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COMPARATIVE MORPHOLOGICAL ANALYSIS OF THE SPECIES RUTILUS ARALENSIS (RUTILUS: LEUCISCINAE) IN THE AYDAR-ARNASAY LAKES SYSTEM

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ABSTRACT

This article presents the external morphology, variability of morphometric traits, and comparative analysis of Rutilus aralensis *in the Aydar-Arnasay Lakes system. The external morphology of* Rutilus aralensis *from the Eastern Arnasay and Tuzkon lakes showed similarities. However, individuals from these lakes were characterized by smaller head size and a taller body, while* Rutilus aralensis *from Lake Aydar exhibited more elongated body and snout.*

KEYWORDS: *Aydar-Arnasay lakes system, Eastern Arnasay, Tuzkon, Aydar,* Rutilus aralensis*, morphometric traits.*

The genus *Rutilus* Rafinesque, 1820, belonging to the subfamily Leuciscinae, is widely distributed throughout Eurasia (from Western Europe to Eastern Siberia). Due to differences in morphological traits and the existence of intermediate forms, identifying species within this genus poses significant challenges.

L.S. Berg, in 1916, recognized the population of *Rutilus rutilus* in the Aral Sea basin as a distinct subspecies, *R. r. aralensis* (Berg, 1916; 1949). M. Kottelat (1997), applying the phylogenetic species concept, considered all subspecies of *Rutilus rutilus* as synonyms of the main species.

According to B.A. Levin et al. (2017), who assessed the status of nominal species of *Rutilus* from Eastern Europe to Eastern Siberia, three major phylogenetic classes were identified: (1) *R. frisii*, (2) *R. rutilus s. str.*, and (3) a group of six Ponto-Caspian nominal taxa (*R. caspicus*, *R. heckelii*, *R. rutilus aralensis* Berg, 1916, *R. rutilus lacustris* (Pallas, 1814), *R. schelkovnikovi*, and *R. stoumboudae* Bianco & Ketmaier, 2014). The authors proposed that these taxa could be synonymized under *Rutilus lacustris* (Pallas, 1814) based on priority in nomenclature, and elevated *R. r. lacustris* from subspecies to species rank.

Although several studies on the morphological traits of *Rutilus* species have been conducted, the molecular systematics and phylogeny of the Aral roach in Uzbekistan's water bodies have not been explored. Therefore, based on binomial nomenclature considered "valid" by M. Kottelat (1997; 2007) and R. Froese & D. Pauly (2023) in the FishBase database (http://www.fishbase.org), the Aral roach cannot be accepted as *R. rutilus* or *R. lacustris* based solely on mtDNA data obtained by B.A. Levin et al. (2017). Until diagnostic traits are developed through a rigorous examination of genetic distances, morphological traits, and nDNA markers among the Ponto-Caspian-Aral lineages, the species in Uzbekistan's waters should continue to be classified as *Rutilus aralensis*.

Rutilus aralensis (Berg, 1916) is an eurybiont species that has adapted to various ecological habitats, distinguished by its abundance, wide distribution, and resilience to anthropogenic impacts. Despite being a common, low-value species, it holds significant fishing importance due to its abundance in plains water bodies (rivers, lakes, reservoirs) of Uzbekistan (Abdullaev & Urchinov, 1989; Amanov, 1985; Kamilov, 1973; Kottelat, 1997).

Some information regarding the morphological characteristics of *Rutilus aralensis* in the Aydar-Arnasay lakes system was previously provided by I.S. Tagayev (1991) and I.S. Tagayev & A.A. Amanov (1988).

This article presents the morphological features and comparative description of the Aral roach (*Rutilus aralensis*) in the Aydar-Arnasay Lakes system.

MATERIALS AND METHODS

The materials on *Rutilus aralensis* were collected during the spring and summer seasons from 2020 to 2024 from the Eastern Arnasay, Tuzkon, and Aydar lakes of the Aydar-Arnasay Lakes system. Meristic and plastic (morphometric) traits of the fish were measured according to I.F. Pravdin (1966) both in freshly caught individuals and in specimens fixed in 4% formalin in the laboratory. A total of 125 samples, with body lengths ranging from 10.9 to 20.4 cm, weights from 16 to 245 g, and ages from 1+ to 4+, were analyzed. Plastic traits are given as percentages relative to body or head length.

Statistical analysis of morphometric traits included determining range (Lim.), mean (M), standard error (m), standard deviation (SD), variance (S^2), and coefficient of variation (Cv, %). Significance of differences between means was evaluated using Student's *t*-test at a 5% significance level ($P \leq 0.05$) (Lakin, 1990).

The following abbreviations were used for meristic and plastic traits

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Meristic Traits

D – dorsal fin rays; A – anal fin rays; l.l. – lateral line scales; sp.br. – gill rakers; vert. – vertebrae.

Plastic Traits

l – total body length; c – head length; ao – snout length; o – eye diameter; po – postorbital distance; hc – head height; io – interorbital width; H – body depth; h – caudal peduncle depth; aD – predorsal distance; pD – postdorsal distance; lca – caudal peduncle length; 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; PV – pectoral to pelvic fin distance; VA – pelvic to anal fin distance.

RESULTS AND DISCUSSION

L.S. Berg (1949) reports the meristic characteristics of the species *Rutilus aralensis* as follows: D III 9–11, A III 9–11, l.l. 38–45, sp.br (9) 10–15.

I.S. Tagayev and A.A. Amanov (1988) provide the following meristic characteristics of *Rutilus aralensis* from the Aydar-Arnasoy lake system: D III 9–11, A III 9–11, l.l. 39–44, sp.br 9–14 (generalized data).

According to our data, the meristic characteristics of *Rutilus aralensis* in the Aydar-Arnasoy lake system are described as follows: D III 9–11, A III 9–11, P I 14–16, V I 8–9, l.l. 38–45, sp.br. 9–12, vert. 39–40 (generalized data).

The external morphological characteristics of *Rutilus aralensis* from the Aydar-Arnasoy lake system — including the Eastern Arnasoy, Tuzkon, and Aydarkol lakes — are presented in Tables 1 to 3.

Table 1

Morphological characteristics of *Rutilus aralensis* from Eastern Arnasoy lake (n=43)

Characters	*Lim.*	*M±m*	*SD*	S^2	*Cv %*
l, mm	109-157	126,5±1,85	12,10	146,40	9,56
Meristic Characters					
D	III 9-11	9,95±0,07	0,49	0,24	4,88
A	III 9-11	10,12±0,07	0,45	0,20	4,43
P	I 14-16	14,84±0,08	0,53	0,28	3,58
V	I 8-9	8,05±0,03	0,21	0,05	2,65
l.l.	38-45	41,88±0,23	1,48	2,20	3,54
sp.br	9-11	9,98±0,07	0,46	0,21	4,63
vert.	39-40	39,23±0,07	0,43	0,18	1,09
Plastic Characters					
c/l	20,51-24,79	22,44±0,15	0,99	0,97	4,40
ao/l	5,31-7,03	6,21±0,06	0,36	0,13	5,83
o/l	4,64-6,25	5,29±0,06	0,36	0,13	6,85
po/l	9,40-12,40	10,94±0,13	0,83	0,68	7,55
hc/l	14,84-18,42	16,57±0,12	0,78	0,62	4,74
io/l	7,69-10,91	8,73±0,11	0,73	0,53	8,32
H/l	25,66-33,33	29,45±0,21	1,40	1,95	4,74
h/l	9,65-13,22	10,79±0,13	0,86	0,73	7,94
aD/l	46,02-56,20	50,89±0,28	1,82	3,31	3,57
pD/l	33,04-39,84	36,56±0,21	1,41	1,99	3,85
lca/l	17,09-21,14	19,05±0,19	1,23	1,52	6,48
lD/l	12,68-17,74	14,60±0,18	1,18	1,38	8,05
hD/l	14,52-24,59	21,71±0,27	1,75	3,06	8,06
lA/l	9,09-13,22	11,02±0,17	1,11	1,24	10,11
hA/l	12,40-17,21	14,34±0,18	1,18	1,39	8,23
lP/l	16,52-20,18	18,17±0,15	0,96	0,92	5,29
lV/l	14,49-25,00	17,51±0,24	1,58	2,50	9,04
PV/l	23,01-30,40	26,16±0,21	1,38	1,91	5,29
VA/l	21,93-28,10	24,13±0,20	1,33	1,78	5,52
ao/c	23,08-31,03	27,71±0,24	1,61	2,58	5,79
o/c	20,69-26,92	23,58±0,21	1,41	1,98	5,96

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po/c	42,86-53,85	48,70±0,37	2,41	5,80	4,95
hc/c	66,67-81,48	73,89±0,57	3,74	13,96	5,06
io/c	33,33-48,00	38,98±3,53	3,53	12,45	9,05

Table 2
Morphological characteristics of *Rutilus aralensis* from Tuzkon lake (n=45)

Characters	*Lim.*	*M±m*	*σ*	S^2	*Cv %*
l, mm	114-204	142,09±3,54	23,76	564,45	16,72
Meristic Characters					
D	III 9-11	10,07±0,07	0,45	0,20	4,44
A	III 9-11	10,16±0,07	0,47	0,23	4,67
P	I 14-16	14,78±0,08	0,56	0,31	3,79
V	I 8-9	8,04±0,03	0,21	0,04	2,59
l.l.	39-45	42,04±0,22	1,48	2,18	3,51
sp.br	9-11	9,93±0,07	0,45	0,20	4,50
vert.	39-40	39,22±0,06	0,42	0,18	1,07
Plastic Characters					
c/l	20,51-24,39	22,50±0,15	0,99	0,99	4,41
ao/l	4,60-7,10	6,22±0,07	0,46	0,21	7,39
o/l	4,11-6,40	5,18±0,07	0,47	0,22	9,04
po/l	9,40-12,53	10,95±0,12	0,80	0,64	7,30
hc/l	14,84-18,67	16,62±0,13	0,87	0,76	5,24
io/l	7,20-10,19	8,55±0,10	0,67	0,45	7,84
H/l	23,90-34,20	29,05±0,35	2,37	5,64	8,17
h/l	9,30-12,90	10,65±0,13	0,86	0,74	8,07
aD/l	48,10-53,47	50,66±0,21	1,40	1,97	2,77
pD/l	33,04-39,84	36,27±0,23	1,56	2,44	4,30
lca/l	17,09-21,14	19,12±0,18	1,20	1,44	6,28
lD/l	12,68-17,74	14,53±0,16	1,06	1,13	7,30
hD/l	14,52-24,59	21,38±0,25	1,68	2,81	7,84
lA/l	9,09-13,01	11,00±0,15	0,99	0,98	9,02
hA/l	12,10-17,21	14,12±0,17	1,15	1,32	8,14
lP/l	16,40-19,35	17,84±0,12	0,82	0,67	4,59
lV/l	14,49-25,00	17,16±0,24	1,60	2,56	9,33
PV/l	23,61-30,40	25,89±0,19	1,24	1,54	4,80
VA/l	21,93-28,10	24,17±0,19	1,26	1,59	5,22
ao/c	20,10-31,00	27,65±0,29	1,97	3,89	7,13
o/c	17,90-26,30	23,04±0,28	1,89	3,57	8,20
po/c	42,90-53,60	48,63±0,37	2,49	6,20	5,12
hc/c	66,70-81,50	73,95±0,53	3,52	12,41	4,76
io/c	31,40-45,80	38,05±3,46	3,46	12,00	9,10

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Table 3
Morphological characteristics of *Rutilus aralensis* from Aydarkol lake (n=37)

Characters	*Lim.*	*M±m*	*σ*	*S²*	*Cv %*
l, mm	112-190	138,41±3,80	23,14	535,30	16,72
Meristic Characters					
D	III 9-11	9,95±0,07	0,40	0,16	4,07
A	III 9-11	10,00±0,08	0,47	0,22	4,71
P	I 14-16	14,73±0,10	0,61	0,37	4,13
V	I 8-9	8,08±0,05	0,28	0,08	3,42
l.l.	39-44	41,68±0,27	1,62	2,61	3,88
sp.br	10-12	10,30±0,11	0,66	0,44	6,42
vert.	39-40	39,16±0,06	0,37	0,14	0,95
Plastic Characters					
c/l	21,13-26,50	23,42±0,23	1,40	1,96	5,97
ao/l	5,70-8,10	6,70±0,10	0,63	0,40	9,48
o/l	3,70-5,80	4,98±0,09	0,58	0,33	11,57
po/l	9,68-13,10	10,98±0,13	0,81	0,66	7,42
hc/l	11,80-19,00	16,46±0,21	1,30	1,70	7,91
io/l	6,70-10,30	8,49±0,13	0,78	0,61	9,17
H/l	24,50-32,10	28,26±0,37	2,25	5,07	7,97
h/l	8,70-12,90	10,47±0,17	1,02	1,04	9,76
aD/l	48,90-60,30	53,52±0,58	3,52	12,40	6,58
pD/l	34,38-45,80	38,09±0,50	3,03	9,18	7,96
lca/l	17,74-23,70	20,34±0,25	1,52	2,31	7,47
lD/l	12,68-17,74	14,46±0,19	1,15	1,32	7,94
hD/l	14,52-25,69	21,49±0,31	1,87	3,48	8,69
lA/l	9,09-14,20	10,94±0,18	1,10	1,21	10,04
hA/l	12,10-17,10	13,94±0,20	1,22	1,50	8,79
lP/l	16,40-22,30	17,720,19	1,17	1,37	6,61
lV/l	14,70-25,00	17,17±0,30	1,84	3,37	10,69
PV/l	22,40-31,80	27,02±0,43	2,59	6,70	9,58
VA/l	21,30-30,70	25,48±0,44	2,68	7,18	10,52
ao/c	24,00-32,10	28,60±0,35	2,13	4,54	7,45
o/c	15,20-25,90	21,32±0,45	2,72	7,41	12,77
po/c	39,30-53,60	46,99±0,61	3,73	13,91	7,94
hc/c	44,50-81,50	70,53±1,08	6,55	42,87	9,28
io/c	29,50-43,30	36,41±4,15	4,15	17,19	11,39

Research results showed that the variation coefficients of most morphometric characteristics of *Rutilus aralensis* species are characterized by a moderate level of variability. Among the 19 plastic traits related to body length, the distance between the pectoral and anal fins is highly variable; the snout length, eye diameter, interorbital width, forehead width, body height, height of the caudal peduncle, length of the caudal peduncle, length of the base of the dorsal fin, height of the dorsal fin, length of the base of the anal fin, height of the anal fin, length of the pelvic fin, and the distance between the pelvic and anal fins are moderately variable traits, while the remaining ones are considered low-variable. Among the five plastic traits of the head, the forehead width shows high variability, whereas the others fall within the range of moderate variability (see Table 4).

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Table 4
Morphological characteristics of *Rutilus aralensis* in the Aydar-Arnasoy lake system (summary data, n=125)

Characters	*Lim.*	*M±m*	σ	S^2	*Cv %*
l, mm	109-204	135,66±1,90	21,24	451,26	15,66
Meristic Characters					
D	III 9-11	9,99±0,04	0,45	0,20	4,49
A	III 9-11	10,10±0,04	0,47	0,22	4,61
P	I 14-16	14,78±0,05	0,56	0,32	3,80
V	I 8-9	8,06±0,02	0,23	0,05	2,87
l.l.	38-45	41,88±0,14	1,52	2,30	3,62
sp.br	9-12	10,06±0,05	0,54	0,30	5,40
vert.	39-40	39,21±0,04	0,41	0,17	1,04
Plastic Characters					
c/l	20,51-26,50	22,75±0,11	1,20	1,44	5,27
ao/l	4,60-8,10	6,36±0,05	0,53	0,28	8,40
o/l	3,70-6,40	5,16±0,04	0,48	0,23	9,39
po/l	9,40-13,10	10,95±0,07	0,81	0,65	7,37
hc/l	11,80-19,00	16,55±0,09	0,99	0,97	5,96
io/l	6,70-10,91	8,60±0,06	0,72	0,52	8,43
H/l	23,90-34,20	28,95±0,19	2,09	4,37	7,22
h/l	8,70-13,22	10,64±0,08	0,91	0,83	8,56
aD/l	46,02-60,30	51,59±0,24	2,65	7,01	5,13
pD/l	33,04-45,80	36,91±0,20	2,19	4,81	5,94
lca/l	17,09-23,70	19,46±0,13	1,42	2,03	7,32
lD/l	12,68-17,74	14,53±0,10	1,12	1,25	7,70
hD/l	14,52-25,69	21,53±0,16	1,75	3,07	8,14
lA/l	9,09-14,20	10,99±0,09	1,06	1,12	9,64
hA/l	12,10-17,21	14,14±0,11	1,18	1,40	8,38
lP/l	16,40-22,30	17,92±0,09	0,99	0,98	5,54
lV/l	14,49-25,00	17,28±0,15	1,66	2,76	9,61
PV/l	22,40-50,43	26,48±0,25	2,81	7,89	10,61
VA/l	21,30-35,04	24,64±0,19	2,12	4,49	8,60
ao/c	20,10-32,10	27,95±0,17	1,94	3,75	6,92
o/c	15,20-26,92	22,72±0,20	2,23	4,97	9,81
po/c	39,30-53,85	48,17±0,27	2,97	8,79	6,16
hc/c	44,50-81,50	72,92±0,44	4,90	23,99	6,72
io/c	29,50-48,00	37,88±3,81	3,81	14,54	10,07

The higher variability of plastic traits compared to meristic traits in *Rutilus aralensis* indicates that these plastic traits are more dependent on the fish's habitat, diet, and water temperature conditions, i.e., plastic traits reflect the ecological variability of the living environment.

When comparing the morphometric characteristics of male and female *Rutilus aralensis* in the Aydar-Arnasoy lake system, no significant differences were found between the sexes.

The comparative analysis of morphometric traits of *Rutilus aralensis* in the Aydar-Arnasoy lake system is presented in Tables 5.

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Table 5
Comparative analysis of morphometric characteristics of *Rutilus aralensis* in the Aydar-Arnasoy lake system

Characters	East Arnasoy	Tuzkon	Aydarkol	t-kriteriya		
	***M±m* (I)**	***M±m* (II)**	***M±m* (III)**	**I-II**	**I-III**	**II-III**
l, mm	126,5±1,85	142,09±3,54	138,41±3,80	-	-	-
Plastic Characters						
c/l	22,44±0,15	22,50±0,15	23,42±0,23	0,24	3,62*	3,47*
ao/l	6,21±0,06	6,22±0,07	6,70±0,10	0,01	4,23*	3,96*
o/l	5,29±0,06	5,18±0,07	4,98±0,09	1,17	2,93*	1,78
po/l	10,94±0,13	10,95±0,12	10,98±0,13	0,04	0,22	0,18
hc/l	16,57±0,12	16,62±0,13	16,46±0,21	0,31	0,44	0,66
io/l	8,73±0,11	8,55±0,10	8,49±0,13	1,26	1,43	0,33
H/l	29,45±0,21	29,05±0,35	28,26±0,37	0,96	2,89*	1,53
h/l	10,79±0,13	10,65±0,13	10,47±0,17	0,75	1,52	0,87
aD/l	50,89±0,28	50,66±0,21	53,52±0,58	0,67	4,27*	4,98*
pD/l	36,56±0,21	36,27±0,23	38,09±0,50	0,92	2,95*	3,51*
lca/l	19,05±0,19	19,12±0,18	20,34±0,25	0,26	4,17*	4,04*
lD/l	14,60±0,18	14,53±0,16	14,46±0,19	0,32	0,56	0,27
hD/l	21,71±0,27	21,38±0,25	21,49±0,31	0,89	0,54	0,27
lA/l	11,02±0,17	11,00±0,15	10,94±0,18	0,07	0,31	0,26
hA/l	14,34±0,18	14,12±0,17	13,94±0,20	0,90	1,49	0,68
lP/l	18,17±0,15	17,84±0,12	17,720,19	1,74	1,88	0,53
lV/l	17,51±0,24	17,16±0,24	17,17±0,30	1,02	0,87	0,03
PV/l	26,16±0,21	25,89±0,19	27,02±0,43	1,19	0,52	2,59*
VA/l	24,13±0,20	24,17±0,19	25,48±0,44	0,64	1,99*	2,91*
ao/c	27,71±0,24	27,65±0,29	28,60±0,35	0,15	2,12*	2,08*
o/c	23,58±0,21	23,04±0,28	21,32±0,45	1,50	4,73*	3,35*
po/c	48,70±0,37	48,63±0,37	46,99±0,61	0,12	2,46*	2,38*
hc/c	73,89±0,57	73,95±0,53	70,53±1,08	0,07	2,87*	3,01
io/c	38,98±3,53	38,05±3,46	36,41±4,15	1,24	2,99*	1,94

Note: Differences identified by –*marked traits are presented ($P \leq 0.05$).*

*No statistically significant differences were found between Rutilus aralensis from Sharqiy Arnasoy and Tuzkon lakes for the main morphometric traits under consideration. When comparing the indices of Rutilus aralensis from Sharqiy Arnasoy and Aydarkol lakes, significant differences were observed in 8 body traits (c, ao, o, H, aD, pD, lca, VA) and 5 head traits (ao/c, o/c, po/c, hc/c, io/c). Between Rutilus aralensis from Tuzkon and Aydarkol lakes, differences were identified in 7 body traits (c, ao, aD, pD, lca, PV, VA) and 3 head traits (ao/c, o/c, po/c) (see Table 5).**

CONCLUSIONS

Thus, the comparative morphological analysis of *Rutilus aralensis* in the Aydar-Arnasoy lake system shows that the external morphology of *Rutilus aralensis* from Sharqiy Arnasoy and Tuzkon lakes is very similar to each other. This similarity primarily reflects the comparable living conditions of *Rutilus aralensis* in these two lakes. The *Rutilus aralensis* from Sharqiy Arnasoy and Tuzkon lakes is characterized by a smaller head and higher body, whereas the *Rutilus aralensis* from Aydarkol lake is distinguished by a relatively longer snout and more elongated body.

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