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Phenetic relationships and diagnostic features of sculpins of the genus *Cottocomephorus* (Perciformes: Cottidae)

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ABSTRACT. The author has studied phenetic and taxonomic relationships of the Baikal endemic sculpins of the genus *Cottocomephorus* Pellegrin 1900. For this purpose, the author has performed a morphometric investigation by five meristic and 29 plastic characters, as well as analysed the characteristics of colouring and the number of preopercular spines. The author has confirmed the validity of three species: *C. grewingkii* (Dybowski, 1874), *C. inermis* (Yakovlev, 1890) and *C. comephoroides* (Berg, 1901). The differentiation of the studied species is based on the number of gill rakers and preopercular spines, the width of the interorbital distance, height and width of the head, the length of the pectoral fins and the characteristics of the in-life colouration. Based on the revision of the diagnostic features, the author has suggested a new key to identify species.

Keywords: *Cottocomephorus*, systematics, morphology, phenetic relationships, diagnostic features, Lake Baikal fauna

1. Introduction

J. Pellegrin (1900) determined the genus *Cottocomephorus*, which initially included the only species *C. megalops* Pellegrin, 1900. Subsequently, the composition of the genus changed several times. In general, during the research, along with *C. megalops*, its composition included five more taxa: species that were previously described in the composition of the genus *Cottus* – *C. grewingkii* (Dybowski, 1874), *C. inermis* (Yakovlev, 1890) and *C. comephoroides* (Berg, 1900) as well as varieties described later, *Cottocomephorus grewingkii* – var. *siemienkiewiczii* (Dybowski, 1908) and var. *alexandrae* (Taliev, 1935). Currently, the genus includes three species: *C. inermis*, *C. grewingkii* and *C. alexandrae*. The latter was formed by combining two taxa *C. comephoroides* and *C. grewingkii alexandrae* (Sideleva, 2001; 2003), which is doubtful. This fact requires a study aimed at clarifying the taxonomic boundaries of species and development of a new key to their identification.

2. Material and methods

The study was carried out on the material collected by the author in 1994 – 2012. Fishes were caught with gill nets. During sampling, species and intraspecific forms were identified by size of mature specimens, features of breeding colouration, time and localization of spawning area specified in the original descriptions and subsequent revisions (Yakovlev, 1890; Berg, 1900; Pellegrin, 1900; Taliev, 1935; 1955; Koryakov, 1972).

The nomenclature is shown according to the provisions of the International Code of Zoological Nomenclature (1999). Fig. 1 Shows the images of type specimens. Abbreviations of museum collections: ZISP – Zoological Institute RAS, St.-Petersburg, Russia; BMNH – Natural History Museum, London; ZMB – Humboldt-Universität, Museum für Naturkunde, Zoologisches Museum, Vertebraten (Wirbekltiere), Ichthyologie, Berlin; MNHN – Muséum National d'Histoire Naturelle, Paris.

C. inermis and *C. comephoroides* were caught in the period before spawning, from December to March, at depths of 100-200 m. Both species are characterized by relatively large dimensions: females reach 180 mm TL and males – 210 mm. The initial identification was carried out by colouration characteristics. Dark-purple colour of the back and head, as well as lack of dark stripes on the pectoral fins, are characteristic of *C. inermis*, whereas dark-olive colour of the back and head, as well as dark stripes of the pectoral fins, are characteristic of *C. comephoroides* (Fig. 2, Fig. 3).

C. grewingkii was caught in the zone of a shallow platform at a depth of 1-2 m during spawning in March, May, June, and September. This species has smaller sizes of up to 130-140 mm, spotty colouration (brown spots against an olive background) and bright yellow pectoral fins with dark stripes in males (Fig. 4). Spawned specimens identified as *C. grewingkii alexandrae* were caught in early June at a depth of 100 m near the

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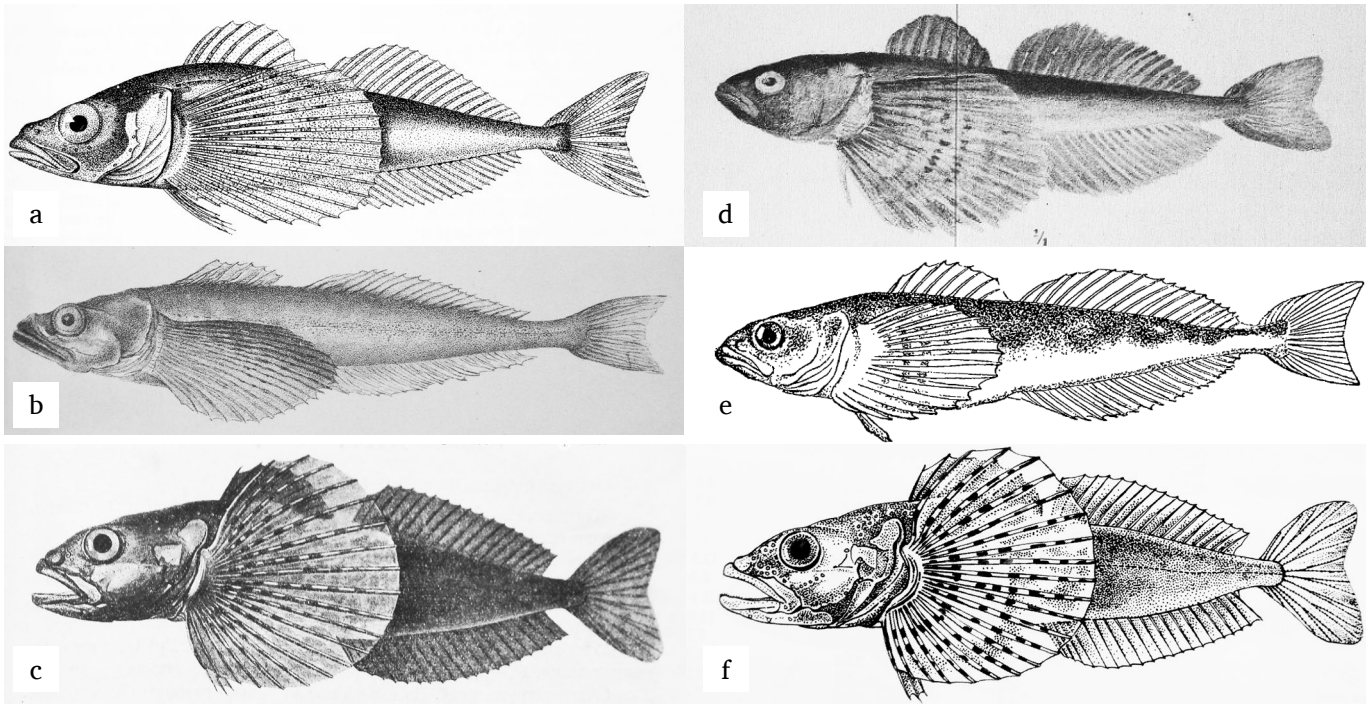

Fig. 1. Images of type specimens: a) neotype C. inermis ZISP 6350: male, 203 mm TL (Sideleva, 2003); b) syntype C. comephoroides ZISP ?: female, 159 mm TL (Berg, 1900); c) holotype C. siemienkiewiczii ZISP ?: male, 180 mm TL (Dybowski, 1908); d) lectotype C. grewingkii (?) BMNH 1897.7.5.4.(1): male, 130 mm TL (Dybowski, 1908); e) syntype C. grevingkii alexandrae: female, 102 mm TL (Taliev, 1935); f) ? 'lectotype-neotype' C. alexandrae: male, 170 mm TL (Sideleva, 2003)

eastern coast of the Northern Baikal, i.e. in the area indicated by Taliev (1955) as a likely breeding site of this form. These specimens differed from a typical form by the predominance of the brown colouration of the body and fins. Males also differed in the proportions of the head (Fig. 5) according to the original description (Taliev, 1955).

In total, we examined 53 specimens of *C. inermis*, 90 – *C. comephoroides,* 456 – *C. grewingkii*, including 38 specimens of *C. grewingkii alexandrae*.

The morphometric examination was carried out by five meristic and 29 plastic characters. We analysed: number of rays in the first (D_1) and second (D_2) dorsal, pectoral (*P*), and anal (*A*) fins, number of gill rakers (*sp.br*); length (*c*) and width (*bc*) of the head, length (*l*), height (*H*) and width (*w*) of the trunk; length (*lpc*) and height (*h*) of caudal peduncle; antedorsal (*aD*), postdorsal (*pD*), anteventral (*aV*), anteanal (*aA*), pectroventral (*P-V*) and ventroanal (*V-A*) distances; length of insertions of the first (lD_1) and second (lD_2) dorsal and anal (*lA*) fins; length of maximum rays in the first (hD_1) and second (hD_2) dorsal, anal (*hA*), pectoral (*lP*), and ventral (*lV*) fins; snout length (*ao*); longitudinal eye diameter (*o*); postorbital distance (*po*); head height near occiput (*cH*) and near vertical of the eye middle (*ch*); interorbital distance (*io*); and length of upper (*lmx*) and lower (*lmd*) jaws. Statistical processing of the material was performed by the generally accepted methods (Plokhinsky, 1980). Tables 1 and 3 show the variability of meristic and plastic characters. Selections were compared by factor analysis methods (PCA) using SPSS 8.0 software (Laerd Statistics, 2015). For assessment of the degree of differences, *CD* coefficient was used (Mayr, 1969).

Fig. 2. Lateral views of *C. inermis* (in top) and *C. comephoroides* (in bottom)

3. Results and discussion

Analysis of differences using the *CD* coefficient (Table 2, Table 4) has shown taxonomically significant differences between *C. inermis* and *C. comephoroides* by six characters in males and two characters – in females, between *C. inermis* and *C. grewingkii* – by five-nine characters and between *C. comephoroides* and *C. grewingkii* – by one-four characters. Differences are mostly in the number of rays in pectoral fins, fin base lengths and lengths of rays in fins, the height of the head, the interorbital distance and the diameter of the eye, which have highest values in *C. inermis*, the lowest values – in *C. grewingkii* and the intermediate ones – in *C. comephoroides*. There is an opposite pattern in the number of gill rakers. *C. inermis* have the lowest number (11-15), unlike the other species and forms that have 15-20 or 16-20 rakers.

There are discrete differences in the plastic characters between *C. inermis* and *C. grewingkii*, as well as the males of two *C. grewingkii* forms, typical and Northern Baikal one. At the same time, both forms have fewer differences between each other than with *C. comephoroides* and do not have taxonomically significant differences with other *C. grewingkii* populations.

Principal Components Analysis (PCA) of the variability of meristic and plastic characters in males has shown that the first and second principal components account for 36.3% of the total variance. The length of the pectoral fins yields the highest positive load on the first principal component, whereas the number of gill rakers – the negative one. For the second principal component, the width and height of the head at the occiput yield the highest positive load, and the ventroanal distance – the lowest one. In females, the first and second principal components account for 30.7% of the total variance. The number of rays in the pectoral fins and length of the head yield the highest positive load on the first principal component, whereas the length of the trunk and the length of the anal fin base – the negative one. For the second principal component, the highest positive load are the height of the body and height of the head at the occiput, and the negative one are the length of the body and snout.

Along with the above listed morphological features, these species differ in the combination of such characters as the number of preopercular spines (three to five in *C. inermis* and *C. comephoroides*, and one in *C. grewingkii*) and the colour

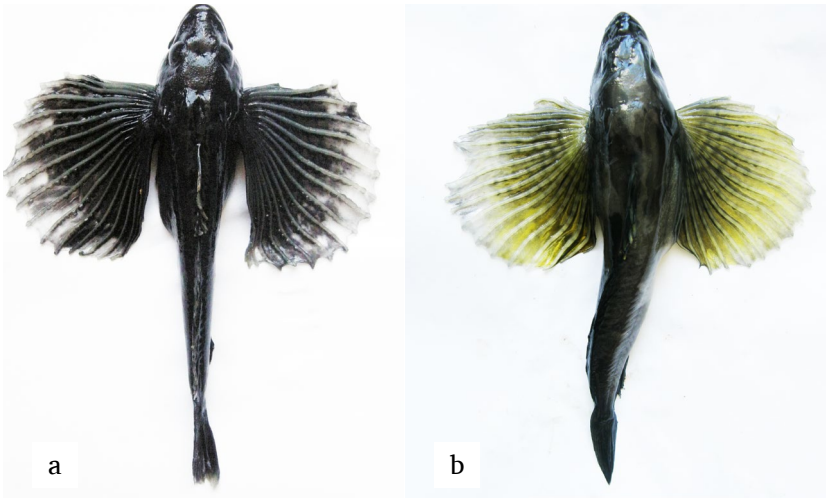

Fig. 3. Dorsal views of males in spawning coloration: a) *C. inermis*; b) *C. comephoroides*.

Fig. 4. Lateral views of *C. grewingkii* (June generation): a) male; b) female

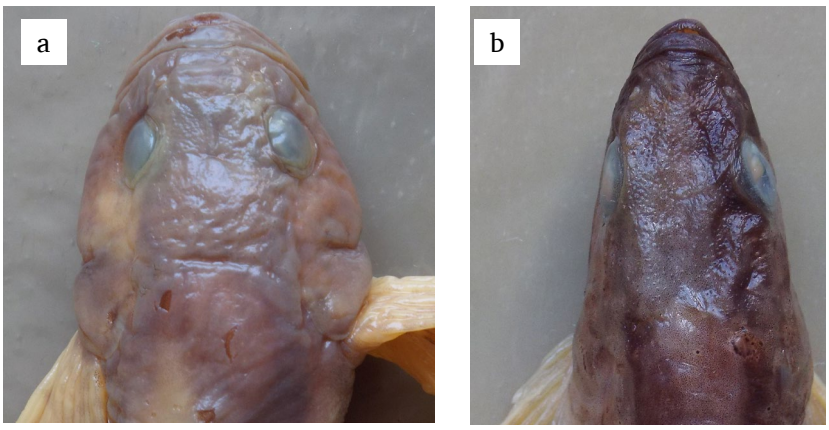

Fig. 5. Dorsal views of *C. grewingkii* males heads: a) 'typical form' (Southern Baikal, May generation); b) '*alexandrae* form' (Northern Baikal, March generation).

Table 1. The total length (*TL*), fork length (*FL*), standard length (*SL*), weight (*W*) and morphometric characters of males of the species of the genus *Cottocomephorus*

	C. inermis	C. comephoroides	C. grewingkii		
	(n = 33)	(n = 60)	'typical form' (48)	'alexandrae form' (13)	other populations (208)
TL	192.9 177.0-210.3	171.0 131.8-201.3	120.6 103.8-134.5	119.8 113.0-127.4	115.6 80.3-134.5
FL	184.4 169.5-200.4	162.4 125.8-192.5	116.7 101.0-131.8	116.3 109.7-122.2	112.2 79.0-130.0
SL	162.5 151.0-177.5	145.6 107.4-172.4	103.8 88.7-116.7	102.8 96.2-107.9	99.5 69.3-116.3
W	92.5 51.4-210.0	55.8 14.9-96.8	21.0 16.4-24.9	12.0 6.5-19.2	16.8 5.8-24.9
Meristic characters					
D_1	8.4 ± 0.10 7-9; 0.55	8.0 ± 0.07 7-9; 0.58	8.5 ± 0.08 7-10;0.58	8.3 ± 0.23 7-10; 0.82	8.2 ± 0.03 7-10; 0.50
D_2	19.1 ± 0.14 18-21; 0.78	18.2 ± 0.11 17-20; 0.84	18.4 ± 0.12 17-20;0.83	19.1 ± 0.23 18-21; 0.83	18.5 ± 0.05 17-20; 0.73
P	20.7 ± 0.10 19-22; 0.58	19.9 ± 0.08 19-21; 0.63	18.8 ± 0.08 18-20;0.59	18.8 ± 0.15 18-20; 0.53	18.8 ± 0.04 17-21; 0.64
A	21.3 ± 0.12 20-23; 0.68	21.1 ± 0.09 20-23; 0.71	20.6 ± 0.12 19-22;0.80	21.5 ± 0.21 20-23; 0.75	21.0 ± 0.04 19-22; 0.61
sp.br.	13.1 ± 0.16 11-15; 0.95	17.5 ± 0.17 15-20; 1.28	18.8 ± 0.20 17-23;1.41	17.7 ± 0.20 16-19; 0.72	18.7 ± 0.09 16-23; 1.27
Plastic characters in % *SL*					
c	28.2 ± 0.17 26.6-30.9; 1.00	27.8 ± 0.13 25.2-31.4; 1.02	26.7 ± 0.14 24.0-28.8;0.98	26.5 ± 0.25 24.8-28.2; 0.89	25.7 ± 0.07 23.1-29.3; 1.04
L	76.5 ± 0.27 72.4-79.2; 1.55	75.1 ± 0.31 67.6-83.9; 2.41	74.1 ± 0.24 68.9-77.0;1.69	77.5 ± 0.51 74.6-81.2; 1.84	78.7 ± 0.10 73.8-85.8; 1.47
H	20.7 ± 0.30 17.8-25.4; 1.75	17.4 ± 0.23 14.3-21.3; 1.78	20.4 ± 0.14 18.5-22.9;0.94	14.2 ± 0.37 12.2-17.3; 1.35	17.3 ± 0.11 12.2-21.3; 1.64
h	4.4 ± 0.04 4.0-5.1; 0.24	3.9 ± 0.05 3.1-4.8; 0.41	4.2 ± 0.04 3.7-4.8;0.29	4.2 ± 0.08 3.8-4.7; 0.30	4.5 ± 0.03 3.6-6.0; 0.37
B	15.5 ± 0.30 12.1-18.4; 1.72	13.1 ± 0.17 9.5-16.0; 1.32	15.5 ± 0.15 13.5-17.4;1.05	11.2 ± 0.34 9.8-14.5; 1.22	13.5 ± 0.08 10.5-16.4; 1.20
aD	33.1 ± 0.22 30.2-35.1; 1.27	32.7 ± 0.15 30.0-35.6; 1.17	31.4 ± 0.17 28.7-33.9;1.19	30.5 ± 0.41 26.9-32.7; 1.47	31.4 ± 0.11 25.4-40.0; 1.52
pD	11.7 ± 0.20 8.8-14.5; 1.14	12.7 ± 0.15 9.1-15.3; 1.19	13.1 ± 0.14 11.1-14.9;0.95	13.0 ± 0.41 9.9-15.6; 1.46	13.0 ± 0.07 10.4-16.0; 1.06
aV	27.9 ± 0.35 24.0-32.4; 2.01	26.3 ± 0.19 23.4-30.0; 1.48	26.2 ± 0.31 15.1-29.8;2.15	24.7 ± 0.18 23.7-26.2; 0.66	25.3 ± 0.14 14.3-37.2; 2.07
aA	54.1 ± 0.31 50.2-58.0; 1.77	54.7 ± 0.24 50.1-58.5; 1.84	51.0 ± 0.28 44.9-54.6;1.93	50.5 ± 0.36 48.3-53.0; 1.30	50.1 ± 0.12 45.2-55.5; 1.77
pl	9.8 ± 0.12 8.3-11.5; 0.69	10.4 ± 0.11 8.6-12.5; 0.87	10.0 ± 0.26 7.8-17.7;1.78	9.8 ± 0.20 8.5-10.7; 0.71	9.7 ± 0.06 7.3-12.3; 0.88
PV	3.2 ± 0.10 2.0-4.4; 0.55	3.0 ± 0.08 1.7-4.5; 0.59	3.3 ± 0.07 2.4-4.8;0.49	2.4 ± 0.15 1.8-3.6; 0.53	2.9 ± 0.03 1.6-4.2; 0.45
VA	28.6 ± 0.42 24.8-33.5; 2.39	30.4 ± 0.23 26.8-35.1; 1.77	26.2 ± 0.26 21.0-30.4;1.80	27.9 ± 0.41 25.9-30.6; 1.46	26.6 ± 0.15 21.5-40.1; 2.17
lD_1	22.1 ± 0.22 19.0-25.4; 1.25	22.6 ± 0.20 19.5-28.7; 1.56	21.0 ± 0.22 17.4-23.8;1.55	20.6 ± 0.44 17.6-22.8; 1.59	21.1 ± 0.10 17.3-25.3; 1.50
lD_2	35.4 ± 0.26 32.6-39.1; 1.51	33.7 ± 0.20 30.5-36.9; 1.56	35.8 ± 0.26 31.6-39.6;1.82	36.3 ± 0.45 33.1-38.8; 1.64	35.4 ± 0.13 31.5-40.5; 1.83

	C. inermis	C. comephoroides	C. grewingkii		
	(n = 33)	(n = 60)	'typical form' (48)	'alexandrae form' (13)	other populations (208)
hD$_1$	11.8 ± 0.17 10.3-14.3; 0.96	10.5 ± 0.11 8.7-12.8; 0.83	9.9 ± 0.14 7.7-13.3;0.98	10.9 ± 0.20 9.6-12.3; 0.74	10.5 ± 0.05 8.1-13.1; 0.79
hD$_2$	14.4 ± 0.16 12.3-16.2; 0.92	12.1 ± 0.11 10.1-14.0; 0.89	11.9 ± 0.11 10.6-14.0;0.80	13.0 ± 0.25 11.5-14.6; 0.91	12.1 ± 0.05 9.7-15.2; 0.78
lA	37.2 ± 0.21 34.8-39.1; 1.19	36.2 ± 0.22 32.7-40.9; 1.70	39.6 ± 0.19 36.5-42.1;1.34	39.4 ± 0.31 37.2-41.8; 1.11	39.8 ± 0.11 35.6-44.4; 1.58
hA	15.1 ± 0.16 13.3-16.8; 0.93	12.7 ± 0.11 10.9-15.1; 0.89	12.4 ± 0.15 9.7-14.7;1.01	14.4 ± 0.37 12.0-16.0; 1.35	13.1 ± 0.06 10.8-16.2; 0.83
lP	44.1 ± 0.34 40.7-47.5; 1.95	36.3 ± 0.27 31.7-40.2; 2.08	34.8 ± 0.36 23.3-39.8;2.52	36.5 ± 0.48 32.9-39.5; 1.72	35.5 ± 0.15 29.9-42.6; 2.10
lV	17.9 ± 0.16 15.7-19.5; 0.92	13.9 ± 0.11 12.3-15.9; 0.83	13.9 ± 0.12 11.9-15.6;0.83	14.6 ± 0.24 13.6-16.3; 0.86	14.0 ± 0.06 11.6-16.7; 0.81
Plastic characters in % *c*					
ao	31.9 ± 0.24 29.2-34.4; 1.36	32.1 ± 0.20 28.7-35.4; 1.51	32.9 ± 0.26 28.9-37.5;1.79	29.5 ± 0.33 28.0-32.2; 1.19	31.1 ± 0.11 27.0-36.1; 1.63
o	25.1 ± 0.60 20.8-41.4; 3.42	23.6 ± 0.28 18.5-28.1; 2.14	22.4 ± 0.24 17.6-26.7;1.69	22.6 ± 0.30 21.1-24.5; 1.07	22.0 ± 0.10 18.2-25.6; 1.40
op	40.4 ± 0.30 37.0-44.3; 1.70	42.2 ± 0.24 38.0-47.1; 1.87	43.4 ± 0.32 38.9-48.8;2.25	44.9 ± 0.53 41.5-47.9; 1.92	43.2 ± 0.13 37.6-49.1; 1.92
bc	65.7 ± 1.08 52.6-78.0; 6.21	55.3 ± 0.71 45.7-68.5; 5.47	76.7 ± 0.91 64.4-89.6;6.31	55.6 ± 1.36 44.9-66.8; 4.92	64.7 ± 0.34 53.3-77.5; 4.87
hcz	66.9 ± 0.46 60.4-70.8; 2.66	55.2 ± 0.56 45.2-64.7; 4.35	66.7 ± 0.54 58.7-75.9;3.75	53.1 ± 0.79 46.8-58.3; 2.86	61.0 ± 0.26 51.8-70.8; 3.72
hco	53.5 ± 0.53 46.1-59.9; 3.04	44.0 ± 0.37 36.8-50.5; 2.87	54.7 ± 0.76 44.4-81.7;5.25	43.5 ± 0.54 40.1-46.5; 1.94	48.4 ± 0.25 38.7-61.2; 3.56
io	19.6 ± 0.40 16.2-24.9; 2.33	19.5 ± 0.28 15.3-24.8; 2.14	27.8 ± 0.26 24.0-32.7;1.77	25.6 ± 0.64 20.7-30.1; 2.30	24.4 ± 0.15 19.1-29.8; 2.22
lmx	51.9 ± 0.30 47.8-55.8; 1.70	47.9 ± 0.30 42.5-51.7; 2.35	47.6 ± 0.33 43.4-52.7;2.29	49.1 ± 0.48 46.4-51.5; 1.72	49.1 ± 0.14 43.0-55.1; 2.08
lmd	60.7 ± 0.36 57.1-65.4; 2.07	56.5 ± 0.26 50.2-61.2; 1.98	58.3 ± 0.46 53.7-66.8;3.17	56.7 ± 0.65 53.4-63.0; 2.33	57.9 ± 0.17 52.6-66.7; 2.41

Note: Above the line – mean value and its error; under the line – limits of variation of character and mean square deviation.

Table 2. Differences in the morphometric characters of males of species and intraspecific forms of the genus *Cottocomephorus* reaching a taxonomically significant level (CD > 1.28)

	1	2	3	4
1. *C. inermis*				
2. *C. comephoroides*	*sp.br., hA, lP, lV, hcz, hco*			
3. *C. grewingkii*: 'typical form'	*P, *sp.br., hD*$_2$*, lA, *lP, *lV, io*	*bc, hcz, hco, io*		
4. *C. grewingkii*: 'alexandrae form'	*P, *sp.br., *H, B, *lP, lV, hcz, hco, io*	*aA, io*	**H, B, bc, *hcz, hco*	
5. *C. grewingkii*: Other populations	*P, *sp.br., hD*$_2$*, lP, lV*	*aA*	–	–

Note: * - characters for which there is hiatus.

Table 3. The total length (*TL*), fork length (*FL*), standard length (*SL*), weight (*W*) and morphometric characters of females of the species of the genus *Cottocomephorus*

	C. inermis	*C. comephoroides*	*C. grewingkii*		
	(n = 20)	(n = 30)	'typical form' (30)	'alexandrae form' (25)	other populations (132)
TL	141.8 115.7-179.7	143.4 121.2-166.2	121.7 113.4-129.5	120.7 107.7-131.0	106.0 85.7-130.0
FL	134.3 110.0-170.5	135.3 113.6-157.0	119.3 111.2-127.2	116.6 104.4-126.5	102.0 10.7-126.6
SL	120.5 97.5-156.0	121.9 100.8-142.0	106.2 98.9-113.4	104.0 93.0-113.3	92.0 75.4-113.3
W	24.6 10.4-64.3	31.8 14.2-45.4	8.1 6.5-10.7	15.9 9.4-19.7	10.6 4.7-18.5
Meristic characters					
D_1	8.6 ± 0.11 8-9; 0.49	8.0 ± 0.07 7-9; 0.41	8.1 ± 0.09 7-10; 0.47	8.1 ± 0.05 8-9; 0.27	8.1 ± 0.04 7-9; 0.49
D_2	18.6 ± 0.15 17-20; 0.66	17.6 ± 0.14 16-19; 0.76	18.4 ± 0.14 17-20; 0.76	18.3 ± 0.15 17-20; 0.73	18.1 ± 0.05 16-20; 0.62
P	20.2 ± 0.13 19-21; 0.60	19.5 ± 0.11 18-21; 0.62	18.5 ± 0.12 17-20; 0.67	18.9 ± 0.12 18-20; 0.59	18.2 ± 0.05 17-20; 0.57
A	21.1 ± 0.11 20-22; 0.50	20.7 ± 0.08 20-21; 0.46	21.0 ± 0.12 20-22; 0.63	20.8 ± 0.17 19-22; 0.85	20.8 ± 0.06 19-22; 0.65
sp.br.	12.8 ± 0.23 11-15; 1.04	17.7 ± 0.27 15-20; 1.47	18.2 ± 0.20 15-20; 1.11	18.2 ± 0.19 16-19; 0.95	18.3 ± 0.10 16-20; 1.11
Plastic characters in % *SL*					
c	26.5 ± 0.17 24.8-28.0; 0.77	26.9 ± 0.16 24.7-28.5; 0.90	25.4 ± 0.16 24.0-27.2; 0.88	26.2 ± 0.19 24.0-28.8; 0.93	24.0 ± 0.10 21.7-26.9; 1.13
L	77.1 ± 0.23 75.5-79.4; 1.03	75.4 ± 0.29 70.1-78.4; 1.61	77.6 ± 0.22 75.2-79.9; 1.19	78.1 ± 0.23 75.5-79.9; 1.15	78.8 ± 0.13 69.8-81.7; 1.47
H	17.7 ± 0.36 15.1-22.4; 1.62	17.4 ± 0.37 13.6-21.7; 2.02	16.1 ± 0.19 14.1-17.9; 1.02	17.4 ± 0.26 15.0-19.9; 1.28	17.3 ± 0.23 11.7-22.5; 2.63
h	4.0 ± 0.06 3.3-4.5; 0.27	3.6 ± 0.05 3.0-4.5; 0.29	3.8 ± 0.04 3.4-4.1; 0.22	4.2 ± 0.04 3.7-4.5; 0.22	3.8 ± 0.02 3.2-4.7; 0.27
B	11.7 ± 0.40 9.1-15.5; 1.79	12.7 ± 0.28 9.7-15.2; 1.51	11.9 ± 0.19 9.4-13.7; 1.04	12.8 ± 0.21 10.5-14.8; 1.07	13.1 ± 0.15 8.6-19.2; 1.78
aD	31.2 ± 0.25 29.1-33.3; 1.11	32.6 ± 0.16 30.8-34.1; 0.89	31.0 ± 0.19 28.3-32.6; 1.04	31.4 ± 0.18 30.0-33.1; 0.90	30.2 ± 0.12 24.5-33.7; 1.38
pD	12.6 ± 0.27 10.5-14.6; 1.22	13.0 ± 0.20 10.5-14.9; 1.10	13.4 ± 0.15 11.4-14.9; 0.84	13.6 ± 0.17 12.1-15.8; 0.85	13.6 ± 0.10 10.6-16.1; 1.15
aV	25.4 ± 0.22 22.7-26.8; 1.00	26.1 ± 0.21 23.9-28.2; 1.13	24.1 ± 0.21 22.1-26.3; 1.17	25.2 ± 0.18 22.6-27.1; 0.92	23.7 ± 0.11 21.0-27.2; 1.23
aA	55.2 ± 0.35 53.4-60.0; 1.57	55.6 ± 0.83 34.7-61.4; 4.57	53.2 ± 0.26 50.7-55.7; 1.40	51.8 ± 0.34 47.8-56.1; 1.69	52.7 ± 0.14 48.7-56.3; 1.57
pl	10.8 ± 0.16 9.4-12.2; 0.72	11.0 ± 0.26 8.8-15.8; 1.42	10.2 ± 0.17 8.3-12.8; 0.95	10.3 ± 0.16 8.7-11.9; 0.82	10.2 ± 0.09 5.7-12.6; 1.04
PV	2.8 ± 0.14 1.7-3.9; 0.63	3.2 ± 0.12 2.1-4.2; 0.63	2.8 ± 0.07 2.0-3.3; 0.36	3.0 ± 0.16 1.7-4.8; 0.78	3.1 ± 0.05 1.8-5.7; 0.63
VA	31.6 ± 0.56 27.5-38.6; 2.49	31.8 ± 0.49 26.7-37.2; 2.71	30.0 ± 0.33 26.5-33.2; 1.82	27.8 ± 0.32 24.5-30.9; 1.58	30.0 ± 0.15 24.0-33.7; 1.78
lD_1	23.4 ± 0.33 20.9-26.5; 1.47	24.4 ± 0.21 21.4-26.4; 1.17	22.7 ± 0.22 20.7-25.0; 1.22	21.4 ± 0.20 19.5-23.0; 1.01	23.3 ± 0.15 18.7-34.1; 1.77
lD_2	33.2 ± 0.27 31.5-36.0; 1.22	31.3 ± 0.28 26.8-34.0; 1.51	33.7 ± 0.24 31.4-36.9; 1.30	33.3 ± 0.29 30.5-36.2; 1.43	33.5 ± 0.12 29.4-38.0; 1.41

	C. inermis	*C. comephoroides*	*C. grewingkii*		
	(n = 20)	(n = 30)	'typical form' (30)	'alexandrae form' (25)	other populations (132)
hD_1	12.0 ± 0.20 10.0-13.3; 0.90	10.8 ± 0.16 9.0-12.8; 0.88	11.4 ± 0.18 9.6-13.5; 0.98	10.4 ± 0.16 8.1-11.7; 0.82	10.9 ± 0.08 7.8-13.7; 0.94
hD_2	12.7 ± 0.19 11.5-14.8; 0.87	11.4 ± 0.15 9.9-13.9; 0.81	11.7 ± 0.12 10.3-13.1; 0.65	11.4 ± 0.17 9.6-13.2; 0.86	11.1 ± 0.07 8.6-12.5; 0.79
lA	33.3 ± 0.33 30.0-36.0; 1.49	33.2 ± 0.27 29.8-35.8; 1.45	36.6 ± 0.21 35.1-39.7; 1.17	37.1 ± 0.25 34.7-39.7; 1.25	36.8 ± 0.13 28.2-43.1; 1.50
hA	12.2 ± 0.19 10.5-14.2; 0.86	11.2 ± 0.12 9.7-13.1; 0.65	11.5 ± 0.15 9.7-13.2; 0.84	11.8 ± 0.13 10.3-13.1; 0.63	10.9 ± 0.07 9.0-13.3; 0.85
lP	35.1 ± 0.50 31.3-38.6; 2.24	32.2 ± 0.34 29.6-37.6; 1.86	32.4 ± 0.35 28.3-36.4; 1.91	32.0 ± 0.41 27.6-36.0; 2.06	31.3 ± 0.16 22.4-35.2; 1.78
lV	14.4 ± 0.17 13.2-15.8; 0.76	12.0 ± 0.14 10.0-14.2; 0.74	12.1 ± 0.11 11.2-13.4; 0.63	12.7 ± 0.16 10.8-14.1; 0.80	11.9 ± 0.07 10.1-14.0; 0.79
Plastic characters in % *c*					
ao	29.5 ± 0.28 27.4-31.5; 1.26	31.3 ± 0.30 28.9-35.9; 1.62	28.8 ± 0.22 26.4-31.8; 1.19	29.5 ± 0.38 25.6-34.1; 1.92	30.2 ± 0.17 26.3-37.9; 1.98
o	31.3 ± 0.44 27.3-36.9; 1.95	27.9 ± 0.38 23.1-32.1; 2.10	25.4 ± 0.23 21.1-27.1; 1.24	24.1 ± 0.30 21.2-26.9; 1.52	25.0 ± 0.14 20.6-29.9; 1.55
op	37.7 ± 0.40 34.7-40.9; 1.79	39.2 ± 0.37 35.7-43.6; 2.00	41.3 ± 0.30 37.1-45.5; 1.66	44.2 ± 0.43 38.8-48.2; 2.15	41.1 ± 0.19 34.8-46.3; 2.15
bc	50.8 ± 0.95 44.6-60.8; 4.23	51.1 ± 0.78 42.6-58.5; 4.27	55.0 ± 0.50 49.2-62.0; 2.75	55.6 ± 0.67 48.9-62.0; 3.35	57.9 ± 0.43 46.5-84.9; 4.93
hcz	59.0 ± 0.76 52.9-66.8; 3.40	56.0 ± 0.93 43.3-62.9; 5.09	56.5 ± 0.53 50.4-63.2; 2.91	57.7 ± 0.73 48.6-63.2; 3.65	59.1 ± 0.34 49.4-68.5; 3.95
hco	46.3 ± 0.81 41.4-57.8; 3.60	42.5 ± 0.54 35.9-48.4; 2.97	43.6 ± 0.35 38.9-47.7; 1.93	43.6 ± 0.51 35.7-48.7; 2.53	44.5 ± 0.25 37.0-52.5; 2.86
io	14.6 ± 0.31 11.9-17.5; 1.40	17.3 ± 0.34 13.8-21.3; 1.85	21.6 ± 0.26 19.0-23.8; 1.41	24.1 ± 0.43 20.3-28.1; 2.13	22.4 ± 0.24 15.5-29.8; 2.75
lmx	46.0 ± 0.42 42.1-50.0; 1.89	45.6 ± 0.32 41.8-50.5; 1.77	44.0 ± 0.26 41.3-46.6; 1.41	44.8 ± 0.38 41.4-50.0; 1.89	43.9 ± 0.22 36.4-50.8; 2.49
lmd	57.0 ± 0.36 54.7-60.3; 1.59	56.5 ± 0.32 53.5-62.0; 1.74	55.0 ± 0.30 50.9-59.0; 1.65	55.2 ± 0.35 50.4-58.7; 1.76	55.5 ± 0.23 47.3-63.8; 2.60

Note: Above the line – mean value and its error; under the line – limits of variation of character and mean square deviation.

Table 4. Differences in the morphometric characters of females of species and intraspecific forms of the genus *Cottocomephorus* reaching a taxonomically significant level (CD > 1.28)

	1	2	3	4
1. *C. inermis*				
2. *C. comephoroides*	*sp.br., lV*			
3. *C. grewingkii*: 'typical form'	*P, sp.br., lA, lV, *o, *io*	*lA, io*		
4. *C. grewingkii*: 'alexandrae form'	**sp.br., lA, *o, po, *io*	lD_1*, lA, io*	–	
5. *C. grewingkii*: Other populations	*P, *sp.br., c, lV, o, io*	*c*	–	–

Note: * - characters for which there is hiatus.

of the pectoral fins with dark horizontal stripes in *C. comephoroides* and *C. grewingkii*, and without them in *C. inermis*.

The diagrams (Fig. 6) show that the spread of the first two principal components of the *C. grewingkii alexandrae* samples is not beyond the spread limits of other *C. grewingkii* populations, which confirms the statement of Koryakov (1972) that this subspecies is invalid.

The spread of *C. comephoroides* is intermediate between *C. inermis* and *C. grewingkii*. At the same time, the *C. comephoroides* males are very similar to *C. grewingkii* and the females – to *C. inermis*. This fact does not allow us to consider these fish as conspecific of either species.

The suggestion of Sideleva (2001) about the conspecificity of *C. grewingkii alexandrae* and *C. comephoroides*, as well as the consequent synonymy of *C. comephoroides* as an inadequate senior synonym, found no confirmation. Indeed, both forms similarly differ from the type species *C. grewingkii* by plastic characters and colouration. Only four and five characters of the 13 ones indicated by Taliev (1955) confirm taxonomically significant differences (Table 2). However, the number of preocular spines in *C. comephoroides* does not correspond to the diagnosis of *C. grewingkii alexandrae*, having three-five spines versus one spine. The name *C. comephoroides* is adequate from the original publication (Berg, 1900) and is the earliest name of this taxon according to the provisions of the Code (International Code…, 1999).

Therefore, the genus *Cottocomephorus* includes three valid species and has the following nomenclature:

Genus *Cottocomephorus* Pellegrin, 1900

Cottocomephorus Pellegrin, 1900: 354. Masc.

Cottocomephorus megalops Pellegrin, 1900. Type by monotypy

***Cottocomephorus inermis* (Yakovlev, 1890)**

Cottus inermis Yakovlev, 1890: 52 (holotype by monotypy is lost; Angara River near Irkutsk; collected by V.E. Yakovlev, December 1888); neotype: ZISP 6350 was designated by Sideleva (2003: 166, Fig 13.22); Irkut river (tributary of Angara River); collected by R.K. Maack, 1855.

Cottocomephorus megalops Pellegrin, 1900: 354 (holotype by monotypy MNHN 97–590; Angara River near Irkutsk; collected by L. Mangini, 1897).

***Cottocomephorus comephoroides* (Berg, 1901)**

Cottus comephoroides Berg, 1900: 338, Fig. 3, Table 8. (syntypes ZISP 11531 (19), 11532 (9) Baikal, Selenginskoye shoal, depth 255 m, collected by East Siberian branch of the Imperial Geographical Society, 1898; 11533 (20) Baikal near Goloustnoye village and 11535 (4) Baikal near Pesochnoye village, collected by Shostakevich and Soldatov, June 1898; 11534 (3) Baikal, collected by Botkin, 1897 (Berg, 1900) and BMNH 1905.12.4.18 (1) Lake Baikal, Selenginskoye shoal (Eshmeyer, 2006)).

Cottocomephorus grewingkii var. *siemienkiewiczii* Dybowski 1908: 559, Fig. 20 (holotype by monotypy not found in ZISP; Lake Baikal).

Cottocomephorus alexandrae (sic.) – Sideleva,

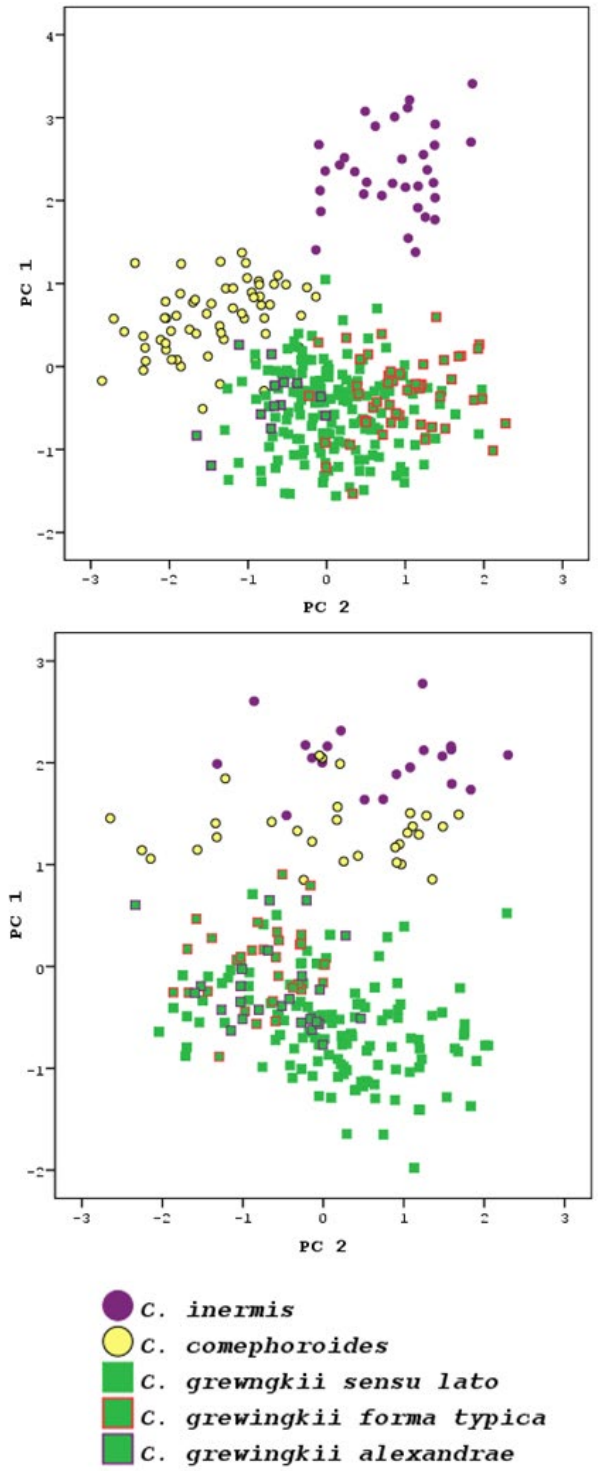

Fig. 6. Distribution of species of genus *Cottocomephorus* in space of a first (PC1) and second (PC2) principal components by meristic and plastic characters: males (in top) females (in bottom).

2003: 164, Fig. 13.19, Fig. 13.20, Table 42 (rediscription; lectotype ZISP 36608; Baikal, northern part; collected by A.A. Bazikalova, 1949); Sideleva et al., 2006: 295 (lectotype renamed to neotype). Both designations are unavailable under the Code (1999).

***Cottocomephorus grewingkii* (Dybowski, 1874)**

Cottus grewingkii Dybowski, 1874: 384, Pl. 1 (Fig. 1) (lectotype designated by B. Dybowski (1908), probably – BMNH 1897.7.5.4.(1), paralectotypes (8) – ZMB 7808(8); Lake Baikal, collected by B. Dybowski.

Cottocomephorus grewingki var. *alexandrae* Taliev, 1935: 64, Fig. 4, Table 1. (syntypes (7): (1) Baikal, near Marituy village, depth 100 m, 3 June 1930 and (2) Baikal, near Marituy village, depth 500 m, 15 June 1930, collected by Baikal Limnological Station (BLS) – whereabouts unknown; BLS 7010 (1) Baikal near Svyatoy Nos peninsula, depth 300 m, 14 August 1931 and BLS 7273 (3) Baikal, between of Tankhoy and Vydrino villages, depth 330 m, 31 August 1932 – not found in The Baikal Museum at the ISC SB RAS ex Baikal Limnological Station).

Cottocomephorus grewingki alexandrae Taliev, 1955: 287, Table 14. Fig., (rediscription; syntypes (28) whereabouts unknown; Kicherskaya bay, collected by Taliev, 17 November 1943). On figures 114 and 115 accompanying the description depicted specimens of *C. comephoroides* – probably ZISP 36608 and ZISP 36608a, collected by A.A. Bazikalova in 1949.

4. Conclusion

The results of the studies have confirmed the phenotypic isolation and diagnosability of three species of the genus *Cottocomephorus*: *C. inermis, C. comephoroides* and *C. grewingkii*. The revision of diagnostic characters suggests the following key to identify the species:

1 (4) The preopercle has three-five small sharp spines. The interorbital distance less than the diameter of the eye.

2 (3) The rays of the pectoral fins have dark spots forming horizontal stripes or arranged randomly. 16-12, less commonly 15, gill rakers: *C. comephoroides*

3 (2) The rays of the pectoral fins lack dark spots. 11-15 gill rakers: *C. inermis*

4 (1) The preopercle has one, less commonly two, rounded rudimentary spines. The interorbital distance more than the diameter of the eye.

The rays of the pectoral fins have dark spots forming horizontal stripes. 16-23, less commonly 15, gill rakers: *C. grewingkii*

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References

Berg L.S. 1900. The fishes of Lake Baikal. Annuaire du Muzee Zoologique de l'Academie Imperiale des Sciences [Directory of the Zoological Museum of the Imperial Academy of Sciences] 5: 326–372. (in Russian, with descriptions of new taxa in Latin)

Dybowski B. 1874. The fishes of the Baikal water system. Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien [Proceedings of the Imperial-Royal Zoological-Botanical Society in Vienna] 24: 384–394. (in German) [https://archive.org/stream/verhandlungender241874kais#page/382/mode/2up]

Dybowski B. 1908. New investigations of the fauna of Lake Baikal. Kosmos 33: 536–574. (in Polish with Esperanto summary)

International Code of Zoological Nomenclature: fourth edition. 1999. In: Ride W.D.L., Cogger H.G., Dupuis C. et al. (Eds.). London: International Trust for Zoological Nomenclature Publ. [https://www.iczn.org/the-code/the-international-code-of-zoological-nomenclature/the-code-online/]

Koryakov E.A. 1972. Pelagic sculpins of Lake Baikal. Moscow: Nauka Publ. (in Russian)

Laerd Statistics. 2015. Principal Components Analysis (PCA) using SPSS statistics. [https://statistics.laerd.com/spss-tutorials/principal-components-analysis-pca-using-spss-statistics.php]

Mayr E. 1969. Principles of systematic zoology. New York: McGraw-Hill Publ. DOI: 10.2307/2412606

Pellegrin J. 1900. New fish from Lake Baikal. Bulletin du Muséum National d'Histoire Naturelle [Bulletin of the National Museum of Natural History] 4: 354–356. [https://www.biodiversitylibrary.org/item/27174#page/368/mode/1up]

Plokhinskiy N.A. 1980. Biometric algorithms. Moscow: Moscow University Press. (in Russian)

Sideleva V.G. 2001. List of fishes from Lake Baikal with descriptions of new taxa of cottoid fishes. Proceedings of the Zoological Institute 287: 45–79.

Sideleva V.G. 2003. The endemic fishes of Lake Baikal. Leiden: Backhuys Publ.

Sideleva V.G., Neyelov A.V., Voronina E.P. et al. 2006. Catalog of specimens in the collection of the Zoological Institute, Russian Academy of Sciences. Osteichthyes, Scorpaeniformes, Cottoidei. Part. II. St. Petersburg: Zoological Institute Russian Academy of Sciences Publ. (in Russian with English introduction)

Taliev D.N. 1935. New forms of Sculpins from Lake Baikal. Travaux de la Station limnologique du Lac Baikal [Proceedings of Lake Baikal Limnological Station] 6: 59–68. (in Russian with German summary)

Taliev D.N. 1955. Sculpin fishes of Lake Baikal (Cottoidei). Moscow, Leningrad: Nauka Publ. (in Russian)

Yakovlev V.E. 1890. On the fish fauna of the Angara. Izvestiia Vostochno-Sibirskogo otdela Imperatorskago geograficheskago obschestva [News of the East Siberian branch of the Imperial Geographical Society] 21: 49–57. (in Russian)