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GROWTH RATE OF BREAM [Abramis brama (L.)] IN LAKE DĄBIE

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ABSTRACT

Length and weight growth rates of 206 bream individuals caught in 1992 and 1995 were back-calculated. Different types (non-linear vs. linear) of a relationship between the scale caudal radius and body length were revealed to prevail in the two years. The 1992 bream grew very rapidly during the first four years of life, the growth rate slowing down later on. On the other hand, the bream growth in 1995 was more uniform over time. No sex- or age-dependent differences in growth rate were found. The Lake Dąbie bream population belongs to the fast growing populations of the species.

Key words: bream, rate of growth, length-weight relationship

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INTRODUCTION

The Lake Dąbie bream growth rate had been already studied by Kompowski [6, 7] in 1974-1977 and 1985-1986 and by Abdel-Baky [1] in 1981. Results reported by those authors showed the growth indices to vary, which might have been related to habitat variability within a large water body on the one hand and to variations in climatic or ecological conditions on the other. It was therefore thought purposeful to follow up those studies several years later. The bream growth rate study reported in this paper was a part of a more comprehensive project, supported by the Committee for Scientific Research's funds for statutory activitie,s on "Fish growth rate under non-stable conditions of the River Odra mouth area".

MATERIALS AND METHODS

A total of 206 bream individuals caught within 1992 (101 individuals) and 1995 (105 individuals) were examined. In 1992, the population was sampled four times from July until November, while all the 1995 individuals were collected in November. Only the 1992 fish were sexed. A detailed summary of the materials studied is given in Table 1. Figs 1 and 2 show the length and age distributions. Domination of the 6-yr-old fish is typical of both years; however, a higher number of older, hence larger, bream was examined in 1995.

Table 1. Description of the samples examined [l.c. (cm); W (g)]

Date of capture	Females			Males			Indet. sex			Total		
	n	range		n	range		n	range		n	range	
17 July 1992	14	l.c.	29.5-40.5	5	l.c.	30.5-37.0	-	l.c.		19	l.c.	29.5-40.5
		W	524-1283		W	582-954		W			W	524-1283
28 August 1992	13	l.c.	29.5-39.0	10	l.c.	30.0-34.5	2	l.c.	12.0-12.5	25	l.c.	12.0-39.0
		W	535-1108		W	540-838		W	20		W	20-1108
17 October 1992	17	l.c.	30.0-34.0	18	l.c.	29.5-36.0	-	l.c.		35	l.c.	29.5-36.0
		W	640-950		W	600-1000		W			W	600-1000
30 November 1992	8	l.c.	29.5-43.0	14	l.c.	30.0-41.0	-	l.c.		22	l.c.	29.5-43.0
		W	500-1650		W	550-1200		W			W	500-1650
Total 1992	52	l.c.	29.5-43.0	47	l.c.	29.5-41.0	2	l.c.	12.0-12.5	101	l.c.	12.0-43.0
		W	500-1650		W	540-1200		W	20		W	20-1650
11 November 1995										105	l.c.	22.7-47.0
											W	245-2675

Fig. 1. Fish length distribution in samples studied

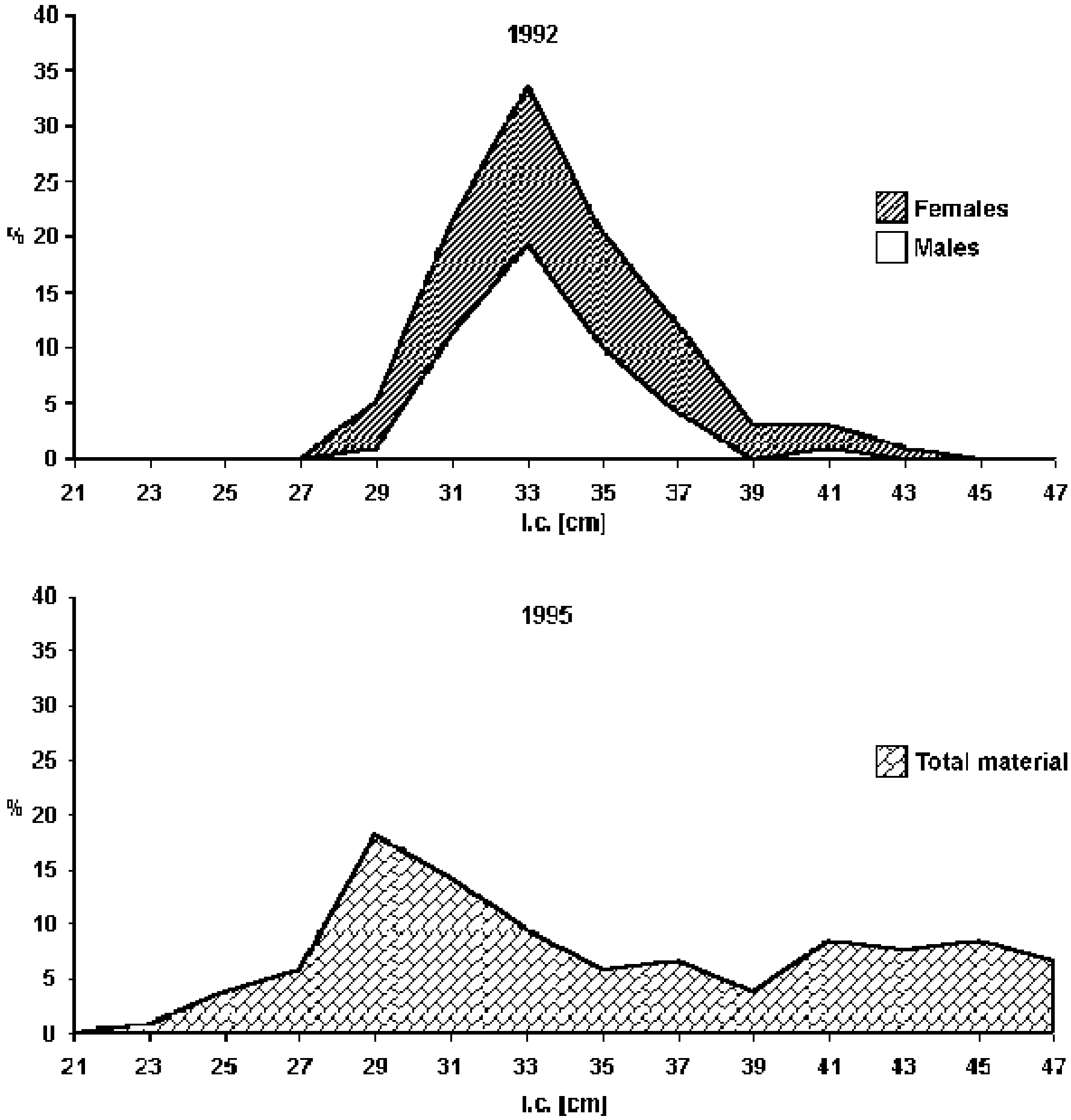
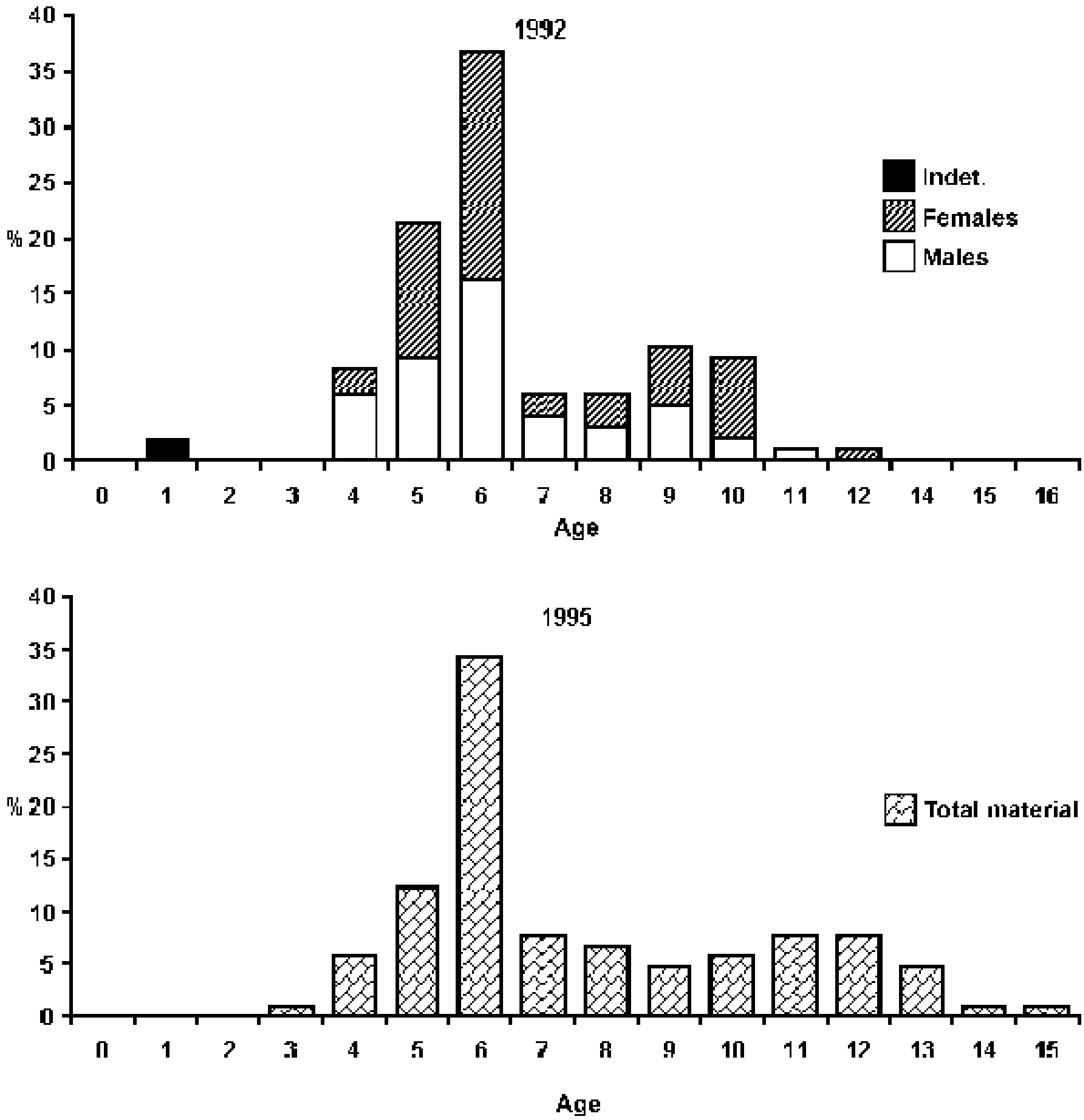


Fig. 2. Fish age distribution in samples studied



The fish age was determined from scales collected from the mid-part of the body above the lateral line. There were large within- and between-sample differences in legibility of seasonal growth zones on the scales. In about 10% of the individuals, due to the presence of larval ring, the existence of the first anual ring was doubtful. Due to the high density of the fringe seasonal rings in those individuals aged 10+, age of the oldest fish can be treated as hypothetical only, although the difference relative to the actual age should not exceed 1-2 years.

The body length (longitudo corporis) growth rate was back-calculated from scale caudal radius measurements. The scale caudal radius-fish body length relationship is shown in Fig. 3. The relationship differed between the years. In 1992, the equation describing the line plotted from empirical data representing mean values for adult individuals (body length > 30 cm) contained a free term equal to 23.9. In this case, the Vovk method [3] was used and an

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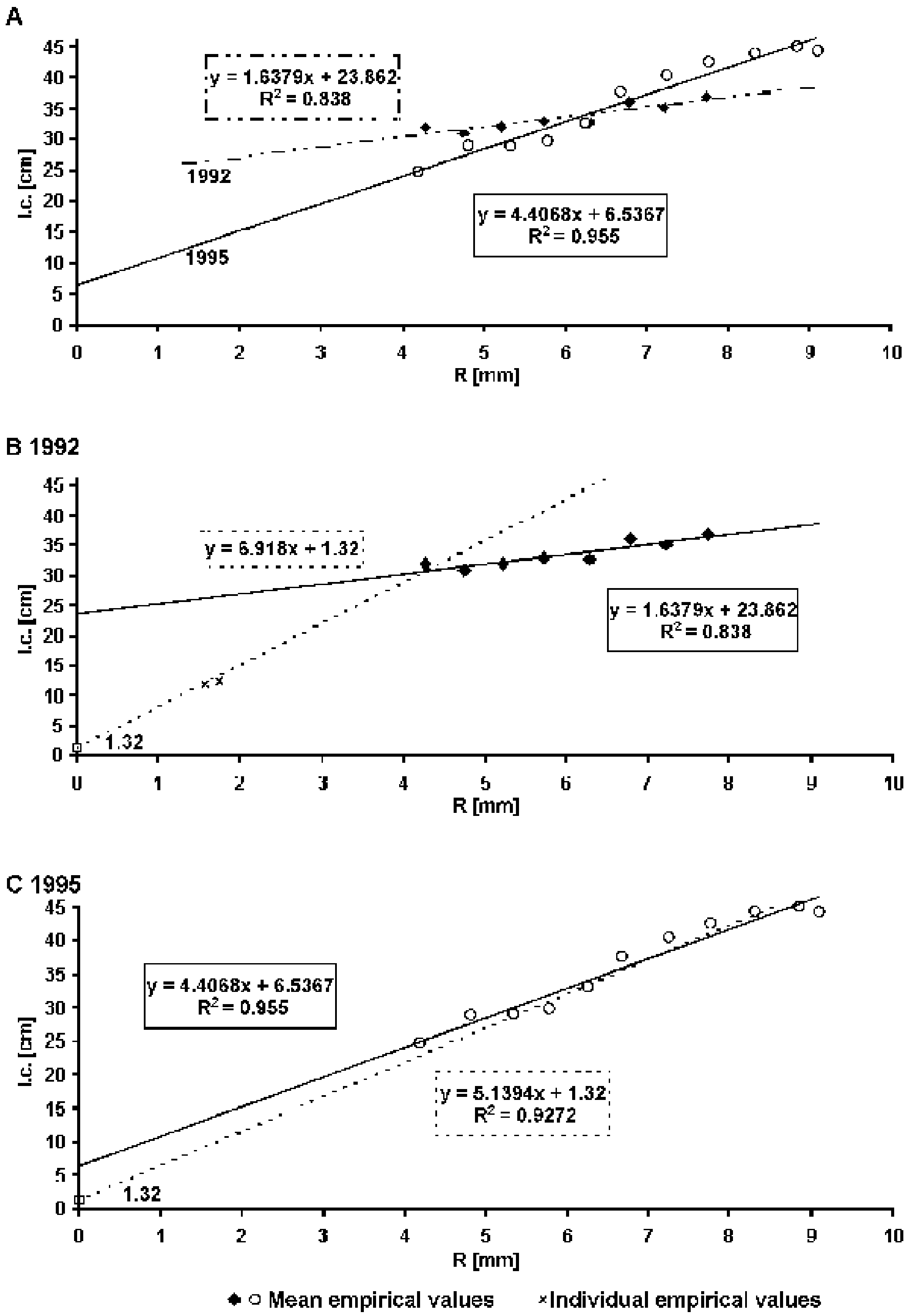
auxiliary line was plotted from 1.32 cm [4] to the nearest empirical data point, as shown in Fig. 3B. The location of empirical data points representing the two juvenile fish in the sample confirms that the broken line plotted in this way and indicative of a non-linear relationship fits the data well.

Fig. 3. Fish body length–scale caudal radius relationship



The relationship describing the scale radius-body length relationship in the fish caught in 1995 contains a free term equal to 6.5 cm. In this case, a shift of the line to 1.32 cm on the length axis (which, according to Heese [4], concerned samples containing juveniles) produced no clear reduction in the coefficient of determination (Fig. 3C). Therefore, back calculations on the 1995 data were performed with the Rosa Lee equation, corrected by 1.32 cm.

The back-calculated lengths were used to compute the von Bertalanffy equations; thereupon, after the length-weight relationships were calculated with the power function, modified von Bertalanffy equations describing the weight growth rate were derived. To compare growth rates of fish belonging to different age groups, the GL growth coefficients [8] were calculated for each group, which necessitated the use of a binomial equation with respect to change of length with time. The GL values were calculated as definite integrals within age limits from 0 to 10 years (rather than to tmx, as in Szypuła).

RESULTS

Tables 2 and 3 contain back-calculated body lengths in age groups. The mean values indicate the bream caught in 1992 to have grown at a faster rate. Those fish attained higher annual length increments over the first 4 years of life. Older fish grew faster in 1995, but they became longer as of the age of 8 years. This is illustrated by Fig. 4 showing both back-calculated mean length and curves plotted from the von Bertalanffy model. The 1995 curve shows a better fit to the empirical data. On the other hand, a stronger levelling off of the growth rate past the age of 4 is observed in 1992. Consequently, a considerably lower asymptotic length and a higher katabolic coefficient k were obtained in that year. Noteworthy is also the fact that the 1992 data set produced decidedly higher coefficients of variation, which evidences a substantial body length variability within the population (Tables 2 and 3).

Table 2. Length growth rate in different bream age groups in 1992 (l.c., mean body length; dl, length increment; SD, standard deviation; v, coefficient of variation; n, sample size)

Age group	n	Age											
		l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	l_{12}
I	2	7.75											
IV	9	8.15	15.45	22.50	27.80								
V	21	8.41	14.86	21.63	26.52	29.79							
VI	36	7.00	11.78	17.55	23.99	28.78	31.30						
VII	6	7.71	14.19	20.20	26.28	30.02	32.07	33.36					
VIII	6	8.06	13.63	20.45	25.48	29.63	32.02	33.29	34.00				
IX	10	8.24	15.45	22.82	28.08	30.97	32.58	33.81	34.64	35.27			
X	9	9.40	16.10	23.06	29.68	32.07	33.37	34.59	35.48	36.27	36.97		
XI	1	10.02	16.01	23.08	27.64	31.29	32.32	33.37	34.70	35.86	36.39	36.87	
XII	1	11.32	20.22	25.46	29.27	31.98	33.63	35.42	36.13	38.01	38.85	39.52	40.10
l.c.		7.93	13.92	20.37	26.12	29.79	31.93	33.88	34.84	35.86	37.09	38.2	40.10

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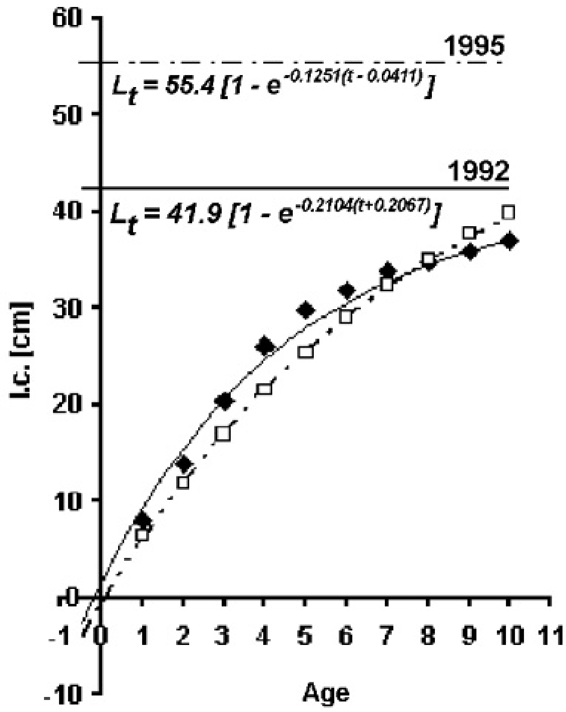
dl	7.93	5.99	6.45	5.75	3.67	2.14	1.95	0.96	1.02	1.23	1.11	1.90
SD	1.75	3.24	4.41	4.24	3.31	2.45	1.82	2.07	2.38	2.64	1.87	
n	101	99	99	99	90	69	33	27	21	11	2	1
v	22.10	23.30	21.70	16.20	11.10	7.70	5.40	5.90	6.60	7.10	4.90	

Table 3. Length growth rate in different bream age groups in 1995 (l.c., mean body length; dl, length increment; SD, standard deviation; v, coefficient of variation; n, sample size)

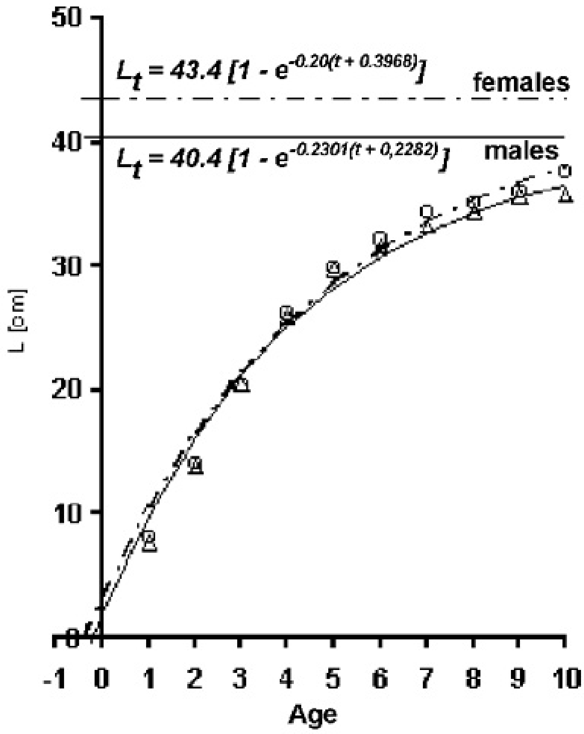
Age group	n	Age														
		l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	l_{12}	l_{13}	l_{14}	l_{15}
III	1	7.70	13.19	19.90												
IV	6	6.42	12.58	18.22	23.12											
V	13	6.38	11.82	16.70	21.55	26.23										
VI	36	6.45	11.73	17.51	21.75	25.30	28.91									
VII	8	6.13	12.07	17.48	22.10	26.70	29.83	33.85								
VIII	7	5.60	10.39	14.74	18.84	23.21	26.82	30.01	33.36							
IX	5	6.32	11.48	15.60	20.10	24.88	29.26	32.32	34.71	37.06						
1X	6	7.03	12.27	16.73	22.60	26.95	31.19	35.46	37.82	39.91	41.92					
XI	8	6.60	13.06	17.88	22.82	26.61	30.27	33.09	35.54	37.77	39.81	41.47				
XII	8	6.14	11.42	16.17	20.70	25.34	29.93	33.15	36.68	38.84	40.85	42.55	44.13			
XIII	5	6.47	11.37	15.91	20.52	24.31	27.62	30.32	33.74	35.94	38.11	39.84	41.20	42.83		
XIV	1	6.38	10.09	14.59	17.10	20.11	25.22	28.14	29.53	31.62	34.17	37.61	39.51	40.76	42.48	
XV	1	5.40	8.51	11.25	15.27	18.06	20.31	23.43	26.54	30.94	34.80	37.49	40.22	42.58	43.76	45,49
l.c.		6,38	11.77	16.91	21.44	25.40	29.08	32.42	35.04	37.64	39.87	41.15	42.59	42.50	43.12	45.59
dl		6,38	5.39	5.14	4.53	3.96	3.68	3.34	2.62	2.60	2.23	1.28	1.44	-0.09	0.62	2.47
SD		0,88	1.88	2.42	2.60	2.60	2.96	2.99	2.94	2.88	2.63	2.35	2.35	1.60	0.64	
n		105	105	105	105	98	85	49	41	34	29	23	15	7	2	1
v		13,79	15.97	14.31	12.13	10.24	10.18	9.22	8.39	7.65	6.60	5.71	5.52	3.76	1.48	

Fig. 4. Growth rate of bream caught in 1992 and 1995



No significant sex-dependent differences in growth rate were revealed in 1992 (Fig. 5). The male and female curves took similar shapes, and the von Bertalanffy equation parameters were similar.

Fig. 5. Growth rate of bream males and females caught in 1992



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As shown by the analysis of age-dependent differences in growth rate (Table 4), in neither of the two years did the Rosa Lee phenomenon occur. No regular pattern of changes in GL could be detected, which evidences a similar growth rate of fish differing in age. The higher mean value obtained in 1992 confirms the faster growth of the bream caught in that year. By the same token, the similar GL values of males and females demonstrate that both sexes were growing at a similar rate.

Table 4. Age–specific length growth rate in bream

$$\left(GL = \int_0^{10}\left(a + bt + ct^2\right)dt,\ t = \text{time (years)}\right)$$

	1992				1995			
	l.c. = a + bt +ct^2							
Age group	a	b	c	GL	a	b	c	GL
IV	-0.530	9.100	-0.525	275	-0.425	7.149	-0.315	248
V	-0.204	8.973	-0.589	250	0.932	5.607	-0.111	253
VI	-0.364	7.015	-0.272	256	0.005	6.652	-0.308	230
VII	1.304	9.180	-0.600	272	-0.111	6.572	-0.251	244
VIII	-0.686	8.703	-0.545	247	0.583	5.133	-0.130	219
IX	0.249	8.990	-0.579	259	0.308	5.892	-0.197	232
X	2.271	8.260	-0.493	271	0.060	6.609	-0.240	251
XI					0.812	6.460	-0.260	244
XII					-0.124	6.141	-0.201	239
XIII					1.162	5.498	-0.181	226
Total	0.679	7.798	-0.426	255	0.075	5.993	-0.209	231
Females	0.844	7.748	-0.418	257				
Males	0.308	7.981	-0.450	252				

The length-weight relationship (Fig. 6) turned out similar in both years. In spite of some between-sample differences in length distribution (more larger individuals and the absence of the smallest ones in 1995), the power function parameters are similar and the curves overlap. On the other hand, the weight growth curves (Fig. 7), although producing a pattern similar to the length growth curves of Fig. 4, show a larger difference past the age of 8 in favour of the bream caught in 1995 and conform to the principle of weight growing in proportion to the length cube. Due to the same reason, the difference between asymptotic weights was much larger than that between the asymptotic lengths. The two weight growth curves are sigmoid; their characteristic inflection points (where annual increments begin to decrease) fall at the age of 6 years in 1992 and as late as 11 years in 1995.

Fig. 6. Length–weight relationship of bream caught in 1992 and 1995

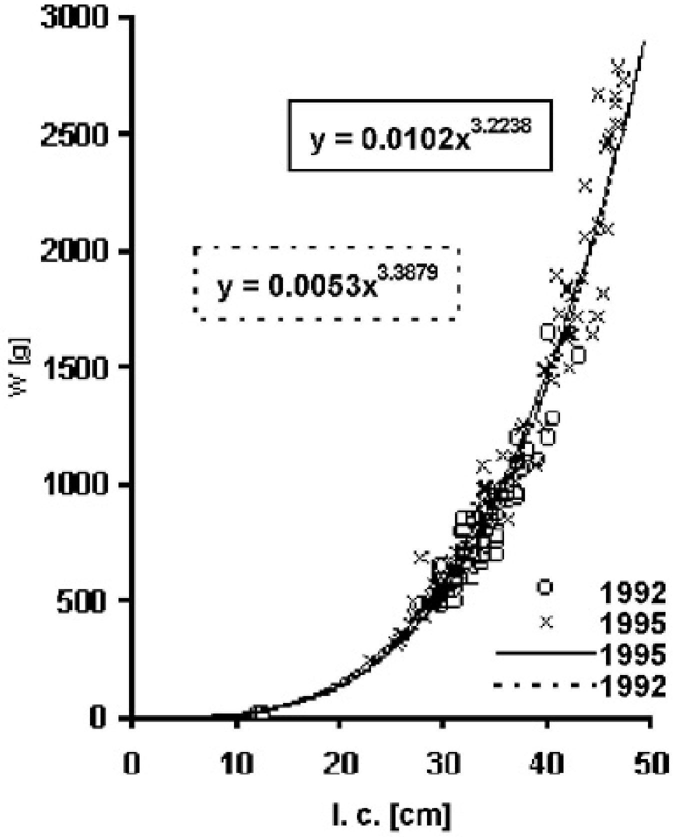
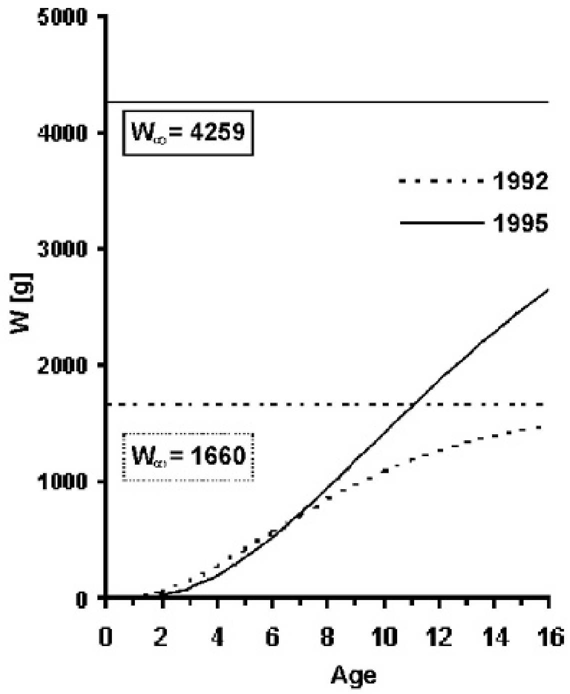


Fig. 7. Weight growth rate of bream caught in 1992 and 1995



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DISCUSSION

This study demonstrated the Lake Dąbie bream population to be non-homogenous. Not only did the 1992 and 1995 samples differ substantially in the bream growth rate, but - characteristically - different types of scale caudal radius-body length relationship were revealed to prevail in both years. The relationship was non-linear in 1992, while in 1995 it was close to linearity. Although both types of the relationship had already been recorded in bream, they occurred in different water bodies. For example, Heese [4] found a linear relationship to occur in four out of the six water bodies he studied (including the Kamień and Szczecin Lagoons, adjacent to Lake Dąbie), non-linear relationships prevailing in the remaining two reservoirs. Interestingly, the equation describing the non-linear relationship in the Lake Pierzchały ($L = 1.66 + 7.52R - 0.33R2$), derived by Heese, almost exactly fits the 1992 data reconstructed in Fig. 3B. The linear relationship determined for the 1995 data may be compared with both the linear relationship derived by Heese for the water bodies neighbouring Lake Dąbie and linear relationships derived by Abdel-Baky [1] for Lake Dąbie as well. The regression coefficients obtained by the two authors referred to were similar (ranging within 4.27-4.99); however, values of their equations' free terms (1.32-2.48) were clearly lower. They examined scales collected from small individuals, which were absent in the 1995 sample of this study. A linear radius-length relationship was reported also by Kompowski [6] in the River Regalica and Lake Dąbie bream, but that author collected the scales from below the lateral line. Further studies should show if the type of the relationship (linear vs. non-linear) changes throughout the year in relation to seasonal asynchrony in growth of fish body and scales.

The Lake Dąbie bream growth rate variability has already been demonstrated in the literature. Kompowski [7] pointed to the fact that the growth of young fish (age < 8 years) became accelerated in the period between 1974/1979 and 1985/1986, a slowed-down rate being recorded at the same time in older bream. This was reflected by a change in the von Bertalanffy equation parameters: the asymptotic length dropped from 54.4 to 44.6 cm and the katabolic coefficient increased from 0.113 to 0.175, which corresponds to the difference found between the 1995 and 1992 samples of the present study (55.4 vs. 41.9 cm asymptotic length and 0.1251 vs. 0.2104 katabolic coefficient). It is evident that the changes described were not chronologous. Their irregularity is confirmed by data reported by Abdel-Baky [1] who, based on materials collected in 1982, that is between the two series of data collected by Kompowski [7], observed a much slower growth rate ($L = 47.28$; $k = 0.12$; $to = 0.0467$).

The observations described above tend to support a conclusion that the Lake Dąbie bream population is not homogenous. The lack of homogeneity can be noticed when examining the scales, as both their shapes and legibility of seasonal zones and proportions between annual rings differ, even between individuals of the same age and caught the same day. This is reflected in the high coefficients of individual variability (Tables 2 and - particularly - 3). Without more in-depth studies, it is difficult to pinpoint causes of the variability. Both the habitat variability within the large (56 km2) area of the Dąbie and the species' migrations in the River Odra estuary (including the Pomeranian Bight) may be taken into account, in which case every sample collected from the Dąbie can produce different data. To determine the population mean growth rate would, then, require a sufficiently abundant set of systematically collected samples. It ought to be mentioned here that the roach, a species which, too, occurs in Lake Dąbie and migrates into the Pomeranian Bight, shows growth rate which is stable over a long period of time [9].

Although having a variable mean growth rate, the bream examined showed some growth-related characteristics to be constant. Within each sample analysed, the growth rate of individuals belonging to different age groups proved invariant. This may mean that the fish growth rate was not affected by environmental conditions changing over recent years. In the 1992 sample, no clear sex-related difference in growth rate was found, which confirms earlier observations of Abdel-Baky [1] concerning the same lake. Moreover, the length-weight relationship, similar in the two samples of this study, did not deviate from that found by Kompowski [7] and Abdel-Baky [1].

According to classification of Backiel and Zawisza [2], the Lake Dąbie bream meets the criteria of "good" growth: l.c. = 31.5 cm when aged 9 years and l.c. = 37 cm before the age of 11. In spite of the clear variability, the above criteria are met by both the two samples of the present study and the bream studied by Kompowski [6, 7], and even - although close to the lower limit - the fish described by Abdel-Baky [1]. The growth rate found in this study for 1992 can be even qualified as "very good", as the values obtained by bream during the first 8 years of life are comparable to those of very fast growing brackish water populations from southern Europe [5].

CONCLUSIONS

1. The Lake Dąbie bream show a fast growth rate.
2. The Lake Dąbie bream population is not homogenous. The fish caught in different years differ in their growth rates and in types of scale caudal radius-body length relationship.
3. No sex- or age-dependent differences in growth rate are observed.
4. The weight growth rate is, in different samples, related only to the length growth rate as the length-weight relationship is constant.

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