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Craniological features as available diagnostic characters for the short-barb Crimean gudgeon *Gobio krymensis* (Gobioninae, Cyprinidae)

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A b s t r a c t . The comparative craniological analysis of the short-barb Crimean gudgeon from the Chernaya River (south-western Crimea) and *Gobio gobio* from the Volga River basin, as well as the study of morphological characters used for identification of *G. gobio carpathicus* natio *krymensis* by B e r g (1949) and *G. gobio kovatschevi* by B ă n ă r e s c u et al. (1999) resulted in conclusion about the specific status of *G. krymensis*. Several craniological characters, namely the relative lengths of supracleithra and cleithra, preopercle width and the modal numbers of pores in several bones, are presumed to be available characters for its identification, as well as barbel length.

Key words: Crimean gudgeon, cranial morphology, taxonomy

Introduction

Our studies on the morphology and karyology of gudgeon from *Gobio gobio* (Linnaeus, 1758) sensu lato as well as the analysis of biogeography of freshwater fishes and freshwater molluscs revealed these gudgeon to be represented by several species with similar appearance (V a s i l ' e v a et al. 2004). The correct identification of these species as well as definition of their diagnostic characters and areas had to be the main goals of further investigations in gudgeon. And one of unresolved problems is the situation with gudgeon from the Crimean Peninsula. The division of these gudgeon into two different forms at first was presented by B e r g (1949). He considered gudgeon from the Alma and Kacha Rivers (western part of the Crimean Peninsula) to be related to the Dniester gudgeon *G. gobio sarmaticus* Slastenenko, 1934 and identified the populations from the Salgir and Biyuk-karasu Rivers (eastern part of the Crimean Peninsula) as *Gobio gobio carpathicus* natio *krymensis* Delyamure, 1937. But D e l y a m u r e & S m i r n o v (1975) indicated that B e r g (1949) had classified Crimean gudgeon as two different forms based on his own data, as well as materials presented to him by D e l y a m u r e . This indication means that unknown work cited by B e r g (1949) as "D e l y a m u r e 1937" really was not published. Thus the responsible author for "*krymensis*" is D e l y a m u r e in B e r g (1949).

B e r g (1949) also believed the western Crimean gudgeon to be identical to *G. gobio kovatschevi* Chichkoff, 1937 and considered Salgir gudgeon closely related to gudgeon from the western Transcaucasian (*G. gobio lepidolaemus* natio *caucasicus* Kamensky, 1901 sensu Berg), as well as to *G. gobio bulgaricus* Drensky, 1926. Later, D e l y a m u r e (1964) also distinguished these two forms of Crimean gudgeon: endemic "Crimean" (Salgir) gudgeon occurred in the Salgir River, Bolshaya Karasyevka River and Simferopol and Belogor Reservoirs,

and "Dniester" (west-Crimean) gudgeon inhabited the Alma and Kacha Rivers as well as Alma and Bakhchisarai Reservoirs and several ponds1. He indicated that the "Crimean" gudgeon had a longer snout, shorter barbels and unpigmentated pectoral fins.

But Delyamure & Smirnov (1975), after comparative analysis of morphometric characters in western (Alma River) and eastern (Salgir River) Crimean gudgeon, concluded them to be very similar and to belong to the same subspecies, namely *G. gobio carpathicus* Vladykov, 1925. The same idea about the taxonomic status of Crimean gudgeon was also concluded by Movchan & Smirnov (1981). But in the last taxonomic revision of the Common gudgeon *Gobio gobio* (Bănărescu et al. 1999) two forms of Crimean gudgeon are distinguished again. The authors believe that the "southern form" from the Biyuk-karasu and Salgir Rivers, at first "classified as "*Gobio gobio carpathicus* natio *krymensis* by "Delyamure (1937)", must be combined with small-eyed gudgeon from the eastern catchment of Bulgaria in subspecies *G. gobio kovatschevi*, whereas the "western" Crimean gudgeon from the Alma River is deemed to belong to nominotypical subspecies of the Common gudgeon.

These contradictory conclusions about taxonomic relations between eastern and western Crimean gudgeon, as well as between them and the Bulgarian *G. gobio kovatschevi,* and "the absence of any significant morphometric differences" between all these forms and between other subspecies of *G. gobio* sensu lato (Bănărescu et al. 1999) induced us to begin the investigations of Crimean gudgeon and to first search for new diagnostic morphological characters. Consequently, this first step of our investigations presents the obtained results of comparative craniological analysis of the short-barb Crimean gudgeon from the Chernaya River and Common gudgeon *G. gobio* s. stricto, followed by discussion on their taxonomic relations.

Material and Methods

The short-barb Crimean gudgeon with pectoral fins usually lost pigment spots (the form conformed to "*krymensis*" sensu Berg (1949) and Delyamure (1964)) were collected for craniological study in 1981 in the Chernaya River at Sevastopol (south-western coast of the Crimea). For comparative analysis we used a sample of Common gudgeon *Gobio gobio* s. stricto (see Vasil'eva et al. 2004) from the Volga River basin. It was also collected in 1981 in the Yakot' River (Moscow District, Dmitrov region).

All specimens, which were fixed with kitchen salt were later processed in the laboratory where their total length (TL) was measured. Cranium and bones were cleaned and separated after the fish head had boiling water poured over it. A system of measurements and qualitative characters earlier developed for craniological analysis of Cyprinid fishes (Vasil'eva & Daraselia 1989, Vasil'eva & Ustarbekov 1991a,b) was used. This system includes 49 craniological indices and 16 characters that describe the numbers of orbital bones, pharyngeal teeth and pores in different cephalic sensory canals, as well as the shape of several bones. The cranium length was measured from the anterior end of the vomer to the posterior end of the basioccipitale, and the lengths of different bones were measured between the most distant parts.

The standard statistic univariate analysis ($M \pm m$, t_{st}) revealed that 18 craniological indices exhibited significant differences between the samples studied. Only these characters, as well

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*[1] Smirnov (1971) identified gudgeons from the Alma River as *G. gobio carpathicus krymensis* with the reference to Delyamure (1940), but there is no any information on such gudgeon in this paper.

Table 1. Craniological indices of gudgeon from different rivers.

Character	Yakot' River (n=10)		Chernaya River (n=5)	
	ranges	M±m	ranges	M±m
TL (mm)	99.0–114.0	107.0	60.0–99.0	73.6
In % of cranium base length				
LScl	29.3–33.5	31.7±0.41	35.3–38.5	36.9±0.59
LCl	66.0–71.1	68.9±0.50	74.8–78.1	76.4±0.64
SFr	20.0–23.8	22.5±0.38	23.1–27.9	25.4±0.88
SSp	45.0–50.8	47.7±0.59	48.8–55.4	51.2±1.20
HSoc	27.0–28.9	28.1±0.25	28.3–30.8	29.7±0.53
WBoc	10.5–12.6	11.6±0.19	12.6–15.5	13.8±0.87
WGap	15.5–26.5	20.7±1.25	21.4–27.9	24.4±1.36
LSeth	18.0–21.4	19.7±0.36	20.7–24.4	21.6±0.70
In % of individual bone length				
WInl	34.8–85.7	51.9±4.74	20.9–51.0	34.5±4.82
WIn3	27.6–34.9	30.3±0.66	13.2–28.1	20.8±2.70
WOp	68.5–84.7	77.5±1.59	74.6–84.3	81.1±1.69
WPop	20.8–23.3	22.2±0.29	24.0–26.1	24.7±0.38
HIop	31.8–38.9	34.2±0.80	35.8–41.0	38.6±1.23
HPm	23.2–31.0	25.9±0.68	21.6–24.6	23.3±0.63
HpPm	39.3–44.7	42.9±0.48	33.7–44.6	40.0±1.81
HD	13.9–20.5	17.1±0.70	19.2–24.6	22.3±1.01
HpD	49.5–56.6	53.4±0.72	52.3–67.5	59.6±2.85
HQ	7.4–16.5	12.7±0.90	12.3–20.9	16.5±1.63

Abbreviations: TL – total body length; LScl – supracleithrum length; LCl – cleithrum length; SFr – cranium width at the level of frontalia; SSp – cranium width at the level of sphenotica; HSoc – cranium depth at the level of supraoccipital bone; WBoc – width of masticatory plate of basioccipital pharyngeal process; WGap – gape width (between the ends of dentalia); LSeth – supraethmoid length; WInl – the last (5-th) infraorbital width; WIn3 – the third infraorbital width; WOp – opercle width; WPop – preopercle width; HIop – interopercle depth; HPm – premaxilla depth; HpPm – premaxilla process depth; HD – dentary depth (at the level of the first pore); HpD – dentary process depth; HQ – quadratum cut depth; n – number of specimens.

as the number of specimens examined are presented in Table 1. The scheme for their measurements is presented in Fig.1 for *Gobio gobio* s. stricto from the Yakot' River. The coefficient of differences (CD) (M a y r 1969) was also used to evaluate the level of differences.

In addition, the main external diagnostic characters (barb length, horizontal diameter of eye and pigmentation of pectoral fins) were studied in several samples from the collection of the Zoological Museum of the Moscow State University (ZMMU). Other samples were studied: Crimean gudgeon collected in the Chernaya River together with materials for craniological analysis (# P-15872, 2 spec.) and in 2004 (# P-21357, 9 spec.), Crimean gudgeon from the Alma River (# P-3351, 12 spec., collected in 1936), and Common gudgeon from different parts of its area, defined by V a s i l ' e v a et al. (2004): the Moskva River basin (P-442, 5 spec., P-2705, 1 spec., P-16229, 4 spec., P-16819, spec., P-17966, 2 spec., P-21235, 9 spec.); the Volga River basin (P-3441, the Moksha R., 45 spec.; P-21040, the Sura R., 1 spec.; P-21234, the Kobra R., 7 spec.; P-21206, the Vytebet' R., 1 spec.; P-21236, the Mytets R., 5 spec.); the Northern Dvina River (P-1606, 1 spec., P-1612, 46 spec.); the Akhya River, Estonia, (P-19039, 1 spec.); Northern Bohemia (P-13033, 1 spec.).

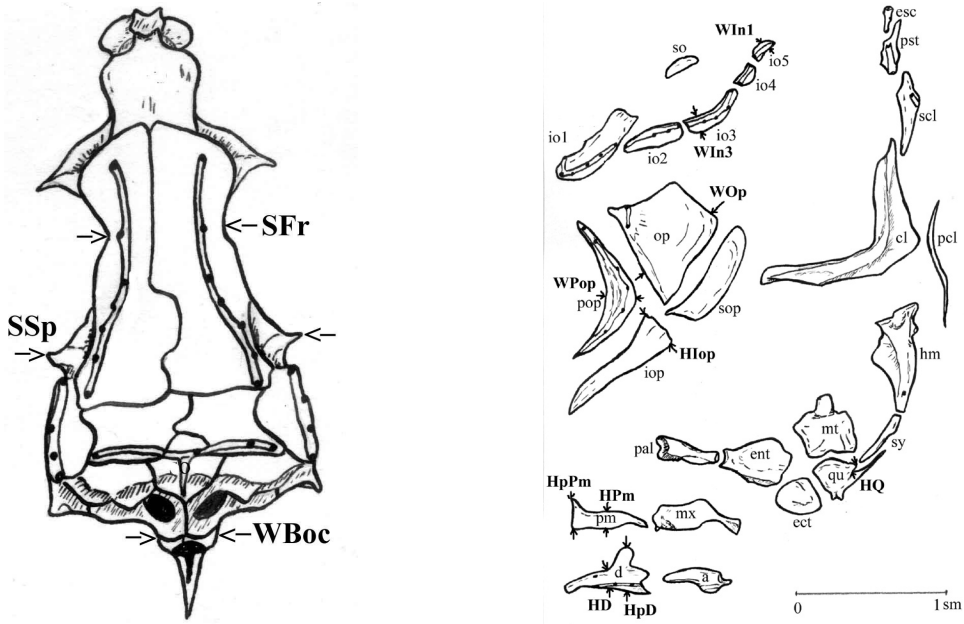

Fig. 1. Neurocranium (a – dorsal view) and structure of skull bones (b) of *Gobio gobio* from the Yakot' River with the scheme of measurements: Bones: (a) - articular bone; (cl) - cleithrum; (d) - dentary; (ect) - ectopterygoid; (ent) - entopterygoid; (esc) - extrascapular; (hm) - hyomandibular; (io1) - the first infraorbital (=lacrimal); (io2) - (io5) - the second – the fifth infraorbitals; (iop) - interopercle; (mt) - metapterygoid; (mx) - maxilla; (op) - opercle; (pal) - palatin; (pcl) - postcleithra; (pm) - premaxilla; (pop) - preopercle; (pst) - posttemporal; (qu) - quadrat; (scl) - supracleithrum; (so) - supraorbital; (sop) - subopercle. Measurements: (SFr) – cranium width at the level of frontalia; (SSp) - cranium width at the level of sphenotica; (WBoc) – width of masticatory plate of basioccipital pharyngeal process; (WInl) – the last infraorbital width; (WIn3) - the third infraorbital width; (Wop) – opercle width; (WPop) - preopercle width; (HIop) – interopercle depth; (HPm) – premaxilla depth; (HpPm) – premaxilla process depth; (HD) – dentary depth; (HpD) – dentary process depth; (HQ) – quadratum cut depth.

Results

External morphological characters used for the identification of "*natio krymensis*" (Berg 1949) and G. *gobio kovatschevi* (Bănărescu et al. 1999)

The comparative morphological analysis proves that short-barb gudgeon from the Chernaya River to completely correspond to Crimean "natio *krymensis*" sensu Berg (1949). These gudgeon have very short barbels that never reach the middle of the pupil. Relatively longer barbels that reached or surpassed the anterior edge of the eye (Fig. 2a) were found in small specimens with standard length SL 38.5 and 41.8 mm (P-15872). In contrast, barbels in larger fishes never reached the anterior edge of the eye and more often reached the posterior edge of nostril. At the same time gudgeon from the Alma River had much longer barbels that reached beyond the middle of the eye (Fig. 2b). Thus these two forms significantly differ in this character ($p < 0.05$) with their ranges of values in specimens of similar sizes not overlapping or slightly overlapping (Table 2): CD between samples with mean body length 70–82 mm varies from 2.92 for lb in % SL to 2.90 for lb in % c. Significantly longer barbels have been found also on *G. gobio* s. stricto of the same sizes, *G. gobio kovatschevi* (Table 2), and gudgeon from the Dniester, Dnieper and Don Rivers (Movchan & Smirnov 1981, our unpublished data).

Table 2. Several morphometric characters of gudgeons from different populations.

Species, population	SL, mm	lb in % SL	lb in % c	o in % SL	o in % c
Gobio krymensis					
Chernaya R., 1981 (n=2)	38.5-41.8 40.2	5.0-5.5 5.3	18.4-19.1 18.8	5.7-6.0 5.9	20.0-21.9 21.0
Chernaya R., 2004 (n=9)	75.0-91.1 82.0	3.3-5.8 4.4±0.27	12.2-23.1 16.8±1.17	4.0-5.4 4.9±0.18	15.0-21.5 18.8±0.72
Gobio gobio					
Roading (Bănărescu 1962)	78.5-88.5 84.0	4.9-6.0 5.3	——— 19.0*	6.5-7.0 6.8	——— 24.2*
Vistula R. (Rolik 1965)	55.0-124.0 68.2-88.3	5.1-8.7 6.3-7.3	——— 24.4-27.6*		
Mazury L. (Rolik 1965)	75.0-95.0 84.3	4.7-5.8 5.2±0.1	——— 21.3*		
Oder R. (Rolik 1965)	60.0-119.0 73.3	5.7-8.5 7.0±0.2	——— 25.1*		
Gobio sp.					
Alma R. (n=12)	58.0-88.0 70.0	8.2-10.7 9.1±0.23	31.2-40.0 35.2±0.82	4.9-6.6 5.6±0.14	18.9-24.4 21.7±0.47
Alma R. (Delyamure & Smirnov 1975)	44-77 62.6	5.4-9.3 7.0	——— 26.7*	5.0-7.0 5.6	——— 21.2*
Gobio gobio kovatschevi (sensu Bănărescu et al. 1999)					
Provadiskaya R. (Bănărescu et al. 1999)	63-105 73.4	6.5-10.5 8.2	——— 29.9*	4.2-6.0 5.3	——— 19.2*

Abbreviations: SL – body length (from the anterior part of the head to visible base of the caudal fin); lb – length of barbel; o – horizontal diameter of eye; c – head length; n – number of specimens. Above the line – range of values of a character; under the line – mean, or mean with error, or range of means in different samples. * The data are calculated by means of barbel length and head length in % of body length and by means of horizontal diameter of eye and head length in % of body length.

Fig. 2. The short-barb Crimean gudgeon from the Chernaya River (SL=41.8 mm) (a) and gudgeon from the Alma River (SL=67.0 mm) (b).

Distinct black spots were absent from the pectoral fins of small gudgeon from the Chernaya River (P-15872) as well as from fins of the most larger specimens (77.8 %). In contrast gudgeon from the Alma River had black spots on the pectoral fins.

At the same time both gudgeon from both the Chernaya River and the Alma River have relatively small eyes (Table 2). But only short-barb gudgeon from the Chernaya River conform to the diagnosis of *G. gobio kovatschevi* presented by B ă n ă r e s c u et al. (1999): horizontal diameter of their eye was 61.1–69.4 % interorbital distance (io) in small specimens and 52.5–70.0 (average mean 61.5±2.01) in larger ones. By comparison the eye diameter in gudgeon from the Alma River (P-3351) varied from 65.2 to 93.8 % io (average mean 74.2±2.70), and thus was intermediate between values presented for *G. gobio kovatschevi* (59–71 %) and *G. gobio gobio* (greater than 75 %) by B ă n ă r e s c u et al. (1999).

C r a n i o l o g i c a l d a t a

As was mentioned above, the comparative craniological analysis of the short-barb Crimean gudgeon and *G. gobio* s. stricto from the Yakot' River revealed significant differences ($p < 0.05$) in 18 craniological indices (Table 1). Three of these indices demonstrate the most prominent differences (CD>1.28) with sample values not overlapped. They are supracleithrum length, LScl, (CD=1.99), cleithrum length, LCl, (CD=2.49), and preopercle width, WPop, (CD=1.42).

In addition, short-barb Crimean gudgeon differ from *G. gobio* from the Yakot' River in several qualitative characters. Most short-barb gudgeon have 9 pores in the preopercular-mandibular canal on the preopercle bone (40 % on the left bone and 60 % on the right), with the ranges 8–11 pores on the left side and 7–9 pores on the right side. The only specimen with a symmetric state has 9 pores on each side. Whereas gudgeon from the Yakot' River usually have 7–8 pores on preopercle bone (60 % on the left bone and 90 % on the right one), with 7–8 pores in symmetrical specimens. Among short-barb gudgeon also, specimens with 8 pores in the supraorbital canal on frontal (rarely also on parietal) bone prevailed: 60% on the left side and 40 % on the right. Two symmetrical specimens had 8 pores on each side. Gudgeon from the Yakot' River usually had 7 pores in the supraorbital canal, often both on the frontal and parietal bones (50 % on the left side and 70 % on the right side), with symmetrical specimens characterized by 7 pores on each side. In the temporal portion of the infraorbital canal there were 3–5, more often 4 pores (50 %) on the left side of short-barb gudgeons and only 4 pores on the right side. Most of gudgeon from the Yakot' River had 5 pores in the temporal portion of infraorbital canal (60 % on the left side and 90 % on the right side).

Besides, short-barb gudgeon from the Chernaya River and *G. gobio* from the Yakot' River differ in general shape of some bones, at first in the shape of extrascapular, hyomandibular, supraorbital bones, as well as interopercle, preopercle and premaxilla (Figs. 1b, 3).

Discussion

The results of comparative morphological analysis confirm short-barb gudgeon from the Chernaya River to be identical to the gudgeon from the Salgir and Biyuk-karasu Rivers defined by B e r g (1949) as *Gobio gobio carpathicus* natio *krymensis,* as well as to endemic "Crimean" (Salgir) gudgeon sensu D e l y a m u r e (1964). At the same time our results demonstrate significant differences between this form and the "long-barb" gudgeon that occurred in the Alma River (and also in Kacha River according to B e r g 1949 and D e l y a m u r e

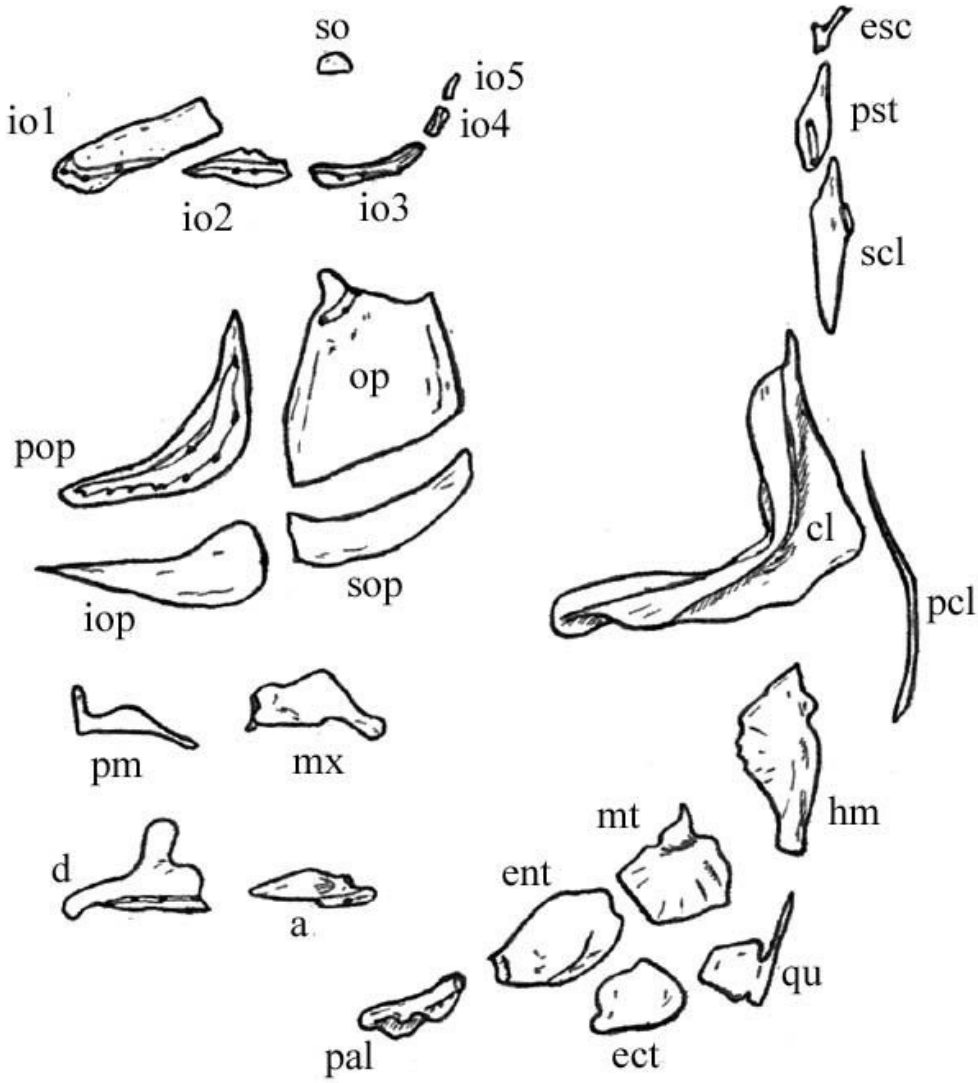

Fig. 3. Structure of cranial bones of the short-barb Crimean gudgeon from the Chernaya River. Abbreviations for bones are the same as on Fig. 1.

1964). Taking into consideration the absence of short-barb specimens in material later studied by Delyamure & Smirnov (1975) from the Biyuk-karasu (collection from 1935 with average mean of barbel length 7.03 % body length) and Salgir Rivers (in collection from 1970 average mean of barbel length was 25.4±0.66 % head length with ranges 21.8–41.4 % and 7.1±0.20 % body length with ranges 5.7–8.6 %) the sympatric occurrence of two forms in these rivers should be supposed. At least in the past, with possible superseding short-barb gudgeon by long-barb form. In this case the existence of two gudgeon species in the Crimean Peninsula should be concluded.

The comparative analysis of short-barb Crimean gudgeon and gudgeon from near-by European rivers (Dnieper, Dniester, Don), as well as *Gobio gobio* s. stricto and Bulgarian

gudgeon separated by B ă n ă r e s c u et al. (1999) in *G. gobio kovatschevi,* demonstrate constant differences in barbel length. And the most similar to short-barb Crimean gudgeon in this character is *G. gobio* s. stricto. But craniological analysis revealed significant differences between this species and short-barb Crimean gudgeon. The latter has elongated supracleithra and cleithra, wider preopercle, less prominent differences in average means of another 15 craniological indices and also differs in general shape of some bones as well as in modal numbers of pores of cephalic sensory system in several canals. These craniological differences are more prominent than craniological differences between *G. gobio* and recently described gudgeon species *G. kubanicus* Vasil'eva et Vasil'ev, 2004 (V a s i l ' e v a et al. 2004) and correspond with karyological differences observed between short-barb Crimean gudgeon and Common gudgeon (see V a s i l ' e v a et al. 2004).

All these results conclude in specific status of short-barb Crimean gudgeon as *G. krymensis* and presume several craniological characters, namely the relative length of supracleithra and cleithra, preopercle width and the modal numbers of pores in several bones, to be available characters for its identification, as well as barbel length. The complete redescription of this species with the historic analysis of gudgeons from the Crimean Peninsula is contemplated in the next special publication.

A c k n o w l e d g e m e n t s

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