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Age determination, growth and maturity of the bleak *Alburnus alburnus* (L.) (Cyprinidae) in Lake Øyeren, SE Norway

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Age, growth and maturity have been examined in bleak *Alburnus alburnus* (L.) collected in Lake Øyeren in 1975, 1976 and 1977. Otoliths were found to be more suitable than scales for age determination, while opercula were unsuitable. No difference in the growth of males and females of age 0—IV could be detected in the material, and males have a shorter life span than females. Males and females reach sexual maturity at an age of 3 years. The spawning period is in June-July, and lasts for about one month.

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INTRODUCTION

Age determination of bleak *Alburnus alburnus* (L.) using scales has been described by several authors (e.g. Kugel 1942, Williams 1967, Biró 1975). However, in many freshwater fish species the interpretation of scales often gives too low age for older specimens. Opercula are more reliable than scales for age determination of several cyprinids (Hansen 1977, 1978a, 1980). Similary, otoliths are more reliable than scales for age determination of several salmonids (Nordeng 1961, Ausen 1976, Jonsson 1976).

The main purpose of this study was to examine the suitability of scales, opercula and otoliths as ageing objects for bleak by an examination of zone formation, zone reliability and the number of zones of the three objects. Data on age, growth and maturity of the lake Øyeren bleak are also presented.

Lake Øyeren (approximate UTM grid reference: 32VPM 25 30) is described by Holtan (1970) and Skulberg (1972). Hansen (1978b) has given a survey of the fish fauna of the lake. Bleak is abundant during summer, especially in the shallow, northern parts of the lake.

MATERIAL AND METHODS

The material was collected in the northern, shallow part of the lake during the periods 23 Oct. — 18 Nov. 1975, 10 May — 9 Nov. 1976 and 6 May — 16 Jul. 1977. Ice conditions and low water level prevented fishing during December — April.

The material from 1975 was caught by electrofishing and consisted of 99 fish in the size range 20—55 mm. This sample was used for comparison of observed and back-calculated fish lengths after the first growth season. Part of this material was also used in Fig. 1. The material from 1976 and 1977 was collected using beach seine (mesh size: 7.5 mm) and gill nets (mesh sizes: 10, 16 and 19.5 mm) at intervals of one or two weeks during the fishing periods. The 1976-material, consisting of 441 specimens, was left out from age and growth analysis due to suspected negative effects of gill net selection. Yet, part of this material, i.e. 65 specimens of nearly identical size, were used for examination of zone formation in scales and otoliths during one entire growth season. The age and growth analysis was carried out using a total of 222 specimens caught in 1977, supplemented with material from 1975 (n = 99) and 1977 (n = 65).

For each fish total length (mm), weight (g) and, in mature specimens, sex were noted. Scales were collected from the area between the dorsal and the anal fin, pressed on celluloid strips (Smith 1954) and read in a projector. Zones defined as winter zones in scales were identified according to Bagenal and Tesch (1978). Checks were quite often found, which exhibited one ore more of the criteria of winter zones, but were usually identified as false zones because of presence only on certain parts of the scale, and not in all scales.

The opercula from 100 fish were removed,

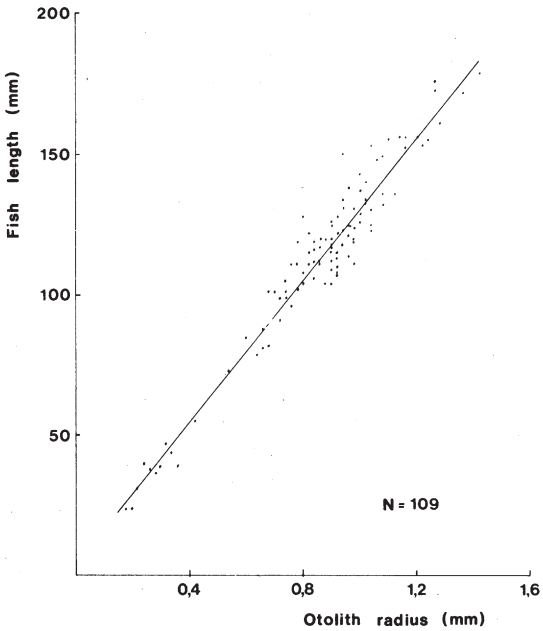

Fig. 1. Linear regression between total fish length (L) and otolith radius (R) of the bleak from Lake Øyeren. $L = 4.2 + 127.2\ R$ ($r = 0.97$, $p < 0.01$)

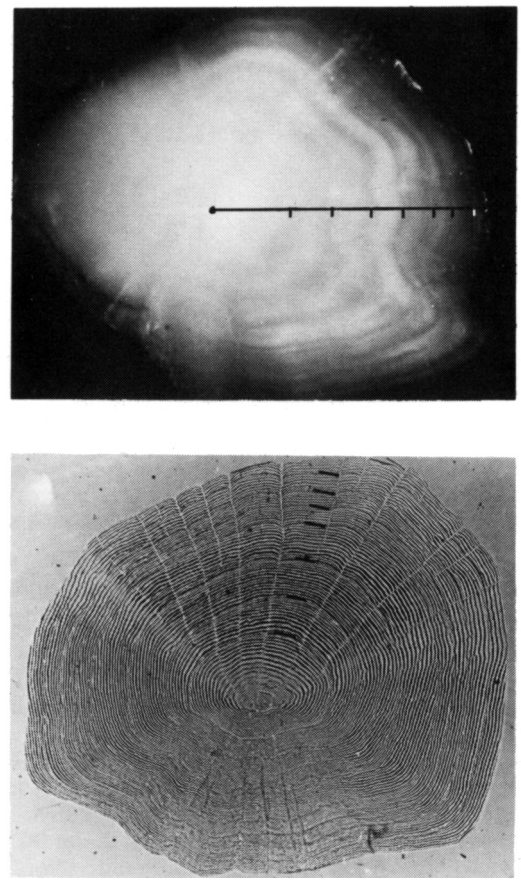

Fig. 2 a. Left otolith of bleak (female), caught 9 Nov. 1976, total length 159 mm. 7 winter zones are identified. The measured radius and estimated otolith-centre are indicated.
b. Scale of the same bleak as in Fig. 2 a. As on the corresponding otolith 7 winter zones are identified.

cleaned in boiling water, rinsed and dried. However, because of almost complete lack of visible zones, opercula were found unsuitable for age determination.

The otolith pairs were removed and stored dry. Before reading, the otoliths were cleared in 96% etanol for 1—7 days, depending on otolith thickness. They were then transferred to 1,2 propandiol for direct examination, with their convex lateral side downwards, against a dark background at a magnification of 50x. For ageing and back-calculating the left otolith was always used. Age was determined by counting the number of zones. It was sometimes difficult to delimit the end of the first zone, and those cases were not used in back-calculating growth. False zones were easy to identify because they were much thinner and usually only appeared in one of the otoliths.

All scales and otoliths were read twice independently. At each reading the number of zones was determined. In cases where the two readings of a scale or an otolith disagreed, the object was read once more. If the third reading a_3 reed with one of the two preceding, this was considered as being the correct age. When all three readings were dissimilar, the object was excluded from further analysis. In this way scales from 7 fish (3.2%), but no otoliths, were excluded.

In order to back-calculate growth from otoliths, it is necessary that otoliths and fish grow proportionally, and that this relationship is known. Regression analysis by least square method of the plot of fish length against otolith radius gave the linear relationship shown in Fig. 1. If, however, the constant 4.2 in the equation is eliminated (i.e. $g = 0$) the relationship is expanded as $L = 131.6\ R$. Since a t-test ($t = 0.13$, $p < 0.01$) showed no significant difference between these two equations, the generalized equation was used in back-calculating the growth.

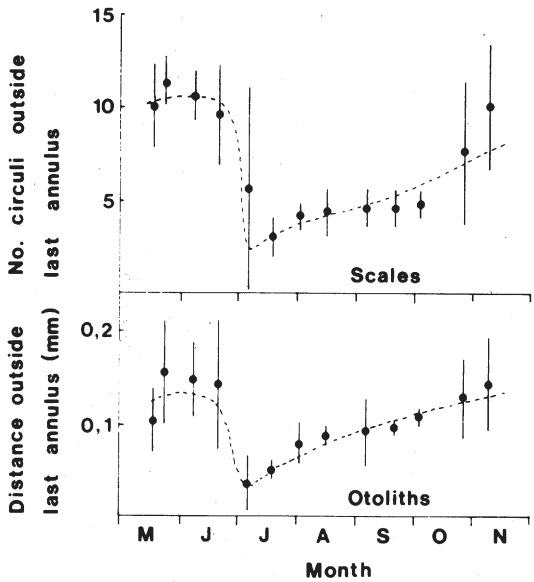

Fig. 3. Growth outside last winter zone in scales and otoliths from bleak of age groups II—IV, caught in 1976. The points and bars represent the mean of 5 observations ± 2 S.E. The curves are drawn by eye.

RESULTS AND DISCUSSION

Zone formation in otoliths and scales

Otoliths have not previously been discussed for use in age determination of bleak. Bleak otoliths are relatively small. The outermost lateral side of the otoliths is strongly convex, while the inner side is slightly concave. On the concave side distinct opaque and hyaline zones are easily recognizable, representing summer and winter growth respectively according to Williams and Bedford (1974). The zones were best developed in the posterior part of the otoliths, as seen in Fig. 2a, and they were always counted and measured along the radius shown on the figure. A distinct otolith-centre was impossible to localize, and its position was estimated in each otolith, assuming the geometrical centre to be the true otolith-centre.

Several authors have described bleak scales with regard to their use for age determination (e.g. Masterman 1923, Kugel 1942, Williams 1967). Fig. 2b shows a scale of bleak from Lake Øyeren.

Earlier observations indicate that identifiable year zones are formed once a year in otoliths of a number of salmonids (e.g. Ausen 1976, Jonsson 1976), and in scale of bleak and certain other cyprinids (e.g. Holčík 1967, Williams 1967, Hansen 1980). Fig. 3 shows that the zone of bleak in Lake Øyeren is formed only once a year, at the beginning of July, for both otoliths and scales. Table 1 shows that the conformity

Table 1. Comparison of two independent age readings of bleak scales and otoliths. Number of scales and otoliths are grouped according to deviation (in zones) between readings. Number of zones are given according to second reading. The material is caught in 1977.

	Scales				Otoliths		
		Deviation				Deviation	
No. of zones	Total	0	1	2	Total	0	1
0	—	—	—	—	—	—	—
1	2	2	—	—	1	1	—
2	16	13	3	—	22	22	—
3	29	24	5	—	38	35	3
4	61	52	9	—	60	57	3
5	33	28	4	1	29	28	1
6	8	6	2	—	2	2	—
7	9	4	5	—	3	2	1
8	40	33	6	1	52	50	2
9	18	10	7	1	2	2	—
10	4	3	1	—	3	3	—
11	—	—	—	—	9	6	3
All groups combined	220	175	42	3	221	208	13

Table 2. Comparison between independent age readings of corresponding scales and otoliths in bleak caught in 1977. The numbers on the diagonal show the number in which scales and otoliths gave identical readings.

Number of zones in otoliths	Number of zones in scales: 1	2	3	4	5	6	7	8	9	10	11	Total
1	1											1
2		20	2									22
3			28	7								35
4			5	51	3							59
5				1	25	2						28
6						2						2
7				1			1					2
8							6	43				49
9								1	3			4
10								2	1	1		4
11								1	3	2		6
Total	1	20	35	60	28	4	7	47	7	3		212

between the age readings was better for otoliths than for scales. In scales deviations of two years appeared only for older fish.

Comparison between otoliths and scales for age determination

In 14 fish the scales showed one more zone than the otoliths, and in 23 fish the otoliths appeared to have more zones than the scales, with deviation increasing for older fish (Table 2). The first winter zone may be absent in scales of bleak (Huitfeldt-Kaas 1927, Kugel 1942). However, a comparison of back-calculated growth at age I in otoliths and scales did not indicate any lack of the first winter zone in scales from Lake Øyeren bleak. Moreover, all back-calculated lengths at age I from otoliths lie within the size range of the 1975-material (all 0 + bleak), except for one that lies between this range and the age II-range. Thus, it seems that in this material the first winter zone does not lack in otoliths. The increasing deviations between the number of zones in otoliths and scales of older fish indicate that zone formation ceases at an earlier age in scales than in otoliths. In addition, the frequent presence of false scale zones made scale interpretation more uncertain. It seems reasonable to conclude that otoliths are better suited than scales for age determination of bleak. The following age and growth study is therefore based on otoliths.

The fact that strong and weak year classes agree rather closely in the catches of 1976 and 1977 as shown on Fig. 4, supports the accuracy of otoliths as objects for age determination in bleak.

Growth

For age IV and below there was no significant difference in growth of male and female bleak (Mann-Whitney's U-test). There were too few males in age V and above to test any difference in the growth pattern between the two sexes, and the growth data were pooled as presented in Table 3. Female bleak have elsewhere been shown to grow faster than males after reaching maturity (e.g. Kieckhäfer 1967, Wohlgemuth 1979).

The present material included eight specimens of age XI bleak (Table 3). Also one age XII bleak

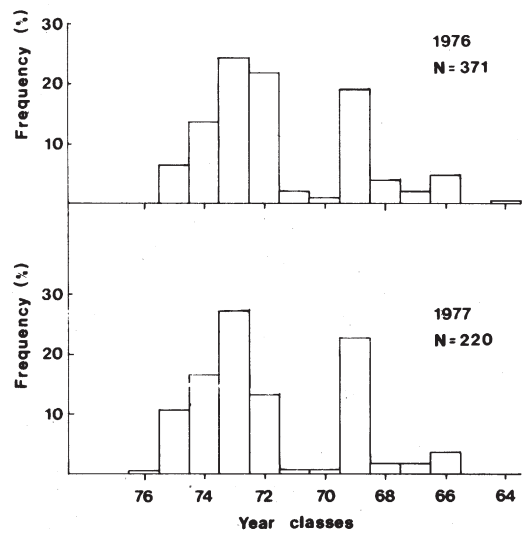

Fig. 4. Year class distribution of bleak caught in 1976 and 1977.

Table 3. Back-calculated lengths (mm) of male and female bleak, obtained from measurements of otoliths. Fish, in which the first winter zone was not measurable, are only included in age groups IX—XI and their numbers given in brackets. The material is caught in 1977.

Age at capture	No. of fish	Length at age I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	1	62										
II	23	52	86									
III	31	39	85	108								
IV	39	47	83	108	124							
V	19	40	80	106	123	135						
VI	2	44	83	107	124	138	148					
VII	3	41	69	92	106	118	127	138				
VIII	36	54	81	101	116	128	137	147	156			
IX	4 (2)	42	74	102	115	125	135	144	153	163		
X	4 (3)	41	79	105	123	135	142	148	155	160	167	
XI	8 (6)	38	70	99	120	133	141	148	154	159	165	172
Mean		46	82	105	120	130	138	147	155	160	166	172

from the 1976-material was registered. Bleak older than 8 years have previously been reported only by Huitfeldt-Kaas (1927). Bleak from other European lakes and river systems usually seem to grow faster and attain a lower maximum age than is shown in Table 3 (e.g. Kugel 1942, Kieckhäfer 1967, Williams 1967, Chitravadivelu 1971, Biró 1975, Wohlgemuth 1979). The reason for this may be that bleak in Lake Øyeren, at the northern edge of its distribution area, is adapted to slower growth and longer life span compared to Mid-European bleak populations. An additional explanation could be the use of scales as the ageing object in earlier studies, so that larger European bleak in fact may have been older than determined.

Maturity

As shown in Fig. 5 the frequency of females increases with increasing age, which shows that bleak males have a shorter life span than females. This has been reported earlier for other bleak populations (e.g. MacKay and Mann 1969, Bastl 1977). There seems to be little difference between the sexes at the age at which sexual maturity is reached (Table 4). Most bleak matured at an age of 3 years. Yet 2 mature males at age I were found. A tendency for some males to mature earlier than females has been reported from other bleak populations (Kugel 1942, Kieckhäfer 1967). The age at maturity found in Lake Øyeren agrees largely with that of other bleak populations (e.g. MacKay and Mann 1969, Papadopol 1970).

The spawning period of the bleak in Lake Øyeren is relatively long. In 1977 spawning started in mid-June, and lasted for about one month. Other authors (e.g. MacKay and Mann 1969, Papadopol 1970, Bastl 1977) have stated that bleak spawn mainly during early or mid summer, which is in agreement with the present results. However, the present investigations give no direct information as to whether or not the bleak in Lake Øyeren is an intermittent spawner, a spawning behaviour that has been recorded earlier (e.g. MacKay and Mann 1969, Papadopol 1970).

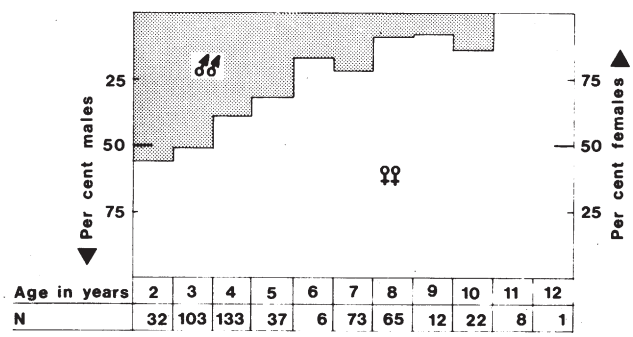

Fig. 5. Sex distribution for different age groups of mature bleak caught in 1976 and 1977.

Table 4. Number of immature and sexually mature bleak in age groups I—V, caught in 1976 and 1977.

Age group	Immatures		Matures		Total
	n	%	Males	Females	
I	23	92	2	0	25
II	43	57	18	14	75
III	23	18	53	50	126
IV	8	6	52	81	141
V	0	0	12	25	37
Total	97		137	170	404

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