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Variability and problem of species identification of sculpins of the genus *Cyphocottus* (Pisces: Cottidae)

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ABSTRACT. Based on the material collected during the fieldwork seasons from 1996 to 2007 in the amount of 223 specimens, we studied phenetic relationships and taxonomic structure of the genus *Cyphocottus*. Two valid species, *C. megalops* and *C. eurystomus*, within the taxonomic boundaries established by D.N. Taliev (1955) were confirmed in the genus *Cyphocottus*. Interspecific differences in *C. eurystomus* are manifested in greater values of interorbital distance, the height of the head, body and caudal peduncle, as well as in smaller values of eye diameter and caudal peduncle length. Polymorphism in the definitive sizes, colour and the number of neuromasts in the lateral line is typical of *C. eurystomus*. At the same time, all populations have specific characters of *C. eurystomus* different from *C. megalops*. We found no intraspecific variability in *C. megalops*.

Keywords: Baikal endemic sculpins, genus *Cyphocottus*, phenetic and taxonomic relationships, Lake Baikal

1. Introduction

V.G. Sideleva founded the genus *Cyphocottus*, humpback sculpins, including two species, *C. megalops* and *C. eurystomus* (Sideleva, 2003). The name of the genus *Cyphocottus* originates from the Latinized Greek words “*cyphos*”, which means humpback, and “*cottus*”, which is sculpin, thus, reflecting the morphological feature of these fish. Genetic studies confirmed the validity of this genus (Kontula et al., 2003). Type species, *C. megalops*, was originally described within the genus *Cottus* (Gratzianov, 1902). Later, it was placed within the genera *Limnocottus* (Berg, 1906; Sideleva, 1982), *Abyssocottus* (Gratzianov, 1907) and *Asprocottus* (Taliev, 1955). Overall, during the studies, four species were described: *Cottus megalops* (Gratzianov, 1902); *Limnocottus megalops elegans* (Taliev, 1948) and *Asprocottus megalops eurystomus*, which included two subspecies, namely the “type” subspecies inhabiting the Selenga shallow water, Barguzin Bay and the Maloye More Strait and the “Southern Baikal” subspecies inhabiting, as follows from its name, the southern basin of Lake Baikal. The latter subspecies differs from the former one by a variegated colour and some plastic and meristic characters (Taliev, 1955). Subsequently, the name *C. eurystomus* was entrenched not only for this subspecies but also for all spotty individuals as well as the name *C. megalops* – for monochromic individuals (Sideleva, 2003).

The confusion in the identification of taxa is due to two circumstances. First, the original description of *C. megalops* was made for an juvenile individual with exterior features that were not completely formed. Second, for a long time, there were no new findings of this species. Between the first finding in 1891, “the second discovery” of the species in 1943 and our samplings from 2000 to 2007, the intervals were more than half a century. The collected material allows us to solve the problems concerning the identification of taxa and consider their intraspecific variability.

2. Material and methods

This study was based on the material collected from 1996 to 2007. A total of 223 specimens were examined (Table 1). The species were identified by characters indicated by D.N. Taliev (1955) and V.G. Sideleva

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Table 1. List of samples and analyses

No. of samples	Name of locality	Date	Number of neuromasts	Other morphological characters
		Cyphocottus megalops		
1	Chivyrkuy Bay estuary	16 August 2006	1	1
2	Barguzin Bay	19 June 2000	4	5
3	the Selenga shallow water	27 May 2007	7	7
	the Selenga shallow water	17 June 2000	-	9
4	area near the estuary of the Buguldeika River	08 June 2003	10	18
		Cyphocottus eurystomus (monochromic form)		
5	area near the estuary of the Kichera River	02 June 2007	5	5
6	Frolikha Bay	04 June 2002	-	9
7	Tompa Bay	05 June 2002	-	14
8	Shegnanda Cape	06 June 2002	5	5
9	Bolshiye Vorota Strait	November 2004	25	25
	Bolshiye Vorota Strait	30 May 2007	6	6
10	Khoboy Cape	19 June 2000	3	8
11	the Selenga shallow water	29 October 2004	30	30
		Cyphocottus eurystomus (spotty form)		
12	Chivyrkuy Bay estuary	20 September 1999	11	11
13	area near the estuary of the Buguldeika River	08 June 2003	25	25
14	Gremyachinsk Cape	March 2005	10	10
15	Bolshaya Kosa Cape	07 June 2002	1	1
	Solontsovaya Bay	22 June 2000	1	1
16	Ushkany Islands	21 June 2000	1	6
	Ushkany Islands	07 June 2003	1	1
17	Bolshiye Koty Bay	July 2003	1	1
	Listvenichny Bay	13 February 1996	5	5
	Listvenichny Bay	December 2000	3	6
	Listvenichny Bay	December 2001	3	5
	Listvenichny Bay	May 2002	7	7
	area near the Slyudyanka town	March 2000	2	2

(2003). Due to discrepancies in the identification of *C. megalops* in the above references, the two forms were compared for compliance with the characters of the holotype descripted by V.I. Gratzianov (1902) for ten plastic characters. As an alternative, the following was used: the *C. megalops* (sensu Sideleva, 2003) selection consisting of 15 juvenile individuals collected in the northern part of Lake Baikal, Frolikha and Tompa bays (form A in Table 2) and the *C. megalops* (sensu Taliev, 1955) selection consisting of 40 adult individuals from different areas of Lake Baikal (form B in Table 2). The study of interspecific and intraspecific variability was carried out on 17 samples by 17 meristic and 29 plastic characters. The selections were compared by principal component analysis (PCA) technique using the SPSS 8.0 software (Laerd Statistics, 2015)

3. Results and discussion

Identification of taxa

The analysis of phenetic relationships of the juvenile *C. megalops* (sensu Sideleva, 2003) specimens, the adult *C. megalops* (sensu Taliev, 1955) specimens and the *C. megalops* holotype has revealed that these selections diverge in the space of principal components by such characters as eye diameter, the height of body and head in the space of the first principal component as well as by the postorbital distance and the interorbital distance, head length and caudal peduncle length in the space of the second principal component (Table 2). The *C. megalops* holotype occupied the centre on the scatter plot of the *C. megalops* (sensu Taliev, 1955) selection (Fig. 1). Therefore, the identification of taxa proposed by D.N. Taliev (1955) should be considered correct, to which we will adhere below.

The distinctive features of *C. megalops* are an oblong body, large oval eyes (eye diameter is usually larger than the snout length) and monochromic colour: the brown back, yellow-brown sides and yellowish-grey fins (Fig. 2A). The distinctive features of *C. eurystomus* are a tall fusiform body forming a hump behind the occiput and round eyes with a diameter smaller than the snout length. The colour of the body and fins varies significantly (Fig. 2B-2E); therefore, the division into monochromic and spotty forms is rather nominal.

Variability of definitive sizes

There were no differences in the sizes of adult *C. megalops* individuals (Table 3). The total length (TL) of the studied specimens ranged from 93 to 127 mm. D.N. Taliev (1955) gave similar data (110-120 mm). In contrast, the sizes of *C. eurystomus* are subject to significant variability. Four size groups can be distinguished: large (TL up to 215, 160-185 mm on average) individuals inhabiting the Selenga shallow

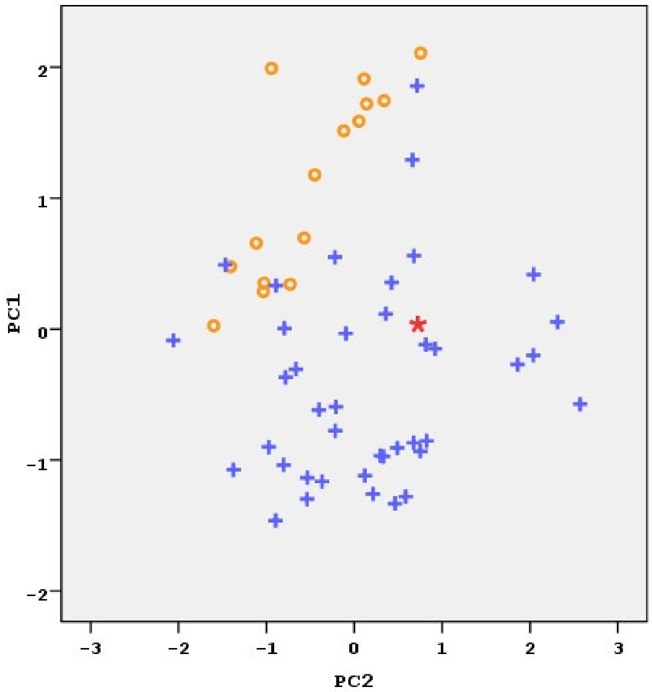

Fig.1. Phenetic relationships between the holotype of *C. megalops* and potentially conspecific specimens: red star – holotype of *C. megalops,* orange circles – juvenile specimens of *C. megalops* sensu Sideleva (2003), blue cross – adult specimens of *C. megalops* sensu Taliev (1955).

Table 2. Values of the key morphological characters and component score coefficient matrix for analysis of the *Cyphocottus megalops* identification

	Holotype of *C. megalops*	Examined forms		Principal Component	
		A	B	1	2
Total length (mm)	71.0	74.2 63.6-84.2	110.9 93.2-127.1	% of Variance	
Standard length (mm)	60.0	60.8 52.4-69.3	92.4 76.0-107.1	38.340	16.777
Plastic characters in % of standard length					
head length	31.7	34.3 ±0.77 33.0-35.8	31.7±0.91 29.6-33.9	0.188	-0.218
height of the trunk	18.3	20.0±1.43 17.5-21.9	15.7±2.28 12.2-21.7	0.232	-0.136
height of caudal peduncle	5.0	5.5±0.29 5.1-6.0	5.4±0.35 4.4-6.3	0.156	0.231
length of caudal peduncle	19.2	16.9±1.07 15.2-19.2	16.4±1.21 13.7-18.8	-0.003	-0.373
Plastic characters in % of head length					
snout length	28.9	27.9±1.36 25.5-31.3	26.9±1.78 19.7-30.9	0.094	0.155
longitudinal eye diameter	31.6	24.7±1.44 21.9-27.1	27.3±2.12 21.7-32.4	-0.176	0.017
postorbital distance	44.7	41.1±1.66 37.9-44.5	41.6±1.74 37.5-46.1	0.041	0.438
width of the head	63.2	70.4±4.68 63.2-79.3	63.8±9.73 53.0-94.7	0.166	-0.166
head height near occiput	50.0	52.8±2.84 47.2-56.0	46.7±4.18 41.0-61.1	0.235	-0.050
interorbital distance	10.5	7.2±1.50 5.2-9.6	6.2±1.54 3.4-11.0	0.151	0.302

Note: Above the line – average values and standard deviations, below the line – limits of variability of the characteristic value. Symbols: form A – juveniles of *C. megalops* sensu Sideleva, 2003; form B – *C. megalops* sensu Taliev, 1955.

water and the northern part of the Maloye More Strait; medium individuals (TL up to 165 mm, 130-145 mm on average); small individuals (TL up to 135-145 mm, 100-125 mm on average) and dwarfs (TL up to 96 mm). Small and medium individuals are found throughout Lake Baikal; dwarfs were found only at one site, near Khoboy Cape at a depth of 100 m.

Variability of morphometric characters

The study of the variability in the number of neuromasts in sensory lines has revealed the absence of interspecific differences. At the intraspecific level, in *C. megalops* and monochromic form of *C. eurystomus*, the number of neuromasts in the lateral line increases from the northern to the southern part of the range (Table 3). The greatest number of neuromasts is typical of the *C. eurystomus* population in the Selenga shallow water. The scatter plot of the selections in the space of principal components (Table 4, Fig. 3A) shows this as a displacement of the scatter area of this population along the axis of the second principal component to the right side of the plot.

Analysis (PCA) of other morphometric characters showed that body height, caudal peduncle height, head height near occiput, and interorbital distance yield the greatest positive loading on the first principal component, and caudal peduncle length and eye diameter – the negative one. These characters determine interspecific differences. Body length yields the greatest positive loading on the second principal component, and head length – the negative one. These characters determine the difference of *C. eurystomus* in the Selenga shallow water from other populations of this species (Table 5, Fig. 3B).

4. Conclusions

This study has revealed interspecific differences between *C. megalops* and *C. eurystomus* manifested in greater values of interorbital distance, the height of the head, body and caudal peduncle, as well as smaller values of eye diameter and caudal peduncle length, in *C. eurystomus*. The population of *C. eurystomus* in the Selenga shallow water differs from other populations of this species by the same characters. Therefore, this population and *C. megalops* represent the

Table 3. Component score coefficient matrix for analysis of the number of neuromasts in the sensory lines of 17 samples of the *Cyphocottus* sculpins

Characters	Principal Component	
	1	2
	% of Variance	
	37.181	15.540
number of neuromasts in a left supraorbital line	0.140	-0.151
right supraorbital line	0.150	-0.176
left infraorbital line	0.155	-0.012
right infraorbital line	0.151	-0.049
left temporal line	0.131	-0.052
right temporal line	0.140	-0.106
left occipital line	0.118	0.063
right occipital line	0.137	0.063
left preopercular-mandibular line	0.157	-0.107
right preopercular-mandibular line	0.159	-0.023
left lateral line	0.090	0.470
right lateral line	0.085	0.474

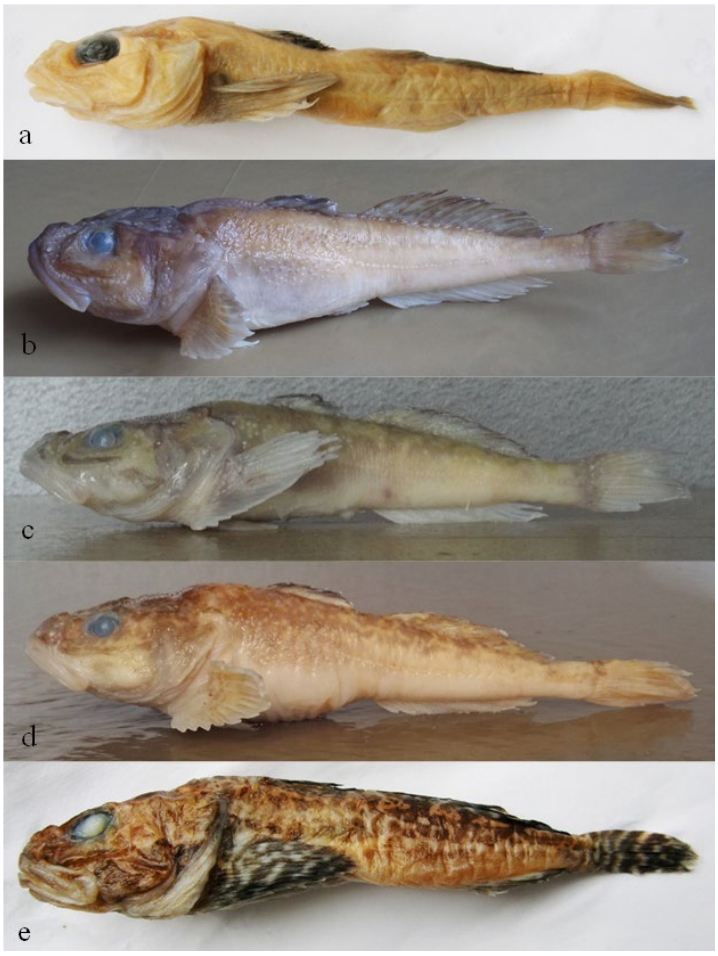

Fig.2. Variability of colours: A. C. *megalops;* B-E. C. *eurystomus:* (B and C) – monochromic form; (D and E) – spotty form.

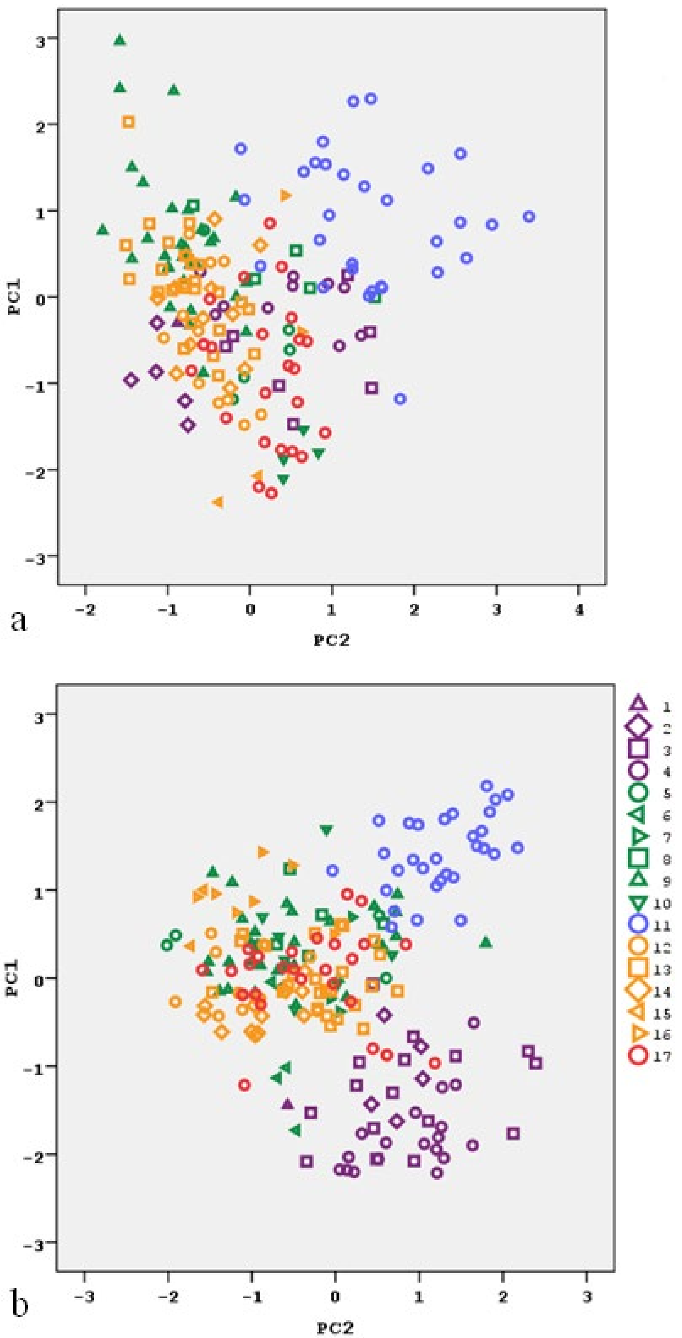

Fig.3. Distribution of 17 samples of sculpins of the genus *Cyphocottus* in the space of the first (PC1) and second (PC2) principal components: A. by numbers of neuromasts; B. by other meristic and plastic characters. Numeration of samples as in Table 1. Colour of symbols: violet – *C. megalops*; green and blue – a monochromic form of *C. eurystomus* (blue – the Selenga shallow water as the type locality); orange and red – a spotty form of *C. eurystomus* (red – the southern basin of Lake Baikal as the type locality).

Table 4. Component score coefficient matrix for analysis of morphological characters of 17 samples of the *Cyphocottus* sculpins

Characters	Principal Component	
	1	2
	% of variance	
	28.480	9.962
Meristic characters		
number of rays in the first dorsal fin	-0.011	0.070
second dorsal fin	0.012	0.169
left pectoral fin	0.056	-0.085
anal fin	0.026	0.130
number of gill rakers	-0.027	0.009
Plastic characters in % of standard length		
head length	0.032	-0.230
length of the trunk	0.015	0.192
height of the trunk	0.088	-0.053
height of caudal peduncle	0.080	0.045
width of the trunk	0.071	-0.047
antedorsal distance	0.046	-0.196
postdorsal distance	-0.034	0.092
anteventral distance	0.030	-0.130
anteanal distance	0.007	-0.167
length of the caudal peduncle	-0.068	0.002
pectroventral distance	0.063	-0.008
ventroanal distance	-0.001	-0.036
length of insertions of the first dorsal fin	0.019	-0.007
second dorsal fin	0.043	0.034
height of the first dorsal fin	-0.002	-0.058
second dorsal fin	0.056	0.056
length of insertions of the anal fin	0.056	0.093
height of anal fin	0.048	0.093
length of pectoral fin	0.062	0.089
length of ventral fin	0.020	0.053
Plastic characters in % of head length		
snout length	0.067	0.026
longitudinal eye diameter	-0.079	0.050
postorbital distance	0.071	0.051
width of the head	0.075	-0.043
head height near occiput	0.087	0.000
head height near eye	0.074	0.043
interorbital distance	0.088	0.006
length of upper jaw	0.076	0.041
length of lower jaw	0.048	0.032

Table 5. Size of specimens and values of the key morphometric characters of the *Cyphocottus* sculpins samples

№ of samples	Characters										
	TL	SL	*l.l.*	*c*	*H*	*h*	*pl*	*ao*	*o*	*hcz*	*io*
1	98.2	81.5	51-58	33.7	20.1	5.3	18.8	27.3	27.3	52.7	6.5
2	117.6 98.9-127.1	98.9 83.9-105.2	39-59	32.0±0.81 30.7-33.0	16.2±0.99 14.7-17.2	5.4±0.35 4.7-5.7	16.2±1.16 14.7-18.0	27.7±1.82 25.6-30.9	24.4±2.10 21.7-26.3	49.2±3.55 44.4-53.8	7.4±1.30 5.3-8.5
3	108.1 93.2-125.0	89.2 76.0-103.0	73.7±11.5 55-89	31.9±1.03 29.6-33.9	17.0±2.33 13.7-21.7	5.4±0.40 4.4-6.3	16.4±1.34 13.7-17.9	26.7±2.34 19.7-30.8	27.2±2.17 23.8-32.4	48.6±4.35 42.9-61.1	6.1±1.73 3.4-11.0
4	112.1 98.6-125.6	94.0 82.8-107.1	75.4±8.19 58-87	31.4±0.58 30.2-32.5	14.0±0.92 12.2-16.0	5.3±0.31 4.9-6.1	16.4±0.99 14.4-18.8	26.9±0.99 24.9-28.8	28.2±1.16 26.3-30.7	44.0±2.01 41.0-49.7	5.9±1.28 4.3-9.4
5	145.4 131.7-157.0	121.3 110.0-130.6	60-72	33.9±1.19 32.0-35.5	20.9±2.13 16.8-23.1	6.3±0.26 5.8-6.5	15.5±0.87 14.3-16.6	28.7±1.02 27.6-30.5	19.8±1.10 18.6-21.4	57.0±2.98 51.7-60.4	12.9±1.21 11.3-14.8
6	98.4 70.7-134.8	81.7 57.8-114.0	60-64	33.7±0.44 33.1-34.4	18.5±0.94 17.2-20.4	5.4±0.23 5.0-5.7	17.2±1.40 14.7-19.2	27.1±1.16 25.1-28.6	24.0±2.45 18.4-26.4	50.9±2.91 47.2-56.1	7.1±2.03 5.2-11.6
7	85.0 63.6-155.7	70.3 52.4-132.9	56-68	34.0±1.10 32.0-35.8	20.5±0.85 19.0-21.9	5.5±0.37 4.9-6.1	16.2±0.92 14.1-18.0	28.2±1.55 26.3-31.3	23.6±2.07 19.5-27.1	54.8±2.02 50.5-59.2	8.5±1.92 5.6-12.6
8	133.5 124.0-151.0	111.0 103.4-121.7	63-86	33.5±0.92 32.4-34.4	22.4±1.47 20.1-24.2	6.1±0.23 5.8-6.4	15.7±0.87 14.7-17.3	29.3±1.46 27.5-31.9	21.9±1.44 20.3-24.4	60.5±2.40 57.0-64.1	11.6±1.10 10.4-13.6
9	160.1 135.0-181.5	135.1 112.2-153.5	61.5±4.22 52-72	34.1±1.15 32.0-36.8	20.6±1.36 18.3-23.9	6.4±0.50 5.5-7.7	13.8±1.08 11.5-15.9	28.4±0.96 26.1-30.2	19.6±1.11 16.9-21.7	53.7±3.13 46.0-60.2	11.9±1.49 9.4-15.2
10	88.9 76.0-96.1	74.9 64.5-81.8	64.8±4.21 60-71	34.4±0.80 33.2-35.6	23.7±1.61 20.5-25.6	5.7±0.86 4.9-7.8	13.6±1.37 11.3-15.4	27.6±0.83 26.5-28.9	22.5±1.60 19.5-24.8	54.2±3.45 49.4-60.9	11.2±1.60 9.6-14.3
11	185.8 154.7-214.5	156.2 129.5-181.0	91.7±11.7 71-122	32.5±0.84 30.8-34.3	23.0±1.33 20.7-25.7	7.0±0.46 5.7-7.9	13.6±0.87 12.1-15.1	30.5±1.18 28.1-33.6	19.4±1.58 15.2-22.1	60.1±3.00 52.5-67.2	14.6±1.83 10.8-18.4
12	124.6 113.3-141.2	104.1 94.6-119.0	60.0±3.69 54-67	34.6±0.98 32.0-35.8	19.9±0.88 18.6-21.3	6.1±0.48 5.5-7.2	15.1±1.10 13.4-16.8	28.5±1.00 26.5-30.4	22.1±1.67 20.1-26.2	53.3±3.50 49.1-61.4	10.4±1.61 7.9-13.4
13	144.8 110.8-165.6	123.3 93.9-143.0	58.3±3.74 48-65	33.9±1.09 31.5-36.1	20.5±1.70 16.9-23.2	6.2±0.39 5.5-7.0	14.7±1.10 13.0-17.6	28.3±1.03 26.3-30.3	21.9±1.26 18.6-24.5	53.3±2.89 46.9-60.0	11.5±0.91 10.0-13.9
14	124.6 113.7-136.0	107.3 96.6-119.1	60.9±5.16 51-71	33.9±0.69 33.0-35.4	19.1±0.89 17.4-20.6	5.6±0.30 5.2-6.4	14.4±1.02 12.8-16.0	27.9±0.81 26.3-29.7	24.1±1.55 20.8-26.8	53.5±2.25 50.0-57.0	10.5±1.10 8.9-12.3
15	74.4-91.1	61.5-77.0	50-54	34.3-37.0	21.6-25.2	5.2-5.8	13.5-16.3	27.9-33.7	20.3-24.6	53.7-56.6	9.5-14.7
16	122.5 117.7-131.3	103.3 98.1-111.3	73-74	34.6±0.84 33.5-35.7	25.0±1.86 22.1-27.5	5.6±0.31 5.0-5.9	14.3±0.62 13.4-15.1	30.4±1.18 28.8-32.6	21.0±1.39 19.3-22.9	57.3±3.54 51.6-61.1	12.8±1.08 10.9-14.2
17	119.2 96.3-144.7	100.4 81.9-122.4	65.6±4.69 54-72	34.5±1.08 32.1-36.8	19.8±1.88 14.7-22.8	5.6±0.45 4.5-6.3	14.8±1.12 11.9-16.9	28.1±1.51 23.8-31.1	22.5±0.87 20.7-23.9	54.0±3.53 47.2-60.9	12.7±2.03 10.5-18.5

Note: Above the line – average values and standard deviations, below the line – limits of variability of the characteristic value. Symbols: TL – total length, SL – standard lenth, *l.l.* – number of neuromasts in the lateral sensory line; *c* – head length, *H* – height of the trunk, *h* – height of caudal peduncle, *lpc* – length of caudal peduncle, *ao* – snout length, *o* – longitudinal eye diameter, *cH* – head height near occiput, *io* – interorbital distance. Numeration of samples as in Table 1.

extreme forms of variability in sculpins of the genus *Cyphocottus*. The other selections, although filling the space between them, do not proceed to the intermediate form per se. They differ from each other by the number of neuromasts in sensory lines, colour and definitive sizes. Any combination of the selections, which is homogenous in one of these characters, will be heterogeneous in the rest. They all have the characters of *C. eurystomus* and differ from *C. megalops*. We have not found the intraspecific variability in *C. megalops*.

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Conflicts of interest

The author declare no conflicts of interest.

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