

Age determination and growth in the Tench *Tinca tinca* (L.) in Lake Jorkjenn, southern Norway.

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The age and growth of tench *Tinca tinca* (L.) collected from Lake Jorkjenn, southern Norway was investigated. Otoliths and opercular bones were found more suitable for age determination than scales. The maximum age was 18 years, higher than previously reported. This difference is explained by the use of different ageing techniques, and fishing pressure. Most important for the year-to-year variation in growth was found to be the mean air temperature in September since this may lead to an extension of the growth season.

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INTRODUCTION

Tench *Tinca tinca* (L.) inhabit lakes, rivers and brackish water in Europe and Asia (Muus & Dahlstrøm 1978). The species has a limited distribution in southern Norway, where it was implanted 150 years ago (Huitfeldt-Kaas 1918).

The reliability of different ageing techniques in tench has not previously been studied. Scale reading is the most frequently used ageing technique both for tench (e.g. Moroz 1968) and for most other cyprinids. But in some cyprinids it has been demonstrated that otoliths (Backe-Hansen 1982) and opercular bones (Hansen 1978, 1980) are more reliable for ageing purposes than scales.

No data exists as to the biology of tench in Norway. Therefore I examined the growth of tench at the north-western limit of its distribution, and compared the suitability of otoliths, scales and opercular bones for ageing.

MATERIAL AND METHODS

The fish were collected using gill nets (10 nets graded from 10–52 mm bar mesh, 2–8 mm mesh increment) from Lake Jorkjenn, southern Norway (58°34'N, 8°53'E). Fishing was carried out in August 1984 when a total of 58 specimens was captured (range 27–39 cm, mean 32.4 cm). The tench were measured to the nearest 0.1 cm, and their sex and degree of sexual maturity were determined (Pęczalska 1968).

Both sacculus otoliths were removed, cleaned and stored dry. The opercular bones were dip-

ped in boiling water, cleaned, and air dried for several weeks. The otoliths and opercular bones were viewed under a stereoscopic microscope against a dark background, using ethanol as refracting medium. When reading the opercular bones Le Cren's (1947) method for perch *Perca fluviatilis* L. was employed. Scales were collected from the area between the dorsal and anal fin and stored dry. Cleaned scales were read using a microfiche reader. Winter zones were identified according to Bagenal & Tesch (1978). Two independent readings were made from each object. When discrepancies occurred between readings, another reading was made.

Otoliths were used for back-calculation of individual growth. When back-calculating one usually assumes that otoliths and fish grow proportionally, and that this relationship is known. In my material, however, the youngest tench (0–3 years) are missing. A relationship between fish length and otolith size through the whole length range will therefore be uncertain (Snedecor & Cochran 1973). Lea-Dahl's method (Dahl 1910) for back-calculation was used and this assumes a direct relationship between fish length and otolith size. Several authors have demonstrated such a relationship in other cyprinids e.g. bream *Abramis brama* (L.) and rudd *Scardinius erythrophthalmus* (L.) (Steinmetz 1974), white bream *Blicca bjoerkna* (L.) (Hansen 1980), and bleak *Alburnus alburnus* (L.) (Backe-Hansen 1982).

Calculations of relative growth were carried out according to Svårdson (1961) and Kempe (1962). The annual length increment is calcula-

ted for all age groups, and a standard of growth is calculated as the mean annual length increment for all age groups pooled. The annual growth increment for each age group is then expressed as a percentage of the standard of growth. Relative growth during the various years is obtained by weighing the percentages of each age group in the same year. As there are few tench older than 12 years, these fish are not considered when estimating relative growth.

RESULTS AND DISCUSSION

Reproducibility

All otoliths and the majority of the opercular bones had distinct summer and winter zones (Fig. 1a, b). In some opercular bones, however, the first zone was indistinct, and in older individuals this zone could be difficult or impossible to discern. This is probably caused by increasing bone thickness. Similar observations have been made in roach *Rutilus rutilus* (L.) (Mann 1973), chub *Leuciscus cephalus* (L.) (Mann 1976), and white bream (Hansen 1980). The absence of the first zone was detected by comparing the mean back-calculated length at age one. The difference between the two readings of otoliths and opercular bones was small, a mean of 0.28 and 0.36 respectively.

The particular shape of tench scales (Fig. 1c), makes age determination difficult in old individuals. In the youngest individuals (4 years old) the independent scale readings gave identical results, but in older individuals the difference between readings was great (mean 0.82 years).

The number of zones in otoliths, scales and opercular bones

The comparison of the number of zones in otoliths and scales demonstrated that scales had fewer zones than otoliths (Tab. 1). The difference increasing with increasing otolith age. This indicates that zone formation ceases at an earlier age in scales than in otoliths. Reduced growth and absence of zone formation in scales after maturation have been reported in several cyprinids e.g. roach (Hansen 1978), white bream (Hansen 1980), and bleak (Backe-Hansen 1982). Thus, the use of scales for age determination would underestimate the age of tench in Lake Jorkjenn.

Otoliths and opercular bones usually gave the same age estimate (Tab. 2). This indicates that the hard structure in the head region increases in size throughout their lifetime. In older tench the

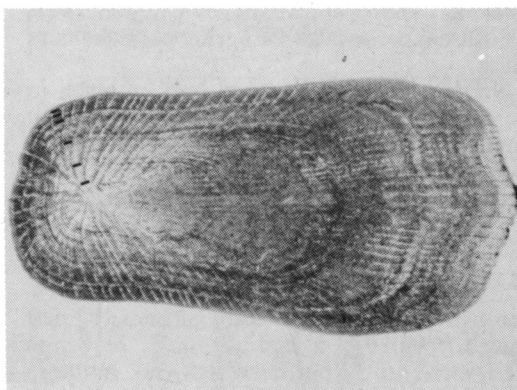
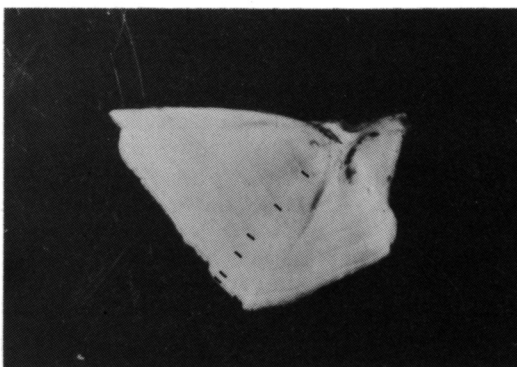
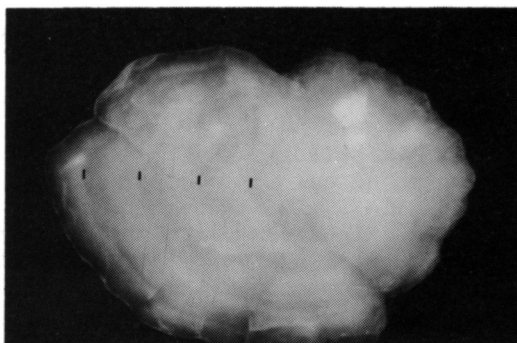


Fig. 1a. Otolith of tench caught 23. August 1984, total length 28.1 cm. 4 zones are identified.
b. Opercular bone of tench, total length 33.0 cm. 6 zones are identified.
c. Scale of 11 years old tench (according to the otolith), total length 35.6 cm. 6 zones are identified.

Table 1. Comparison between independent age readings of corresponding scales and otoliths in tench. The numbers on the diagonal show the number of tench in which scales and otoliths gave identical readings.

	Number of zones in scales																		Total	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	1																			25
2		1																		1
3			1																	4
4				1																3
5					1															6
6						1														4
7							1													3
8								1												4
9									1											4
10										1										3
11											1									4
12												1								4
13													1							1
14														1						1
15															1					1
16																1				1
17																	1			1
18																		1		1
Total																				56

Table 2. Comparison between independent age readings of corresponding opercular bones and otoliths in tench. The numbers on the diagonal show the number of tench in which opercular bones and otoliths gave identical readings.

	Number of zones in opercular bones																		Total	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	1																			26
2		1																		5
3			1																	6
4				1																4
5					1															3
6						1														4
7							1													4
8								1												4
9									1											1
10										1										1
11											1									1
12												1								1
13													1							1
14														1						1
15															1					1
16																1				1
17																	1			1
18																		1		1
Total																				58

opercular bone usually gave ages one year less than that of corresponding otoliths. This is probably due to increased bone thickness which made it difficult to identify the first winter zone.

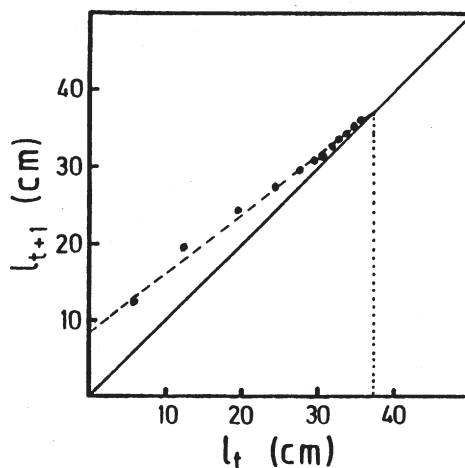


Fig. 2. Walford-plot of tench in Lake Jorkjenn. The regression line $y = 0.077x + 8.67$, $r = 0.99$ is fitted, and its intercept with the line of equality gives the estimated ultimate length ($L_{\infty} = 37.4$ cm). The intercept with the ordinate gives the estimated length at the end of the first year of life.

Van Oosten (1941) stated that fisheries research workers had «woefully neglected» to evaluate age determination by the scale method. He stressed that the validity of a method must be established for each species of fish studied. When growth is reduced due to maturity being reached, or to food limitation, it is possible that there will be a change in the appearance of an annulus and that the method of age determination will have to be modified (Beamish & McFarlane 1983). The present observations support the need for confirmation of the method. It was not possible to check the validity of the age determinations in fish of known age. But it seems reasonable to conclude that otoliths and opercular bones are better suited for the age determination of tench than scales. When estimates of age using different techniques agree there is an added degree of confidence in the determination (Chilton & Beamish 1982).

The von Bertalanffy growth model and the use of the Walford plot technique (Dickie 1978) may be used to check whether the first winter zone in the ageing object has been registered, since the back-calculated and predicted lengths assigned to the 0+ age-class may be compared (Hellawell 1974). The tench in Lake Jorkjenn were predicted to be 8.7 cm at age 1 by using the Walford-plot (Fig. 2). This almost agrees with the back-calculated length (Tab. 3). It also imp-

Table 3. Back-calculated lengths (mm) of male and female tench, obtained from measurements of otoliths.

Age group	Number	Length at age																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
4	26	62	125	195	250														
5	1	78	156	209	265	286													
6	5	62	126	196	247	288	309												
7	3	61	119	186	245	287	313	331											
8	6	63	129	203	246	275	298	315	330										
9	4	59	113	188	237	274	302	319	335	349									
10	3	55	122	188	246	267	285	299	310	320	335								
11	4	55	120	187	236	257	275	291	303	316	328	337							
12	4	54	114	173	220	255	282	299	312	323	335	349	359						
13	1	67	135	207	263	278	292	307	318	332	347	361	378	386					
18	1	41	82	136	172	212	231	252	270	284	302	315	321	333	344	353	361	372	384
Mean		60	123	193	244	272	293	307	318	326	332	342	355	260	344	353	361	372	384

lies a direct proportionality between fish length and otolith length, as assumed in this paper.

Growth

In age group 4 males and females had similar empirical body length (t-test, $P > 0.05$). There were too few individuals in age group 5 and above to test for differences in the growth pattern between the sexes, and the material was pooled (Tab. 3). Identical male and female growth patterns are reported in tench from the river Danube (Moroz 1968).

Tench from Lake Jorkjenn exhibit the same growth in the first 6 years as tench in other European river systems, but after 6 years tench in

this study exhibit much slower growth than previously reported (Svetovidova 1960, Moroz 1968). Svetovidova (1960) reported 9 years as maximum age in tench, while Moroz (1968) reported 6 years as maximum. In this study the maximum age was 18 years. This difference is probably due to the use of scales for ageing in previous studies which according to this study underestimates the age of older tench. The intensive fishing in Central Europe may also have influenced the age distribution in favour of younger tench. In Lake Jorkjenn, on the other hand, the fishing pressure is insignificant.

Calculations of relative growth demonstrate variation between years (Tab. 4), but the variation is small. Growth in perch is shown to be directly proportional to summer air temperature (Neuman 1976). In the search for a relationship between growth and temperature correlation analyses were carried out (Tab. 5). Mean air temperature in September was found most important for the year-to-year variation in growth, possibly because high air temperatures in September may lead to an extension of the growth season.

Table 4. Relative growth in tench and monthly mean air temperature during the years 1972–1983. (The air temperatures are obtained from Landvik Meteorological Station, Grimstad).

Year	Relative growth	Temperature				
		June	July	Aug.	Sept.	Oct.
1972	89	13.4	17.3	14.8	10.4	7.2
1973	94	14.6	17.9	14.9	11.3	5.3
1974	97	15.0	15.1	15.2	12.2	6.2
1975	97	14.0	17.0	18.6	12.5	8.2
1976	100	15.8	18.1	17.3	10.4	7.1
1977	106	15.1	16.4	15.4	11.1	8.8
1978	97	15.3	15.0	15.3	10.8	8.6
1979	111	14.5	16.1	14.3	11.7	7.0
1980	117	15.0	16.9	15.3	12.9	5.9
1981	129	12.8	15.5	15.7	13.0	6.5
1982	143	14.3	17.5	16.2	12.6	8.1
1983	128	14.3	18.0	16.5	12.2	8.6

Table 5. The correlation between relative growth and mean monthly air temperature.

Month	r	Level of significance
June	-0.28	$p > 0.05$
July	0.11	$p > 0.05$
August	0.08	$p > 0.05$
September	0.67	$p < 0.05$
October	0.19	$p > 0.05$

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