

Sławomir RUNOWSKI¹, Janusz GOLSKI*¹, Mieczysław GRZELAK²,
Wojciech ANDRZEJEWSKI¹, Jan MAZURKIEWICZ¹, Maciej MURAWSKI²

¹ Institute of Zoology Division of Inland Fishery and Aquaculture Poznan University of Life Sciences

Wojska Polskiego 71 c 60-625

² Department of Grassland and Natural Landscape Sciences Poznan University of Life Sciences Dojazd 11 60-632 Poznań

*email: golski@up.poznan.pl

BIOLOGICAL CHARACTERISTICS OF SPAWNING POPULATION OF VENDACE (*COREGONUS ALBULA* L.) FROM LAKE ŚREMSKIE (MIĘDZYCHÓD DISTRICT)

Summary

The objective of studies carried out in 2011 was to investigate the most important biological traits of the spawning population of the vendace from Lake Śremskie lying in the Międzychód-Sieraków Lakeland and to compare the results to the literature data. The biological material was obtained in the autumn, immediately before spawning. To achieve the objective of the research the following features were studied: sex structure, growth rate, fish condition, fertility as well as biometric and meristic traits of the studied vendace. At the same time, the most important physico-chemical water indices were determined to provide a characteristic of the environmental conditions. On the basis of physical and chemical indicators the status of water was classified as good. The vendace from the investigated water body may be classified to the group of very good growth rate (significantly above the average), reaching in the third year of life on average the total length of 22.4 cm. Fulton's index of fish condition ranged from 0.78 to 1.25 with a mean value of 0.89. The mean absolute fertility was 12714 eggs, while relative fertility was 11994 eggs per 100 g of body mass. Considering the quantitative traits, the fish population of Lake Śremskie differs non-significantly regarding the greatest and the smallest body height from the populations with a good growth rate described by Bernatowicz. The meristic traits of the studied population do not significantly deviate from the values reported by other researchers, except for filtration processes.

Key words: vendace (*Coregonus albula* L.), ecological status, growth rate, fish condition, fertility index, population characteristics

CHARAKTERYSTYKA BIOLOGICZNA (STADA TARŁOWEGO) TARŁOWEJ POPULACJI SIELAWY (*COREGONUS ALBULA* L.) Z JEZIORA ŚREMSKIEGO (POW. MIĘDZYCHODZKI)

Streszczenie

Celem przeprowadzonych w 2011 roku badań było poznanie najważniejszych parametrów biologicznych populacji sielawy z jeziora Śremskiego, leżącego na pojezierzu Międzychodzko-Sierakowskim oraz porównanie uzyskanych wyników do danych literaturowych. Materiał biologiczny pozyskano w okresie jesiennym, tuż przed rozpoczęciem tarła. Aby zrealizować cel badań określono strukturę płci, wiek, tempo wzrostu, kondycję, płodność, a także cechy populacyjne (mieralne i policzalne) badanych sielaw. Równocześnie oznaczono najważniejsze wskaźniki fizykochemiczne wody, pozwalające scharakteryzować warunki środowiskowe jeziora. Na podstawie wskaźników fizykochemicznych stan wód zbiornika uznano jako dobry. Sielawa z badanego zbiornika należy do grupy o bardzo dobrym wzroście (znacznie powyżej średniej krajowej), osiągając w trzecim roku życia średnio 22,4 cm długości całkowitej. Wartość wskaźnika kondycji Fultona wahała się od 0,78 do 1,25, przy średniej 0,89. Średnia płodność absolutna wyniosła 12714 szt. jaj, natomiast płodność względna 11994 szt. jaj na 100 g masy ciała. Biorąc pod uwagę cechy mieralne populacja śremska nieznacznie różni się pod względem wysokości ciała od innych populacji o dobrym wzroście, opisanych przez Bernatowicza. Cechy policzalne badanej populacji nie odstają od wartości podanych przez innych badaczy, z wyjątkiem liczby wyrostków filtracyjnych.

Słowa kluczowe: sielawa (*Coregonus albula* L.), jezioro Śremskie, stan ekologiczny, tempo wzrostu, kondycja, płodność, cechy populacyjne

1. Introduction

The vendace is one of the most valuable species in the fishery economy among the species living in Polish lakes. This results from the important biological and economic attributes of the vendace, including its shoaling lifestyle, rapid growth rate, as well as high nutritive and taste value [1, 2]. The vendace being a planktonophagous species uses food resources of the pelagic zone and it can contribute to an increase of lake productivity, while at the same time removing from the lake a significant amount of organic matter [3, 4].

The vendace has high environmental requirements and is therefore an indicator species.

The number of lakes, where vendace are found, fluctuates greatly depending mainly on fish stocking. *Coregonidae* retreat from the environment together with the progressing eutrophication process, while this phenomenon is mainly connected with disturbances of natural fish spawning. The disappearance of spawning grounds in consequence affects the population size of adult fish [1, 3, 5-7].

A very important factor is also connected with changes in the species composition of the zooplankton, which is the basic food of vendace [8].

Locally, especially in lakelands, vendace may be of some economic importance, being a source of food with high taste and health value. Dishes and preparations from vendace, promoted as an environmentally friendly product,

may be local culinary symbols of the region. Fishfarmers with appropriate lakes and technical equipment, by promoting valuable species such as vendace and whitefish, boost their business competitiveness, thereby increasing profits.

Fishery management, carried out in accordance with the principles of sustainable development, is in line with the trend towards organic agriculture through production and promotion of healthy food. Basic species of this trend in terms of fishing potential should be first of all vendace and whitefish.

To implement a new model of ecological fishery management on lakes it is necessary to know the exact environmental status and food resources, as well as the structure of fish fauna species and population parameters of key species. Lakes differ in terms of numerous environmental factors, resulting in considerable variability of biological characteristics such as e.g. hatching survival, growth and fertility in fish populations, including the vendace [8]. These differences result from local adaptability to environmental conditions exhibited by a given population [7, 9-11]. At the same time, inter-population differences may be the result of intensive stocking and exploitation, as the intensity of fishery production must be adapted to the nature and trophic conditions of reservoirs and to the biological characteristics of fish species that inhabit them.

Having this in mind, it was decided to explore production capabilities of lakes in the Wielkopolska region, with particular emphasis on vendace.

This paper presents the first part of research results, concerning the vendace population of Lake Śremskie, unique on the national scale and located in the Sieraków-Międzychód Lakeland.

2. Study area, materials and methods

Lake Śremskie is located in the north-western part of the Wielkopolska region, the Międzychód-Sieraków Lakeland in the Sierakowski Landscape Park. The landscape park comprises numerous postglacial lakes. Within the Park there are 63 lakes with an area of min. 1 ha, the largest of which is Lake Chrzypsko (304 ha), while Lake Śremskie is the deepest (45 m).

In the direct catchment area of Lake Śremskie arable land predominates occupying about 67% of the area, while forests account for 28.4%. Built-up areas include two small villages of Chalin and Śrem occupying 1.4% of the surface. The lake lies in a basin surrounded by high banks, with the exception of its south side.

The surface water elevation of the lake is 39.3 m above sea level, while the surrounding hills rise up to 70 m above sea level. Lake Śremskie with an area of 117.6 hectares is one of the largest water bodies of the Sierakowski Landscape Park. The maximum depth is 45 meters, classifying the lake as the deepest in the Wielkopolska region. The bottom of the basin is highly diverse with numerous depressions and underwater elevations. Lake Śremskie is a dimictic water body with relatively limited exposure to wind, which affects the time and speed of water mixing and epilimnion depth. The most important morphometric parameters are presented in Table 1.

In order to realize the objective of this study the following traits of the investigated vendace were determined: sex structure, growth rate, fish condition, fecundity, as well as biometric and meristic traits. At the same time the most im-

portant physico-chemical indices of water were determined to characterize environmental conditions.

Table 1. Morphometric parameters of Lake Śremskie
Tab. 1. Parametry morfometryczne Jeziora Śremskiego

Parameter	Lake Śremskie
Height [a.s.l.]	39,3
Area [ha]	117,6
Volume [thous.m ³]	23735
Max. depth [m]	45,0
Mean depth [m]	20,2
Max length [m]	1620
Max width [m]	1050
Shore line length [m]	4700
Development of shore line	1,22
Exposure indicator	5,8

Source: own work / Źródło: praca własna

Fish for studies were caught in mid-November 2011 using gill nets with a 22 mm mesh size. Water samples were collected in the period of summer stagnation in the end of August and during winter stagnation in the beginning of February. In summer and in winter thermal and oxygen profiles were prepared to determine the stratification and oxidation of waters. Also the visibility of the Secchi disc was recorded. Furthermore, in the summer period water samples were collected to determine the following physico-chemical indices: pH, biochemical oxygen demand (BOD₅), total phosphorus, total nitrogen, proper electrolytic conductivity and chlorophyll a contents.

Fish were stored frozen at -28°C in special plastic bags, which prevented water sublimation from fish bodies. After defrosting the mass of each fish was measured accurate to 0.1 g. A total of 25 body shape parameters were measured (Table 2) and the most important meristic traits were recorded. Furthermore, for female fish the mass of gonads was determined and on the basis of sampled gonad sections their absolute fecundity and relative fecundity were defined. In order to determine the age of fish, scales were sampled along the lateral line of the body from the place between the adipose fin and the dorsal fin [12]. Growth rate of vendace was determined by the method of back calculations according to Lea [13].

On the basis of the measurements, Fulton's coefficient was calculated, which defines the correlation between length and individual mass of fish [14].

Results of the above measurements are shown in tables for their further analysis, which in effect will provide biological characteristics of the vendace population from Lake Winnogóra.

3. Results and discussion

3.1. Environmental conditions – physico-chemical indices

At the end of August marked lake water stratification was observed, with the epilimnion thickness of 5 m, that of the metalimnion being 4 m, while the hypolimnion started from 10 m depth (Table 3). The temperature of the epilimnion was slightly over 22°C, while that of the lower hypolimnion was 5.5°C. The considerable water stratification and low temperature of the bottom layers classify Lake Śremskie as a deep, relatively static dimictic lake. Such lakes are characterised by a lower primary productivity, which has a positive effect on their water quality [15].

Table 2. Quantitative and meristic traits and their symbols
 Tab. 2. Cechy mierzone i policzalne oraz ich oznaczenia

Quantitative traits		Meristic traits	
Symbol	trait	Symbol	trait
X ₁	lateral head length	PD	dorsal fin
X ₂	preorbital distance	PD T	PD hard rays
X ₃	eye diameter	PD M	PD soft rays
X ₄	postorbital distance	PA	anal fin
X ₅	head height	PA T	PA hard rays
X ₆	head width	PA M	PA soft rays
X ₇	total fish length	PC	caudal fin
X ₈	caudal length	PC M	PC soft rays
X ₉	body length	PP	pectoral fins
X ₁₀	predorsal length	PP T	PP hard rays
X ₁₁	postdorsal length	PP M	PP soft rays
X ₁₂	greatest body height	PV	ventral fins
X ₁₃	preanal length	PV T	PV hard rays
X ₁₄	smallest body height	PV M	PV ventral rays
X ₁₅	caudal peduncle length	l.l.	scale number on lateral line
X ₁₆	caudal fin length	l.l.s/i	scale no. over and under lateral line
X ₁₇	pectoral fin length	Sp. branch.	no. of filtration processes
X ₁₈	ventral fin length	RB	number of subbranchial rays
X ₁₉	dorsal fin height		
X ₂₀	anal fin height		
X ₂₁	dorsal fin base length		
X ₂₂	anal fin base length		
X ₂₃	distance between pectoral fin and ventral fin		
X ₂₄	distance between ventral fin and anal fin		
X ₂₅	length of adipose fin		

Source: own work / Źródło: praca własna

Table 3. Temperature and oxidation in Lake Śremskie waters in the summer and winter periods
 Tab. 3. Termika i natlenienie wód w Jeziorze Śremskim w okresach letnim i zimowym

Depth [m]	Summer stagnation			Winter stagnation		
	°C	mgO ₂ l ⁻¹	% O ₂	°C	mgO ₂ l ⁻¹	% O ₂
0	22.8	15.3	182	0.3	10.8	77
1	22.6	14.3	169	2.9	10.7	82
2	22.4	14.1	166	3.8	10.4	81
3	22.3	13.2	155	3.8	10.4	81
4	22.2	13.3	155	3.8	10.3	80
5	22.1	12.4	145	3.8	10.3	80
6	18.2	10.1	110	3.7	10.3	80
7	14.0	9.4	94	3.7	10.3	80
8	11.4	8.2	77	3.7	10.2	79
9	9.3	6.9	62	3.8	9.8	77
10	7.7	5.7	49	3.8	9.7	77
11	7.6	5.5	47	3.8	8.8	69
12	7.6	5.5	47	3.6	8.8	69
13	7.7	5.3	46	3.7	8.5	66
14	7.7	5.2	45	3.7	8.2	64
15	7.8	5	43	3.7	8.2	64
20	6.8	4.2	36	3.7	7.6	59
25	5.9	3.9	28	3.4	7.6	59
30	5.5	2.7	21	3.4	7.6	59
35	5.7	1.6	13	3.4	7.2	56
40	5.5	1.3	11	3.4	7.0	55
...						
45	5.5	0.8	7	3.3	7.0	52

Source: own work / Źródło: praca własna

Table 4. Values of major physico-chemical indicators representing water quality in Lake Śremskie
 Tab. 4. Wartości najważniejszych wskaźników fizykochemicznych obrazujących jakość wody w Jeziorze Śremskim

Indicator	Value	Status
Mean saturation of hypolimnion with oxygen [%]	26	good
P _{total} [mgP*l ⁻¹]	0.05	good
N _{total} [mgN*l ⁻¹]	1.07	good
Visibility of Secchi's disc [m]	3.1	good
Conductivity [μS*cm ⁻¹]	475	good
Chlorophyll "a" content [μg*l ⁻¹]	4.70	good
Final status		Good status
TSI	46.7	

Source: own work / Źródło: praca własna

Table 5. Age, sex and length of vendace from Lake Śremskie population
 Tab. 5. Wiek, płeć oraz długość sielaw z populacji Śremskiej

Number of individuals	Age	Sex structure		Length range lt [cm]
		♂	♀	
3	1+	-	3	14.6 – 17.3
34	2+	18	16	17.5 – 21.8
32	3+	10	22	21.6 – 23.7
4	4+	-	4	23.8 – 27.1
73		28	45	

Source: own work / Źródło: praca własna

Aerobic conditions in the analysed lake may be considered as good, as indicated by the value of mean oxygen saturation in the hypolimnion (Table 4). Up to a depth of 30 m the dissolved oxygen content in water exceeded 2 mg l^{-1} , while only immediately above the bottom the value of this parameter dropped to less than 1 mg. In terms of dissolved oxygen levels Lake Śremskie is exceptional among the other deep lakes in the region, in which already the upper metalimnion level is frequently deoxygenated.

Such a situation is characteristic of eutrophic lakes [16]. In those lakes in the summer season the area, where fish can live and feed, is drastically limited and this may have a negative effect on fish condition and their growth rate. [17] stated that the critical minimal oxygen content in a vendace reservoir should not drop below 4 mg L^{-1} . This value in Lake Śremskie is maintained until 25 m deep. In the winter period oxygen content from the surface to the bottom fluctuated around 7 mgL^{-1} .

Based on 6 physico-chemical indices, water in that lake may be classified to water quality class 2, which corresponds to good ecological status (Table 4). Also Carlson's Trophic State Index for Lakes, calculated based on phosphorus and chlorophyll a contents and the depth of the Secchi disc visibility indicate relatively low fertility of the lake equivalent to mesotrophy.

In terms of fishery management the analysed water body may be classified as a vendace lake with very good habitat conditions for this species. Fish culture yield of such lakes is approx. 34 kg ha^{-1} , including approx. 5.5 kg of vendace [15].

3.2. Structure of the studied population

Studies on vendace population biology in Lake Śremskie were based on 73 individuals caught in the autumn period.

Analysis indicated that in the catches from gill nets with a 22 mm mesh size 2- and 3-year old specimens predominated, accounting for over 90 % of the total catch (Table 5). Only single caught specimens were aged 1+ and 4+, while no 5-year old fish were found. Czerniejewski et al. [18], who studied the vendace population in three West-Pomeranian lakes (using gill nets with a 24 mm mesh size) found an overwhelming dominance of 3-year old fish amounting to 78%. Another study of Czerniejewski and Filipiak [4] concerning vendace from 6 West-Pomeranian lakes reported that in commercial catches specimens aged 2+ were markedly predominant.

It is of interest that among the caught vendace there were many more females, with the ratio of males to females of 1:1.6. However, it must be stressed here that the catches came from the lake pelagic zone and therefore it is highly likely that at the time of our catches the male fish stayed near the shore in the spawning zones. Czerniejewski et al. [18] reported quite different results recording the predominance of males at an 8:1 ratio.

The length of the studied fish ranged from 14.6 to 27.1 cm, with the predominance of specimens of 17.5-23.7 cm in length. These lengths are similar to those reported by Ciepielewski [19, 20] who investigated the efficiency of vendace gill nets with mesh size of 18, 22 and 24 mm. That author reported that 22mm gill nets showed the highest selectivity (1) for fish with a mean length of 19.5 cm, ranging from 16.6 to 22.4 cm.

3.3. Growth rate

According to Radziej [21], fish growth depends on environmental conditions. In the case of fish, in contrast to homeothermic animals, their body growth is continued even after they reach sexual maturity, although it is at a significantly slower rate. Vendace in lakes of the Baltic Sea catchment area are characterized by a considerable variability of growth rate.

The mean increments of the vendace studied in individual years are shown in fig. 6. According to the division developed by Szczerbowski [22], the growth rate of vendace from Lake Śremskie is very fast, much greater than the national mean. In water bodies located in that area growth rate varies, e.g. in Lake Winnogóra [23] this species is characterized by a medium growth rate, reaching in the 3rd year of life the length of almost 20 cm, while in Lake Gorzyń [24] the increments are comparable to those in the population from Lake Śremskie. According to Fiszer et al. [10], vendace in the 4 Wielkopolska lakes analyzed in that study had markedly slower growth rates than in this water body. Analyses of growth increments for fish from 186 investigated Polish lakes [25] showed that growth of vendace from Lake Śremskie is faster than the mean increment for all analyzed lakes (Table 6). Vendace in most of these lakes in the first year of life grew up to 12 cm, while in Lake Śremskie during the same period the fish reached 15.1 cm. Also in the second year of life analysed vendace grew faster than fish in most Polish populations reaching on average 17.4 cm in comparison to 18.8 cm for the Lake Śremskie population. At the age of 3+ differences in growth rate are still marked, as vendace from Lake Śremskie reaches the length of 22.4 cm, while the mean for the lakes analysed by Marciniak [1970] was 20.3 cm. What is of interest, Marciniak in the late 1960's observed in vendace from Lake Śremskie an even faster growth rate amounting to 14.5, 20.9, 25.6, 27.7 and 29.0, which ranked the analysed population as the first in Poland.

Table 6. Growth rate of vendace population from Lake Śremskie

Tab. 6. Tempo wzrostu populacji sielawy z Jeziora Śremskiego

	1+	2+	3+	4+
Lenght l.t. [cm]	15.1	18.8	22.4	25.5
length increment [%]		21.3	18.6	14.4
Mass [g]	53	88	128	182
weight gain [%]		66	45	42

Source: own work / Źródło: praca własna

3.4. Fulton's coefficient of fish condition

Biological characteristics of vendace were also based on the fish condition coefficient shown in Table 7.

The determination of fish condition is of significant importance in ichthyology. When the relation of body mass to body length is adequate, then the condition is good confirming a good nutritional status of the fish. The condition coefficient is most useful in relation to fish, in which the proportion between their body mass and body length changes slightly with age.

Opuszyński [14] reported that in salmonid fish, Fulton's coefficient is close to 1. The mean value for the Śremskie population was 0.89; in the case of significant fluctuations it ranged from 0.78 to 1.25. Czerniejewski et al. [18] com-

pared the condition of vendaces from the lakes in West Pomerania and obtained significantly lower values. In Lake Wełtyń, where the authors found the best fish condition, the condition indicator showed on the average the value of 0.79 within the range from 0.59 to 1.09.

Table 7. Fish condition coefficient and fish mass

Tab. 7. Współczynnik kondycji oraz masa ryb

	Fulton's coefficient	Mass [g]
Number of individuals	73	
Minimum	0.78	44
Maximum	1.25	222
Mean value	0.89	113.4
Standard deviation	0.078	24.9

Source: own work / Źródło: praca własna

Table 8. Indicators describing fecundity of vendace population in Lake Śremskie

Tab. 8. Wskaźniki opisujące płodność populacji sielawy z jeziora Śremskiego

	Absolute fertility [number of spawn eggs]	Relative fertility [number/ 100 g]	GSI [%]
Number of individuals	37	37	37
Minimum	6916	5287	1.19
Maximum	18588	14574	31.91
Mean value	12714	11394	16.53
Standard deviation	4749	3346	8.198

Source: own work / Źródło: praca własna

In turn, in four lakes from the Wielkopolska region: Dominickie, Strzeszyńskie, Gorzyńskie and Lubikowskie [10], the mean values were almost identical to those in the described water bodies.

3.5. Fecundity

Fecundity is an indicator indispensable for the rational fishing economy. From the number of 73 vendace caught in Lake Śremskie, 37 female spawners were used for fecundity determination, as the others were already past spawning.

The mean absolute fertility was 12714 eggs, while relative fertility was 11394 eggs/100 g body mass. The gonadosomatic index was recorded at 16.53 %. It needs to be stressed that there are significant differences between the minimal and the maximal values, particularly in reference to the GSI index (Table 8).

Vendace is a fish species with a relatively low fecundity, which is partially compensated by the comparatively early sexual maturity. According to Bernatowicz et al. [3], depending on environmental conditions male individuals are able to reproduce most frequently in the second year of life, while females reach their reproduction maturity in the third year of life. Many authors believe that in Polish lakes, because of water temperature, both the males and females are able to reproduce already at the age of 1+ [19, 20, 26, 27, 28]. Fish age most probably depends on the origin of fish either from the eastern or the western part of the country. The collected research material, because of its homogeneity, permitted to determine fish fecundity only at the age of 2+ and 3+.

Vendace fecundity, as well as that of other fish species, is subject to different fluctuations depending on environmental and population factors [29]. Bernatowicz et al. [3] believes that vendace in the lakes of West Poland is characterized by a greater fecundity than those of the species specimens found in the eastern part of the country. The value of the gonadosomatic index depends primarily on the age of fish, on fish body length and body mass, as well as the environmental conditions. In Polish lakes this parameter is highly variable. In the water bodies of West Pomerania the size of gonads amounted to 14.63 up to 23.16 % body mass [5]. A still wider range (9.5-33.2%) was reported by Bernatowicz [30] for the Mazurian lakes.

Czerniejewski and Filipiak [31], who studied the reproductive potential of vendace from West Pomerania lakes, found the highest absolute fecundity in the range of 6 900 – 22 230 spawn eggs in specimens from Lake Drawsko, while the smallest number (within 2610 – 4120) was found in Lake Pelcz. The highest value of the gonadosomatic coefficient (on the average 20.3 %) was found by the above mentioned authors in Lake Moryńskie, while the lowest value (14.9%) was recorded in Lake Drawsko. In the above-mentioned four lakes of Wielkopolska, coefficients were similar to the population from Lake Śremskie [10].

3.6. Population characteristics

Meristic traits are of considerable significance in the identification of particular species or forms within a given family [2].

The mean number of hard rays in the dorsal fin is 3, while the mean number of soft rays is 8.6 (Table 9). These values are characteristic of vendace and they are contained within the ranges given by Thienemann [32], Berg [33], Czerniejewski and Filipiak [31]. Also regarding the ray number in the caudal, anal and ventral fins, the Śremskie population does not differ from other Polish populations. In the caudal fin on the average 22.8 soft rays were found, while in the anal fin 3.0 hard rays and 11.1 soft rays were present, whereas in the ventral fin it was 1.0 and 10.0 rays, respectively.

Table 9. Meristic traits of vendace population from Lake Śremskie

Tab. 9. Cechy merystyczne charakteryzujące populację sielawy z jeziora Śremskiego

Trait	Numb. of ind.	Mean value	Minimum	Maximum	Standard deviation
PD pr. T	73	3.07	2	4	0.312
PD pr. M	73	8.59	8	9	0.495
PC pr. M	73	22.81	21	25	0.753
PA pr. T.	73	3.00	2	4	0.297
PA pr. M.	73	11.17	10	13	0.513
PV pr. T	73	1.00	1	1	0.00
PV pr. M.	73	9.96	9	11	0.318
PP pr. T.	73	1.00	1	1	0.000
PP pr. M.	73	13.94	13	15	0.539
RB	73	7.77	7	9	0.519
LI	73	81.92	72	91	3.844
LI l(s)	73	8.18	7	9	0.550
LI 2 (i)	73	7.19	6	8	0.576
Sp. branch	73	40.51	36	45	2.343

Source: own work / Źródło: praca własna

The number of hard rays in the pectoral fin of the studied population was 1, thus it agrees with the value reported by many authors [2, 3]. In the case of soft rays the average number is 13.9, while Thienemann [32] reported the mean number of 14-15. Walczak [5] found 13 soft rays in the pectoral fin.

The number of subbranchial rays is on average 8.8, ranging from 7 and 9, thus agreeing with the values reported by other researchers [4, 5, 32].

The next meristic trait used for the studied population was the number of scales in the transverse and longitudinal rows. According to Radziej [21], the number of scales in the lateral line in vendace ranges between 70 and 91; for the Śremskie population the mean number of scales was 81.9. Radziej [21] reported that in vendace found in Poland the number of scales above the lateral line is 7-9, while below the lateral line there are 6-8 scales. Fish from the investigated population do not differ regarding this trait, with the mean values of 8.2 and 7.2, respectively.

The final meristic trait identifying the studied population was the number of filtering processes on the first left branchial arch. This number may be used to differentiate between related subspecies and even geographic populations.

In the case of the studied vendace a relatively small number of filtration processes was found, i.e. 36 to 45, with 40 as the mean value.

The number of filtration processes on branchial arches is connected with the formation of filtration ability of the branchial system [14]. Berg [33] found in his studies a total of 36-54 processes, while Gašowska [34] reported for the entire Polish population the range of 35-52, while for the Mazurian lakes the number was 37-49. Czerniejewski and Filipiak [31] for the lakes Drawsko and Pełcz Wielki gave an average of 40 with a range of 35-43. The

studied vendace shows a structure of the filtration apparatus, which matches the average variability of the species, but within a smaller range. In the investigations conducted by Fisher et al. [11] in the Wielkopolska lakes Gorzyńskie and Strzeszyńskie vendace has a significantly lower number of filtration processes, while in lakes Dominickie and Strzeszyńskie the average values are similar to those of the Śremskie population.

In the presented work the meristic traits were used to characterize and define the shape and proportions of the whole fish body and the fins in relation to the caudal length.

The values of meristic features closely depend on environmental conditions, which primarily include availability and accessibility of food and water temperature in the water body. There are known forms of hungry fish with a distinctly big head and a small dorsal arching of the body, which significantly deviate from the characteristic body shape for a given taxon.

The lateral length of the head (X_1) for vendace from Lake Śremskie accounts for 19.94 % of the caudal length of the fish body (Table 10). Analysis of this parameter shows that among the studied vendace there are no fish with the "hungry form". According to Bernatowicz et al. [3], the vendace is characterized by a relatively small head (constituting about 20 % of fish length). The studied population has the lateral head length similar to the values reported by other authors [4].

Values of the other features describing the shape of the head, such as the preorbital eye diameter, head width and head height, do not deviate from literature data referring to the vendace population from other lakes.

Also the values of traits describing the shape of the trunk range within the values quoted by researchers for the Polish populations [2, 3, 11, 34-35]. No differences have been observed in the shape, distribution and the length of fins.

Table 10. Biometric traits (% of x_8) of vendace population from Lake Śremskie

Tab. 10. Cechy biometryczne charakteryzujące populację sielawy z jeziora Śremskiego

Trait	Numb. of ind.	Mean value	Minimum	Maximum	Standard deviation	Coefficient of variation
X_1	72	19.94	18.23	22.55	0.911	4.57
X_2	72	5.04	3.83	6.34	0.504	9.99
X_3	72	4.59	3.85	5.92	0.367	7.99
X_4	72	10.19	8.98	12.25	0.583	5.72
X_5	72	10.26	8.85	11.84	0.615	6.00
X_6	72	8.12	7.34	9.41	0.45	5.51
X_7	72	111.50	106.39	114.89	1.74	1.56
X_8	72	100	100	100	0.000	0.00
X_9	72	94.71	92.21	96.16	0.93	0.99
X_{10}	72	47.77	43.47	51.89	1.76	3.70
X_{11}	72	43.60	38.29	47.74	1.91	4.38
X_{12}	72	21.14	17.42	24.44	1.50	7.08
X_{13}	72	69.66	65.18	73.95	1.78	2.56
X_{14}	72	6.75	5.91	7.78	0.42	6.23
X_{15}	72	8.64	6.48	12.73	1.15	13.92
X_{16}	72	22.22	18.71	25.31	1.31	5.88
X_{17}	72	13.95	11.57	16.29	0.89	6.36
X_{18}	72	14.04	12.28	15.99	0.79	5.60
X_{19}	72	12.96	10.67	15.41	1.10	7.86
X_{20}	72	8.89	7.14	10.74	0.77	8.64
X_{21}	72	9.47	7.98	11.53	0.76	8.06
X_{22}	72	12.12	9.92	14.95	0.92	7.58
X_{23}	72	29.03	25.51	33.83	1.93	6.65
X_{24}	72	22.79	18.70	27.05	1.76	7.72
X_{25}	72	5.08	3.85	6.72	0.57	11.15

Source: own work / Źródło: praca własna

4. Concluding remarks

1. Lake Śremskie is exceptional in terms of environmental parameters among the other deep water bodies of the Wielkopolska region. In this lake there are very good conditions for vendace throughout its entire life cycle.
2. The tested population exhibits very good growth rate and high fecundity.
3. Among population traits we need to stress a slightly lower number of filtration processes in comparison to the national mean, which predisposes the analysed population to collect food of greater dimensions.
4. Gill nets of 22 or 24 mm mesh size are most suitable for the economic vendace harvesting in the analysed water body.
5. Running a sustainable fishery management taking into consideration protection of valuable nature resources the analysed water body may produce approx. 600 kg of vendace annually.

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