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MORPHOMETRIC CHARACTERISTICS OF EUROPEAN GRAYLING (*THYMALLUS THYMALLUS* L.) IN TRANSCARPATHIAN RIVERS

A. I. KUCHERUK [1]

A. I. MRUK [1]

V. O. KOVALENKO [2]

[1] – *Institute of Fisheries of NAAS of Ukraine*

[2] –*National University of Life and Environmental Sciences of Ukraine*

The article contains the analysis of morphometric features of European graying from Transcarpathian rivers. The sexual dimorphism is as a rule typical for all grayling species (Thymallus): males have longer bases of dorsal and anal fins, higher dorsal fin and longer pectoral fin than females. The majority of the analyzed features were characterized by relatively low level of variability – the coefficient of variation varied from 2.2 to 16.5%. The detected differences between some morphometric features of adult and juvenile fish can be explained by the peculiarities of the development of hydrodynamic properties of European grayling.

Key words: *European grayling, Transcarpathian rivers, morphometric features*

The territory of Ukrainian Carpathians located within the Danube and Dniester catchments is the most water rich area in Ukraine and it contributed to the development of favorable natural conditions for multispecies fish fauna complexes [1, 7].

Unfortunately, the environmental conditions on water bodies of this region are characterized by high instability with a general tendency for deterioration [9, 10]. Accordingly, the impact of external factors on fish fauna is mainly negative that in turn results in certain reduction of the quantitative composition of fish fauna, replacement of dominant species, deterioration of population and individual biological characteristics. One of the most important aspects of such impact is the reduction of the number of stenobiont species, 14 of which have already been

listed in the Red Book of Ukraine. One of species, which requires special protection in the Carpathian region, is European grayling (*Thymallus thymallus* L.).

This is the only representative of the family Thymallidae in Ukrainian rivers. Currently, it inhabits mountain reaches of the Dniester catchment and its tributaries – Stryi, Opir, Lomnitsa, as well as in the Danube catchment (Trancarpathian region) – in middle and upper Tisa, Teresva, Tereblia, and Rika rivers [7].

Currently, the information on biological characteristics of European grayling in Transcarpathian rivers is scarce and this fact restricts the development of measures on the restoration of its populations based on artificial reproduction.

One of the most representative methods, which allows determining the environmental effect on individual fish and their adaptive capacity, detecting inter-population peculiarities due to geographic or hydrological isolation, as well as assessing the consequences of possible inbreeding (that is very important because of the small quantity of brood fish), is morphometric analysis [11, 12].

Aim of the work is to study the ontogenetic variability of the morphometric features of adult and juvenile European grayling, to determine their sexual dimorphism as well as the peculiarities of grayling morphology in Transcarpathian rivers.

Materials and methods The data for morphometric analysis were collected in spring-summer period of 2013-2014 in Transcarpathian rivers (Tisa, Krasna, Teresva, Chorna, Tereblya). The materials were collected with the assistance of Zakarpattya Fish Protection Inspection. Fish was taken from poachers' gill net and preserved in 10% formalin solution. In total, 89 European grayling of different age groups were collected. Processing of the preserved materials was carried out in the laboratory conditions.

Morphometric analysis was carried out according to generally accepted ichthyological techniques [8]. In total, 62 adult fish of 19.5 to 27.7 cm fork length (43 females and 19 males) and 27 juvenile fish of 10.3 to 17.0 cm fork length were processed and analyzed. Sexual maturity of fish was determined visually by dissection. Fish were weighed using electronic scales to the nearest 0.001 g and

morphometric measurements were taken using a caliper and measuring tape. Following metric features were used for the analysis:

Ac – fork length, **ad –** standard length, **od –** body length, **an –** snout length, **np –** eye diameter, **aa_5 –** length of the middle part of the head, **ao –** head length, **po –** postorbital length of head, **lm** – occipital height of head, **aa_6 –** maxillary length, **k_1l_1** – mandibular length, **qh –** maximum body depth, **ik –** minimum body depth, **aq**- predorsal distance, **rd –** postdorsal distance, **az –** preventral distance, **ay** – preanal distance, **fd –** caudal peduncle length, **qs –** dorsal fin base length, **tu** – maximum dorsal fin height, **ee_1** – anal fin base length, **ej** – maximum anal fin height, **vx** – pectoral fin length, **zz_1** – pelvic fin length, **vz –** distance between pectoral an pelvic fins, **zy** – distance between pelvic and anal fins.

Comparison of samples and mean values was carried out using Student's t-test. Statistical processing of data was done in MS Excel [6, 8].

Results and discussion Within its wide natural range, European grayling can be found not everywhere but mainly in mountain rivers and streams with clear cold water and lakes with high oxygen content. European grayling as the majority of salmonids is characterized by high inter-population heterogeneity related to the peculiarities of living in the water bodies of different types [3, 4].

Morphometric studies of adult European grayling from Transcarpathian rivers showed that main features varied within the range typical for this species with some peculiarities visible in time aspect. E.g., a comparison of morphometric features of grayling from the Teresva River [13] with our data demonstrates the presence of significant differences ($p<0.05$) for the features related to hydrodynamic characteristics (body depth, head length, dorsal fin base length) and feeding conditions (maxillary and mandibular lengths).

The majority of the analyzed features were characterized by relatively low variability – the coefficient of variation ranged from 2.2 to 16.5% and only the eye diameter had a very high variability of up to 31.1%. Consequently, a conclusion can be drawn on certain uniformity (at least of the analyzed morphometric

features) of different grayling populations in Transcarpathian rivers and on the similarity of environmental conditions of this species here.

Aquaculture works often face the necessity of the sexual identification of European grayling; therefore we carried out a study for determining the differences between females and males of this species.

Sexual dimorphism of European grayling altogether is typical for all its populations and systematic groups (*Thymallus*) [2]. This species is characterized by clearly pronounced sexual dimorphism by coloration during spawning period. Significant differences ($p<0.05$) were observed for following morphometric features: males have longer bases of dorsal and anal fins, higher dorsal fin and longer pectoral fin than females. Other values of morphometric features are not significant (Table 1).

It is considered that ontogenetic variations of morphometric parameters are related mainly to ecological specifics of the taxon. It is especially true for fish, which inhabit different areas within their range with dissimilar environmental conditions, specific characters of feeding, reproduction and population structures [2, 3, 4, 5].

Within the framework of our studies, we carried out an analysis of differences between adult and juvenile European grayling. As a result, it was found that significant differences were found only for 13 of 25 analyzed morphometric features: mandibular length; maximum and minimum body depth; predorsal, preventral, and preanal distances; maximum dorsal fin height; distance between P and V; distance between V and A; snout length; maxillary length. This fact allows asserting on certain increase of several morphometric features in adult European grayling compared to juvenile fish in the Transcarpathian rivers. It is necessary to note that for other populations of this species, age-related differences were detected only for snout length [2, 8, 9].

1.Morphometric features of European grayling in Transcarpathian rivers, 2012

Features	Females (n=43)			Males (n=19)			t_{ct}	Both sexes (n=62)		
	max-min	M±m	σ	max-min	M±m	σ		max-min	M±m	Σ
ac	29-19.5	22.6±0.43	2.77	27.7-20.5	22.5±0.41	1.76	0.13	29-19.5	22.6±0.31	2.44
% of fork length										
ad	98.2-90.5	93.3±0.29	1.87	89.3-79.5	94.25±0.47	1.99	0.42	101.9-89.3	94.1±0.26	2.05
od	92.9-63.1	75.4±0.72	4.58	79.5-70.7	74.76±0.54	2.28	0.83	92.9-63.1	75.2±0.44	3.5
an	8.3-5.3	6.3±0.11	0.69	8.4-4.8	6.07±0.22	0.94	0.88	8.4-4.8	6.2±0.10	0.76
np	6.2-2.4	4.6±0.15	0.99	6.2-3.6	4.68±0.21	0.88	0.25	6.2-2.4	4.6±0.12	1.43
aa_5	19.5-12	13.9±0.39	2.48	17.1-10.8	14.03±0.33	1.41	0.23	19.5-12	14.1±0.18	2.15
ao	24.4-17.7	19.5±0.19	1.21	26.2-17.5	19.77±0.45	1.91	0.64	26.2-17.5	19.6±0.18	1.43
po	13.0-8.0	10.2±0.21	1.33	13.8-8.3	10.20±0.29	1.21	0.56	13.8-8.0	10.2±0.16	1.26
lm	17.0-7.9	13.7±0.23	1.49	16.7-11.4	14.33±0.41	1.72	1.37	17.0-7.9	13.9±0.19	1.47
aa_6	11.5-5.5	7.4±0.21	1.35	8.8-5.5	7.20±0.24	1	0.7	11.5-5.5	7.4±0.16	1.22
k_1l_1	13.0-7.9	9.2±0.17	1.12	11.6-7.3	9.12±0.27	1.16	0.19	13.0-7.3	9.2±0.14	1.1
qh	30.2-18.2	22.4±0.45	2.89	28.6-18.6	22.87±0.78	3.29	0.57	30.2-18.2	22.5±0.37	2.95
ik	9.6-5.5	7.3±0.18	1.13	9.6-6.1	7.26±0.22	0.94	0.22	9.6-5.5	7.3±0.13	1.05
aq	44.4-32.1	36.9±0.46	2.97	38.3-30.6	35.15±0.53	2.23	2.56	44.4-30.6	36.4±0.36	2.82
rd	45.3-35.4	39.4±0.33	2.14	41.7-35.9	39.29±0.36	1.51	0.32	45.3-35.4	38.8±0.61	4.79
az	52.1-44.3	47.6±0.35	2.24	50.0-43.3	46.76±0.43	1.81	1.56	52.1-43.3	47.3±0.27	2.11
ay	74.4-66.7	70.4±0.32	2.06	74.4-65.1	70.07±0.61	2.57	0.48	74.4-65.1	70.3±0.28	2.18
fd	20.7-13.3	15.7±0.29	1.86	17.3-13.3	15.36±0.33	1.41	0.91	20.7-13.3	15.6±0.22	1.7
qs	23.8-10.3	19.9±0.43	2.75	25.0-16.3	21.84±0.42	1.79	3.31	25.0-10.3	20.5±0.33	2.59
tu	16.2-10.0	13.3±0.21	1.34	19.1-10.6	14.53±0.47	1.98	2.53	19.1-10.0	13.7±0.21	1.63
ee1	11.0-7.3	9.5±0.12	0.76	13.1-8.8	10.08±0.22	0.92	2.61	13.1-7.3	9.6±0.11	0.84
ej	15.1-10.0	12.3±0.19	1.19	14.7-11.0	12.37±0.24	1.03	0.04	15.1-10.0	12.3±0.14	1.12
vx	17.3-12.5	15.0±0.17	1.1	18.6-12.5	15.20±0.35	1.47	0.6	18.6-12.5	15.0±0.15	1.2
zz_1	19.2-9.1	13.9±0.26	1.66	18.6-12.8	15.23±0.34	1.44	3.14	19.2-9.1	14.3±0.21	1.67
vz	33.3-24.1	29.3±0.32	2.08	34.9-23.1	28.46±0.67	2.84	1.18	34.9-23.1	29.1±0.29	2.32
zy	28.3-18.5	23.5±0.33	2.11	26.1-20. 0	23.25±0.41	1.75	0.46	28.3-18.5	23.4±0.25	1.96
% of head length										
an	45.0-26.0	32.3±0.57	3.65	40.0-22.2	30.83±1.07	4.54	1.2	45.0-22.2	31.9±0.50	3.91
np	30.0-11.7	23.8±0.82	5.26	29.5-16.4	23.79±1.07	4.53	0.22	30.0-11.7	23.8±0.63	4.93
aa_5	83.3-54.5	71.4±1.82	11.6	88.9-60.0	71.23±1.66	7.04	0.71	88.9-54.5	71.4±1.30	10.23
po	65.1-40.0	52.3±0.99	6.32	64.4-38.2	51.89±1.59	6.74	0.46	65.1-38.2	52.2±0.80	6.29
lm	85.0-41.1	70.5±1.23	7.85	88.9-54.5	71.44±2.02	8.59	0.59	88.9-41.1	70.8.±1.0	7.89
aa_6	54.0-27.3	38.0±0.92	5.9	48.0-25.5	36.73±1.43	6.07	0.98	54.0-25.5	37.7±0.74	5.84
k_1l_1	58.3-40.0	47.1±0.72	4.63	64.0-32.7	46.47±1.67	7.07	0.67	64.0-32.7	47.0±0.68	5.36

We noted that the length of dorsal fin base in juvenile European grayling was larger than in adult fish and it decreased with age (Table 2). Thus, in the age aspect, the major changes of morphometric features are related first of all to the enhancement of hydrodynamic characteristics. It can be explained by the peculiarities of the hydrological regime of Transcarpathian rivers: adult grayling inhabit mainly river reaches with increased velocity of water current.

2. Morphometric features of juvenile European grayling from Transcarpathian rivers, 2013

Fetures	Min-max	M±m	σ
Ls	10.3-17.0	13±0.39	2
% of fork length			
Ad	88.5-95.8	92.88±0.34	1.74
od	69.2-86.7	73.91±0.62	3.18
an	6.1-2.8	4.53±0.17	0.89
np	3.4-5.4	4.46±0.10	0.49
aa_5	11.9-19.2	14.30±0.28	1.44
ao	14.6-20.8	18.86±0.28	1.45
po	7.5-11.4	9.16±0.18	0.93
lm	11.0-17.0	13.48±0.29	1.5
Aa_6	3.6-7.1	5.10±0.16	0.81
K1l1	7.3-10.7	8.40±0.15	0.78
qh	15.2-22.4	18.70±0.36	1.83
ik	4.6-7.3	5.56±0.12	0.6
aq	30.2-36.1	33.11±0.27	1.39
rd	30.8-40.9	36.78±0.44	2.27
az	34.3-54.1	43.81±0.75	3.82
ay	63.1-72.7	67.17±0.52	2.65
fd	7.7-19.3	13.41±0.49	2.49
qs	16.9-22.6	20.15±0.25	1.3
tu	10.9-21.6	17.17±0.51	2.62
ee1	6.8-10.6	8.31±0.18	0.93
ej	11.4-16.4	12.65±0.20	1.01
Vx	11.8-18.6	14.34±0.34	1.75
Zz1	11.3-17.0	13.15±0.30	1.55
vz	20.9-28.4	24.65±0.37	1.87
zy	17.5-24.4	21.50±0.37	1.87
% of head length			
an	26.0-45.0	24.03±0.91	4.64
Np	14.0-30.0	23.75±0.64	3.26
Aa_5	54.5-80.0	76.39±2.35	12
po	40.0-62.5	48.77±1.11	5.65
lm	41.1-85.0	71.84±1.88	9.57
Aa_6	27.3-42.5	27.11±0.87	4.43
K1l1	40.0-52.0	44.81±1.09	5.56

The degree of variability of the analyzed features of European grayling with age increase does not show any tendency for decrease that compared to the results

of studies of other population characteristics [12] indicates on favorable and stable conditions for this species in Transcarpathian rivers.

We detected significant differences between morphometric features of European grayling from Transcarpathian rivers and fish from the Sars River, which is located on the same geographical latitude and has a length of 135 km that allows us to compare population features in these rivers [9] (Table 3).

3. Morphometric differences of European grayling from Transcarpathian rivers and Sars River

Features	Adult fish		t_{ct}	Juvenile fish		t_{ct}
	Transcarpathian rivers	Sars River		Transcarpathian rivers	Sars River	
	M±m	M±m		M±m	M±m	
ac	22.6±0.31	20.8±3.10		13	12.8	
% of fork length						
An	6.2±0.10	7.11±0.06	7.8	4.53±0.17	6.79±0.05	0.11
Np	4.6±0.12	4.9±0.06	2.3	4.46±0.10	5.73±0.05	0.29
Ao	19.6±0.18	21.5±0.11	9	18.86±0.28	22.29±0.07	0.19
Po	10.2±0.16	9.9±0.05	1.3	9.16±0.18	9.93±0.05	0.3
Lm	13.9±0.19	14.4±0.10	2.3	13.48±0.29	14.03±0.07	0.16
aa_6	7.4±0.16	5.5±0.05	11.3	5.10±0.16	5.99±0.04	0.18
k_1l_1	9.2±0.14	10.4±0.06	7.9	8.40±0.15	11.72±0.10	0.39
Qh	22.5±0.37	20.6±0.22	4.4	18.70±0.36	19.62±0.14	0.12
Ik	7.3±0.13	6.8±0.06	3.5	5.56±0.12	6.58±0.03	0.3
Aq	36.4±0.36	35.5±0.22	2.1	33.11±0.27	35.68±0.12	0.46
Rd	38.8±0.61	39.7±0.22	1.4	36.78±0.44	39.80±0.14	0.77
Az	47.3±0.27	46.7±0.32	1.4	43.81±0.75	46.38±0.17	0.56
Ay	70.3±0.28	70.9±0.28	1.5	67.17±0.52	69.55±0.22	0.5
Fd	15.6±0.22	15.9±0.19	1	13.41±0.49	16.24±0.10	0.27
Qs	20.5±0.33	21.5±0.20	2.6	20.15±0.25	21.31±0.11	0.52
Tu	13.7±0.21	13.9±0.21	0.8	17.17±0.51	12.97±0.11	0.2
ee1	9.6±0.11	9.4±0.11	1.3	8.31±0.18	9.91±0.08	0.22
Ej	12.3±0.14	12.1±0.14	1	12.65±0.20	11.76±0.09	0.35
Vx	15±0.15	15.06±0.13	0.3	14.34±0.34	14.87±0.09	0.3
zz_1	14.3±0.21	14.2±0.14	0.4	13.15±0.30	13.71±0.07	0.41
Vz	29.1±0.29	27.3±0.34	3.9	24.65±0.37	26.42±0.18	0.39
Zy	23.4±0.25	25.3±0.23	5.7	21.50±0.37	24.30±0.11	0.11
% of head length						
An	31.9±0.50	32.6±0.65	0.9	24.03±0.91	30.47±0.17	0.93
Np	23.8±0.63	22.8±0.23	1.4	23.75±0.64	25.77±0.24	0.68
Po	52.2±0.80	46.5±0.28	6.7	48.77±1.1	44.59±0.24	1.13
Lm	70.8±1	67.5±0.84	2.5	71.84.±1.88	63.00±0.31	1.91
aa_6	37.7±0.74	25.7±0.15	15.8	27.11±0.8	26.94±0.17	0.89
k_1l_1	47±0.68	48.8±0.22	2.5	48.81±1.09	50.18±0.22	1.11

We used the results of measurement of multiple-age fish from four samples. Average fork length of adult fish from Transcarpathian rivers was 22.6 cm, from Sars River – 20.8 cm; juvenile fish had average length of 13.0 and 12.8 cm, respectively. Comparison of grayling samples from Transcarpathian rivers and Sars River demonstrated that juvenile fish did not significantly differ by morphometric features indicating that juvenile fish did not have age-related features that is a consequence of an increased conservatism of juvenile fish to living conditions. For adult fish, significant difference was detected for 10 of 25 morphometric features. E.g., such features as snout length, head length, mandibular length, distance between V and A were larger in grayling from the Sars River, while maxillary length, distance between P and V, maximum and minimum body depths, postorbital length of head were larger in grayling from Transcarpathian rivers. I.e., adult European grayling are characterized by a little bit longer body length and higher values to dorsoventral direction and at the same time they had smaller head and snout but longer upper jaw.

The presented differences in morphometric features of European grayling from different rivers is an expected consequence of the differences in fish living conditions. In our opinion, a significant enough is hydrological regime: Sars River is more lowland compared to rapid Carpathian streams. This is also confirmed by the allometry, which is observed for a number of morphometric features (first of all, for the features related to hydrodynamic characteristics) of European grayling from Transcarpathian rivers. Feeding conditions can also play a certain role – the parameters of linear growth of European grayling from Transcarpathian rivers significantly exceed those for fish from the Sars River [10]. Thus, the suggestion proposed by some authors [13] that European grayling in Ukrainian waters have own peculiarities compared to the typical European form is generally confirmed by our study.

Conclusions

Mean length of juvenile European grayling in Transcarpathian rivers was 10.3-17.0 cm, adult fish – 19.5-27.7 cm. Sexual dimorphism was detected for

following features: males had longer bases of the dorsal and anal fins and longer pectoral fins than females.

Variability of the majority of morphometric features was insignificant, the coefficient of variation ranged from 2.2 to 16.5% that indicated on the uniformity of living conditions.

An analysis of the dynamics of morphometric features indicates on the presence of significant differences (upward) between juvenile and adult fish by 13 features.

A comparison of the morphometric features of European grayling from the Sars River and Transcarpathian rivers did not detect significant differences between these features in juvenile fish, however, significant differences were observed between 10 of 25 features in adult fish.

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МОРФОМЕРИЧНА ХАРАКТЕРИСТИКА ХАРІУСА ЄВРОПЕЙСЬКОГО (*THYMALLUS THYMALLUS* L.) В РІЧКАХ ЗАКАРПАТТЯ

А. І. Кучерук, А. І. Мрук, В. О. Коваленко

В даній роботі проаналізовані морфометричні показники харіуса європейського з річок Закарпаття. Статевий диморфізм харіуса, в цілому, є типовий для всіх представників роду Thymallus: у самців довші основи спинного і анального плавців, більш високий спинний та довші грудні плавці, ніж у самок. Більшість з проаналізованих ознак характеризувалась відносно невисоким ступенем мінливості - коефіцієнт варіації коливався від 2,2 до 16,5%. Виявлені відмінності за рядом пластичних ознак між статевозрілими

особинами та молоддю харіуса європейського, які можна пояснити особливостями формування його гідродинамічних характеристик.

Ключові слова: *харіус європейський, ріки Закарпаття, пластичні ознаки, статевий диморфізм*

МОРФОМЕРИЧЕСКАЯ ХАРАКТЕРИСТИКА ХАРИУСА ЕВРОПЕЙСКОГО (*THYMALLUS THYMALLUS* L.) В РЕКАХ ЗАКАРПАТЬЯ

А. И. Кучерук, А. И. Мрук, В. А. Коваленко

В данной работе проанализированы морфометрические показатели хариуса европейского из рек Закарпатья. Половой диморфизм хариуса, в целом, типичен для всех представителей рода Thymallus: у самців, по сравнению с самками, более длинные основы спинного и анального плавников, более высокий спинной и более длинные грудные плавники. Большинство из проанализированных признаков характеризовалось относительно невысокой степенью изменчивости: коэффициент вариации колебался от 2,2 до 16,5 %. Обнаружены отличия по ряду пластических признаков между половозрелыми особями и молодью, которые можно объяснить особенностями формирования гидродинамических характеристик хариуса европейского.

Ключевые слова: *хариус европейский, реки Закарпатья, пластические признаки, половой диморфизм*