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Age, growth and maturity of the white bream *Blicca bjoerkna* (L.) in Lake Øyeren, SE Norway

LARS P. HANSEN

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Age, growth and maturity have been examined in a material of white bream *Blicca bjoerkna* (L.) collected in Lake Øyeren between April 1974 and October 1975, and in September 1976. Opercular bones were found more suitable than scales for age determination. As the inner zones in operculars from older fish often could be missing, scales were used for control. The females of white bream reach maturity at an age of 4 years, and most males mature one year earlier. When maturity is reached, the males grow slower than the females, and also have a shorter life span. Spawning takes place in June.

L.P. Hansen, Directorate for Wildlife and Freshwaterfish, Fish Research Division, Box 63, 1432 Ås-NLH, Norway.

INTRODUCTION

White bream *Blicca bjoerkna* (L.) is distributed in the south eastern part of Norway. In the river Glomma drainage it is found north to Lake Øyeren (Huitfeldt-Kaas 1918) where it is one of the most common fish species (Hansen 1978 a).

Age determination of white bream using scales has been described by Geyer (1939) and this method has been generally used as in other cyprinids (Hartley 1947, Frank 1958, 1962, Klimczyk-Janikowska 1974). Hansen (1978 b), however, concluded that opercular bones were better suited than scales in ageing roach *Rutilus rutilus* (L.) older than 7 years from Lake Øyeren. In the present study scales and opercular bones were compared in order to find the most reliable age determination method for the white bream.

There are few data on the biology of white bream in Norway. Since 1974 fish biology investigations have been carried out in Lake Øyeren (Brabrand 1977, 1978, Hansen 1977, 1978 a, b, Bjørnebråten 1978, Pethon 1978, Backe-Hansen 1979, Øien 1979, Hansen and Brabrand 1979). This work concerning age, growth and maturity of white bream in Lake Øyeren, has been part of these investigations.

Lake Øyeren is described by Holtan (1970) and Skulberg (1972). Details regarding vegetation are given by Rørslett (1972) and Brabrand (1977), while Hansen (1978 a) surveyed the fish species in the lake.

MATERIAL AND METHODS

Sampling

In 1974 and 1975 material was collected weekly in the northern part of the lake from the end of April/beginning of May to the end of June. From July to end of November in 1974 and from July to October in 1975 fishing was carried out every third week. A supplementary material was collected in September 1976. The fish were caught in gill nets (24, 29, 35 and 45 mm knot to nearest knot). There was no fishing in the winter because of a thick ice cap and low water level. In random samples from the catches each specimen was examined for total length (mm), weight (5 g), sex, ripening stage and gonad weight (0.1 g). From the material collected in 1975 about 30 scales and both opercular bones were removed from each fish in order to determine the time of zone formation. The total material collection in the end of August and in September 1975, and in September 1976 was used in age and growth studies (Tab. 1). For these samples gill nets with mesh size 19.5 mm knot to nearest knot were also used.

Age determination

Celluloid impressions of scales (Smith 1954) were read in a projector. Opercular bones were dipped in boiling water, cleaned, dried for several weeks and read in glycerol on a dark back-

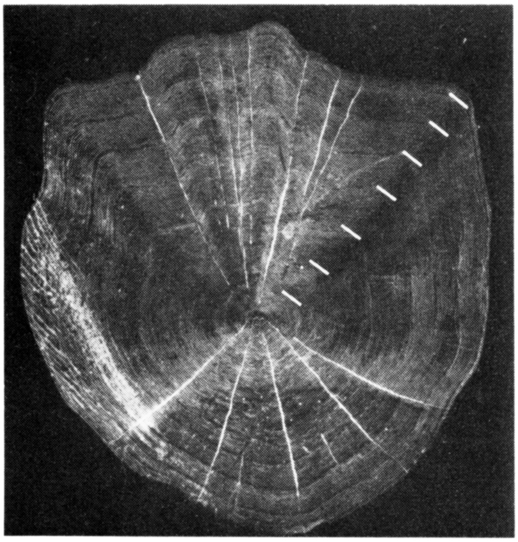

Fig. 1. Scale of white bream (210 mm). 7 zones can be identified.

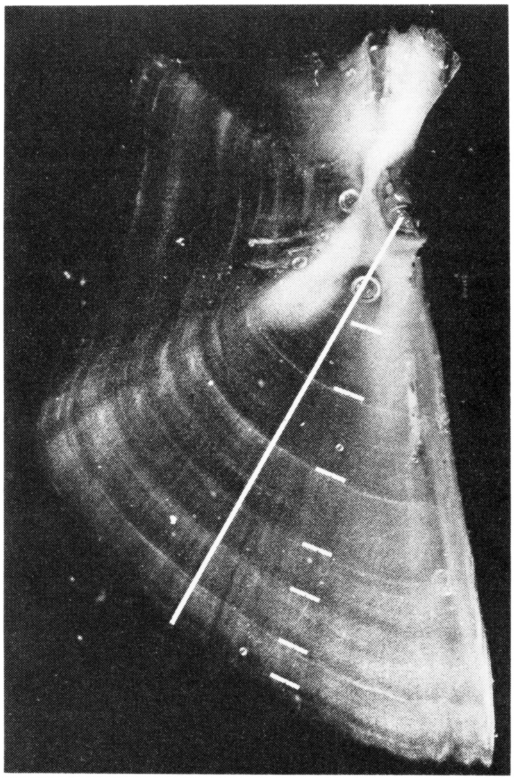

Fig. 2. Opercular bone of white bream (same specimen as in Fig. 1). 7 zones can be identified. The solid line indicates the operculum size.

ground. Two independent readings were made from each scale and opercular bone.

Figures 1 and 2 show a scale and opercular bone from the same specimen. Scales of young fish were easy to read, and the few false zones present were identified according to Chugunova (1963). When reading the opercular bones I principally followed Le Cren's (1947) method for perch *Perca fluviatilis* L.

Backcalculation of growth

The linear regression of fish length on opercular bone size (Fig. 3) gave the equation L = 10.65 + 17.09 Op (r = 0.989) where L is total fish length (mm) and Op is opercular bone size (mm) as defined in Fig. 2. However, it has some practical advantages to use direct proportionality when backcalculating fish lengths from opercular bones. Using a t-test it was found that the constant 10.65 was not significantly different from zero (t = 0.28) and a line through the origin, L = 18.06 Op, was then accepted.

RESULTS

Age determination

Fig. 4 indicates that the zones are formed in June/July for both scales and opercular bones, which is at the same time as in Lake Øyeren roach (Hansen 1978 b). In England the scale zones are formed in May/June (Hartley 1947).

For young fish the two independent scale readings gave practically the same result (Tab. 2), but in older individuals there were increased deviation between the readings. For opercular bones the readings agreed better than with sca-

Tab. 1. The material used in age and growth studies. Sc = scales, Op = opercular bones.

	Males		Females		Unsexed		Total	
Year	Sc	Op	Sc	Op	Sc	Op	Sc	Op
1975	35	34	75	73	1	1	111	108
1976	21	21	88	88	—	—	109	109
Total	56	55	163	161	1	1	220	217

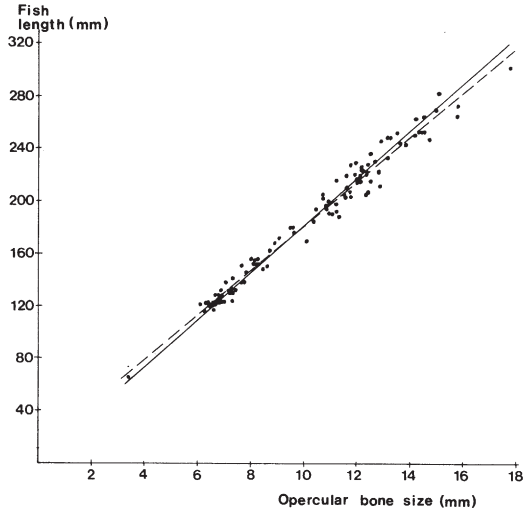

Fig. 3. Relationship between fish length and opercular bone size. L = 10.65 + 17.09 Op. (r = 0.989, n = 108) (broken line) and L = 18.06 Op. (solid line).

les, which indicates that it is easier to identify opercular bone zones than scale zones in older fish. When the two independent scale or opercular bone readings differed, the true age was accepted as the result of a third reading. There was a high correlation between scale and opercular readings up to an age of 12 years (Tab. 3). In older fish there were more zones in opercular bones than in scales, which indicates that the zone formation ceases in scales at a lower age than in opercular bones.

In many opercular bones the first zone was indistinct, and it even disappeared in bones of some older individuals. The reason was probably the increased bone thickness. Similar observations have been made on opercular bones from roach (Banks 1970, Mann 1973, Linfield 1974, Hansen 1978 b), pike *Esox lucius* L. (Frost and Kipling 1958, Mann 1976 a), and chub *Leuciscus cephalus* (L.) (Mann 1976 b). Absence of the first zone could be demonstrated by comparison with mean length of one year old fish, mean backcalculated length at age one, control reading with scales, and Ford-Walford plots (Ford 1933, Walford 1946). 43 opercular bones lacked the first zone, and one bone the first two zones. In the age and growth analyses absent zones have been added.

Tab. 2. Assessing the reliability of age determinations of white bream by repeated independent readings of scales and of opercular bones. Number of scales and operculars summarized according to degree of deviation between readings (in years). Allocation in groups of number of zones by second reading.

	Scales					Operculars		
		Deviation					Deviation	
No of zones	Total	0	1	2	3	Total	0	1
0	—	—	—	—	—	—	—	—
1	1	1	—	—	—	1	1	—
2	29	29	—	—	—	28	28	—
3	17	17	—	—	—	16	16	—
4	1	1	—	—	—	1	1	—
5	5	5	—	—	—	5	4	1
6	8	7	1	—	—	6	6	—
7	15	14	1	—	—	13	13	—
8	3	3	—	—	—	5	4	1
9	16	14	2	—	—	16	16	—
10	1	—	1	—	—	1	1	—
11	9	4	3	1	1	2	1	1
12	4	2	2	—	—	3	3	—
13	2	2	—	—	—	3	1	2
14	—	—	—	—	—	3	2	1
15	—	—	—	—	—	3	2	1
16	—	—	—	—	—	—	—	—
17	—	—	—	—	—	—	—	—
18	—	—	—	—	—	2	1	1
	111	99	10	1	1	108	100	8

Tab. 3. Comparison between independent age readings of scales and opercular bones from the same fish. The numbers on the diagonal show the number in which the two objects gave the same results.

Number of zones in opercular bones	Number of zones in scales																			
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
2	—	—	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	28
3	—	—	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16
4	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
5	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	5
6	—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	6
7	—	—	—	—	—	—	1	11	1	—	—	—	—	—	—	—	—	—	—	13
8	—	—	—	—	—	—	—	3	2	—	—	—	—	—	—	—	—	—	—	5
9	—	—	—	—	—	—	—	1	—	15	—	—	—	—	—	—	—	—	—	16
10	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
11	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	2
12	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—	3
13	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	3
14	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	3
15	—	—	—	—	—	—	—	—	—	—	—	2	—	1	—	—	—	—	—	3
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
18	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	2
Total	0	1	28	16	1	5	7	15	3	16	1	9	4	2	0	0	0	0	0	108

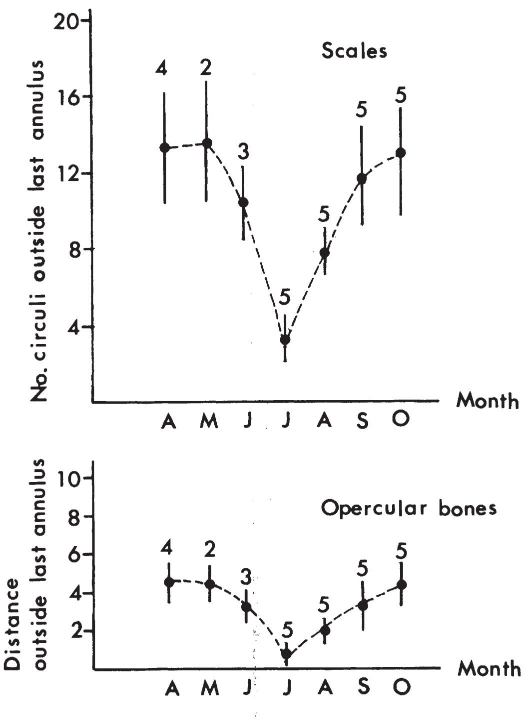

Fig. 4. Growth outside last zone on scales and opercular bones (occular units) from white bream less than 5 years old in 1975. The points and bars represent mean ± 2SE, the figures are number of fish.

It was not possible to check the reliability of the age determinations against fish of known age, but it seems that both scales and opercular bones can be used for age determination of fairly young white bream. For older fish, however, opercular bones were better suited than scales. But because opercular bones from older fish may lack the inner zones the age determinations were controlled with scales.

Because of the frequent differences between the two independent opercular readings from 13 + individuals and older, only fish younger than 13 years were used in the growth analyses.

There was considerable variation in the distribution of the different year classes (Fig. 5). A total picture of the year class strength could not be given because the mortality was unknown. But appearently there was a strong 1973 and week 1971 year class.

Growth

A Mann-Whitney U-test on fish size distribution of three different year classes of males and females (Tab. 4) showed no difference in length distribution of the two sexes at age 2 + and 3 + . But at an age of 7 + there was a significant difference. Therefore the sexes were separated in the growth analyses.

Tables 5 and 6 show backcalculated lengths for males and females. Females have a higher

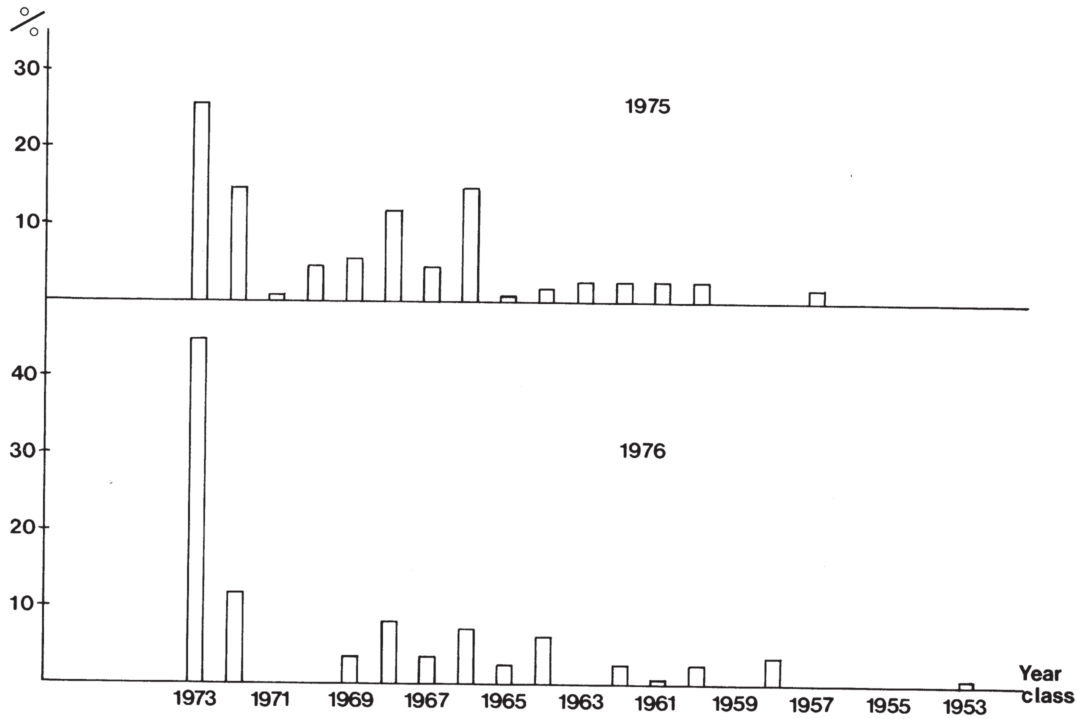

Fig. 5. Year class distribution of the materials sampled in 1975 and 1976.

growth rate than males after 4 years of age. Lee's phenomenon (Lee 1912) appears to be present among females (Tab. 6). This is also apparent from the lower backcalculated lengths than observed (Tab. 7). The material of older males may be to small to detect the phenomenon. Calculations of relative growth according to Svärdson (1961) and Kempe (1962) (Tab. 8), suggested small variations in growth from year to year, but Lee's phenomenon may influence the results. However, a Spearman rank correlation analysis showed significant correlation ($r_S = 0.66$) at the 5% level between relative growth in different years in the materials, indicating the validity of the method.

Tab. 4 Results of the Mann-Whitney U-test on size distributions of males and females. The numbers in brackets give the number of fish, and U_s is the Mann-Whitney statistic.

Age	Mean length Females	Males	U_s	P
2+	124.7(15)	125.9(13)	101	$p>0.05$
3+	152.2(9)	152.9(7)	35	$p>0.05$
7+	218.9(8)	189.0(5)	40	$p<0.05$

Maturity

The sex ratio (males/females) decreased with increasing age (Tab. 9) suggesting that males have a shorter life span than females. Females and some males reach maturity at an age of 4 years, but most males mature one year earlier (Tab. 10). Older fish with resting gonads were not found, indicating that spawning takes place each year after maturity is reached. In 1974 the white bream spawned from 10 June to 1 July and in 1975 spawning started at the end of May and lasted to about 20 June. The ripeness coefficient reached maximum shortly before spawning and then decreased (Fig. 6). There was no growth in the gonads before August—September.

DISCUSSION

When the water level in Lake Øyeren rises in the spring the white bream migrate from the deeper part of the lake to the delta area in the

Tab. 5. Mean backcalculated lengths (mm) of males obtained from opercular bones.

Age at capture	Number of fish	Backcalculated length in mm at age I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0+													
1+													
2+	13	48	88										
3+	22	45	83	121									
4+	3	44	82	126	150								
5+	—												
6+	2	37	68	95	126	146	165						
7+	5	42	76	105	126	145	163	178					
8+	1	43	83	111	135	155	171	190	202				
9+	5	39	75	111	135	146	158	169	182	192			
10+	1	45	84	112	133	147	156	168	177	187	194		
11+	1	50	87	121	137	151	162	175	181	185	194	203	
12+	1	—	67	97	119	139	163	181	189	195	204	211	218
Weighted mean		44	79	111	133	147	163	177	186	190	197	207	218

northern part. Catches in those areas suggest that white bream is one of the most common fish species (Hansen 1978 a). The delta area is very important for spawning and feeding during the summer. Late in the autumn the white bream returns to the deeper parts of the lake.

When the white bream reach maturity, females grow faster than males which is in accordance with the results of Alm (1922) and Geyer (1939). The material also suggests a shorter life span for males than females. The fact that white bream males in Lake Øyeren mature one year earlier than the females tend to support the statement that individuals which mature first die early (Gerking 1957, Nikolsky 1969). In general fast growing individuals tend to reach maturity earlier and die earlier than slowly growing individuals of the same sex and year class. This is assumed to be the main reason for the occurrence of Lee's phenomenon in unexploited fish populations (Gerking 1957, Ricker 1975) and could be the reason for Lee's phenomenon in the Lake Øyeren white bream.

The growth of white bream in Lake Øyeren conforms to that in other populations studied (e.g. Geyer 1939, Hartley 1947, Frank 1958,

Tab. 6. Mean backcalculated lengths (mm) of females obtained from opercular bones. The figures in brackets give the number of operculars with readable inner zone.

Age at capture	Number of fish	Backcalculated length in mm at age I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0+													
1+													
2+	15	45	86										
3+	43	45	81	119									
4+	11	45	80	122	157								
5+	5 (4)	39	74	113	153	182							
6+	4 (3)	36	73	107	144	174	198						
7+	12 (5)	45	79	113	143	169	188	206					
8+	13 (8)	44	77	108	138	160	180	198	213				
9+	15(10)	41	76	114	147	161	176	192	205	217			
10+	8 (6)	46	82	119	148	169	186	200	213	224	236		
11+	4 (3)	39	72	104	137	162	176	187	198	209	219	229	
12+	9 (4)	49	76	106	131	150	168	182	194	205	214	224	234
Weighted mean		43	78	113	144	166	182	194	205	214	223	227	234

Tab. 7. Comparison between observed mean lengths (mm) at age (t +) and backcalculated mean lengths (mm) at age (t + 1)

Age	Males		Females	
	Observed	Backcalculated	Observed	Backcalculated
3	126	111	125	113
4	143	133	147	144
5	165	147	179	166
6	—	163	201	182
7	179	177	214	194
8	189	186	218	205
9	212	190	225	214
10	199	197	229	223
11	200	207	246	227
12	209	218	236	234

Tab. 8. Relative growth during the years 1966 to 1975.

Years of growth	Relative growth	
	1975 material	1976 material
1966—1967	98.3	93.0
1967—1968	93.1	95.0
1968—1969	102.0	109.3
1969—1970	95.3	104.4
1970—1971	85.6	89.9
1971—1972	90.0	86.6
1972—1973	106.0	98.8
1973—1974	108.8	99.3
1974—1975	109.5	104.9
1975—1976	103.2	117.1

Tab. 9. The sex ratio for several age groups.

Age group	Males	Females	Sex ratio M:F
< 3	13	15	0,87
3—5	25	59	0,42
6—8	8	29	0,28
9—11	7	27	0,26
> 11	2	31	0,06
Total	55	161	0,34

Tab. 10. Number of immature and developing individuals in age groups 3—5.

Age next birthday		3	4	5
Male	Immature	4	0	0
	Developing	9	24	2
Female	Immature	15	0	0
	Developing	0	43	3

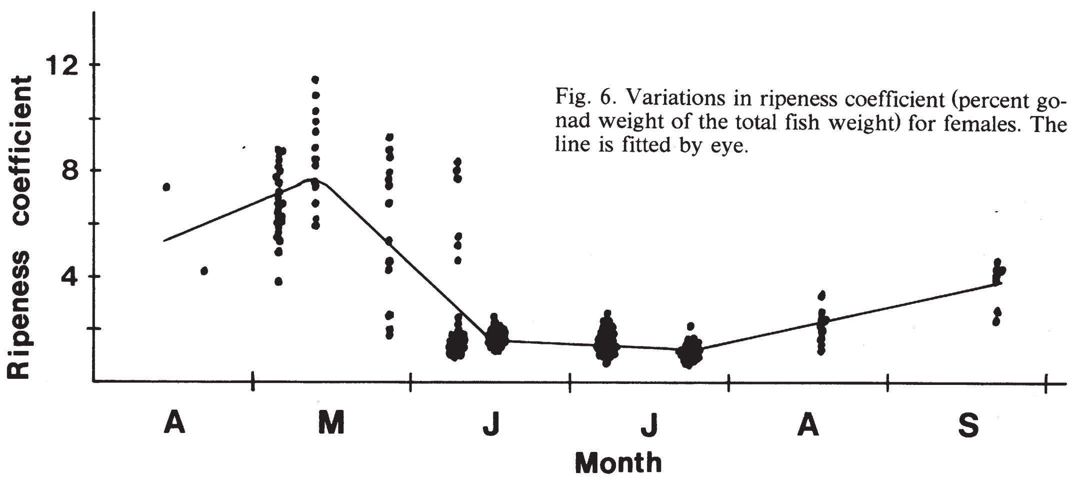

Fig. 6. Variations in ripeness coefficient (percent gonad weight of the total fish weight) for females. The line is fitted by eye.

1962, Klimczyk-Janikowska 1974, Knowles 1974), but it is faster than in populations studied by Järnefeldt (1921) and Alm (1922).

The white bream spawned much later than roach and bream *Abramis brama* (L.) (Hansen 1977), as has also been observed elsewhere (Järnefeldt 1921, Alm 1922, Geyer 1939, Berg 1964). This fact supports Huitfeldt-Kaas' (1918) suggestions of the stenothermal warmwater character of the white bream, which may explain its late immigration to Norway after the glacial period.

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REFERENCES

Alm, G. 1922. Bottenfaunaen och fiskens biologi i Yxtasjön samt jämförande studier över bottenfauna och fiskavkastning i våra sjöar. *Meddn K. LantbrStyr 236*, 1—186.

Backe-Hansen, P. 1979. *Alder, vekst og gonadeutvikling hos laue,* Alburnus alburnus *(L.), i Nordre Øyeren.* Unpublished thesis. Zoological museum, University of Oslo. 69 pp.

Banks, J.W. 1970. Observations on the fish population of Rostherne Mere, Cheshire. *Fld Stud. 3*, 357—379.

Berg, L.S. 1964. *Freshwater fishes of the U.S.S.R. and adjacent countries.* II. Israel program for scientific translations, Jerusalem. 496 pp.

Bjørnebråten, K. 1978. *Gytelokalisering og undersøkelse av yngel og småfisk i Nordre Øyeren.* Unpublished thesis. Zoological museum, University of Oslo. 91 pp.

Brabrand, Å. 1977. *Næringsvalg hos fire karpefisker, mort,* (Rutilus rutilus) *(L.), vederbuk* (Leuciscus idus) *(L.), brasme* (Abramis brama) *(L.) og flire* (Blicca bjoerkna *(L.) i Nordre Øyeren, med spesiell vekt på interspesifikk næringskonkurranse.* Unpublished thesis. Zoological museum, University of Oslo. 131 pp.

Brabrand, Å. 1978. Karpefisk renser vassdrag og øker fiskeproduksjonen. *Forskningsnytt 23(5)*, 29—33.

Chugunova, N.I. 1963. *Age and growth studies in fish.* National science foundation, Washington. 132 pp.

Ford, E. 1933. An account of the herring investigations conducted at Plymouth during the years from 1924—1933. *J.mar.biol. Ass. U.K. 19*, 305—384.

Frank, S. 1958. Stári a rychlost rustu cejnka malého (*Blicca bjoerkna* Linnaeus) v Cechách. (Alter und Wachstum des Güsters (*Blicca bjoerkna* Linnaeus) in Böhmen). *Vêst, čsl. Spol. zool. 22*, 238—260.

Frank, S. 1962. A contribution to the growth of roach, rudd and white bream in some waters of Czechoslovakia and Poland. *Vêst. čsl.Spol. zool. 26*, 65—74.

Frost, W.E. and C. Kipling. 1958. The determination of the age and growth of pike *(Esox lucius* L.) from scales and opercular bones. *J.Cons. perm. int. Explor. Mer 24*, 314—341.

Gerking, S.D. 1957. Evidence of aging in natural populations of fishes. *Gerontologia 1*, 287—305.

Geyer, F. 1939. Alter und Wachstum der wichtigsten Cypriniden ostholsteinischen Seen. *Arch. Hydrobiol. 34*, 543—644.

Hansen, L.-P. 1977. *Karakteristikk av noen fiskearter i Nordre Øyeren med særlig vekt på alder, vekst og reproduksjon hos mort,* Rutilus rutilus *(L., 1758), brasme,* Abramis brama *(L., 1758) og flire,* Blicca bjoerkna *(L., 1758).* Unpublished thesis. Zoological museum, University of Oslo. 136 pp.

Hansen, L.-P. 1978a. Forekomst og fordeling av noen fiskearter i Nordre Øyeren. *Fauna* (Oslo) *31*, 175—183.

Hansen, L.-P. 1978b. Age determination of roach, *Rutilus rutilus* (L.), from scales and opercular bones. *Arch. Fisch Wiss 29*, 93—98.

Hansen, L.P. and Å. Brabrand 1979. Rundmarken *Thwaitia rischta* funnet på karpefisk i Øyeren. *Fauna (Oslo) 32*, 156—160.

Hartley, P.H.T. 1947. The natural history of some British freshwater fishes. *Proc. zool. Soc.Lond. 117*, 129—206.

Holtan, H. 1970. *Øyeren; en limnologisk undersøkelse 1961—1968.* Norsk institutt for vannforskning, Oslo. 48 pp.

Huitfeldt-Kaas, H. 1918. *Ferskvandsfiskenes utbredelse og innvandring i Norge.* Centraltrykkeriet, Kristiania. 106 pp.

Järnefelt, H. 1921. Untersuchungen über die Fische und ihre Nahrung im Tuusulasee. *Acta Soc. Fauna Flora fenn. 52*, 1—160.

Kempe, O. 1962. The growth of roach *(Leuciscus rutilus* L.) in some Swedish lakes. *Rep.Inst. Freshwat.Res. Drottningholm 44*, 42—104.

Klimczyk-Janikowska, M. 1974. Food and biometric characteristic of the silver bream *(Blicca bjoerkna* L.) from the reservoir at Goczaxkowice.*Acta Hydrobiol. 16*, 241—254.

Knowles, C.M. 1974. *Vorkommen, Verbreitung und Biologie der häufigsten Fischarten der Unterelbe unter besonderer Berücksichtigung der Plötze* (Rutilus rutilus *(L.)) und des Kaulbarsches* (Acerina cernua *(L.)).* Diplomarbeit. Universität Hamburg. 85 pp.

Le Cren, E.D. 1947. The determination of the age and growth of the perch *(Perca fluviatilis)* from the opercular bone. *J.anim. Ecol. 16*, 188—204.

Lee, R.M. 1912. An investigation into the methods of

growth determination in fishes. *Publs. Circonst. Cons. perm.int.Explor. Mer 63,* 1—35.
Linfield, R.S.J. 1974. The errors likely in ageing roach *Rutilus rutilus* (L.) with special reference to stunted populations, — In: Bagenal, T.B. (ed.) *Ageing of fish.* Unwin Brothers, Old Woking, pp. 167—172.
Mann, R.H.K. 1973. Observations on the age, growth, reproduction and food of the roach. *Rutilus rutilus* (L.) in two rivers in southern England. *J.Fish Biol. 5,* 707—736.
Mann, R.H.K. 1976a. Observations on the age, growth, reproduction and food of the pike *Esox lucius* (L.) in two rivers in southern England. *J.Fish. Biol. 8,* 179—197.
Mann, R.H.K. 1976b. Observations on the age, growth, reproduction and food of the chub *Squalius cephalus* (L.) in the river Stour, Dorset. *J.Fish Biol. 8,* 265—288.
Nikolsky, G.V. 1969. *Theory of fish population dynamics as the biological background for rational exploitation and management of fishery resources.* Oliver & Boyd, Edinburgh. 323 pp.
Pethon, P. 1978. Age, growth, and maturation of natural hybrids between roach *(Rutilus rutilus* (L.)) and bream *(Abramis brama* (L.)) in Lake Øyeren, SE Norway. *Acta Hydrobiol. 20,* 281—295.
Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd Can. 191,* 1—382.
Rørslett, B. 1972. *Resipientforholdene i Romeriksvassdragene Nitelva, Leira og Rømua; II Botaniske undersøkelser.* Norsk institutt for vannforskning, Oslo. 85 pp.
Skulberg, O. 1972. *Resipientforholdene i Romeriksvassdragene Nitelva, Leira og Rømua; I. Hovedrapport; hydrografi; eksperimentelle undersøkelser; modellanalyse; konklusjoner.* Norsk institutt for vannforskning, Oslo. 104 pp.
Smith, S.H. 1954. Method of producing plastic impressions of fish scales without using heat. *Progve Fish Cult. 16,* 75—78.
Svärdson, G. 1961. Ingen effekt av sikodlingen i Kalmarsund, *Svensk FiskTidskr. 70,* 23—26.
Walford, L.A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. mar.biol.Lab., Woods Hole 90,* 141—147.
Øien, K. 1979. *En sammenligning av tarmhelmintene hos vederbuk,* Leuciscus idus *(L.), mort,* Rutilus rutilus *(L.), brasme,* Abramis brama *(L.) og flire,* Blicca bjoerkna *(L.) fra to lokaliteter i Øyeren med særlig vekt på krasserne.* Unpublished thesis. Zoological museum, University of Oslo. 72 pp.