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# Description of the external morphological characters of the Turkestan gudgeon *Gobiolepidolaemus* (Gobionidae) from the Yrgaity River (Shu River basin)

The article is devoted to the native fish species of Central Asia — the Turkestan gudgeon *Gobiolepidolaemus* — an inhabitant of the water bodies of Southern Kazakhstan. According to some researchers, various populations of this species are still poorly studied and may represent separate forms. In Kazakhstan water bodies, populations of the Talas, Shu, Sarysu and Karatau river systems were previously studied, but the available data on morphological variability are often incomplete. A more detailed study of individual populations is needed, based on freshly collected material and more accurate methods. The aim of the article was to describe the external morphological characteristics of the Turkestan gudgeon *Gobiolepidolaemus* (Gobionidae) from the Yrgaity River (right tributary of the Shu River). External morphological characters were studied on 21 specimens. A detailed description of the coloration, body proportions and fin shape, meristic characters (the number of scales and fin rays) is given, and for the first time for the Turkestan gudgeon, squamation on various areas of the body are described in detail. Three types of breast squamation, a specific feature of the Turkestan gudgeon, have been identified. A comparative analysis was carried out with literature data on Turkestan gudgeon populations from various water bodies. Minor differences were revealed in the number of lateral line scales and branched rays in the fins. Our data on breast squamation of the Turkestan gudgeon from the Yrgaity River do not correspond to the results of a previous study of the population from this river.

*Keywords*: Turkestan gudgeon, *Gobiolepidolaemus*, Gobionidae, native species, morphology, squamation, Yrgaity River, Shu River.

## *Introduction*

Gudgeons of the genus *Gobio* are widespread in Europe, Transcaucasia, Central Asia, Siberia and the Far East. Recently, they have been the object of considerable attention from researchers due to poorly studied species diversity and changing taxonomy. New species are still being described and their phylogenetic relationships are being revealed [1–5].

Turkestan gudgeon *Gobiolepidolaemus* Kessler, 1872 is an indigenous species of Central Asia, also inhabiting the water bodies of Southern Kazakhstan. This form was first described by Kessler in 1872 as *Gobiofluviatilis* var. *lepidolaemus* from the Syrdarya river basin. Subsequently, the Turkestan gudgeon was known for a long time as a subspecies of the common gudgeon *Gobiogobio*, widespread in water bodies of Europe and Asia, from Portugal to the Amur basin and the rivers of the northwestern coast of the Sea of Japan [6–8]. Currently, *Gobiogobio*is considered not as one polymorphic species, but as a combination of several morphologically similar species [3, 9–11]. As a result of the latest large-scale molecular genetic study of the phylogenetic relationships of *Gobiogobio* sensulato, the species status of 11 forms of gudgeons was confirmed, and separate phylogenetic lineages of gudgeons corresponding to species rank were discovered [4].

Currently, the Turkestan gudgeon is also considered as an independent species [4, 12-13]. Mousavi-Sabet et al. [14] redescribed *G. nigrescens* from the Haririver basin (territory of Afghanistan and Turkmenistan), previously classified as a Turkestan gudgeon. The expected close affinity between *G. nigrescens* and *G. lepidolaemus* from the border basin of the Aral Sea, as well as other neighboring forms of gudgeons, was not confirmed as a result of molecular analyzes. Mousavi-Sabet et al. [14] also point out that freshwater fishes from the Aral Sea basin, as well as from other water bodies of Central Asia and Siberia, have not been sufficiently studied, so it is possible that there is more than one species of gudgeons in these regions.

The morphological variability of the Turkestan gudgeon in the water bodies of Kazakhstan, in general, has not been sufficiently studied. There are data on the populations of the Talas, Shu, Sarysu and Karatau rivers [7, 15, 16], but there is a lack of detailed studies based on rich material from the various basins and unified methods are needed to ensure comparable results.

Our study aimed to describe the external morphological characters of the Turkestan gudgeon *Gobiolepidolaemus* (Gobionidae) from the Yrgaity River (Shu River basin). The article is intended to supplement the available data on the morphological variability of this species.

## *Material and methods*

The fish were caught with net traps on July 20, 2018 in the Yrgaity River (right tributary of the Shu river) near the village Nogaybay (Zhambyl region). A large concentration of gudgeons was observed at the catch site — more than 15 individuals swam into the net within half an hour. The fish were fixed in a 4 % formaldehyde solution in horizontally placed plastic bottles, which caused their bodies and fins to straighten.

Plastic features were measured on 9 specimens (*TL* — 91–110 mm) using a digital caliper with an accuracy of 0.1 mm. All measurements were made in a straight line directly between two points. To focus on poorly studied characters, we decided not to conduct a full analysis of plastic features and measured fish only to determine body proportions. Meristic features and scale cover were studied on 21 specimens (*TL* 81–113 mm). To increase the accuracy of the analysis of meristic characters and scale cover, fish were stained in a *KOH* solution (0.3 %) with the addition of Alizarin Red. The fin rays and scale number were counted according to Kottelatand Persat [3] and Kottelatand Freyhof [17]. We analyzed the number of branched rays in the dorsal, anal, caudal, pectoral and pelvic fins, the number of lateral line scales, scale rows between dorsal-fin origin and lateral line, scale rows between lateral line and pelvic-fin origin, circumpeduncular scales, as well as the number of spots on the side of the body. Numerical data were processed in *MS Excel* 2016, the minimum and maximum values of the characteristic (*lim*), the mean value (*M*), its error (*m*), standard deviation (σ), and coefficient of variation (*CV*) were obtained.

The squamation was analyzed on the following areas of the body:

A. Side of the body — from the operculum to the posterior edge of the anal fin base;
B. Caudal peduncle — from the posterior edge of the anal fin base to the caudal fin base;
C. Back — from the occiput to the anterior edge of the dorsal fin base;
D. Breast — from the isthmus to the posterior edge of the pectoral fin base;
E. Belly — from the posterior edge of the pectoral fin base to the anterior edge of the ventral fin base.

## *Results and discussion*

*Coloration.*

The coloration of the Turkestan gudgeon is similar to that of other gudgeon species. Among the possible differences, we can note the less visible spots on the body sides, which are almost not visible in the anterior part of the body (Fig. 1).

The body sides and caudal peduncle are variegated with faint horizontal dark stripes. The dorsal part of the head and body is gray-brown or greenish-brown, and often very dark and even almost black. The sides of the body are silvery-brown, the abdominal part is silvery.

The head has numerous irregularly shaped brown spots on the forehead, cheeks and opercula. A pronounced dark stripe stretches from the eye to the snout. The iris of the eye has a dark border.

The fin rays colored with dark spots, which are well expressed on the dorsal and caudal fins, but less pronounced on other fins (Fig. 2).

Figure 1. Live coloration of the Turkestan gudgeon from the Yrgaity River (Shu River basin)

*Body proportions and fin shape.*

The maximum body depth is much greater than its width and the length of the caudal peduncle. The length of the caudal peduncle is much greater than its width. The minimum body depth is greater than the caudal peduncle width. The head length is on average equal to the maximum body depth and greater than the caudal peduncle length. The head depth at the occiput is much greater than the half of the head length and, on average, greater than the head width. The barbels are long and extend beyond the middle of the eye.

The anterior edge of the dorsal fin base is located slightly in front of the vertical of the anterior edge of the ventral fin base. The dorsal fin tips are rounded, less often are slightly acute. The dorsal margin of the fin is slightly concave (Fig. 2-A). The dorsal-most tip of the dorsal fin is formed by the first branched ray. The first unbranched ray is very short — partially buried in the skin, the second unbranched ray does not exceed half the length of the third unbranched ray (Fig. 3-A).

The anal fin tips are rounded, its ventral edge is slightly concave or straight. The ventral-most tip of the anal fin is formed together by the first and second branched rays, rarely — only by the second branched ray. The first unbranched ray is very short, partially buried in the skin. The second unbranched ray does not exceed half the length of the third unbranched ray.

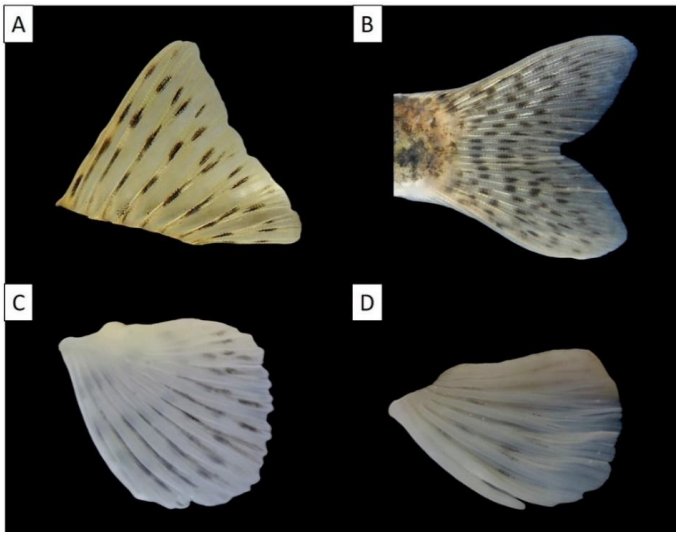


Figure 2. Fins of the Turkestan gudgeon from the Yrgaity River (Shu River basin):
A — dorsal; B — caudal; C — right pectoral; D — right ventral

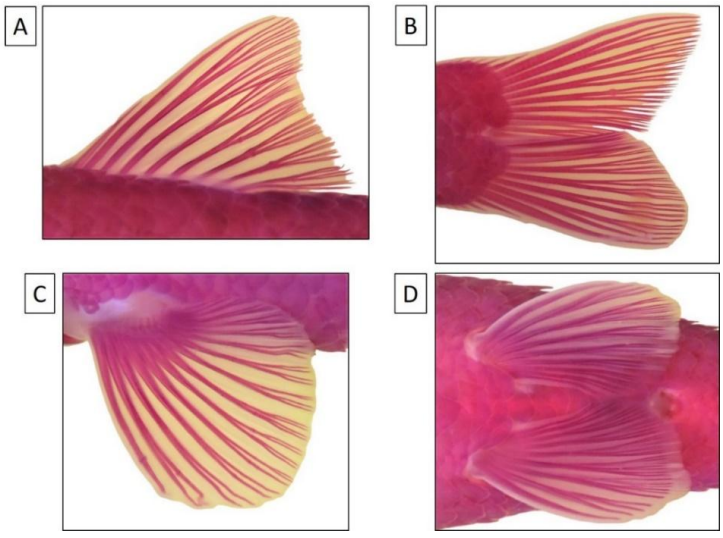


Figure 3. Stained fins of the Turkestan gudgeon from the Yrgaity River (Shu River basin):
A — dorsal; B — caudal; C — right pectoral; D — ventral

Caudal fin length is approximately equal to the caudal peduncle length. The caudal fin tips are rounded (Fig. 2-B). The inner unbranched rays do not reach the tips of the outer branched rays. The upper lobe tip is usually formed by the first and second outer branched rays, and the lower lobe tip is usually formed by the second and third outer branched rays (Fig. 3-B).

The pectoral fins make up more than 65 % of the distance between the pectoral and ventral fin bases. The pectoral fin tips are rounded, the posterior edge is straight or slightly concave (the right and left fins may differ in shape) (Fig. 2-C). The pectoral fin tips are formed by the second and third, or third and fourth branched rays. The unbranched ray almost reaches the first branched ray (Fig. 3-C).

The pelvic fins are shorter than the pectoral ones, extend beyond the anus and make up more than 75 % of the distance between ventral and anal fin bases. The ventral fin tips are rounded (Fig. 2-D). The ventral fin tips are formed by the second or second and third branched rays. The unbranched ray almost reaches the first branched ray (Fig. 3-D).

*Meristic characters.*

Meristic characters of the Turkestan gudgeon from the Yrgaity River are presented in Table 1.

38–41 scales in lateral line; $5^{1/2}$–$6^{1/2}$scale rows between dorsal-fin origin and lateral line, $3^{1/2}$–$5^{1/2}$scale rows between lateral line and pelvic-fin origin; 14–16 circumpeduncular scales.

Dorsal fin with 3 unbranched and $7^{1/2}$ branched rays; anal fin with 3 unbranched and $6^{1/2}$ branched rays; caudal fin with 16–18 branched rays; pectoral fin with 1 unbranched and 14–16 branched rays; ventral fin with 1 unbranched and 7–8 branched rays. Seven examined specimens had an asymmetry in the number of branched rays in pectoral fins and only one specimen had an asymmetry in ventral fins.

The number of spots on the right and left sides of the body do not differ and ranges from 8 to 11.

Table 1

**Meristic characters of the Turkestan gudgeon *Gobiolepidolaemus* from the Yrgaity River (Shu River basin). n=21**

| Character | *lim* | *M* ± *m* | σ | *CV*(%) |
|---|---|---|---|---|
| Number of lateral line scales on trunk | 37–40 | 38.8 ± 0.17 | 0.77 | 1.98 |
| Number of lateral line scales on caudal fin | 0–2 | 1.0 ± 0.15 | 0.67 | 70.2 |
| General number of lateral line scales | 38–41 | 39.7 ± 0.19 | 0.85 | 2.13 |
| Number of scale rows between dorsal-fin origin and lateral line | 5–6 | 6.0 ± 0.05 | 0.22 | 3.67 |
| Number of scale rows between lateral line and pelvic-fin origin | 3–5 | 4.0 ± 0.04 | 0.32 | 7.91 |
| Number of circumpeduncular scales | 14–16 | 14.8± 0.12 | 0.54 | 3.65 |
| Number of branched rays in dorsal fin | 7 | 7.0 ±0.00 | 0.00 | 0.00 |
| Number of branched rays in anal fin | 6 | 6.0 ± 0.00 | 0.00 | 0.00 |
| Number of branched rays in caudal fin | 16–18 | 17.0 ± 0.07 | 0.32 | 1.86 |
| Number of branched rays in pectoral fins | 14–16 | 14.8 ± 0.13 | 0.56 | 3.80 |
| Number of branched rays in ventral fins | 7–8 | 7.0 ± 0.02 | 0.11 | 1.55 |
| Number of spots on body sides | 8–11 | 9.7 ± 0.20 | 0.90 | 9.30 |

Few comparative meristic data on the Turkestan gudgeon are available. There are some data on the variability of meristic characteristics of gudgeons from the Shu River basin in Luzhin [18] and Mitrofanov [7]) (Table 2).

Tabe 2

**Meristic characters of the Turkestan gudgeon *Gobiolepidolaemus* from the Yrgaity Riverin comparison with literature data on population from the Shu River**

| Character | Luzhin (1950), n=35 | Mitrofanov (1988), n=25 (hybrids) | | Yrgaity River (2020), n=21 (present data) | |
|---|---|---|---|---|---|
| | *M* ± *m* | Limits | *M* ± *m* | Limits | *M* ± *m* |
| Number of lateral line scales | 39.88 ± 0.23 | 35–44 | 39.12 ± 0.47 | 38.5–41 | 39.9 ± 0.16 |
| Number of branched rays in dorsal fin | - | 7–8 | 7.68 | 7 | 7.0 ±0.00 |
| Number of branched rays in anal fin | - | 6–7 | 6.88 | 6 | 6.0 ± 0.00 |
| Number of spots on body sides | 9.16 ± 0.23 | 7–10 | 8.36 ± 0.29 | 8–11 | 9.7 ± 0.20 |

Number of lateral line scales in the Shu River population is more variable, but mean value is similar to Yrgaity River population. According to Mitrofanov [7], the Shu River gudgeons have slightly larger number of rays in the dorsal and anal fins, and slightly smaller number of spots on the body sides. Perhaps these differences reflect the hybridization with *Abbotinarivularis*i ndicated by this author.

Comparison of meristic characters of gudgeons from the Yrgaity River with data on other river systems [7] revealed some differences (Table 3).

Table 3

**Meristic characters of the Turkestan gudgeon *Gobiolepidolaemus* from the Yrgaity Riverin comparison with literature data [7]**

| Character | Sarysu River (1969), n=15 | Talas River (1958), n=19 | Karatau Rivers (1969), n=26 | Yrgaity River(2020), n=21 (present data) |
|---|---|---|---|---|
| Number of lateral line scales | 38.07 ± 0.28 | 38.0 ± 0.48 | 38.76 | 39.9 ± 0.16 |
| Number of branched rays in dorsal fin | 7.5 | 6.95 | 7.15 | 7.0 ±0.00 |
| Number of branched rays in anal fin | 5.93 | 5.5 | 5.61 | 6.0 ± 0.00 |

Gudgeons from the Sarysu, Talas and Karatau rivers have, on average, a slightly smaller number of lateral line scales and branched rays in the anal fin. Also, the Sarysu and Karatau minnows have a slightly larger number of branched rays in the dorsal fin.

Comparison with the latest data on gudgeons of the Talas River [15] showed that they have a slightly smaller number of lateral line scales and a slightly larger number of branched rays in the dorsal and anal fins (Table 4).

Table 4

**Meristic characters of the Turkestan gudgeon *Gobiolepidolaemus* from the Yrgaity River in comparison with data on population from the Talas River**

| Character | Talas River (2013), n=16 (Bekkozhaeva, 2014) [15] | | Yrgaity River (2020), n=21 (present data) | |
|---|---|---|---|---|
| | Limits | ***M* ± *m*** | Limits | ***M* ± *m*** |
| Number of lateral line scales | 37–40 | 38.5 ± 0.86 | 38.5–41 | 39.9 ± 0.16 |
| Number of branched rays in dorsal fin | 7–8 | 7.5 | 7 | 7.0 ±0.00 |
| Number of branched rays in anal fin | 6–7 | 6.5 | 6 | 6.0 ± 0.00 |
| Number of spots on body sides | 8–12 | 10.0 | 8–11 | 9.7 ± 0.20 |

*Squamation.*

The scales of the studied specimens of the Turkestan gudgeon are large, especially on the body sides, and on the breast the scales are slightly smaller. The scales are fully imbricated over almost the entire body. With the exception of the breast area, the scale cover is continuous, completely covering the back, sides of the body and caudal peduncle, belly, and also slightly extending to the base of the caudal peduncle. At the same time, the area on the breast in front of the bases of the pectoral fins may be fully or partially scaled.

Horizontal and diagonal rows of scales can be distinguished on the sides of the body (Fig. 4-A) and the caudal peduncle (Fig. 4-B). The depth of the scales here is greater than its length. Some particularly deep scales may occupy space in two horizontal rows at once (Fig. 4-A).

The scales on the back also form horizontal and diagonal rows, and their depth is greater than their length (Fig. 5-A), while the scales on belly are arranged rather chaotically, and their size decreases as they approach the breast region (Fig. 5-B).

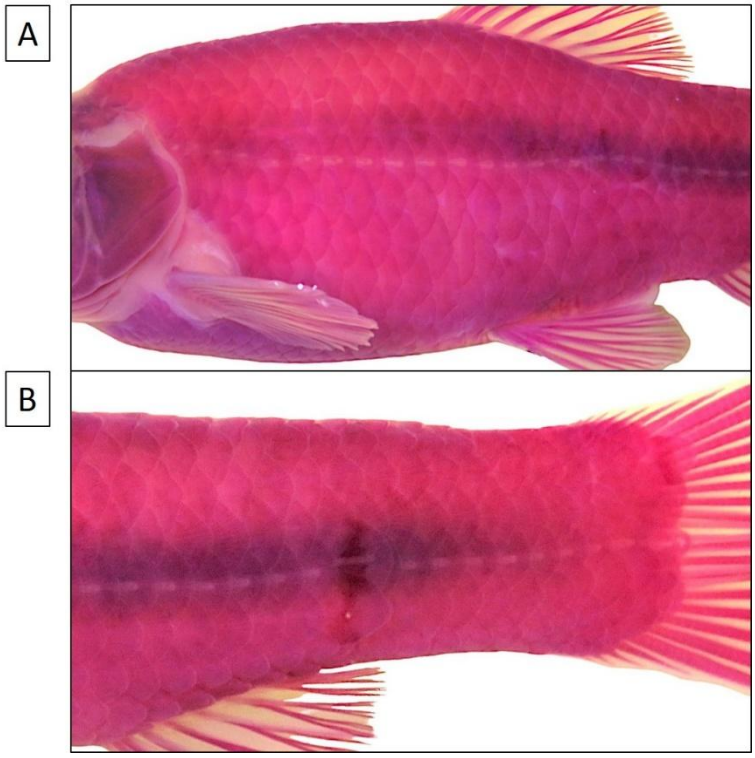


Figure 4. Stained scale cover of the Turkestan gudgeon from the Yrgaity River (Shu River basin).
A — the body side; B — caudal peduncle

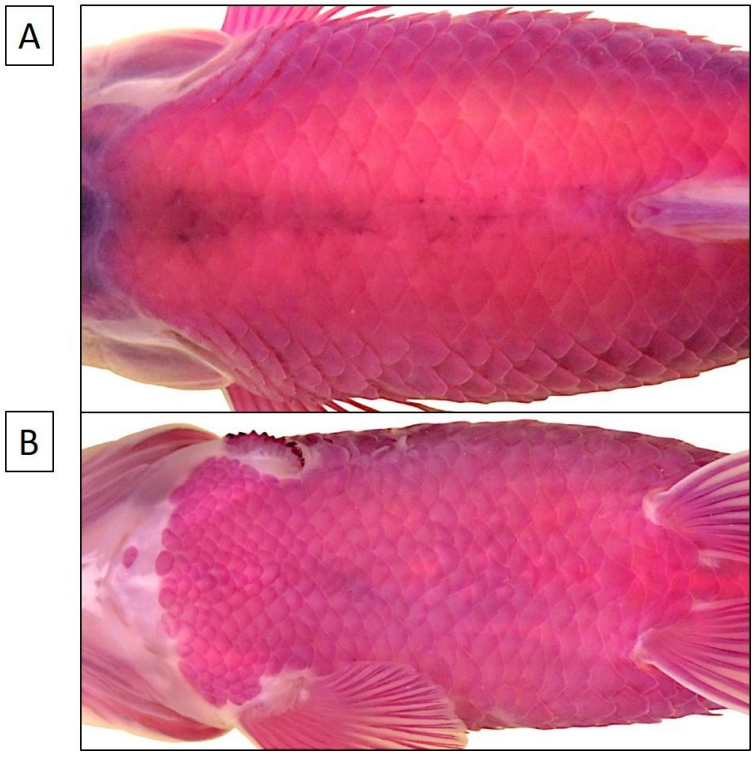


Figure 5. Stained scale cover of the Turkestan gudgeon from the Yrgaity River (Shu River basin).
A — back; B — belly

The area between the bases of the pectoral fins is fully scaled. The breast scales can reach the gill membranes and also extend under them. In few cases, the scales reach the isthmus. The breast scales are noticeably smaller than on the other areas of the body and arranged mostly chaotically. The types of breast squamation vary individually. In accordance with the five types of breast squamation identified by Naseka et al. [19], three types were found in the 21 analyzed specimens of the Turkestan gudgeon:

Type 1 — the scale cover reaches the anterior edge of the bases of the pectoral fins;

Type 2 — the scale cover reaches approximately half the distance between the anterior edge of the bases of the pectoral fins and the isthmus (Fig. 6-B);

Type 3 — the scale cover reaches, or almost reaches the isthmus (Fig. 6-A).

The above types concern only the continuous scale cover and do not concern individual scales, which can extend further and even border the isthmus.

Type 2 breast squamation is the most common and was found in 81 % of the Turkestan gudgeon specimens analyzed (Fig. 6-B).

The other two types of breast squamation were less common — type 1 was found in two specimens, and type 3 in two specimens (Fig. 6-A).

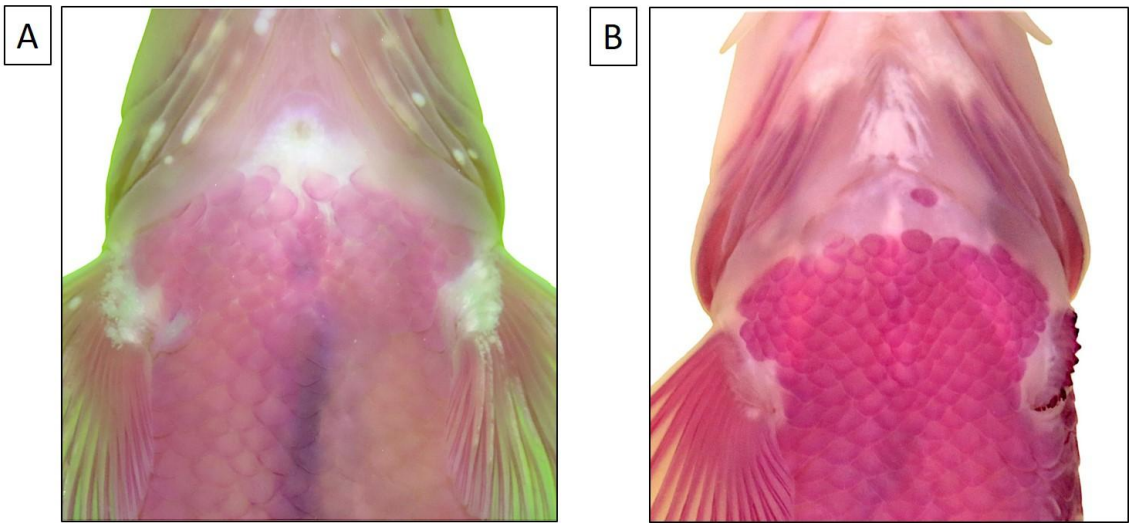


Figure 6. Stained breast squamation of the Turkestan gudgeon from the Yrgaity River (Shu River basin).
A — scale cover reaches or almost reaches the isthmus;
B — scale cover reaches approximately half the distance between the anterior edge of the bases of the pectoral fins and the isthmus

A scaled breast is a characteristic feature of the Turkestan gudgeon [20, 21]. According to Berg [20], the breast of the Turkestan gudgeon is scaled to the base of the pectoral fins, but sometimes specimens are found with unscaled breast, as in the common gudgeon. Mitrofanov [7] noted that the breast of the Turkestan gudgeon in different populations is not always fully scaled, and the fullest scaling is observed in gudgeons of the mountain rivers of Karatau. Thus, samples from different rivers show a varied picture, but the above-mentioned authors did not propose unambiguous criteria for determining the degree of breast squamation.

Bekkozhayeva and Mamilov [16], based on samples of Turkestan gudgeon from various rivers of Southern Kazakhstan, identified three types of breast squamation: 1) fully scaled (the scale cover reaches the isthmus); 2) partially scaled (the scale cover reaches the bases of the pectoral fins); 3) unscaled (the scale cover does not reach the posterior edge of the bases of the pectoral fins). The types of breast squamation varied significantly even within the same basin and even within the same river. Thus, according to Bekkozhayeva and Mamilov [16], in 56 % of the studied specimens from the Yrgaity River the breast was partially scaled, in 41 % — unscaled, and only in 4 % — fully scaled. These data are not consistent with our observations, according to which in 81 % of specimens from the Yrgaity River the scale cover extended beyond the bases of the pectoral fins and no specimens were found with a fully scaled breast (the scales do not reach the posterior edge of the bases of the pectoral fins).

According to Mitrofanov [7] and Bekkozhayeva and Mamilov [16], the reason for the significant variability in breast squamation may be the hybridization of the Turkestan gudgeon with *Abbotinarivularis* — an alien species in Kazakhstan water bodies, whose breast is unscaled. We did not found this species in the Yrgayty River. Berg [20] pointed out the variable nature of the breast squamation back in 1905, before the penetration of the *Abbotinarivularis* into the water bodies of Kazakhstan. Hybridization with this species requires detailed study using genetic methods, and some variability in breast squamation may be natural for the Turkestan gudgeon.

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## Ырғайты өзенінен (Шу өз. бассейні) алынған түркістандық теңге балығының *Gobiolepidolaemus* (Gobionidae) сыртқы морфологиялық белгілерінің сипаттамасы

Мақала Орталық Азияның жергілікті балық түрі — Оңтүстік Қазақстан су қоймаларының тіршілік иесі *Gobiolepidolaemus* түркістандық теңге балығына арналған. Кейбір зерттеушілердің пікірінше, бұл түрдің популяциялары әлі де аз зерттелген және басқа формалары да болуы мүмкін. Қазақстандық популяциялардың ішінде Талас, Шу, Сарысу және Қаратау өзендері жүйесінің популяциялары бұрын зерттелген, бірақ морфологиялық өзгергіштігі туралы қолда бар деректер көбінесе толық емес, шашыраңқы және нақты емес. Жоғары сапалы материалға және дәлірек әдістерге негізделген жеке популяцияларды толығырақ зерттеу қажет. Мақаланың мақсаты Ырғайты (Шу өзенінің оң саласы) өзенінен алынған *Gobiolepidolaemus* (Gobionidae) түркістандық теңге балығының сыртқы морфологиялық белгілерін сипаттау. Сыртқы морфологиялық белгілері 21 жеке түрде зерттелді. Жүзу қанаттарының түс ерекшеліктері, дене бөліктері мен пішіні, меристикалық сипаттамалары (жүзу қанаттарының сәулелер саны мен қабыршақтары), сондай-ақ алғаш рет түркістандық теңге балығының денесінің әр бөлігінің қабыршақ жамылғыларының ерекшелігі егжей-тегжейлі сипатталған. Түркістандық теңге балығының түрге тән ерекшелігі болып табылатын көмей жағының қабыршақтарының үш түрі анықталды. Әртүрлі су қоймалардан түркістандық теңге балығының популяциясы туралы әдеби деректермен салыстырмалы талдау жүргізілді. Қанаттарының тармақталған сәулелері және бүйір сызығының қабыршақтарында шамалы айырмашылықтар анықталды. Ырғайты өзенінен алынған түркістандық теңге балығының көмейінің қабыршақтану сипаты туралы деректеріміз осы өзеннің популяциясының бұрынғы зерттеу нәтижелеріне ұқсамайды.

*Кілт сөздер*: түркістандық теңге балық, *Gobiolepidolaemus*, Gobionidae, жергілікті түр, морфология, қабыршақ жамылғысы, Ырғайты өзені, Шу өзені.

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## Описание внешне-морфологических признаков туркестанского пескаря *Gobiolepidolaemus* (Gobionidae) из р. Ыргайты (бассейн р. Шу)

Статья посвящена аборигенному виду рыб Центральной Азии — туркестанскому пескарю Gobiolepidolaemus, обитателю водоемов Южного Казахстана. По мнению некоторых исследователей, различные популяции данного вида еще слабо изучены и могут представлять собой отдельные формы. Из казахстанских популяций ранее изучались популяции речных систем Талас, Шу, Сарысу и рек Каратау, однако имеющиеся данные по морфологической изменчивости зачастую неполны, разрозненны и неточны. Необходимо более детальное изучение отдельных популяций, основанное на новом материале и более точных методах. Целью статьи было описание внешне-морфологических признаков туркестанского пескаря Gobiolepidolaemus (Gobionidae) из р. Ыргайты (правый приток р. Шу). На 21 особи были изучены внешне-морфологические признаки. Приведено подробное описание особенностей окраски, пропорций тела и формы плавников, меристических признаков (число лучей в плавниках и чешуй), а также впервые для туркестанского пескаря детально описаны особенности чешуйного покрова на различных участках тела. Выявлено три типа очешуенности горла — видоспецифичного признака туркестанского пескаря. Произведен сравнительный анализ с литературными данными по популяциям туркестанского пескаря из различных водоемов. Обнаружены незначительные отличия в количестве чешуи в боковой линии и ветвистых лучей в плавниках. Наши данные по характеру очешуенности горла туркестанского пескаря из р. Ыргайты не совпадают с результатами предыдущего исследования популяции из данной реки.

*Ключевые слова:* туркестанский пескарь, Gobiolepidolaemus, Gobionidae, аборигенный вид, морфология, чешуйный покров, р. Ыргайты, р. Шу.

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