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# COMPARATIVE ANNUAL GROWTH ANALYSIS OF *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 (PISCES: CYPRINIDAE) IN TWO LAKE SYSTEMS OF NORTHERN GREECE

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**ABSTRACT**

Age and annual growth from observed and back-calculated lengths and weights of *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 were studied in two Greek Lakes (Lakes Volvi and Vistonis) which constitute the southwestern limit of the species distribution. Age was estimated from scales. The annuli were formed from February to March. Following lengthwise and weight wise annual growth it was found that there was an intense rate of growth during the first four years of life and especially for the first two ones, but it continues steadily up to the older ages. The comparison of growth from observed and back-calculated lengths according to sex indicated that in general there is no statistically significant difference between males and females and between the two fish populations. From the determination of the Ford's (κ) growth constant and $l_{oo}$, it was found that the rate of growth in all cases is higher in Lake Vistonis, and the males are longer than females having higher growth rates and achieving greater final lengths. The examination of weight wise growth indicated the superiority of the fishes of Lake Vistonis, which is more eutrophic than Lake Volvi and provides better feeding conditions for fish populations.

**KEY WORDS :** Cyprinidae, *Chalcalburnus chalcoides macedo-nicus,* Lakes Volvi & Vistonis (Greece), scalimetry, age, growth

## INTRODUCTION

The genus *Chalcalburnus* (Pisces: Cyprinidae) includes five species. The most widespread species is *Chalcalburnus chalcoides* whose geographic distribution extends from Asia to Europe, occurring mainly in the Ponto-Caspian region and the Danube river system (BANARESCU, 1964). In Europe and Greece there are two species, namely the *Chalcalburnus belvica* and *Chalcalburnus chalcoides*. The first is endemic in Lake Prespa (ECONOMIDIS, 1986). The second includes thirteen different subspecies (BATTALGIL, 1941; BANARESCU, 1961, 1964; BANARESCU *et al.*, 1971; ECONOMIDIS, 1986). The genus *Chalcalburnus* is leaving mainly in freshwater (lakes and rivers) or in euryhaline ecosystems (estuaries of big rivers). The subspecies *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 is endemic in Northern Greece and it occurs in the ecosystem of Lake Volvi (common name ”Yelartza”), and in Lake Vistonis and River Filiouris (common name “Alaya”) (ECONOMIDIS, 1973, 1974, 1991; ECONOMIDIS and SINIS, 1982).

Few studies have been carried out exclusively on the biology of *Chalcalburnus chalcoides*, while many systematic, ecological and administrative studies also include some biological data (SMIRNOV, 1929; MARTI, 1930; TROICKIJ, 1949; ABDURACHMANOV, 1953, 1975; SUCHANOVA, 1959; POPOVA, 1961; BITECHINA and MALESKO, 1970; LOSAKOV, 1963; KASYMOV, 1975; BITECHINA *et al.*, 1978; SCHERBUCHA, 1965). In this study, the growth of the subspecies *Chalcalburnus chalcoides macedonicus Chalcalburnus chalcoides* Stephanidis, 1971 in two Greek lakes, Volvi and Vistonis (Fig.1) has been studied and compared in terms of age determination, annual growth, time of annual ring formation and length-weight relationship.

## MATERIALS AND METHODS

Fish samples were taken monthly from September 1983 to October 1984. In addition, once during the same period, a fish sample containing a large number of specimens was taken from each lake for the determination of annual growth (“annual growth catch”). Fish were caught using seine nets with a mesh size of 14 to 50 mm and a seine net (mesh size 8 to 10 mm), in order to include young fish for the "annual growth catch". In total, 1042 fish from Lake Volvi were studied, 672 of which came from the monthly sample collections and 370 from the "annual growth catch". A total of 1099 fish from Lake Vistonis were studied, from which 586 came from the monthly sample collections and 513 from the "annual growth catch". Fish were preserved in 5% formalin solution immediately after capture.

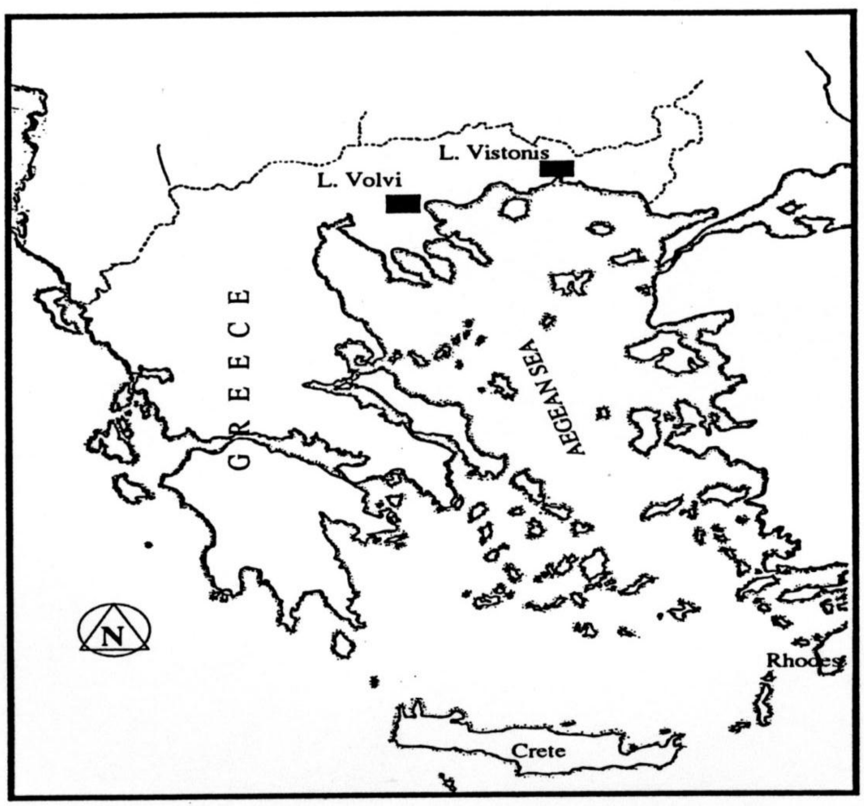


Fig.1 - Lakes Volvi and Vistonis in North Greece

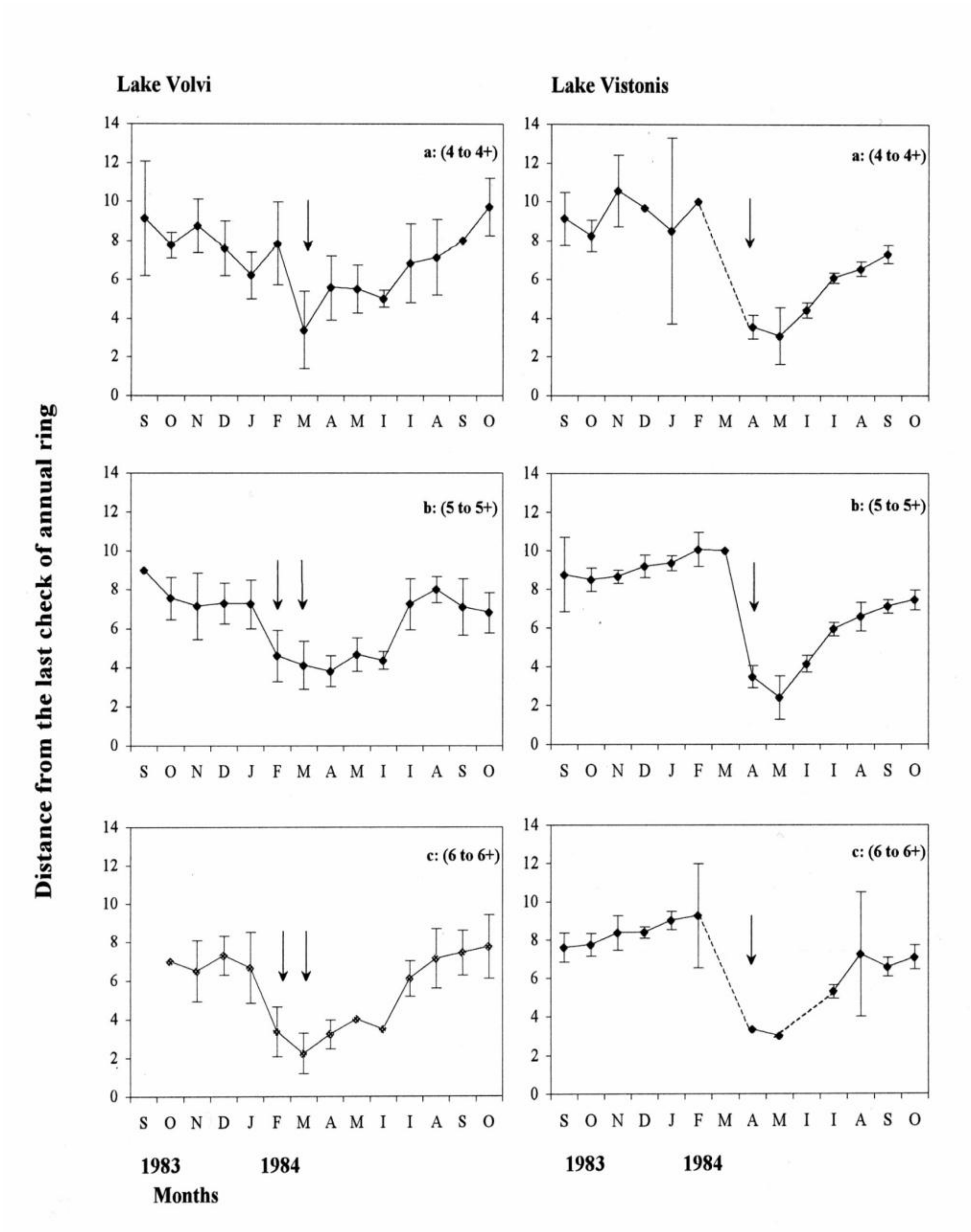


Fig.2 - Monthly changes of the distance from the last annulus to the margin of the scale *Chalcalburnus chalcoides macedonicus* and the time of the annulus formation for ages 4 to 4+ (a), 5 to 5+ (b) and 6 to 6+ (c), for both sexes in Lakes Volvi and Vistonis

Fish age was determined using scales removed from the left side of the fish, from an area just in front of the dorsal fin and above the lateral line. Scales were cleaned in 8% (w/v) NaOH (TESCH, 1971; MANN, 1973) and age was determined with the aid of a projector (magnification X 42.2). The age determined from the scale margins was confirmed using the first three of the five criteria of GRAHAM (1928). The last two were not applicable.

Net body weight was obtained by subtracting the weight of the digestive system and the gonads from the total body weight (LAGLER, 1972; RICHARD *et al.*, 1983). The total, fork and body length were measured according to ANDERSON & GUTREUTER (1983). The fork length was used mainly in the calculation and presentation of results, since the abdominal lobe of the caudal fin is longer than the dorsal lobe. The time of formation of the annulus was determined from the average distance of the last annulus from the margin of the scale (HELLAWELL, 1971; MANN, 1974; LIBOSVASKY, 1976; PETHON, 1978; LINFIELD, 1979 a, b; VESEY & LANGFORD, 1985). The time of formation was determined by measuring the distance from the last annuli to the scale margin in fish aged 4+, 5+ and 6+ from the monthly samples in each lake. These ages were selected since they were represented in almost all monthly samples.

To find out the best fitting between fish body length to scale radius were used equations suggested by LEE, SHERRIF, CARLANDER and MONASTYRSKY (LAGLER, 1972).

The relationship between net body meight (NW) and fork length (FL) was examined. The data from the "annual growth catch" of each lake were correlated separately.

## RESULTS AND DISCUSSIONS

### Age determination and time of the annual ring formation on scales

The data was examined combined in terms of sex but separately for each age. The average values of the distances and the 95% confidence intervals are illustrated in figure 2. A comparison of the results indicated that the annual ring is formed in March in Lake Volvi and in April in Lake Vistonis. In Lake Volvi fish with a new ring start to appear in February, and by April there are only a few fish not having formed an annulus. In Lake Vistonis, fish do not have an annulus in February but in April all the fish have formed a new one.

## Observed annual increase of length

In the "annual growth catch" from Lake Volvi there were no fish aged 1+ or males aged 8+. The percent mean annual growth increases up to age 2+, and thereafter decreases gradually up to age 8+, with the exception of age 4+ (Table 1). The growth increment from 3+ to 4+ is higher in comparison to growth increment 2+ to 3+. For the majority of the fishes in the age classes examined, the average length of females was slightly greater than that of the males. The opposite holds only for age 4+. A comparison of the average male and female lengths in each age class, using analysis of variance and the Fisher PLSD test, showed that the difference were not statistically significant. From table 1, it is evident that growth continues until the last age examined and is most intense up to age 4+.

In the "annual growth catch" from Lake Vistonis there were no male fish aged 7+ and 8+ (Table 2). The percent mean annual growth rate during age 1+_ is greater than those of the other ages. At age 4+ there is a marked increase in the mean growth rate. The percent increase is the same for both sexes. The percent annual growth rate is generally low, and remains relatively constant at all ages, with the exception of age 4+ where it is quite high. Above age 4+, growth tends to decrease.

## Body length - scale radius relationship

The correlation coefficient calculated during the fitting of Lee's linear equation for both populations under examination was one of the highest in all three cases for males, females and combined sexes (Table 3). In Lake Vistonis there is a better correlation between fish length and scale radius, while $R^2$ is higher in all the cases. The correlation coefficients obtained from fitting the remaining equations were of the same order of magnitude or lower. Therefore, Lee's equation was used in all cases for the back calculation of lengths from scale-radius.

Covariance analysis was used to determine if differences existed between the constants (a and b) of the calculated equations between the two lakes for the combined sexes. Using covariance analysis, the intercept (a) and the slope (b) of the straight lines for males and females from both lakes were compared. From the comparison of b, it was found that $P_{(0.01)} = 4.51$, therefore the slopes do not differ from each other. From the comparison of a, it was found that $P_{(0.01)} = 4.3$, therefore the intercepts differ from each other. Consequently, the equations have the same slope (b) but different intercept (a).

Table 1

Back-calculated and observed mean fork length (mm), mean annual growth and percentage of mean annual growth of *Chalcalburnus chalcoides macedonicus* in Lake Volvi

Lake Volvi: Males

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 0 | | | | | | | | |
| 1981 | 2+ | 10 | 94.44 | 120.64 | | | | | | |
| 1980 | 3+ | 10 | 93.52 | 119.35 | 141.10 | | | | | |
| 1979 | 4+ | 16 | 92.42 | 117.30 | 136.90 | 154.30 | | | | |
| 1978 | 5+ | 37 | 90.53 | 113.92 | 133.16 | 151.20 | 164.90 | | | |
| 1977 | 6+ | 11 | 92.06 | 114.64 | 136.20 | 152.70 | 168.50 | 181.00 | | |
| 1976 | 7+ | 6 | 92.02 | 117.95 | 138.40 | 155.70 | 170.70 | 183.40 | 193.90 | |
| 1975 | 8+ | 0 | | | | | | | | |
| Total fish | | 90 | 90 | 90 | 80 | 70 | 54 | 17 | 6 | |
| Mean length (back calculated) | | | 91.92 | 116.23 | 135.70 | 152.50 | 166.30 | 181.80 | 193.90 | |
| Mean annual growth (back calculated) | | | 91.92 | 24.31 | 19.47 | 16.80 | 13.80 | 15.50 | 12.10 | |
| % of mean annual growth (back calculated) | | | 47.41 | 12.54 | 10.04 | 8.66 | 7.12 | 7.99 | 6.24 | |
| Mean length (observed) | | | | 117.20 | 138.88 | 166.44 | 177.79 | 189.92 | 193.60 | |
| Mean annual growth (observed) | | | | 117.20 | 21.68 | 27.56 | 11.35 | 12.13 | 3.68 | |
| % of mean annual growth (observed) | | | | 60.54 | 11.20 | 14.24 | 5.86 | 6.27 | 1.90 | |

(to be continued)

Lake Volvi: Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 0 | | | | | | | | |
| 1981 | 2+ | 4 | 113.57 | 133.45 | | | | | | |
| 1980 | 3+ | 10 | 109.90 | 131.80 | 146.85 | | | | | |
| 1979 | 4+ | 43 | 110.64 | 131.60 | 148.72 | 162.58 | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 5+ | 137 | 109.75 | 129.23 | 145.67 | 160.13 | 171.56 | | | |
| 1977 | 6+ | 56 | 110.22 | 129.13 | 144.54 | 158.26 | 170.20 | 180.12 | | |
| 1976 | 7+ | 23 | 110.37 | 129.72 | 146.16 | 160.13 | 172.27 | 183.22 | 192.35 | |
| 1975 | 8+ | 7 | 110.63 | 130.27 | 145.91 | 159.91 | 174.20 | 183.84 | 192.91 | 200.70 |
| Total fish | | 280 | 280 | 280 | 276 | 266 | 223 | 86 | 30 | 7 |
| Mean length (back-calculated) | | | 110.11 | 129.79 | 146.00 | 160.17 | 171.38 | 181.25 | 192.48 | 200.70 |
| Mean annual growth (back-calculated) | | | 110.11 | 19.68 | 16.21 | 14.17 | 11.21 | 9.87 | 11.23 | 8.22 |
| % of mean annual growth (back-calculated) | | | 54.86 | 9.81 | 8.08 | 7.06 | 5.56 | 4.93 | 5.60 | 4.10 |
| Mean length (observed) | | | | 118.03 | 140.00 | 165.32 | 179.65 | 193.93 | 206.92 | 216.65 |
| Mean annual growth (observed) | | | | 118.03 | 21.97 | 25.32 | 14.33 | 14.28 | 12.99 | 9.73 |
| % of mean annual growth (observed) | | | | 54.48 | 10.14 | 11.69 | 6.61 | 6.59 | 6.00 | 4.49 |

(to be continued)

Lake Volvi: Males + Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 0 | | | | | | | | |
| 1981 | 2+ | 14 | 105.31 | 128.39 | | | | | | |
| 1980 | 3+ | 20 | 103.01 | 126.61 | 144.62 | | | | | |
| 1979 | 4+ | 59 | 102.75 | 125.59 | 144.06 | 159.60 | | | | |
| 1978 | 5+ | 174 | 101.57 | 122.89 | 140.79 | 156.78 | 169.26 | | | |
| 1977 | 6+ | 67 | 102.22 | 122.93 | 140.25 | 155.30 | 168.60 | 179.54 | | |
| 1976 | 7+ | 29 | 102.39 | 124.07 | 142.18 | 157.58 | 170.95 | 182.86 | 192.76 | 20 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1.60 |
| 1975 | 8+ | 7 | 102.52 | 124.13 | 141.34 | 156.74 | 172.45 | 183.06 | 193.04 | |
| Total fish | | 370 | 370 | 370 | 356 | 336 | 277 | 103 | 36 | 7 |
| Mean length (back-calculated) | | | 102.18 | 123.85 | 141.57 | 157.03 | 169.36 | 180.72 | 192.82 | 201.60 |
| Mean annual growth (back-calculated) | | | 102.18 | 21.67 | 17.72 | 15.46 | 12.33 | 11.36 | 12.10 | 8.78 |
| % of mean annual growth (back-calculated) | | | 50.68 | 10.75 | 8.79 | 7.67 | 6.12 | 5.63 | 6.00 | 4.36 |
| Mean length (observed) | | | | 117.39 | 139.32 | 165.63 | 179.24 | 193.39 | 206.46 | 216.65 |
| Mean annual growth (observed) | | | | 117.39 | 29.93 | 26.61 | 13.61 | 14.15 | 13.07 | 10.19 |
| % of mean annual growth (observed) | | | | 54.18 | 10.12 | 12.28 | 6.28 | 6.53 | 6.03 | 4.70 |

Table 2

Back-calculated and observed mean fork length (mm), mean annual growth and percentage of mean annual growth of *Chalcalburnus chalcoides macedonicus* in Lake Vistonis

Lake Vistonis: Males

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 14 | 91.96 | | | | | | | |
| 1981 | 2+ | 80 | 87.50 | 112.26 | | | | | | |
| 1980 | 3+ | 29 | 86.84 | 111.22 | 131.04 | | | | | |
| 1979 | 4+ | 8 | 89.60 | 112.29 | 133.10 | 151.40 | | | | |
| 1978 | 5+ | 78 | 88.83 | 112.84 | 133.85 | 152.64 | 168.27 | | | |
| 1977 | 6+ | 46 | 89.03 | 112.42 | 133.86 | 153.85 | 170.76 | 185.29 | | |
| 1976 | 7+ | 5 | 88.09 | 112.92 | 134.26 | 153.98 | 171.15 | 188.40 | 201.08 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 8+ | 1 | 90.76 | 113.38 | 138.32 | 159.78 | 176.60 | 194.58 | 211.40 | 224.16 |
| Total fish | | | 261 | 247 | 167 | 138 | 130 | 52 | 6 | 1 |
| Mean length (back-calculated) | | | 88.42 | 112.05 | 133.37 | 153.08 | 169.33 | 185.77 | 202.80 | 224.16 |
| Mean annual growth (back-calculated) | | | 88.42 | 23.63 | 21.32 | 19.71 | 16.25 | 16.44 | 17.03 | 21.36 |
| % of mean annual growth (back-calculated) | | | 39.45 | 10.54 | 9.51 | 8.79 | 7.25 | 7.33 | 7.60 | 7.53 |
| Mean length (observed) | | | 103.43 | 120.90 | 132.82 | 170.04 | 184.62 | 192.88 | - | - |
| Mean annual growth (observed) | | | 103.43 | 17.47 | 11.92 | 37.22 | 14.58 | 8.26 | - | - |
| % of mean annual growth (observed) | | | 53.62 | 9.06 | 6.18 | 19.30 | 7.56 | 4.28 | | |

(to be continued)

Lake Vistonis: Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 11 | 85.58 | | | | | | | |
| 1981 | 2+ | 107 | 83.03 | 108.38 | | | | | | |
| 1980 | 3+ | 28 | 81.18 | 104.05 | 123.79 | | | | | |
| 1979 | 4+ | 8 | 88.00 | 114.47 | 136.34 | 155.83 | | | | |
| 1978 | 5+ | 51 | 83.32 | 108.99 | 131.70 | 152.84 | 170.00 | | | |
| 1977 | 6+ | 37 | 83.68 | 108.67 | 132.10 | 152.56 | 170.60 | 185.80 | | |
| 1976 | 7+ | 8 | 81.90 | 105.99 | 129.27 | 150.25 | 169.14 | 183.42 | 198.74 | |
| 1975 | 8+ | 2 | 83.01 | 108.90 | 131.80 | 151.40 | 170.50 | 187.70 | 203.20 | 217.20 |
| Total fish | | | 252 | 241 | 134 | 106 | 98 | 47 | 10 | 2 |
| Mean length (back-calculated) | | | 83.21 | 108.18 | 130.29 | 152.75 | 170.14 | 185.50 | 199.63 | 217.20 |
| Mean annual growth (back-calculated) | | | 83.21 | 24.97 | 22.11 | 22.46 | 17.39 | 15.36 | 14.13 | 17.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 7 |
| % of mean annual growth (back-calculated) | | | 38.31 | 11.50 | 10.18 | 10.34 | 8.00 | 7.07 | 6.51 | 8.09 |
| Mean length (observed) | | | 104.19 | 118.91 | 129.80 | 174.10 | 188.00 | 197.61 | 205.12 | 223.00 |
| Mean annual growth (observed) | | | 104.19 | 14.72 | 10.89 | 44.30 | 13.90 | 9.61 | 7.51 | 17.88 |
| % of mean annual growth (observed) | | | 46.72 | 6.60 | 4.88 | 19.87 | 6.23 | 4.31 | 3.37 | 8.02 |

(to be continued)

Lake Vistonis: Males + Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 25 | 88.72 | | | | | | | |
| 1981 | 2+ | 187 | 88.15 | 109.88 | | | | | | |
| 1980 | 3+ | 57 | 83.86 | 107.61 | 127.49 | | | | | |
| 1979 | 4+ | 16 | 88.63 | 113.30 | 134.73 | 153.72 | | | | |
| 1978 | 5+ | 129 | 85.97 | 110.79 | 132.62 | 152.47 | 168.80 | | | |
| 1977 | 6+ | 83 | 86.22 | 110.45 | 132.89 | 153.21 | 170.71 | 185.63 | | |
| 1976 | 7+ | 13 | 84.72 | 109.14 | 131.69 | 152.21 | 170.45 | 185.93 | 200.23 | |
| 1975 | 8+ | 3 | 86.31 | 111.09 | 134.69 | 154.95 | 173.24 | 190.74 | 206.67 | 220.24 |
| Total fish | | | 513 | 488 | 301 | 244 | 228 | 99 | 16 | 3 |
| Mean length (back-calculated) | | | 85.66 | 110.05 | 131.82 | 152.82 | 169.64 | 185.82 | 201.43 | 220.24 |
| Mean annual growth (back-calculated) | | | 85.66 | 24.39 | 21.77 | 21.00 | 16.82 | 16.18 | 15.61 | 18.81 |
| % of mean annual growth (back-calculated) | | | 38.89 | 11.07 | 9.88 | 9.54 | 7.64 | 7.35 | 7.09 | 8.54 |
| Mean length (observed) | | | 130.91 | 119.77 | 131.46 | 170.29 | 185.68 | 195.65 | 205.12 | 223.00 |
| Mean annual growth (observed) | | | 130.91 | 15.86 | 11.69 | 38.83 | 15.39 | 9.97 | 9.47 | 17 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | .8<br>0 |
| % of mean annual growth (observed) | | | 46.60 | 7.11 | 5.24 | 17.41 | 6.90 | 4.47 | 4.25 | 8.<br>02 |

Table 3

Estimation of the parameters of the “fork length - scale radius” relationship of *Chalcalburnus chalcoides macedonicus* in Lakes Volvi and Vistonis with the Lee’s linear equation L = a + bS, where a, b = constants, L = fork length, S = Scale radius (magnification X 42.2), $R^2$ = coefficient of correlation and N = number of fishes

| | **Lake Volvi** | | | **Lake Vistonis** | | |
|---|---|---|---|---|---|---|
| | **Males** | **Females** | **Males + Females** | **Males** | **Females** | **Males + Females** |
| a | 58.40 | 83.70 | 72.90 | 54.80 | 48.80 | 51.50 |
| b | 1.23 | 1.00 | 1.10 | 1.16 | 1.19 | 1.18 |
| $L_{min}$ | 98.6 | 112.3 | 98.6 | 95.8 | 99.4 | 95.8 |
| $L_{max}$ | 193.6 | 225.1 | 225.1 | 199.7 | 237.2 | 237.2 |
| $R^2$ | 0.66 | 0.55 | 0.60 | 0.87 | 0.95 | 0.91 |
| N | 90 | 280 | 370 | 260 | 253 | 513 |

## Back-calculated annual increase of length

The back-calculated lengths for each fish were estimated and the results for each sex as well as for combined sexes are given in tables 1 and 2. From these data, it is evident that the highest mean annual growth is observed during age 1. At this age, all fish are sexually immature. From age 2, when sexual maturity begins, there is a reduction in growth rate of the population. The mean annual increase in length is characterized by a constantly declining rate from age 1 to age 8. This results from the examination of each sex separately, as well as from the combination of both sexes.

The mean fork lengths of male fish from Lake Volvi were slightly shorter than those of females. The difference in length was statistically significant for ages 1 to 5 ($L_1$-$L_5$). For ages 6 and 7, the mean lengths were almost the same and there is no statistically significant difference.

From the mean values of fork length calculated for the fish of Lake Vistonis, it is evident that males are a little longer than females. This difference occurs up to age 3. From age 4 to 7, male and female lengths are almost the same and do not differ statistically.

## Estimation of growth parameters

Ford-Walford equations were calculated from the mean back-calculated lengths of each age class for males, females and combined sexes and for each population studied.

Table 4

Mean back-calculated lengths $l_t$, $l_{oo}$, $l_{oo}$-$l_t$, and $\kappa$,
for the *Chalcalburnus chalcoides macedonicus* in Lakes Volvi and Vistonis

Lake Volvi

| | **Males** $l_{oo} = 276.19$ $\kappa = 0.874$ | | **Females** $l_{oo} = 254.55$ $\kappa = 0.868$ | | **Combined sex** $l_{oo} = 259.4$ $\kappa = 0.867$ | |
|---|---|---|---|---|---|---|
| **Age** | $l_t$ | $l_{oo}-l_t$ | $l_t$ | $l_{oo}-l_t$ | $l_t$ | $l_{oo}-l_t$ |
| 1 | 91.92 | 184.27 | 110.11 | 144.44 | 102.18 | 157.22 |
| 2 | 116.23 | 159.36 | 129.79 | 124.76 | 123.85 | 135.55 |
| 3 | 135.70 | 140.49 | 146.00 | 108.55 | 141.57 | 117.83 |
| 4 | 152.50 | 123.69 | 16.17 | 94.38 | 153.03 | 102.37 |
| 5 | 166.30 | 109.89 | 171.38 | 83.17 | 169.36 | 90.04 |
| 6 | 181.80 | 94.39 | 181.25 | 73.30 | 180.72 | 78.68 |
| 7 | 193.90 | 82.89 | 192.48 | 62.04 | 192.82 | 66.58 |
| 8 | - | - | 200.70 | 53.85 | 201.60 | 57.80 |

Lake Vistonis

| | **Males** $l_{oo}$ **= 646.15** **κ = 0.961** | | **Females** $l_{oo}$ **= 369.77** **κ = 0.914** | | **Combined sex** $l_{oo}$ **= 439.39** **κ = 0.914** | |
|---|---|---|---|---|---|---|
| **Age** | $l_t$ | $l_{oo}-l_t$ | $l_t$ | $l_{oo}-l_t$ | $l_t$ | $l_{oo}-l_t$ |
| 1 | 88.42 | 557.73 | 83.21 | 286.56 | 85.66 | 353.73 |
| 2 | 112.05 | 534.10 | 108.18 | 261.59 | 110.05 | 329.34 |
| 3 | 133.37 | 512.78 | 130.29 | 239.48 | 131.82 | 307.57 |
| 4 | 153.08 | 493.07 | 152.75 | 217.02 | 152.82 | 286.57 |
| 5 | 169.33 | 476.82 | 170.14 | 199.63 | 169.64 | 269.75 |
| 6 | 185.77 | 460.38 | 185.50 | 184.27 | 165.82 | 253.57 |
| 7 | 202.80 | 443.35 | 199.63 | 170.14 | 201.43 | 237.96 |
| 8 | 224.16 | 421.99 | 217.20 | 152.57 | 220.24 | 219.15 |

From these equations $l_{oo}$ and κ were calculated. Values are given in table 4 together with the differences of $l_{oo}-l_t$ for each age class. In figure 3, a graphic representation of the Ford-Walford equation is given as well as the decrease in growth for each population. From the very high correlation coefficients ($R^2$) of all equations, it is evident that there is a very good fit of the equations to the data. Covariance analysis indicated that the slopes (b, that is κ) for $P_{(0.01)} = 5.18$ they are not different for males and females in both lakes. However, the intercepts (a) for $P_{(0.01)} = 4.82$, differ from each other.

## Observed annual increase of weight

Judging from the values of table 5 for lake Volvi, it seems that there is no essential difference between the net weight of males and females up to age 5+. The slight difference that occurs is not statistically significant. At ages 6+ and 7+, the females are a little heavier than the males. However, the difference was not statistically significant (Fisher PLSD Test), and there is only an indication that females above age 5+ tend to be a little heavier than males. According the same table (Table 5), the values of male mean annual growth follow the expected trend of reduced growth rates with increasing age, even though at age 4+ growth is slightly higher. This growth is also valid for the females, which have a corresponding rate of growth up to age 5+. However, from age 5+ to 8+, mean annual growth increases steadily to values, which are higher than those of the males. This is the main reason, which supports the view that the females of Lake Volvi over age 5+ gain weight faster than the males.

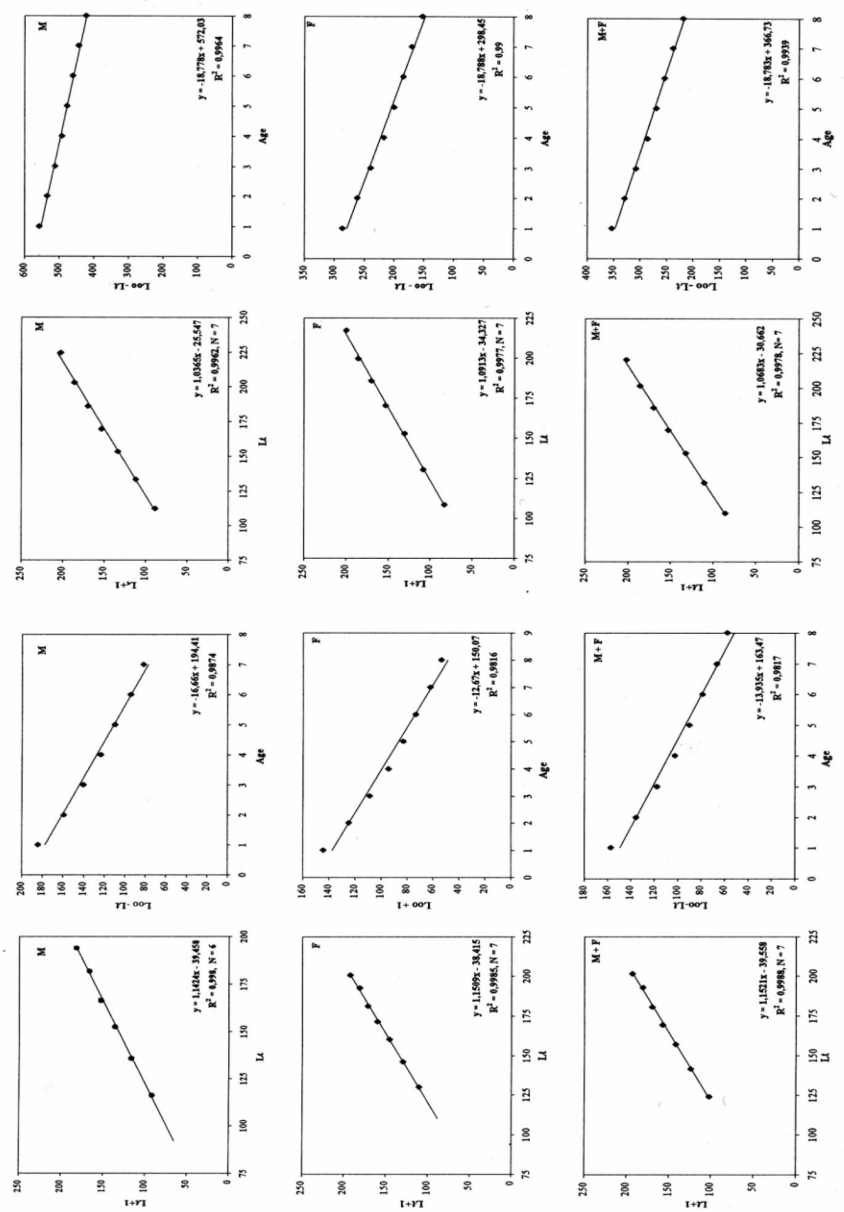


Fig.3 - Graphical presentation of the back-calculated fork lengths (FL) for *Chalcalburnus chalcoides macedonicus* with Ford-Waldorf method and the decrease of growth, according to sex and independently sex, in Lakes Volvi and Vistonis

Table 5

Back-calculated and observed mean net weight (g), mean annual growth and percentage of mean annual growth of *Chalcalburnus chalcoides macedonicus* in Lake Volvi

Lake Volvi: Males

| Year class | Age | n | $L_1$ | $L_2$ | $L_3$ | $L_4$ | $L_5$ | $L_6$ | $L_7$ | $L_8$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 0 | | | | | | | | |
| 1981 | 2+ | 10 | 7.68 | 17.66 | | | | | | |
| 1980 | 3+ | 10 | 7.43 | 17.03 | 30.09 | | | | | |
| 1979 | 4+ | 16 | 7.14 | 16.06 | 27.15 | 40.78 | | | | |
| 1978 | 5+ | 37 | 6.65 | 14.54 | 24.71 | 38.06 | 51.12 | | | |
| 1977 | 6+ | 11 | 7.05 | 14.85 | 26.68 | 39.36 | 55.01 | 70.16 | | |
| 1976 | 7+ | 6 | 7.03 | 16.36 | 28.18 | 42.05 | 57.49 | 73.38 | 88.67 | |
| 1975 | 8+ | 0 | | | | | | | | |
| Total fish | | 90 | 90 | 90 | 80 | 70 | 54 | 17 | 6 | |
| Mean weigth (back calculated) | | | 7.01 | 15.56 | 26.35 | 39.18 | 52.61 | 71.22 | 88.67 | |
| Mean annual growth (back calculated) | | | 7.01 | 8.55 | 10.79 | 12.83 | 13.43 | 18.61 | 17.45 | |
| % of mean annual growth (back calculated) | | | 7.91 | 9.64 | 12.17 | 14.47 | 15.15 | 20.98 | 19.68 | |
| Mean weigth | | | | 16.05 | 27.42 | 55.20 | 66.60 | 79.50 | 87.20 | |
| Mean annual growth | | | | 16.05 | 11.37 | 27.78 | 11.40 | 12.90 | 7.70 | |
| % of mean annual growth | | | | 18.41 | 13.04 | 31.86 | 13.07 | 14.79 | 8.83 | |

(to be continued)

Lake Volvi: Females

| Year class | Age | n | $L_1$ | $L_2$ | $L_3$ | $L_4$ | $L_5$ | $L_6$ | $L_7$ | $L_8$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 0 | | | | | | | | |
| 1981 | 2+ | 4 | 14.08 | 24.40 | | | | | | |
| 1980 | 3+ | 10 | 12.58 | 23.38 | 33.81 | | | | | |
| 1979 | 4+ | 43 | 12.87 | 23.26 | 35.30 | 48.11 | | | | |
| 1978 | 5+ | 137 | 12.53 | 21.87 | 32.89 | 45.42 | 57.46 | | | |
| 1977 | 6+ | 56 | 12.71 | 21.81 | 32.03 | 43.64 | 55.92 | 67.84 | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 7+ | 23 | 12.77 | 22.15 | 33.27 | 45.42 | 58.27 | 71.90 | 84.87 | |
| 1975 | 8+ | 7 | 12.87 | 22.47 | 33.08 | 45.21 | 60.53 | 72.73 | 85.72 | 98.10 |
| Total fish | | 280 | 280 | 280 | 276 | 266 | 223 | 86 | 30 | 7 |
| Mean weigth (back-calculated) | | | 12.67 | 22.19 | 33.15 | 45.46 | 57.25 | 69.30 | 85.07 | 98.10 |
| Mean annual growth (back-calculated) | | | 12.67 | 9.52 | 10.69 | 12.31 | 11.79 | 12.05 | 15.77 | 13.03 |
| % of mean annual growth (back-calculated) | | | 12.92 | 9.70 | 11.17 | 12.55 | 12.02 | 12.28 | 16.08 | 13.28 |
| Mean weight | | | | 16.00 | 27.72 | 51.47 | 66.11 | 87.10 | 107.80 | 128.30 |
| Mean annual growth | | | | 16.00 | 11.72 | 23.75 | 14.64 | 20.99 | 20.70 | 20.50 |
| % of mean annual growth | | | | 12.47 | 9.13 | 18.51 | 11.41 | 16.36 | 16.14 | 15.98 |

(to be continued)

Lake Volvi: Males + Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 0 | | | | | | | | |
| 1981 | 2+ | 14 | 11.21 | 21.72 | | | | | | |
| 1980 | 3+ | 20 | 10.32 | 20.72 | 32.48 | | | | | |
| 1979 | 4+ | 59 | 10.23 | 20.16 | 32.05 | 45.32 | | | | |
| 1978 | 5+ | 174 | 9.84 | 18.73 | 29.66 | 42.67 | 55.27 | | | |
| 1977 | 6+ | 67 | 10.05 | 18.75 | 29.28 | 41.32 | 54.55 | 67.46 | | |
| 1976 | 7+ | 29 | 10.11 | 19.35 | 30.66 | 43.41 | 57.16 | 71.77 | 85.77 | |
| 1975 | 8+ | 7 | 10.15 | 19.38 | 30.05 | 42.63 | 58.87 | 72.04 | 86.20 | 99.8 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 |
| Total fish | | 370 | 370 | 370 | 356 | 336 | 277 | 103 | 36 | 7 |
| Mean weigth (back-calculated) | | | 10.04 | 19.23 | 30.22 | 42.90 | 55.38 | 68.97 | 85.86 | 99.81 |
| Mean annual growth (back-calculated) | | | 10.04 | 9.19 | 10.99 | 12.68 | 12.48 | 13.59 | 16.89 | 13.95 |
| % of mean annual growth (back-calculated) | | | 10.06 | 9.21 | 11.01 | 12.70 | 12.50 | 13.62 | 16.92 | 13.98 |
| Mean weight | | | | 16.04 | 27.55 | 52.49 | 66.22 | 86.00 | 107.10 | 125.30 |
| Mean annual growth | | | | 16.04 | 11.51 | 24.94 | 13.73 | 19.78 | 21.10 | 21.20 |
| % of mean annual growth | | | | 12.50 | 8.97 | 19.44 | 10.70 | 15.42 | 16.45 | 16.52 |

Table 6

Back-calculated and observed mean net weight (g), mean annual growth and percentage of mean annual growth of *Chalcalburnus chalcoides macedonicus* in Lake Vistonis

Lake Vistonis: Males

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 14 | 7.09 | | | | | | | |
| 1981 | 2+ | 80 | 5.94 | 13.96 | | | | | | |
| 1980 | 3+ | 29 | 5.78 | 13.95 | 25.00 | | | | | |
| 1979 | 4+ | 8 | 6.46 | 14.43 | 26.43 | 41.81 | | | | |
| 1978 | 5+ | 78 | 6.26 | 14.68 | 26.96 | 43.04 | 60.90 | | | |
| 1977 | 6+ | 46 | 6.31 | 14.49 | 26.97 | 44.27 | 64.30 | 85.81 | | |
| 1976 | 7+ | 5 | 6.08 | 14.72 | 27.26 | 44.40 | 64.69 | 91.05 | 114.81 | |
| 1975 | 8+ | 1 | 6.76 | 14.93 | 30.31 | 50.65 | 72.33 | 102.14 | 137.21 | 169.04 |
| Total fish | | | 261 | 247 | 167 | 138 | 130 | 52 | 6 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean weigth (back calculated) | | | 6.16 | 14.32 | 26.62 | 43.48 | 62.27 | 86.61 | 118.35 | 169.04 |
| Mean annual growth (back calculated) | | | 6.16 | 8.16 | 12.30 | 16.86 | 18.79 | 24.34 | 31.74 | 50.69 |
| % of mean annual growth (back calculated) | | | 3.64 | 4.83 | 7.28 | 9.97 | 11.12 | 14.40 | 18.78 | 29.98 |
| Mean weigth | | | 11.16 | 18.57 | 25.66 | 63.22 | 83.91 | 96.70 | | |
| Mean annual growth | | | 11.16 | 7.41 | 7.09 | 36.56 | 21.69 | 12.79 | | |
| % of mean annual growth | | | 11.54 | 7.66 | 7.33 | 37.81 | 22.43 | 13.23 | | |

(to be continued)

Lake Vistonis: Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 11 | 5.55 | | | | | | | |
| 1981 | 2+ | 107 | 4.99 | 12.65 | | | | | | |
| 1980 | 3+ | 28 | 4.61 | 10.97 | 20.11 | | | | | |
| 1979 | 4+ | 8 | 6.11 | 15.31 | 28.17 | 44.91 | | | | |
| 1978 | 5+ | 51 | 5.05 | 12.90 | 24.97 | 41.97 | 60.85 | | | |
| 1977 | 6+ | 27 | 5.13 | 12.77 | 25.23 | 41.97 | 61.60 | 82.98 | | |
| 1976 | 7+ | 8 | 4.76 | 11.70 | 23.40 | 39.54 | 59.78 | 79.33 | 104.96 | |
| 1975 | 8+ | 2 | 4.99 | 12.86 | 25.03 | 40.61 | 61.48 | 85.98 | 113.41 | 143.10 |
| Total fish | | | 252 | 241 | 134 | 106 | 98 | 47 | 10 | 2 |
| Mean weigth (back-calculated) | | | 5.03 | 12.57 | 24.05 | 41.89 | 61.03 | 82.51 | 106.61 | 143.10 |
| Mean annual growth (back-calculated) | | | 5.03 | 7.54 | 11.48 | 17.84 | 19.14 | 21.48 | 24.10 | 36.49 |
| % of mean annual growth (back-calculated) | | | 3.52 | 5.27 | 8.02 | 12.47 | 13.37 | 15.01 | 16.84 | 25.50 |
| Mean weight | | | 11.14 | 17.60 | 23.62 | 69.10 | 87.70 | 102.50 | 117.00 | 15 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 2.30 |
| Mean annual growth | | | 11.14 | 6.46 | 6.02 | 45.48 | 18.60 | 14.70 | 14.50 | 35.30 |
| % of mean annual growth | | | 7.31 | 4.24 | 3.95 | 29.86 | 12.21 | 9.65 | 9.52 | 23.18 |

(to be continued)

Lake Vistonis: Males + Females

| **Year class** | **Age** | **n** | **$L_1$** | **$L_2$** | **$L_3$** | **$L_4$** | **$L_5$** | **$L_6$** | **$L_7$** | **$L_8$** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 1+ | 25 | 6.27 | | | | | | | |
| 1981 | 2+ | 167 | 5.42 | 13.31 | | | | | | |
| 1980 | 3+ | 57 | 5.14 | 12.36 | 22.45 | | | | | |
| 1979 | 4+ | 16 | 6.26 | 14.82 | 27.27 | 43.38 | | | | |
| 1978 | 5+ | 129 | 5.61 | 13.70 | 25.80 | 42.15 | 60.30 | | | |
| 1977 | 6+ | 83 | 5.67 | 13.55 | 25.98 | 42.88 | 62.74 | 84.26 | | |
| 1976 | 7+ | 13 | 5.33 | 12.99 | 25.18 | 41.90 | 62.41 | 84.74 | 110.00 | |
| 1975 | 8+ | 3 | 5.69 | 13.83 | 27.24 | 44.61 | 66.08 | 92.72 | 122.96 | 153.81 |
| Total fish | | | 513 | 488 | 301 | 244 | 228 | 99 | 16 | 3 |
| Mean weigth (back-calculated) | | | 5.54 | 13.38 | 25.25 | 42.49 | 61.37 | 84.57 | 112.34 | 153.81 |
| Mean annual growth (back-calculated) | | | 5.54 | 7.84 | 11.87 | 17.24 | 18.88 | 23.20 | 27.77 | 41.47 |
| % of mean annual growth (back-calculated) | | | 3.60 | 5.11 | 7.72 | 11.21 | 12.27 | 15.08 | 18.05 | 26.96 |
| Mean weight | | | 11.15 | 18.02 | 24.74 | 62.65 | 85.10 | 100.10 | 117.00 | 152.30 |
| Mean annual growth | | | 11.15 | 6.87 | 6.72 | 37.91 | 22.45 | 15.00 | 16.90 | 35 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | .30 |
| % of mean annual growth | | | 7.32 | 4.51 | 4.41 | 24.89 | 14.74 | 9.85 | 11.10 | 23.18 |

The values of mean net weight of fish from Lake Vistonis (Table 6) indicate that at primary ages there is no difference in weight between males and females. This is also evident from the analysis of variance and the Fisher PLSD tests. Females are heavier at ages 5+ and 6+.

**Length - weight relationship**

Equations best fitting the data for the males, females and for the combination of both sexes were generated.

For the calculation of constants a and b in the Le Cren equations, the equation was log transformed taking the form of a first degree polynomial:

$$W = a L^b \Rightarrow \log W = \log a + b \log L$$

The correlation coefficients ($R^2$) of all the equations were close to one, indicating a good linear correlation. In addition, b in all the equations is greater than 3 and therefore growth is allometric, that is, the increase in fish weight is greater than the increase in length (RICHARD *et al.*, 1983).

The relationships for Lake Volvi and Lake Vistonis are shown in Table 7. The slopes b of the regression lines for the males and females of the two lakes do not differ significantly between them ($P_{(0.01)}$ = 4.64) using analysis of covariance. However, there are significant differences between the intercepts ($P_{(0.01)}$ = 4.51).

Table 7

Estimation of the parameters of the "fork length - net weight" relationship of *Chalcalburnus chalcoides macedonicus* in Lakes Volvi and Vistonis with the Le Cren log transformed equation logW = loga + blogL, where a, b = constants, W = net weight, L = fork length, $R^2$ = coefficient of correlation and N = number of fishes

| **Lake Volvi** | | | **Lake Vistonis** | | |
|---|---|---|---|---|---|
| **Males** | **Females** | **Males + Females** | **Males** | **Females** | **Males + Females** |

| | | | | | | |
|---|---|---|---|---|---|---|
| a | -5.83 | -5.86 | -5.79 | -6.14 | -6.00 | -6.06 |
| b | 3.40 | 3.41 | 3.38 | 3.56 | 3.49 | 3.52 |
| $W_{min}$ | 9.4 | 13.3 | 9.4 | 9.0 | 9.5 | 9.0 |
| $W_{max}$ | 87.2 | 140.4 | 20.7 | 112.8 | 183.3 | 183.3 |
| $L_{min}$ | 98.6 | 112.3 | 98.6 | 95.8 | 99.4 | 95.8 |
| $L_{max}$ | 193.6 | 225.1 | 225.1 | 199.7 | 237.2 | 237.2 |
| $R^2$ | 0.956 | 0.957 | 0.962 | 0.996 | 0.997 | 0.996 |
| N | 90 | 280 | 370 | 260 | 253 | 513 |

**Back-calculated annual increase in weight**

The mean back-calculated weights (using the relationship above) of the fish of Lakes Volvi and Vistonis are presented in Tablea 5 and 6, according to sex and for the total number of fish. In Lake Volvi, it can be observed that males have a lower weight than females up to age 5+. From the values of mean annual growth, it is evident that both male and female fish continue to grow normally at all ages. This occurs up to age 7+ for males and age 8+ for females without any considerable decrease in growth rate.

The values of the mean back-calculated weights of the fish from Lake Vistonis according to sex indicate that a reverse growth model is valid in this lake, at least for younger ages (<5). The males of all ages are a little heavier than the females.

## CONCLUSIONS

Fish scales of the family Cyprinidae are suitable for age determination (JEARLD, 1983). The same is true for *Chalcalburnus chalcoides macedonicus* scales. TROICKIJ (1949), SUCHANOVA (1959), SCHERBUCHA (1965), BITECHINA and MALESKO (1970) and ABDURACHMANOV (1975) have used the scales for age determination of this species. SMIRNOV (1929), after many attempts and modifications of various techniques, managed to discern only two annual rings in the operculum of older fish. POPOVA (1961) used both scales and rays of the caudal fin for age determination, but got better results from the scales. In POPOVA's study, the operculum and the length-frequency method were also used for the determination of age. However, the results in both cases were not satisfactory.

While carrying out age determination from the scales, another ring was often observed just after the annual ring. This ring was neither very distinct nor complete and its boundaries are lost or overlap with those of the annual ring. This is the " reproductive " ring, which is not present on all scales and does not always occur during each reproductive period (SMIRNOV, 1929; TROIICKIJ,

1949; SUCHANOVA, 1959; SCHERBUCHA, 1965; BITECHINA and MALESKO, 1970; ABDURACHMANOV, 1975).

The examination of the annual increase in length of the species in both lakes showed that there is an intense rate of growth during the first two age classes, which is maintained relatively high until the IV age class, where after it gradually decreases. From the time that the majority of the population is sexually mature, there is a general decrease in growth rate that continues steadily up to the older ages. The elongation process continues up to the oldest age class, which was determined (VIII) in both fish populations. The declining growth rate constitutes a general phenomenon, which is observed for all species of fish (NIKOLSKY, 1963, 1969).

Age class IV seems to constitute the landmark-year in the life of the species, because before and after this year there is an intense differentiation of its growth. Examination of the observed lengthwise growth reveals that in the older age class (> IV) the fish of Lake Vistonis are somewhat longer than those of Lake Volvi (statistically only in V). The same conclusion can be obtained from the back-calculated growth of length. In the younger age classes (< VI), the observed lengthwise growth indicates a relative superiority of the fish in Lake Volvi.

A comparison of the lengthwise growth of the fish according to sex indicated that in Lake Volvi there is a slight superiority of the females in terms of length, which is evident both from the observed (statistically non significant) and the calculated growth. The same conclusion can be drawn from the examination of observed growth for the fish population of Lake Vistonis. However, consideration of the calculated growth indicates that some differentiation occurs, which in most cases causes the males to be superior to the females. However, in general and in the most cases these differentiations are small and there is no real statistically significant lengthwise growth differentiation between males and females and between the two fish populations.

For the best possible determination of lengthwise growth and for the deduction of reliable results, the growth rate was calculated using ($\kappa$), the growth constant of Ford, and $l_{oo}$, the maximum length. The growth constant of each age class in all cases is higher in Lake Vistonis. In addition, the maximum lengths ($l_{oo}$) which would be attained by fish, if these continued living in the same environment, are also attained in Lake Vistonis. It is logically acceptable that the fish of Lake Vistonis have higher growth rates and larger final lengths compared with those of Lake Volvi, since better food conditions exist in Lake Vistonis (MOUSTAKA, 1988; ZARFDJIAN, 1989; KILIKIDIS *et al.*, 1984). The comparative examination of the rate of growth ($\kappa$) and maximum lengths ($l_{oo}$) between the sexes demonstrates for each population that males are superior to females, exhibiting higher growth rates and achieving greater final lengths.

The examination of weightwise growth using the observed and calculated net fish weights leads to almost the same general conclusions as those obtained from lengthwise growth. Net weights of the fish from Lakes Volvi and Vistonis indicate that there is a more marked increase in the primary age classes. Weight increase continues with age but with a continuuuuously declining rate.

Comparing the results from the two fish populations, there is a differentiation in the weight increase between the younger and older individuals with a dividing line at age class IV. The younger fish of this age class increase in weight at nearly the same rate in both lakes, with a slight superiority of those in Lake Volvi. Above age 4+, there is a clear differentiations and the fish in Lake Vistonis increase in weight with higher rates, achieving thus higher final weights. The somewhat faster growth of fish in Lake Volvi during the primary ages (< IV), which is however nor statistically significant, could be explained by the greater environmental homogeneity and stability in this ecosystem. The more eutrophic environment of Lake Vistonis provides greater food supplies for its fish populations. The result that is derived can be comprehended even better from the growth of fish of older ages, where the observed differentiation is statistically significant. Other factors which could be added to the above are the absence of natural predators, at least of older age classes, and the lack of interest in fishing of this species in Lake Vistonis (KOKKINAKIS, 1992).

The comparison of the growth of the fish from the observed and calculated net weights according to sex shows that at younger ages in both fish populations there is no differentiation. Only in the older age classes (for Lake Volvi > VI and for Lake Vistonis > V) the differentiation between the two sexes becomes perceptible. Thus, from the observed growth, it is evident that in both fish populations the females are superior in relation to weight, whereas from the calculated growth tha males are superior. Generally, these differences are essentially unimportant and not statistically significant and cannot under any conditions express clear tendencies of differentiation of the mean weights according to age for both sexes.

By comparison with the data of other investigators (SMIRNOV, 1929; MARTI, 1930; ABDURACHMANOV, 1953, 1975; POPOVA, 1961; SCHERBUCHA, 1965; BITECHINA and MALESKO, 1970), it appears that the subspecies *Chalcalburnus chalcoides macedonicus*, in both ecosystems where it is encountered in Greece, has a smaller average size (weight and length) in every class, in relation to other populations of the same species or other subspecies, which have been studied.

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