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Age, Growth and Reproduction Characteristics of *Vimba vimba persa* in South-East of Caspian Sea (Iran)

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Abstract: In this study, age, growth and reproduction characteristics of *Vimba vimba persa* of Gorgan river in Golestan province (Iran) were studied from 1999-2000. In 1999, Males and in 2000 females dominated all age classes and this phenomenon is characteristic of species from unstable and variable environments. The von Bertalanffy growth function displayed variation in growth rates between the sexes in 2 years. Females had a higher length (in 1999: $L\infty = 416.5$ mm, $K = 0.13$ and in 2000: $L\infty = 295.2$ mm, $K = 0.27$) than males (in 1999: $L\infty = 341$ mm, $K = 0.19$ and in 2000; $L\infty = 247.4$ mm, $K = 0.32$).

Key words: *Vimba vimba persa*, age, growth, reproduction, Gorgan river, Iran

INTRODUCTION

Ecological factors affect the basic biological characteristics of fish population (Erdogan *et al*., 2002) such as age, growth and reproduction and as these characters play a key role in fish population management they are in great biological interest (Lagler, 1972).

The vimba, *Vimba vimba persa* (Pallas, 1811) is widely distributed in the river systems of Caspian, Azov, Baltic and Black sea, also in Western Europe (Robins *et al*., 1991). The species is benthopelagic and lives in fresh and brackish waters (Riede, 2004). This fish is harvested by local people for culinary purpose and is considered as a sport fishery species (Abdoli, 2000). According to Berg (1949), this fish population that live in lakes migrate upstream for spawning from the beginning of May to the end of July. Even though, there have been some studies on the systematic and biological characteristics of the vimba (Berg, 1949; Moroz, 1970; Gaygalas, 1970; Wajdowicz, 1974; Kuliev, 1988; Backiel and Bontemps, 1996; Khaval, 1998; Abbasi *et al*., 2004, 2005), however there are still little known about the environmental biology of this species. Recently because of over fishing and deterioration of its spawning grounds, this species is considered as a near threatened species for the region (Kiabi *et al*., 1999). The aim of this study was to investigate some biological characteristics such as age, growth and reproduction characteristics of *Vimba vimba persa* from Gorgan river during 2 years.

MATERIALS AND METHODS

The study area in the estuary part of Gorgan river was about 300 km long, 10-25 m wide and 20-150 cm deep, located in North-Eastern of Iran along the Southern shores of the Caspian sea (Fig. 1, Table 1). The specimens were caught monthly between March 1999 to May 2000 (but during spawning migration it was carried out weekly) by using cast-net (mesh size 10 mm), gillnets (mesh size 9-25 mm) in river and beach seine (mesh size 8-25 mm) in ground estuary in Caspian sea. All specimens (n = 445) were preserved in neutralized formaldehyde (10%) and transferred to the university laboratory where total length, wet weight and gonad weight were recorded to the nearest 1.0 mm, 0.1 and 0.01 g, respectively. Following, Lagler (1972) method 10-15 scales from the left side of the body between the lateral line and dorsal fin were removed and mounted dry between the two slides for binocular microscopic study. The previous growth of vimba was determined by back-calculation from the scale as its shape was most suitable for back-calculation. The body-scale relationship was best described by a power function. Hence, the length was back-calculated applying the following equation:

$$L_t = \left(\frac{S_t}{S}\right)(L - \alpha) + \alpha$$

Where:

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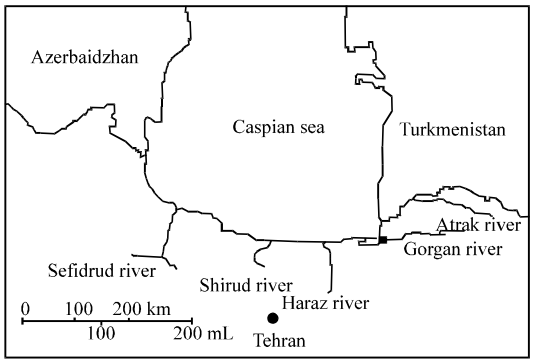

Fig.1: Location of the Gorgan river in the South-East of the Caspian sea

Table 1: Environmental characterization of the Gorgan river in spring of 2000 (min-max)

T (°C)	Salinity (%)	Turbidity (μs cm^{-1})	Conductivity (mg L^{-1})
22.8±5.54	0.66±0.42	583.54±303.6	11.01±7.58
(9.8-28.8)	(0.02-1.19)	(203-999)	(0.688-21.6)

L_t = The total length of the fish at age t
L = The total length of the fish at capture
S_t = The radius of the scale at age t
S = The radius of the scale at capture
α = Intercept on the linear regression relationship between TL and total scale radius (Bagenal, 1978)

The von Bertalanffy growth equation was fitted to mean back-calculation length at age, separately for males and females. According to Ricker (1975), the form of the growth curve is:

$$L_t = L_\infty \left\{1 - e^{-k(t-t_0)}\right\}$$

Where:
L_t = The total length of fish at the time t
L_∞ = The asymptotic total length to which the fish tend to grow
K = The growth coefficient
t_0 = The hypothetical time when the fish total length is zero

To evaluate the reliability of the growth parameters obtained by age readings they were compared to the results of other growth studies using the same species. The widely used growth performance index (Φ', phi prime) was applied to compare the fish growth (Munro and Pauly, 1983):

$$\Phi' = \log k + 2\log L_\infty$$

The seasonal changes in body condition were expressed using a derivative of growth, the condition factor index (Bagenal, 1978):

$$K = \left(\frac{W}{L^b}\right) * 100$$

Where:
W = Total weight
L = Total length and b is the slop of line

Fecundity was estimated by the Gravimetric method (Bagenal, 1978). Sex was determined by examination of the gonad tissue, visually. The gonad somatic index was calculated separately for the males and females according to the following equation:

$$GSI = \left(\frac{W_g}{W}\right) * 100$$

Where:
W_g = Gonad weight
W = Total body weight (Wootton, 1990)

The overall ratio of males to females was tested with Chi-square (χ^2) test (Zar, 1999). An Analysis of Co-variance (ANCOVA) was performed to test significant differences in growth pattern, weight-length relationship and gonad weight between 2 years.

RESULTS

According to the results, age of captured fish ranged from 1-7 years, the total length ranged between 7.8-30.5 cm and maximum recorded length was 30.5 cm, corresponding to a 7 years old female. The abundant age-class was 6^+ and 3^+ in 1999 and 2000, respectively (Fig. 2).

Length, weight, length-weight relationships and condition factor for each year are shown in Table 2. The slope of the regression (b) showing that the weight increased allometrically with the total length. By comparison between 2 years, females were longer than males within each age class. Furthermore, the length of vimba in 1999 was significantly (p = 0.05) higher than that in 2000. No significant (p = 0.05) difference was observed in weight between males and females in both years. An ANCOVA showed that there was a significant (p = 0.05) difference in terms of weight among males in 2 years but not females. According to the derived equation based on the scales reading data, there was a non-linear relationship (power function) between total length and total scale radius. The back-calculation Total Length (TL) of each age group were smaller than the observed length of the same age group when captured (p = 0.05). The mean back-calculation TL at age indicated a rapid growth in the 1st year of life but a decline during the 2-7 years (Table 3).

Table. 2: The quantities of length, weight, condition factor and length-weight relationship [ln (W) = lna+bln (TL)] of *Vimba vimba persa* in Gorgan river

Sex	No. of fish	Tl (mm)±SD	Weight (g)±SD	lna	b	R^2	K±SD
1999							
Male	53	217.0±38.4	121.8±53.8	-11.77	3.06	0.98	0.88±0.056
Female	69	227.2±34.9	149.6±66.4	-12.14	3.14	0.97	0.76±0.075
2000							
Male	206	182.3±15.5	62.1±17.8	-12.30	3.15	0.90	0.65±0.550
Female	115	189.0±17.9	74.4±25.7	-12.37	3.17	0.91	0.65±0.057

Table 3: Average back-calculation Tl (mm) at age (L_1-L_7) from scale measurements of both sexes of *Vimba vimba persa* in 2 years

Sex	L_1	L_2	L_3	L_4	L_5	L_6	L_7
1999							
Male	90.00	141.46	171.07	196.85	226.70	247.42	272.00
Female	115.08	158.78	189.40	213.05	242.40	264.70	289.76
2000							
Male	116.74	154.19	177.44	197.66	217.22	-	-
Female	100.45	148.90	179.60	206.38	233.83	-	-

Table 4: Growth parameters and the performance index (Φ') for both sexes of *Vimba vimba persa* from Gorgan river

Sex	L_∞ (mm)	K ($year^{-1}$)	t_0 (years)	r^2	Φ'
1999					
Male	341.0	0.19	-0.64	0.95	4.34
Female	416.5	0.13	-1.40	0.96	4.35
2000					
Male	247.4	0.32	-0.99	0.87	4.29
Female	295.2	0.27	-0.57	0.93	4.37

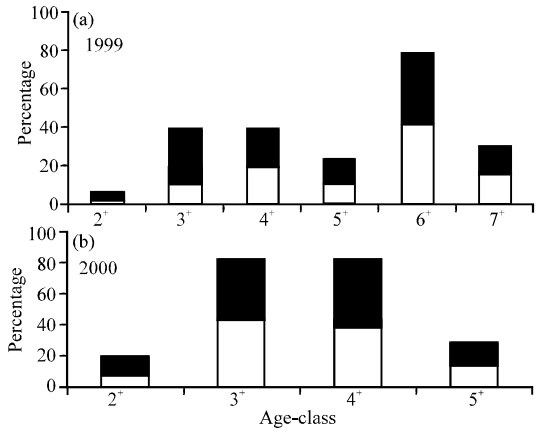

Fig. 2: Proportion of female and male *Vimba vimba persa* by age class from the Gorgan river in 1999. Black: female and white: male

The lengths decreased slightly with an increased number of rings but the serious Lee phenomenon was not expected to appear. The parameters of the von Bertalanffy growth function fitted to mean back-calculation TL at age. Overall growth performance for each sex separately is shown in Table 4. The difference between calculated value of phi prime (Φ') for captured vimba specimens in both years showed a narrow margin (4.29 and 4.37, respectively). The sex ratio of males to females in 1999 was 1:1.22 which was not statistically different ($\chi^2 = 1$, $p = 0.05$) from unity but in 2000, this ratio was 1.8:1 which was statistically different from unity ($\chi^2 = 26.28$, $p = 0.05$). The sex ratios for the vimba, divided into age classes showed that approximately males dominated all classes (Fig. 2).

The fecundity of vimba in Gorgan river varied from 5046 eggs in a specimen with length of 133 mm and 3^+ years old to 21491 eggs in a specimen with length of 231 mm and 5^+ years old in 2000. The mean individual absolute fecundity of vimba was 15157±5721 in 1999 and 9852±3788 in 2000. An ANCOVA taking the fish length as a co-variable and the year as a factor showed a significant ($p = 0.05$) difference in fecundity between the females in 2 years. A positive correlation between fecundity to body weight and gonad weight was found ($p \leq 0.05$). The relationship between fecundity and body weight and gonad weight was expressed by a semi log equation as:

$$\ln(\text{fecundity}) = 0.548 \ln W_b + 0.313 \ln Wg + 6.06$$
$$n = 105;\ r = 0.82$$

The assessment of the main spawning period was based on the GSI analysis and direct observation of the gonads. The gonad somatic index varied from 1.27-22.03 for the females and from 0.23-9.66 for the males. The highest values for both sexes were determined at the end of April, 2000. The GSI values of males were significantly ($p \leq 0.05$) lower than those of females, additionally in terms of GSI values there were not significant ($p \geq 0.05$) differences between males and females in 2 years.

DISCUSSION

Many researchers have stressed the need to validate the methods used to determine fish age (Carlander, 1987). One validation method is to use different skeletal elements for age determination. Scales are most frequently used for age determination because their collection is relatively easy and is not lethal (Berg, 1949; Wajdowicz, 1974; Kuliev, 1988; Tarkan *et al*., 2005). In terms of vimba, the most abundant age groups in commercial catch are 3^+, 4^+ and 5^+ (Moroz, 1970; Kuliev, 1988; Abbasi *et al*., 2005). In this study, the age of specimens ranged between 2 and 7 years and because of the large mesh size, fish <2 years old were not represented.

The condition factor of vimba from Gorgan river varies from 0.46-0.99 with average of 0.69±0.09, nearly equal for both sexes during 2 years. According to the result of a study was coducted by Moroz (1970) on Danube's vimba, he reported the condition factor of 1.09-2.46 (in May, 1964 and estuarian zone of the Danube)

and 1.78-2.05 (in November 1966 and 100 km from the mouth of the Danube). In agreement with Moroz's results, Kuliev (1988) recorded the condition factor of 1.03-1.82 and 1.07-1.45 for Kyzylagach bay and Agarkhan bay vimba, respectively. The condition factor of the Gorgan river vimba was significantly lower than of the others. In addition, the condition factor for vimba was function of season and age of the fish. According to Moroz (1970), the reduction in the condition factor toward spring is due to a reduction in the feeding rate and to the intensive process of maturation of the sexual products taking place at this period.

In this study both sexes at both years showed positive allometric growth pattern. The allometric growth might be due to the fact that all specimens were in prime condition during the onset of the spawning season, causing heavier body weight and therefore, a higher b value. The value of b in the length-weight relationship of males and females in both years were close to each other. Geological location and associated environmental condition such as; seasonality, stomach fullness, disease and parasite loads, age, maturity and sex can also affect the value of b (Bagenal and Tesch, 1978).

Plotting of mean length against age of fish (Fig. 3) in different reservoirs indicated that Dnieper vimba has a relatively higher body Length (TL) than fish of the same age in other vimba population as reported by Berg (1949), Moroz (1970), Wajdowicz (1974) and Kuliev (1988). This might be due to better environmental condition which may have resulted in better and higher production of food supply for vimba population (Mann, 1973).

In the present study, maximum length of vimba was recorded at 30.5 cm for specimens captured in 1999. In both years, the calculated $L\infty$ value of females was higher than that of males but in contrast the growth rate (K) for females was >1 for males. Based on the results of Froese and Binohlan (2003), the von Bertalanffy growth parameter for vimba was $L_t = [520 \{1 - EXP - 0.19 (t+0.7)\}]$. The reason for this may be that females grow faster than males and live longer (Weatherly, 1972). In this study, asymptotic lengths was calculated for each sex separately as well as for the combined 2 years showed that in 1999 the related value was higher than in 2000.

Different values of $L\infty$ were observed; these can be explained by the changes in the habitat conditions and size of specimens.

In this study, the estimated growth performance index (Φ') for both sexes and in 2 years were nearly equal. These evidences confirm the reliability of the vimba growth curve as the overall growth performance showed minimum variance for this species as it is independent of growth rate. Shikhshabekov (1979) stated that the spawning

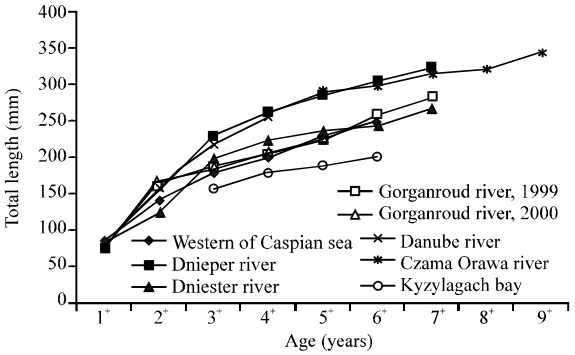

Fig. 3: Growth in length of *Vimba vimba* at several locations. Reported by Berg (1949), Moroz (1970), Wajdowicz (1974) and Kuliev (1988) and past and present studies

Table 5: Absolute fecundity of *Vimba vimba* from different basins

Rivers or lakes	Absolute fecundity (no. of eggs)	Sources
Welna	80000	Kaj (1958)
Czarna Orawa	22000-47500	Wajdowicz (1974)
Vistula	40000-100000	Morawska (1964)
Dniepr	11400-136400	Volskis (1976)
Kuban	28100-90900	Volskis (1976)
Niemen	30700-75500	Volskis (1976)
Lake Ostrowieckie	21000-120000	Hliwa and Martyniak (2002)
Gorgan	6213-31920	Present study
Gorgan	5046-21491	Present study

migration of the vimba begins in April when water temperature is <10-12°C, however it is varied from year to year depending on water temperature. In this study, spawning started in March at a water temperature of 11.9°C. Tarkan *et al.* (2005) suggested the most important factors which trigger spawning in cyprinids are photoperiod and temperature. Moreover, spawning occurs from April to May and vimba get mature in the 2nd or 3rd year of life and 4 years old fish are predominant in the spawning population. Similar spawning characteristics were recorded by several researchers for the vimba within its distribution range (Kuliev, 1988).

In this study, mass-scale migration was recorded in the 1st half of April at water temperature of 22-23°C. However, the comparison of the obtained results of vimba fecundity from present study (Table 5) to that of reported by some other researchers such as Kaj (1958), Morawska (1964), Wajdowicz (1974) and Hliwa and Martyniak (2002) indicated that the results are not correspond to that from others.

CONCLUSION

There were no significant differences in growth patterns between males and females from both years. The

condition factor and the gonad somatic index indicated that reproduction occurred around April and May. The condition factor was varied from 0.46-0.99 with average of 0.69±0.09 which was nearly equal for both sexes and years.

Fecundity ranged from 5046-21491 eggs/female and correlated significantly with body weight and gonad weight and non-significantly with body length and age.

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