

## BIOLOGICAL CHARACTERISTICS OF SPAWNING POPULATION OF VENDACE (*COREGONUS ALBULA* L.) FROM LAKE CHŁOP (MIĘDZYRZECZ DISTRICT)

### Summary

Results presented in this study were collected within the framework of a project aiming at the determination of potential for vendace colonisation and production in lakes of western Poland and as such they are a continuation of previously published studies. The objective of studies carried out in 2011 was to investigate the most important biological traits of the population of the vendace from Lake Chłop lying in the Lubuskie Lakeland and to compare the results to the literature data, including those from the previously described Lake Śremskie. To achieve the objective of the research the following parameters 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 physicochemical water indices were determined to provide a characteristic of the environmental conditions. The status of water was classified as moderate, with the deterioration of the water status caused by the low oxygen saturation of the hypolimnion and high contents of chlorophyll *a*. The vendace from the investigated water body may be classified to the fish group of very good growth rate and condition, only slightly inferior to the vendace from Lake Śremskie. In the third year of life this species reaches on average the total length of 22.0 cm, while Fulton's index of fish condition ranged from 0.68 to 1.10 with a mean value of 0.82. We need to stress here markedly lower fecundity of the vendace population from Lake Chłop in comparison to the population from Lake Śremskie. Considering the quantitative traits, the fish population of Lake Chłop differs non-significantly regarding the body depth in 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.), Lake Chłop, ecological status, growth rate, fish condition, fertility index, population characteristics

## CHARAKTERYSTYKA BIOLOGICZNA TARŁOWEJ POPULACJI SIELAWY (*COREGONUS ALBULA* L.) Z JEZIORA CHŁOP (POW. MIĘDZYRZECKI)

### Streszczenie

Przedstawione w pracy wyniki zgromadzono w ramach projektu, mającego na celu rozpoznanie możliwości bytowania i produkcji sielawy w jeziorach zachodniej Polski, są zatem kontynuacją opublikowanych wcześniej badań. Celem przeprowadzonych w 2011 roku badań było poznanie najważniejszych parametrów biologicznych populacji sielawy z jeziora Chłop, leżącego na Pojezierzu Lubuskim oraz porównanie uzyskanych wyników do danych literaturowych, w tym do wyników z opisywanego wcześniej jeziora Śremskiego. 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 oraz biologiczne wody, pozwalające scharakteryzować warunki środowiskowe. Stan ekologiczny wód jeziora uznano jako umiarkowany, parametrami zaniżającymi ocenę były niskie nasycenie hypolimnionu tlenem oraz wysoka zawartość chlorofilu *a*. Sielawa z badanego zbiornika należy do grupy o bardzo dobrym wzroście i kondycji, nieznacznie tylko ustępując sielawie z jeziora Śremskiego. W trzecim roku życia osiąga średnio 22,0 cm długości całkowitej, wartość wskaźnika kondycji Fultona dla całej próby wahała się od 0,68 do 1,1, przy średniej 0,82. Uwagę zwraca znacznie niższa płodność sielawy z jeziora Chłop, w stosunku do populacji z jeziora Śremskiego. Pod względem cech mierzalnych badana populacja nieznacznie różni się pod względem wygrzbiecienia od innych populacji o bardzo 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 Chłop, stan ekologiczny, tempo wzrostu, kondycja, płodność, cechy populacyjne

### 1. Introduction

The vendace is one of the most valuable fish species in our ichthyofauna both in terms of its natural and economic value. Due to its high environmental requirements it is an indicator species; unfortunately, as a result of eutrophication progressing increasingly in the course of several decades this species is currently in decline in many lakes [3, 5,

7, 12]. Thanks to its high culinary and nutritive value, vendace meat is considered as delicate. The species is associated with lake districts and in many regions of northern Poland it is the most important fish species, treated as an iconic symbol of the regional cuisine.

Over the last 50 years the area of water bodies providing suitable conditions for the vendace has considerably decreased [3, 5, 6, 16, 33]. In the 1970's the vendace was

found in approx. 500 lakes, while currently it is only in 200, which accounts for around 30% of total area [2]. Among the 54 lakes in the Międzychód-Sieraków lake district with the total area of 2880 ha the vendace lives in as few as 13 with the total area of 1085 ha.

The above considerations indicate the urgent need to implement various measures to reverse this trend, consisting in protection and reclamation of its habitat as well as reintroduction. This may be guaranteed thanks to the rational fishery management, executed following the principles of sustainable development, consistent with the guidelines for organic farming.

In order to implement the new model of fishery lake management it is necessary to accurately determine their ecological status and nutrition base, as well as the species structure of ichthyofauna and population parameters of key species.

Results presented in this study were collected within the framework of a project aiming at the determination of potential for vendace colonisation and production in lakes of western Poland. These results are a continuation of previously published studies [29], concerning the vendace population in Lake Chłop located in the Lubuskie Lakeland.

## 2. Study area, materials and methods

Lake Chłop is located in the eastern part of the Lubuskie region, the Lubuskie Lakeland in the Pszczewski Landscape Park. The Landscape Park is known for its postglacial lakes, including 31 lakes with an area of min. 10 ha, the largest and deepest of which is Lake Lubikowskie (314 ha, 35 m). Surface waters account for 11.8% of Landscape Park area.

Lake Chłop is a ribbon lake extending from the north to the south. It has a diverse shoreline with a narrow, winding harbour in its eastern part. Forests cover as much as 74% of immediate catchment of the lake, fields account for 21%, while 5% is barren land. Lake Chłop is a stratified, dimictic water body with a slight openness index, which influences water mixing rate and the depth of the epilimnion.

The most important morphometric parameters are given in Table 1.

Table 1. Morphometric parameters of Lake Chłop  
Tab. 1. Parametry morfometryczne jeziora Chłop

Parameter	Lake Chłop
Height [a.s.l.]	53.7
Area [ha]	227.8
Volume [thous. m <sup>3</sup> ]	20579.6
Max. depth [m]	23.0
Mean depth [m]	9.0
Max. length [m]	4150
Max. width [m]	975
Shore line length [m]	12350
Development of shore line	2.31
Exposure indicator	25.3

Source: / Źródło: WIOŚ, IMGW

The study focused on the analysis of the following traits of the investigated vendace population: sex structure, growth rate, fish condition, fecundity, as well as biometric and meristic traits. At the same time the most important physicochemical indices of water were determined in order to characterise environmental conditions.

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

Source: results of own studies / Źródło: wyniki badań własnych

Fish specimens for the analyses were caught in mid-November 2011, during autumn circulation, using gill nets with a 22 mm mesh size. In turn, water samples were collected at the end of August in the period of summer stagnation. Water stratification and oxidisation was established based on the thermal and oxygen profiles. Also the Secchi depth was recorded. Furthermore, in the summer period water samples were collected to determine the following physicochemical indices: pH, total phosphorus, total nitrogen, specific electrolytic conductivity and chlorophyll a contents.

Fish were stored frozen at  $-28^{\circ}\text{C}$  in special plastic bags to prevent water sublimation from fish bodies. After defrosting the mass of each fish was measured accurate within 0.1 g. A total of 25 body shape parameters were measured (tab. 2) and the most important meristic traits were recorded. Furthermore, the mass of gonads was determined for female fish and on the basis of sampled gonad sections their absolute fecundity and relative fecundity were established. In order to determine fish age, scales were sampled from the lateral line of the body between the adipose fin and the dorsal fin [4]. Growth rate of the vendace was determined by the method of back calculations according to Lea [31].

On the basis of these measurements, Fulton's coefficient was calculated, which defines the correlation between length and individual mass of fish [26].

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 Chłop.

### 3. Results and discussion

#### 3.1. Environmental conditions – physicochemical indices

At the end of August a marked thermal and oxygen stratification was observed in the lake, the epilimnion was 6 m in thickness, the metalimnion was 4 m thick, while the hypolimnion started at a depth of 10 m (Fig. 1). The temperature of the epilimnion was slightly over  $23^{\circ}\text{C}$ , while that of the lower hypolimnion was  $6.5^{\circ}\text{C}$ . Lake Chłop in comparison to the previously investigated Lake Śremskie [29] is characterised by a less marked thermal stratification, higher hypolimnion temperature and as a consequence - slightly higher primary production. Higher lake productivity may be connected with a deteriorated water quality [17].

Oxygen conditions in the analysed lake are the primary factor resulting in a deterioration of water quality (Fig. 1). Within the entire hypolimnion anaerobic conditions are found starting from the depth of 10 m.

Such conditions are typical of eutrophic lakes [22], in which the area, where fish can live and feed in the summer season is drastically limited, which may potentially have an adverse effect on fish condition and their growth rate. Muller and Stadelman [25] stated that the critical minimal oxygen content in a vendace reservoir should not drop below  $4\text{ mg L}^{-1}$ . Such a value in Lake Chłop during the summer stagnation period is maintained only to a depth of 9 m.

Based on the other physicochemical indices, water in that lake may be classified to water quality class 2, which corresponds to good ecological status (tab. 3). As it was mentioned above, the index deteriorating the final classification was connected with oxygen saturation of the hypolimnion. Also Carlson's Trophic State Index for Lakes, calculated based on phosphorus and chlorophyll a contents, as well as the Secchi depth, indicate relatively low fertility of the lake, equivalent to an early stage of eutrophication.

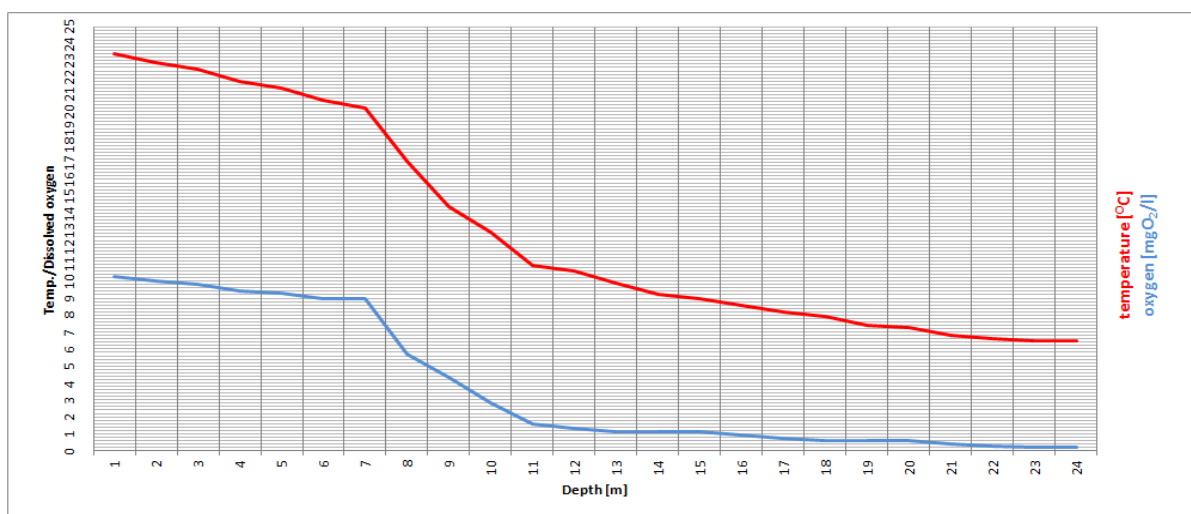
Table 3. Values of major physicochemical indicators representing water quality in Lake Chłop

Tab. 3. Wartości najważniejszych wskaźników fizykochemicznych obrazujących jakość wody w jeziorze Chłop

Indicator	Value	Status
Mean oxygen saturation of hypolimnion [%]	0	below good
$P_{\text{total}}$ [ $\text{mgP}^*\text{l}^{-1}$ ]	0.06	good
$N_{\text{total}}$ [ $\text{mgN}^*\text{l}^{-1}$ ]	0.99	good
Secchi depth [m]	2.6	good
Conductivity [ $\mu\text{S}^*\text{cm}^{-1}$ ]	477	good
Chlorophyll "a" content [ $\mu\text{g}^*\text{l}^{-1}$ ]	19.3	below good
TSI	54.6	

Source: results of own studies / Źródło: wyniki badań własnych

In terms of fishery management the analysed water body may be classified as a vendace lake with very good habitat conditions for this species. Typically fish culture yield of such lakes is approx.  $34\text{ kg ha}^{-1}$ , including approx.  $5.5\text{ kg vendace}$  [13].



Source: results of own studies / Źródło: wyniki badań własnych

Fig. 1. Temperature and oxidisation in Lake Chłop waters during the summer stagnation

Rys. 1. Termika i natlenienie wód w jeziorze Chłop podczas stagnacji letniej

### 3.2. Structure of the studied population

Studies on vendace population biology in Lake Chłop were based on the analysis of 120 specimens caught in the autumn period.

This analysis showed that in the catches from gill nets with a 22 mm mesh size 2- and 3-year old specimens predominated, accounting for almost 100 % of the total catch (tab. 4). Similarly as it was in Lake Śremskie, only single caught specimens were aged 1+ and 4+, while no 5-year old fish were found. Czerniejewski et al. [13], 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 %. In another study concerning vendace from 6 West-Pomeranian lakes Czerniejewski and Filipiak [12] reported that in commercial catches specimens aged 2+ were markedly predominant.

Table 4. Age, sex and length of vendace from Lake Chłop population

Tab. 4. Wiek, płeć oraz długość sielaw z jeziora Chłop

Number of individuals	Age	Sex structure		Length range lt [cm]
		♂	♀	
9	1+	5	4	13.5 – 17.1
49	2+	16	33	16.5 – 21.0
55	3+	10	45	21.1 – 22.7
7	4+	-	7	23.3 – 27.5
120		31	89	

Source: results of own studies / Źródło: wyniki badań własnych

Table 5. Growth rate of vendace population from Lake Chłop

Tab. 5. Tempo wzrostu populacji sielawy z jeziora Chłop

	1+	2+	3+	4+
Length l.t. [cm]	14.2	18.1	22.0	25.1
Length increment [%]		27.5	21.5	14.1
Mass [g]	45	81	123	177
Weight gain [%]		88	52	44

Source: results of own studies / Źródło: wyniki badań własnych

Table 6. Fish condition coefficient and fish mass

Tab. 6. Współczynnik kondycji oraz masa ryb

	Fulton's coefficient	Mass [g]
Number of individuals	120	
Minimum	0,68	36
Maximum	1,10	197
Mean value	0,82	107.3
Standard deviation	0,057	24.9

Source: results of own studies / Źródło: wyniki badań własnych

Table 7. Indicators describing fecundity of vendace population in Lake Chłop

Tab. 7. Wskaźniki opisujące płodność populacji sielawy z jeziora Chłop

	Absolute fertility [number of spawn eggs]	Relative fertility [number/100 g]	GSI [%]
Number of individuals	71	71	
Minimum	5679	5107	1.73
Maximum	13487	12605	25.76
Mean value	9873	9227	15.21
Standard deviation	3359	2921	7.124

Source: results of own studies / Źródło: wyniki badań własnych

It is of interest that among the caught vendace there were many more females, with the ratio of males to females of 1:2.9. However, it must be stressed here that since the catches came from the lake pelagic zone, it is highly likely that at the time of the catches the male fish were staying in the spawning zones near the shore. In contrast, Czerniejewski et al. [13] reported opposite results, recording the predominance of males at an 8:1 ratio.

The length of the studied fish ranged from 13.5 to 27.5 cm, with the predominance of specimens of 16.5-22.7 cm in length. These lengths are similar to those given by Ciepielewski [9, 10] who investigated the efficiency of vendace gill nets with mesh size of 18, 22 and 24 mm. In his studies that author reported the greatest selectivity (1) of 22mm gill nets for fish with a mean length of 19.5 cm, ranging from 16.6 to 22.4 cm.

Table 8. Meristic traits of vendace population from Lake Chłop.

Tab. 8. Cechy merystyczne charakteryzujące populację sielawy z jeziora Chłop.

Trait	Numb. of ind.	Mean value	Minimum	Maximum	Standard deviation
PD pr. T	120	3.07	2	4	0.282
PD pr. M	120	8.87	8	10	0.365
PC pr. M	120	22.77	20	26	1.041
PA pr. T.	120	3.00	2	4	0.242
PA pr. M.	120	11.33	10	13	0.624
PV pr. T	120	1.00	1	1	0.00
PV pr. M.	120	9.86	9	12	0.416
PP pr. T.	120	1.00	1	1	0.000
PP pr. M.	120	13.93	13	15	0.480
RB	120	7.66	6	9	0.570
Ll	120	81.97	72	90	3.870
Ll 1(s)	120	8.16	7	9	0.430
Ll 2 (i)	120	7.16	6	8	0.410
Sp. branch	120	40.16	36	47	2.799

Source: results of own studies / Źródło: wyniki badań własnych

Table 9. Biometric traits (% of x8) of vendace population from Lake Chłop  
 Tab. 9. Cechy biometryczne charakteryzujące populację sielawy z jeziora Chłop

Trait	Numb. of ind.	Mean value	Minimum	Maximum	Standard deviation	Coefficient of variation
X <sub>1</sub>	120	20.63	19.22	23.21	0.729	3.49
X <sub>2</sub>	120	5.31	3.32	6.68	0.500	9.41
X <sub>3</sub>	120	5.23	4.51	5.96	0.288	5.51
X <sub>4</sub>	120	10.35	8.48	11.64	0.500	4.83
X <sub>5</sub>	120	10.79	9.18	12.21	0.566	5.24
X <sub>6</sub>	120	8.56	7.51	9.61	0.405	4.74
X <sub>7</sub>	120	112.71	107.16	115.75	1.452	1.29
X <sub>8</sub>	120	100	100	100	0.000	0.00
X <sub>9</sub>	120	94.67	91.50	96.36	0.848	0.90
X <sub>10</sub>	120	48.67	44.64	52.54	1.531	3.15
X <sub>11</sub>	120	41.86	37.51	45.27	1.578	3.77
X <sub>12</sub>	120	21.11	17.67	23.61	1.157	5.48
X <sub>13</sub>	120	70.20	66.07	74.08	1.562	2.23
X <sub>14</sub>	120	6.90	6.15	7.95	0.315	4.57
X <sub>15</sub>	120	8.17	4.96	12.36	1.121	13.74
X <sub>16</sub>	120	23.28	15.13	26.81	1.600	6.88
X <sub>17</sub>	120	14.60	12.64	16.89	0.839	5.75
X <sub>18</sub>	120	14.02	11.65	16.03	0.795	5.67
X <sub>19</sub>	120	13.64	10.79	16.16	0.863	6.32
X <sub>20</sub>	120	9.34	7.73	11.67	0.749	8.02
X <sub>21</sub>	120	9.31	7.09	10.98	0.721	7.74
X <sub>22</sub>	120	11.89	9.57	13.51	0.798	6.71
X <sub>23</sub>	120	27.9	24.19	32.19	1.367	4.90
X <sub>24</sub>	120	22.51	18.85	25.40	1.309	5.81
X <sub>25</sub>	120	4.87	3.35	6.31	0.581	11.95

Source: results of own studies / Źródło: wyniki badań własnych

### 3.3. Growth rate

As it was stated e.g. by Radziej [28], fish growth depends on environmental conditions. In contrast to homeothermic animals, body growth in fish is continued even after they reach sexual maturity, although it is at a significantly slower rate. A considerable variability of growth rate is observed in vendace populations in lakes of the Baltic Sea catchment area.

The mean body size increments of the vendace specimens studied in individual years are shown in tab. 5. According to the division developed by Szczerbowski [30], the growth rate of vendace from Lake Chłop is fast, exceeding the national mean and being only slightly lower than in Lake Śremskie. In water bodies located in that area the growth rates vary. For instance in Lake Winnogóra [27] this species is characterised by a medium growth rate, reaching in the 3<sup>rd</sup> year of life the length of almost 20 cm, while in Lake Gorzyń [21] the increments are comparable to those in the populations from Lakes Śremskie and Chłop.

According to Fiszer et al. [18], vendace in the 4 Wielkopolska lakes analysed in their study had markedly slower growth rates in comparison to the data recorded for this water body. Analyses of growth increments for fish from 186 investigated Polish lakes [23] showed that the growth rate of vendace from Lake Chłop is faster than the mean increment for all the other analysed lakes. In the first year of life vendace in most of those lakes grew on average to max. 12 cm, while in Lake Chłop during the same period the fish reached 14.2 cm. Also in the second year of life the analysed vendace grew faster than those in most Polish populations, reaching on average 17.4 cm. At the age of 3+ differences in growth rate are still marked, as vendace specimens from Lake Chłop reached the length of 22.0 cm,

while the mean for the lakes analysed by Marciniak [23] was 20.3 cm.

### 3.4. Fulton's coefficient of fish condition.

Biological characteristics of vendace were also based on the fish condition coefficient shown in Table 6. 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 classified as good, thus confirming a good nutritional status of the fish. The condition coefficient is most useful in relation to these fish species, in which the proportion between their body mass and body length changes slightly with age.

Opuszyński [17] reported that in salmonid fish Fulton's coefficient is close to 1. The mean value for the Chłop population was 0.82, in the case of significant fluctuations ranging from 0.68 to 1.10. When comparing the condition of vendaces from the lakes in West Pomerania Czerniejewski et al. [13] obtained significantly lower values. In Lake Weltyń, where those authors reported the best fish condition, the mean value was 0.79, with the coefficient levels ranging from 0.59 to 1.09.

In turn, in the four lakes from the Wielkopolska region: Dominickie, Strzeszyńskie, Gorzyńskie and Lubikowskie [18], the mean values were almost identical to those in the water bodies mentioned above.

### 3.5. Fecundity

Fecundity is the primary indicator required for the maintenance of rational fishing economy. From the total of 89 female vendace caught in Lake Chłop, 71 spawners were used for fecundity determination, as the others were already past spawning.

The mean absolute fertility was 9873 eggs, while relative fertility was 9227 eggs/100 g body mass. The gonadosomatic index was recorded at 15.21 %. We need to stress here a lower fecundity in comparison to Lake Śremskie as well as significant differences between the minimal and the maximal values, particularly in reference to the GSI index (tab. 7).

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 typically able to reproduce in the second year of life, while females reach their reproduction maturity in the third year of life. Many authors are of an opinion that in Polish lakes, because of water temperature, both the males and females are able to reproduce already at the age of 1+ [8, 9, 10, 15, 24]. Fish reproduction maturity 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 fecundity only for fish at the age of 2+ and 3+.

Vendace fecundity, as well as that of other fish species, varies greatly depending on environmental and population factors [34]. According to Bernatowicz et al. [3] vendace in the lakes of West Poland exhibit greater fecundity than 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 % of body mass [33], while an even wider range (9.5-33.2%) was reported for the Mazurian lakes by Bernatowicz [2, 3].

Czerniejewski and Filipiak [11], who studied the reproductive potential of vendace from West Pomerania lakes, found the highest absolute fecundity in the range of 6900 – 22 230 spawn eggs in specimens from Lake Drawsko, while the smallest number (within 2610 – 4120) was recorded for fish from Lake Pełcz. The highest value of the gonadosomatic coefficient (mean 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, these coefficients were higher than in the population from Lake Chłop [18].

### 3.6. Population characteristics

Meristic traits are of considerable significance in the identification of particular species or forms within a given family [7].

In the analysed population the mean number of hard rays in the dorsal fin is 3.1, while the mean number of soft rays is 8.9 (tab. 8). These values are characteristic of vendace and they are contained within the ranges given by Thienemann [32], Berg [1] and Czerniejewski and Filipiak [11]. Also regarding the ray number in the caudal, anal and ventral fins, the Chłop population does not differ from other Polish populations. In the caudal fin on the average 22.7 soft rays were found, while in the anal fin 3.0 hard rays and 11.3 soft rays were present, whereas in the ventral fin it was 1.0 and 9.0 rays, respectively.

The number of hard rays in the pectoral fin of the studied population was 1, thus it agrees with the value reported

by many other authors [2, 5]. In the case of soft rays the average number is 13.9, while Thienemann [32] reported the mean number of 14 – 15 and Walczak [33] found 13 soft rays in the pectoral fin.

The number of subbranchial rays is on average 7.7, ranging from 7 and 9, thus agreeing with the values reported by other researchers [11, 32, 33].

The next meristic trait used in the analyses of the studied population was the number of scales in the transverse and longitudinal rows. According to Radziej [28], the number of scales in the lateral line in vendace ranges between 70 and 91, while for the Chłop population the mean number of scales was 82.0. In turn, Radziej [28] 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 referred to 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 47, with 40.2 as the mean value. The number of filtration processes on branchial arches is connected with the formation of filtration ability of the branchial system [17]. Berg [1] found in his studies a total of 36-54 processes, while Gąsowska [20] reported for the entire Polish population the range of 35 – 52, whereas for the Mazurian lakes the number was 37 – 49. In turn, Czerniejewski and Filipiak [11] 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. [19] in the Wielkopolska lakes Gorzyńskie and Strzeszyńskie vendace have a significantly lower number of filtration processes, while in lakes Dominickie and Strzeszyńskie the average values are similar to those of the investigated population.

In the presented work the meristic traits were used to characterise 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 as well as water temperature in a given water body. Forms of hungry fish are known, characterised by 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 Chłop accounts for 20.6 % of the caudal length of the fish body (tab. 9). Analysis of this parameter shows that among the studied vendace there are no fish with the "hungry form". According to Bernatowicz et al. [2], the vendace is characterised 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 [2].

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 other investigated Polish populations [2, 5, 14, 19, 20]. No differences have been observed in the shape, distribution or the length of fins.

#### 4. Concluding remarks

1. Lake Chłop is characterised by inferior environmental parameters in comparison to Lake Śremskie; however, in relation to the other deep water bodies in the Wielkopolska region its water quality is classified as good. Conditions found in the lake are satisfactory and meet the requirements of the vendace for the entire life cycle of this fish species.
2. The analysed population exhibits very good growth rate and high fecundity.
3. The markedly lower fecundity than that recorded in Lake Śremskie is a cause for concern.
4. Among the recorded 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.
5. Gill nets of 22 or 24 mm mesh size are most suitable for the economic vendace harvesting in the analysed water body.
6. A sustainable fishery management ensuring protection of valuable nature resources of the analysed water body may produce approx. 800-1000 kg of vendace annually.

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