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PHENOTYPIC CHANGES OF VENDACE (*COREGONUS ALBULA* (LINAEUS, 1758)) IN THE LAKES OF LITHUANIA

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Vendace (*Coregonus albula*) belongs to Salmonidae family, Coregoninae subfamily. This group is known as phylogenetically young; therefore, variations in the growth rate and morphological characters of individuals are common within populations. It is said that morphological variations depend more on the hydrologic and hydrobiologic parameters of the lake where vendace live than on the genetic heredity. Thus when parameters in the lake are changing, there is a possibility that morphologic parameters of vendace are changing too. The main aim of this work was to evaluate the growth rate of vendace in different Lithuanian lakes which have different trophicity levels and hydrological parameters. It was also aimed at performing a morphological analysis of these vendace, to set reasons of observed differences and, finally, to compare the results with earlier vendace investigations in Lithuania. All the measurements of morphometric parameters was made by sliding calipers.

By using Von Bertalanffy equation the investigated populations distribute into three groups by the growth rate. It is noticed that the growth rate of vendace in the same population could change during quite short a period of time, but significant influence of the growth rate to morphometric parameters was not observed. It is possible that during a 10 year period poulations investigated became similar in three morphometric parameters. Morphometrical parameters of vendace in Gavys, Baluošas and Asalnai lakes became similar; the reason of this fact could be population mixing because of artificial breeding and/or the alterations in ecological conditions of these lakes.

Key words: vendace, growth rate, von Bertalanffy, morphological characters

INTRODUCTION

Currently coregonids are common throughout the Holarctic circumpolaric and live almost in all North Eurasian and North American waters, except Greenland. Coregonids got into the Arctic and Atlantic basins comparatively recently, so the structure of the populations here are still developing (Reshetnikov, 2004). Vendace had occurred in the territory of Lithuania 12-10 thousand years ago after the last icing in the Quaternary period. Living surroundings of these fish were formed in a vast territory due to glacial melting on floods and droughts periods. During periods of dramatic climatic changes many of the lakes, where immigrated vendace, became isolated, so the features of fish of the same species were developed depending on their living surroundings, this shaped a wide spectrum of genetic and morphological features in a subfamily of coregonids (Yakhnenko et. al., 2008). These fish are characterized by immense morphological variability, different growth time, body shape, nourishment and other features.

In the research, carried out in Latvia, were analyzed morphological features of vendance 50 years ago introduced from the lakes Peipus and Ladoga to different lakes. It was found out, that morphological features of vendace populations in various lakes were changing due to ecological reasons. Relative eye size remained larger in populations living in poor transparency of water, while a shorter and wider head is typical of vendace from water bodies with a good food reserve. Some authors suggest that external morphometric features change more due to acclimatization in new water body and not by inheritance. Hydrobiology parameters of the lakes have influence on morphological features of vendace. There is also noticed the correlation between morphometric features of vendace and depth and stretch of the lake. Over time varying some parameters of lakes can lead to changes of morphometric parameters of vendace (Oreha & Škute, 2009).

Vendace is an important species to commercial fishing, so it is necessary to observe its abundance and the population quality. In 1950–1983 vendace was caught in 58 lakes of Lithuania. In 1974–1985 vendace made 6.8%, while in 1996–1999 – 15.9% of all the catch. The research of cold water fish in Lithuanian lakes have indicated that the quality of vendace population is influenced by the parameters of water body (temperature mode, transparency and oxygen concentration). One of the most important factors is volume of cold water (t≤10 – 15ºC) in a lake and trophicity level. Best conditions for vendace to grow is thermal deep lakes, where thermal water zone t≤15ºC composes 60% of total lake water and the transparency is more than 5 meters. Lower growth of vendace is noticed in moderately thermal deep lakes where temperature zone t≤10 ºC composes 30% of all lake water and the transparency is less than 5 meters. Coregonids are cold water fish; the optimal physiological temperature for vendace is 15ºC (Pernaravičiūtė & Balkuvienė, 2000).

It is stated that variations of vendace growth may also be influenced by autumn water conditions, which determine the development of the eggs at spawning grounds at hatching time; the density and quality of the food available at the time of hatching and in spring; the size of the spawning stock, which determines intraspecific food competition, and indirectly the condition, growth rate and fecundity of the fish. During the research has been noticed a negative correlation with cohort density and the size of the whole stock (Viljanen, 2004). Harmin and Persson (1986) suggested that short-term fluctuations in vendace populations and individual growth speed are due to asymmetrical competition for food between different age-classes of vendace.

MATERIALS AND METHODS

Research material was collected in 2010–2012 from twenty Lithuanian lakes (the number of the fish used for research and the parameters of studied lakes are shown in Table 1).

Vendace were fished with 18–28 mm mesh size gill nets, weighted and measured, scales were taken to determine age of the fish. For growth analysis the total vendace length in each age-group was measured indirectly according to the distance of annual rings from the centre of the scale (method of age back-calculation). Scales were photographed using binocular that magnifies the impression up to 8–32 times, measurements made using Sigma Scan Pro 5 program accurate to 0.01mm. Rosa Lee (1920) formula was applied for calculations:

$$L_n = \frac{r_n}{r} (L-a)+a$$

Where: L_n - fish body length at age n
L – estimated fish length on catch time
r_n – scale radius length to the annual ring at age n
r – scale radius
a – fish length at which scales begin to form.

Table 1.
The number of the fish used for research and the parameters of studied lakes

Lake	Number of investigated fish			Parameters of lake		
	♀	♂	In total	Area (ha)	Max. depth (m)	River basin
Aisetas	6	14	20	1073,4	42	Šventoji, Neris
Alaušas	18	12	30	505,7	40	Žeimena, Neris
Asalnai	9	6	15	263,5	33	Žeimena, Neris
Baluošas	10	14	24	442,2	33,1	Žeimena, Neris
Bebrusai	8	1	9	367,9	24	Šventoji, Neris
Čičirys 2010	27	7	34	715	39,2	Lukšta (Ilukstė),
Čičirys 2011	18	8	26	715	39,2	Lukšta (Ilukstė),
Daugai	6	3	9	912,7	42,5	Merkys, Nemunas
Drūkšiai	16	12	28	4226,7	33,3	Dysna, Dauguva
Gavys	25	0	25	123,5	41,5	Žeimena, Neris
Ilgai	17	5	22	135	35,5	Strėva, Nemunas
Parsvėtas	15	12	27	87,4	<20	Dauguva
Prūtas	16	14	30	463,4	<20	Dauguva
Sugardas	13	5	18	122,8	<20	Dauguva
Šventas	17	8	25	439,7	18,2	Šventoji, Neris
Tauragnas	10	1	11	512,7	62,5	Žeimena, Neris
Ūkojas	18	8	26	190,3	30,5	Žeimena, Neris
Vajuonis	15	5	20	230,1	20	Žeimena, Neris
Virintai	5	7	12	256	35	Šventoji, Neris
Vencavas	17	9	26	226,8	48,4	Šventoji, Neris
Vištytis	20	5	25	1971	50	Prieglius, Baltijos jūra

Scales of vendace start to form at the length of 15-25 mm of the fish, so in the calculations a = 20 mm.

Czerniajewsky and Rybczyk (2008) suggest that of the mathematical models of fish growth rate: Ford-Walford, von Bertalanffy and second degree polynomials, the best fit was obtained with the von Bertalanffy mathematical model. So, to define vendace growth in different Lithuanian lakes von Bertalanffy's equation was applied in this study, according to which main vendace growth parameters in populations were calculated:

$$L_t = L_\infty \,[1 - e^{-k\,(t-t_0)}]$$

L_t - fish body length at age *t*
L_∞ - theoretical maximum estimated fish length
k - coefficient of growth rate
t_0 - hypothetical age at which fish length equals 0 cm (Czerniejewski & Rybczyk, 2008).

When researched populations are short lived, correlation between L_∞ and k is recognized, in one case a high value of L_∞ combines with a low value of k shows the same results as in other case low value of L_∞ and high value of k, so φ' value was calculated for all analyzed populations according to the formula o' = Logk + 2 LogL_∞ (Pauly & Murno, 1984). Thus, the single parameter was received to compare the growth of the same fish species raised in different lakes (De Graaf & Prein, 2005).

To establish the correlation between weight and length (body condition) the equation TW = a × FL was made use of, where a and b – regression equation's parameters, TW – fish weight, g (Bagenal & Tesch, 1978; Kaupinis, 2005).

For morphometric analysis was used freshly caught fish and morphometric features were measured with mechanical callipers accurate to 0.1 mm. A total of 24 morphometric parameters were measured in accordance with the modified whitefish measurement methods (Chouinard et. al., 1996; Kaupinis, 2005). Features measurement and values are presented in Table 2.

All morphometric characters significantly correlate with body length, so the data transformation is necessary to eliminate this correlation. Data recalculation method needs to be chosen appropriately as vendace growth in different lakes is variable. Log-transformation of morphometric data still significantly correlates with body length, so the best recalculation methods of morphometric characters are methods of principal components and regression analysis as best to eliminate length differences. So, transformation of data was chose on the basis of regression analysis to residuals (Kaupinis, 2005).

All individual morphometric values, recalculated for residuals using the linear regression model, were tested using the Kolmogorov-Smirnov test and therefore no reliable deviation of normal distribution ($p>0.05$) was noticed in any sample. Consequently, parametric statistics was used for further analysis.

Statistical data was processed using programs of STATISTICA 7.0 and Excel. Kolmogorov-Smirnov test was applied to check if data distributes normally: if the difference of normal distribution was significant ($p<0.05$) – non-parametric statistics was used, if it was not significant ($p>0.05$) – parametric statistics. Specific methods are mentioned in the results of the research. Descriptive statistics was used also: mean, standard error, confidence intervals.

Univariate and multivariate analyses were employed in the study:
1. Univariate parametric – dispersive analysis (ANOVA) for investigation of differences in many groups.

Table 2.
The measured morphological features and values (Kaupinis, 2005).

Abbrevation	**Description of morphometric characters**
PD	Predorsal distance: from the snout end to the origin of the dorsal fin
POD	Postdorsal distance: from the end of the perpendicular, drawn from the end of the dorsal fin to the
PrV	Preventral distance: from the end of the snout to the origin of the pelvic fin
PA	Preanal distance: from the end of the snout to the origin of the anal fin
TTL	Length of the anterior part of body: from the hill cover edge to the origin of dorsal fin
LUL	Length of the posterior part of body: from the end of dorsal fin to the origin of anal fin
PL	Caudal peduncle length: from the end of the perpendicular, drawn from the end of the anal fin to the middle of the body, to the end of the body.
H	Body depth: from the beginning of the dorsal fin to the ventral surface of the body
H1	Caudal peduncle depth
LD	Length of the dorsal fin: from the origin to the end of the dorsal fin
HD	Height of the dorsal fin: length of the longest ray of the dorsal fin
LA	Length of the anal fin: from the origin to the end of the anal fin
HA	Height of the anal fin: length of the longest ray of the
LP	Length of the pectoral fin: from the base part of the first ray to the end of the fin
LV	Length of the pelvic fin: from the base part of the first ray to the end of the fin
PV	Length of the pelvic fin: from the origin to the end of the pelvic fin
VA	Distance from the origin of the pelvic fin to that of the anal fin
LC	Head length: from the snout end to the farthest gill cover edge
HC	Head height: across the eye
O	Horizontal diameter of the eye: from the anterior to the posterior edge of the eye
PO	Postorbital length: from the posterior edge of the orbit to the farthest gill cover edge
R	Preorbital length: from the snout end to the anterior edge of the eye
LMX	Maxillary length
LMD	Mandibule length

2. Multivariate parametric – discriminant analysis in order to ascertain whether or not populations are distributed significantly into different groups, cluster analysis (Kaupinis, 2005).

RESULTS

1. Vendace growth variation

1.1. Growth analysis

Total length means of vendace were calculated according to the annual rings of the scales. Significant differences of total length in all age-groups of vendace were recorded (ANOVA, $p<0.01$). The maximum body length average of the first year vendace is 13.37±0.42 cm specific to population of Asalnai, though maximum body length vendace reach in Lake Čičirys at the age of 4 years (30.14±0.38 cm). Čičirys population experienced the highest annual increase of body length, which only starts to decline in the fourth year of life. In other populations, the increase of body length is highest during the first year, while on the second and third year of life it decreases 2-3 times.

Averages of length were used to calculate the growth parameters of separate vendace populations by von Bertalanffy's growth equation. Comparing the calculations of fish length of Rosa Lee (1920) formula and von Bertalanffy's growth equation, we found no significant difference (ANOVA $p>0.05$), so von Bertalanffy's equation fits to describe data of the research.

Highest L_∞ values are in the lakes of Sugardas and Čičirys, accordingly 57 and 48 cm, while lowest in the lakes of Alaušas and Vištytis, accordingly 16.4 and 15.5 cm. Graphically, according to the values of φ', the populations of lake vendace are divided into three groups (Figure 1). Slow-growing fish group is composed of Alaušas, Vištytis, Gavys, Vajuonis, Daugai and Sugardas populations, which φ' values are in the interval between 2.379 and 2.466, middle-growing group is composed of Bebrusai, Vencavas, Tauragnas, Prūtas, Parsvėtas, Ūkojas, Aisetas and Virintai populations, which φ' values are between 2.519 and 2.565. Quickly-growing vendace are in the lakes of Asalnai, Baluošas, Šventas and Čičirys, which φ' is between 2.672 and 2.777.

As the correlation between φ' and maximum depth and area of the lake is not significant ($p>0.05$), such division to the groups does not depend on the maximum depth of the lake. It is also can not be stated, that vendace growth rates depend on the population of the lake smelt (*Osmerus eperlanus* (Linaeus, 1758)) which live together, because smelt is found in the lakes Vištytis, Gavys and Daugai of slow-growing vendace population group, Ūkojas and Aisetas of middle-growing group, and Asalnai and Čičirys of quickly-growing vendace group.

1.2. Ratio of weight-length in different lakes

Female fish dominate against male in the catch from investigated lakes, accordingly 66.74% and 33.26%. Largest groups were those of age 2+ and 3+. It is determined, that female vendace length and body weight in the above mentioned age-groups are bigger compared to male, though significant differences of body length in the 2+ age-group (ANOVA, $p<0.05$) is found only in populations of Asalnai and Parsvėtas, and of body weight in populations of Asalnai, Baluošas, Drūkšiai, Parsvėtas and Šventas. In age-group 3+ body length of female and male significantly differ in lakes Čičirys, Drūkšiai and Ūkojas, while body weight - in Čičirys, Sugardas and Ūkojas. Females' body length and weight are bigger than males', because females has already been started to incubate the eggs when measurements were done, so the length and weight rates were calculated separately for males and females. This ratio for females is described by the equation $y=0.002967 \times x3.42$, where y – weight, g, and x – body length (FL), cm. Regression coefficient =3.42, significant ($p<0.001$), coefficient of determination

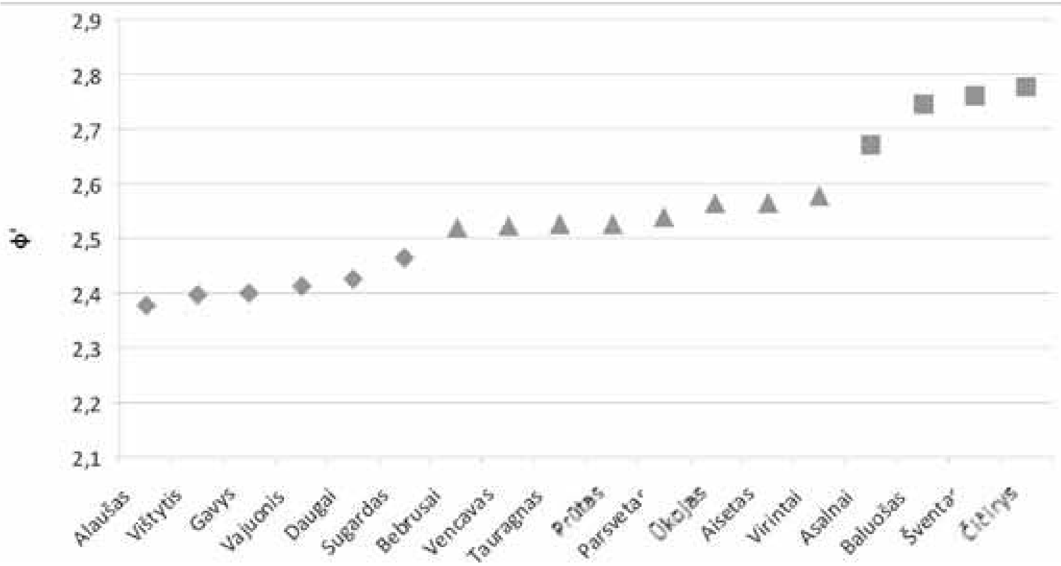

Figure 1. φ' values of vendace growth of the investigated lakes.

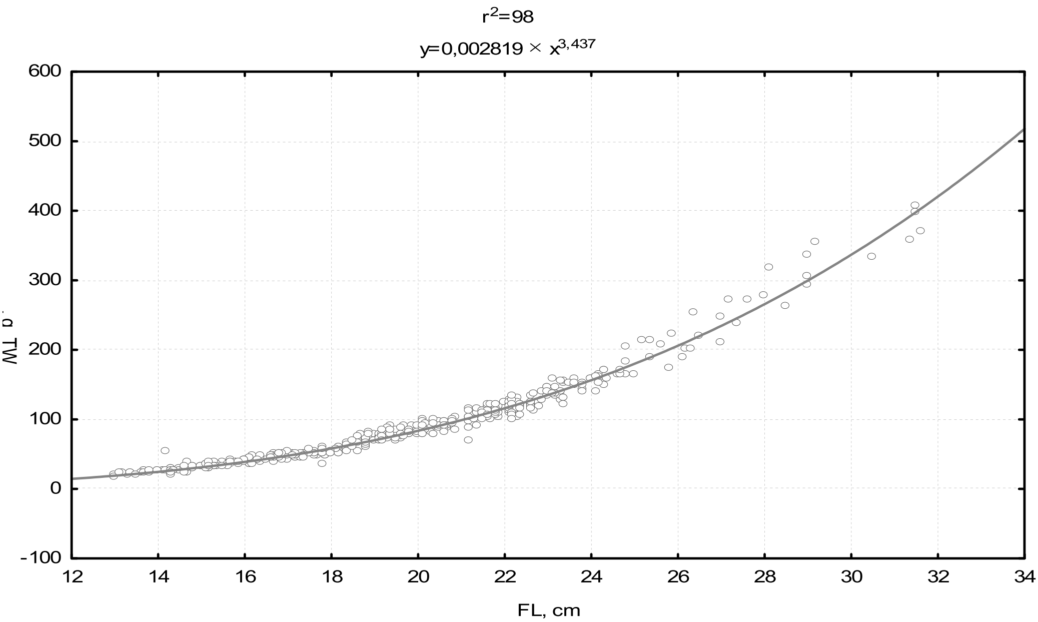

Figure 2. Vendace weight (y) dependence on length (x).

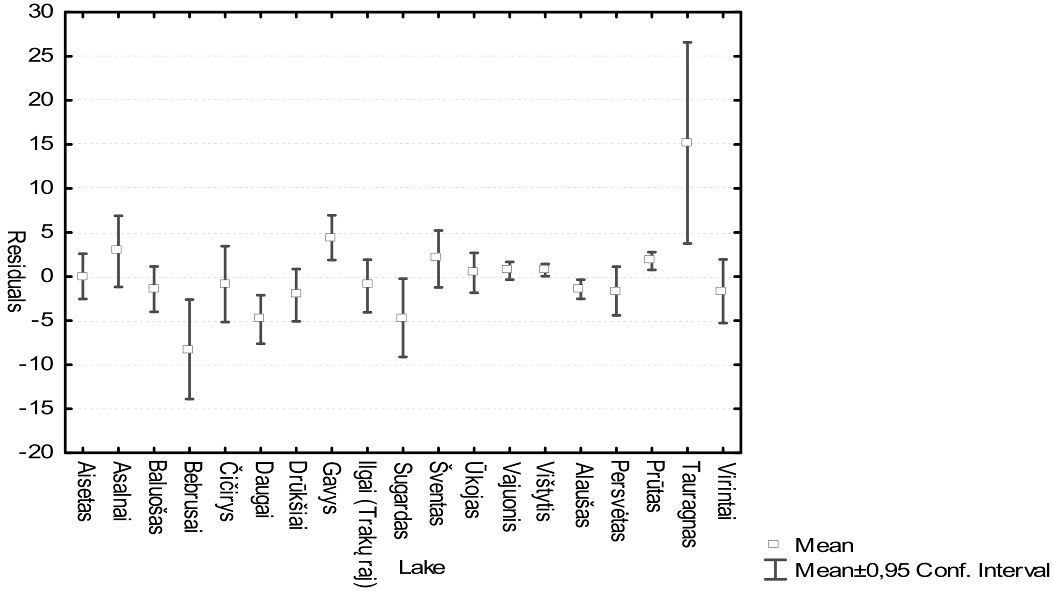

Figure 3. Vendace body condition values (residual error).

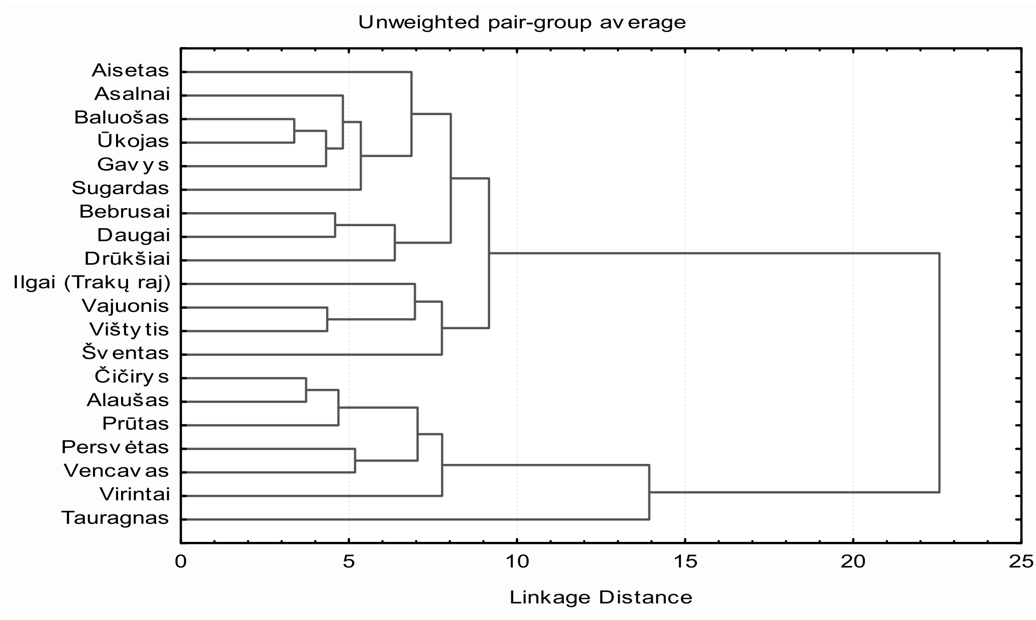

Figure 4. Mahalanobis distances between vendace populations in cluster analysis according to morphometric features.

r^2=0.98. Males' body length and weight rate was described by the equation y=0.002407 × x3.48. Regression coefficient =3.48, , significant (p<0.001), coefficient of determination r^2=0.97. However, calculation of confidence intervals of regression parameters a and b separately for females and males, reported that their boundaries overlap. So the difference of the genders body condition is not significant and further both vendance genders were analyzed together by the equation y=0.002819 × x3.437 (Figure 2), where regression coefficient 3.437 – significant (p<0.001), coefficient of determination r^2= 0.98. Linear regression describes data well.

Assessing the differences between the mass-length dependence in different populations and the analysis of residual errors of the regression line (Figure 2) we tried to find out in which lakes similar length vendace have greater weight.

Vendace length and weight rate in various lakes significantly different (p<0.001) according to ANOVA. The highest average of residual errors' is typical for vendance in Lake Tauragnas, according to its body condition they differ significantly from most other populations (Figure 3). Also, one of the biggest value's of body condition is in Gavys. Lowest rate of weight-length is characterized in vendace of Bebrusai. This rate in other populations' individuals is quite similar.

2. Morphometric analysis

2.1. Morphometric features differences between populations

ANOVA revealed that all lakes vendace significantly differ in 21 out of 24 morphometric features (p<0.05), there were no significant differences in preanal distance (PA) (p= 0.649), length of anterior part of body (TTL) (p=0.709) and pectoral fin length (LP) (p= 0.644), so these features do not have any influence in further calculations.

Significant differences between sexes were established in eight out of 17 populations of vendace, according to ANOVA. It was determined that females can differ more than one feature from the male. Most, 19 of the 24 differing features were found between the sexes of vendace population in Asalnai, 3 features in Vajuonis, Prūtas and Ilgai, 2 features in Aisetas and Drūkšiai, 1 in Vištytis and Baluošas. There was noticed no significant differences in other populations (lakes of Vencavas, Ūkojas, Šventas, Sugardas, Parsvėtas, Čičirys and Alaušas). A. Kaupinis (2005) suggests, that combination of statistical analysis of male and female morphometric data shows no significant differences (the results of statistical analysis are similar). This was confirmed in analyzing data of this investigation, so morphometric data of male and female was combined.

Discriminant analysis was performed to determine whether morphometric features of vendace differ in different lakes. The total classification of populations by morphometric features is correct 61.96%. The best ranked vendace are in Vencavas, Alaušas, Vištytis and Prūtas, 88.46%, 86.67%, 84% and 83.33%, respectively. Fish of these populations differ most by morphometric features.

Cladogram of Mahanalobis distances shows how the vendace populations spread according to their morphometric features. Mostly distinguished are vendace, inhabiting Lake Tauragnas, other populations compose three groups. One group is populations of lakes – Prūtas, Čičirys, Alaušas, Vencavas, Parsvėtas and Virintai. Second group: Šventas, Vištytis, Vajuonis and Ilgai, while third group composed of all the rest lakes, where Gavys, Ūkojas, Baluošas and Asalnai are adjacent, although it is obvious that river basin is not the most important factor to determine morphologic features of vendace. Populations in the cladogram spread independently to earlier defined growth rate group of vendace.

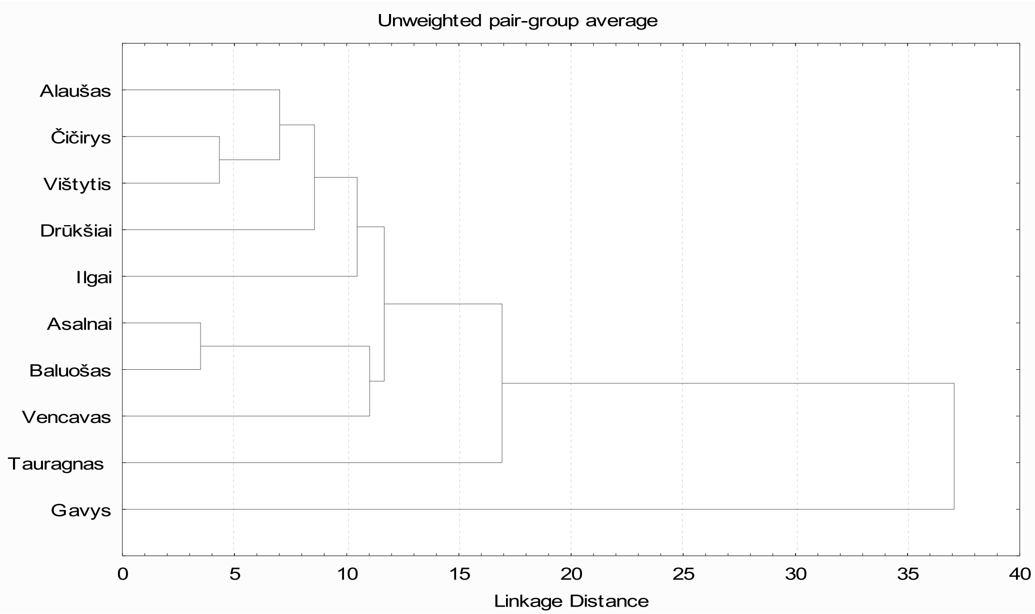

Figure 5. Mahalanobis distances for morphometric features between vendace populations in cluster analysis in 1998-2003.

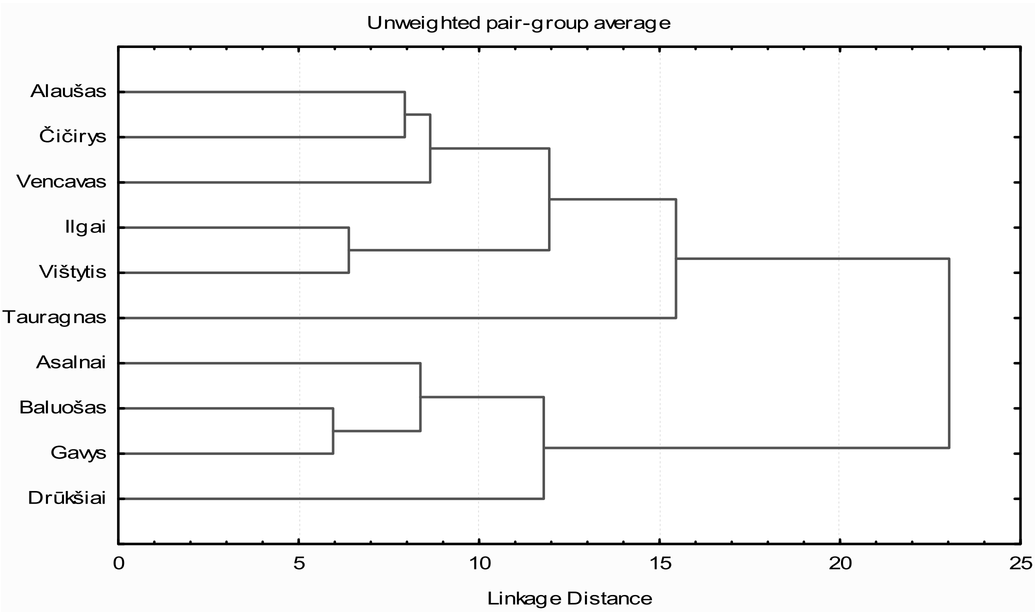

Figure 6. Mahalanobis distances for morphometric features between vendace populations in cluster analysis measured in 2010-2011.

2.3. Vendace morphometric variations

Data collected in 1998-2003 by A. Kaupinis and our collected data during the period of 2010-2012 in the same tenth lakes was used to ensure whether morphometric features vary in different years. Thus, Mahalanobis distances based on morphometric features between populations for different year's data were calculated separately, in order to find out if morphometric features have changed during past time interval. Cladograms were drawn according them (Figure 6 and 7). It is also possible to compare the allocation of the same lakes in earlier year and now.

Same lakes' populations range differently in different years. According to Mahalanobis distances of 1998-2003, the vendace population of Lake Gavys is the most different from all other lakes populations (Figure 5). Alaušas, Čičirys, Vištytis, Drūkšiai and Ilgai vendace populations compose one group, obviously, growth character has no influence on vendace morphometry (Čičirys and Vištytis vendace get in one group, but based on growth character they are in different groups). Other group is composed of vendace populations of Asalnai, Baluošas and Vencavas, and most different from others are Gavys and Tauragnas populations according to Mahalanobis distances between morphometric features.

According to the data of 2010-2011 (Figure 6) populations of Tauragnas and Drūkšiai are most different from others. Vendace from lake Gavys are similar to those of Baluošas and Asalnai, this may be related to the fact that for many years Gavys was inhabited with vendace from those lakes. Figure 5 shows that location of populations does not depend on river basins, though in Figure 6 populations of lakes Gavys, Baluošas and Asalnai in basin of Žeimena are most similar. So, in 12 years time vendace has assimilated in lakes of Žeimena basin. It is obvious, that these features vary when fish generations changes. Thus, it would not be right to relate these features only to river basin, which lake belongs to.

DISCUSSION

Investigated lakes divides into 3 groups according to growth rate by von Bertalanffy's equation. Growth parameter φ' of low-growing vendace group is between 2.379 and 2.466, middle-growing and quickly-growing vendace parameter φ' is respectively between 2.519 and 2.565 and between 2.672 and 2.777. It was found that the fastest growth is specific to Lake Čičirys while lowest to vendace in lakes Alaušas and Vištytis. Such distribution of populations by growth rates is quite hard to interpret, but it was defined that maximum depth of the lake and population of lake smelts living together in some lakes do not have any significant influence. Viljanen (1988) suggests that vendace inhabiting the southernmost lakes are characterized by the highest growth rates, where lakes are of higher productivity and better nourishment. Viljanen et al. (2004) also notice that vendace growth rate strongly depends on separate age-groups and whole population strength in the lake, the strength of an age-group shows a negative correlation to its growth rates. It is stated that the strength of vendace populations vary depending on that year spawning conditions, so it may be that growth rates in the populations should be variable. Kaupinis (2005) says there is no clear line among distinguishable vendace growth groups. Population of the same lake may be referred to another group in different year, depending on the growth character differences in different years.

To summary the weight-length dependence research of investigated vendace populations was noticed, that female body length and weight in most common age-groups are higher than males, no significant difference was determined between male and female weight-length ratio according to the regression equation. Comparing the body condition of vendace between different lakes, according to residuals on regression line, the highest vendace weight increase is in Tauragnas, they differ significantly according to this feature from all other investigated populations. One of the biggest values was determined in Gavys also. Lowest weight increase specific for vendace of Bebrusai, while populations of other lakes does not distinguish particularly. Highest values of body condition in Kaupinis (2005) research was found in vendace of Čičirys and Ūkojas, while they did not distinguish in this research, so it could be stated that weight-length values of vendace has changed from 2005. Though, well-nourishment values are more stable compared to the variation of growth rates (Kaupinis, 2005).

Significant differences were found in eight populations out of 17 investigated lakes, when investigating morphometric differences between vendace genders in different populations. Females in one population can differ from males by several features, while in others can be no differences. Kaupinis (2005) dissertation results shows that Vencavas vendace males differ from female by anal fin length (HA), pectoral fin length (LP), ventral fin length (LV) and eye diameter (O), whereas this research detected no significant difference between Vencavas male and female. Similar situation is in populations of some other lakes. Therefore, no stable features distinguishing vendace genders in populations can be detected. Sexual dimorphism is not expressed; in some populations may be significant differences according to some features, in other populations according to others, while in thirds could be no significant differences between genders. Also, features by which differ vendace males and females in population of the same lake at different generation may not coincide.

Morphometric research of different lakes vendace populations by 2010-2012 years data noticed, that investigated fish by ANOVA significantly differ by 21 morphometric feature out of 24, differences are not significant by preanal distance, tangent length and pectoral fin length. Kaupinis (2005) research showed that different lakes vendace differ by all 24 features, so assumption that vendace of Lithuanian lakes have assimilated by above mentioned features could be made. On the other hand, differences of the results may occur due to different lakes of the researches. Qualification of different lakes vendace populations according to morphometric features in discriminant analysis is genuine by 61.96%. Investigated populations divides into four groups in cluster analysis according to Mahalanobis distances between morphometric features of different lakes vendace populations.

Tauragnas vendace distinguish mostly of all populations by morphometric (as well as body condition), this may be related to rapidly changing conditions due to eutrophication processes in this lake (Bukelskis & Balevičius, 2007). No dependence on vendace morphometric features of growth rates in population was noticed.

Investigation, whether morphometric features change with vendace generation, showed that populations of same lakes get into different groups at different years, according to Mahalanobis distances between morphologic features. Based on 1998-2003 research data vendace in Gavys were most different from all other lakes populations, on 2010-2012 years data this populations was close to populations of Baluošas and Asalnai, while vendace of Tauragnas were most different. Populations of Žeimena basin lakes Gavys, Baluošas and Asalnai appear adjacent. So, if it is not a coincidence, it could be stated that vendace of some Žeimena basin have assimilated during 12 years. The reason of this could be vendace population mixing by fish stocking. Lakes, inhabited with low-growing vendace, are stocked by vendace of Tauragnas, thus this research had defined it has influence on vendace morphology, while positive influence to growth character was not determined. Generally, morphometric features does not depend on river basin in populations of Lithuanian lakes. Obvious, these features vary in population when generations change. Kaupinis and Bukelskis (2004) suggests that vendace morphometric features are related to ecological conditions and its' changes in the lakes. According to Oreha and Škute (2009) fish eye is bigger in a poor transparency of water, a shorter and wider head in lakes with good food reserve. So, hydrobiological lake parameters have influence on morphometric features of vendace. Changing climate and lake parameters could lead to morphometric vendace features changes. May be thought that mixing populations by fish stocking could change individual, over a long period of time established, population-specific morphometric features, thus reducing population opportunities to adapt to the living environment.

Interesting situation occurs with vendace population of Virintai. For many years it was stated that vendace do not live in this lake, as they have become extinct due to rapid changes in the lake and eutrophication process (Bukelskis & Balevičius, 2007). However, in 2012 this lake vendace catch statistics were significant, although they did not live in here earlier. Also known, that earlier this lake was not stocked with vendace. Adjacent lake of Susiedas was stocked with vendace larvae, incubated of reproducers spawn caught in lake Tauragnas, therefore these fish accessed the adjacent lake Virintai. Morphologic similarity between vendace of Virintai and Tauragnas is noticed in this research. Vendaces of Tauragnas and Virintai are in the same middle-growing group according to the growth rates. Although, vendace of these two lakes differ significantly by body condition, however body condition depends on nourishment conditions in the lake and it is stated this parameter varies rapidly (Kaupinis, 2005). Virintai vendace are most similar to Tauragnas vendace according to morphometric data. Therefore, based on the similarity of morphometry and growth rates it could be predicated that vendace inhabiting lake Virintai came from vendace population of Tauragnas.

CONCLUSIONS

To describe the growth rates of individuals in vendace populations von Bertalanffy's equation was used and according it's parameters φ' was calculated. Investigated vendace populations divides into 3 groups according to growth rate: low-growing, middle-growing and quickly-growing vendace.

It could be stated that investigated lakes vendace have changed morphologically and now they are similar according to 3 morphometric features: preanal distance (PA), length of anterior part of body (TTL) and pectoral fin length (LP).

Morphometric features of vendace of Gavys, Baluošas and Asalnai lakes in Žeimena basin became similar to each other, this could have happened because of population mixing by stocking and/or due to changed ecological conditions in lakes, however river basin, which lake belongs to, is not the most important factor determining vendace morphometric features.

According to similarity of morphometric and growth rates could be stated that vendace in lake Virintai appeared from lake Tauragnas.

REFERENCES

Bagenal, T. B. & Tesch, F. W. 1978. Age and growth. Methods of Assessment of Fish Production in Fresh Waters (Bagenal T.B. – Ed.). Oxford, 101-136.

Bukelskis, E. & Balevičius, A. 2007. Biologinė kaita sausumos vandenyse [Biological change of inland waters]. Globali aplinkos kaita, 188-206. (In Lithuanian)

Chouinard, A., Pigeon, D. & Bernatchez, L. 1996. Lack of specialization in trophic morphology between genetically differentiated dwarf and normal forms of lake whitefish (*Coregonus clupeaformis* Mitchill) in Lac de I'Est, Quebec. Canadian Journal of Zoology 74: 1989-1998.

Czerniejewski, P. & Rybczyk, A. 2008. Variations in age and length growth rates of vendace, *Coregonus albula* (L.), from selected lakes in western Pomerania. Archives of Polish Fisheries 16: 63-74.

De Graaf, G. & Prein, M. 2005. Fitting growth with the von Bertalanffy growth function: a comparison of three approaches of multivariate analysis of fish growth in aquaculture experiments. Aquaculture Research 36: 100-109.

Harmin, S. F. & Persson, L. 1986. Asymetrical competition between age classes as a factor causing population oscillations in an obligate planktivorous fish species. Oikos 47: 223-232.

Kaupinis, A. & Bukelskis, E. 2004. Vendace (*Coregonus albula* (L.)) growth and morphological diversity in lakes of Lithuania. Acta Zoologica Lituanica 14, 1: 3-12.

Kaupinis, A., 2005. Lietuvos ežerų sykinių žuvų vidurūšinė morfologinė ir genetinė įvairovė [Intraspecies genetic and morphological variations of coregonid fish in the lakes of Lithuania]. Daktaro disertacija. Vilnius, 163 p. (In Lithuanian)

Oreha, J. & Škute, N. 2009. Morphological characteristics of local population of European vendace *Coregonus albula* (L.) of some lakes of Latvia during 50 years. Proceedings of the Latvian Academy of Sciences. Section B, 63, 6: 271-278.

Pauly, D. & Murno, J. L. 1984. Once more on the comparison of growth in fish and invertebrates. Fishbyte 2, 1: 21.

Pernaravičiūtė, B. & Balkuvienė, G. 2000. Influence of physical water parameters on the growth and abundance of vendace and smelt under natural and thermogradient conditions. Acta Zoologica Lituanica 10, 4: 24-31.

Reshetnikow, Y. S. 2004. Coregonid fishes in Arctic waters. Annales Zoologici Fennici 41: 3-11.

Viljanen, M. 1988. Population Dynamics of vendace (*Coregonus albula* L.) in Finland. University of Joensuu. Publications in Sciences 12: 1-19.

Viljanen, M., Turunen, T. & Väisänen, P. 2004. Fluctuations in year–class strength and growth of the vendace (*Coregonus albula* (L.)) in the small, mesohumic, oligotrophic Suomunjärvi, a lake in eastern Finland. Annales Zoologici Fennici 41: 241-248.

Yakhnenko, V. M., Mamontov, A. M. & Luczynski, M. 2008. East-Siberian coregonid fishes: their occurrence, evolution and present status. Environmental Biotechnology 4, 2: 41-53.