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ALIEN FISH SPECIES IN THE KARGALY STATE WILDLIFE SANCTUARY (THE SYRDRAYA RIVER, REPUBLIC OF KAZAKHSTAN)

Abstract. The Syrdarya river is one of the main rivers of Central Asia. A sharp ecological crisis happened here at the last quarter of the XX century as a result of irrational water use. Government of the Republic of Kazakhstan undertakes some measures to mitigate ecological situation in the region. Presence of alien fish species considered as an indicator of environment changes. Our research was conducted during 2015-2017 in the Kargaly state wildlife sanctuary for evaluate modern diversity and dynamics of alien fish species without fishery press. This preserve is situated at a typical segment of floodplain part of the Syrdarya river. Two main types of fluvial biotopes as a circulating lake in former riverbed and river *per se* were investigated. Conventional methods of water and fish investigations were used. Water temperature, turbidity, pH, mineralization, concentrations of dissolved oxygen and some heavy metals (*Fe, Cu, Cd, Pb*) were investigated. Significant variability of these physical and chemical parameters depended from precipitation and flood regulation, and strongly impact on fish communities. 14 indigenous and 11 alien fish species were discovered. Alien fish species were presented by white amur *Ctenopharyngodon idella*, silver carp *Hypophthalmichthys molitrix*, abbottina (or false gudgeon) *Abbottina rivularis*, pseudorasbora [or stone moroco, or topmouth gudgeon] *Pseudorasbora parva*, sawbelly *Hemiculter leucisculus*, bitterling *Rhodeus ocellatus*, gambusia [or mosquitofish] *Gambusia holbrooki*, chinese medaka *Orizias sinensis*; eleotris [or beautiful sleeper] *Micropercops cinctus*; goby fish *Rhinogobius cheni*; and snakehead *Channa argus*. There all alien fish species were presented as well by adult as young individuals that indicated quite favorable living conditions for them. Heterogeneity of fish distribution was revealed as a result of their environmental plasticity. Variability of fish number and species composition depend upon flood regimen. Indigenous piscivorous fish species effectively control alien others. Unstable and unlike to natural flood regimen is more favorable for alien fish species.

Key words: fishes, fauna, indigenous, alien, Syrdarya river, Kargaly State Wildlife Sanctuary, abiotic conditions.

Introduction. During the first half of the last century the Aral-Syrdarya watershed was one of the most important fishery regions not only for the Republic of Kazakhstan, but for the former USSR too [1]. First introductions of fishes from the Caspian basin had been done in 1930-thes and were failed. Second introduction of the grass carp, black carp, silver carp, spotted silver carp was provided from the Amur river basin in 1960-thes and accompanied with introduction of some other unintentional fish species. G.M.Doukravets and V.P.Mitrofanov gave detailed description of the history of fish introductions for the periods of sustainable hydrological regiment of the Syrdarya river and before crisis [2]. Crop production became the priority for the region in the second part of the XX century. Irrational use of waters of the Syrdarya and Amudarya rivers lead to flow reduction, the surface of the Aral Sea decrease and drastic changes in ecosystems of the region that was named as ecological catastrophe or ecological crisis [3-6]. In the first decade of the XXI century the Government of the Republic of Kazakhstan realized some actions for reduce the problem and now the flow of the Syrdarya river exceeds the evaporation. In the Kazakhstan

sector of the river several nature protected areas has been created for rehabilitation of flood-plain ecosystems and conservation of native biodiversity [5-7].

It is known that richness and diversity of alien fish species can be a result of disturbances of freshwater ecosystems as well as its cause [8, 9]. Generally, biological invasions are considered as an unfavorable factor for native fish fauna [10, 11]. However, the impact of each alien fish species should be assessed singly [12]. So that investigation of modern diversity of alien fish species in the Syrdarya river is scientifically interesting and important for efficient management of fish resources and protection of native fish fauna.

Fishery selectively impacts on fish fauna by catching the biggest fishes which play important role in food webs. This kind of human activity is prohibited in state wildlife reserves and so there is possible to evaluate indirect human impacts as water pollution, soil erosion, and alien fish species to water biota. An evaluation of diversity and relative abundance of alien fish species in the Kargaly State Wildlife Sanctuary (KR) was the aim of our investigation.

Materials and Methods. KR located on the Syrdarya river southward of the Shiili town. Coordinates of the cordon are 43°57'52.2" N, 66°48'52.5" E. The protection of flood-plain vegetation is the general purpose of the KR. Protected site is typical for the plain segment of the Syrdarya river. The river bed is bended and creates some floodplain lakes. Hydrological regimen of the site is completely regulated with irrigation dams and is not purposed for any other aims.

Data were collected in summer time 2015-2017. Physical and chemical water characteristics were assessed by the most common methods [13, 14]. Turbidity of the water was determined using a turbiditymeter HI 93703 "Hanna Instruments", salinity, temperature and pH – using joint device of the same manufacturer HI 98129. The color of the water was determined visually, the odor was organoleptic. The content of individual elements in water samples was determined by inductively coupled plasma mass spectrometry (ICP-MS) in accordance with [15, 16].

Drag net 15 m length with 3 mm mesh size, gill nets 25 length and mesh sizes from 16 to 100 mm, hook fishing tackles were used for fish catches. The precise quantitative evaluation of fishes cannot be realized for any big lake or river [17], and so one site on the main stream and a site on the floodplain lake were chosen for investigation of dynamics of fishes. The main criteria for the sites choice were the ability to provide total fish catchment and presence of alien fish species in the first year of investigation.

The names for many common fish species were given according to the FishBase [18]. Local subspecies, which taxonomical status has not been revised, were given under original names. Fishes analysis was done according to the most common scheme by I.F.Pravdin [19]. Big fishes with total weight about 1kg and more were investigated at the catchment site, smaller fishes were fixed in 4% formaldehyde and then analyzed in the laboratory. The age of fish in the samples was determined from analysis of scales and vertebrae [20, 21].

Some indexes of fish assemblages were used as: N – total number of fishes per 100 m^2, S – number of species (richness), D – Simpson's index of diversity, E – Simpsons's index of uniformity, H – Shennon's index, e – Pielou's index of uniformity [22]. Indigenous and alien fish species were counted. Binary logarithm was used for Shennon's and Pielou's indexes calculating.

Results and discussion. Volume of water in the Syrdarya river in the KR is regulated with irrigation dams and depended on precipitation and cropland area. During the investigation period the least level of water was observed in 2015 and the maximal in 2017. The data presented in the table 1 show significant fluctuation of the main characteristics in different years. In the all investigated samples of water concentrations of *Fe, Cu, Cd* and *Pb* did not exceed the maximal permissible concentration for fishery water bodies.

Fish fauna of the KR were presented by native fish species as well as some alien. Indigenous fish species here are pike *Esox lucius* Linnaeus, 1758; roach *Rutilus rutilus* (Linnaeus, 1758); Syrdarya dace *Squalius squaliusculus* (Kessler, 1874); redeye *Scardinius erythrophthalmus* (Linnaeus, 1758); Aral shemaya *Alburus (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).

Table 1 – General characteristics of water biotopes in 2015-2017

Biotope	Year	Water characteristics					
		Color	Temperature, °C	Turbidity, FTU	pH	Mineralistion, ppm	Dissolved oxygen, ppm
Main stream	2015	clear brown	26.1-29.3	79-81	6.5-8.2	540-602	6.02-8.16
	2016	clear brown	29.3	94	6.7-8.0	598-602	6.58-7.14
	2017	brown	26.1	101	6.9-7.1	540-543	No data
Flood-plain lake	2015	green	25.1-29.0	9.12	6.5-7.2	563	6.70-8.03
	2016	blue green	24.3-29.0	12.61	7.0-7.2	691	7.21-7.72
	2017	blue green	27.8-28.2	8.31	7.4-7.5	603	No data

Alien fish species are 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), ocellated bitterling *Rhodeus ocellatus* (Kner, 1866), mosquitofish *Gambusia holbrooki* (Girard, 1859), Chinase medaka (or ricefish) *Orizias sinensis* Chen, Uwa et Chu, 1989; beautiful sleeper *Micropercops cinctus* (Dabry de Thiersant, 1872); Chinese goby *Rhinogobius cheni* (Nichols, 1931); snakehead *Channa argus* (Cantor, 1842). All revealed fish species were presented by adults as well as young fishes that indicated their satisfactory survival rate in the present conditions.

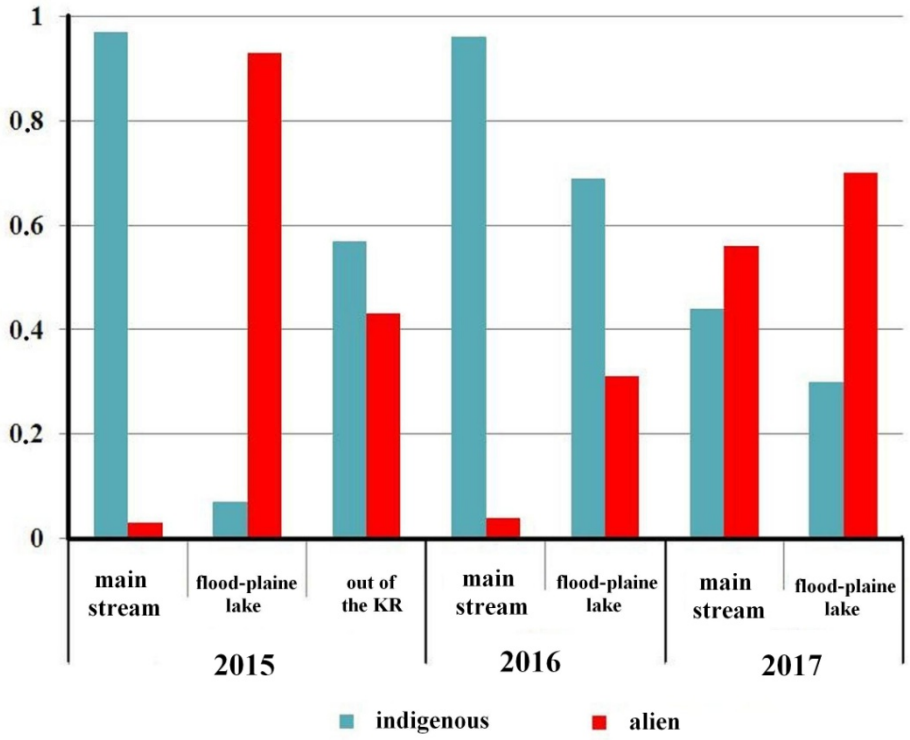
Table 2 – Indexes of young fish assemblages in the KR 2015-2017

Indexes	2015 год			2016 год		2017 год	
	Main stream	Flood-plain lake	Out of the KR	Main stream	Flood-plain lake	Main stream	Flood-plain lake
Number of indigenous fishes:							
Goldfish	0	0	19	1	2	2	8
Carp	0	0	0	3	0	0	0
Roach	30	1	14	21	15	30	12
Bystyanka	0	0	0	0	3	0	0
Sabrefish	0	0	0	0	0	0	3
Asp	2	1	0	19	11	4	0
Perch	0	0	0	3	0	0	0
Pike-perch	6	0	0	0	0	0	0
Number of alien fishes:							
Abbottina	1	0	3	0	0	0	0
Pseudorasbora	0	1	2	0	4	26	15
Bitterling	0	0	11	0	0	1	1
Sawbelly	0	0	0	0	0	0	15
Silver carp	0	0	0	1	2	0	0
Medaka	0	0	1	0	0	10	11
Chinese goby	0	26	1	1	6	2	10
Beautiful sleeper	0	0	7	0	2	6	2
Indexes:							
S, species	4	4	8	7	8	8	9
N, individuals	39	29	58	49	45	81	77
D	1.62	1.24	4.53	2.92	4.83	3.78	6.64
E	0.40	0.31	0.57	0.42	0.60	0.42	0.74
H (log_2)	1.06	0.64	2.44	1.89	2.58	2.19	2.86
e (log_2)	0.53	0.32	0.81	0.67	0.86	0.69	0.90

Maximal age of investigated pseudorasbora was 3 years old, false gudgeon, ocellated bitterling and mosquitofish - 2 years old, medaka, beautiful sleeper and goby – only 1 year old. It is less that is known for these species form native range [23]. So that, we can suppose an effective control of lifespan of these alien fish species doing by indigenous predatory fish species.

Spotted silver carp *Aristichthys nobilis* (Richardson, 1845), black amur *Mylopharyngodon piceus* (Richardson, 1846), anabarillius *Anabarilius polylepis* (Regan, 1904) and three-lips *Opsariichthys uncirostris* (Temminck et Schlegel, 1846) were known in the basin [2, 24], but were not revealed in boundaries of the KR. Spotted silver carp and black amur are commercially valuable fish species, and never been usual in the Kazakhstan part of the river [2]. For the Syrdarya river *Anabarilius polylepis* only once had been mentioned by V.E.Karpov [24 – p.156]. Most probably naturalization of this species did not happen. Unintentional introduction of three-lips in the Syrdarya watershed was the result of neglecting introduction of grass carp and silver carp from water bodies of China [25, 26]. This fish species was revealed in the all Kazakhstan segment of the river, but only by 1-2 specimens for every case [27].

Indexes of young fish assemblages in shallow places of the river and floodplain lake are presented in the table 2. Young roaches and asps dominated in the shore zone of the river in relatively water-short 2015 and 2016, but in high-water 2017 there dominated alien pseudorasbora. Young fishes of indigenous roach and alien Chinese goby dominated in the shallows of the flood-plain lake. Only alien fish species dominated there in 2017 (figure).



Indigenous and alien fish ratio in 2015-2017

Adult indigenous fishes like roach, asp, sabrefish as well as their baby fishes each year dominated at the depth from 1 and 5-10 m far away from the shore in spite of dominance of alien fishes in the shallow waters. Only snakehead as alien fish species was able to live in the depth water. It was only one alien piscivorous fish that inhabited waters in the KR. Snakeheads were observed in the floodplain lake every year during the investigations. 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. 18 fishes were caught using this lure and 16 from them were snakeheads, 2 indigenous piscivorous fishes like pike-perch and pike were caught too.

Table 3 – Adaptive abilities of alien fish species in the Syrdarya river

Fish species	Biotopes	Maximal temperature, °C		Maximal turbidity, FTU		Absence of water plants	
		juv.	adult	juv.	adult	juv.	adult
Grass carp	LC	28	28	9.12	81	I	0
Silver carp	RLC	28	32	9.12	9.12	I	S
Bitterling	RLTC	32	32	101	101	S	S
Pseudorasbora	LTC	34	34	101	101	S	S
Abbottina	LTC	34	34	81	81	S	S
Mosquito fish	LC	34	34	81	81	0	0
Ricefish	LC	34	34	81	101	0	0
Beautiful sleeper	LTC	34	34	81	101	0	S
Snakehead	RLC	32	32	12.61	81	0	I
Chinese goby	RLC	34	34	101	101	S	S

Note. Fishes: juv. - baby fishes, adult - adult fishes. Biotopes: L - lentic, R - main stream, T - tributaries and branches, C - canals. Occurence: U - usual, S -seldom; I - infrequent; 0 - did not revealed.

Some environmental conditions were investigated to better comprehension particularities of fish distribution in the river and adaptive abilities of alien fish species (table 3).

Presented data show that many of alien fish species are able to bear rather hot water from 28 to 34 °C and have tendency to inhabit lentic biotopes where living conditions are too hot for indigenous fish species. If water temperature fall down (in night time or flowage growing), indigenous piscivorous fishes, mostly asp, can effectively regulate the number of alien fishes at sites without aquatic plants and tree roots.

Interaction between alien and native fish fauna as well as cumulative impact of all stressors on the native fauna was weakly known until recently [9]. The obtained data allow clarify the cause of the sharp increase of number of alien fish species in the most water full year. High level of river during spring time creates wide spawning area for many of indigenous and alien fish species. Then water decrease leads to isolation many small water bodies in the high-water bed. Increase of temperature of water up to 28–32 °C results in elimination of indigenous fishes and gives advantages alien fishes like pseudorasbora, ricefish and goby fish. Subsequent scenario depends on flow volume:

1) Prolonged low level of water will lead to the fishes die (usually birds have time to eat up all the fishes) as that happened in 2015 and 2016, or

2) Repeated increase of water level and submergence of the small water bodies will give the alien fish species a chance to fully realize their ability to multiple spawning as that happened in 2017.

Indigenous alien fishes as asp and pike-perch can do an effective control of the number of alien fish species in uncovered and slightly covered by water plants sites, but their avoid thickly grassed shallow places.

Conclusions:

1. Fluctuating level of water in the Syrdarya river during summer season benefits alien fishes to spawn in flooded shallows.

2. Native piscivorous fish species are able doing an effective control of alien non-commercial fish species in uncovered sites of the main stream and lake.

Obtained data confirm heterogeneity and landscape-level impacts of non-native aquatic species that obliged society and scientists to scrutinize interaction between indigenous and alien fish species in the local scale for the further integration obtained knowledge for whole basin [28].

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ҚАРҒАЛЫ ҚОРЫҒЫНДАҒЫ БӨГДЕ БАЛЫҚ ТҮРЛЕРІ (ҚАЗАҚСТАН РЕСПУБЛИКАСЫ, СЫРДАРИЯ ӨЗЕНІ)

Аннотация. Сырдария өзені - Орталық Азиядағы ең маңызды өзендердің бірі. XX ғасырдың соңғы ширегінде су ресурстарын тиімсіз пайдалану нәтижесінде күрделі экологиялық дағдарыстар болды. Қазақстан Республикасының Үкіметі осы аймақтағы экологиялық жағдайларды жақсартуға бағытталған шаралар ұйымдастырады. Суқойма жағдайының көрсеткіштерінің бірі бөгде балық түрлерінің көптігі болып табылады. Сондықтанда 2015-2017 жылдары Қарғалы мемлекеттік табиғи қорық аумағындағы бөгде балық түрлерінің қазіргі алуантүрлілігіне және динамикасына, балық қауымдастық құрамына балық аулауды болдырмаудың әсері туралы зерттеулер жүргізілді. Бұл қорық өзеннің жазық ағынының сегментінде орналасқан. Тіршілік ету ортасының негізгі екі түрі зерттелді: өзен және ағынды өзендер. Су құрамын және балықты зерттеудің дәстүрлі әдістері пайдаланылды. Кейбір ауыр металдар (Fe, Cu, Cd, Pb) және температура, ластану, минералдану, pH, ерітілген оттегі зерттелді. Осы параметрлердің елеулі ауытқуы судың шығарылу режиміне және ихтиофаунаның алуантүрлілік құрылымын анықтауға байланысты. Мұнда барлығы 14 жергілікті және 11 бөгде балық түрлері кездесті. Бөгде балық түрлері ақ амур *Ctenopharyngodon idella*, ақ дөңмаңдай *Hypophthalmichthys molitrix*, жалған теңге - балық *Abbottina rivularis*, амур шабағы *Pseudorasbora parva*, құрлықұрсақ *Hemiculter leucisculus*, теңбіл кекіре *Rhodeus ocellatus*, гамбузия *Gambusia holbrooki*, медака *Orizias sinensis*; элеотрис *Micropercops cinctus*; бұзаубас балық *Rhinogobius cheni* және жыланбас - балықтары *Channa argus* кездесті. Барлық шабақтар және ересек бөгде балық түрлері көрсетілген, бұл олардың тіршілік етуіне қолайлы жағдайлардың бар екенін көрсетеді. Экологиялық пластинкада балықтың біркелкі бөлінбеуі анықталды. Түрлер мен особтар санының өзгергіштігі гидрологиялық режимге байланысты. Ашық суқоймаларда жергілікті жыртқыш балық түрлері бөгде балық түрлерінің санын тиімді пайдалануға мүмкіндік береді. Судың тұрақсыз режимі бөгде балық түрлеріне қолайлы болып табылады.

Түйін сөздер: балық, фауна, жергілікті, бөгде, Сырдария, Қарғалы мемлекеттік табиғи қорық, абиоти-калық фактор.

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ЧУЖЕРОДНЫЕ ВИДЫ РЫБ В КАРАГАЛИНСКОМ ЗАКАЗНИКЕ (РЕКА СЫРДАРЬЯ, РЕСПУБЛИКА КАЗАХСТАН)

Аннотация. Сырдарья является одной из важнейших рек Центральной Азии. В результате нерационального использования водных ресурсов в последней четверти двадцатого века здесь произошел острый экологический кризис. Правительство Республики Казахстан предпринимает меры, направленные на смягчение экологической ситуации в этом регионе. Обилие чужеродных видов рыб является одним из индикаторов состояния водоемов. В 2015-2017 годах было проведено изучение современного разнообразия и динамики чужеродных видов на территории Карагалинского государственного природного заказника, что позволяет избежать влияния промысла на сообщество рыб. Этот заказник расположен на сегменте равнинного течения реки. Были изучены два основных типа местообитаний – проточная старица и собственно река. Применялись традиционные методики изучения воды и рыб. Были изучены температура, мутность, минерализация, pH, содержание растворенного кислорода и некоторых тяжелых металлов (*Fe, Cu, Cd, Pb*). Существенные колебания данных параметров зависят от режима пропусков воды и определяют структуру разнообразия ихтиофауны. Всего здесь было обнаружено 14 аборигенных и 11 чужеродных видов рыб. Чужеродные виды представлены белым амуром *Ctenopharyngodon idella*, белым толстолобиком *Hypophthalmichthys molitrix*, абботтиной *Abbottina rivularis*, псевдорасборой *Pseudorasbora parva*, востроброшкой *Hemiculter leucisculus*, глазчатым горчаком *Rhodeus ocellatus*, гамбузией *Gambusia holbrooki*, медакой *Orizias sinensis*; элеотрисом *Micropercops cinctus*; бычком *Rhinogobius cheni* и змееголовом *Channa argus*. Все чужеродные виды представлены молодью и взрослыми особями, что указывает на благоприятные условия их существования. Неравномерность распределения рыб определяется их экологической пластичностью. Изменчивость числа видов и особей зависит от гидрологического режима. Аборигенные хищные виды рыб эффективно контролируют численность чужеродных на открытых участках водоемов. Нестабильный режим попусков воды благоприятствует чужеродным видам рыб.

Ключевые слова: рыбы, фауна, аборигенный, чужеродный, Сырдарья, Карагалинский государственный природный заказник, абиотические факторы.

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