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A comparative study on morphometric and meristic characters of *Nemipterus japonicus* (Bloch, 1791) in the coasts of India

Edwin Prabakaran T.[1]; Jeyasingh Thompson R. [2*]; Deepak Samuel V.[3]

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Abstract

A total of 200 threadfin bream *Nemipterus japonicus* was collected from Chennai in the east coast and Kochi in the west coast during January to February 2013 and studied for their morphometric and meristic characters. In total, 21 characters were analyzed out of which 3 characters namely dorsal, ventral and anal fins were not considered since they were unaltered. The findings indicate that 91% of the total variation in the data can be accounted for by three clusters. Small values of 1-R**2 ratio for the three clusters obtained indicate good clustering. The small values of p ($\leq$0.0001) indicate that there are significant differences in the variables of Chennai and Kochi data which are shown through MANOVA. This might depict that the fish of Chennai and Kochi might be of 2 different stocks. Moreover, the study has also aided in identifying the importance of regular monitoring of stock assessment and the biology of commercially important fishes.

Keywords: *Nemipterus japonicus*, Threadfin bream, Biometric study, Coastal area, India, Morphometric, Meristic characters

1- Department of Statistics, Loyola College, Chennai-600034
2- Deptment of Statistics, Madras Christian College, Chennai-600059.
3- UNDP, Gulf of Mannar Biosphere Reserve Trust, JawanBhavan, Ist Floor, Devipattinam Road, Kenikarai, Ramanathapuram, Tamilnadu, 623 501 India
*Corresponding author's Email: jeyasinghthompson.r@gmail.com

Introduction

The Japanese threadfin bream *Nemipterus japonicus* (Nemipteridae) constitutes an important group of commercial fishes in India. About 20 *Nemipterus* species have been recorded by Weber and Beaufort (1936), out of which 10 species have been well recognized from Indian coastal waters as reported in Somashekar (2013), *viz. Nemipterus marginatus* (Cauvier, Valenciennnes), *N. hexodon* (QuoyandGailard), *N. leteus* (Schneider, 1801), *N. japonicus* (Bloch, 1791), *N. mesoprion* (Bleeker, 1853), *N. tolu* (Valenciennes), *N.delagoae*(Smith, 1941), *N. metopias* (Bleeker, 1852), *N. bleekeri* (Day, 1875) and *N. nematophorus* (Bleeker, 1853). Satyanarayanan *et al.* (1972) reported that threadfin breams were abundant in the ocean area beyond 200 m depth. Threadfin breams are sub-demersal in nature and are observed to move in schools with distribution from the Mediterranean Sea to the Indo-west Pacific (Russel, 1990). In the Indian coast, *N. japonicus* is caught maximum numbers during the south-west monsoon season, particularly in the west coast of India. The catch is abundant in the coastal regions of Kerala and usually the catch rate shoots up during the monsoon period. Substantial research work has been carried out on the family of *N. japonicus* in terms of their stock assessment, biology and a few reports exist on the length-weight relationships too. A useful report regarding the catch, effort and biology from Cochin (Kochi now) are available (Vinci, 1983; Nair and Jayaprakash, 1986; John, 1989; Murty *et al.*, 1992). Further, there is a research report on biology, and population dynamics from the Vishakhapatnam coast (Rajkumar *et al.* 2003).A study on the differential growth rate was also recently investigated (Joshi, 2010) while, a study on the age determination and feeding habits of this species from the Northern Oman Sea has been carried out of late by Afshari *et al.* (2013).

An attempt to study the meristic and morphometric characteristics of *N. japonicus* in two locations from the east and west coasts of India is carried out in the present research. The aim is to understand whether the two locations namely Chennai and Kochi in India had significant differences in the population. This study is a means of assenting analysis by which we either confirm or fail to confirm the research hypothesis (i.e. our prior expectation) that *N. japonicus* fish at Chennai and Kochi do not differ significantly in their meristic and morphometric characteristics.

Materials and methods

A sample of size n=200 fish belonging to the threadfin bream species was collected from two different states, namely Tamil Nadu (Chennai, Kasimedu - 13° 7'32.82"N; 80°17'49.64"E) and Kerala (Kochi - 9°58'8.52"N; 76°14'52.57"E) (Fig.1).

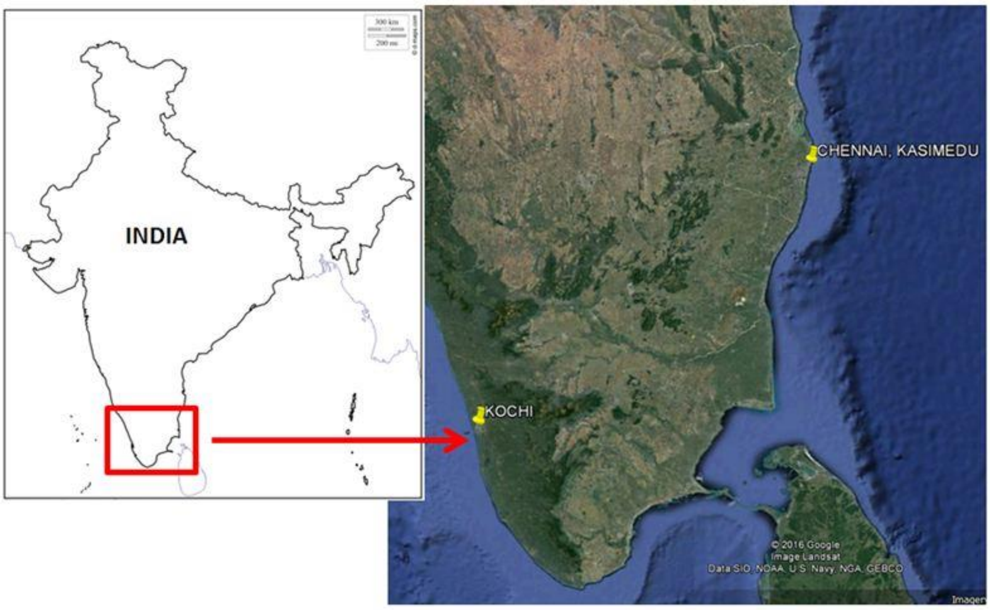

Figure 1: Map of study areas Chennai (east coast) Kochi (west coast).

100 specimens from each of the sites were collected from trawl nets and analyzed during the period of January - February 2013. The information was collected regarding the morphometric and meristic characters. Due to the vastness of the population, we decided to select a sample from the population. A total of 21 variables which comprises 5 meristic and 16 morphometric characters were analyzed. As we found that the counts for 3 variables namely dorsal fin (DF), anal fin (AF) and ventral fin (VF) were unaltered for fish of both coasts, we considered only 18 variables (Table 1) for the statistical analysis. By using variable clustering of the statistical analysis system (SAS), it was found that the 3 variables namely total weight (TW), pectoral fin (PF) and caudal fin (CF) did not form a linear combination. Hence, we could not include these 3 variables for our study. Therefore, we have taken only 15 variables for our analysis. Further, 7 fish out of 200 fish sampled were found to be outliers using the measure of dispersion. Omitting outliers resulted in data reduction. Hence, only a sample of 193 specimens was considered.

We use variable clustering procedure to divide a set of variables into non-overlapping clusters in such a way that each cluster is a linear combination of variables. Thus, each cluster can essentially be interpreted as uni-dimensional cluster of variables. For each cluster, PROC VARCLUS computes the first principal component and the centroid component and, tries to maximize the sum across clusters of the variation accounted for by the cluster components. PROC VARCLUS was used to divide the variables into 3 clusters and each cluster was treated as a subtest, with the subtest scores given by the cluster components.

Table1: The variables considered for analysis.

No.	Variable	Description
1	SL	Snout length
2	ED	Eye diameter
3	POL	Post orbital length
4	PDL	Pre dorsal length
5	PPD	Pre pelvic distance
6	WDF	Width of dorsal fin
7	HL	Head length
8	BD	Body depth
9	STL	Standard length
10	FL	Fin length
11	TL	Total length
12	CPL	Caudal peduncle length
13	PDL1	Post dorsal length
14	TW	Total weight
15	PF	Pectoral fin
16	CF	Caudal fin
17	DFL^{min}	Dorsal fin spine minimum
18	DFL^{max}	Dorsal fin spine maximum
19	DF	Dorsal fin
20	AF	Anal fin
21	VF	Ventral fin

The Data set created by SAS programming of PROC VARCLUS displays the output of clusters (SAS, 2014).

Proper selection of the sample is highly necessary for the significance of the results of the data analysis. If not, the results will be unpredictable and possibly biased. We have considered the selection of sample on the basis of convenience sampling method on both the coastal regions during the same period of time and we measured the morphometric and meristic characters with a digital vernier caliper up to 1 mm accuracy and weighed with a digital balance up to the nearest 0.1g. For the analysis, we have used PROC VARCLUS, MANOVA, Correlation and descriptive statistics.

Results

The Japanese threadfin bream collected from Chennai and Kochi was tested with cluster variation for morphometric and meristic characters. For each cluster, Table 2 displays the number of variables in the cluster, the cluster variation, the total explained variation and the proportion of the total variance explained by the variables in the cluster. The column labeled “Variation Explained” in this table provides the sum of the explained variation over all clusters. The final ‘Proportion’ represents the total explained variation divided by the sum of cluster variation. This value, 0.9052, indicates that about 91% of the total variation in the data can be accounted for by the three clusters. Tables 2 and 3 display how the variables are clustered.

Table 2: Cluster summary for 3 clusters by oblique centroid component analysis variation among meristic and morphometric characters (Chennai and Kochi, 2013).

Oblique centroid component cluster analysis cluster summary for 3 clusters					
Cluster	**Members**	**Cluster variation**	**Variation explained**	**Proportion explained**	**Second eigenvalue**
1	5	5	4.509411	0.9019	0.2738
2	8	8	7.277176	0.9096	0.4180
3	2	2	1.790684	0.8953	0.2093

Total variation explained=13.57727, Proportion=0.9052

Table 3: Cluster analysis of meristic and morphometric characters (Chennai and Kochi, 2013).

3 Clusters		R^2 with		1-R**2 ratio
Cluster	**Variable**	**Own cluster**	**Next closest**	
Cluster 1	HL	0.9511	0.8738	0.3872
	TL	0.9127	0.8948	0.8295
	DFL^{min}	0.7854	0.5149	0.4423
	DLF^{max}	0.9281	0.7227	0.2592
	POL	0.9320	0.7451	0.2666
Cluster 2	SL	0.9281	0.7600	0.2997
	STL	0.9851	0.8120	0.0794
	FL	0.9747	0.8888	0.2275
	BD	0.9142	0.7445	0.3359
	ED	0.6223	0.4684	0.7106
	PDL	0.9332	0.8636	0.4902
	PPD	0.9577	0.7900	0.2013
	WDF	0.9620	0.7831	0.1753
Cluster 3	CPL	0.8953	0.6613	0.3090
	PDL1	0.8953	0.6066	0.2660

The clusters are represented in the form of a dendrogram in Fig. 2.

Table3 displays the R^2 value of each variable with its own. The R^2 value for a variable with the nearest cluster should be low if the clusters are well separated. The last column displays the1-R^{**}2ratio for each variable. Small values of this ratio indicate good clustering. Those small values that indicate significant difference in the variables among Chennai and Kochi data are shown through MANOVA. The multivariate ANOVA is simply an ANOVA with several dependent variables. That is, the ANOVA tests for the difference in means between two or more groups, while MANOVA tests for the difference in two or more *vectors* of means. In Generalized Linear Model (GLM) procedure all univariate statistics (ANOVA) show that majority of all morphometric measurements are significantly different for the investigated fish of Chennai and Kochi (p<0.0001). Hence Chennai and Kochi have significantly a different stock of *N. japonicus* fish from the variables studied (Table 4).

Other statistics can be calculated in addition to Wilks' λ. The following is a short list of some of the popularly reported test statistics for MANOVA:

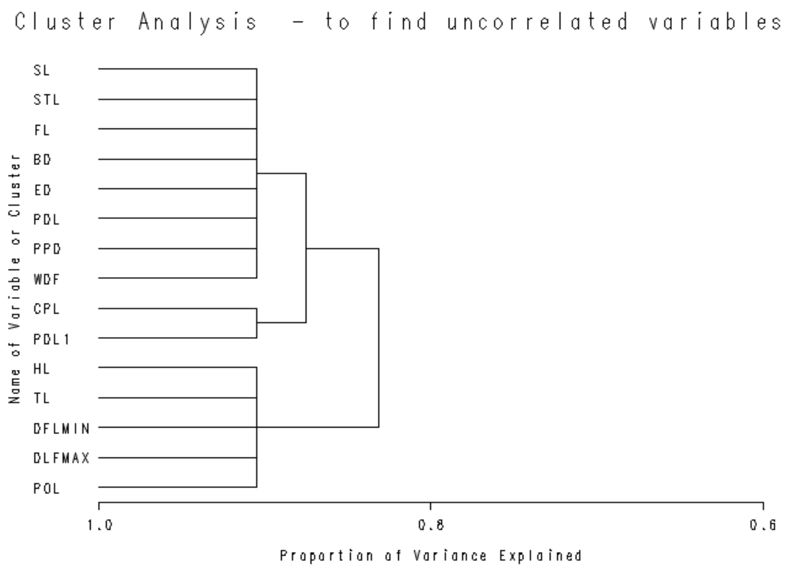

Figure 2: Cluster dendrogram for *Nemipterus japonicus* using morphometric and meristic variables (Chennai and Kochi, 2013).

Table 4: MANOVA test for meristic and morphometric characters (Chennai and Kochi, 2013).

MANOVA test criteria and exact F statistics for the typothesis of no overall sample effect H = Type III SSCP matrix for sample; E=Error SSCP matrix; S=1 M=6.5 N=87.5					
Statistic	**Value**	**F value**	**Num DF**	**Den DF**	**Pr>F**
Wilks' Lambda	0.05425894	205.68	15	177	<.0001
Pillai's Trace	0.94574106	205.68	15	177	<.0001
Hotelling-Lawley Trace	17.43014129	205.68	15	177	<.0001
Roy's Greatest Root	17.43014129	205.68	15	177	<.0001

- Wilks' λ=pooled ratio of error variances to effect variance plus error variance.

This is the most commonly reported test statistic, but not always the best choice.

Gives an exact F-statistic.

- Hotelling's trace=pooled ratio of effect variance to error variance.
- Roy's Greatest root (also called Roy's Largest root)=$Max_i(\lambda_i)$.
- Pillai's trace=trace$[H(H+E)^{-1}]$

Some statisticians consider it to be the mostpowerful and most robust of the four statistics namely Wilks' Lambda, Pillai's Trace, Hotelling-Lawley Trace and Roy's Greatest Root.

From Table 4, all tests indicate that there are significant differences in morphometric and meristic characters of *N. japonicus*observed at Kochi and Chennai.

We observed from the pooled correlation coefficients for Chennai as well as for Kochi (asgiven in Table 5) that there is better association among the variables. Due to an increase in total length (TL), other variables proportionately increase. From the descriptive statistics, we found that Kochi has greater differences in the majority of the morphometric and meristic variables in comparison to Chennai as seen in the Table6.

Table 5: Pooled correlation co-efficient of morphometric and meristic variables (Chennai and Kochi, 2013).

	Correlations														
	SL	HL	STL	FL	TL	BD	CPL	DFL MIN	DLF MAX	ED	PDL	PDL1	POL	PPD	WDF
SL	1.000	0.905	0.952	0.947	0.900	0.908	0.755	0.671	0.814	0.705	0.925	0.757	0.840	0.954	0.933
HL	0.905	1.000	0.925	0.960	0.948	0.847	0.702	0.796	0.917	0.712	0.944	0.609	0.961	0.917	0.901
STL	0.952	0.925	1.000	0.988	0.944	0.951	0.831	0.707	0.844	0.765	0.950	0.796	0.849	0.966	0.982
FL	0.947	0.960	0.988	1.000	0.962	0.931	0.791	0.757	0.887	0.744	0.964	0.736	0.902	0.964	0.971
TL	0.900	0.948	0.944	0.962	1.000	0.886	0.752	0.786	0.895	0.708	0.938	0.669	0.900	0.927	0.930
BD	0.908	0.847	0.951	0.931	0.886	1.000	0.822	0.622	0.759	0.706	0.903	0.811	0.759	0.931	0.942
CPL	0.755	0.702	0.831	0.791	0.752	0.822	1.000	0.524	0.618	0.636	0.772	0.791	0.600	0.780	0.805
DFLMIN	0.671	0.796	0.707	0.757	0.786	0.622	0.524	1.000	0.842	0.572	0.753	0.368	0.799	0.681	0.700
DLFMAX	0.814	0.917	0.844	0.887	0.895	0.759	0.618	0.842	1.000	0.623	0.872	0.503	0.916	0.830	0.833
ED	0.705	0.712	0.765	0.744	0.708	0.706	0.636	0.572	0.623	1.000	0.705	0.573	0.630	0.710	0.742
PDL	0.925	0.944	0.950	0.964	0.938	0.903	0.772	0.753	0.872	0.705	1.000	0.707	0.897	0.960	0.937
PDL1	0.757	0.609	0.796	0.736	0.669	0.811	0.791	0.368	0.503	0.573	0.707	1.000	0.502	0.760	0.782
POL	0.840	0.961	0.849	0.902	0.900	0.759	0.600	0.799	0.916	0.630	0.897	0.502	1.000	0.855	0.829
PPD	0.954	0.917	0.966	0.964	0.927	0.931	0.780	0.681	0.830	0.710	0.960	0.760	0.855	1.000	0.954
WDF	0.933	0.901	0.982	0.971	0.930	0.942	0.805	0.700	0.833	0.742	0.937	0.782	0.829	0.954	1.000

Table 6: Descriptive statistics for meristic and morphometric characters (Chennai and Kochi, 2013).

S. No	Sample	Var_name	Min	Mean	Median	P90	P95	P99	Max	Var	StdDev	Skew	Range
1	Chennai	BD	2.8	4.0871	3.80	5.30	5.60	6.80	6.8	0.663	0.8142	1.11697	4.0
2	Kochi	BD	4.1	5.0900	5.10	5.65	5.70	5.90	6.0	0.165	0.4056	-0.12434	1.9
3	Chennai	CPL	1.0	2.0204	1.90	2.50	2.80	3.20	3.2	0.139	0.3732	1.01350	2.2
4	Kochi	CPL	1.7	2.3320	2.30	2.70	2.70	2.90	2.9	0.057	0.2382	-0.02331	1.2
5	Chennai	DFLMIN	0.7	0.9376	0.90	1.10	1.10	1.30	1.3	0.014	0.1169	0.55545	0.6
6	Kochi	DFLMIN	0.8	1.2400	1.30	1.45	1.50	1.55	1.6	0.026	0.1602	-0.19864	0.8
7	Chennai	DLFMAX	1.1	1.5677	1.50	2.00	2.10	2.10	2.1	0.071	0.2667	0.62920	1.0
8	Kochi	DLFMAX	1.9	2.4570	2.40	2.80	2.95	3.10	3.1	0.063	0.2516	0.38014	1.2
9	Chennai	ED	0.8	1.0925	1.10	1.20	1.30	1.70	1.7	0.017	0.1296	1.58236	0.9
10	Kochi	ED	0.9	1.2100	1.20	1.30	1.30	1.40	1.4	0.008	0.0870	-0.57211	0.5
11	Chennai	FL	10.1	12.7667	12.00	16.00	17.10	19.40	19.4	4.422	2.1029	1.24234	9.3
12	Kochi	FL	13.8	17.1740	17.15	18.55	18.70	19.20	19.5	1.041	1.0204	-0.38160	5.7
13	Chennai	HL	2.6	3.4505	3.30	4.00	4.50	5.60	5.6	0.262	0.5115	1.62765	3.0
14	Kochi	HL	4.2	5.0730	5.10	5.50	5.60	5.70	5.7	0.102	0.3200	-0.17991	1.5
15	Chennai	PDL	3.0	3.9151	3.70	4.80	5.40	6.00	6.0	0.425	0.6516	1.31367	3.0
16	Kochi	PDL	4.3	5.3170	5.35	5.80	5.90	6.10	6.1	0.143	0.3779	-0.32585	1.8
17	Chennai	PDL1	1.3	1.8731	1.70	2.60	2.80	3.00	3.0	0.190	0.4357	1.05247	1.7
18	Kochi	PDL1	1.7	2.1180	2.10	2.40	2.40	2.55	2.6	0.045	0.2115	-0.08465	0.9
19	Chennai	POL	1.0	1.3129	1.30	1.60	1.70	2.10	2.1	0.045	0.2128	1.41939	1.1
20	Kochi	POL	1.6	2.5540	2.50	2.90	2.90	3.00	3.0	0.055	0.2355	-0.76662	1.4
21	Chennai	PPD	2.8	4.0742	3.80	5.20	5.90	6.30	6.3	0.676	0.8222	0.99539	3.5
22	Kochi	PPD	4.3	5.4530	5.45	5.90	6.00	6.20	6.2	0.121	0.3477	-0.25425	1.9
23	Chennai	SL	0.6	1.0419	1.00	1.50	1.60	2.00	2.0	0.081	0.2853	0.88832	1.4
24	Kochi	SL	1.2	1.4970	1.50	1.70	1.70	1.80	1.8	0.019	0.1389	0.10078	0.6
25	Chennai	STL	8.9	11.2989	10.50	14.30	15.60	17.90	17.9	3.974	1.9936	1.30286	9.0
26	Kochi	STL	12.0	14.4890	14.50	15.50	15.85	16.30	16.4	0.756	0.8694	-0.29218	4.4
27	Chennai	TL	12.5	16.5398	15.70	20.00	23.20	26.70	26.7	7.328	2.7070	1.49054	14.2
28	Kochi	TL	17.9	22.6480	22.55	24.75	25.45	26.50	27.0	2.954	1.7187	-0.07807	9.1
29	Chennai	TW	20.0	57.7419	50.00	100.00	110.00	130.00	130.0	722.020	26.8704	0.71689	110.0
30	Kochi	TW	50.0	90.4000	90.00	110.00	115.00	122.50	125.0	274.081	16.5554	-0.16711	75.0
31	Chennai	WDF	4.1	5.5828	5.20	7.40	7.60	8.70	8.7	1.140	1.0677	1.13167	4.6
32	Kochi	WDF	6.0	7.2230	7.20	8.00	8.00	8.40	8.6	0.286	0.5344	0.00018	2.6

Discussion

The present study was undertaken to compare the morphometric and meristic characters of *N. japonicus* from the east and west coasts of India and identify whether the same species have significant difference in the variables under study. The analysis revealed that Kochi located on the west coast had higher differences than Chennai in the majority of the variables. As per the work carried out by Pawar (2011), there was no significant difference in the morphometric and meristic ratios for stock assessment from three different localities in India viz. Mumbai, Ratnagiri and Panaji. Isometric growth pattern was observed and the study envisaged that the fish that landed at all the three localities belonged to a single stock. Joshi (2010) in his study compared males and females of *N. mesoprion*, another commercially important Nemipterid off Kochi. His study revealed the biology and population dynamics and in terms of length –weight relationship, there was no significant difference among the sexes. An analysis on meristic characters for *N. japonicus* was carried out by Sreekanth *et al.* (2013) from four southern states namely Andhra Pradesh, Tamil Nadu in the east coast and Maharashtra, Kerala in the west coast on the same species. Their study brought forth 15 characters (variables) that had no significant difference between locations that depicted the similarity of the stock collected. The interesting finding in their study was the difference in the counts of gill rakers that helped them to confirm population and stocks in various locations. In our study, the gill rakers count was eliminated and only macro characters for meristic values were carried out. Moreover, following the standard morphometric and meristic characters, 21 characters were identified and readings were recorded.

In earlier studies Edwin Prabakaran *et al.* (2014) had attempted to study 16 morphometric and meristic characters of 489 *N. japonicus* collected from Chennai waters and observed that there was a high degree of correlation of the characters to the total length of the fish. In the work carried out by Sreekanth *et al.* (2015), various stocks were identified for threadfin breams based on morphometric characters and the samples were collected from 4 different sites along the east and west coasts. The 21 morphometric distances measured have indicated that there were more than 1 stock present in the east and west coasts of India. From the descriptive statistics in the present study, it was observed that Kochi has high difference in majority of the morphometric and meristic variables in comparison to Chennai. This clearly portrays that the populations that were sampled at both the sites were from different stocks. In a study carried out by Krishnamoorthi (1971) on *N. japonicus*, it was observed that this species attains an average length of 150mm (15cm) in the 1st year, 210mm (21cm) in the 2nd year and 240mm (24cm) at the end of the 3rdyear along the Andhra Pradesh (west) coast. The study also brings to light the spawning season to be from November to March and the size involved is from 160–170mm (16-17cm). In the case of Kerala west coast, Vinci (1983) reports that the peak landing during the 80s was September and records a size increase of 136mm (13.6cm) for the 1st year, 186mm (18.6cm) for the 2nd year and 236mm (23.6cm) for the 3rd year. Similarly a study for Veraval coast in Gujarat (Gopal and Vivekanandan, 1991) have identified that this species matures at 180mm (18cm) total length. In the present study, the maximum size recorded in Chennai waters was 267mm (26.7cm) total length and from Kochi waters 270mm (27cm) total length. The study also suggests that adults above the maturation sizes were caught in abundance *vis-a-vis* providing information that the larger size exists in the wild. Nammalwar (1972) suggested that biometric studies in relation to sex ratio from Porto-Novo waters as an important tool to study measurements based on secondary sexual characters. The peak season for *N. japoniucs* was found to be from October to March in this region especially in size. Since the study was focused only the growth parameters, an attempt on sex ratio, Gonado somatic index and other biology related information was not attempted in this study.

The present study on the morphometric and meristic characters for the threadfin bream *N. japonicas* helps in understanding the minor differences that ascertain and differentiate populations that are diverse from each other. Application of statistics thus comes into effect in assisting fishery biologists involved in stock assessments for natural stocks that are being depleted due to overexploitation arising from demand both locally and globally. Regular stock assessment will help in proper exploitation of the resources of threadfin breams because they are currently exploited with great demand. Though there is no overexploitation, the trend to change is not far off purely due to the local demand.

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