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Length-Girth Relationships of Selected Trawl Resources of Cochin Coast, Kerala

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Abstract

Trawling is a major fishing method which contributes significantly to the marine catches of India. Among the many negative impacts that are attributed to trawling, generation of bycatch is the most significant and different technical measures have been adopted world over to reduce bycatch during trawling operations. The optimum mesh size for a technical device is determined by conducting selectivity experiments using different methods, in which length is the main criteria for analysis. However, fish retention in the codend is primarily decided by the girth rather than length, which is often difficult to measure in field and hence length is taken as a proxy for girth. Knowledge of the length-girth relationships of major species would be an additional input for designing gears and deriving an optimum mesh size/shape for trawl codends. The length-girth relationships of 15 commercially important species targeted by trawls along Cochin coast were derived. The results indicated that thirteen of these species had no significant variation in the value of slope, whereas for *Pampus argenteus* and *Trichiurus lepturus,* the values for the slope, differed significantly ($p<0.05$, t-test) indicating that the mesh size requirement would be different for these species. Though estimates did not consider the sex or condition of the fishes studied, the results of the study will be an added input for deriving selectivity estimates.

Keywords: Trawling, fish girth, bycatch, mesh size, codend, selectivity, MLS

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Introduction

Trawling contributes more than 50% of the total marine catches in India. The recent estimates show that there are 35228 trawlers in the country (CMFRI, 2010). Bottom trawling along Indian waters generates about 1.2 million tonnes of discards, which comprises mostly of juveniles (Pramod, 2010) and there are reports that the low value bycatch is increasing in the Indian scenario (Dineshbabu et al., 2013). Kerala with a coastline of 590 km has 3678 trawlers along its coast and contributes significantly to the total marine landings of the state (CMFRI, 2010). The issues related to trawling are highlighted by many studies (Kurup et al., 2003; Bijukumar & Deepthi, 2006; Boopendranath et al., 2012). Occurrence of more than 281 species in the bycatch from shrimp trawlers operating along Central Kerala coast (Gibinkumar et al., 2012). Many BRD's have been field tested in trawls along the Kerala coast and are found to be effective in reducing juvenile fish capture by increasing the length at capture (Boopendranath et al., 2008; Madhu, 2018).

The proportion of different body parts of fish to the total length is an important morphological metric which often relates to the condition of fish and swimming abilities (Wootton, 1999). This also gives important insights into ecological hierarchy of the species in prey-predator relationships (Pauly, 2000). The length and the corresponding girth data can often be important inputs for regulating the mesh sizes of fishing gear used for fish capture (Mendes & Fonseca, 2006). Although, length is the most common metric used for selectivity studies, the shape of the fish is an additional information required for deriving an optimum mesh size for the gear, particularly in a mixed species fishery (Efanov et al., 1987; Matsushita & Rosidi, 1997; Natasume & Matasuishi, 2003). Fish retention in the codend is primarily decided by the girth rather than to length of fish and hence, is the most important metric for selectivity studies (Hunter & Wheeler, 1972). However, relationship between girth and length if derived, will serve as an additional input for deducing an optimum mesh size for gears in a mixed species trawl fishery, because fishes of same length can have different girths and therefore different optimum mesh sizes for conservation (Santos et al., 1995,1998; Matsushita & Rosidi, 1997; Stergion & karpouzi, 2003). The shape and size of the meshes used, will significantly affect the selectivity of codends (Baranov, 1999; Reis & Pawson, 1999) and the mesh size in codend is fixed on the premise that the juveniles get adequate space to wriggle out through the meshes if captured. There are only a few studies that report length-girth relationship of fishes from Indian waters and these are often restricted to the freshwater fish. Hence, the objective of this study was to derive the relationship between the girth and length of fishes targeted by trawls along Cochin coast and relate the results to optimum mesh size stipulated in the fishery.

Material and Methods

Fish samples for girth measurements were collected during the experimental trawling carried out on-board FV Matsyakumari (17.70 m L_{OA}, 325 bhp), along the coastal waters off Cochin, Kerala. Fishing operations were carried out in depths between 10-50 m during January to March 2017. A 24.47 m off-bottom trawl was used for the experimental fishing operation and the samples were collected from a total of 24 hauls. The trawl net used had a 40 mm Square Mesh Panel (SMP) of dimensions 1 m x 1 m, which was fixed on the anterior dorsal of the codend. A cover net (10 mm mesh size and made of PA twine of 1.5 mm Ø thickness) with length of 1.5 m and mouth opening of 1 m x 1 m, was attached to the panel to collect and quantify the escapees from the square mesh panel.

Specimen collected from the total catch, which was approximately 2-5% of the total catch of that species, were kept separately in a rigid container to avoid compression and disfigurement due to activities on the deck. The total length, standard length and the weight of each specimen was measured individually and recorded. The length and weight of each fish was measured to the nearest millimetre and gram respectively. The girth was measured at three different locations on the body of the fish as shown in Fig. 1. A polyamide multifilament (PA) twine was first wound around the predetermined position on fish and the corresponding circumference as noted on the twine was measured using a scale. All the girth measurements were taken perpendicular to the length of the fish body.

Regression analyses were carried out to determine the relationships between the TL and the maximum girth measurements of 14 fish species. Non-metric Multidimensional Analysis (nMDS) was also carried out to depict the shape of the different fishes in the multi-dimensional space. Analysis of covariance was used to test if the slope of the relationships between maximum girth and length of the different species varied.

Results and Discussion

A total of 85 species were retained in the codend

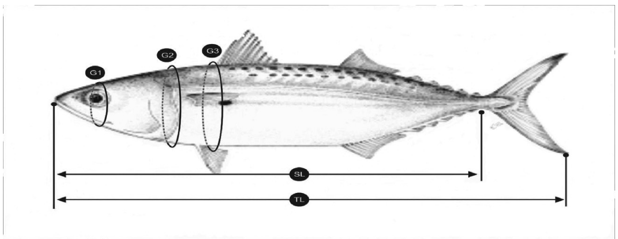

Fig. 1. The locations of measurements taken on the body of fish (G1, G2 and G3)

Table 1. Morphometric measurements of fish with descriptions

Morphometric measures	Descriptions
Total length (TL)	Distance between the anterior most extremity of the body and the posterior most extremity of the body
Girth length 1 (G1)	Circumference around the line that passed through the mid eye
Girth length 2 (G2)	Circumference around the line that passes through the posterior end of the operculum
Girth length 3 (G3)	The region where the fish has the maximum circumference

during the experiments and morphometric measurements of 40 species, that were regularly present in the catches, were made and is given in Table 2. The linear regression lines and regression equations of relationships of the maximum body girth and the total length of 14 commercially important species with enough numbers for representing different length class were only considered for the analysis. The regression coefficients *'a'* and *'b'* along with standard errors of the relationship are given in Table 3. The maximum girth was used to derive the relationship, since this is the most important metric that decides the escapement of fish through the mesh lumen. Maximum girth values ranged from 8.71 to 41.71% of the total length of these species. The average length of fishes that were caught in the trawlnet and that were used for the regression analysis is also shown in the Table 3. The Minimum Legal Size (MLS) for available species as per Mohamed et al. (2014), is also indicated in the table for comparisons. Out of the 15 species considered for the analysis, the MLS for six species were available and among this the average length of *T. lepturus* was significantly lower than the stipulated size for landing legally.

Figures of the maximum girth plotted against the total length for each species are shown in Fig. 3 and 4. The relationship between the girth and length of the commercially important species shows that only three species (*P. argenteus, S. insidiator* and *T. lepturus*) out of the 15 species studied, had significantly different values for the G3 compared to other species. This shows that when a gear is designed, particularly for multi-species fishery, necessary caution, need to be taken to optimize the mesh size, so as to avoid non-targets and a particular size or shape of mesh will not be effective to capture legal sized fishes (Efanov et al., 1987; Millar & Walsh, 1992). The L-G relationships of all the species studied were plotted on to a single graph for ease of interpretation (Fig. 3). No significant changes in the slopes values were noticed for other species, indicating that one optimum mesh size could be considered in the codend to achieve Minimum Legal Size (MLS) restrictions. Whereas this will not work for three species *viz., P. argenteus, S. insidiator* and *T. lepturus* for which the slopes are significantly different. *T. lepturus*, with a slope value of 0.12, may not require a very large mesh size to attain LFM objective, but the morphology of the species will have significant bearing on its escapement. However, *P. argenteus* with the value of slope at 1.09, may need very large mesh sizes to achieve the Length at First Maturity (LFM) length criterion. The nMDS diagram also confirms the difference in the shape for the three species that were identified using the regression test (Fig. 2).

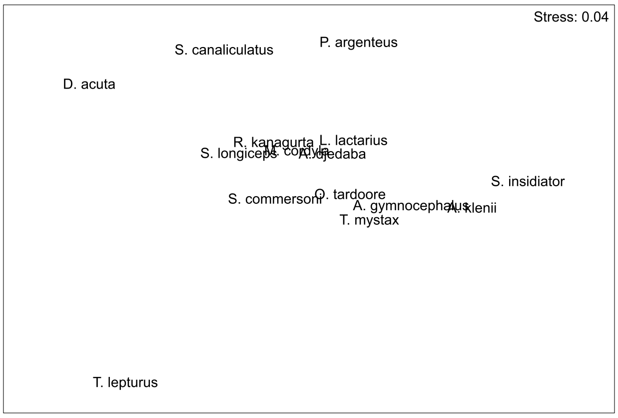

Fig. 2. nMDS plot showing the girths measurements (G3) of different species studied

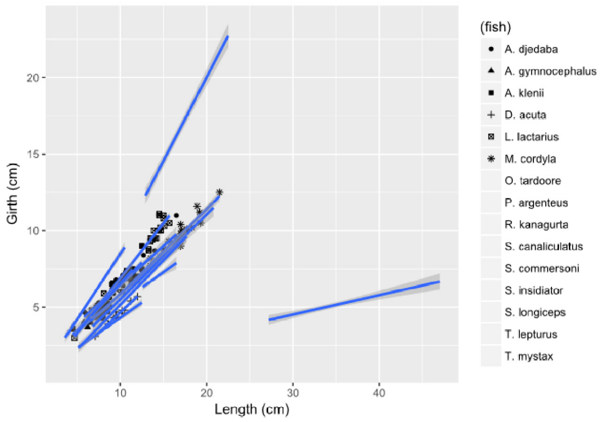

Fig. 3. Length-girth relationship derived for the 15 species. (The variations in the values of slope was compared to 0.5)

Trawl codend selection, however, is a complex process which involves interaction with operational parameters of the trawl and the biological characteristics of the fish that is being targeted. Hence, though it would be possible to determine the most optimum mesh size empirically using girth measurements, extensive field trials using different mesh sizes and shapes would be required to eventually determine the most effective mesh size or shape that can be considered optimum for a fishery. However, length-girth relationship values,

Table 2. The average measurements at three locations (G1, G2 and G3 with standard errors) for the species observed during the experimental trawling operations

SPECIES	G1±SE*	G2±SE*	G3±SE*
Pampus argenteus	9.15±0.43	12.98±0.63	15.59±0.80
Rastrelliger kanagurta	6.17±0.33	7.52±0.42	7.89±0.46
Scomberomorus guttatus	5.71±0.23	6.85±0.29	7.46±0.29
Thryssa dussumieri	3.41±0.26	4.71±0.37	5.32±0.46
Sardinella fimbriata	5.00±0.51	6.46±0.78	7.26±0.64
Esculosa thoracata	3.85±0.07	4.90±0.12	5.63±0.15
Alepes kleinii	5.04±0.11	6.00±0.14	6.38±0.14
Stolephorus indicus	2.67±0.36	3.42±0.71	3.80±0.67
Secutor insidiator	4.56±0.17	5.49±0.17	6.08±0.18
Johnius dussumieri	5.81±0.22	7.1±0.37	7.44±0.34
Trichiurus lepturus	4.81±0.11	5.07±0.15	5.05±0.13
Alepes djedaba	5.22±0.16	6.38±0.21	6.76±0.21
Anodontostoma chacunda	6.12±0.07	8.78±0.12	9.69±0.13
Megalaspsis cordyla	7.10±0.16	9.08±0.22	9.54±0.25
Ambassis gymnocephalus	3.67±0.05	4.38±0.05	4.67±0.06
Thryssa mystax	3.94±0.15	5.49±0.18	6.10±0.20
Scomberoides tol	4.52±0.21	5.77±0.29	6.70±0.29
Nibea maculata	5.52±0.15	6.2±0.20	6.74±0.20
Otolithes cuvieri	5.43±0.59	6.75±0.93	7.3±1.04
Stolephorus commersonni	2.51±0.09	3.15±0.14	3.45±0.17
Opisthopterus tardoore	5.08±0.18	6.15±0.19	6.55±0.21
Thryssa malabarica	4.19±0.17	6.13±0.16	7.04±0.23
Carangoides hedlendensis	7.05±0.23	8.36±0.31	9.05±0.32
Lactarius lactarius	6.12±0.32	7.15±0.41	7.67±0.46
Triacanthus biaculaetus	7.98±1.19	9.78±0.79	9.76±0.68
Dussumieria acuta	3.15±0.14	4.01±0.16	4.4±0.32
Otolithes ruber	6.14±0.34	7.62±0.42	7.94±0.44
Sardinella gibbosa	3.47±0.15	4.27±0.21	5.00±0.27
Sardinella longiceps	5.32±0.07	6.51±0.07	6.86±0.10
Johnius borneersis	5.9±0.51	7.56±0.58	7.56±0.58
Johnius amblycephalus	6.88±0.40	8.88±0.74	9.28±0.73
Nemipterus japonicus	6.62±0.24	7.97±0.26	8.75±0.25
Thryssa kammalensis	4.33±0.46	6.06±0.63	6.73±0.54
Siganus canaliculatus	4.47±0.14	5.04±0.20	5.24±0.23
Sphyraena jello	4.47±0.23	5.26±0.33	5.98±0.45
Scomberomorus commerson	6.47±0.16	7.88±0.27	8.45±0.26
Mene maculata	11.83±0.64	12.28±0.68	12.13±0.70
Leiognathus equulus	4.77±0.06	5.76±0.07	6.25±0.07
Gaza minuta	4.57±0.22	5.2±0.18	5.37±0.23
Parastromateus niger	8.4±0.22	11.15±0.37	11.7±0.43

*standard error of mean

Table 3. The regression parameters with standard errors of the relationship between length and girth (G3) of 15 commercially important trawl resources

Species	*a*	SE of *a*	*b*	SE of *b*	r^2	Avg. Len. (cm)	MLS
Lactarius lactarius	-0.235	0.205	0.716	0.017	0.983	9.8	10 TL
Trichiurus lepturus	0.838	0.626	0.124	0.018	0.597	32.9	46 TL
Dussumieria acuta	-0.625	0.319	0.529	0.032	0.967	9.4	
Rastrelliger kanagurta	-0.348	0.187	0.569	0.012	0.989	13.1	14 TL
Alepes kleinii	0.559	0.372	0.588	0.036	0.828	9.9	
Secutor insidiator	-0.069	0.306	0.856	0.042	0.877	6.5	
Alepes djedaba	1.841	0.352	0.462	0.032	0.877	10.7	
Megalaspsis cordyla	0.275	0.511	0.556	0.031	0.933	17.3	19 TL
Ambassis gymnocephalus	1.116	0.352	0.461	0.045	0.704	7.9	
Thryssa mystax	-0.663	0.289	0.581	0.025	0.926	11.5	
Stolephorus commersonnii	0.348	0.204	0.396	0.025	0.895	7.1	
Opisthopterus tardoore	0.794	0.473	0.506	0.041	0.812	10.7	
Siganus canaliculatus	0.284	0.533	0.627	0.068	0.864	7.6	
Sardinella longiceps	1.257	1.028	0.401	0.073	0.587	13.9	10 TL
Pampus argenteus	1.800	0.866	1.090	0.052	0.954	16.7	13 TL

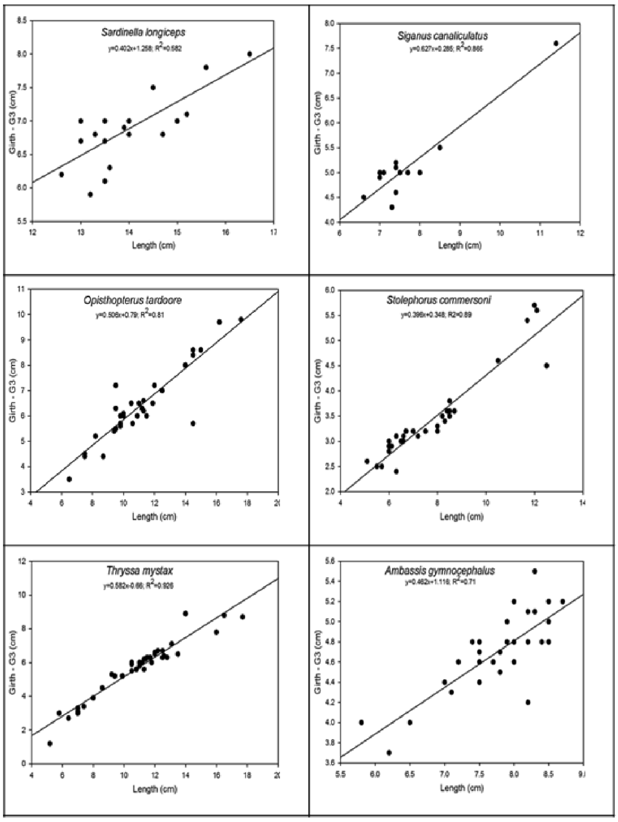

Fig. 3. Length-girth relationship of *S. longiceps, S. canaliculatus, O. tardoore, S. commersoni, T. mystax* and *A. gymnocephalus*. The relationship equations are also shown in the respective figure

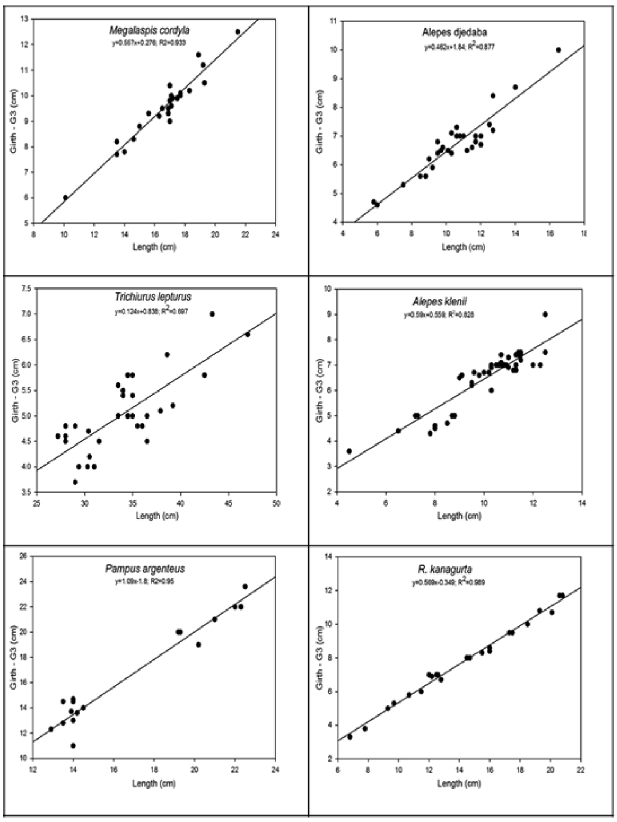

Fig. 4. Length-girth relationship of *M. cordyla, A. djedaba, T. lepturus, A. kleinii, P. argenteus,* and *R. kanagurta*. The equations for the relationship are also shown in the figure

can work as an initial seed, to begin with, which would considerably reduce operational cost for field tests.

The relationships between the length and girth derived for 15 commercially important species showed that values of the slope of regression equation (b), taken as a proxy for body shape varied considerably for three species, from the rest. All the other species formed a single cluster, which indicated that a common mesh size would suffice to meet the biological criteria on which the length of capture if fixed, for example the LFM. The results will be an important input for designing gears and can complement the escapement data generated from selectivity studies for deriving optimum mesh size for codend in a multi-species trawl fishery. Variations in the estimates of the regression parameters are expected, if classification and analysis were carried out taking the sex and condition of fish into account. But this study did not differentiate between sexes nor the biological condition of fish, so the results may be applicable only for the length classes studied without any classifications.

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