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Note

Length weight relationship and otolith morphometry of twelve species of sciaenids (Family: Sciaenidae) from Mumbai waters, India

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ABSTRACT

Length-weight relationship of 12 fish species belonging to the family Sciaenidae landed at New Ferry Wharf, Sassoon Dock and Versova fish landing centers of Greater Mumbai were estimated between September 2006 and August 2007. A normal distribution of calculated 'b' values ranged from 2.3585 to 3.5458 and r^2 values of length-weight relationship varied from 0.6356 to 0.9886. The Student's t-test revealed that the b values significantly differed in 7 of the 12 species studied ($p<0.05$). Morphometric relationship between otolith dimensions and fish weight were also studied. The significance of parameters like otolith length, width and mass was correlated for estimation of fish weight employing multiple regression model. ANCOVA test indicated that difference between left and right sagitta in otolith length, width and mass were insignificant (t-test, $p<0.05$). Results also indicated better correlation between fish weight and otolith measurement. Analysis of morphometric relationships concluded that otolith length, width and mass are good indicators of total length and weight in the species studied.

Keywords: Length weight relationship, Morphometry, Otolith, Sagitta, Sciaenids

Sciaenids are important groups of fish landed by trawlers in India. They have wide distribution in Indian, Pacific and Atlantic Oceans (Longhurst and Pauly, 1987; Sasaki, 1989). Globally, family sciaenidae comprises about 70 genera and 270 species (Nelson, 2006). India has a representation of about 48 species belonging to 27 genera (Mohan, 1991). Annual average catch of sciaenids in the state of Maharashtra is about 28,455 t contributing 6.71% to the total marine catch of Maharashtra during the period 2001-2012 (Anon., 2012), whereas the annual average catch of India during 2001-12 was 1,52,914 t contributing about 21.9% of the demersal catch and 5.34% of the total marine fish catch of India (Anon., 2001). In India, the species mainly contributing towards the fishery are *Otolithoides biauritus, Protonibea diacanthus, Otolithus ruber, Otolithus cuvieri, Johnius macrorhynus, Johnius glaucus, Johnius elongatus, Johnius carutta, Pennahia anea, Johnieops borneensis* and *Johnius sina*.

The study of length-weight relationship of fishes was originally used to provide information on the condition of fish and to determine whether somatic growth was isometric or allometric (Le Cren, 1951). Growth of fish is usually indicated through increase in length and weight and it is the most appropriate characteristic to estimate the population at a particular time. Length and weight measurements in conjunction with age data can give information on the stock composition, age at maturity, life span, mortality, growth and production (Beyer, 1987; Bolger and Connoly, 1989; King, 1996a, b). The length-weight relationship has been used in the conversion between fish length and weight to provide some measure of biomass (Froese, 1998).

Otolith growth is related to increase in size of the fish and generally follows an allometric increase in dimensions (Chilton and Beamish, 1982). Messieh and MacDougall (1984) noted that some population components may have significant intraspecific differences in otolith morphometrics. In addition to the use of otoliths for estimating age of fish, they may also be used to characterise stock specific differences or to interpolate size at age, based on some relation between otolith and fish dimensions (Hunt, 1979). More recent studies have applied otolith morphometrics to models for estimating fish age (Boehlert, 1985; Pawson, 1990). Trout (1954) and Templemann and Squires (1956) demonstrated their utility in retrieving fish size from the size of otoliths.

Sciaenids are known to possess very large otoliths, but there are meager information about the morphology and morphometry of otoliths in these species. Aim of the present study was to provide information regarding otolith morphometry and length-weight relationship of 12 species of sciaenids commonly found in Mumbai waters.

Weekly random samples were collected from New Ferry Wharf, Sassoon Docks and Versova fish landing centers of Greater Mumbai, north-west coast of India, during September 2006 and August 2007. Attempt was made to maintain a proper size ratio. Species of sciaenids were identified using the diagnostic characters as per Trewavas (1977) and Fisher and Bianchi (1984). Samples were collected weekly for the study of length-weight relationship in which attempt was made to include random sample of the species maintaining proportionate sex ratio. A total of 12 species *viz., Johnius belangerii*, *Johnius dussumieri*, *J. elongatus*, *J. glaucus*, *Johnieops macrorhynus*, *J. borneensis*, *J. sina*, *O. cuvieri*, *O. ruber*, *O. biauritus*, *P. diacanthus* and *P. anea* were sampled. Total length was measured to the nearest millimeter and weighed to the nearest 0.01 g using a digital electronic balance.

Length-weight relationship was calculated separately for male and female following the equation of Le Cren (1951):

$W= a.L^b$

The parameters a and b were estimated by linear regression on the transformed equation:

$\log W = \log a + b \log L$

The coefficient of correlation "r" was determined in order to know the relationship between the two parameters. Significance of difference at 5% level between the regression coefficients of the sexes was tested by ANCOVA (Snedecor and Cochran, 1967). To test "b" value against the value of "3", student's t-test was employed to predict any significant deviation. The t-statistic was calculated as follows:

The hypothesis given is, H_0: Growth is isometric *i.e.*, H_0: b = 3

H_1: Growth is not isometric *i.e.,* H_1: $b \neq 3$ $t = (b-3)/S_b$

where, S_b= Standard error of 'b'

The largest otolith, sagitta from 3005 specimens (6010 otoliths) were extracted out of the optic capsule using fine forceps which were then cleaned and stored dry in glass vials. Maximum otolith length (OL) and width (OW) were measured in mm, using vernier caliper. The measurements of otolith length (OL) and width (OW), dimensions like tip from top to bottom when the otolith is placed dorsally and also in the same position the left to right (breadth) at the point when it is maximum is taken with the help of vernier caliper. The parameters compared with the total length (TL) and fish weight (FW), were: otolith length (OL), otolith width (OW) and otolith mass (OM). The morphometric relationships among compared characters were established using a log converted simple linear regression model, which best fit the data distribution (Myers, 1990; Griffiths and Heemstra, 1995). The appropriateness of the linear model was determined by plotting the residuals against the independent variable. The relationships of otolith characters measured were established using standard statistical methods, and differences between right and left sagittae were tested using a paired t-test. The regression coefficients were compared and when significant differences ($p<0.05$) were not found, the null hypothesis ($b_{right} = b_{left}$) was accepted and any one of them was selected randomly from each individual. On the other hand, when the equation does differ statistically ($p<0.05$), linear regression was reported for each parameter (OL, OW and OM) separately.

The length-weight relationship in fishes is affected by a number of factors including season, habitat, maturity of gonad, sex, diet and condition of stomach, health and preservation technique (Tesch, 1971). The 'b' values close to 3.0, indicate isometric growth of species without change in its form along the ontogenic growth. The results of the length-weight relationship of twelve species of sciaenids are presented in Table 1. The correlation coefficient of the length-weight relationship ranged from 0.6356 to 0.9886. In the present investigation, 'b' value was found to deviate from cubic law in *J. belangerii*, *J. elongatus*, *J. glaucus*, *O. cuvieri*, *O. biauritus*, *P. diacanthus* and *P. anea* indicating allometric growth whereas *J. dussumieri*, *J. macrorhynus*, *J. borneensis*, *J. sina* and *O. ruber* indicated isometric growth with 'b' value close to 3 ($p<0.05\%$).

The study on relationships between otolith measurements like otolith length, width and mass against fish weight indicated specific linear regression for each species. Correlation coefficient 'r' for fish weight against otolith length for twelve species ranged from 0.2808 to 0.9411. The regression coefficient of fish weight against otolith weight for the 12 species ranged from 0.1116 to 0.9221, while it ranged from 0.4153 to 0.9537 for fish weight against otolith mass (Table 2). Significant differences were observed between left and right otoliths in *J. macrorhynus*, *J. borneensis*, *J. belangerii, O. biauritus*, OM in *J. sina, J. elongatus,* OM, OW and OL in *J. dussumieri, P. diacanthus, P. anea,* OW and OL in *J. belangerii,* OM, OW and OL in *J. dussumieri,* OM in *J. elongatus,* OW and OL in *O. cuvieri* and *O. ruber*. Statistical analyses revealed that most of the parameters

Table 1. Length weight relationship of 12 species of family sciaenidae from Mumbai waters. All regression were statistically significant ($p<0.05$)

Species	Sex	Total length range (mm)	n	Weight range (g)	Equation (TL *vs.* FW)	r^2
J. belangerii	P	82-193	451	10.3-98.8	$FW= - 4.2975\ TL^{2.6826}$	0.8952
	M	82-185	232	10.3-98.8	$FW= - 4.1853\ TL^{2.4385}$	0.8689
	F	85-193	219	12.5-90.3	$FW= - 4.1562\ TL^{2.5864}$	0.8865
J. dussumieri	P	80-260	450	08.2-72.3	$FW= - 6.2274\ TL^{3.5458}$	0.9460
	M	85-260	212	10.5-72.3	$FW= - 4.6885\ TL^{2.8535}$	0.9626
	F	80-258	238	08.2-65.5	$FW= - 5.0875\ TL^{3.0158}$	0.9542
J. elongatus	P	95-179	461	11.3-54.5	$FW= - 4.1586\ TL^{2.5863}$	0.6356
	M	98-179	235	11.3-50.5	$FW= - 4.2254\ TL^{2.3585}$	0.7865
	F	95-173	226	13.0.-54.5	$FW= - 4.1377\ TL^{2.5817}$	0.7658
J. glaucus	P	85-223	317	15.5-142.4	$FW= - 3.5832\ TL^{2.4483}$	0.7453
	M	80-223	155	15.5-142.4	$FW= - 3.8876\ TL^{2.5384}$	0.7558
	F	85-198	162	20.4-140.7	$FW= - 4.0576\ TL^{2.5817}$	0.7946
J. macrorhynus	P	82-268	410	15.1-235.2	$FW= - 6.1565\ TL^{3.4827}$	0.9346
	M	80-268	195	15.1-230.2	$FW= - 5.2572\ TL^{3.1754}$	0.9703
	F	82-261	215	18.5-235.2	$FW= - 4.8856\ TL^{3.0456}$	0.9886
J. borneensis	P	75-258	497	10.0-250.6	$FW= - 5.2552\ TL^{3.1563}$	0.9843
	M	75-258	262	10.0-182.5	$FW= - 5.4685\ TL^{3.2763}$	0.9445
	F	88-248	235	20.2-250.6	$FW= - 5.3285\ TL^{3.1658}$	0.9573
J. sina	P	75-230	458	7.0-125.6	$FW= - 5.2452\ TL^{3.1523}$	0.9406
	M	75-192	226	7.0-105.5	$FW= - 5.2511\ TL^{3.1453}$	0.9423
	F	82-230	232	8.0-125.6	$FW= - 5.2702\ TL^{3.1675}$	0.9325
O. cuvieri	P	52-285	477	15.2-262.2	$FW= - 4.9708\ SL^{2.9356}$	0.9765
	M	52- 352	252	35.0-254.3	$FW= - 4.4452\ TL^{2.7561}$	0.9745
	F	75-285	225	15.2-262.2	$FW= - 4.24421\ TL^{2.7525}$	0.9523
O. ruber	P	70-272	483	15.2-285.6	$FW= - 5.5265\ TL^{3.2653}$	0.9854
	M	70-248	228	15.2-278.2	$FW= - 5.4321\ TL^{3.277}$	0.9752
	F	97-272	255	25.2-285.6	$FW= - 5.2360\ TL^{3.2688}$	0.9743
O. biauritus	P	85-740	485	50.0-785.8	$FW= - 1.423\ TL^{2.5394}$	0.7575
P. diacanthus	P	100-315	552	15.0-350.0	$FW= -1.782\ TL^{2.8567}$	0.9672
P. anea	P	92-261	447	12.3-252.0	$FW= - 4.4731\ TL^{2.8516}$	0.9562
	M	92-261	232	15.2-225.5	$FW= - 3.8566\ TL^{2.7852}$	0.9415
	F	90-250	215	12.3-252.0	$FW= - 3.7638\ TL^{2.8857}$	0.9756

Table 2. Relationship between otolith morphometric parameters and fish weight

Species	n	OL *vs.* Fish weight	r^2	OW *vs.* Fish weight	r^2	OM *vs.* Fish weight	r^2
J. belangerii	250	$FW= - 1.194\ OL^{3.185}$	0.7065	$FW= - 0.553\ OW^{3.117}$	0.5817	$FW= - 2.760\ OM^{1.206}$	0.8869
J. dussumieri	250	$FW= - 2.655\ OL^{4.540}$	0.9247	$FW= - 2.253\ OW^{5.11}$	0.9106	$FW= - 2.932\ OM^{1.6}$	0.8115
J. elongatus	250	$FW= - 1.559\ OL^{3.524}$	0.3728	$FW= - 1.506\ OW^{4.080}$	0.6674	$FW= 2.907\ OM^{1.497}$	0.7863
J. glaucus	250	$FW= - 0.885\ OL^{2.806}$	0.4447	$FW= - 0.512\ OW^{2.835}$	0.3731	$FW= - 2.483\ OM^{0.971}$	0.4153
J. macrorhynus	255	$FW= - 1.657\ OL^{3.607}$	0.8333	$FW= -1.642\ OW^{4.378}$	0.7458	$FW= 2.735\ OM^{1.234}$	0.7302
J. borneensis	250	$FW= - 1.380\ OL^{3.426}$	0.5157	$FW= - 1.021\ OW^{3.773}$	0.3670	$FW= 2.890\ OM^{1.468}$	0.4950
J. sina	250	$FW= - 1.552\ OL^{3.575}$	0.6890	$FW= - 0.969\ OW^{3.507}$	0.5260	$FW= 2.861\ OM^{1.381}$	0.6802
O. cuvieri	250	$FW= - 1.150\ OL^{3.286}$	0.9411	$FW= - 0.837\ OW^{3.433}$	0.9221	$FW= 2.87\ OM^{1.161}$	0.9537
O. ruber	250	$FW= 0.165\ OL^{2.025}$	0.8093	$FW= 0.7813\ OW^{1.812}$	0.7661	$FW= 2.871\ OM^{1.000}$	0.4773
O. biauritus	250	$FW= - 2.659\ OL^{4.194}$	0.7779	$FW= - 1.650\ OW^{4.268}$	0.8078	$FW= 2.860\ OM^{1.346}$	0.8281
P. diacanthus	250	$FW= 0.849\ OL^{1.159}$	0.2808	$FW= 1.587\ OW^{0.389}$	0.1116	$FW= 3.658\ OM^{1.785}$	0.9130
P. anea	250	$FW= - 0.322\ OL^{2.551}$	0.8782	$FW= - 0.473\ OW^{2.937}$	0.8176	$FW= 2.777\ OM^{1.055}$	0.8072

OL: otolith length (mm), OW: otolith width (mm), OM: otolith mass (g)

measured did not show significant morphometric differences between left and right otoliths (Table 3).

The present investigation on otolith morphology revealed great variation in structure and size of sagitta among the sciaenids. Trewavas (1977) reported strong changes in the sagittal morphology during the development stages in sciaenids. According to Volpedo and Echeverria (1999), these variations may be due to the way the $CaCO_3$ is deposited during the sagitta development, besides other biological factors. Wei *et al.* (2010) also opined that the structure and change in location might play a major role in the structural modifications. Generally it is observed that it is uniformly deposited in young ones but as the otolith grows along with fish, the deposition of salt occurs mainly in the front back axis, resulting in elongation of the otoliths.

The left otoliths of *O. ruber* and *O. cuvieri* appear to be bigger than the right. It agrees with the findings of

Table 3. Differences between right and left otoliths (sagitta) of twelve species of sciaenids from Mumbai waters tested by paired t-test

Species	S.L. (mm)	Parameter	n	t- value	df	P-value
J. macrorhynus	140 - 265	OM	255	0.6655	254	0.50633
		OW	255	-0.19435	254	0.84605
		OL*	255	4.08915	254	5.8144E-05
J. sina	130 - 190	OM*	250	3.03007	249	0.003249
		OW	250	-0.0502	249	0.960079
		OL	250	1.9028	249	0.06048
J. borneensis	140 - 255	OM	250	0.21426	249	0.83086
		OW	250	-1.05775	249	0.293120
		OL*	250	2.56322	249	0.012152
J. belangerii	105 - 193	OM	250	-1.45616	249	0.150236
		OW	250	0.84413	249	0.401739
		OL*	250	3.49191	249	0.000874732
J. dussumieri	150 - 260	OM*	250	-2.2860	249	0.02476
		OW*	250	3.97738	249	0.000147082
		OL*	250	5.00739	249	3.00356E-06
J. elongatus	140 - 176	OM*	250	-2.1212	249	3.00356E-06
		OW	250	-1.7408	249	0.08586
		OL	250	1.13341	249	0.260699
J. glaucus	125 - 220	OM	250	-1.0873	249	0.28096
		OW	250	-1.9024	249	0.061619
		OL	250	0.2682	249	0.789408
O. cuvieri	140 - 260	OM	250	-0.4646	249	0.64322
		OW*	250	3.6520	249	0.000428
		OL*	250	9.74306	249	6.46E-16
O. ruber	225 - 268	OM	250	0.7120	249	0.4797
		OW*	250	-2.9012	249	0.005513
		OL*	250	2.3368	249	0.02349
O. biauritus	181 - 410	OM	250	0.36431	249	0.71666
		OW	250	0.78897	249	0.43264
		OL*	250	-1.9567	249	0.054154
P. diacanthus	120 - 305	OM*	250	2.25656	249	0.02663
		OW*	250	2.7782	249	0.006741
		OL*	250	4.40293	249	3.12375E-05
P. anea	163 - 230	OM*	250	3.3846	249	0.00115
		OW*	250	3.0795	249	0.002921
		OL*	250	8.49053	249	1.685E-12

OM: otolith mass (g), OW: otolith width (mm) and OL: otolith length (mm).
*Significant differences between left and right otoliths ($p < 0.05$)

Battaglia *et al.* (2010) but in contrast with the finding of Harvey *et al.* (2000). Munk and Smikrud (2002) explained the asymmetry between left and right otolith of yellow eye (*Sebastes ruberrimus*) and quillback (*Sebastes maliger*), which was attributed to differences in crystallisation.

The selective pressures act on sagittae, so that their morphology meets specific auditory needs (Popper and Coombs, 1982; Gauldie, 1988). Further, the effects of differences in growth rate is caused by environmental factors such as water temperature, depth, mineral and food availability (Lombarte and Lleonart, 1993; Arellano *et al.*,1995; Aguirre and Lombarte, 1999). Constraints in terms of physical packing of sagittae within the skull have also been cited by several researchers, especially those treating closely related species with large sagittae (Gaemers, 1984; Smith, 1992; Arellano *et al.,* 1995). Otolith size differences are also related to fish growth, but otoliths in very large fishes can be much smaller than small fish and *vice versa* (Campana, 2004). A limited comparison made by Friedland and Reddin (1994) suggested greater genetic influences on otolith shape.

Analysis of morphometric relationships of the twelve sciaenid fish species indicated that the otolith length, width and mass can be used as good indicators of fish length and weight. Baldas *et al.* (1997) using potential models in stripped weak fish (50-600 mm SL) and linear models in white mouth croakers (140-370 mm TL) developed linear models to describe the relationship between length of fish and length of otolith in king weakfish. Among the characteristics of fish otolith, its shape has high interspecific variability which is useful in fish identification (Battaglia *et al.*, 2010). The results of the present investigation provide useful information on fish weight (FW) *vs* otolith length (OL); otolith width (ow) and otolith mass (OM) relationships for the sciaenid fishes. The present investigation on 12 species of sciaenids would certainly add to the knowledge of length-weight relationship *vis-a-vis* otolith sizes and encourage further research on the subject involving many other species of croakers from different geographic regions of the world.

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