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NEW DATA ON MORPHOMETRY AND BIOLOGY OF ALIEN SNAKEHEAD *CHANNA ARGUS* IN THE SYRDARYA RIVER

The Amur (or northern) snakehead, *Channa argus* (Cantor, 1842), was unintentionally introduced in the Aral basin in 1961-1963. This fish species now distributed worldwide and is considered as a dangerous invader. Furthermore number and abundance of alien fish species is considered as an index of unfavorable state of water ecosystems. Therefore, the investigation of morphological and biological variability in space and time should reveal ecological plasticity of the population of Amur snakehead in the Syrdarya River. Fishes for the examination were caught using standard fishing tackles. Physical and chemical water characteristics were assessed by the most common methods. Turbidity of the water, salinity, temperature and pH, color and odor of the water were determined. The population of snakehead was presented by adult and young fishes. Growth rate was slowly than in the first time of naturalization. Comparative analysis of morphological features did reveal neither significant shifts nor reduction of variability of the population in the Syrdarya River. Adult fishes cared their young fishes longer that it was supposed before. Grow rate of the fishes was slowly than in the first time after introduction. Minimal body length of mature fishes was about 280 mm. Amur snakehead is trophic competitor with indigenous piscivorous fish species. Now the Amur snakehead is a regular member of fish community in the Syrdarya River.

Key words: *Channa argus*, Amur snakehead, Syrdarya River, morphology, biology

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Сырдария өзеніндегі амур жыланбас *Channa argus* балығының биологиясы және морфологиясы туралы жаңа мәліметтер

Амур жыланбас *Channa argus* (Cantor, 1842) балығы 1960 жылдары Арал теңізі бассейніне кездейсоқ жерсіндірілген. Бұл түр жергілікті түрлерге қауіпті болып табылады. Суқойма жағдайының көрсеткіштерінің бірі бөгде балық түрлерінің көптігі болып табылады. Біздің зерттеуіміздегі мақсатымыз, жыланбас балығының морфологиялық және биологиялық ерекшеліктерін зерттеу және бастапқы жерсіндірілген уақыттағы авторлардың мәліметтерімен салыстыру болып табылады. Аулау үшін стандартты аулау құралдары пайдаланылды және морфометриялық талдау дәстүрлі схема бойынша жүргізілді. Су температура, ластану, минералдану, pH, ерітілген оттегі зерттелді. Осы параметрлердің елеулі ауытқуы судың шығарылу режиміне және ихтиофаунаның алуантүрлілік құрылымын анықтауға байланысты. Алынған мәліметтерге қарағанда, морфометриялық көрсеткіштердің көпшілігінде өзгергіштіктер анықталған жоқ. Бұрынғыға қарағанда, аталық және аналықтары өздерінің ұрпақтарына ұзақ уақыт бойы қамқорлық жасайтыны байқалды. Линейлік өсу жылдамдығы (денесінің ұзындығының өсуі) бұрынғы көрсетілген мәліметтерге қарағанда төмен. Уылдырық шашуы порционды, Сырдария өзенінде уылдырықты 2-3 рет шашады, көктемнен жазғы уақытқа дейінгі аралықта. Жыныстық жетілу кезеңінде минималды дене ұзындығы 280 мм құрайды. Өзеннің

төменгі ағысындағы жерлерде жыланбас балығы жергілікті жыртқыш балықтардың қорегіне бәсекелес болып табылады. Қазіргі уақытта, жыланбас балықтар Сырдария өзенінде үнемі тіршілік ететін түрлердің бірі болып табылады.

Түйін сөздер: *Channa argus*, амур жыланбас, Сырдарья, морфология, биология.

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Новые данные по морфометрии и биологии чужеродного змееголова *Channa argus* в р. Сырдарья

Амурский змееголов *Channa argus* (Cantor, 1842) был ненамеренно вселен в бассейн Аральского моря в начале 1960-х годов. Этот вид считается одним из наиболее опасных вселенцев. Кроме того, обилие и состояние чужеродных видов могут служить индикаторами состояния водоемов и источниками их неблагополучия. Целью проведенной работы являлось изучение морфологической изменчивости и биологических характеристик змееголова в сравнении с ранним периодом натурализации в этом бассейне. Для отлова рыб применялись стандартные орудия лова. Показано, что крючковая снасть обладает большой селективностью в отношении данного вида. Также изучались основные характеристики среды обитания – температура, мутность, рН, содержание растворенного в воде кислорода. Изменение этих параметров зависит от режима попусков воды в р.Сырдарья и влияет на состояние сообщества рыб. В сравнении с данными предыдущих авторов не выявлено существенных изменений морфометрических показателей. Биологической особенностью является более продолжительный, чем это предполагалось ранее, период заботы взрослых особей о своем потомстве. Скорость линейного роста оказалась меньше, чем в ранних источниках. Нерест порционный, в р.Сырдарья проходит 2-3 раза в течение лета. Минимальный размер тела при достижении половой зрелости составляет около 280 мм. На изученном участке р.Сырдарья змееголов является конкурентом в питании местных хищных видов рыб. В настоящее время змееголов стал одним из постоянных членов сообщества рыб реки Сырдарья.

Ключевые слова: *Channa argus*, амурский змееголов, Сырдарья, морфология, биология.

Introduction

Non-indigenous species have become a widespread and significant component of human-induced global environmental change, and are having a major impact on the Earth's ecosystems (Biological invasions..., 2004:1-436; Simberloff et al., 2013:58-66). Alien species do significant impact to aquatic and terrestrial ecosystems. The chief factors affecting fish in watersheds around the world are habitat loss and species introductions, followed by chemical pollution, hybridization, and overharvesting (Allan, Flecker, 1993: 32-43; Saunders et al., 2002: 30-41; Closs et al., 2016: 37-75). Exotic fishes are widely recognized as a major disturbance agent for native fish. Evaluating the ecological effects of invaders presents many challenges and the problem is greatly augmented in parts of the world where the native fauna is poorly known and where exotic species are commonplace (Pascual et al., 2002:101–113).

The integrity of aquatic ecosystems was disturbed worldwide after intentional and

unintentional introductions and invasions (Moyle, Light, 1996: 149-161; Riccardi, MacIsaac, 2011: 211-224). Biological invasions have become numerous in freshwaters around the world. As a result, many bodies of fresh water now contain dozens of alien species. Alien fishes disrupt the food web from its apex or centre. Alien species create “no-analogue” ecosystems that will be difficult to manage in the future. Interactions between alien species and other contemporary stressors of fresh water ecosystems are strong and varied. Because disturbance is generally thought to favour invasions, stressed ecosystems may be especially susceptible to invasions, as are highly artificial ecosystems. In turn, alien species can strongly alter the hydrology, biogeochemical cycling, and biotic composition of invaded ecosystems, and thus modulate the effects of other stressors (Strayer, 2010: 152-174; Riccardi, MacIsaac, 2011: 211-224). Matsuzaki et al. (2013: 1071–1082) demonstrated that both exotic and translocated species may change functional diversity and functional group composition, which

might have dramatic consequences for ecosystem processes.

Native fish fauna of the basin of the Aral Sea was drastically changed during second part of the XX-th century after unreasonable water management and introduction of alien fishes (Ermakhanov et al., 2012:3-9). The Amur (or northern) snakehead, *Channa argus* (Cantor, 1842), was unintentionally introduced in the Aral basin in 1961-1963 (Doukravets, Mitrofanov, 1992: 6-44). This fish species now distributed worldwide and considered as a dangerous invader (Courtenay, Williams, 2004: 1-143; Gascho Landis et al., 2011:123-131).

Biological and phenotypic plasticity, namely the ability of an organism to express different phenotypes from a single genotype in response to its environment, can help to understand how well is state of fish populations (Willis et al., 2005: 284-295; Pérez-Rodríguez et al., 2013: 62-70). Therefore we conducted this investigation of Amur snakehead in the Syrdarya River.

Materials and methods

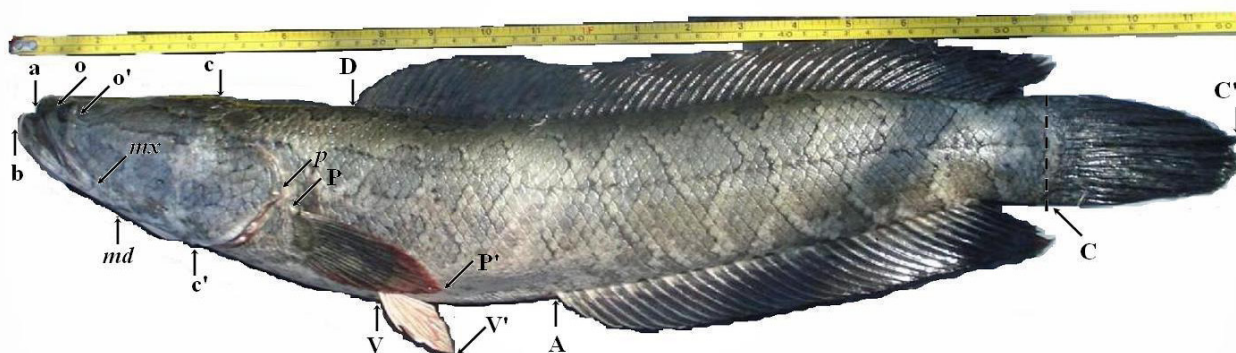
The investigation was carried out in the Kargaly State Wildlife Sanctuary located on the Syrdarya River southward of the Shiili town (the cordon situated at 43°57'52.2» N, 66°48'52.5» E). Fishes for the examination were caught using hook fishing tackles and gill nets 25 length and mesh sizes from 30 to 60 mm.

Data were collected in summer time 2014-2017. Physical and chemical water characteristics were

assessed by the most common methods (Unified..., 1973: 1-346; Handbook..., 1977:1-541). Turbidity of the water was determined using a turbidimeter HI 93703 «Hanna Instruments», salinity, temperature and pH – using joint device of the same manufacturer HI 98129. The color and odor of the water were determined organoleptic.

Morphological analysis of fishes was performed using materials fixed in 4% neutral formalin as it was described by I.F.Pravdin (Pravdin, 1966:1-376). Common scheme of morphometric analysis is presented on figure 1. The following clearly distinguishable countable characters were examined as the number of gill rakers on the first arch (Sp.br.); total number of vertebrae (Vert.); scales in the lateral line (l.l.); scales above lateral line and scales below lateral line; sharpen and branched rays in the dorsal fin (D total); sharpen and branched rays in the anal (A total), pectoral (P) and pelvic (V) fins. All vertebrae were counted including the last one bearing the hypurale bone. The last branched ray in the second dorsal and anal fins, which in some fishes looks like two separate rays, was counted as one if its main branches grew from the same base. The last ray in the pectoral and pelvic fins was always included in the number of branched rays even if it was not branched.

Total length (L, in mm), body length without caudal fin (l, in mm), total weight (Q, in g), and body weight without inner organs (q, in g) was measured. Fulton's condition factor was calculated by I.F.Pravdin (Pravdin, 1966:1-376).



aC' = total length (L); aC= body length or standard length (l); ao – snout length (ao); oo' – horizontal length of orbit (o); o'p= postorbital head length (op); ap= head length (c); cp' = head depth at the level of occiput (hc); amx = upper jaw length (mx); bmd = lower jaw length (md); aD = predorsal length (aD); aV = preventral length (aV); aA = preanal length (aA); A'c = length of the caudal peduncle (ca); AA' = length of the base of the anal fin (lA); AZ = height of the anal fin (hA); PP' = length of the pectoral fin (lP); VV' = length of the pelvic fin (lV); VA = pelvic base to anal origin length (VA).
ID – base of dorsal fin, hD – depth of dorsal fin

Figure 1 – Scheme of morphometric measurements:

Results and discussion

Snakeheads were one of the regular fish species in a big meander situated in the Kargaly State Wildlife Sanctuary. The length of the meander was about 7 km with maximal width about 300 m and depth about 4

m. The meander kept connection with the river and so there was running water there. Volume of water in the Syrdarya River is regulated with several irrigation dams situated over Kargaly State Wildlife Sanctuary and depended on precipitation and cropland area. Some water characteristics are given in table 1.

Table 1 – Abiotic characteristics of water in the meander, 2014-2017

Year	Abiotic characteristics of water					
	Color	°C (14-16 p.m.)	Turbidity, FTU	pH	Dissolved oxygen, mg per dm ³	Dissolved matter, mg per dm ³
2014	brown-green	26.5-27.3	13.00	6.8-7.2	7.9-8.0	691
2015	green	25.1-29.0	9.12	6.5-7.2	6.7-8.0	563
2016	green	27.8-28.2	12.61	6.9-7.2	7.2-7.7	691
2017	blue-green	25.1-27.2	8.31	7.4-7.5	No data	603

Snakehead lived there together with various native and alien fish species. Pike *Esox lucius* Linnaeus, 1758; roach *Rutilus rutilus* (Linnaeus, 1758); Syrdarya dace *Squalius squaliusculus* (Kessler, 1874); redeye *Scardinius erythrophthalmus* (Linnaeus, 1758); Aral shemaya *Alburnus (Chalcalburnus) chalcoides aralensis* (Berg, 1923); stripped bystryanka *Alburnoides taenatus* (Kessler, 1872); asp *Aspius aspius* (Linnaeus, 1758); eastern bream *Abramis brama orientalis* Berg, 1949; Aral white-eye *Abramis sapa aralensis* Tiapkin, 1939; sabrefish *Pelecus cultratus* (Linnaeus, 1758); goldfish *Carassius gibelio* (Bloch, 1782); carp *Cyprinus carpio* Linnaeus, 1758; perch *Perca fluviatilis* Linnaeus, 1758 and sander (pike-perch) *Sander lucioperca* (Linnaeus, 1758) are the indigenous for the Syrdarya River. Alien fish species were grass carp *Ctenopharyngodon idella* (Valenciennes, 1844), silver carp *Hypophthalmichthys molitrix* (Valenciennes, 1844), false gudgeon *Abbottina rivularis* (Basilewsky, 1855), topmouth gudgeon (pseudorasbora) *Pseudorasbora parva* (Temminck et Schlegel, 1846), sawbelly *Hemiculter leucisculus* (Basilewsky, 1855), rosy bitterling *Rhodeus ocellatus* (Kner, 1866), mosquitofish *Gambusia holbrooki* (Girard, 1859), Chinese medaka (or ricefish) *Orizias sinensis* Chen, Uwa et Chu, 1989; beautiful sleeper *Micropercops cinctus* (Dabry de Thiersant, 1872); Chinese goby *Rhinogobius cheni* (Nichols, 1931). All revealed fish species were presented by adults as well as young fishes that indicated their satisfactory survival rate in the present conditions.

Snakehead is single predatory among alien fish species. Native predators are pike, asp, sander, and

perch is an omnivorous fish. Examination of the feeding revealed prevalence of the indigenous fish species like roach, goldfish and carp. In contrast with indigenous piscivorous fishes, snakehead prefers hunting close to shoreline and willingly eats died fishes. This particularity allows selective angling of snakehead using bits of fishes for lure. 16 specimens were snakeheads from 18 fishes that were caught using this lure. Native piscivorous fishes like pike-perch and pike were caught too. In contrast with native piscivorous high water temperature (about 28 °C) did not diminish engorgement of snakeheads. These fishes did not stop hunter in any time of summer days. Snakeheads took the baits, and we observed hunting fishes in many shallow sites.

Structure of the population of snakehead consisted from fishes of the different ages and included adult fishes as well as young ones. That indicated suitable environment for snakehead reproduction. In the Amur River basin the fishes become mature in the 2 years old and more than 300 mm of body length (Nicol'sky, 1956: 1-551). The same happened in the Syr Darya. There snakeheads were able to spawn up to five times per year (Nicol'sky, 1956: 1-551). We can suggest that snakeheads can spawn about three times per year that correspond to the early data (Doukravets, 1992:286-316).

Maximal body length of the fishes from our catches was 600 mm that less that is known for the native area (maximal total length = 100 cm by Novikov et al., 2002: 1-552). Therefore living conditions did not forward to long life span of snakeheads in the Syrdarya River.

In the Syr Darya basin the grow rate was less than those for fish from its native range in the Amur River basin for the first ages of life, but after reaching sexual maturity it begin to match the

growth rates of fish in the native range as was shown previously by Dukravets and Machulin (Dukravets, Machulin, 1978:222-228). Our data show that now Amur snakeheads grew slowly (Table 2, figure 2).

Table 2 – Body length growth of snakeheads (mm)

Statistics	Age, years					Authors, water body
	0	1	2	3	4	
Minimum	102	147	226	314	435	Our data 2012-2017, running-water meander on Syr Darya River
Maximum	120	191	276	399	440	
M, average	114	173	255	349	438	
±m, mean deviation	4.7	10.6	10.7	20.3	2.4	
±s, standard deviation	6.6	13.8	14.4	27.6	2.7	
number of fishes	6	9	9	8	5	
Minimum	138	236	318	385	440	Ereschenko, 1970:1-292; Khalmatov, 1972:264-266; Doukravets, Machulin, 1978:203-208 Doukravets, 1992: 286-316; Syr Darya watershed
Maximum	229	435	520	605	685	
Minimum	225	340	435	519	583	Nicol'sky, 1956: 1-551 the Amur watershed
Maximum	245	366	461	554	615	

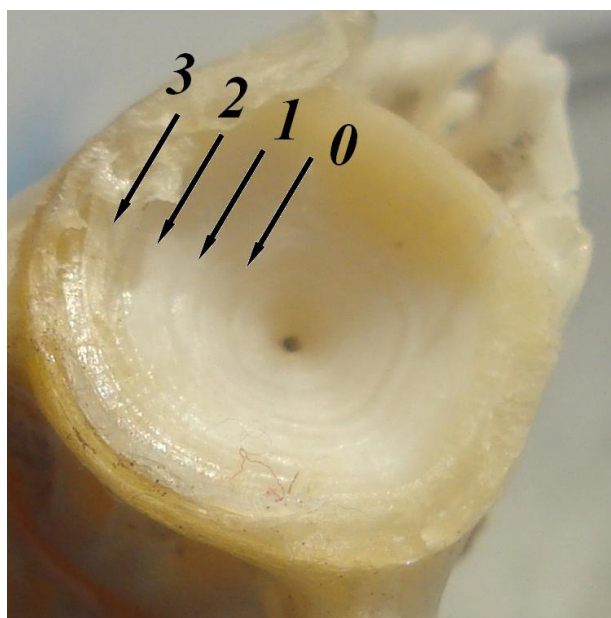


Figure 2 – The vertebra of snakehead 435 mm body length, July 2017, year rings are pointed

Snakeheads care about their baby fishes (Berg, 1949: ; Gouseva, Zholdasova, 1986:98-134; Popova, 2003:141-144; Gascho Landis et al., 2011: 123-

131). However participation of parents is disputable. Some authors (Nicol'sky, 1956:1-551; Doukravets, 1992:286-316) wrote that only male care about eggs and babies. Other authors (Soin, 1960:127-137; Gouseva, Zholdasova, 1986:98-134) suggested both parents care about young fishes. We observed how two big snakeheads take care about their young fishes when those fed in shallow waters. When observer tried to come closer to shoreline all fishes quickly run to brush of *Vallisneria* at the depth about 1.5 m. The big fishes came to the surface after about 3-5 minutes. If any peril was not observed, the young fishes started to feed again. In incomprehensible situation adult fishes carried young ones from the shoreline and hang up on the border of visibility near to the water surface. After that young fishes periodically came to the water surface to swallow air and quickly went back to the deep (Figure 3). Therefore, it was revealed that adult fishes protect their babies much longer that was known previous (Popova, 2003: 141-144).

Comparative analysis of morphological features of the snakehead did not reveal neither significant shifts nor reduction of variability in time and space of population in the Syr Darya river (table 3).

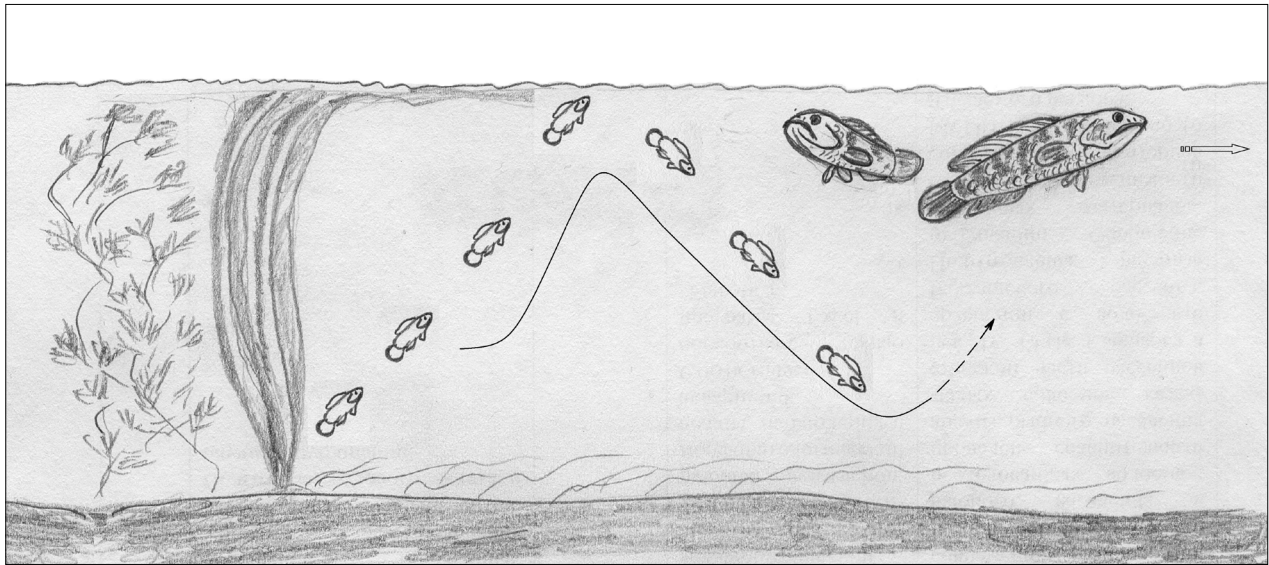


Figure 3 – Care of adult snakeheads on their baby fishes (original picture)

Table 3 – Features of snakehead from different samples

Features	Our data						Aral watershed (Doukravets, 1992)		Amur (Nicol'sky, 1956)	
	min	max	Mean	$\pm m$	$\pm s$	CV	min	max	min	max
l	2	3	4	5	6	7	8	9	10	11
L, mm	182.5	600	401.7	94.63	120.17	29.92				
lst, mm	153	515	339.2	82.05	103.91	30.63		770		745
Q, g	57.45	1300	602.2	291.82	371.55	61.70		6600		
q, g	53.53	1200	627.9	336.56	403.44	64.25				
Fulton	0.90	1.67	1.23	0.214	0.253	20.63			No data	
Clark	0.88	1.47	1.17	0.192	0.220	18.86			No data	
Counted										
l.l.	62	70	66.3	1.58	1.98	2.989	60	72	60	75
l.l.ca	3	7	5.4	0.92	1.16	21.33			no data	
l.l.s	8	10	9.0	0.53	0.76	8.399	8	12	no data	
l.l.in	15	22	18.5	2.36	2.64	14.26	16	26	no data	
D total	43	54	50.1	2.53	3.28	6.547	47	54.5	49	54
A total	28	35	33.4	1.23	1.78	5.327	30	38	32	38
P	17	22	18.3	0.89	1.28	7.007	16	19	no data	
V	6	8	6.1	0.25	0.52	8.42	no data		no data	
sp.br	8	13	9.7	0.92	1.28	13.15	no data		10	12
Vert	45	60	54.4	3.35	4.14	7.616	50	60	no data	
in % from lst:										
aD	32.9	39.2	34.9	1.31	1.74	4.98	26.3	38.1	34.4	41.7
pD	3.2	5.9	4.5	0.48	0.67	15.04	3.2	10.6	no data	
aA	50.8	60.4	54.1	2.20	2.79	5.17	49.8	60.9	no data	
aV	37.0	47.4	40.2	1.96	2.69	6.69	35.0	42.6	no data	

Continuation of Table 3

Features	Our data						Aral watershed (Doukravets, 1992)		Amur (Nikol'sky, 1956)	
	min	max	Mean	±m	±s	CV	min	max	min	max
l	2	3	4	5	6	7	8	9	10	11
aP	31.1	87.6	36.8	7.01	14.21	38.61	no data		no data	
PV	10.0	14.9	12.2	0.86	1.29	10.65	9.3	16.1	12.4	13.4
VA	12.5	15.8	14.2	0.79	0.98	6.89	11.1	20.0	no data	
lca	4.2	7.8	6.1	0.61	0.86	14.12	4.5	11.4	8.2	9.6
lc	30.1	36.9	32.3	1.57	2.01	6.20	24.7	34.9	29.4	36.6
ao	4.9	7.2	5.5	0.34	0.53	9.52	4.0	8.1	5.9	9.3
oh	2.3	4.6	3.1	0.53	0.69	21.89	1.5	3.9	2.3	7.1
ov	2.1	4.6	3.4	0.55	0.83	24.24	no data		no data	
op	23.2	26.1	24.5	0.79	1.00	4.09	17.4	24.1	22.1	22.9
l mx	11.7	14.1	12.8	0.48	0.61	4.74	11.0	14.2	no data	
l md	14.2	18.5	16.5	1.13	1.38	8.37	no data		no data	
h co	5.3	10.5	7.6	0.76	1.17	15.33	no data		no data	
h c	12.2	18.8	14.5	1.44	1.80	12.37	12.3	17.4	no data	
io	5.3	7.5	6.0	0.46	0.60	9.94	4.5	7.2	6.1	9.0
H	15.2	22.1	17.9	1.86	2.21	12.35	15.5	25.1	18.2	19.8
h	8.0	9.9	9.0	0.35	0.48	5.29	8.1	11.0	9.4	10.1
l D	57.3	62.5	59.8	1.16	1.51	2.52	48.1	64.8	53.7	60.8
h D	6.4	14.9	8.6	1.67	2.31	26.71	4.8	10.5	8.2	10.3
l A	36.7	42.5	39.4	1.01	1.43	3.63	31.8	43.7	34.1	40.1
h A	6.3	13.1	8.6	1.32	1.85	21.50	5.0	12.7	8.6	11.1
l P	12.6	18.1	15.3	1.03	1.43	9.37	11.3	17.2	14.5	16.6
l V	8.3	11.4	9.4	0.66	0.89	9.39	6.9	11.0	8.0	10.0
l Cm	15.9	19.7	18.2	0.91	1.14	6.27			13.0	14.8

Conclusion

The population of snakehead was presented by adult and young fishes. Growth rate was slowly than in the first time of naturalization. Comparative analysis of morphological features did not reveal neither significant shifts nor reduction of variability of population in the Syr Darya river

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