

Studies on length groups and length-weight relationship of puffer fishes (Pisces: Tetraodontidae) in the catches off Visakhapatnam, India

P. Padmavathi, K. Sujatha* & V.A. Iswarya Deepti

Department of Marine Living Resources, Andhra University, Visakhapatnam – 530 003, India

* [E.mail: sujatha.mlr@gmail.com]

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The fishes of family Tetraodontidae were collected from the trawl, trammel net, shore seine and hook and line catches of Visakhapatnam (lat 17°39'N; long 83°14'E) from January 2009 to December 2011. Of the 15 species, a total of 2751 specimens belonging to ten species, regularly represented in the catches of this region, were collected for length frequency distribution and length-weight relationship (LWR) studies. From LWR estimates b value varied from 2.8113 to 3.0223. These studies on length frequency and LWR for *Arothron immaculatus*, *A. stellatus*, *Chelonodon patoca*, *Lagocephalus lagocephalus*, *L. guentheri*, *L. inermis*, *L. lunaris*, *L. sceleratus*, *Takifugu oblongus* and *Torquigener hypselogeneion* has been estimated for the first time from Indian waters.

[**Keywords:** length frequency distribution, LWR, ten species of puffer fish, Vishakhapatnam]

Introduction

The trawl, trammel net catches include over 11% of the economically less important by-catch of finfishes¹. This constitutes not only juveniles of commercially important species and small size fish but also non-edible species like fishes of the order Tetraodontiformes. A detailed study on species composition, length groups represented in the catches and length-weight relationship could enable monitoring short and long term effects of multispecies stock exploitation on overall species potential of this region. Toadfishes are also part of the discarded by-catch in the South East Trawl Fishery (SETF). Tetraodontids are caught by recreational fishers; however they are apparently not targeted. They are also caught by both trawlers and purse-seiners but mostly thrown away as the unwanted by catches back into the sea in near shore waters. This perhaps offers ample and fresh food for puffers helping in thriving of their populations in an unchecked manner. Although tetraodontids are used commercially, basic ecological knowledge of natural populations is usually scarce. More information is required at species level over space and time to formulate methods to reduce trawl by catches.

Family Tetraodontidae includes fifteen species²⁵ belonging to six genera *Arothron* Muller, 1841; *Canthigaster* Swainson, 1839; *Chelonodon* Muller, 1839; *Lagocephalus* Swainson, 1839; *Takifugu* Abe, 1949 and *Torquigener* Whitley, 1930.

Studies on LWR of species of the family Tetraodontidae are very meagre²⁻¹⁵. Few studies were carried out in the species *Chelonodon patoca*, *Lagocephalus laevigatus*, *Arothron stellatus*, *L. sceleratus*, *L. lagocephalus*¹⁵⁻¹⁸. In Indian waters these studies were carried out in the species *L. spadiceus*²⁰⁻²².

The present study contributes to the knowledge of length frequency distribution and LWR of ten species belonging to five genera of puffer fishes of the family Tetraodontidae. These biological parameters have been estimated for the first time from Indian waters for the species *Arothron immaculatus* (Bloch and Schneider, 1801), *A. stellatus* (Bloch & Schneider, 1801), *Chelonodon patoca* (Hamilton, 1822), *Lagocephalus lagocephalus* (Linnaeus, 1758), *L. guentheri* (Ribeiro, 1915), *L. inermis* (Schlegel, 1850), *L. lunaris* (Bloch & Schneider, 1801), *L. sceleratus* (Forster,

1788), *Takifugu oblongus* (Bloch, 1786), *Torquigener hypselogeneion* (Bleeker, 1852).

Material and Methods

The present study is based on random samples collected mainly at Visakhapatnam fisheries harbour, during the period January 2009 to December 2011. Samples are also collected from traditional fish landing centres from the catches of hook & line, shore seine, trammel net and beach seine. Samples of Tetraodontids represented in the trawl by-catches were collected thrice a week as soon as the catches were off loaded. Over a greater part of the year, the mini trawlers (commonly called mechanized boats) do the fishing during the forenoon and in the early part of the afternoon, until about 6 P. M. From the latter half of the November to March, trawling is done at night.

For length frequency distribution and LWR a total of 2751 individuals belonging to ten species of family Tetraodontidae were collected. After identification, total length data were obtained from the fish measured to the nearest millimeter from the tip of mouth to the tip of caudal fin ray and weight measured to nearest gram. For length frequency studies the specimens were grouped to the next 10 mm interval. Data from samples of each month was pooled and percentage length frequency was calculated.

The determination of the relationship between length and weight was based on the pooled data regardless of time of capture, sex and stage of maturity for the species through log-transformed data. LWR was not estimated to the rare species that are represented in the catches of this region.

The relationship between the length and weight of a fish is usually expressed by the equation¹⁰,

$$W = aL^b$$

Where W - body weight (g)
L - total length (mm)
a - coefficient related to body form and
b - exponent

The adherence of the empirical points was analytically demonstrated by calculating the regression coefficient (r^2), which indicates the percentage of deviation from the theoretical straight line. Statistical significance level of r^2 and 95% confidence limits of the parameters a and b were also estimated. Values of the exponent b provide information on fish growth and it may range from 2.5 to 3.5²⁴. When $b=3$,

increase in weight is isometric. When the value of b is other than 3, increase in weight is allometric, (positively allometric if $b>3$, negative allometric if $b<3$)⁶.

Results and Discussion

Family Tetraodontidae is represented by fifteen species in the catches of Visakhapatnam. Studies on length frequency distribution and LWR was carried out only for ten species (Table 1). Other five species are rare in the catches of Visakhapatnam²⁵. In the species *Arothron immaculatus*, *Chelonodon patoca*, *Lagocephalus guentheri* and *Takifugu oblongus* all the length groups are represented in the catches of trawl and traditional gear almost throughout the year. Species *L. inermis*, *L. lunaris* and *L. sceleratus* are represented only in trawl catches and are rare in shore seine catches. *A. stellatus* is common in shore seine catches and rare in trawl catches. *Torquigener hypselogeneion* is rare in trawl by catches and shore seine catches. Specimens of *Lagocephalus lagocephalus* and large sized specimens of *L. inermis*, *L. lunaris*, were caught with hook and line and in surface trolling at 40m to 90m depth region, sometimes even at 110m depth along with skipjack and yellowfin tuna.

Of the ten species monthly length frequency distribution graphs for the species *Chelonodon patoca*, *Lagocephalus guentheri*, *L. lunaris* and *Takifugu oblongus* is given in Fig 1 to 4. The pooled annual length frequency distribution graphs for *Arothron immaculatus*, *L. inermis*, *L. Lagocephalus*, *L. sceleratus* and *Torquigener hypselogeneion* is given in Fig. 5.

For Genus *Arothron*, study is carried out in two species; *A. immaculatus* and *A. stellatus*. In the species *A. immaculatus* all length groups represented in the catches in the month of January to April, July, August, October, November and December. The length range 100-290 represented in the catches in the months of February, March and December and the largest specimen 37.5 cm TL collected in the month of March. *A. stellatus* occurs in the months of February, March, June, August, November and December. The length range 100-470 mm TL represented in the months of June and December. The estimated LWR of *A. immaculatus* ($b= 2.8113$) and *A. stellatus* ($b = 3.0223$) revealed that growth pattern is allometric negative and isometric respectively.

In *Chelonodon patoca* monthly length frequency distribution graph reveals that this

species occurs throughout the year except in the month of May which is the trawl ban period i.e closed season for central east coast of India. Common size represented in the catches in all the months of year is 90-210 mm TL. The length range 60-90 mm TL occurs in the months from March to June and August. The estimated LWR reveals that growth pattern is allometric negative (Table 1).

In the genus *Lagocephalus* present study is carried out in four species *L. guentheri*, *L. inermis*, *L. lagocephalus* and *L. sceleratus*. In *L. guentheri* the size groups 110 to 300 mm TL represented predominately in the catches throughout the year except in May and December. Monthly length frequency distribution graph reveals that specimens less than 100 mm TL occur from February to April, July and October. *L. inermis* occurs in January to March and June to December. Specimens of length range 150-480 mm TL represented in the catches in July, August, November, December.

Specimens measuring below 150 mm TL occur in March, July, August and December. *L. lagocephalus* occurs from February to July, October and November. Specimens of length range 200-300 mm TL occur predominately in the catches. Samples contain oceanic and pelagic specimens that were collected from the

deeper waters off Visakhapatnam from surface waters beyond shelf zone and around 55 nautical miles away from the shores. Only adult specimens (5 female with mature gonad, 24 males with mature testis and one spent) are represented in the hook and line catches along with flying fish (*Cheilopogon cyanopterus*, Gollabhamalu in Telugu). It grows to 73.5 cm TL²⁶. Monthly length frequency distribution graphs of *L. lunaris* reveals that it occurs throughout the year except in May. Specimens of length range 110 to 210 mm TL are predominately represented in the catches and specimens measuring less than 100 mm TL occur in February to April.

L. sceleratus occurs from February to March and July to September. Specimens of length range 50-130 mm TL occur in the months of February and March and those measuring less than 185 mm TL represented in the catches in the month of February.

For LWR the values of constants a and b were estimated from log transformation values of length and weight as Log-4.4906+2.9057 log L in *Lagocephalus inermis*; Log-4.258+2.7025 log L in *L. lagocephalus*; Log-4.3682+2.9010 log L in *L. lunaris*; Log-4.8056+2.9486 log L in *L. sceleratus*. This reveals that the growth pattern in all these four species is allometric negative.

Table 1: Length range and length weight relationship of ten species of the family Tetraodontidae from the catches off Visakhapatnam

Species	n	Length range (cm TL)	Weight range (g)	Log a	W= aL ^b	(r ²) original data	(r ²) log transformed data	Growth Type
<i>Arothron immaculatus</i>	131	11.0-37.5	22-775	-4.263	W=0.00002670L ^{2.8113}	0.84	0.86	Allometric (-)
<i>A. stellatus</i>	26	8.2-57.0	12-4400	-4.6884	W=0.00006404L ^{3.0223}	0.86	0.92	Isometric
<i>Chelonodon patoca</i>	581	6.5-29.0	5-600	-4.2732	W=0.00002895L ^{2.8448}	0.86	0.88	Allometric (-)
<i>Lagocephalus guentheri</i>	937	3.8-37.4	1.2-495	-4.2271	W=0.00002414L ^{2.7595}	0.83	0.94	Allometric (-)
<i>L. inermis</i>	50	10.0-56.5	18-3250	-4.4906	W=0.00003862L ^{2.9057}	0.94	0.99	Allometric (-)
<i>L. lagocephalus</i>	67	20.3-38.0	72-450	-4.258	W=0.00001147L ^{2.7025}	0.82	0.84	Allometric (-)
<i>L. lunaris</i>	552	8.5-28.0	10-464	-4.3682	W=0.00002319L ^{2.9010}	0.85	0.86	Allometric (-)
<i>L. sceleratus</i>	176	3.8-18.5	1.5-64	-4.8056	W=0.00001538L ^{2.9486}	0.85	0.85	Allometric (-)
<i>Takifugu oblongus</i>	175	15.5-34.0	54-780	-4.4793	W=0.00002321L ^{2.9138}	0.83	0.87	Allometric (-)
<i>Torquigener hypselogeneion</i>	56	4.1-13.0	1.2-46	-4.6232	W=0.00001224L ^{2.8961}	0.90	0.90	Allometric (-)

In *Takifugu oblongus* monthly length frequency distribution graph reveals that this species is represented in the catches in all months of the year except in January, May and November. Juvenile specimens represented in the catches from July to October. For LWR the values of constants a and b were estimated from log transformation values of length and weight as $\text{Log-}4.4793+2.9138 \log L$. This reveals that growth pattern is allometric negative.

Torquigener hypselogeneion occurs

February to April, July to October and December. Largest specimen 13.0 cm TL collected in September. Specimens of length range 200-300 mm TL represented in February, March and July to October and those measuring less than 200 mm TL length occur July to October. For LWR the values of constants a and b were estimated from log transformation values of length and weight as $\text{Log-}4.6232+2.8961 \log L$. This reveals that the growth pattern is allometric negative.

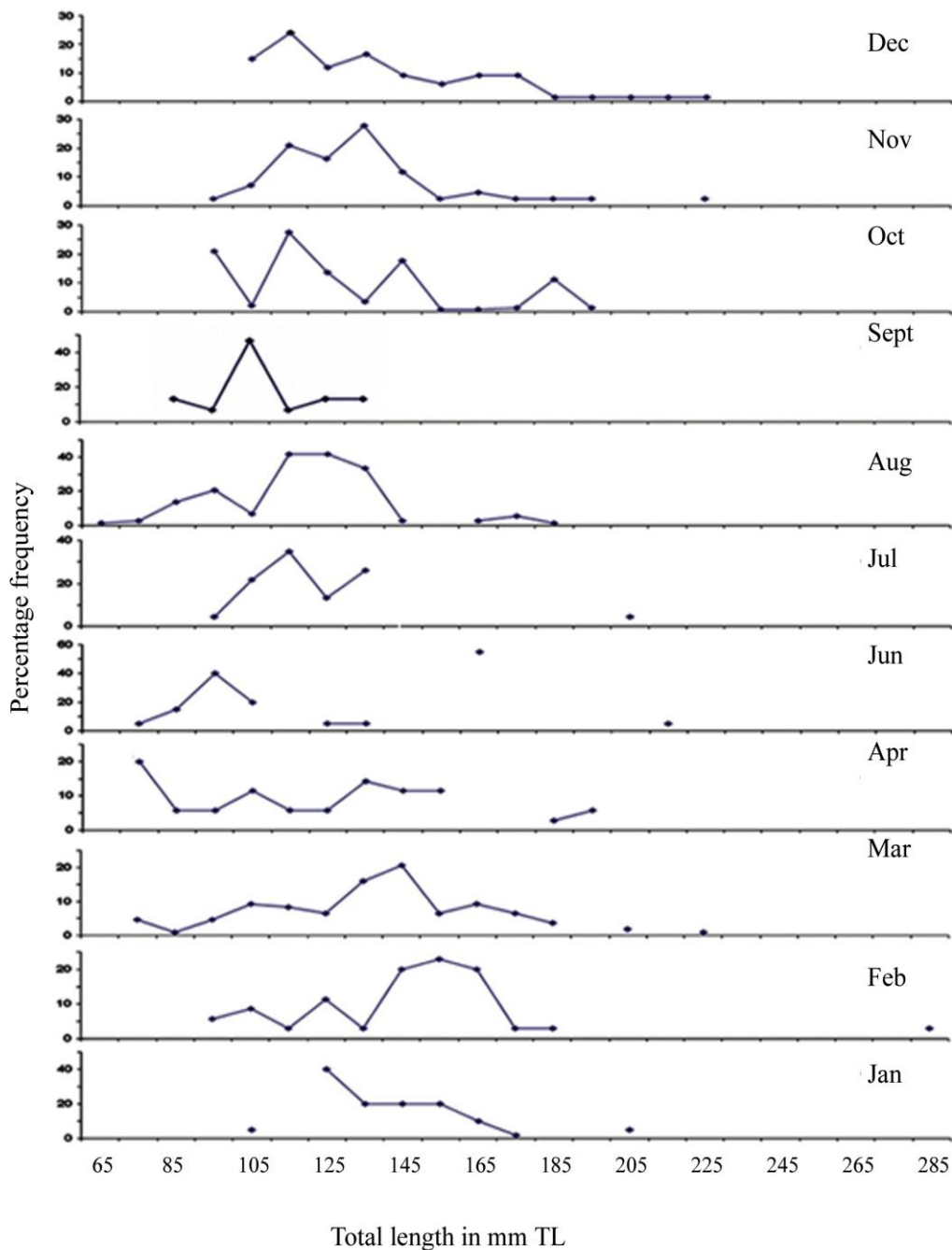


Fig. 1 Monthly length frequency distribution of *Chelodon patoca* represented in the catches of Visakhapatnam

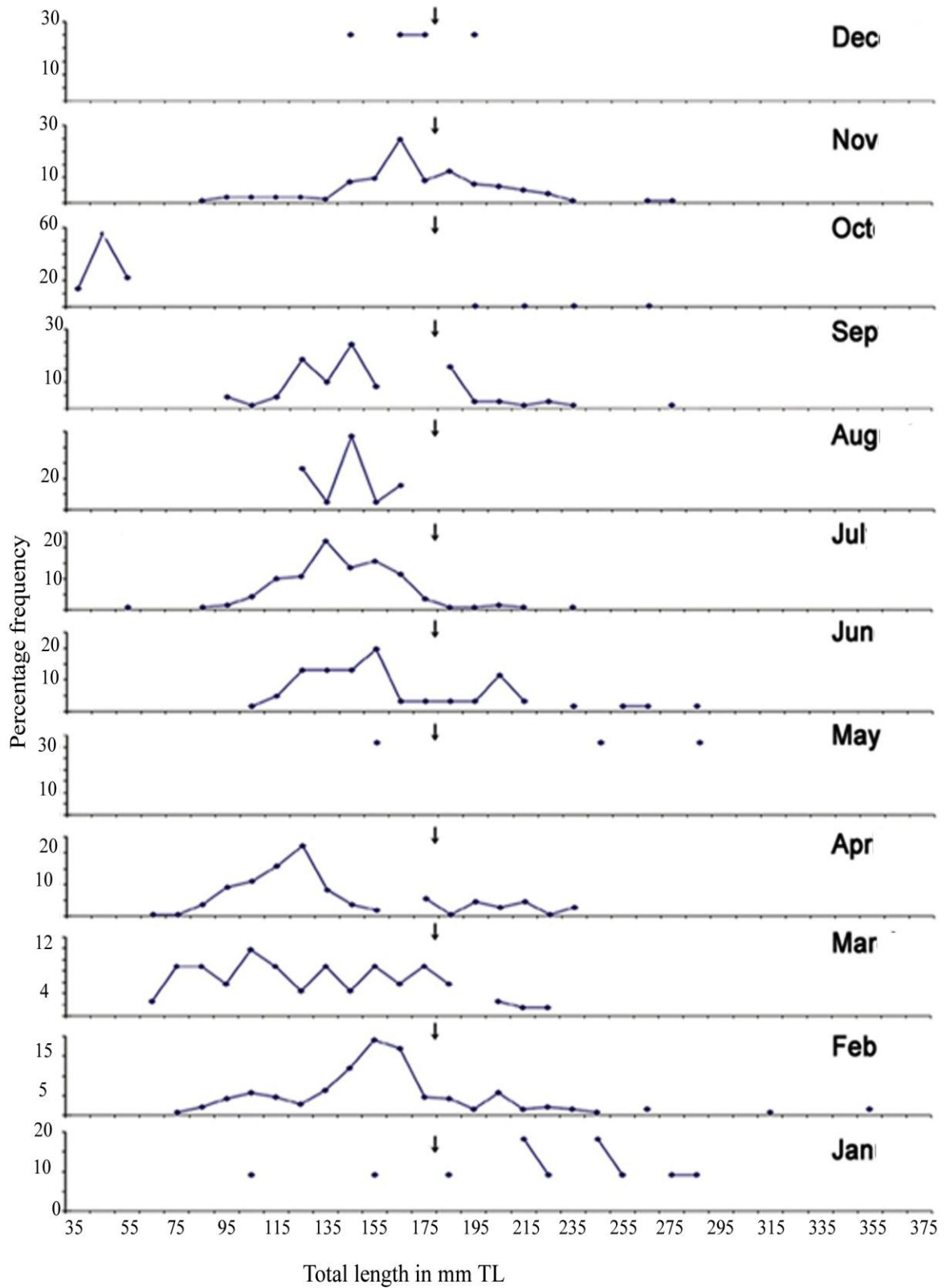


Fig. 2 Monthly length frequency distribution of *Lagocephalus guentheri* represented in the catches of Visakhapatnam

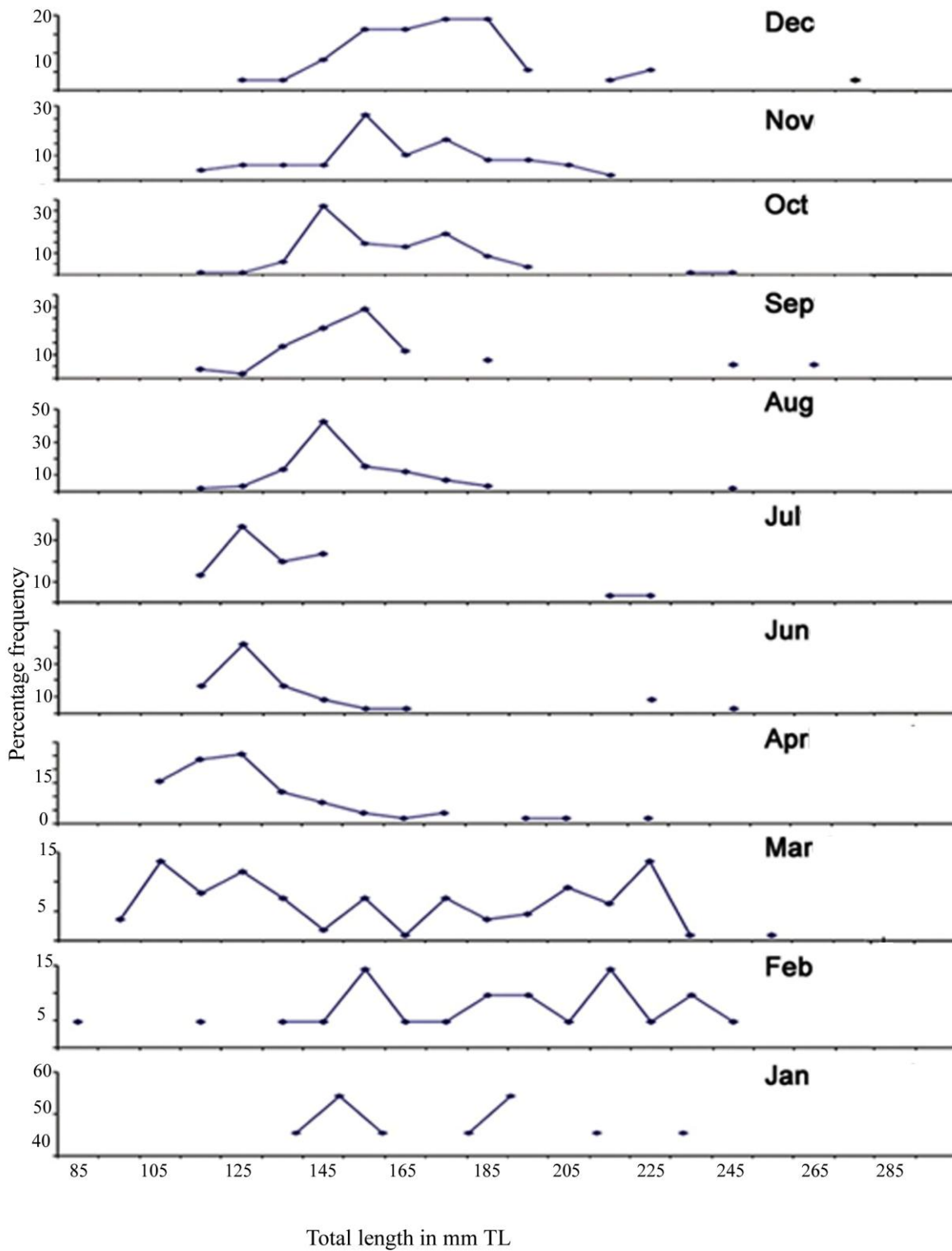


Fig. 3 Monthly length frequency distribution of *Lagocephalus lagocephalus* represented in the catches of Visakhapatnam

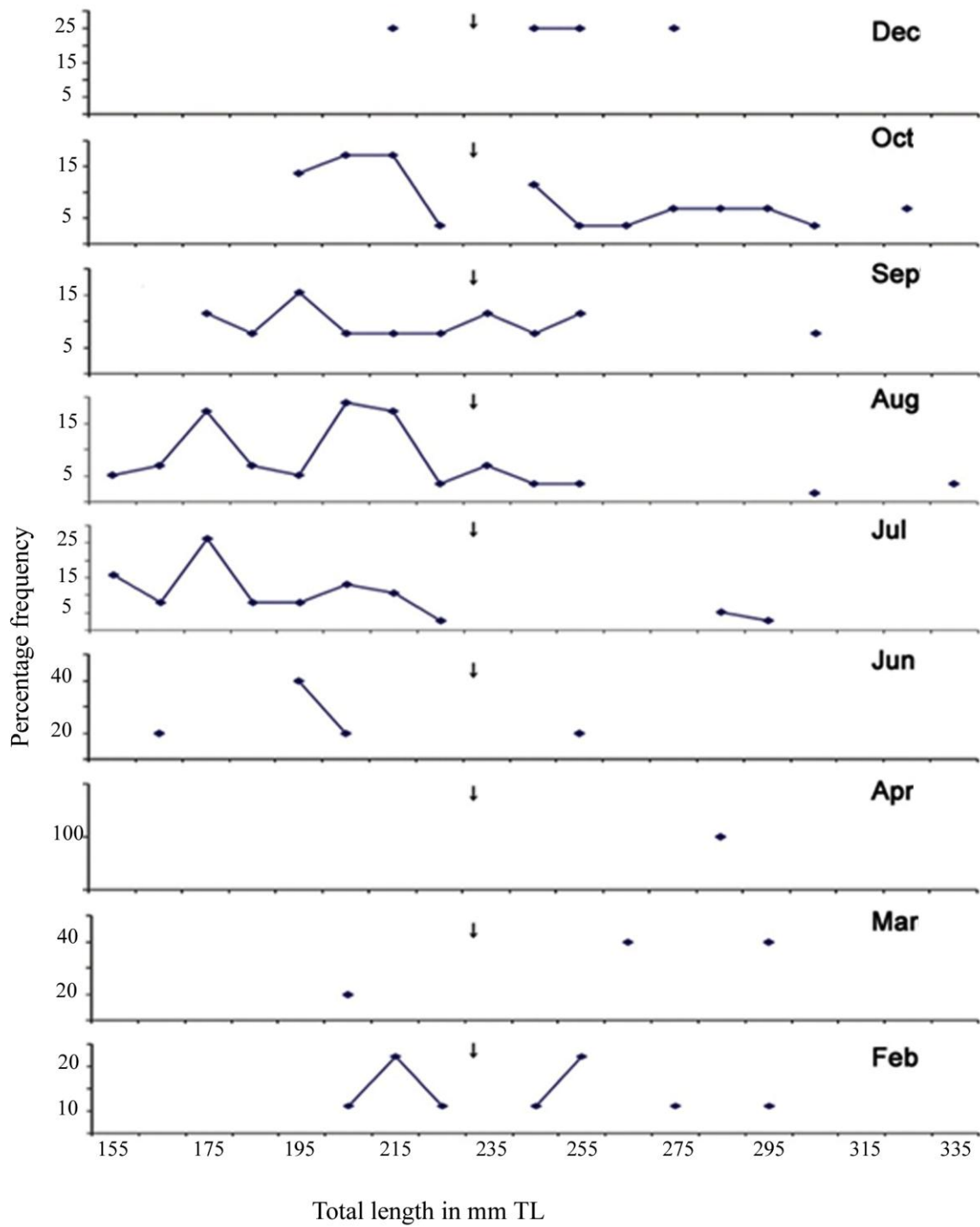


Fig. 4 Length weight relationship of *Takifugu oblongus* represented in the catches of Visakhapatnam

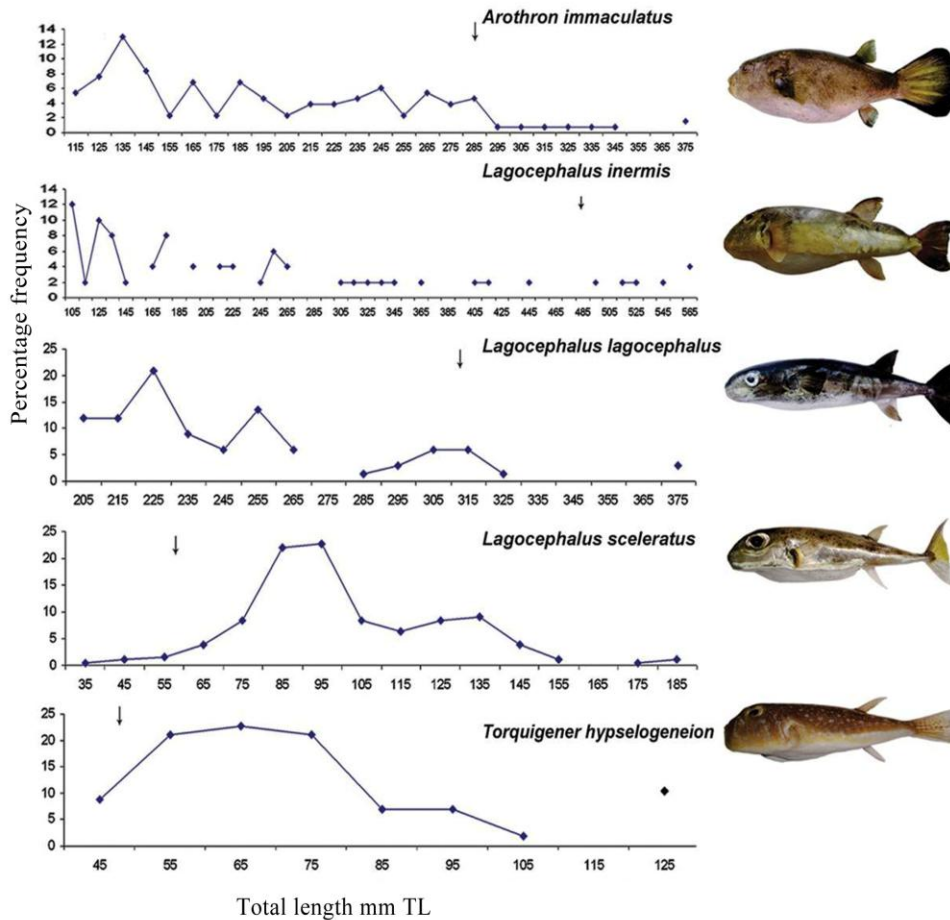


Fig. 5 Pooled annual length frequency distribution of five species of tetraodonts

In the present study ‘b’ values range from 2.7025 (*Lagocephalus lagocephalus*) to 3.0223 (*Arothron stellatus*). The obtained ‘b’ value 3.302 for *L. lagocephalus* by earlier author is higher than estimated in the present study 2.7025⁶. LWR studies in *L. scleratus* from different regions were carried out, the recorded ‘b’ values in pooled samples are 2.924, 2.86, 2.979, 2.893 and in the present study the estimated ‘b’ value 2.9486 is in agreement with the previous authors^{9,27-30}.

According to earlier authors studies on LWR for *Chelonodon patoca* with regression value 2.913 and 2.86 respectively; the ‘b’ value in the present study is 2.8448^{8,30}. The estimated ‘b’ value for *L. inermis* as 2.95 by previous author³¹ is very close to the present study value 2.9057. For *A. immaculatus* ‘b’ value is 2.763 while in the present study it is estimated to be 2.8113³². The ‘b’ value for *A. stellatus* in the present study is 3.0228 which

is higher than the value obtained from New Caledonia, indicate changes in the ecological condition⁹.

The disproportional growth between length and weight can be attributed to environmental factors which inhibit growth³³. Frequency of immature individuals in the population and food availability also influence these LWR parameters and the variations in the regression coefficient may also be related to sex, size and season²⁵⁻²⁶. A comparison with the previous studies revealed that ‘b’ value and regression coefficient exhibit inter and intra specific variations. When comparing LWRs available in the literature, one might find wide variability in parameter estimates for a single species. This is due to the fact that the LWR is greatly affected by many factors related to population variability and to sampling and estimation methods. Sampling related factors include sample size, length

distribution in the sample and type of length measure, while nutritional conditions account for intrinsic biological variability³⁶.

Conclusion

A total of 15 puffer fish species were recorded from this region²⁵. The present study contributes to the knowledge of length groups represented in the catches, length frequency distribution and length weight relationship studies of ten species that are regularly represented in the catches of Visakhapatnam during the period January 2009 to December 2011. These studies were carried out for the first time from Indian waters for *Arothron immaculatus*, *A. stellatus*, *Chelonodon patoca*, *Lagocephalus lagocephalus*, *L. guentheri*, *L. inermis*, *L. lunaris*, *L. sceleratus*, *Takifugu oblongus* and *Torquigener hypselogeneion*.

The species *Chelonodon patoca*, *Lagocephalus guentheri*, *L. lunaris* and *Takifugu oblongus* all the length groups are represented in the catches of trawl and traditional gear almost throughout the year. The specimens of *Lagocephalus lagocephalus* caught with hook and line and in surface trawling at 90-110 m depth along with skipjack and yellowfin tuna.

LWR studies reveal that nine of the ten species showed negative allometric growth and *b* values ranged from 2.7025 to 2.9486. *Arothron stellatus* showed isometric growth and *b* value estimated as 3.0223.

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