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An Investigation on Monthly Distribution of Sexual Maturity Stages and Sex Ratio for the Four Speciesof Family Mugilidae along Karachi Coast of Pakistan

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Abstract:A study was conducted to examine monthly variations in the distribution of sexual maturity stages and sex ratios of the four species *Liza melinoptera*, *Liza macrolepis* and *Valamugil speigleri* and *Mugil cephalus* of family Mugilidae during the 21 months period extend from April 2010 to December 2011 at Karachi coast, Pakistan. From the results of the present study, it was concluded that the species selected in this study have prolonged spawning season that extend from September till the end of April or sometimes in May, while the peak spawning season was mostly observed in the months of December and January or sometimes in April, which indicates that all these species were winter breeder (October to April) along Karachi coast. Furthermore, the overall sex ratios of the four selected mullet species observed during the 21 months of study period revealed that males were significantly more dominant in the catches of *L. melinoptera* and *V. speigleri,* while in *L. macrolepis,* females were significantly more numerous than males. However, the overall sex ratio (1: 0.93) of *M. cephalus* showed that both males and female sexes were almost equally distributed, hence, such variation in sex ratio was found be insignificant (χ^2= 1.623; p > 0.05).

Key words: Mullet Species · Monthly Distribution of Sexual Maturity Stages · Sex Ratio

INTRODUCTION

Mullets or grey mullets of the family Mugilidae consist of 18 genera and 81 species [1]. They are found in tropical, subtropical and temperate regions of the world, but few species found in cool waters. Commonly found in coastal shallow water at 20m depth, while some species spend their whole lives in fresh water habitats, *i.e.*, *Liza abu*. Grey mullets are catadromous group of fishes that use sea as their spawning ground and estuaries or rivers or lakes as their nursery grounds. When fry reach at the sexual maturity stage, they return back to the seawater, where their sexually maturation becomes completed and start spawning [2], however, the exact information about sea characteristics i.e., current, depth, temperature etc. and the specific location necessary for their spawning activities is still unknown. Vast studies have been carried out about the various biological aspects of grey mullets includes its reproduction, sexual maturity stages, spawning season and sex ratio by several researchers such as, Irani [3], Ibanez and Gallardo-Cabello [4], Ibanez and Gutierrez-Benitez [5], El-Halfawy [6], Ilkyaz *et al*. [7], Patimar [8] and Cabral-Solis *et al*. [9] respectively. Though mullets of the family Mugilidae are world widely distributed, therefore, several workers have observed the spawning seasons of various mullet species throughout the different regions of the world. However, as far as this knowledge is concerned, the pervious published literature regarding to maturity stage distribution and sex ratio of the four selected mullet species of this study along the Pakistan Coast was still scarce. Furthermore, the information regarding to the spawning seasons of two mullet species (*L. melinoptera* and *V. speigleri*) of this study was still limited. Therefore, present study was conducted to observe the monthly variations in the distribution of sexual maturity stages and sex ratios of the four selected mullet species along Karachi coast.

MATERIALS AND METHODS

Fish Sampling: Samples of the four studied species of family Mugilidae were collected monthly from the landings at Karachi fish harbor, during the period of April 2010 to December 2011, which were caught mainly with

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the help of gillnets, castnets, liftnets and beach seines. Total catch (n = 1006) contain 307 individuals of *L. melinoptera*, 244 of *L. macrolepis,* 293 of *V. speigleri* and 162 of *M. cephalus*, respectively. In laboratory, each specimen was identified to species level in by using the FAO field guide [10]. Total length (TL) of each specimen was measured in centimetres from the tip of snout to the end of caudal fin using measuring board. Then fishes were immediately dissected to examine the maturity stages of both male and female individuals of each species.

Monthly Distribution of Sexual Maturity Stages: Sex of the each specimen was determined by examination of gonads with naked eye. Monthly distribution of maturity stages and sex ratios were also determined for each fish sample. For the examination of gonads, each fish was open by dissecting its abdomen from the right side. Sexual maturity stages were noted in the form of I, II, III, IV, V, or VI stages on the basis of colour, shape, size of gonads as described by EL-Halfawy [6] as follows;

- Stage I (immature or without identifiable sex).
- Stage II (developing or identifiable sex).
- Stages III (developed or mature stage).
- Stage IV (mature or pre-spawning stage).
- Stage V or VI (spawning stage or ripe stage).

Sex Ratio: The overall sex ratios of each mullet species were tested with Chi-square analysis (χ^2) at the 5% significant level (α= 0.05) by using the following model 1 as follows;

$$X^2 = \sum (O - E)2 / E \qquad (1)$$

where,
O and E are observed and expected frequencies. The expected frequencies were calculated by the following formula as follows;

$$E = R.C / n \qquad (2)$$

where,
R = row total, C = column total and n is the sample size.

The degrees of freedom (df) associated with a contingency table possessing r rows and columns equals (r-1) (c-1). Chi-square test revealed a significant departure from theoretically expected sex ratio (1male: 1female). The values of Chi-square (χ^2) were calculated by Minitab statistical software (version 14.1) following Zar [11]. As both male and female individuals of four studied species were extremely identical in their external morphology, therefore, sex was determined internally by the examination of gonads in all specimens collected for each month and then sex ratio was calculated and analyzed its departure from theoretically expected value (1male: 1female).

RESULTS AND DISCUSSION

Monthly Distribution of Maturity Stages in Mullets: Monthly distribution of maturity stages for the male and female sexes of the four selected mullet species found in the Karachi coast were presented in Tables 1-4. Sexual maturity stages observed in present study were classified into five maturity stages, as stage I to stage V or VI (running/ spent stage) on the basis of variation in shape, size and colour of gonads in different successive stages. Results of the present study revealed that variations were reported in the monthly distribution of I to V sexual maturity stages among the male and female sexes for these mullet species along Karachi coast, which might be due to the differences in the growth rates among the male and female fishes [12], because El-Halfawy [6] reported that generally males of mullets were sexually mature earlier than females or due to some other reasons as described above. According to the results obtained in this study, it was further recognized that fishing or commercial landings of these mullet species should be prohibited especially during the spawning months, as it might have effect on the total populations of juveniles or gravid females of all these mullet species. Furthermore, the present study revealed that *L. melinoptera* found along the Karachi coast have prolonged spawning season that starts from September and continued till the end of April or May (Table1), while the spawning period of *L. macrolepis* was prolonged and extending from September to May, with a distinct peak was observed in months of January, April and September to December (Table 2), therefore, like other mullet species, *L. macrolepis*is also spawn during the winter season at Karachi coast. While in contrast, Luther [13] reported the spawning period of *Liza macrolepis* near Mandapamext ends from June to February, with a distinct peak in the months of July to August; Marais [14] recorded the spawning season *of Liza macrolepis* during the period from May to November in the Natal estuary of South Africa. Present study also revealed that the spawning season of *Valamugils peigleri* along the Karachi coast extends from November to April

Table 1: Monthly distribution of sexual maturity stages and sex ratio of *Liza melinoptera*

	Female						Male						
	Sexual maturity stages (%)						Sexual maturity stages (%)						
Month	N	I	II	III	IV	V	N	I	II	III	IV	V	Sex ratio
						Year 2010							
April	15	0.0	6.66	20.0	53.3	20.0	15	6.6	6.6	20.0	46.7	20.0	1:1
May	8	0.0	0.0	12.5	37.5	50.0	15	0.0	6.6	6.6	33.3	53.3	1:0.53
June	6	16.6	33.3	50.0	0.0	0.0	2	50.0	50.0	0.0	0.0	0.0	1:3.00
July	3	66.6	33.3	0.0	0.0	0.0	1	100.0	0.0	0.0	0.0	0.0	1:3.00
August	5	60.0	20.0	20.0	0.0	0.0	6	66.6	33.3	0.0	0.0	0.0	1:0.83
September	15	0.0	0.0	40.0	46.6	13.3	20	0.0	5.0	15.0	75.0	5.0	1:0.75
October	6	0.0	0.0	16.7	66.6	16.7	10	0.0	0.0	20.0	70.0	10.0	1:0.60
November	9	0.0	0.0	11.1	77.7	11.1	3	0.0	0.0	0.0	66.6	33.3	1:3.00
December*	14	0.0	0.0	0.0	85.7	14.2	6	0.0	0.0	0.0	83.3	16.6	1:2.33
Total sex ratio in year 2010 =													1:1.04[c]
						Year 2011							
January*	8	0.0	0.0	0.0	87.5	12.5	5	0.0	0.0	0.0	80.0	20.0	1:1.60
February	4	0.0	0.0	0.0	75.0	25.0	3	0.0	0.0	0.0	75.0	25.0	1:1.33
March	4	0.0	0.0	0.0	75.0	25.0	4	0.0	0.0	0.0	50.0	50.0	1:1
April	6	0.0	0.0	0.0	16.7	83.3	6	0.0	0.0	16.7	16.7	66.6	1:1
May	5	20.0	40.0	40.0	0.0	0.0	4	50.0	25.0	25.0	0.0	0.0	1:1.25
June	2	50.0	50.0	0.0	0.0	0.0	8	62.5	37.5	0.0	0.0	0.0	1:0.25
July	2	100.0	0.0	0.0	0.0	0.0	4	100.0	0.0	0.0	0.0	0.0	1:0.50
August	4	75.0	25.0	0.0	0.0	0.0	8	75.0	25.0	0.0	0.0	0.0	1:0.50
September	7	0.0	0.0	71.4	28.6	0.0	24	0.0	12.5	66.6	16.7	4.17	1:0.29
October	8	0.0	0.0	37.5	62.5	0.0	10	0.0	0.0	30.0	70.0	0.0	1:0.80
November	4	0.0	0.0	0.0	75.0	25.0	4	0.0	0.0	0.0	75.0	25.0	1:1
December*	6	0.0	0.0	0.0	83.3	16.6	8	0.0	0.0	0.0	87.5	12.5	1:0.75
Total sex ratio in year 2011 =													1:0.68[c]
Total catch	141						166	Total sex ratio in years 2010 and 2011					1:0.85[a]

N = number of males or females, * shows the peak spawning season, [a] showsChi-square χ^2) test significant at $p<0.05$;
[c] showsChi-square χ^2) test insignificant at $p>0.05$.

Table 2: Monthly distribution of sexual maturity stages and sex ratio of *Liza macrolepis*

	Female						Male						
	Sexual maturity stages (%)						Sexual maturity stages (%)						
Month	N	I	II	III	IV	V	N	I	II	III	IV	V	Sex ratio
						Year 2010							
April*	3	0.0	0.0	0.0	66.6	33.3	10	0.0	0.0	0.0	90.0	10.0	1:0.3
May	7	0.0	0.0	0.0	28.6	71.4	6	0.0	0.0	0.0	16.7	83.3	1:1.2
June	5	60.0	40.0	0.0	60.0	0.0	9	66.6	22.2	11.1	0.0	0.0	1:0.6
July	2	100.0	0.0	0.0	0.0	0.0	6	66.6	33.3	0.0	0.0	0.0	1:0.3
August	3	75.0	25.0	0.0	0.0	0.0	5	75.0	25.0	0.0	0.0	0.0	1:0.6
September*	16	6.3	18.7	37.5	37.5	0.0	10	0.0	10.0	10.0	80.0	0.0	1:1.6
October	3	0.0	0.0	66.6	33.3	0.0	3	0.0	0.0	33.3	66.6	0.0	1:1.0
November*	9	0.0	0.0	0.0	88.8	11.1	5	0.0	0.0	20.0	80.0	0.0	1:1.8
December*	27	0.0	0.0	0.0	92.3	7.4	3	0.0	0.0	0.0	100.0	0.0	1:9.0
Total sex ratio in year 2010 =													1:1.31[a]
						Year 2011							
January*	12	0.0	0.0	0.0	91.6	8.3	1	0.0	0.0	0.0	100.0	0.0	1:12.0
February	4	0.0	0.0	0.0	75.0	25.0	4	0.0	0.0	0.0	50.0	50.0	1:1.0
March	4	0.0	0.0	0.0	75.0	25.0	4	0.0	0.0	0.0	75.0	25.0	1:1.0
April*	3	0.0	0.0	0.0	100	0.0	6	0.0	0.0	0.0	83.3	16.7	1:0.5
May	3	0.0	0.0	33.3	66.6	0.0	6	0.0	0.0	0.0	33.3	66.6	1:0.5
June	6	33.3	50.0	16.7	0.0	0.0	0		Data not available				
July	8	62.5	37.5	0.0	0.0	0.0	0		Data not available				
August	8	75.0	12.5	12.5	0.0	0.0	2	0.0	0.0	100.0	0.0	0.0	1:4.0
September*	16	0.0	0.0	6.3	93.7	0.0	2	0.0	0.0	0.0	100.0	0.0	1:8.0
October	4	0.0	0.0	50.0	50.0	0.0	1	0.0	0.0	0.0	100.0	0.0	1:4.0
November	8	0.0	0.0	25.0	62.5	12.5	1	0.0	0.0	0.0	100.0	0.0	1:8.0
December*	8	0.0	0.0	0.0	87.5	12.5	1	0.0	0.0	0.0	100.0	0.0	1:8.0
Total sex ratio in year 2011=													1:3.0[a]
Total catch	159						85	Total sex ratio in years 2010 and 2011=					1:1.87[a]

Table 3: Monthly distribution of sexual maturity stages and sex ratio of *Valamugils peigleri*

	Female						Male						
	Sexual maturity stages (%)						Sexual maturity stages (%)						
Month	N	I	II	III	IV	V	N	I	II	III	IV	V	Sex ratio
						Year 2010							
April*	12	0.0	0.0	0.0	83.3	16.7	9	0.0	0.0	0.0	88.8	11.1	1:1.33
May	9	0.0	0.0	0.0	22.2	77.7	3	0.0	0.0	0.0	33.3	66.6	1:3.00
June	7	14.3	28.6	57.1	0.0	0.0	9	66.6	22.2	11.1	0.0	0.0	1:0.78
July	5	60.0	20.0	20.0	0.0	0.0	6	83.3	16.7	0.0	0.0	0.0	1:0.83
August	3	66.6	33.3	0.0	0.0	0.0	9	77.7	22.2	0.0	0.0	0.0	1:0.33
September	15	73.3	20.0	6.6	0.0	0.0	51	19.6	35.3	43.1	1.96	0.0	1:0.29
October	12	75.0	16.7	8.3	0.0	0.0	6	16.7	50.0	33.3	0.0	0.0	1:2.00
November	3	0.0	0.0	33.3	66.6	0.0	6	0.0	16.7	16.7	66.6	0.0	1:0.50
December*	12	0.0	0.0	0.0	91.6	8.3	15	0.0	0.0	0.0	86.6	13.3	1:0.80
Total sex ratio in year 2010=													1:0.68[a]
						Year 2011							
January*	5	0.0	0.0	0.0	80.0	20.0	4	0.0	0.0	0.0	75.0	25.0	1:1.25
February*	1	0.0	0.0	0.0	100.0	0.0	8	0.0	0.0	0.0	75.0	25.0	1:0.13
March	2	0.0	0.0	0.0	50.0	50.0	8	0.0	0.0	0.0	62.5	37.5	1:0.25
April*	10	0.0	0.0	0.0	80.0	20.0	6	0.0	0.0	0.0	83.3	16.7	1:1.67
May	2	0.0	0.0	0.0	50.0	50.0	3	0.0	0.0	33.3	66.6	0.0	1:0.67
June	6	50.0	33.3	16.7	0.0	0.0	2	0.0	50.0	50.0	0.0	0.0	1:3.00
July	4	50.0	25.0	25.0	0.0	0.0	1	100.0	0.0	0.0	0.0	0.0	1:4.00
August	1	100.0	0.0	0.0	0.0	0.0	4	0.0	50.0	50.0	0.0	0.0	1:0.25
September	1	0.0	100.0	0.0	0.0	0.0	8	12.5	37.5	50.0	0.0	0.0	1:0.13
October	4	0.0	50.0	50.0	0.0	0.0	4	0.0	25.0	75.0	0.0	0.0	1:1.00
November	4	0.0	0.0	75.0	25.0	0.0	4	0.0	0.0	75.0	25.0	0.0	1:1.00
December*	5	0.0	0.0	0.0	100.0	0.0	4	0.0	0.0	0.0	100.0	0.0	1:1.25
Total sex ratio in year 2011=													1:0.80[a]
Total catch	123						170	Total sex ratio in years 2010 and 2011					1:0.72[a]

Table 4: Monthly distribution of sexual maturity stages and sex ratio of *Mugil cephalus*

	Female						Male						
	Sexual maturity stages (%)						Sexual maturity stages (%)						
Month	N	I	II	III	IV	V	N	I	II	III	IV	V	Sex ratio
						Year 2010							
April	5	60.0	20.0	20.0	0.0	0.0	3	33.3	33.3	33.3	0.0	0.0	1:1.67
May	2	50.0	50.0	0.0	0.0	0.0	3	66.6	33.3	0.0	0.0	0.0	1:0.67
June	2	50.0	50.0	0.0	0.0	0.0	9	55.6	33.3	11.1	0.0	0.0	1:0.22
July	1	100.0	0.0	0.0	0.0	0.0	6	66.6	16.7	16.7	0.0	0.0	1:0.17
August	2	0.0	50.0	50.0	0.0	0.0	3	0.0	33.3	66.6	0.0	0.0	1:0.67
September	1	0.0	0.0	100.0	0.0	0.0	3	0.0	0.0	100.0	0.0	0.0	1:0.33
October	1	0.0	0.0	0.0	100.0	0.0	6	0.0	0.0	33.3	66.6	0.0	1:0.17
November	1	0.0	0.0	0.0	100.0	0.0	6	0.0	0.0	16.7	83.3	0.0	1:0.17
December*	3	0.0	0.0	0.0	100.0	0.0	9	0.0	0.0	0.0	88.8	11.1	1:0.33
Total sex ratio in year 2010=													1:0.37[a]
						Year 2011							
January*	8	0.0	0.0	0.0	87.5	12.5	4	0.0	0.0	0.0	75.0	25.0	1:2.00
February	8	0.0	0.0	0.0	25.0	75.0	4	0.0	0.0	0.0	25.0	75.0	1:2.00
March	4	0.0	75.0	25.0	0.0	0.0	2	0.0	50.0	50.0	0.0	0.0	1:2.00
April	6	0.0	33.3	66.6	0.0	0.0	1	0.0	100.0	0.0	0.0	0.0	1:6.00
May	6	0.0	66.6	16.7	16.7	0.0	5	60.0	40.0	0.0	0.0	0.0	1:1.20
June	6	83.3	16.7	0.0	0.0	0.0	1	100.0	0.0	0.0	0.0	0.0	1:6.00
July	8	75.0	12.5	12.5	0.0	0.0	1	100.0	0.0	0.0	0.0	0.0	1:8.00
August	4	25.0	50.0	25.0	0.0	0.0	4	25.0	25.0	50.0	0.0	0.0	1:1.00
September	2	0.0	0.0	50.0	50.0	0.0	4	0.0	25.0	25.0	50.0	0.0	1:0.50
October	2	0.0	0.0	50.0	50.0	0.0	6	0.0	0.0	50.0	50.0	0.0	1:0.33
November*	4	0.0	0.0	0.0	100.0	0.0	2	0.0	0.0	0.0	100.0	0.0	1:2.00
December*	2	0.0	0.0	0.0	100.0	0.0	2	0.0	0.0	0.0	100.0	0.0	1:1.00
Total sex ratio in year 2011=													1:1.66[c]
Total catch	78						84						1:0.93[c]

or sometimes in May as shown in Table 3, respectively. Nevertheless, Wijeyaratne and Costa [15] studied that spawning season of *Valamugilcunnesius* in Negombo Lagoon occurs during the months of March, June, August and December. Suchvariation of spawning season in the fishes belongs to the same genera or same species might be or due to the variations in the physiochemical characteristics of environment in which they lived or due to differential fishing, which probably be related with the season and schooling that occurs in their spawning grounds [15, 16]. The spawning season of *M. cephalus* along the Karachi coast was occurs during the period from September to February, but the peak spawning period of this species was observed in the months from November to January, as shown in Table 4. This result was in consistency with Das [17] who observed the spawning season of *Mugil cephalus*in Goa waters occurs from September to February, with a distinct peak observed from October to December. Chang *et al*. [18] also reported that spawning season of *Mugil cephalus*in Tanshui estuary (Northwest Taiwan) extends from October to February. Though, present study revealed that spawning of this species occurs during winter season, however, it spawn only one time in the year as observed by Rangaswamy [19]. It was observed that fish lives in warm water attain its sexual maturity mostly before those found in cold water, as Coad [20] reported that the mullet species i.e., *Mugil cephalus* found in warm Florida water were sexually mature earlier than those occurred in cold water of Black sea. According to the Brusle [21], these variations might be due to the differences in seawater temperature. The spawning season of *Mugil cephalus* extends from June to November in North Aegean Sea as reported by Koutrakis *et al*. [22], whereas Katselis *et al*. [23] also recorded the spawning season of this species in West Greece occurs during the period from August to October. Sagi and Abraham [24] revealed experimentally that the reproductive activities of mullets were affected by temperature, salinity and short day photoperiod.

Sex Ratio of Mullets: In the present study, sex ratio of the four selected mullet species was also observed during 21 months period from April 2010 to December 2011, as shown in Tables 1-4, respectively. The overall sex ratio was tested with Chi-square (χ^2) analysis at the 5% significant level ($p \leq 0.05$) in order to observe their significant departure from the theoretically expected ratio that is 1 male: 1 female. The result of the present study revealed that the sex ratio of these four mullet species did not remain constant throughout the year. Variations have been observed in proportion of males to females in total catch of each mullet species as shown in Tables 1-4, respectively. During the study, it was observed that females of both *Liza* sp. (*L. melinoptera* and *L. macrolepis*) were significantly more abundant than that of males in the total catch of year 2010, as shown in Tables 1 and 2, respectively. However, chi-square analysis revealed that such variation in sex ratio was considered to be insignificant (χ^2=13.0; $p > 0.05$) for *L. melinoptera* (1 male: 1.04 female), because it was not significantly varied from the theoretically expected ratio (1 male: 1 female), hence, the number of male and female individuals in its population was found to be equal. Though, there was possibility that sex ratio of this species was influenced by the differential fishing exists, but still no evidences were available to showed that this is a case that may be occurs in *L. melinoptera* catch. However, during the spawning season, sex ratio was mostly in the favor of females, hence, this may indicates that the reproductive success of *L. melinoptera* on Karachi coast of Pakistan. Thus, large numbers of females were available for the fewer numbers of males during the breeding season. This may account for its all year presence along Pakistan coast. Some other workers have reported sex ratios in the favor of females for some other *Liza* species (e.g., *Liza ramada*) was found to 1 male: 1.31 female in Akgol-Paradenizlagoons [25]. Lawson *et al*. [26] found the sex ratio 1male: 1.13 female in *Liza falcippinis* from Badagry Creek. Such variation in sex ratio may be due to some ecological or genetic factor [26]. However, the sex ratios of *L. macrolepis*in both years (2010 and 2011) were significantly departed (χ^2= 46.51; $p \leq 0.05$) from the expected sex ratio (1 male: 1 female), hence, indicates the clear abundance of females than males in the total catches of these two years (Table 2), which was in agreement with Luther [13] who also observed the sex ratio (1 male: 1.2 female) in the favours of females in Palk Bay near Mandapam. On the other hand, in the year 2010, the sex ratios of *V. speigleri* (1 male: 0.68 female) and *M. cephalus* (1 male: 0.37 female) revealed the populations of these two species were significantly ($p<0.05$) in favor of males, as shown in the Tables 3 and 4. Sex ratio in the favour of males had also been reported for some non-related species *i.e.*, *Eloplacerta* [27].

The overall sex ratios of the four mullet species observed during the 21 months period revealed that males were significantly more dominant in the catches of *L. melinoptera* and *V. speigleri,* but in case of

L. macrolepis, females were significantly more numerous than males. While in contrast, the overall sex ratios (1: 0.93) of *M. cephalus* shows that both males and female sexes were almost equally distributed, hence, such variation in sex ratio was found be insignificant (χ^2= 1.623; p > 0.05). The number of male and female individuals of each mullet species was also found to be varied in the total catch during year 2011. Analysis of sex ratios of *L. melinoptera* (1 male: 0.68 female) and *V. speigleri* (1 male: 0.80 female) in year 2011 revealed that they had more males than females. However, such departure in sex ratio from the expected sex ratio (1 male: 1 female) was found be insignificant (χ^2=11.06; p > 0.05) in *L. melinoptera.* The analysis of sex ratio of *M. cephalus* (1 male: 1.66 female) and *L. macrolepis* (1 male: 3.0 female) in year 2011 revealed the clear dominance of females individuals in their populations, however, such departure was found be insignificant (χ^2= 9.431; p > 0.05) in *M. cephalus*. Furthermore, it was observed that the sex ratios of *V. speigleri* in both years (2010 and 2011) were in the favour of males. In *L. macrolepis,* the sex ratios calculated for both years (2010 and 2011) were in the favour of females. However, in contrast, sex ratios of *L. melinoptera* and *M. cephalus* were found to vary in two years (2010 and 2011) catches. Therefore, in year 2010, sex ratio of *L. melinoptera* was in the favour of females, while in year 2011, the sex ratio of this species revealed that males were predominated than females, however, chi-square (χ^2) analysis revealed that such variation in sex ratios (in years 2010 and 2011) from the expected sex ratio (1 male: 1 female) was found be insignificant (p > 0.05). Likewise, in year 2010, the sex ratio of *M. cephalus* was in the favour of males and this departure was found be significant (χ^2= 35.65; p<0.05), which was in agreement with Das [17] who also reported the sex ratio of *M. cephalus* was 1.77 male: 1 female in Goa water, hence, indicates that the population of this species was in the favour of males that might be because females may leave the spawning grounds more rapidly than males, which can be considered as an adaptation to make easy preservation of females or more rapid recovery of gonads [28] or due to their higher growth rates than females [12]. While in the present study, the population of *M. cephalus* in year 2011 was in the favour of females, which was in agreement with Lawson and Jimoh [29]. According to the Smith and Deguara [30], these variations in sex ratios obtained for the same species might be because of gear selectivity that mostly modify the total catch of each sex or as a result of complex interactions of various biological factors *i.e.*, variations in growth and mortality rates between two sexes or due to the variation in growth and mortality rates of both sexes among the different zones of an ecosystem or the during the spawning season when individuals of one sex becomes more active and form a large aggregation and could be caught easily in enormous numbers [31] or there was a great possibility that one sex become more sensitive to unfavorable effect of its environmental conditions as compared to the other sex, which resultant in an imbalanced sex ratio in the population. In the present study, it was observed that both male and female sexes of four selected mullet species were not present in the same proportional throughout the year. Das [17] also observed the monthly variations in the sex ratio of *Mugil cephalus* in Goa waters can occurs due to the differential fishing factor that might be relating with the seasons and schooling in its feeding and spawning grounds [16, 32] or also due to selective fishing for large fish, which were mostly preferred by the fishermen [33] or because of certain other factor such as, different habitats or zones, variation in size classes and differences in growth rate between the two sexes may also create an unbalanced proportion in the total catch [12, 34]. Nikolsky [35] observed that the sex ratio was also influence by the availability of food, hence, if food was abundant, than female fishes will be more numerous than males, but if food is limited than females were less abundant, because they required more better condition of environment than males, as bad environmental condition can greatly influence on its growth and development.

CONCLUSION

From the above results, it was concluded that the present study will provides valuable information on the proportion of male to female fish in a population of each mullet species along Karachi coast. It also indicates the dominance of sex over other in a given population of each mullet species. Moreover, this study will also be helpful in providing useful suggestions to the fisheries biologists and fisheries management authorities for fish reproduction and stock size assessment as mullet fishes are widely distributed not only on Pakistan coast but also throughout the various regions of the world.

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