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Original Article

An investigation on morphology, age and growth of the Caspian Sea Kilka (*Clupeonella cultriventris*) in Babolsar, southern Caspian Sea

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Abstract: In this study, 160 fishes were randomly collected from commercial catch by a cone net in Babolsar Port from January to October 2010. The biological features of specimens were measured. 2^+ years old fishes made the dominant age group with 33.75% and 1^+ and 5^+ years old had the least frequency (8.75%). Relationship between length and weight indicated negative allometric growth pattern (b=2.581). The Von-Bertalanffy growth parameters were calculated as L_∞=131.57 mm, k=0.26 and t_0=-1.02. Growth performance index was 1.66 and the total mortality (Z), natural (M) and fishing (F) mortality coefficients were 0.9 year, 0.43 and 0.47, respectively. The exploitation ratio (E) was calculated as 0.52.

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Introduction

Identification of fishes is the first stage to manage the aquatic ecosystem and conservation of the stocks (Yaoungs and Robson, 1978). Kilka belongs to the species *Clupeonella* and Clupeidae or Herring family. There are three genus of Kilka in the Caspian Sea including common Kilka (*Clupeonella cultriventris*), anchovy (*Clupeonella engrauliformis*) and Big-eye Kilka (*Clupeonella grimmi*) that are identified by morphometric parameters (Anonymous, 1978). Kilka is fished by cone nets using under water light to attract fishes at nights (Yermalchev and Sedov, 1990; Fazli and Rouhi, 2002). Kilka has an important role in the Caspian Sea ecosystem and costal countries economic. They are considered as an important part of the trophic chains (Mamedov, 2006) and also a health indicator of the Caspian Sea environment (Fazli, 1990; Razavi Sayyad, 1993; Pourgholam et al., 1996). Their stocks are needed to be protected (Pourgholam et al., 1996). Since 1998, Kilka populations have decreased due to invasion of *Mnemiopsis leidyi* as a new trophic rival, chronic poisoning with oil, phenol and heavy metal pollutants, temperature variation of the Caspian Sea and over-fishing (Paritskii et al., 2001). *Mnemiopsis leidyi* has already damaged the pelagic ecosystem of the central and southern Caspian Sea, directly or indirectly impacting all trophic levels. Previous studies confirm decline of Kilka biomass in some neighbor countries as Mamedov (2006) reported that exploitable biomass of Kilka varied from 18500t to 5100t between 2000-2004 in Azerbaijan. Since Kilka is an important part of diet of some valuable fishes like sturgeon (*Acipenser* spp. and *Huso huso*) and seal (*Phoca caspica*), decline of its biomass can threat their stocks.

There are some studies on distribution (Besharat and Khatib, 1993; Razavi Sayyad, 1993), stock assessment (Pourgholam et al., 1996; Fazli et al., 2002) and biology (Karimzadeh et al., 2010; Fatemi

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et al., 2009; Parafkandeh Haghighi, 2009; Fazli et al., 2002, 2004, 2005, 2007; Sayyad Bourani, 1997) in Kilka of southern part of the Caspian Sea.

The present study aimed to provide a renew of information on biological characteristics of *Clupeonella cultriventris* in southern part of the Caspian Sea. Such information may help to manage Kilka stocks.

Materials and Methods

This study was carried out from January to October 2010. 160 samples were randomly collected from the commercial catches, which taken by fishing boat and cone nets with a 1500 kW light to attract the fish in Babolsar Port, the southern part of Caspian Sea. Samples were preserved in 10% formaldehyde and transported to laboratory. Weight and standard length were measured by a digital scale (0.01 g) and vernier calipers (0.01 mm), respectively. Age was determined using annuli of 10 scales. In order to increase precision of age determination, scales were examined by 3 experts and, in some cases, compared with otolith.

Relationship between length and age estimated using regression model. The standard Von Bertalanffy growth equations and Ford-Walford method were used to estimate growth in each age (Bagenal and Tesch, 1978; Erdogan, 2002):

$$L_t = L_\infty (1-e^{-K(t-t0)})$$

Where L_t is the length-at-age t, L_∞ is the maximum theoretical length, k is growth coefficient and t_0 is equal to age of fish when the length is zero. The growth performance index was calculated using the following equation (Pauly and Munro, 1984):

$$\varphi' = \text{Log } k + 2 \text{ Log } L_\infty$$

The condition factor (CF) and instantaneous growth rate (G) was calculated, respectively, as:

$$CF = W/L^3$$

and

$$G = (Lnw_2 - Lnw_1)/(t_2 - t_1)$$

Where W_1 = initial wet weight of fish, W_2 = final weight of fish, t_1 = age at stocking and t_2 = age at end of the period (usually one year).

Total morality (Z) was calculated based on Beverton and Holt (1956) method follow as:

$$Z = K[\frac{(L\infty - Lc)}{(\overline{Lc} - Lc)}]$$

Where $\overline{L}c$, is average length of captured fishes and Lc is length at first capture. Also, Natural (M) mortality was estimated by Pauly's empirical equation (1984):

$$\text{Ln } M = 0.0066 - 0.279 \text{ Ln } (L\infty) + 0.6543 \text{ Ln } (K) + 0.4634 \text{ Ln } (T)$$

According to Total (Z), Natural (M) mortality and bellow relationship, fishery mortality (F) was calculated as:

$$Z = M + F$$

The exploitation ratio (E) was calculated using the equation:

$$E = \frac{F}{M + F}$$

For the morphological study, 10 features (7 morphometric and 3 meristic features) described by Berg (1949), were measured and illustrated in Tables 2 and 3. Before analysis, data were examined for normality by Kolmogorov-Smirnov test. Morphological features were standardized before the analysis and were compared in different ages by one-way analysis of variance (for metric parameters) and the Kruskal-Wallis test (for meristic parameters).

Result

Age of samples ranged between 1^+ and 5^+. The 2^+ years old fishes were the dominant age group (33.75%) and also 5^+ years old with 8.75% had the lowest frequent age groups (Table 1). The specimens had an average age of 2.9 years.

Standard length ranged from 63 to 115 mm. Mean values and standard deviations of characteristics are shown in Table 2. Morphometric and meristic characteristics did not vary significantly with increasing age (Table 2).

According to length-age relationship, length increased with increasing age logarithmically (Fig. 1, $P<0.001$) indicating that young specimens grow faster than older ones.

Table 1. Mean value of standard length (±SD), weight (±SD) and condition factor of common Kilka.

Age	Number	Frequency (%)	Standard length (mm)	Weight (g)	Condition factor	Growth rate
1^+	16	10	67.4 ± 3.2	3.64± 0.26	1.14 ± 0.08	------
2^+	54	33.75	80.2 ± 6	5.37 ± 1.16	1.03 ± 0.1	0.17
3^+	40	25	95.9 ± 2.1	8.65 ± 1.73	0.98 ± 0.18	0.18
4^+	36	22.5	102.1 ± 1.9	9.32 ± 1.16	0.88 ± 0.12	0.06
5^+	14	8.75	109.1 ±1.8	10.95 ± 1.15	0.88 ± 0.12	0.07
Total	160	100	89.3 ± 13.2	7.38 ± 2.64	0.98 ± 0.15	0.48

Table 2. Mean (±SD) of morphometric-meristic characteristics of common Kilka.

Character/age	1^+(n= 16)	2^+(n= 54)	3^+(n= 40)	4^+(n=36)	5^+(n=14)	Mean
Body depth	15±1.41	18.13±2.67	20.82±2.72	22.21±1.93	23.24±2.82	20.23
Caudal depth	5.62±0.75	7.19±1.71	8.10±1.58	8.05±1.02	8.08±1.05	7.71
Caudal fin length	13±0.82	16±1.83	18.15±1.86	18.83±2.04	19.88±2.18	17.58
Distance between eyes	2.17±0.15	2.81±0.80	3.29±0.76	3.52±0.62	3.43±0.48	3.17
Eyes diameter	3.5±0.27	4.12±0.55	4.51±0.54	4.80±0.38	5.03±0.49	4.45
Head and dorsal fin D	35.50±1.29	40.98±3.18	46.71±4.61	50.29±1.60	51.88±2.87	45.56
Dorsal and caudal fin D*	28±0.82	32.82±3.29	36.62±3.90	39.88±2.52	41.65±1.77	36.17
Dorsal fin rays	14.25±0.50	14.84±0.89	14.80±0.83	14.71±0.86	14.88±0.78	14.79
Pelvic fin rays	14.75±0.50	15.13±2.07	15.09±2.30	14.71±0.81	14.82±0.64	15
Caudal fin rays	28.25±0.96	26.71±3.73	27.30±4.09	27.46±2.08	28.12±1.65	27.24

*D= distance

Table 3. Some biological parameters of *C. cultriventris* were taken from previous studies (Abtahi et al., 2002; Abtahi et al., 2005; Fazli et al., 2006 and Janbaz and Abdolmaleki, 2009) and present study.

Parameter	Fork length (mm)				Body weight (g)				b	Age	Dominant ages
Year	Mean	S.D	Min	Max	Mean	S.D	Min	Max		(year)	(year)
1997	92.8	9.92	67.5	112.5	6.24	1.55	3.1	9.5			
1998	87.3	12.38	57.5	122.5	4.89	1.77	1.4	10.2	2.6	0-5	1 (0-3)
1999	82.5	8.48	47.5	107.5	4.17	1.17	0.8	8			
2000	**81.5**	**6.76**	**57.5**	**107.5**	**3.82**	**0.84**	**1.5**	**7.5**	**2.512**	**0-5**	**2 (0-3)**
2001	88.3	5.89	67.5	107.5	5.24	0.83	1.7	10.9	2.455	0-5	3 (2-4)
2002	85.12	7.84	52	121	4.446	1.35	1.37	14.02	2.28	1-6	3 (2-4)
2004	84.35	---	65	105	4.28	---	1.7	7.19	---	---	---
2008	93.8	11.8	50	127	7.1	2.1	1.1	16.5	2.77	1-6	4 (4-6)
2010*	**90.3**	**13.2**	**63**	**111**	**7.42**	**2.72**	**3**	**13.03**	**2.581**	**1-5**	**2 (2-4)**

According to Pauly test (P<0.05), weight and length had negative allometric relation (b=2.58), showing that the length increased faster than the weight (Fig. 2).

Standard Von-Bertalanffy growth equation was estimated as follow:

$$L_t=123.7\ (1-e^{-0.356(t+1.4)})$$

According to this formula, coefficient growth, infinity length (basically standard length) and age of fish at zero length calculated as 0.3585 per years, 120.71 mm and -1.4 years, respectively. Growth performance index was 1.66.

The total mortality (Z), natural (M) and fishing (F) mortality coefficients were 0.9 year, 0.43 and 0.47,

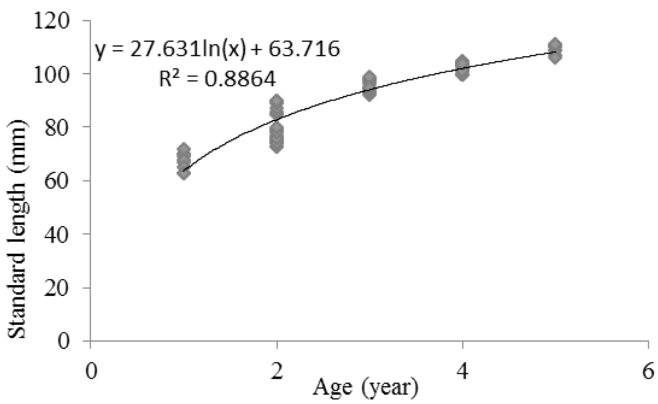

Figure 1. The relationship between standard length and age in common Kilka

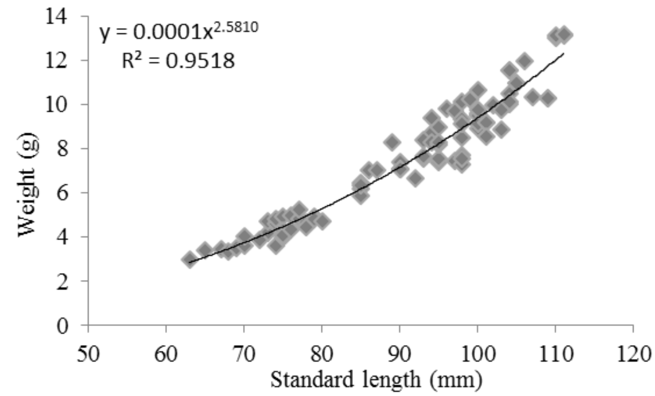

Figure 2. Relationship between standard length and weight, in common Kilka

respectively. The exploitation ratio (E) was calculated as 0.52.

Discussion

Among the *Clupeonella* species, common Kilka (*C. cultriventris*) has a distinctive distribution depth and lives in pelagic area at depth less than 50 m in the Iranian water. Recent study has shown that Kilka stocks are over-exploited (Karimzadeh et al., 2010). Also, comparison of the caught rates of three *Clupeonella* species indicates that, cone net is not proper fishing device for Kilka, so it can be exploited by independent catching methods (Abtahi, 2001; Paritskii et al., 2001; Razavi Sayyad, 1993).

Some biological parameters of *C. cultriventris* which were reported in previous studies are showed in Table 3.

According to Table 3, similar changes have happened in some parameters such as length, weight compositions and regression coefficient (b) since 1997. These changes show that common Kilka stock has been changed. For example the mean fork length was 92.8 mm in 1997 and it decreased to 81.5 during 1997-2000 (Fazli et al., 2006). After 2000, it increased to 93.8 (in 2008) again. In present study it was 90.3 ± 13.2 mm. This variation can be seen in weight, too. Mean body weight of Kilka is reported 6.24 g in 1997, 3.84 g in 2000 and 7.1 g in 2008. Based on the previous and present studies it seems that Kilka population has become younger during 1997-2000 and then older in 2000-2010. Fazli et al. (2006) suggested that after *Mnemiopsis* sp invasion in 1998, the Kilka stock migrated to deeper waters because of food competition with *Mnemiopsis* sp. Migration of common Kilka to deeper waters has resulted in over-exploitation and decrease of *C. engrauliformisas* as the main species in commercial catch (Fazli et al., 2002).

Kilka had negative allometric growth which varied during these years. Variation of the coefficient b depends on species, habitat, sex, age, feeding, season, etc. (Bagenal and Tesch, 1978).

Age composition data help us to understand the effect of environment factors on growth parameters and fishery recruitment (Stevensen and Campana, 1992). At the present study five age groups were found. Age structure varied like other parameters described before. The dominant age has increased from 1^+ to 4^+ since 1999, and decreases to 2^+ (because the mean age is 2.9 and the 3^+ years old have a high frequency (25%), we can considered it equal 3).

A decrease in the mean and maximum length, number of age groups and dominant age in present study, indicate that Kilka population is under pressure and also it can be a sign that other species of Kilka who lived in deeper water may be in risk.

At the present study fishing (F) mortality coefficient was 0.47, whereas Janbaz and Abdolmaleki (2009) reported this value as 0.44. Also the exploitation ratio of common Kilka reported as 0.294 – 0.411 and 0.51 by Chilton et al. (1982) and Janbaz and

Abdolmaleki (2009). At the present study, it was 0.51. All of these data confirm that the Kilka population is under pressure (Fazli et al., 2002).

The analysis of mean values of characteristics did not reveal significant differences between age groups especially in meristic characteristics because, most of specimens were adult (Kilka matured in 2 years old), so there was not a lot of variation in morphological characteristics. The average of body and caudal depths, caudal fin length, distance between eyes, eyes diameter and caudal fin rays of *C. engrauliformis* were 19.3±1.33, 6.96±0.7, 3.61±1.24, 5.59±0.88, 5.02±0.72 and 14.64±2.5, respectively (Rahimi Bashar and Alipour, 2009). Except the caudal fin length and distances between eyes which are higher in common Kilka, other parameters are similar to each other. This is maybe explained by species-specific characteristics'.

In conclusion, it is important to avoid over- and unmanaged fishing in spawning period of *Clupeonella* sp to recruit and preserve their stocks. We suggest continuation of Kilka's biological features to have a good view on status of stocks for better management and conservation. Also we suggest design of special fishing method for common Kilka.

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