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GROWTH RATE, CONDITION AND FECUNDITY OF THE FISHED POPULATION OF VENDACE (*COREGONUS ALBULA* L.) FROM THE GORZYŃSKIE LAKE (MIĘDZYCHÓD DISTRICT)

Summary. The objective of studies carried out in 2007 was the investigation of the most important biological features of the fished vendace population from the Gorzyńskie lake lying in the Międzychód-Sieraków Lakeland. In order to realize this goal, the growth rate, fish condition and fecundity of the fish were studied. Typical fishing equipment was used. In the catches, two-year-old individuals were dominated. Vendace from the studied lake belongs to the group of fish with a quick growth reaching in their third year of life the total length averaging to about 22.01 cm. The mean value of Fulton's condition coefficient in three measurement periods showed 0.902, 0.945 and 0.800 coefficient values, respectively. Vendace from the Gorzyńskie lake is characterised by a high fecundity as compared with the majority of other lakes.

Key words: vendace (*Coregonus albula* L.), growth rate, condition coefficient, fecundity

Introduction

Vendace belongs to the most valued species in fishing economy living in the lakes of the Polish country. This fact results among others from the biological and economic attributes of vendace including their shoal mood of life, quick growth rate, as well as high nutritive and taste values. Vendace, being a planktivorous species, uses food resources of the pelagic zone and it can contribute to an increase of lake productivity and at the same time, it removes from the lake a significant amount of organic matter (BERNATOWICZ 1961).

The number of lakes where vendace occurs is subject to great fluctuations connected mainly with fish stocking. Coregonides retreat from the environment together with the

progressing eutrophication process whereby this phenomenon is mainly connected with the disturbances of the natural fish spawning. The disappearance of spawning grounds in consequence affects the population number of adult fish (WALCZAK 1953, BERNATOWICZ 1961).

Fish populations of the same species which settle some types of waters may significantly differ among each other regarding many biological features. These differences result from the local adaptational abilities of the given population to the environmental conditions. At the same time, interpopulational differences may be the result of intensive stocking and exploitation. Mutual interaction of these factors on the particular populations is manifested in the differences of growth rate, fishing efficiency, vitality of gametes and brood survival (OPUSZYŃSKI 1983). This indicates the necessity of an exact analysis of the populations in the particular lakes.

The objective of this work was the biological characteristics of vendace from Gorzyńskie lake and particularly the estimation of the dynamics of changes in individual body mass, body length and the condition of vendaces in the particular fishing periods (spring, summer, autumn), determination of age and sex structure, growth rate and the calculation of fecundity indices of the studied population.

Material and methods

The Gorzyńskie lake lies in the western part of the Międzychód-Sieraków Lakeland. This aquen belongs to the Gorzyńskie lakes group. This group includes four reservoirs, i.e. Gorzyńskie lake, Gorzyńskie Środkowe lake, Gorzyckie lake and Wielkie Tuczo lake. The Struga Dormowska (the Dormowska River) flows through all the four lakes which are forest lakes deeply interwoven with the moraine landscape (KAJ 1955).

The Gorzyńskie lake has an irregular form with three separate deep waters. The lake bottom is differentiated, with three significantly deeper areas and one elevation in the form of an island covering an area of 1.25 ha. The water mirror area is 80 ha, maximal depth reaches almost 35 m (Table 1). The lake has good natural conditions, it is qualified to the 2nd category of lakes being receptive to degradation. On the basis of the studies carried out in 2006 by the Provincial Environment Protection Inspectorate in Gorzów Wielkopolski, the waters of this reservoir can be counted to the 2nd class of purity (RAPORT... 2007).

Material for the studies consisted of vendaces obtained with gill nets having 22 and 24 cm mesh diameters and 5 m height. Fishing was carried out on May 11, July 25, November 27 and November 28, 2007. The fish for studies included 60, 58 and 100 pcs, respectively. The caught fish were kept at about -28°C .

In laboratory conditions, after defreezing, the total body length (*longitudo totalis*) and body length (*longitudo corporis*) were measured using electronic slide caliper exact to 0.01 mm. Then, using electronic balance (exact to 0.01 g), the vendace body weight was determined.

Scale material for the determination of fish age and for back calculation, found over the lateral line (between the dorsal fin and the adipose fin) was obtained by the method of BERNATOWICZ (1952).

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Table 1. Morphometric indices of the Gorzyńskie lake (JAŃCZAK 1997)

Tabela 1. Wskaźniki morfometryczne Jeziora Gorzyńskiego (JAŃCZAK 1997)

Morphometric index	Value
Area (ha)	79.6
Volume (thous. m ³)	10 109.2
Maximal depth (m)	34.4
Medium depth (m)	12.7
Maximal length (m)	1 400
Maximal width (m)	940
Length of bank line (m)	5 000
Development of bank line	1.58
Exposure index	6.3

Growth rate of vendace length was calculated on the basis of scales by the method of back calculation according to the assumptions of Rose Lee. For fish obtained in spring, the edge coefficient was defined using the formula given by HEESE (1992).

The condition of fish was determined using Fulton's coefficient. The previous length measurements (*longitudo totalis* and *longitudo corporis*) permitted to calculate this parameter (OPUSZYŃSKI 1983).

Individual absolute fecundity of the studied fish was estimated by weight method in wet state. From the defrosted female individuals, gonads were taken, prepared and weighed on electronic balance. Subsequently, according to the procedure, specimens from the middle part of gonads were taken and after weighing, they were placed into flasks and immediately poured over with 4% formalin. Spawn eggs were manually counted in each sample. The method of absolute fecundity consists in the comparison of gonad mass with a small sample having a known number of spawn eggs. Relative fecundity was recorded after recalculation into 100 g body mass. Furthermore, gonadosomatic index was calculated according to the formula given by SZYPUŁA et AL. (2001).

Results and discussion

Population structure

During three catches, vendaces in the age range from 1+ to 4+ were obtained, whereby there definitely dominated two-year-old individuals. They included the following percent proportions: in spring catches – 83.3%, in summer catches – 93.1% and in autumn catches – 84.8% (Table 2). Also three-year-old individuals were caught, their percentage was: 16.7, 6.9 and 13.1%, respectively. There were also some 4+ fish, but they made only 1% of the total number of the caught vendaces. This situation is a common

Table 2. Share of age groups in the particular fishing periods (%)
Tabela 2. Udział grup wiekowych w poszczególnych okresach połowowych (%)

Period	Age groups			
	I	II	III	IV
Spring	0	83.33	16.67	0
Summer	0	93.10	6.90	0
Autumn	1.01	84.85	13.13	1.01

one occurring in fish species with a short period of life whose generation biomass drops significantly after two-three years (CHRISTIANUS 1995, CZERNIEJEWSKI et AL. 2006). A low participation of fish at the age of 1+ can be explained by the use of fishing equipment of a high selectivity. The work of CZERNIEJEWSKI and FILIPIAK (2001 b) referring to vendace from six lakes of West Pomerania indicated that in economic catches, there definitely dominate individuals in the age of 2+.

Among the caught fish, there occurred most frequently fish with the length from 22.34 to 23.57 cm and they made 36.7% of all caught vendaces (Fig. 1). Every fourth obtained fish exceeded the length of 21.07 cm, while 43 individuals (i.e. 19.72%) measured from 23.58 to 24.83 cm. Fish with smaller and greater dimensions than the above described ones occurred sporadically. Such structure of caught fish results from the applied gill nets with 22 and 24 cm mesh diameter. CIEPIELEWSKI (1974), who studied the selectivity of vendace gill nets using mesh diameters of 18, 22, 24 cm determined the selectiveness curves for them. These values describe the body length of fish and not their total length, however, after a more precise analysis, a high convergence of the caught fish sizes was found. The selectivity curves reached their maximal values with

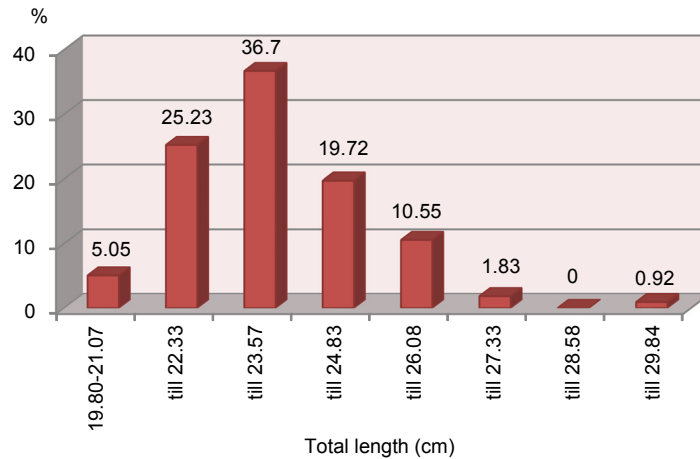


Fig. 1. Share of vendace in the particular length classes (%)
Rys. 1. Udział sielawy w poszczególnych klasach długościowych (%)

the following body lengths (*l.c.*): 16.6 for 18 mm, 19.5 for 22 mm and 21 for 24 mm. The length limits were: 14.1-18.9 cm, 16.6-22.4 cm, and 17.8-24.2 cm, respectively.

The proportion of females to males in the discussed reservoir in the two first periods was approximately 1:1. However, in autumn, there appeared a distinct superiority of male spawners over the female ones. The share of male spawners was as high as 72%. Probably the domination of males in autumn catches was caused by the presence of females on the spawning ground. Similar results were obtained by CZERNIEJEWSKI ET AL. (2006), who recorded during their catches a domination of males in the proportion of 8:1.

Growth rate

Fish growth is one of the significant factors influencing the size structure of fish population and the character of fish number dynamics (ZAWISZA 1961).

In order to trace the growth rate of vendace during the whole year, we have concentrated on the most representative groups dominating in the caught fish group which was at the age of 2+. In each of the fishing periods, females showed a significant superiority of body length over the males (Table 3). Females increase their body length most intensively in the spring-summer period and then, there follows a slowing down of the growth because of an intensive feeding and energy output connected with the developing gonads. Similar differences in the length during the course of the year are observed in males. In the summer-autumn period, their mean total body length changed only by 3 mm. Female bodies increased by the same value in autumn.

Table 3. Changes in body length and body mass in the particular fishing periods for the dominating age group

Tabela 3. Zmiany długości i masy ciała w poszczególnych okresach połowowych w dominującej grupie wiekowej

Characteristics	Spring		Summer		Autumn	
	♀	♂	♀	♂	♀	♂
Total length (<i>l.t.</i>) (cm)						
Min.	20.125	19.824	22.167	21.115	22.822	21.375
Max.	24.281	23.344	26.015	25.168	25.697	25.623
Mean	22.285	21.414	24.077	22.563	24.402	22.885
Deviation	1.408	0.918	0.985	0.918	0.832	0.893
Mass (g)						
Min.	86.8	70.45	109.15	82.7	86.4	73.50
Max.	115.85	108.00	159.35	126.55	161.9	120.05
Mean	101.18	86.31	132.145	106.48	126.42	92.83
Deviation	8.27	9.73	12.83	11.19	19.79	10.10

Also in reference to body mass, females dominate over males (Table 3). The mean body mass of two-year-old females in the autumn period is 102.03 g. Between spring and summer, females increase their weight by about 30 g, while males in the same period gain only 20 g. With the arrival of autumn, in both sexes, a drop in the mean body weight was observed.

In the planning of the vendace resources exploitation, one should take into consideration the period of nutrition intensity and the growth of the fish. According to SVÄRDSON (1979), in the lakes of Sweden, the greatest increments of vendace were found from March to August, while in the lakes of Finland, this period decreases to the time span from May to July (LEHTONEN 1981). In Polish lakes, the intensity of nutrition and growth of vendace is the highest from April to October, whereas about 70% of annual fish increments are obtained by them in June and July (in the period of full summer stagnation). This results from an increased number and concentration of crustacean plankton and from the domination in its species structure of easily caught cladocerans (MARCIAK 1962). Inhibition of vendace length and body mass increments is connected with water temperature drop and thereby with a smaller intensity of feeding and the development of sexual glands (BACKIEL 1952). The above statements indicate that vendace exploitation should be carried out from July to September.

Analysis of the growth rate of the whole population indicates that vendace from the Gorzyńskie lake is characterised by an intensive growth in the two first years of life, then after sexual maturity the growth rate decreases (Fig. 2). During the first year, vendace reaches on the average a length of 13.28 cm in the second year, its increment is 7 cm, while in the third year the increase amounts only to 1.22 cm.

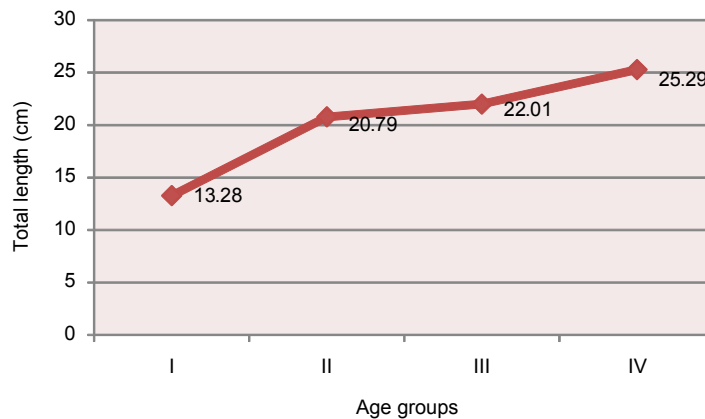


Fig. 2. Growth rate of vendace from the Gorzyńskie lake
Rys. 2. Tempo wzrostu sielawy z Jeziora Gorzyńskiego

MASTYŃSKI (1985) referred to Bernatowicz and confirmed that vendace increment being a population feature is in a specific way stabilized in each lake.

On the basis of data referring to the growth rate of vendaces originating from 146 reservoirs SZCZERBOWSKI (1981) divided the population of this species into groups.

Individuals being in the 3rd year of life and reaching less than 18.3 cm length and their body mass is below 61 g are qualified by him as growing very slowly; fish of 19.8 to 21.5 cm and weighing 69-85 g are classified by him as growing in an average way, while vendaces measuring more than 23.7 cm and having a mass exceeding 112 g are considered by him as growing at a very quick rate. On the basis of this division, vendace population from Gorzyńskie lake can be regarded as one which is growing very fast.

Condition

The definition of fish condition is of significant importance in ichthyology. The knowledge of this parameter is necessary in the rational fish management. The mentioned indicator is most useful in reference to fish in which the dependence between length and body mass changes insignificantly with their age. OPUSZYŃSKI (1983) reported that in salmonid fish, the condition coefficient is close to 1.

Independent of the fishing term, females were characterized by insignificantly higher value of the discussed index, as compared with male fish (Table 4). The difference was the highest in autumn season. In spring, fish condition showed medium values between the two remaining catching periods. In the best condition were the individuals obtained in July; Fulton's coefficient in this case was close to 1. On the other hand, the poorest condition of nutrition was shown by the fish in November, the female spawners reached a value equal to 0.847, while male spawners showed a coefficient of 0.774 (Table 5).

Table 4. Condition coefficient and sex in the particular fishing periods

Tabela 4. Współczynnik kondycji a płeć w poszczególnych okresach połowowych

Sex	Spring	Summer	Autumn
♀	0.921	0.966	0.847
♂	0.873	0.922	0.774
Deviation	0.080	0.172	0.094

Table 5. Condition coefficient of age groups in the particular fishing periods

Tabela 5. Współczynnik kondycji grup wiekowych w poszczególnych okresach połowowych

Period	Age groups			
	I	II	III	IV
Spring	0	0.903	0.866	0
Summer	0	0.940	1.117	0
Autumn	0.704	0.797	0.788	0.688

In two fishing periods, i.e. in spring and summer, no individuals belonging to the I and IV age groups were found, therefore, they were excluded from analyses. The least oscillations of the mentioned conditions occurred in two-year-old vendaces, since in spring, summer and autumn the indices were: 0.903, 0.94 and 0.797, respectively. In the following year of life, there were more distinct differences in the particular seasons of the year. The greatest of them equalling to 0.329 was found in vendaces from the catches in summer and autumn. The mean condition of three-year-old vendaces showed 1.117 in spring and 0.788 in autumn.

Analysis of mean values of this parameter calculated by CZERNIEJEWSKI and FILIPIAK (2001 a) for West Pomerania lakes indicates a slight (not exceeding 3%) domination of vendaces obtained from the Drawsko lake over the population from the Pile reservoir. Also a not great difference was found for vendaces from the lakes Narie and Wierzbiczany (RADZIEJ 1973). The presented parameter oscillated in the range from 1.07 to 1.30. Similar values of the condition coefficient were reached by vendaces from the lakes Tuczno and Siecino (CZERNIEJEWSKI et AL. 2002). On the other hand, individuals from the reservoirs in Pełcz Wielki, Bytyń Wielki and Wełtyń were characterised by a lower condition (0.70-0.80). Fish from the Gorzyńskie lake showed values similar to the latter ones.

Works of CZERNIEJEWSKI et AL. (2002, 2004) referring to lakes: Tuczno, Siecino and Miedwie indicated that females were in a definitely better condition than males. The same regularity was shown by the studied population from the Gorzyńskie lake.

Fecundity

Fish fecundity is one of the important biological features which decide about the herd size. The amount of spawn in the particular species is differentiated, it refers also to populations living in reservoirs with different environmental conditions. Analysis of the discussed parameter in the particular aquens is particularly important in fish with a short life cycle including vendace. The fact is that there exists a danger that with an inconsiderate exploitation the fish may be excessively overfished (CZERNIEJEWSKI et AL. 2003) leading to a significant decrease or even extermination.

The analysed vendaces from the Gorzyńskie lake were characterised by a medium absolute fecundity of 13 925 spawn eggs for the age of 2+, and 11 274 spawn eggs for the age of 3+ (Table 6).

Mean relative fecundity for vendace population from the Gorzyńskie lake at the age of 2+ was 15 194 spawn eggs per 100 g of body mass. On the other hand, vendaces of three years were characterised by a lower value (12 538 pcs per 100 g).

Two-year-old vendaces were distinguished by a greater share of gonad mass in relation to body mass. Their GSI was 23.52%, while in female spawners of 3+, it made 20.58%. In the genadosomatic index, there was a domination of 2+ vendaces and in reference to absolute and relative fecundity, the situation was similar (Table 6).

Vendace belongs to fish with a comparatively low fecundity. It is compensated by a rather quick reaching of sexual maturity. In Polish lakes, the discussed species is able to spawn at the age of 1+ (BUDYCH and IWASZKIEWICZ 1964, BERNATOWICZ 1963). However, many researchers believe that the majority of vendace female spawners are at the age of 2+. This fact was also observed in the lakes of the Sierakowskie Lakeland

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Table 6. Fecundity of vendace from the Gorzyńskie lake
Tabela 6. Płodność sielawy z Jeziora Gorzyńskiego

Parameter	Characteristics	Age	
		2+	3+
Absolute fecundity	Min.	1 847	5 005
	Max.	20 292	15 898
	Mean	13 925	11 274
	Deviation	4.748	5.630
Relative fecundity	Min.	1 891	5 010
	Max.	23 351	19 200
	Mean	15 194	12 538
	Deviation	5.345	7.134
Gonadosomatic index	Min.	4.18	11.06
	Max.	32.91	29.27
	Mean	23.52	20.58
	Deviation	7.651	9.133

(BUDYCH and IWASZKIEWICZ 1964, MASTYŃSKI 1985). Similar is the age of vendace spawning herd in the Mazurian lakes (BERNATOWICZ 1963).

Literature data (CZERNIEJEWSKI et AL. 2003) indicated that the highest absolute fecundity is shown by vendaces from the lakes of Wielkopolska, the Śremskie lake and Chalińskie lake, as well as the Mazurian Isąg lake. A similar amount of spawn in gonads was also found in vendaces from Gorzyńskie lake. According to BERNATOWICZ (1963), vendace fecundity shows a range of 3300 spawn eggs for females at the age of 1+ to 14 100 in females at the age of 4+.

Results of studies carried out by WALCZAK (1953) explicitly indicate that in vendace females occurring in the lakes of West Pomerania, the mass of gonads oscillates between 14.63% and 23.16% of the female body mass. In turn, the measurements of BERNATOWICZ (1963) in reference to the Mamry lake show a still greater mass of gonads which ranges from 13.0 to 28.5%.

In this range, there are also the calculated values of GSI coefficient for the population from the Gorzyńskie lake in the 1980-ies where the gonad mass constituted from 21 to 26.8% of body mass (MASTYŃSKI 1985). Repeated studies of vendace female spawners from that lake in 2007 gave similar results. The mean mass of gonads at the age of 2+ and 3+ amounted to 23.52% and 20.58%, respectively.

Vendace from the Gorzyńskie lake is characterised by a higher relative fecundity in comparison with female spawners from Tuczno reservoir, which also belongs to the Gorzyńskie lakes group (CZERNIEJEWSKI et AL. 2002). At the age of 2+, the mean real

fecundity in the 2+ fish was 15 200 spawn eggs, while in the fish from the Tuczno lake, it was 11 000 spawn eggs. In the successive year of life, the difference was lower, because for 100 g of vendace ovary from the Gorzyńskie lake there were 12 500 spawn eggs, while in case of the population from the Tuczno lake the number was 11 600 spawn eggs.

Conclusions

1. Analysis of the age structure of the studied vendace population has shown that in the Gorzyńskie lake in all fishing periods, there dominated two-year-old fish making 83.3, 98.1 and 84.8% of caught fish, respectively.

2. Sex proportion in vendace population in spring and summer fishing showed 50% both for male and female individuals. However, in autumn, there dominated male vendace.

3. According to the classification by SZCZERBOWSKI (1981), growth rate of fish length and increment of body mass in the third year of life were very good in the studied lake, however, they were lower than in the 1970's.

4. Fulton's condition coefficient of the studied population reached a lower value in each of the three fishing seasons showing 0.9002, 0.9045 and 0.800, respectively.

5. Vendaces from the Gorzyńskie lake are characterised by a comparatively high absolute fecundity giving 13 925 spawn eggs at the age of 2+ and 11 274 spawn eggs at the age of 3+ and a relative fecundity of 15 194 spawn eggs per 100 g of body mass for 2+ and 12 538 spawn eggs for 3+ fish. Absolute fecundity of the Gorzyńskie lake vendaces is higher than the mean value obtained from 23 lakes of Poland.

6. The calculated genadosomatic index (GSI) was 23.52% for the fish at the age of 2+ and 20.58% for 3+ fish. These values are within the values reported by BERNATOWICZ in 1963 (13.0-28.5%).

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TEMPO WZROSTU, KONDYCJA ORAZ PŁODNOŚĆ ŁOWNEJ CZĘŚCI
POPULACJI SIELAWY (*COREGONUS ALBULA* L.) Z JEZIORA GORZYŃSKIEGO
(POW. MIĘDZYCHODZKI)

Streszczenie. Celem przeprowadzonych w 2007 roku badań było poznanie najważniejszych cech biologicznych eksploatowanej rybacko części populacji sielawy z Jeziora Gorzyńskiego, leżącego na Pojezierzu Międzychodzko-Sierakowskim. Aby zrealizować cel pracy, określono tempo wzrostu, kondycję oraz płodność badanych sielaw. Przy zastosowaniu typowych narzędzi rybackich w odłowach dominowały ryby dwuletnie. Sielawa z badanego zbiornika należy do grupy o szybkim wzroście, osiągając w trzecim roku życia średnio 22,01 cm długości całkowitej. Średnia wartość wskaźnika kondycji Fultona w trzech okresach badawczych wyniosła odpowiednio 0,902, 0,945 oraz 0,800. Sielawa z Jeziora Gorzyńskiego cechuje się dużą płodnością w porównaniu z sielawą z większości jezior.

Słowa kluczowe: sielawa (*Coregonus albula* L.), tempo wzrostu, współczynnik kondycji, płodność

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