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Temporal variations of condition and prey-predator status for two Halfbeaks (*Hemiramphus archipelagicus* and *H. lutkei*) in the Karachi Coast of Pakistan through multi-model inference

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The present study focuses on the temporal variations of condition through multiple functions (allometric, K_A; Fulton's, K_F; relative, K_R) and prey-predator status through relative weight (W_R) for two halfbeaks, *Hemiramphus archipelagicus* (Collette & Parin, 1978) and *Hemiramphus lutkei* (Valenciennes, 1847) using the monthly samples from the Karachi Coast of Pakistan during January to December 2014. The smallest individual was 14.0 cm in TL for both species, but the largest individuals were 23.5 in TL for *H. archipelagicus* and 27.8 cm in TL for *H. lutkei*. The BW ranged from 8.0-27.4 g for *H. archipelagicus* and 7.0-37.4 g for *H. lutkei*. There was significant differences in length-frequency distributions (LFDs) between two species (P<0.001). The K_F was highly correlated with TL for both species (Spearman rank test, P<0.001). Therefore, it is suggested that K_F is the best condition factor for assessing the wellbeing of this two Halfbeaks in the Karachi Coast of Pakistan. There was no significant relationships between TL *vs.* K_A (r_s=-0.0264, P=0.056 for *H. archipelagicus* and r_s=-0.0883, P=0.855), TL *vs.* K_R (r_s=-0.0108, P=0.813 for *H. archipelagicus* and r_s= 0.0235, P=0.608) and TL *vs.* W_R (r_s=-0.0099, P=0.828 for *H. archipelagicus* and r_s=0.0235, P=0.608 for *H. lutkei*), but significant relationships were found in TL *vs.* K_F, BW *vs.* K_A, BW *vs.* K_F, BW *vs.* K_R and BW *vs.* W_R (P<0.001) for both species. In addition, the W_R was not significantly different from 100 (Wilcoxon signed rank test, P=0.654 for *H. archipelagicus* and P=0.405 for *H. lutkei*) for both Halfbeaks in the Karachi Coast of Pakistan, indicating the habitat is still in balance condition with the good combination of prey and predators.

[**Keywords**: Halfbeak, relative weight, multiple condition factors, Karachi Coast, Pakistan]

Introduction

The Halfbeak *Hemiramphus archipelagicus* (Collette & Parin, 1978) and *Hemiramphus lutkei* (Valenciennes, 1847) are marine inhabitants of the family Hemiramphidae. The *H. archipelagicus* is commonly known as Buging in Philippines[1], Jumping halfbeak and Halfbeak in Papua New Guinea and Malaysia[2,3]. In addition the *H. lutkei* is known as Mural in India[4], Lutke's halfbeak in Malaysia[3], Tayos in Philippines[5] and Nanyo-Sayori in Japan[6]. Both fishes are widely distributed in Asia including India, Indonesia, Malaysia, Philippines, Samoa and Thailand[7]. The condition factors are the most important parameter which provide information on condition of fish species and the entire community and act as a key factor for management and conservation of natural populations[8,9]. In addition, condition factor is a quantitative parameter of the state of well-being of the fish that will determine present and future population success[10,11]. Furthermore, the relative weight (W_R) can be used to estimate the condition of fish health[12,13]. Also the W_R is essential to know the prey-predator relationships of a fish population in a water body[14].

Studies on various condition factors for different fish species have been documented[15,16,17,18].

However, still there is no research on the condition factor of *H. archipelagicus* and *H. lutkei* from Pakistan or elsewhere through multiple models using a large data series. Therefore, this study reported the first complete description on condition of two Halfbeaks *H. archipelagicus* and *H. lutkei* through multiple condition factors (allometric, Fulton's, relative) and prey-predator status through relative weight in the Karachi Coast, Pakistan using a large number of specimens over a one year study period.

Materials and Methods

This study was conducted in the Karachi Coast of Pakistan from January to December 2014. Samples were collected from the commercial fishers' catches. Fishes were caught using commercial gill nets (minimum mesh size 2.2 cm and maximum mesh size 3.1 cm). The fresh samples were immediately chilled in ice on site and fixed with 10% buffered formalin upon arrival in the laboratory. For each individual, total length (TL) was measured to the nearest 0.1 cm using digital slide calipers (Mitutoyo, CD-15PS; Mitutoyo Corporation, Tokyo, Japan) and whole body weight (BW) was taken on a digital balance with 0.1 g accuracy (Shimadzu, EB-430DW; Shimadzu Seisakusho, Tokyo, Japan).

The K_A of *H. archipelagicus* and *H. lutkei* was calculated using the equation[19]: W/L^b, where W is the body weight (BW, g) and L is the total length (TL, cm), and b is the length-weight relationships (LWRs) parameter. In addition, the K_F was calculated using the equation[20], $K_F = 100 \times (W/L^3)$, where W is the BW and L is the TL. The scaling factor of 100 was used to bring the K_F close to unit. Furthermore, the K_R for each individual was calculated using the equation[21]: $K_R = W/(a \times L^b)$, where W is the BW, L is the TL, and a, b are the LWRs parameter. Moreover, the W_R was calculated by the equation[22] as $W_R = (W/W_S) \times 100$, where W is the weight of a particular individual and W_S is the predicted standard weight for the same individual as calculated by $W_S = a*L^b$ (a and b values obtained from the composite of LWRs throughout the range of the species).

Statistical analyses were performed using Graph Pad Prism 6.5 software (GraphPad Software, Inc., San Diego, CA). The Wilcoxon signed rank test was used to compare the mean relative weight (W_R) with 100. The Spearman rank correlation test was used to analyze the relationship of TL and BW with the condition factors (K_A, K_F, K_R) and relative weight (W_R). Also analysis of covariance (ANCOVA) has been used for statistical analyses. All statistical analyses were considered significant level at 5% (P<0.05).

Results

During the study, a sum of 960 individuals of *H. archipelagicus* (n=480) and *H. lutkei* (n = 480) were sampled from the Karachi Coast. Table 1 and 2 illustrates the descriptive statistics on the length (cm) and weight (g) measurements of these two halfbeaks separately. The smallest individual was 14.0 cm in TL in the month of August and largest individuals was found 23.5 cm TL in several months for *H. archipelagicus*. Also the smallest individual was 14.0 cm in TL in several months and largest individual was found 27.8 cm in TL in the month of December for *H. lutkei*. The minimum and maximum BW was 8.0 g and 27.4 g in the month of February and April for *H. archipelagicus*, correspondingly. In addition the minimum BW was 7.0 g in the month of January and February and maximum BW was 37.4 g in the month of September for *H. lutkei* during this study. The Mann-Whitney *U*-test indicated that there was significant differences in LFDs between species (U=94555, P<0.001).

In our study the minimum and maximum K_A values were found 0.005 and 0.013 in the month of May and October for *H. archipelagicus* (Table 3 and Fig. 1) and 0.007 to 0.012 in several months for *H. lutkei* (Table 4 and Fig. 2). The minimum and maximum K_F was found 0.187 and 0.328 in the month of July and August for *H. archipelagicus* (Table 3 and Fig. 3) and 0.159 to 0.339 in the month of December and June for *H. lutkei* (Table 4 and Fig. 4). Also the minimum value of K_R was 0.796 in October and maximum was found 1.217 in April for *H. archipelagicus* (Table 3 and Fig. 5). Moreover, minimum and maximum values of K_R were 0.844-1.250 in the month of May for *H. lutkei* (Table 4 and Fig. 6). The Lowest and highest values of W_R were 79.60 to 121.71 in the month of October and April for *H. archipelagicus* (Table 3 and Fig. 7) and 84.38 to 124.93 in the month of May for *H. lutkei* (Table 4 and Fig. 8). In our study the spearman rank correlation test indicate that, the relationship between TL *vs.* K_A (r_s=-0.0264, P=0.056 for *H. archipelagicus* and r_s=-0.0883, P=0.855 for *H. lutkei*), TL *vs.* K_R (r_s=-0.0108, P=0.813, for *H. archipelagicus* and r_s=0.0235, P=0.608 for *H. lutkei*) and TL *vs.* W_R (r_s=-0.0099, P=0.828, for *H.*

archipelagicus and r_s=0.0235, *P*=0.608, for *H. lutkei*) were not significant (Table 5 and 6). But TL *vs.* K_F, BW *vs.* K_A, BW *vs.* K_F, BW *vs.* K_R and BW *vs.* W_R were highly significant (*P*<0.001) for both species in the Karachi Coast, Pakistan. According to Wilcoxon signed rank test the W_R was not significantly different from 100 (*P*=0.654 for *H. archipelagicus* and *P*=0.405 for *H. lutkei*) for both the species in the Karachi Coast of Pakistan, indicating the habitat was in balance condition with presence of prey and predator (Fig. 9 and 10).

Table 1− Descriptive statistics on the length and weight measurements of *Hemiramphus archipelagicus* (Collette & Parin, 1978) from the Karachi Coast, Pakistan

Month	*n*	TL (cm)			BW (g)		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD
January	40	15.4	21.5	18.40±2.03	9.1	22.6	16.16±4.50
February	40	15.0	23.0	18.65±2.64	8.0	27.2	15.32±5.91
March	40	14.5	23.5	19.13±2.83	8.5	25.2	16.30±5.90
April	40	14.2	23.5	19.30±2.90	9.0	27.4	16.91±6.44
May	40	15.5	22.4	18.88±2.07	10.0	25.8	18.15±5.21
June	40	16.5	23.3	20.10±2.24	12.1	27.3	19.70±5.44
July	40	15.0	23.2	19.41±2.55	9.3	23.3	16.15±5.32
August	40	14.0	23.1	19.00±2.80	9.0	27.3	18.53±6.50
September	40	15.7	23.5	18.97±2.62	8.8	24.8	16.42±5.61
October	40	14.5	22.4	18.36±2.35	9.0	25.5	17.11±5.22
November	40	15.0	23.2	19.04±2.50	10.0	27.2	19.22±5.92
December	40	15.2	23.5	19.35±2.52	10.0	25.1	17.47±5.54

n, sample size; TL, total length; BW, body weight; Min, minimum; Max, maximum; SD, standard deviation

Table 2− Descriptive statistics on the length and weight measurements of *Hemiramphus lutkei* (Valenciennes, 1847) from the Karachi Coast, Pakistan

Month	*n*	TL (cm)			BW (g)		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD
January	40	14.0	26.2	19.48±3.83	7.0	29.8	16.26±7.78
February	40	14.0	25.3	19.71±3.50	7.0	28.4	16.45±7.15
March	40	15.0	24.2	19.59±2.93	9.0	27.3	16.80±6.30
April	40	15.1	26.2	21.02±3.33	8.3	30.7	19.18±7.35
May	40	14.0	26.4	19.10±3.20	9.1	33.4	16.97±7.63
June	40	14.0	24.7	19.95±3.05	9.3	37.1	18.58±7.83
July	40	15.0	26.7	20.56±3.41	9.2	36.5	18.29±7.95
August	40	15.0	26.2	19.91±2.96	10.0	34.7	20.21±7.64
September	40	14.4	26.1	20.24±3.63	9.1	37.4	22.17±9.59
October	40	14.5	24.3	18.84±3.02	8.1	29.8	17.73±6.63
November	40	15.5	24.1	19.86±2.76	8.3	27.0	18.15±6.01
December	40	16.0	27.8	21.44±3.40	10.2	34.1	20.48±8.13

n, sample size; TL, total length; BW, body weight; Min, minimum; Max, maximum; SD, standard deviation

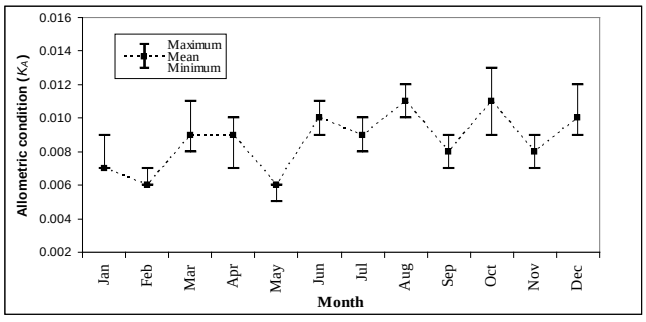

Fig. 1− Monthly changes of allometric condition (K_A) for *Hemiramphus archipelagicus* in the Karachi Coast, Pakistan

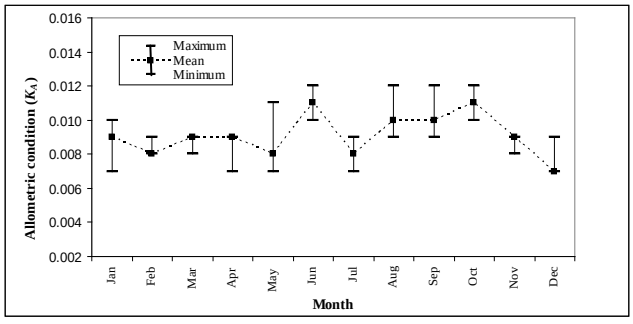

Fig. 2− Monthly changes of allometric condition (K_A) for *Hemiramphus lutkei* in the Karachi Coast, Pakistan

Table 3− Descriptive statistics on the condi tion factors (allometric, K_A; fulton's, K_F; relative, K_R) and relative weight (W_R) of *Hemiramphus archipelagicus* (Collette & Parin, 1978) from the Karachi Coast, Pakistan

Month	Allometric condition (K_A)			Fulton's condition (K_F)			Relative condition (K_R)			Relative weight (W_R)		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
January	0.007	0.009	0.007±0.0005	0.226	0.297	0.254±0.019	0.898	1.142	1.001±0.061	89.77	114.20	100.17±6.13
February	0.006	0.007	0.006±0.0003	0.210	0.267	0.227±0.015	0.958	1.101	1.007±0.041	95.50	109.80	100.45±4.04
March	0.008	0.011	0.009±0.0007	0.190	0.285	0.226±0.025	0.836	1.108	0.998±0.072	83.55	110.83	99.77±7.21
April	0.007	0.010	0.009±0.0006	0.201	0.314	0.227±0.024	0.864	1.217	1.001±0.070	86.41	121.71	100.07±6.95
May	0.005	0.006	0.006±0.0003	0.230	0.285	0.263±0.014	0.914	1.092	0.998±0.044	91.48	109.17	99.88±4.43
June	0.009	0.011	0.010±0.0002	0.216	0.271	0.238±0.014	0.960	1.046	1.003±0.022	95.90	104.64	100.25±2.20
July	0.008	0.010	0.009±0.0004	0.187	0.276	0.215±0.017	0.920	1.148	1.002±0.051	92.00	114.76	100.20±5.07
August	0.010	0.012	0.011±0.0006	0.220	0.328	0.263±0.025	0.860	1.080	0.998±0.053	85.94	108.03	90.80±5.33
September	0.007	0.009	0.008±0.0006	0.190	0.276	0.234±0.023	0.877	1.133	1.002±0.082	87.73	113.26	100.15±8.18
October	0.009	0.013	0.011±0.0010	0.221	0.316	0.271±0.029	0.796	1.160	1.001±0.087	79.60	116.03	100.01±8.75
November	0.007	0.009	0.008±0.0007	0.218	0.313	0.272±0.028	0.858	1.135	0.994±0.081	85.82	113.48	99.41±8.07
December	0.009	0.012	0.010±0.0007	0.193	0.285	0.236±0.022	0.900	1.140	1.004±0.072	90.05	113.97	100.37±7.24

Min, minimum; Max, maximum; SD, standard deviation

Table 4− Descriptive statistics on the condition factors (allometric, K_A; Fulton's, K_F; relative, K_R) and relative weight (W_R) of *Hemiramphus lutkei* (Valenciennes, 1847) from the Karachi Coast, Pakistan

Month	Allometric condition (K_A)			Fulton's condition (K_F)			Relative condition (K_R)			Relative weight (W_R)		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
January	0.007	0.010	0.009±0.0006	0.166	0.261	0.208±0.025	0.867	1.154	1.005±0.074	86.70	115.35	100.54±7.37
February	0.008	0.009	0.008±0.0003	0.173	0.255	0.205±0.019	0.932	1.065	0.998±0.032	93.30	106.52	99.82±3.21
March	0.008	0.009	0.009±0.0004	0.191	0.267	0.216±0.019	0.906	1.093	1.001±0.045	90.60	109.27	100.10±4.52
April	0.007	0.009	0.009±0.0004	0.168	0.242	0.200±0.019	0.865	1.072	1.001±0.051	86.50	107.25	100.14±5.10
May	0.007	0.011	0.008±0.0009	0.182	0.332	0.233±0.034	0.844	1.250	0.998±0.110	84.38	124.93	99.81±10.91
June	0.010	0.012	0.011±0.0005	0.226	0.339	0.262±0.029	0.907	1.132	1.004±0.056	90.70	113.18	100.40±5.56
July	0.007	0.009	0.008±0.0005	0.180	0.273	0.201±0.022	0.900	1.192	1.004±0.065	89.60	119.18	100.40±6.52
August	0.009	0.012	0.010±0.0006	0.193	0.311	0.248±0.023	0.896	1.102	0.998±0.058	89.60	110.19	99.87±5.76
September	0.009	0.012	0.010±0.0005	0.210	0.308	0.255±0.025	0.914	1.137	1.001±0.044	91.40	113.66	100.06±4.42
October	0.010	0.012	0.011±0.0008	0.203	0.297	0.257±0.027	0.911	1.145	1.006±0.073	91.12	114.52	100.65±7.33
November	0.008	0.009	0.009±0.0004	0.189	0.250	0.225±0.018	0.892	1.087	1.002±0.048	89.16	108.72	100.25±4.81
December	0.007	0.009	0.007±0.0005	0.159	0.249	0.200±0.019	0.889	1.143	0.997±0.070	88.86	114.30	99.67±6.98

Min, minimum; Max, maximum; SD, standard deviation

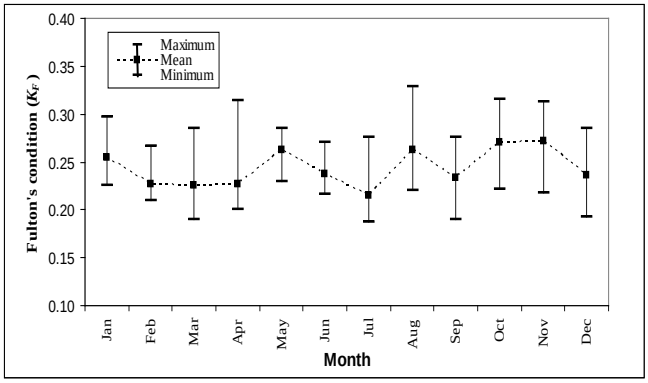

Fig. 3− Monthly changes of Fulton's condition (K_F) for *Hemiramphus archipelagicus* in the Karachi Coast, Pakistan

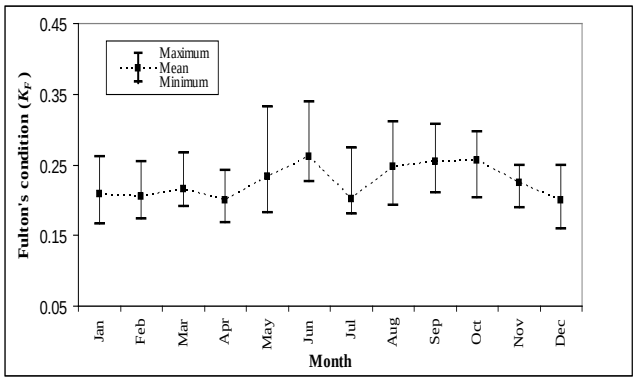

Fig. 4− Monthly changes of Fulton's condition (K_F) for *Hemiramphus lutkei* in the Karachi Coast, Pakistan

Discussion

In our study it was not possible to catch fish smaller than 14.0 cm in TL for both species and larger than 23.5 cm in TL for *H. archipelagicus* and 27.7 cm in TL for *H. lutkei*. But maximum size was recorded as 34 cm TL for *H. archipelagicus*[23] and 35 cm TL for *H. lutkei*[24] which is not similar with our findings

Table 5− Spearman rank correlation coefficient (r_s) for allometric condition (K_A), Fulton's condition (K_F), relative condition (K_R), and relative weight (W_R) with total length (TL, cm), and body weight (BW, g) of *Hemiramphus archipelagicus* (Collette & Parin, 1978) from the Karachi Coast, Pakistan

Correlation	r_s values	95% CL of r_s	*P*- values	Level of significant
TL *vs.* K_A	-0.0264	-0.1183 to -0.0659	*P*=0.564	ns
TL *vs.* K_F	-0.5410	-0.6030 to 0.4720	*P*<0.001	****
TL *vs.* K_R	-0.0108	-0.1029 to 0.0814	*P*=0.813	ns
TL *vs.* W_R	-0.0099	-0.1020 to 0.0823	*P*=0.828	ns
BW *vs.* K_A	0.2064	0.1165 to 0.2930	*P*<0.001	****
BW *vs.* K_F	-0.3182	-0.3986 to -0.2329	*P*<0.001	****
BW *vs.* K_R	0.2309	0.1417 to 0.3163	*P*<0.001	****
BW *vs.* W_R	0.2318	0.1427 to 0.3163	*P*<0.001	****

TL, total length; BW, body weight; K_A, allometric condition factor; K_F, Fulton′s condition factor; K_R, relative condition factor; W_R, relative weight; r_s, spearman rank correlation coefficient; ns, not significant; ****, highly significant, and *P*, shows level of significance

Table 6− Spearman rank correlation coefficient (r_s) for allometric condition (K_A), Fulton's condition (K_F), relative condition (K_R), and relative weight (W_R) with total length (TL, cm), and body weight (BW, g) of *Hemiramphus lutkei* (Valenciennes, 1847) from the Karachi Coast, Pakistan

Correlation	r_s values	95% CL of r_s	*P*- values	Level of significant
TL *vs.* K_A	-0.0883	-0.1004 to 0.0839	*P*=0.855	ns
TL *vs.* K_F	-0.5704	-0.6294 to -0.5047	*P*<0.001	****
TL *vs.* K_R	0.0235	-0.0689 to 0.1154	*P*=0.608	ns
TL *vs.* W_R	0.0235	-0.0688 to 0.1154	*P*=0.608	ns
BW *vs.* K_A	0.2149	0.1253 to 0.3011	*P*<0.001	****
BW *vs.* K_F	-0.3654	-0.4427 to -0.2828	*P*<0.001	****
BW *vs.* K_R	0.2512	0.1629 to 0.3353	*P*<0.001	****
BW *vs.* W_R	0.2513	0.1629 to 0.3353	*P*<0.001	****

TL, total length; BW, body weight; K_A, allometric condition factor; K_F, Fulton′s condition factor; K_R, relative condition factor; W_R, relative weight; r_s, spearman rank correlation coefficient; ns, not significant; ****, highly significant, and *P*, shows level of significance

which can be ascribed due to selectivity of fishing gear or fishermen did not go where the larger size exist[25]. Most of the studies conduct with a single condition factor, but we have used several condition factors (allometric, K_A; Fulton′s, K_F; relative, K_R), Figure 3 and 4 stated that the mean value of K_F was increasing after the month of July and continues to November, this may happened due to high food reserves or sustainable environmental condition[26,27,28]. The value of K_R was decreasing from February to June (except in April) for *H. archipelagicus* (Fig. 5) and from February to April for *H. lutkei* (Fig. 6). From our result it can be postulated that, in this time the water body was not in suitable condition due to pollution or less food[10]. The monthly mean values of W_R were 100 (≈100), that indicate the habitat was in good condition (Fig. 7 and 8). In addition this study confirmed that the both populations were in balance condition with the combination of prey and predators in the Karachi Coast, Pakistan.

Furthermore, in this study for *H. archipelagicus*, the W_R was highest in the month of April and this may happened due to available prey and lowest W_R was found in the month of October and this may due to unavailability of prey and for presence of harmful predator[29] or other physiological stress. For *H. lutkei*, the W_R was highest in the month of May which indicates the favorable condition with availability of prey[30]. This is the first study to assess a well-being of the two halfbeaks through multiple condition factors and to estimate prey-predator status using relative weight in the Karachi Coast, Pakistan. There is no available literature or text on the condition factors and relative weight for *H. archipelagicus* and *H. lutkei* that prevents to compare with our findings.

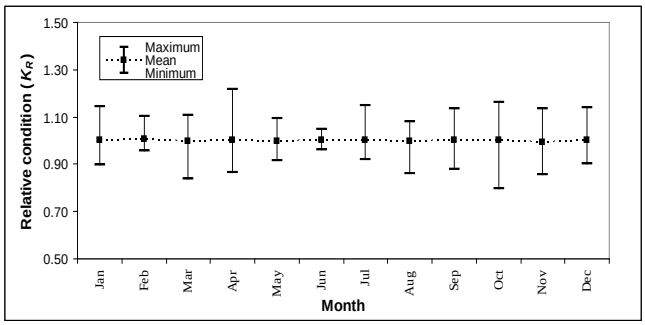

Fig. 5− Monthly changes of relative condition (K_R) for *Hemiramphus archipelagicus* in the Karachi Coast, Pakistan

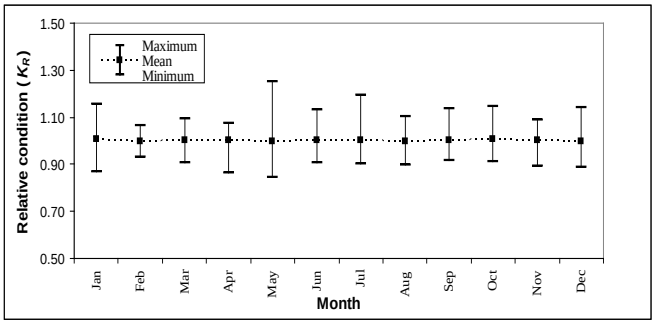

Fig. 6– Monthly changes of relative condition (K_R) for *Hemiramphus lutkei* in the Karachi Coast, Pakistan

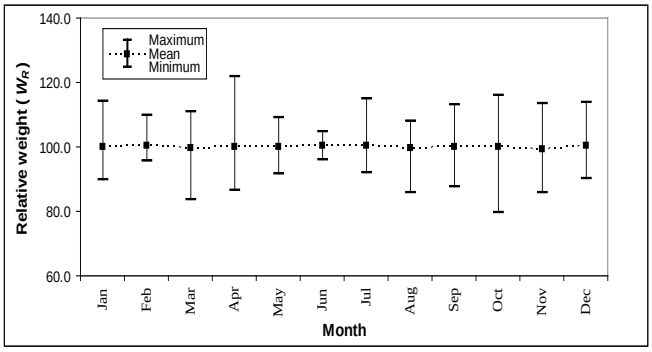

Fig. 7– Monthly changes of relative weight (W_R) for *Hemiramphus archipelagicus* in the Karachi Coast, Pakistan

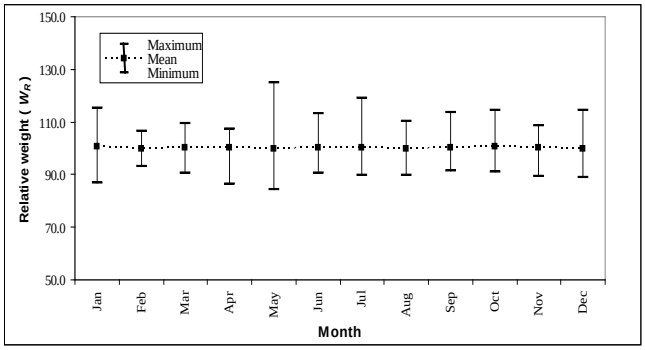

Fig. 8– Monthly changes of relative weight (W_R) for *Hemiramphus lutkei* in the Karachi Coast, Pakistan

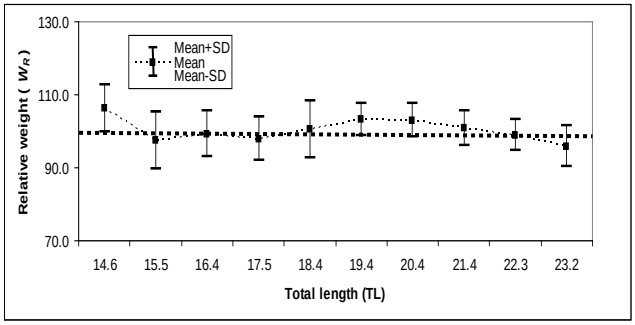

Fig. 9– Relationships between total length (TL) and relative weight (W_R) of *Hemiramphus archipelagicus* in the Karachi Coast, Pakistan

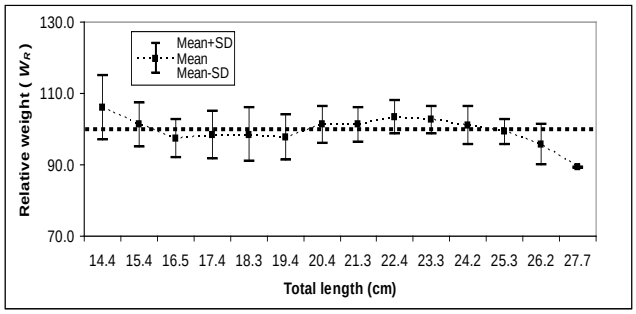

Fig. 10– Relationships between total length (TL) and relative weight (W_R) of *Hemiramphus lutkei* in the Karachi Coast, Pakistan

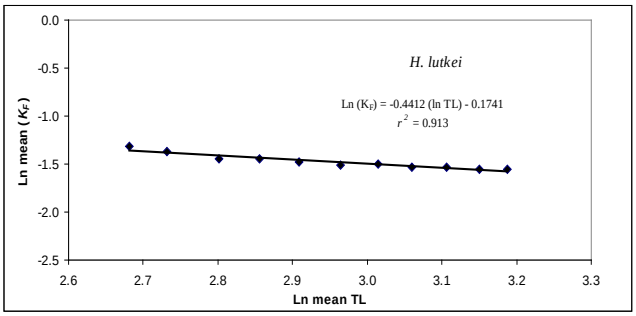

Fig. 11– Relationships between total length (TL) and Fulton's condition factor (K_F) of *Hemiramphus archipelagicus* in the Karachi Coast, Pakistan

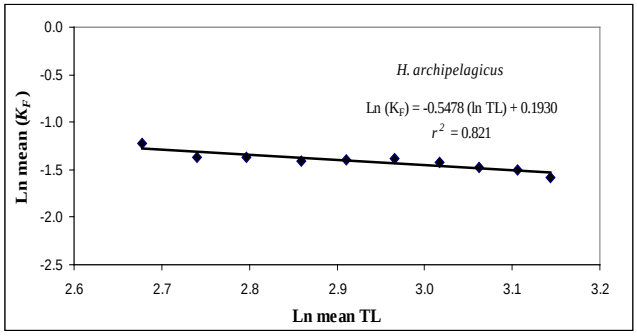

Fig. 12– Relationships between total length (TL) and Fulton's condition factor (K_F) of *Hemiramphus lutkei* in the Karachi Coast, Pakistan

Conclusion

The findings of the present study would be very effective for sustainable management of these two halfbeaks in the Karachi Coast or any other water-bodies.

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