4).

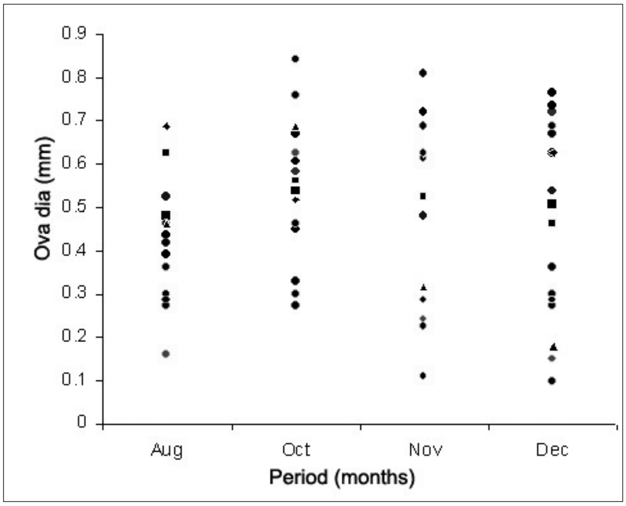

Fig. 6. Seasonal variation of MOD of *L. vitta*

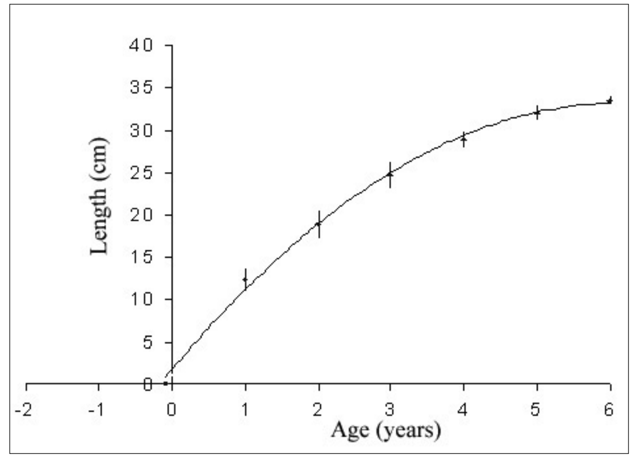

Fig.7. Length at age estimated from the length frequency using Bhattacharya's method

Fecundity: The gonads of ripe *L. vitta* having ripe oocyte collected during October - December were included for fecundity estimates. The fecundity varied between 2,22,016 ± 28,543 and 5,21,482 ± 67,044 eggs per fish. The size-fecundity relationship was linear (r = 0.59 for log length vs fecundity and r = 0.65 for log weight vs fecundity). The highest fecundity (5,616,00 ± 1,29,84) was noticed during October 2008 in a specimen of 31.8cm TL. Davis and West (1993) reported that the (Log) length /fecundity relationship (based on slope value) had not varied significantly with season. In the present study the estimated length fecundity relationship during October to December had not shown much variation.

Population parameters: The von Bertalanffy growth equation was as $L_t = 32.5\ (1-e^{-0.66\ (t\ -\ 0.09)})$ for the year 1999-2000, 31.5 $(1-e^{-0.54\ (t\ -\ 0.024)})$ for the year 2003-04 and $L_t = 33.5\ (1-e^{-0.45\ (t\ -\ 0.014)})$ for the year 2007-08. The length-at-age was estimated using pooled data by Bhattacharya method, which indicated the growth as 12.3±1.36 cm, 18.9± 1.67 cm, 24.72± 1.58 cm, 28.9±.98 cm and 32±0.94 cm in the I, II, III, IV and V year, respectively (Fig. 7). The growth and mortality rates were given in Table 1 for different years. The estimated L for male in the present study was lower than the specimens recorded from Australian waters (42.2 cm). In the present study, sampling was from depth up to 80 m but majority of the samples were collected from zone of ≤ 40 m depth. Davis and West (1992) opined that the distribution of *L. vitta* is up to 120 m depth in Eastern Indian Ocean of Australian coast and larger specimens normally occurred in deeper water.

As a tropical species *L. vitta* is relatively moderate in it's growth (K=0.44 - 0.66 year-1). According to Sparre and Vinema (1993) the fishes with moderate K values are characteristic with moderate natural mortality, whereas it is related to age and size of the fish. K values in the present study is 0.66 year-1 and it's corresponding M value is 1.33, therefore the M/K ratio of *L. vitta* is 2.01. Generally the M/K ratio in fishes falls within the limit of 1.5 -2.5 (Beverton and Holt, 1959) and in the present study M/K ratio is within this limit. However, studies from the Australian waters (Davis and West, 1992) of Indian Ocean revealed that *L. vitta* is slow growing (K= 0.22-0.37) in contrary to this Newman *et al.* (2000) reported higher value (K= 0.85).

The total mortality was estimated from the catch curve (Fig. 8). The fishing mortality (F) was taken by subtraction of M

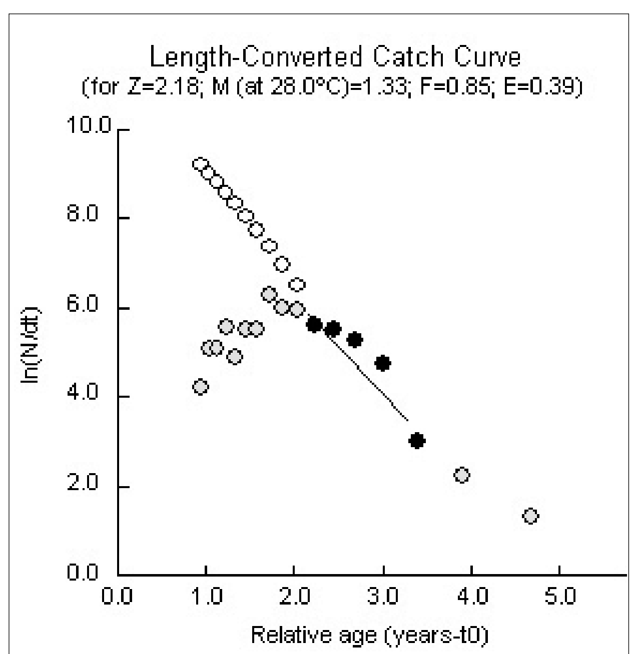

Fig. 8. Length converted Catch curve of *L. vitta*

Table 1. Growth parameters of *L.vitta* during different periods from 1999-2008

Parameters	1999-2000	2003-04	2007-08
N (numbers of specimens)	378	164	114
No. of months sampled	10	7	5
Length range (cm)	12-31	10-30	9-31.8
Weight range (g)	106-372	102-343	98-446
Lmax (cm)	32.55	30.45	33.5
L∞ (cm)	33.5	33.5	33.5
K year-1	0.66	0.54	0.45
Z	2.18	1.75	1.46
F	0.85	0.42	0.13
E	0.39	0.24	0.09
Lc/Lmax	0.69	0.69	0.75
Length at max. F	27	26	26
Lc (50% Length at first capture	22	23	22.6

from Z and it was estimated to be 0.85 whereas M was 1.33 and Z was 2.18. Exploitation ratio (E) was estimated as 0.39 (Table 1). It is suggested that the stock of *L. vitta* in southwest coast is being exploited below the optimum level. The length at first capture (L_c) for selection pattern was 22-23 cm in the basis of gear used in the present study. However, this is likely to change in case of trawler having different mesh size in the code end is used for exploitation.

Acknowledgements

We gratefully acknowledge Dr. K. Vijayakumaran, Director General, Fishery Survey of India, Mumbai for his encouragement. We thank Dr. E. Vivekanandan, Emeritus Scientist, CMFRI, Chennai, for offering valuable suggestions during the preparation of manuscript. The senior author thanks ICAR for financial support.

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