Biological Forum – An International Journal **7**(1): 459-469(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Size Frequency Distribution Patterns of the four Mugilid Species of the Family Mugilidae (Order Mugiliformes) Collected from the Karachi Fish Harbour, Pakistan

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(Received 07 January, 2015, Accepted 18 February, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: As the analysis of size frequency distribution pattern will also provide useful data on the assessment of size structure of a single species or multiple species, therefore, present study was based on the estimation of size frequency data for the male, female and combined sexes of the four selected mugilid species during the period from April 2011 to December 2012. Total catch contain 1006 specimens of these mugilid species includes 307 individuals of *Liza melinoptera,* 244 of *Liza macrolepis,* 162 of *Mugil cephalus* and 293 of *Valamugil speigleri*, respectively. The result of this study revealed that females of both *Liza* sp. e.g., *L. melinoptera* and *L. macrolepis* were dominated in large size groups, however, both male and female individuals of *M. cephalus* were abundant in small size groups but least occurred in the large size groups, while males of *L. melinoptera* usually predominated in the smaller groups. Size frequency data of *V. speigleri* showed that both large and small size groups were predominated in the total catch during the whole study period along the Karachi coast. Hence, variations were found to be noted in the size distribution pattern for each species among the different size groups. Thus, the presence of these four mugilid species in all size groups revealed that the habitat conditions of Karachi coast were suitable for all stages (i.e., immature or larval, fry and mature stages) in the life cycle of each mugilid species in this study.

Key words: size frequency distribution, Mullets or grey mullets, Karachi coast

INTRODUCTION

Fishes of the family "Mugilidae" are commonly known as "grey mullets" or mullets. This family is consists of 18 genera and 81 species (Nelson, 2006; Froese and Pauly, 2011). Worldwide distributed family occurred in marine and brackish waters or estuaries. Commonly found in coastal shallow water at 20m depth. Maximum length is about 100 cm. Most mullet species spawn in sea,and then fry enter into the fresh water where they grow into adult stage (Chang *et al*., 2004). The detail information regarding to the size frequency distribution pattern of these selected mullet species on Pakistan coast was still lacking. However, Luther (1964) and Wijeyaratne and Costa (1987) had studied size frequency distribution of *Mugil cephalus* and *Liza macrolepis* in Palk bay (Mandapam) and Negombo lagoon. Karna*et al*. (2011) observed the size frequency data of *Valamugil speigleri* in Chilika Lagoon. While the size frequency data of *Mugil cephalus*was studied by several workers such as Koutrakis *et al*. (1994), Chang *et al*. (2000) and Cardona *et al*. (2008). No published data was available about the size frequency data of *Liza melinoptera*. However, Thollot (1993) observed that *L. melinoptera* as highly dominant species in Western Samoa mangroves. However, the previous published data regarding to size frequency data for all four selected mullet species of Pakistan coast was still limited. Therefore, the main objectives of present study was to observed the variations in the distribution and proportion of various size groups of the four selected mullet species along the Karachi coast of Pakistan.

MATERIALS AND METHODS

A. Samples collection
A total of 1006 specimens of the four selected mugilid species were collected monthly from the landings at Karachi fish harbour, during the period from April 2011 to December 2012. These fishes were caught mainly with the help of gillnets, castnets, liftnets and beach seines on Karachi coast (Bianchi, 1985).

Each specimen of these mugilid species was identified upto the species level with the help of FAO field guide of Bianchi (1985) and Harrison and Senou (1999). Total body length (TL) of each sample was measured in centimetres. These fishes were then immediately preserved in 10% formaldehyde solution for long time preservation.

B. Size frequency data

Size frequency data was estimated separately for male, female and combined sexes of four mugilid species of this study.

Class mid point was also measured for all size groups with the help of following equation;

$$\text{Class mid point} = \frac{\text{lowest class limit + upper class limit}}{2}$$

RESULTS

Size frequency distribution pattern for the male, female and combined sexes of the four selected mullet species was analyzed in the present study. The result of the present study revealed that the distribution and abundance of the number of individuals of each mullet species was found to be varied among the different size groups, as shown in the Tables (1-12) and Figs. (1-12). Size frequency data of *V. speigleri* showed that both large and small size groups were predominated in the total catch during the whole study period (Tables 7-9). While the size frequency data of *L. melinoptera* confirmed the availability of medium and large sized or adult fishes along the Karachi coast (Table 1-3). The study of size frequency distribution pattern of *M. cephalus* revealed that both male and female sexes were more dominated in the small size groups, but least occurred in the large size groups. However, the females of *L. macrolepis* were totally missing in large group (27.0-29.4 cm) during the study period (Table 6).

DISCUSSION

A. Size frequency data of the combined sexes of mullets

The presence of the four selected mullet species of this study in all size groups revealed that their habitat conditions were suitable for all the stages in the life cycle of each of mullet species in this study. The abundance of these mullet species in large size groups reveals that the condition of their habitats was more suitable for adult fish and hence, provides a good spawning ground for all these species. While in contrast, the absence of large size groups indicating that their habitat conditions were not suitable for spawning or this might be revealing that it was not a site for spawning or due to the migration of adult fishes after spawning (Ranjan *et al*., 2005). The presence of large number of individuals in small groups was indicating that their habitat provides good condition for the initial growth or their spawning season was started. Chang and Tzeng (2000) reported that the distribution of small individuals of mullets in Tanshui estuary may depends on the spawning period and salinity or according to the space (spatial) and time (season) or due to the different conditions of their habitat, stock size, health and other population characteristics that could also be varied in different ecosystem and seasons (Ranjan *et al*., 2005). Hadzley (1997), Cardona (2006) and Abowei (2010) reported that certain abiotic and biotic factors of water can influence on the occurrence and distribution of any mullet species in the wild. According to FAO (2007), mullet species can tolerate a different salinity levels based on their life stages. As adult mullets can tolerate wide range of salinity ranged from 0 (zero) to 75%, hence, they can easily migrate between seawater or other hypersaline areas and fresh water for spawning and feeding (Cardona, 2000), and while their juveniles can tolerate such a wide range of salinity when they reached at 4.7 cm length. Therefore, juveniles mostly preferred the water with low salinity level as reported by Akinrotimi *et al*. (2010).

B. Size frequency data of the male and female sexes of mullets

In the present study, size frequency distribution data was varied according to the sex. Size frequency analysis of four mullet species revealed that females of both *Liza* sp. e.g., *L. melinoptera* and *L. macrolepis* were more dominated in large size groups than males (Tables (3,6); Figs. (3,6). Males of *L. melinoptera* usually predominated in the smaller groups because they mature earlier than females but live less life. While in *M. cephalus,* both males and females were equally abundant in small size groups. However, in large size group (35.6-38.1 cm), the proportion of females was higher (10.26%) than that of males (4.76%), as shown in the Tables (11,12) and Figs. (11,12). Females of *V. speigleri* were equally dominated in small and large size groups, as shown in the Tables (9) and Figs. (9). In general, females of these mullet species were predominated in the large size groups, while male predominance was reported in small size classes. According to the Vicentini and Araujo (2003), these variations in the size frequency data of male and female individuals might be due to the variation in the growth rates between these two sexes, which may cause an unbalanced proportion. The sex that represents the fast growth rate will readily go through the most small size phase, therefore reduce the predation proportion.

Table 1: Size frequency distribution for combined sexes of *Liza melinoptera* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	14.0-14.5	14.25	9	2.93	G
2	14.6-15.1	14.85	37	12.05	D
3	15.2-15.7	15.45	17	5.54	F
4	15.8-16.3	16.05	73	23.78	B
5	16.4-16.9	16.65	45	14.66	C
6	11.0-11.5	11.25	101	32.9	A
7	11.6-18.1	11.85	25	8.14	E
		Total	**307**		

Table 2: Size frequency data for male of *Liza melinoptera* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	14.0-14.5	14.25	10	6.02	E
2	14.6-15.1	14.85	34	20.48	B
3	15.2-15.7	15.45	16	9.64	D
4	15.8-16.3	16.05	43	25.9	A
5	16.4-16.9	16.65	16	9.64	D
6	11.0-11.5	11.25	31	18.67	C
7	11.6-18.1	11.85	16	9.64	D
		Total	166		

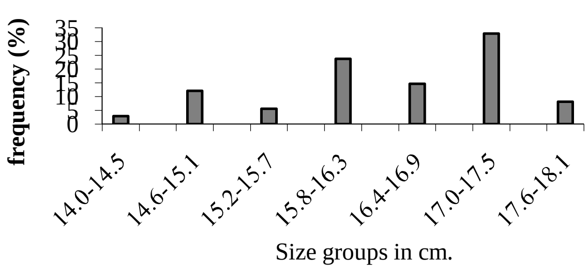

Fig. 1. Size frequency distribution of *Liza melinoptera*.

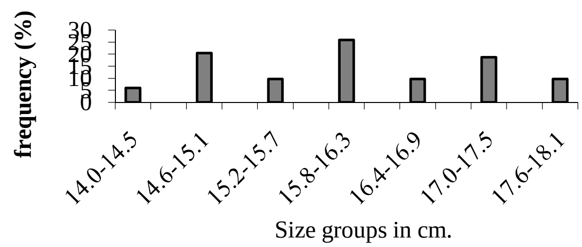

Fig. 2. Size frequency distribution for the male of *Liza melinoptera* n= 166.

Table 3: Size frequency data for female of *Liza melinoptera* (April 2011 to December 2012).

No. of Obs.	Size groups cm.	Class Mid point cm.	No. of samples N	frequency (%)	Rank
1	14.0-14.5	14.25	8	5.67	E
2	14.6-15.1	14.85	3	2.13	F
3	15.2-15.7	15.45	8	5.67	E
4	15.8-16.3	16.05	23	16.31	C
5	16.4-16.9	16.65	29	20.57	B
6	11.0-11.5	11.25	56	39.72	A
7	11.6-18.1	11.85	14	9.93	D
		Total	**141**		

Table 4: Size frequency distribution for the combined sexes of *Liza macrolepis* (April 2011 to December 2012).

No. of Obs.	Size groups cm.	Class Mid point cm.	No. of samples N	frequency (%)	Rank
1	12.0-14.4	13.2	34	13.93	D
2	14.5-16.9	15.7	88	36.07	A
3	11.0-19.4	18.2	43	11.62	C
4	19.5-21.9	20.7	58	23.77	B
5	22.0-24.4	23.2	7	2.87	E
6	24.5-26.9	25.7	7	2.87	E
7	21.0-29.4	28.2	7	2.87	E
		Total	**244**		

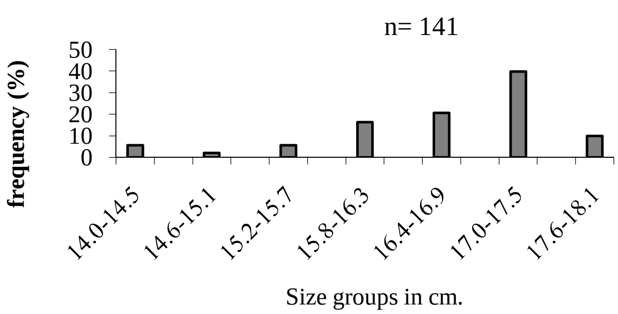

Fig. 3. Size frequency distribution for the female of *Liza melinoptera.*

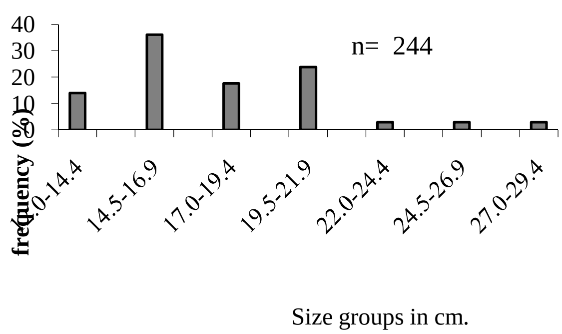

Fig. 4. Size frequency distribution of *Liza macrolepis.*

Table 5: Size frequency data for male of *Liza macrolepis* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	12.0-14.4	13.2	4	4.71	C
2	14.5-16.9	15.7	49	51.65	A
3	11.0-19.4	18.2	25	29.41	B
4	19.5-21.9	20.7	1	1.18	D
5	22.0-24.4	23.2	1	1.18	D
6	24.5-26.9	25.7	1	1.18	D
7	21.0-29.4	28.2	4	4.71	C
		Total	**85**		

Table 6: Size frequency data for female of Liza macrolepis (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	12.0-14.4	13.2	30	18.87	C
2	14.5-16.9	15.7	39	24.53	B
3	11.0-19.4	18.2	18	11.32	D
4	19.5-21.9	20.7	57	35.85	A
5	22.0-24.4	23.2	8	5.03	E
6	24.5-26.9	25.7	7	4.4	F
7	21.0-29.4	28.2	0	-	-
		Total	**159**		

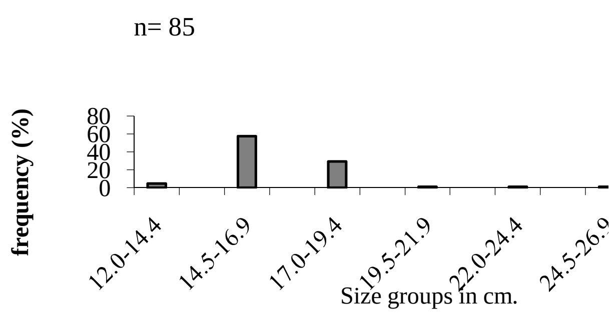

Fig. 5. Size frequency distribution for the male of *Liza macrolepis.*

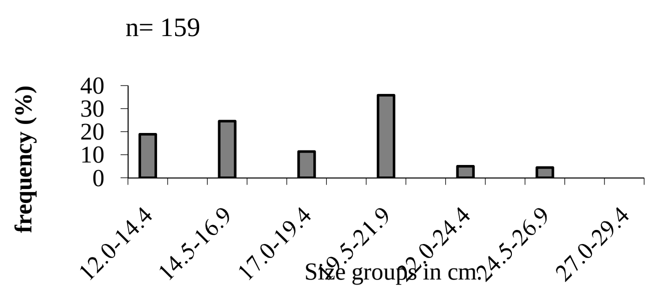

Fig. 6. Size frequency distribution for the female of *Liza macrolepis.*

Table 7: Size frequency distribution for the combined sexes of *Valamugil speigleri* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	13.0-13.9	13.45	42	14.33	C
2	14.0-14.9	14.45	73	24.91	A
3	15.0-15.9	15.45	19	6.48	F
4	16.0-16.9	16.45	31	10.58	E
5	11.0-11.9	11.45	40	13.65	D
6	18.0-18.9	18.45	42	14.33	C
7	19.0-19.9	19.45	46	15.7	B
		Total	**293**		

Table 8: Size frequency data for male of *Valamugil speigleri* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	13.0-13.9	13.45	26	15.29	B
2	14.0-14.9	14.45	47	21.65	A
3	15.0-15.9	15.45	11	6.47	D
4	16.0-16.9	16.45	20	11.76	C
5	11.0-11.9	11.45	20	11.76	C
6	18.0-18.9	18.45	26	15.29	B
7	19.0-19.9	19.45	20	11.76	C
		Total	**170**		

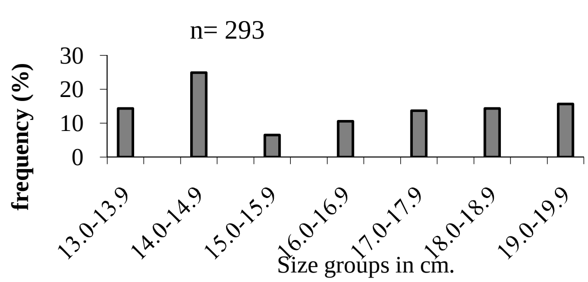

Fig. 7. Size frequency distribution of *Valamugil speigleri.*

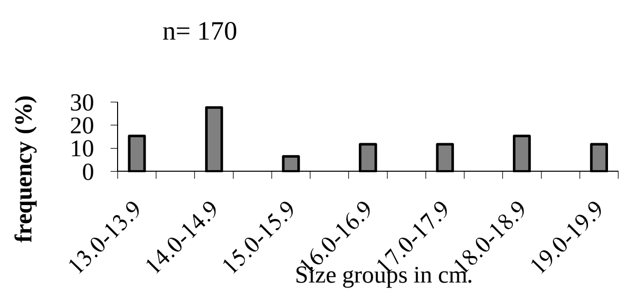

Fig. 8. Size frequency distribution for the male of *Valamugil speigleri.*

Table 9: Size frequency data for female of *Valamugil speigleri* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	13.0-13.9	13.45	17	13.82	C
2	14.0-14.9	14.45	25	20.33	A
3	15.0-15.9	15.45	8	6.5	F
4	16.0-16.9	16.45	11	8.94	D
5	11.0-11.9	11.45	20	16.26	B
6	18.0-18.9	18.45	17	13.82	C
7	19.0-19.9	19.45	25	20.33	A
		Total	**123**		

Table 10: Size frequency distribution for the combined sexes of *Mugil cephalus* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	cm.	N	(%)	
1	20.0-22.5	21.25	27	16.67	B
2	22.6-25.1	23.85	60	31.04	A
3	25.2-21.7	26.45	27	16.67	B
4	21.8-30.3	29.05	15	9.26	C
5	30.4-32.9	31.65	10	6.17	F
6	33.0-35.5	34.25	11	6.79	E
7	35.6-38.1	36.85	12	1.41	D
		Total	**162**		

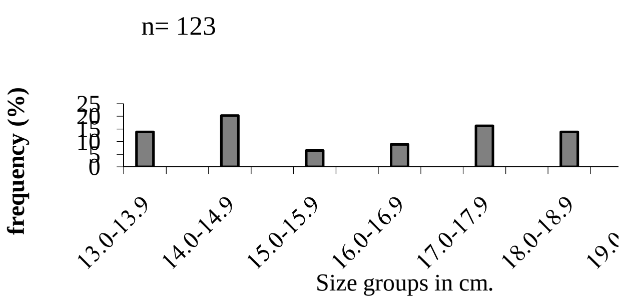

Fig. 9. Size frequency distribution for the female of *Valamugil speigleri.*

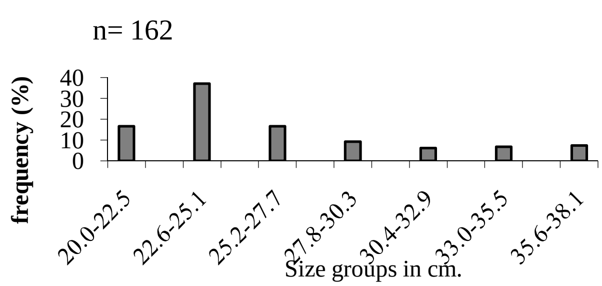

Fig.10. Size frequency distribution of *Mugil cephalus.*

Table 11: Size frequency data for male of *Mugil cephalus* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	**cm.**	**N**	**(%)**	
1	20.0-22.5	21.25	13	15.48	C
2	22.6-25.1	23.85	28	33.33	A
3	25.2-21.7	26.45	19	22.62	B
4	21.8-30.3	29.05	8	9.52	D
5	30.4-32.9	31.65	5	5.95	F
6	33.0-35.5	34.25	7	8.33	E
7	35.6-38.1	36.85	4	4.76	G
		Total	**84**		

Table 12: Size frequency data for female of *Mugil cephalus* (April 2011 to December 2012).

No. of Obs.	Size groups	Class Mid point	No. of samples	frequency	Rank
	cm.	**cm.**	**N**	**(%)**	
1	20.0-22.5	21.25	14	11.95	B
2	22.6-25.1	23.85	32	41.03	A
3	25.2-21.7	26.45	9	11.54	C
4	21.8-30.3	29.05	8	10.26	D
5	30.4-32.9	31.65	5	6.41	E
6	33.0-35.5	34.25	2	2.56	F
7	35.6-38.1	36.85	8	10.26	D
		Total	**78**		

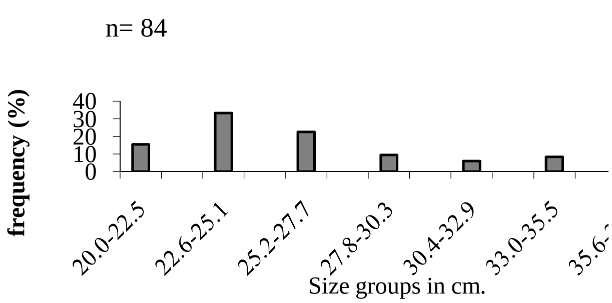

Fig. 11. Size frequency distribution for the male of *Mugil cephalus.*

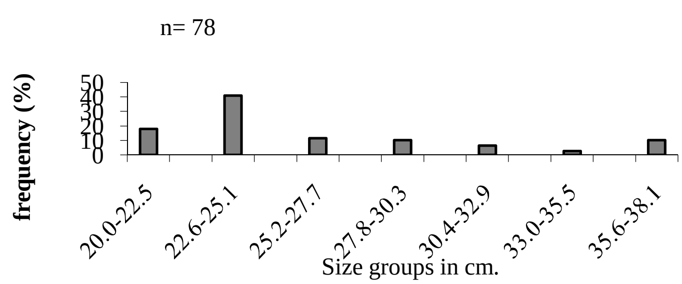

Fig. 12. Size frequency distribution for the female of *Mugil cephalus.*

Hence, fast growth rate in fishes is a defensive mechanism against predators. On the other hand, the sex that showed a slower growth rate will mostly undergo predation, so its abundance in the large size groups will be decreases disproportionally. The variation in the body size of males from that of females may be due to the large preamble size of a particular sex selectively capture by fishermen, that may modify the stock sexual composition (Nikolsky, 1963). The variation also occurred in the growth rate of fish by sex, as observed by Quignard and Farrugio (1981).

If the growth of males is higher than females than males will be slightly predominated in the large size groups, while females will be predominately occurred in the small size groups. El-Halfawy (2004) reported that in natural mullet community, males mature earlier than females, therefore, the size of sexually mature male was found to be smaller than that of female fish. Hence, in this study, it might be possible that females of these mullet species grow faster than males. Thus, females were predominated in the large size groups than males of these selected mullet species. In fact, the females of grey mullets lived longer and therefore, more dominated in older groups. However, these variations in the growth rate of any fish species by sex were not remaining constant in the coastal waters of the different regions of the world or at different latitudes or in the different zones of Bay or estuary as reported by Juras (1984), Vazzoler (1991) and Vicentini and Araujo (2003) for *Micropogonias furnieri* (Sciaenidae) in Sepetiba Bay. Likewise, Karna *et al*. (2011) also observed the variations in size frequency distribution of *Valamugil speigleri* in the three different sectors of Chilika Lagoon. Accordingly, the adults of *V. speigleri* preferred the sector with high salinity or marine water condition and higher depth, while medium size individuals found in the sector with brackish water condition, and juveniles preferred the sector of low salinity and low depth. Furthermore, it has been observed that different size groups can coexists in the same area, however, their abundance was found to be varied due to seasonality, turbidity, vegetation spawning, availability of food and salinity as reported by Koutrakis *et al*. (1994), Cardona (2000), Vicentini and Araujo (2003), Trape *et al*. (2009) and Akinrotimi *et al*. (2010).

Furthermore, the number of males and females in the total catch for each mullet species was also found to be varied. In *L. macrolepis*, the number of females was found to be significantly abundant than that of males in the total specimens (Tables (5,6); Figs. (5,6). While in remaining mullet species, both males and females were more or less equal in numbers in their total catch (Tables (2,3, 8,9,11,12). This may be due to selective fishing factor for catching large-sized fishes that were mostly preferred by the fishermen during the commercial catches and hence, modifying the stock sexual composition (Nikolsky, 1963; Abou-Seedo and Dardzie, 2004).

In *L. macrolepis,* size of females was significantly smaller than that of males (Tables (5,6); Figs. (5,6). While in the remaining mullet species, size of males and females were almost same (Tables (2,3, 8,9,11,12). Oni *et al*. (1983) reported the two main factors such as feeding intensity and reproductive phenomenon were responsible for the size of fish. While Welcome (1979) reported that the size of fish mostly depends on changing in habitat and maturation of gonads. As the size of fish mostly depends on several environmental and physiological factors, therefore, the size measurement is biologically more significant than age (Karna *et al*., 2011). According to the Abowei and Hart (2007), the maximum size attained by a fish species can be varied in different water bodies due to noise pollution from outboard engine, high fishing pressure and industrial activities that cause environmental pollution and degradation.

C. Size frequency data of immature individuals of mullets

In the present study, juveniles or immature individuals (less than 8.0 cm) were absent in the total catch of all four mullet species. Only medium size (mature) and large size (adults) specimens of each mullet species were observed in the present study. This might be due to the several reasons, such as, Firstly, large size fishes were available in the landings at Karachi coast perhaps due to the differential fishing, because fishermen mostly preferred the large-sized individuals during commercial catch(Luther, 1964). Secondly, as juveniles of grey mullets (> 60mm) are active swimmers and move faster, therefore, cannot be capture with bag seine nets. Thirdly, absence of juveniles might be due to their migration from seawater to estuaries, as they mostly preferred the water with low salinity levels (Cardona, 2006; Akinrotimi *et al*. 2010). Hence, juveniles were more concentrated in the lagoons, estuaries and lakes, while large-sized individuals or adults were more concentrated in seawater (Chang *et al*. 2000; Akinrotimi *et al*., 2010). Kautrakis *et al*. (1994) observed that the occurrence of juveniles also depends on spawning season. Therefore, it has been reported that adult mullets migrate towards the sea for spawning and return to brackish water, rivers, or lakes after spawning, while their juveniles migrate towards the estuaries or rivers or lakes for nursery grounds (Thomson, 1997; Chang and Tzeng, 2000). Koutrakis *et al*. (1994), Cardona (2006) and Mickovic *et al*. (2010) observed the seasonal variation in the size frequency distribution of mullets, which might be due the spawning period, salinity, and migration and growth status of fish stock.

CONCLUSIONS

From result of the present study, it had been concluded that the study of the size frequency distribution will provides useful information about the habitat condition, health and water quality of Pakistan coast, which was found to be suitable for the grey mullets. Size frequency data of fish species revealed many ecological and life history traits and alsoconsider as useful tool to determine the ages of fish species (Bagenal and Tesch, 1978), together with catch per unit efforts (CPUE) that provides a details about the different disturbance régime of the coastal waters, spawning grounds and spawning seasons of fish, the general heath, density, condition and status of fish species.

Understanding the size structure of any fish populations is quiet necessary because size is the useful in understanding the growth, reproduction, and recruitment with changes in length of fish as early indicator of disturbance. At the assembly level, Size frequency distributions data will provide clear pictures of the combination of different fish species existing and the body sizes of each individual occur in a particular location and time. Thus, size groups of such distributions can propose processes of occurring across spatial and temporal gradients. Therefore, size frequency distribution is a common method, which is widely used in fisheries management (Ranjan *et al*., 2005; Zubia and Rehana, 2011b).

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