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COMPARATIVE MORPHOLOGICAL CHARACTERISTICS OF THE ARAL ROACH, *RUTILUS ARALENSIS* (CYPRINIFORMES: LEUCISCIDAE), FROM THE SYR DARYA RIVER BASIN, UZBEKISTAN

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ABSTRACT

This article presents the external morphology, the variability of morphometric characters and a comparative analysis of the Aral roach, Rutilus aralensis, from water bodies of the Syr Darya River basin: the Syr Darya River and lakes Arnasay and Yallama. A total of 72 specimens collected in 2022–2026 were examined for 7 meristic and 24 plastic characters following Pravdin (1966). Meristic characters showed low variability (CV < 10%) and remained within the species norm in all samples. The populations of the Syr Darya River and Lake Arnasay differed significantly ($P \leq 0.05$) in head and snout length, predorsal and postdorsal distances, caudal peduncle length, body depth, eye diameter, interorbital width and postorbital distance, whereas the Lake Yallama population occupied an intermediate position between them. The differences revealed reflect the phenotypic plasticity of the species under the contrasting conditions of riverine and lacustrine habitats.

KEYWORDS: *Syr Darya River, Lake Arnasay, Lake Yallama, Rutilus aralensis, meristic characters, plastic characters, morphometric variability.*

INTRODUCTION

Members of the genus *Rutilus* Rafinesque, 1820 (family Leuciscidae) are widely distributed in fresh and brackish waters of Eurasia, from Western Europe to Eastern Siberia. Representatives of this genus are among the important taxonomic and trophic components of the ichthyofauna of rivers, lakes and artificial water bodies (Berg, 1916, 1949; Kottelat, 1997; Kottelat & Freyhof, 2007; Fricke et al., 2026).

The Aral roach, *Rutilus aralensis* (Berg, 1916), is a eurybiont species that shows high adaptability to diverse habitats and to fluctuations of abiotic factors. It is widespread in rivers, lakes, reservoirs and the complex irrigation and drainage networks of the lowland areas of Uzbekistan, and is distinguished by its high abundance and tolerance to anthropogenic pressure (Kamilov, 1973; Amanov, 1985; Abdullayev & Urchinov, 1989). Although *R. aralensis* belongs to the group of low-value commercial fishes, it is one of the main targets of recreational and commercial fishing in local water bodies and constitutes an important food resource for predatory fishes (Kottelat, 1997).

In recent decades, the intensive construction of hydraulic structures in the Syr Darya basin, changes in the hydrological regime and the transformation of hydrochemical conditions have had a considerable impact on the ecological and morphological characteristics of fishes. Under such hydromorphological changes, assessing the phenotypic plasticity and the variability of morphometric characters of *R. aralensis* populations is of considerable scientific and practical importance. The morphometric characteristics of *R. aralensis* in the Aydar-Arnasay lakes system were recently described by Azizov & Mirzayev (2025); however, riverine and lacustrine populations within the Syr Darya basin have not yet been compared.

The aim of the present study was to carry out a comparative morphological analysis of the plastic and meristic characters of Aral roach populations in the Syr Darya basin and to reveal the patterns of their phenotypic variability and regional adaptive features.

MATERIALS AND METHODS

Material on *Rutilus aralensis* was collected in April–June of 2022–2026 from water bodies of the Syr Darya River basin: the Syr Darya River (40°55′36.49″ N, 68°39′47.05″ E), Lake Arnasay (40°48′28.62″ N, 67°43′11.64″ E) and Lake Yallama (40°57′14.33″ N, 68°41′22.72″ E). Meristic counts and plastic (morphometric) measurements were performed according to Pravdin (1966) on freshly caught fish in the field and on specimens fixed in 4% formalin in the laboratory. In total, 72 specimens (Syr Darya River, $n = 24$; Lake Arnasay, $n = 30$; Lake Yallama, $n = 18$) with a standard length of 112–197 mm, a total weight of 15.7–243.4 g and an age of 1+ to 4+ were examined. Part of the material examined here was previously used in a morphometric analysis of *R. aralensis* from the Aydar-Arnasay lakes system (Azizov & Mirzayev, 2025); in the present study, these data were supplemented with new samples and analysed within a different comparative framework, namely riverine versus lacustrine populations of the Syr Darya basin. Plastic characters are expressed as percentages of standard length or head length.

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For each character, the range, mean (*M*), standard error of the mean (*SE*), standard deviation (*SD*), variance (S^2) and coefficient of variation (*CV*, %) were calculated. Variability was considered low at *CV* < 10% and moderate at *CV* = 10–20%. The significance of differences between means was assessed using Student's *t*-test at the 5% significance level ($P \leq 0.05$) (Lakin, 1990).

The following abbreviations are used for meristic and plastic characters. Meristic characters: *D* – dorsal fin rays; *A* – anal fin rays; *P* – pectoral fin rays; *V* – pelvic fin rays; *l.l.* – scales in the lateral line; *sp.br.* – gill rakers; *vert.* – vertebrae. Plastic characters: *SL* – standard length; *CL* – head length; *LR* – snout length; *O* – eye diameter; *PO* – postorbital distance; *HC* – head depth; *IO* – interorbital width; *Bh* – body depth; *AD* – predorsal distance; *PD* – postdorsal distance; *Lca* – caudal peduncle length; *Hca* – caudal peduncle depth; *LD* – dorsal fin base length; *HD* – dorsal fin height; *LA* – anal fin base length; *HA* – anal fin height; *LP* – pectoral fin length; *LV* – pelvic fin length; *P–V* – pectoral–pelvic fin distance; *V–A* – pelvic–anal fin distance.

RESULTS AND DISCUSSION

L.S. Berg (1949) reported the following meristic characters for *Rutilus aralensis*: *D* III 9–11, *A* III 9–11, *l.l.* 38–45, *sp.br.* (9) 10–15.

According to our data, the meristic characters of *Rutilus aralensis* in the Syr Darya River basin are as follows (pooled data): *D* III 9–11, *A* III 9–11, *P* I 14–16, *V* I 8–9, *l.l.* 39–44, *sp.br.* 9–12, *vert.* 39–40.

The external morphological characteristics of *Rutilus aralensis* from the Syr Darya River and lakes Arnasay and Yallama are presented in Tables 1–3.

Table 1. Morphological characteristics of the Aral roach, *Rutilus aralensis*, from the Syr Darya River (*n* = 24)

Character	Range	*M* ± *SE*	*SD*	S^2	*CV*, %
SL, mm	123–197	153.83±5.23	–	–	–
D	III 9–11	10.00±0.06	0.29	0.09	2.95
A	III 9–11	9.92±0.10	0.50	0.25	5.08
P	I 14–16	14.75±0.14	0.68	0.46	4.58
V	I 8–9	8.13±0.07	0.34	0.11	4.16
l.l.	39–44	41.71±0.34	1.68	2.82	4.03
sp.br.	10–12	10.38±0.15	0.71	0.51	6.85
vert.	39–40	39.21±0.08	0.41	0.17	1.06
In % of standard length (SL)					
CL	20.61–25.90	23.29±0.30	1.49	2.22	6.40
LR	4.60–7.80	6.58±0.15	0.74	0.55	11.29
O	3.90–5.74	5.00±0.10	0.50	0.25	10.04
PO	9.34–13.10	10.89±0.17	0.83	0.69	7.65
HC	14.10–19.00	16.76±0.19	0.92	0.85	5.50
IO	6.70–10.30	8.35±0.18	0.86	0.74	10.27
Bh	24.50–34.20	28.35±0.59	2.90	8.41	10.23
AD	48.70–60.10	52.93±0.72	3.53	12.46	6.67
PD	34.90–45.60	37.71±0.45	2.22	4.92	5.88
Lca	17.74–23.40	20.39±0.31	1.50	2.24	7.35
Hca	8.70–12.90	10.67±0.26	1.29	1.65	12.06
LD	12.80–17.10	14.56±0.19	0.91	0.83	6.24
HD	17.07–25.69	21.58±0.35	1.73	3.01	8.04
LA	9.60–14.20	11.04±0.21	1.02	1.05	9.27
HA	12.10–17.21	13.88±0.30	1.45	2.10	10.44
LP	16.40–22.30	17.69±0.25	1.24	1.53	6.99
LV	14.49–25.00	17.28±0.45	2.19	4.81	12.68
P–V	22.40–31.60	26.88±0.61	2.98	8.85	11.07
V–A	21.30–30.40	25.55±0.59	2.89	8.35	11.31
In % of head length (CL)					
LR/CL	20.10–32.10	28.28±0.56	2.76	7.64	9.77
O/CL	16.30–25.00	21.50±0.50	2.46	6.06	11.45
PO/CL	39.30–53.60	46.85±0.81	3.97	15.72	8.46
HC/CL	61.60–80.00	72.15±1.04	5.11	26.14	7.09
IO/CL	29.60–43.80	36.05±0.88	4.31	18.61	11.96

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Table 2. Morphological characteristics of the Aral roach, *Rutilus aralensis*, from Lake Arnasay (*n* = 30)

Character	Range	*M* ± *SE*	*SD*	S^2	*CV*, %
SL, mm	114–183	139.07±3.23	–	–	–
D	III 9–11	10.00±0.10	0.53	0.28	5.25
A	III 9–11	10.13±0.09	0.51	0.26	5.01
P	I 14–16	14.77±0.11	0.63	0.39	4.24
V	I 8–9	8.10±0.06	0.31	0.09	3.77
l.l.	40–44	42.10±0.22	1.21	1.47	2.88
sp.br.	9–11	9.93±0.10	0.52	0.27	5.24
vert.	39–40	39.23±0.08	0.43	0.19	1.10
In % of standard length (SL)					
CL	20.98–24.79	22.45±0.19	1.03	1.06	4.59
LR	5.59–7.03	6.24±0.07	0.36	0.13	5.71
O	4.64–6.25	5.26±0.07	0.37	0.13	6.97
PO	9.42–12.40	10.95±0.15	0.84	0.70	7.67
HC	14.84–18.42	16.46±0.14	0.79	0.63	4.82
IO	7.69–10.74	8.78±0.13	0.69	0.47	7.84
Bh	26.96–33.33	29.63±0.25	1.36	1.86	4.61
AD	48.46–56.20	51.10±0.30	1.62	2.63	3.17
PD	33.04–38.84	36.48±0.26	1.44	2.07	3.94
Lca	17.09–21.14	19.25±0.22	1.23	1.51	6.39
Hca	9.82–13.22	10.93±0.16	0.87	0.75	7.92
LD	12.68–17.74	14.56±0.21	1.15	1.32	7.89
HD	17.60–23.44	21.76±0.24	1.33	1.77	6.11
LA	9.09–13.22	11.02±0.21	1.13	1.27	10.21
HA	12.40–16.15	14.05±0.21	1.17	1.38	8.35
LP	16.52–19.83	17.96±0.15	0.80	0.64	4.47
LV	14.49–25.00	17.35±0.32	1.76	3.10	10.15
P–V	23.61–28.10	26.00±0.23	1.24	1.53	4.75
V–A	22.92–27.34	24.41±0.22	1.20	1.45	4.94
In % of head length (CL)					
LR/CL	25.81–31.03	27.84±0.28	1.56	2.42	5.59
O/CL	20.69–26.92	23.43±0.26	1.43	2.04	6.09
PO/CL	42.86–53.13	48.72±0.44	2.41	5.83	4.96
HC/CL	66.67–81.48	73.38±0.68	3.73	13.88	5.08
IO/CL	33.33–43.75	39.17±0.60	3.29	10.80	8.39

Table 3. Morphological characteristics of the Aral roach, *Rutilus aralensis*, from Lake Yallama (*n* = 18)

Character	Range	*M* ± *SE*	*SD*	S^2	*CV*, %
SL, mm	112–142	126.11±2.08	–	–	–
D	III 9–11	9.94±0.13	0.54	0.29	5.42
A	III 10–11	10.22±0.10	0.43	0.18	4.18
P	I 14–16	14.72±0.14	0.57	0.33	3.90
V	I 8–9	8.06±0.06	0.24	0.06	2.93
l.l.	39–44	41.94±0.36	1.51	2.29	3.61
sp.br.	10–12	10.22±0.13	0.55	0.30	5.36
vert.	39–40	39.17±0.09	0.38	0.15	0.98
In % of standard length (SL)					
CL	20.93–23.92	22.49±0.22	0.93	0.87	4.15
LR	5.70–7.30	6.43±0.10	0.44	0.20	6.91
O	3.70–5.65	5.05±0.13	0.55	0.31	10.97
PO	9.68–12.31	11.01±0.20	0.84	0.71	7.66
HC	14.60–18.42	16.35±0.24	1.03	1.07	6.33
IO	6.70–10.00	8.46±0.18	0.78	0.60	9.17
Bh	24.50–30.58	28.55±0.36	1.54	2.37	5.40
AD	49.57–60.20	52.14±0.67	2.85	8.11	5.46

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PD	34.38–45.60	37.52±0.64	2.72	7.39	7.24
Lca	18.55–21.01	19.53±0.19	0.82	0.67	4.19
Hca	8.80–11.72	10.40±0.17	0.71	0.51	6.84
LD	12.68–17.74	14.32±0.30	1.29	1.67	9.02
HD	14.52–23.44	21.35±0.48	2.02	4.06	9.44
LA	9.09–12.50	10.68±0.24	1.04	1.07	9.70
HA	12.30–16.15	14.12±0.27	1.15	1.32	8.14
LP	16.52–19.35	17.78±0.20	0.83	0.70	4.70
LV	15.00–18.46	16.75±0.22	0.91	0.83	5.45
P–V	24.35–31.20	26.46±0.36	1.53	2.33	5.77
V–A	23.08–29.70	24.69±0.39	1.65	2.71	6.67
In % of head length (CL)					
LR/CL	25.81–34.27	28.64±0.55	2.32	5.38	8.10
O/CL	17.37–25.87	22.44±0.51	2.18	4.76	9.72
PO/CL	44.35–52.26	48.92±0.60	2.56	6.57	5.24
HC/CL	67.51–81.28	72.73±0.95	4.03	16.22	5.54
IO/CL	29.39–44.80	37.69±0.89	3.76	14.12	9.97

The analysis of meristic and plastic characters of *Rutilus aralensis* from the Syr Darya River and lakes Arnasay and Yallama revealed different degrees of similarity among the samples.

In the river sample, standard length (*SL*) ranged from 123 to 197 mm (153.83 ± 5.23 mm). All meristic characters showed low variability (*CV* < 10%), the lowest values being recorded for the number of vertebrae (*CV* = 1.06%), dorsal fin rays (*CV* = 2.95%) and lateral line scales (*CV* = 4.03%). Among plastic characters, low variability was typical, for example, of predorsal distance (*CV* = 6.67%) and head length (*CV* = 6.40%), whereas moderate variability was recorded for pelvic fin length (*CV* = 12.68%), caudal peduncle depth (*CV* = 12.06%) and snout length (*CV* = 11.29%).

The lake samples were characterised by smaller standard lengths: 114–183 mm (139.07 ± 3.23 mm) in Lake Arnasay and 112–142 mm (126.11 ± 2.08 mm) in Lake Yallama. In both lacustrine populations, meristic characters remained within the species norm and showed low variability (*CV* < 10%); for instance, the *CV* for the number of vertebrae was 0.98% in Lake Yallama and 1.10% in Lake Arnasay.

The plastic characters of the lake samples showed phenotypic shifts relative to the river sample. Head length (*CL*/*SL*) was lower in fish from Lake Arnasay (22.45 ± 0.19%, *CV* = 4.59%) and Lake Yallama (22.49 ± 0.22%, *CV* = 4.15%) than in river fish (23.29 ± 0.30%); the difference was significant for Lake Arnasay (*t* = 2.44) and at the threshold of significance for Lake Yallama (*t* = 2.00). Eye diameter relative to head length (*O*/*CL*) showed moderate variability in the river sample (*CV* = 11.45%), whereas in lakes Arnasay (*CV* = 6.09%) and Yallama (*CV* = 9.72%) it remained within the range of low variability.

No significant differences in morphometric characters were found between males and females of *Rutilus aralensis* from the Syr Darya River basin.

The results of the comparative analysis of morphometric characters of *Rutilus aralensis* from the Syr Darya River basin are presented in Table 4.

Table 4. Comparative analysis of morphometric characteristics of the Aral roach, *Rutilus aralensis*, from water bodies of the Syr Darya River basin

Character	Syr Darya River (I)	Lake Arnasay (II)	Lake Yallama (III)	*t*-value		
	M	***M***	***M***	**I–II**	**I–III**	**II–III**
SL, mm	153.83	139.07	126.11	–	–	–
In % of standard length (SL)						
CL	23.29	22.45	22.49	2.44	2.00	0.13
LR	6.58	6.24	6.43	2.16	0.74	1.60
O	5.00	5.26	5.05	2.21	0.32	1.57
PO	10.89	10.95	11.01	0.25	0.46	0.25
HC	16.76	16.46	16.35	1.30	1.35	0.40
IO	8.35	8.78	8.46	2.02	0.42	1.48
Bh	28.35	29.63	28.55	2.14	0.27	2.52
AD	52.93	51.10	52.14	2.53	0.78	1.61
PD	37.71	36.48	37.52	2.47	0.25	1.74
Lca	20.39	19.25	19.53	3.06	2.18	0.86
Hca	10.67	10.93	10.40	0.91	0.79	2.21
LD	14.56	14.56	14.32	0.01	0.71	0.66
HD	21.58	21.76	21.35	0.44	0.39	0.85
LA	11.04	11.02	10.68	0.06	1.13	1.06

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HA	13.88	14.05	14.12	0.48	0.58	0.20
LP	17.69	17.96	17.78	0.96	0.26	0.75
LV	17.28	17.35	16.75	0.12	0.96	1.33
P–V	26.88	26.00	26.46	1.46	0.55	1.13
V–A	25.55	24.41	24.69	1.97	1.13	0.68
In % of head length (CL)						
LR/CL	28.28	27.84	28.64	0.75	0.45	1.44
O/CL	21.50	23.43	22.44	3.60	1.28	1.90
PO/CL	46.85	48.72	48.92	2.14	1.93	0.27
HC/CL	72.15	73.38	72.73	1.03	0.40	0.57
IO/CL	36.05	39.17	37.69	3.02	1.28	1.43

Note: *– statistically significant difference (*$P \leq 0.05$*).*

The comparative analysis of plastic characters of *Rutilus aralensis* from different water bodies of the Syr Darya basin revealed certain phenotypic differences between the riverine and lacustrine populations.

The most pronounced morphological differences were found between the Syr Darya River and Lake Arnasay samples, which differed significantly in 11 of the 24 plastic characters. River fish had a significantly longer head and snout relative to standard length. In turn, fish from Lake Arnasay had a significantly larger eye diameter (relative to both standard length and head length), a greater interorbital width (relative to both standard length and head length) and a longer postorbital distance relative to head length.

The Lake Arnasay population was also distinguished by a deeper body: maximum body depth amounted to 29.63% of *SL*, compared with 28.35% in river fish ($t = 2.14$). At the same time, the predorsal and postdorsal distances, as well as caudal peduncle length, were significantly greater in river fish.

Fish from Lake Yallama occupied an intermediate position in most morphometric parameters and did not differ significantly from the river sample in most of them. The only significant difference was the relatively shorter caudal peduncle of Lake Yallama fish ($t = 2.18$), which brings them closer to the Lake Arnasay population.

Comparison of the two lake samples showed that fish from Lake Arnasay had a greater body depth ($t = 2.52$) and caudal peduncle depth ($t = 2.21$) than those from Lake Yallama.

The higher variability and inter-population divergence of plastic characters compared with meristic ones indicate that plastic characters of *R. aralensis* depend more strongly on habitat conditions, such as water flow, food supply and temperature regime, and thus reflect the ecological variability of the environment. The more elongated body and longer caudal peduncle of river fish and the deeper body of lake fish are consistent with adaptation to flowing and standing water, respectively.

CONCLUSIONS

The comparative analysis of plastic characters of *Rutilus aralensis* populations in the Syr Darya River basin revealed pronounced phenotypic variability and adaptability between riverine and lacustrine biotopes.

The greatest morphological differences were found between the Syr Darya River and Lake Arnasay populations. River fish are characterised by a longer head and snout, as well as greater predorsal and postdorsal distances and caudal peduncle length. In contrast, the Lake Arnasay population is distinguished by a deeper body, a relatively larger eye, a wider interorbital space and a longer postorbital distance.

Specimens of *R. aralensis* from Lake Yallama occupy an intermediate position between the river and Lake Arnasay populations in most morphometric characters; their only significant difference from the river sample is a shorter caudal peduncle.

In addition, *R. aralensis* from Lake Arnasay differs from that of Lake Yallama by a greater body depth and caudal peduncle depth.

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