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Fish biology

GROWTH OF ROACH *RUTILUS RUTILUS* (L.) IN THE RIVER ODRA ESTUARY

WZROST PŁOCI *RUTILUS RUTILUS* (L.) W WODACH ESTUARIUM ODRY

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The back-calculation method was applied to determining growth rate of roach caught in the Międzyodrze, Lake Dąbie, Szczecin Lagoon, and the Pomeranian Bay. Samples were collected from April 1995 to October 1997. The Pomeranian Bay and Międzyodrze individuals showed a faster growth rate than that attributed to other stocks. In each of the areas studied, older females grew faster than males. The Odra estuary roach population can be regarded as one of to the fastest growing populations of the species.

INTRODUCTION

The roach is a common species in the River Odra estuary. Studies on roach in the area date back to the 1920s. This study was spurred by the lack of publications in which growth rates attained by roach in different parts of the estuary would be compared.

Majewski (1980) divided the Odra estuary into 3 parts differing in the degree of the Baltic water inflows: the Pomeranian Bay (the primary estuary) where marine effects prevail; the Szczecin Lagoon (the secondary estuary) where riverine effects predominate; and the Odra mouth combined with Lake Dąbie (the tertiary estuary) where the Baltic effects are very weak. Buchholz (1993) altered the estuary's classification by including the Międzyodrze into it as a part of the tertiary estuary. Environmental conditions in the Odra mouth area are shaped by hydrology and water chemistry. Distributions of BOD_5, COD, and nutrients show the Międzyodrze and the Pomeranian Bay to be less polluted than the Szczecin Lagoon and Lake Dąbie.

The classification referred to above implies a variety of habitat conditions offered to the fish. The present study was aimed at finding out how the variety of environmental conditions affected growth rate of roach inhabiting each part of the estuary.

MATERIAL AND METHODS

The present work is based on the analysis of a total of 999 roach caught by commercial fishermen from April 1995 to October 1997 from the Międzyodrze, Lake Dąbie, the Szczecin Lagoon, and the Pomeranian Bay. Except for the large roach in the Pomeranian Bay, caught with gill nets, all the large individuals were caught with traps. The roach juveniles were caught in the Międzyodrze with scoop nets. Dates of capture and sample sizes are summarised in Tab. 1. The adults and juveniles caught were measured to 0.5 cm and 1 mm, respectively, and weighed to 1 g. Fish age was determined as described by Szypuła (1995). Additional and juvenile rings were identified as recommended by Karpińska-Waluś (1961) and Nabiałek (1984). The scales were treated with a weak NaOH solution and measured along the caudal radius. The standard length (*SL*) of the body was used when processing the data. The standard length (*SL*)–total length (*TL*) relationship is described by the equation $LT = 1.1826\ SL + 0.2851$ ($R^2 = 0.999$).

Table 1

Date of capture and number of individuals examined

Water body	Międzyodrze		Lake Dąbie		Szczecin Lagoon		Pomeranian Bay	
Date and number of individuals	10 Nov '95	97	11 May '95	44	14 Jun '95	43	4 Apr '95	53
	5 Jun '97	63	13 Jul '95	116	24 Apr '96	75	11 Jun '96	82
	26 Jun '97	16	13 Oct '95	91	30 May '96	101	24 Oct '96	43
	1 Jul '97	23			10 Sep '96	111		
	15 Jul '97	34						
	24 Oct '97	7						
Total		240		251		330		178
Grand total								999

Figs. 1 and 2 show length distributions and age structure, respectively, of the fish inhabiting different parts of the estuary.

Growth rate analysis involved the back-calculation method, applied in a version appropriate for the scale radius (*R*)–fish length (*SL*) relationship, determined empirically for each area. Due to the non-linearity of the relationship, the radius corrected as described by Vovk (Čugunova 1959) was used (Fig. 3). Due to the lack of small fish in the samples from Lake Dąbie, the Szczecin Lagoon, and the Pomeranian Bay, scale radii smaller than those of the smallest individuals present in the samples were corrected against the linear equation $y = 1.55 + bx$ passing through points ($R = 0$; $L = 1.55$) and (R_{min}; L_{min}). The value of 1.55 is equal to the fish length at which a scale emerges (Heese 1992), while the coordinates described by R_{min} and L_{min} are typical of the individuals belonging to a class described by the smallest radius and the smallest body length. The corrected radii were substituted as R in the R–L equation. Similar distributions of R–L empirical data points in the Lagoon and in Lake Dąbie were the reason why further calculations were based on a regression line plotted for the data pooled for the two areas. Due to the presence of juveniles in the Międzyodrze sample, the Fraser-Lee method could be applied there, with a correction factor of 2.0791 cm.

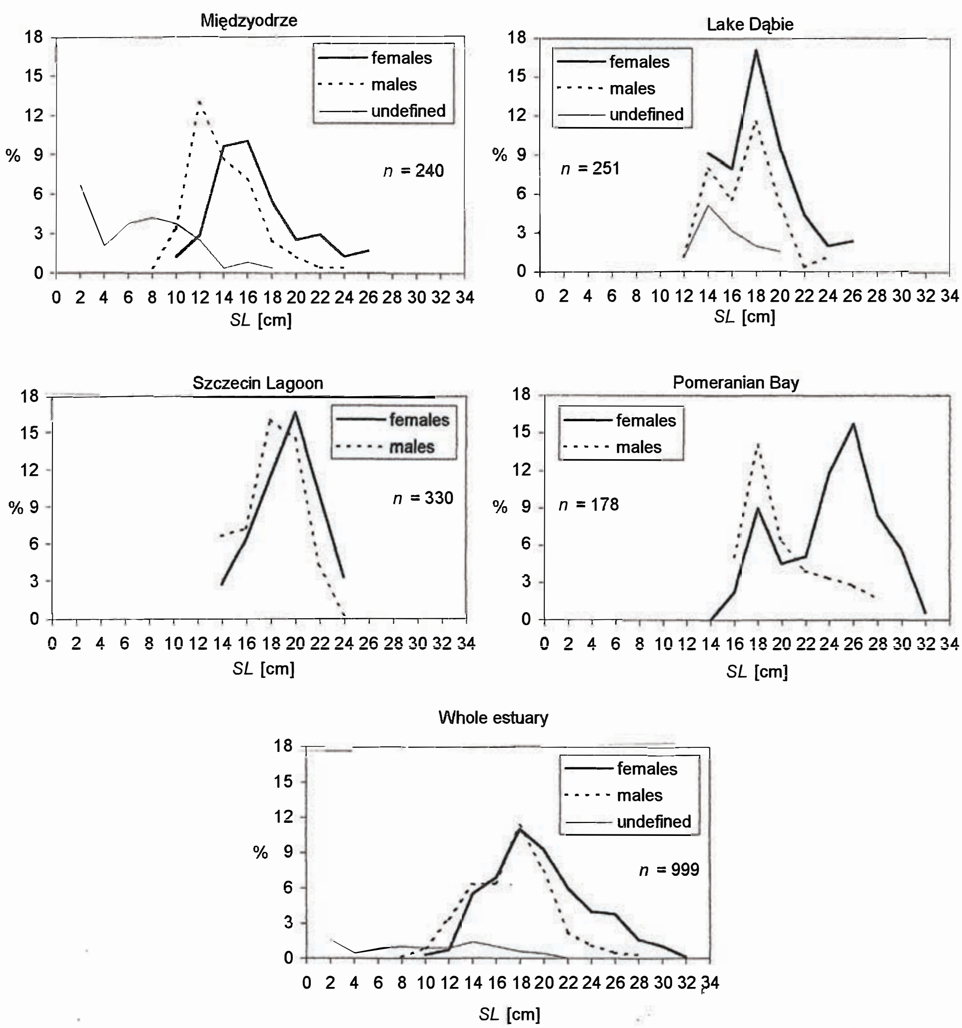


Fig. 1. Roach length distribution in the area studied

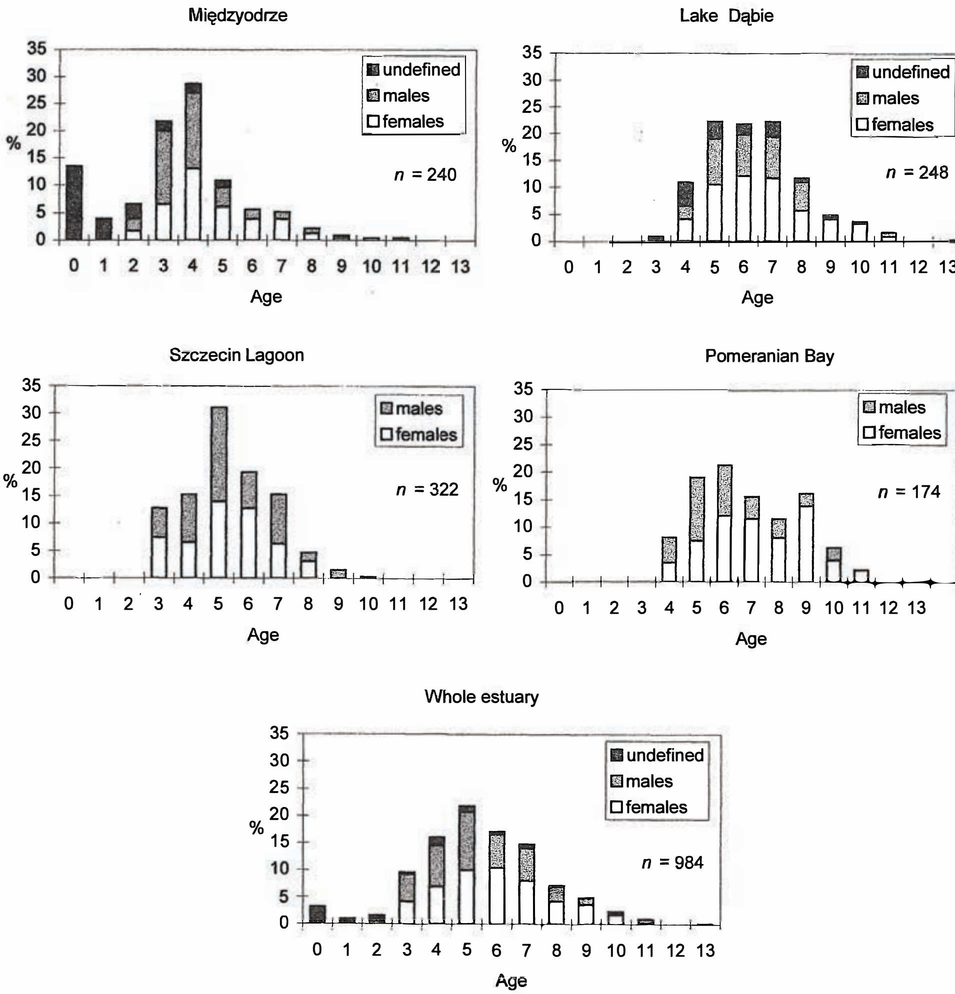
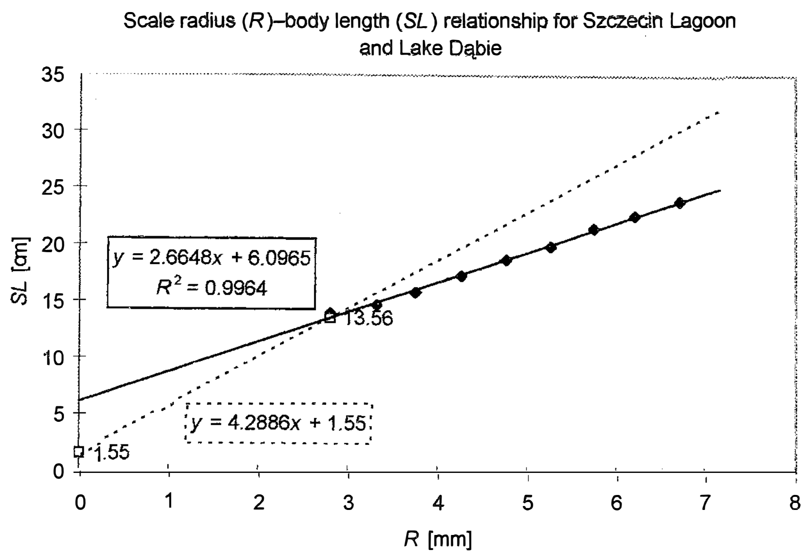


Fig. 2. Roach age distribution in the area studied

The back-calculated results served to express the roach growth rate in the form of the von Bertalanffy equations (Beverton and Holt 1957). In addition, the binomial model described by Szypuła (1977) served to calculate length growth coefficients *GL* as values of integrals for the range of 0–10. The weight growth rate was calculated from the body length (*L*)–body weight (*W*) relationship analysed elsewhere (Więski and Załachowski 2000). An attempt was made to determine environmental effects on the roach growth. Spearman's correlation coefficients (R) were calculated for mean air temperature in the growth season (April–October) and length increments of the 3 youngest age groups. Significance of the correlations was tested at the significance level of 0.05.



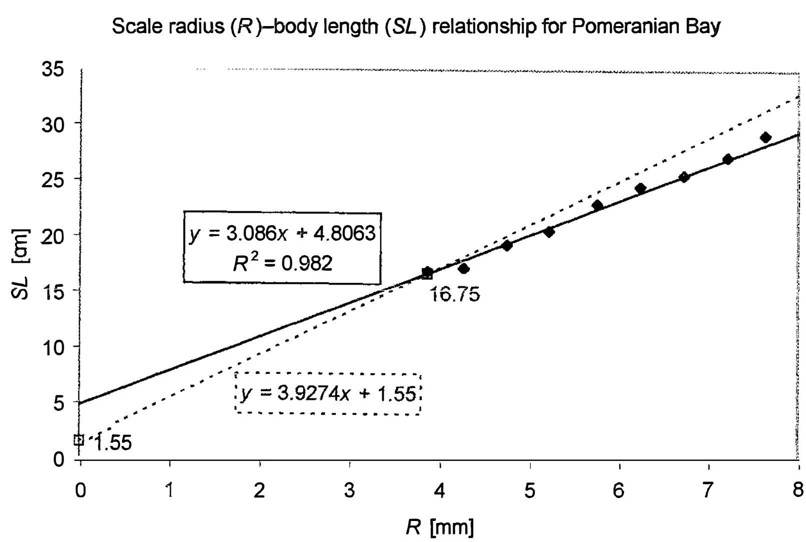


Fig. 3. Scale radius (*R*)–body length (*SL*) relationship for Szczecin Lagoon with Lake Dąbie and Pomeranian Bay

RESULTS

The length growth rate of the Odra estuary roach is illustrated in Fig. 4. The growth model curve plotted from the empirical data is presented on the left-hand side, while the right-hand side shows the von Bertalanffy model curves. The highest length increment was recorded during the first year of life. Between-sexes differences in growth rate were small. As of the fifth year of life, the growth rate clearly slowed down, which was particularly evident in the 6-year-old males; the 9- and 10-year-old males, however, grew clearly faster than the females (Fig. 4a). The comparison of lengths attained during the first four years of life showed a lack of significant differences in mean length for the sets of data from the Lagoon vs. Międzyodrze and from Lake Dąbie vs. Międzyodrze (the Mann-Whitney U test). During the subsequent 5 years of life taken together, mean lengths attained by the fish in each area were significantly different. The Pomeranian Bay roach were the largest, but the Międzyodrze roach attained the highest increments as of the sixth year of life, whereby the older individuals from the two areas were of a similar size (Fig. 4b).

Table 2

Parameters of von Bertalanffy equation and GL coefficient values of roach from the areas studied

Water body	Parameter	Total	Females	Males
Międzyodrze	L_∞	149.0	141.0	478.1
	W_∞	145386	103550	2553702
	K	0.018	0.020	0.005
	t_0	–1.172	–1.039	–1.621
	GL	154	156	150
Lake Dąbie	L_∞	26.3	27.4	22.5
	W_∞	399	449	240
	K	0.156	0.150	0.200
	t_0	–0.309	–0.359	–0.146
	GL	138	140	135
Szczecin Lagoon	L_∞	23.7	24.2	23.1
	W_∞	285	303	264
	K	0.242	0.244	0.240
	t_0	0.036	0.008	0.064
	GL	149	154	142
Pomeranian Bay	L_∞	33.2	35.2	28.4
	W_∞	970	1178	561
	K	0.139	0.127	0.184
	t_0	–0.299	–0.360	–0.140
	GL	160	162	159
Whole estuary	L_∞	32.1	31.1	33.8
	W_∞	775	700	805
	K	0.130	0.143	0.111
	t_0	–0.394	–0.293	–0.542
	GL	148	152	142

The von Bertalanffy equation parameters and values of GL, the growth coefficient, are given in Tab. 2. The model curves seem to confirm trends visible in the distribution of empirical data. Application of GL allows to arrange the areas studied in the order of increasing roach growth rate, from the slowest in Lake Dąbie to accelerating in the Szczecin Lagoon and Międzyodrze to the fastest in the Pomeranian Bay. The very high values of L_∞ and W_∞ in the Międzyodrze roach resulted from high increments later in life, with the uniform growth type.

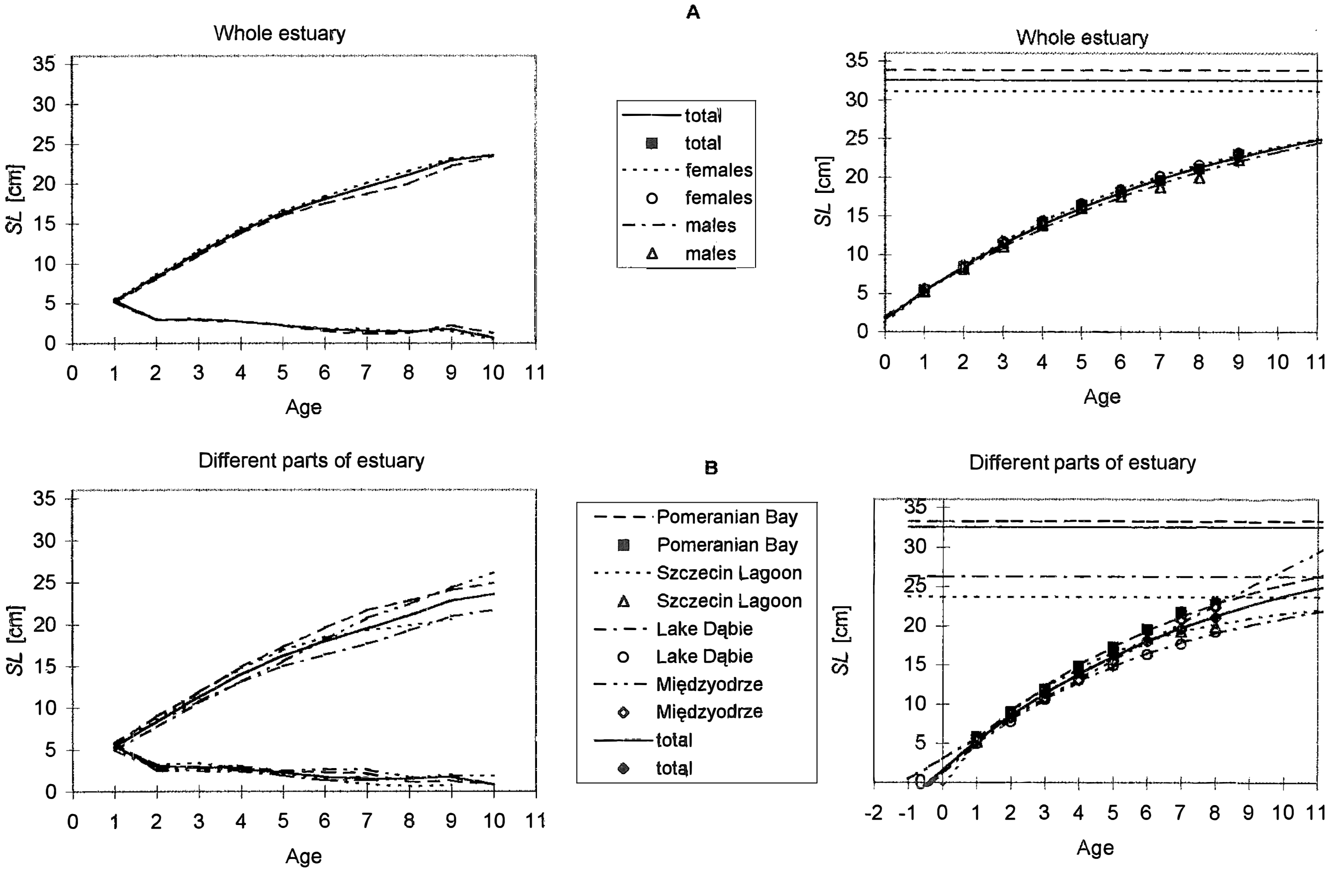


Fig. 4. Length growth rate of roach in the river Odra estuary

Growth of roach from different areas, belonging to different age groups, is illustrated in Fig. 5. Characteristic is the presence of the Rosa Lee phenomenon which, in younger fish, was most pronounced in Lake Dąbie (a much faster growth of the 3-year-old fish), while in older fish it was best marked in the Pomeranian Bay and the Szczecin Lagoon.

The weight growth models confirmed emphasised trends shown by the length growth models (Fig. 6; Tab. 2).

There are no clear trends indicating that better conditions for growth for all the age groups and/or in each area would prevail in any one year. Correlations between temperature and growth were analysed following Pauly (1979); monthly mean air temperatures were used. It was only in Lake Dąbie that a strong correlation between increments in 1-year-old roach and temperature, as measured at two meteorological stations serving the area, was revealed (Tab. 3).

Table 3

Spearman's R correlation coefficients between mean air temperatures in the growth season and length increments of the youngest age groups; Lake Dąbie: 1984–1992; Szczecin Lagoon: 1984–1990; Pomeranian Bay: 1984–1990

Pair of variables			*n*	Spearman's *R* values	*t*(*N*–2)	*p*
T^{D}	&	D_1	10	0.927273	7.005389	0.000112*
T^{D}	&	D_2	10	0.236364	0.688033	0.510885
T^{D}	&	D_3	10	0.078788	–0.223541	0.828717
$T^{D(L)}$	&	D_1	10	0.721212	2.944787	0.018573*
$T^{D(L)}$	&	D_2	10	0.515152	1.700000	0.127553
$T^{D(L)}$	&	D_3	10	0.018182	0.051434	0.960240
T^{SL}	&	SL_1	7	0.392857	0.955258	0.383317
T^{SL}	&	SL_2	7	0.535714	1.418634	0.215217
T^{SL}	&	SL_3	7	0.630656	1.817110	0.128888
T^{PB}	&	PB_1	7	0.214286	0.490552	0.644512
T^{PB}	&	PB_2	7	0.642857	1.876630	0.119392
T^{PB}	&	PB_3	7	0.464286	1.172171	0.293934

T^{D}, temperature measured at the Szczecin Dąbie meteorological station; $T^{D(L)}$, temperature measured at the Lipki meteorological station; T^{SL}, temperature measured at Trzebież; T^{PB}, temperature measured at Miedzyzdroje; indices 1–3 denote age groups; * correlation statistically significant.

DISCUSSION

No publication has so far described growth of the Międzyodrze roach. As Międzyodrze, together with the Odra branches, forms a system of connected reservoirs, the results obtained in this work were compared with those pertaining to the roach inhabiting the Regalica, one of the Odra branches (Filipiak et al. 1977) (Tab. 4). The uniform growth and a lack of statistically significant differences between lengths in different years of life (the Wilcoxon test), found in both cases, allow to infer that the roach living in the Międzyodrze and the Regalica (eastern Odra) belong to a single population having a stable growth rate. The Międzyodrze channels are overgrown by lush aquatic vegetation. Predator pressure on small fishes in such areas is weaker than elsewhere due to the limited scope for movement and poorer visibility. In addition, an area overgrown by submerged vegetation provides more space for colonisation by invertebrates (Savino and Stein 1982). The reason for a faster growth rate of the older Międzyodrze roach can be also sought in a low population density, as seemingly indicated by the age distribution (Fig. 2), although various workers expressed different opinions on density effects on the roach growth rate (Karpińska-Waluś 1961; Kempe 1962).

The growth rate of the Lake Dąbie roach as described by various authors shows a considerable similarity. With respect to individuals aged 5 years and younger, the results obtained in this work are similar to those reported by Załachowski and Krzykawska (1995). Growth of the older fish studied in this work is somewhat slower than that found in other studies (Tab. 4). The stability of growth parameters in the Dąbie over about 20 years was demonstrated by Załachowski and Krzykawska (1995).

Growth of the Szczecin Lagoon roach, as described by different authors, is more variable (Tab. 4). The pre-war German studies often refer to a fast growing roach ("Palmplötze") occurring in that area only. Schiemenz (1928) regarded the Palmplötze as a separate race the spawning period of which did not coincide with that of other populations. The Palmplötze appeared on spawning grounds before the "regular" roach did, in late April, regardless of the weather, and spawned in separate assemblages. There are no reports by Polish workers who would confirm Schiemenz's hypothesis; looking for a fast-growing stock would necessitate comprehensive research involving tagging.

The Pomeranian Bay roach are considered to be a part of the Lagoon roach stock, seasonally migrating into the Bay and returning to the Lagoon to spawn. Schoefer (1979) found the salinity range of 2–3‰ to warrant successful spawning; such is a monthly mean salinity off Świnoujście in spring (Majewski 1980). According to Jaeger et al. (1980), adult roach occur at salinities of up to 18‰. In the present study, the Pomeranian Bay roach showed, apart from the Międzyodrze stock, the fastest length growth rate. Those results were clearly different than the 1994 data reported by Załachowski et al. (1997): a still faster length growth was observed as of the second year of life on. The Pomeranian Bay data are compared with those pertaining to the coastal waters of the former GDR (Tab. 4). There is a characteristic similarity in the roach growth between the Pomeranian Bay, Greifswalder Bodden, and Daenische Wieck (Graef, 1962).

Table 4

Length (*SL*—cm) growth of roach in the Odra mouth and the coastal waters of former GDR

Water body	Author	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9
Pomeranian Bay	this study	5.8	8.9	11.8	14.9	17.3	19.6	21.7	22.8	24.1
Pomeranian Bay	Załachowski et al. 1997	5.6	7.9	10.3	12.9	14.8	17.0	19.3	21.4	22.9
Greifswalder Bodden	Graef 1962		8.3	11.8	14.8	17.6	19.7	21.7	23.4	25.5
Daenische Wiek	Graef 1962		8.5	12.0	14.8	17.1	19.0	21.0	22.2	22.8
Ryck	Graef 1962		9.0	11.8	13.4	16.2				
Szczecin Lagoon	this study	5.2	8.5	11.8	14.7	16.9	18.4	19.3	19.9	20.6
Szczecin Lagoon	Hajdus 1985 *	5.5	8.8	11.7	14.6	17.5	20.0	21.4	22.8	24.2
Szczecin Lagoon	Stasiak 1984 *	5.5	7.5	9.7	11.6	13.5	15.5	17.3	19.0	20.8
Szczecin Lagoon	Nowak 1980 *	6.3	9.9	13.1	15.8	17.3	18.2	19.3	20.6	
Lake Dąbie	this study	5.0	7.7	10.5	13.1	15.0	16.3	17.7	19.2	20.9
Lake Dąbie	Załachowski et al. 1995	5.0	7.7	10.3	12.7	14.8	17.0	18.9	20.5	21.8
Lake Dąbie	Kwiecińska 1984 *	3.1	6.3	9.5	12.3	14.5	15.8	18.2	20.2	22.2
Lake Dąbie	Filipiak et al. 1978	5.1	7.9	10.5	12.9	15.0	17.1	19.4	21.7	22.7
Międzyodrze	this study	5.8	8.3	10.8	13.1	15.6	18.2	20.8	22.4	24.4
Regalica River	Filipiak et al. 1978	4.9	7.3	9.9	12.6	15.1	17.6	19.8	21.9	

* manuscripts available at the Agricultural University of Szczecin.

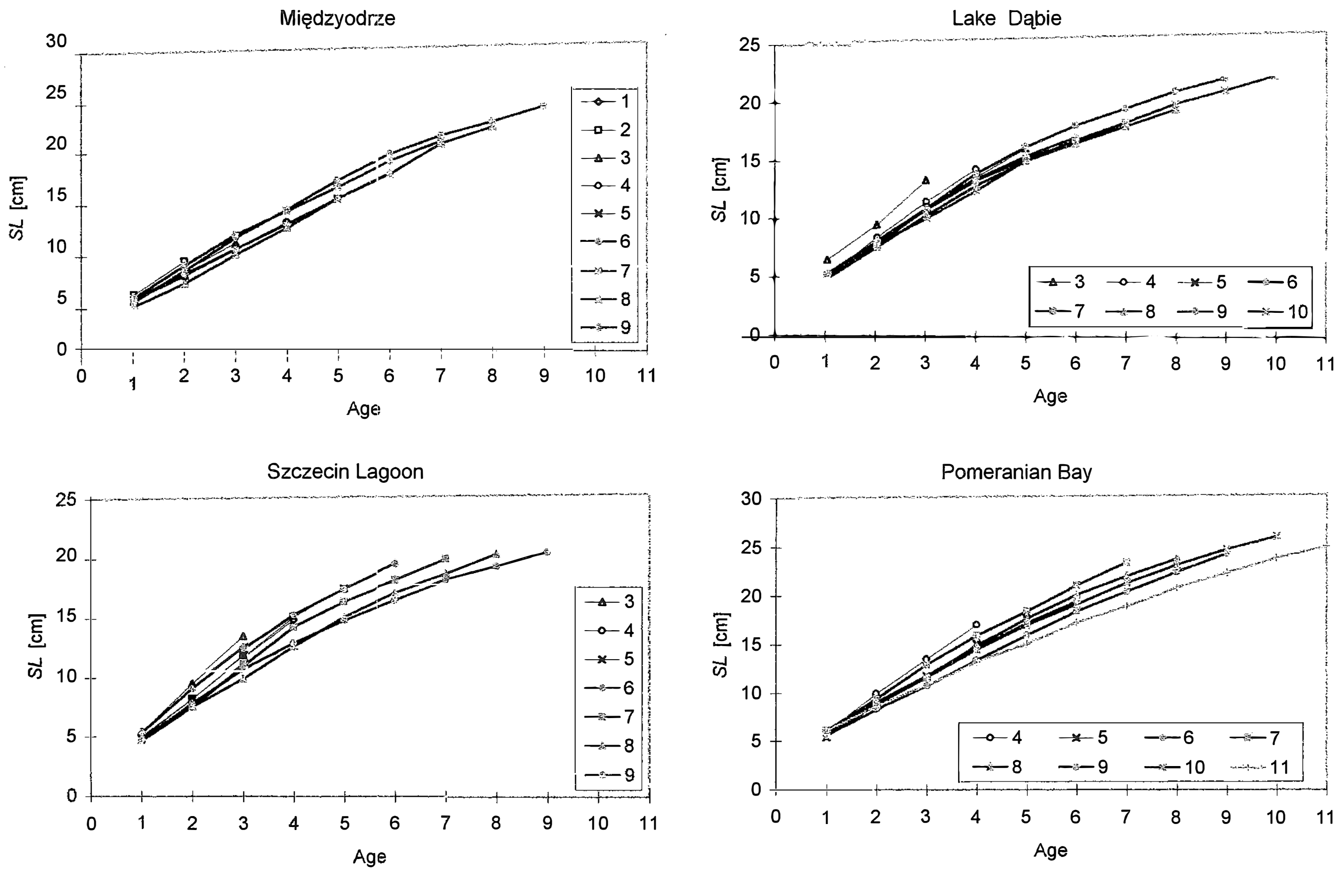


Fig. 5. Growth of age groups of roach in the area studied (1–11 age groups)

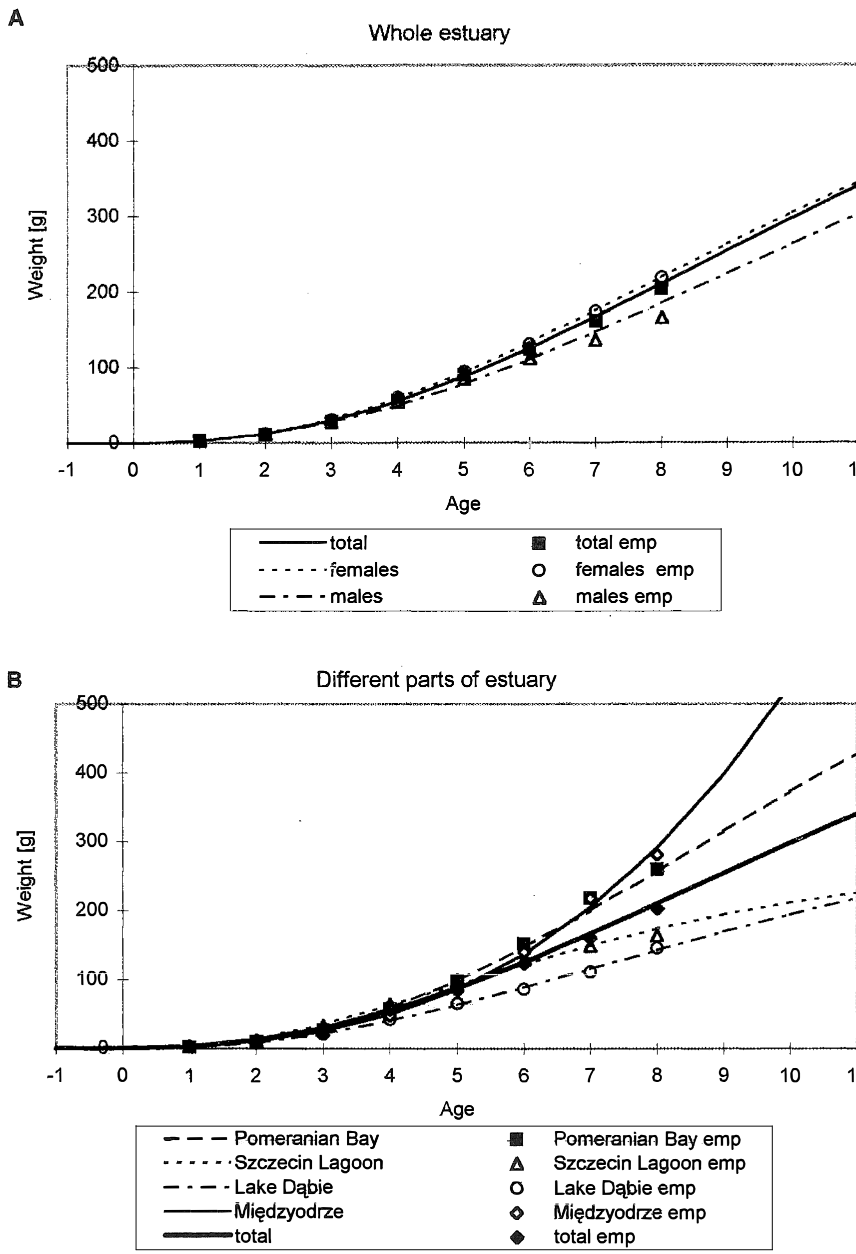


Fig. 6. Weight growth rate of roach in the whole river Odra estuary (A) and in different parts of estuary (B)

The highest length increments found in young roach in all the areas are most likely a result of a high natural mortality during the first overwintering (Wilkońska 1975). Following the growth rate assessment criteria proposed by that author, growth of the roach studied in this work could be classified as ranging from "intermediate" to "extra". The highest growth rate of the Pomeranian Bay fish was close to that described by "extra", but further on in life that growth rate slowed down, as opposed to growth rate of the Międzyodrze roach, classified as "very good" throughout the life spawn.

CONCLUSIONS

1. According to the criteria put forward by Wilkońska (1975), growth rate of the Odra estuary roach could be placed between "intermediate" and "extra".
2. Application of the von Bertalanffy model and the *GL* growth coefficient allows to arrange the areas studied in the order of increasing growth rate, from the slowest in Lake Dąbie to accelerating in the Szczecin Lagoon and in the Międzyodrze to the fastest in the Pomeranian Bay.
3. Growth rate of the Międzyodrze roach was uniform; in the remaining areas, it slowed down with age.
4. In each area, older females showed a faster growth rate than males.
5. The weight growth models applied, confirmed and emphasised the trends demonstrated by the length growth models.
6. In the Lake Dąbie roach, a strong correlation between length increments of 1-year-old individuals and air temperature, as measured at meteorological stations in Szczecin Dąbie and Lipki, was revealed.

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Kazimierz *WIĘSKI*, Włodzimierz *ZAŁACHOWSKI*

WZROST PŁOCI, *RUTILUS RUTILUS* (L.) W WODACH ESTUARIUM ODRY

STRESZCZENIE

Za pomocą metody odczytów wstecznych zbadano tempo wzrostu płoci pochodzących z Międzyodrza, jeziora Dąbie, Zalewu Szczecińskiego oraz Zatoki Pomorskiej. Próby pobierano w okresie od kwietnia 1995 do października 1997 roku.

Zastosowanie modelu von Bertalanffy'ego oraz współczynnika wzrostu *GL* pozwala na uszeregowanie tempa wzrostu długości w poszczególnych zbiornikach: od najwolniejszego w jeziorze Dąbie poprzez wzrastające w Zalewie Szczecińskim i Międzyodrzu, do najszybszego w Zatoce Pomorskiej. W Międzyodrzu tempo wzrostu płoci było równomierne, podczas gdy w pozostałych zbiornikach malało z wiekiem ryb. W każdym z badanych zbiorników samice w starszych latach życia charakteryzowały się szybszym tempem wzrostu. Modele wzrostu masy potwierdziły i uwydatniły tendencje wykazane w modelach wzrostu długości. Stwierdzono obecność zjawiska Rosy-Lee, które wyraźniej zaznaczyło się w poszczególnych zbiornikach niż w całości zbadanego materiału. W młodszych grupach wieku najsilniej zaznacza się w próbie z jeziora Dąbie (znacznie szybszy wzrost ryb 3-letnich), w starszych grupach wyraźniej występuje w próbach z Zatoki Pomorskiej oraz Zalewu, najmniej zaś w materiale z Międzyodrza.

W przypadku płoci z jeziora Dąbie stwierdzono silną korelację pomiędzy przyrostem ryb jednorocznych a temperaturą powietrza zmierzoną na stacjach meteorologicznych w Szczecinie Dąbiu oraz Lipkach.

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