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FAUNA, ECOLOGY AND TAXONOMY OF *CYPRINIFORMES* FISH HELMINTHS IN UZBEKISTAN

Erkinboy Shakarboev[1], *Feruza Safarova*[2], *Djalaliddin Azimov*[2], *Axmet Urimbetov*[1]

Address(es):
[1] The Institute of the Gene Pool of Plants and Animals of Uzbek Academy of Sciences, Bagishamol, 232, 100053, Tashkent, Uzbekistan, +998712890465.
[2] Tashkent State Agrarian University Nukus of Branch, Abdambetov, 361,230100, Nukus, Uzbekistan, +998612292509.

*Corresponding author: shakarboev@rambler.ru

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ABSTRACT

The purpose of the research was to study helminthofauna of fish *Cypriniformes* order in comparative aspect in artificial and natural water bodies and the clarification ways of formation of faunal assemblages and development of scientific bases of prevention of helminthiasis of fish. An extensive and systematic research of helminthofauna of fish water bodies of the order *Cypriniformes* of the northeast of Uzbekistan has realized and taxonomic and faunal analysis of detected parasites has also been carried out. Fauna of parasitic worms of *Cypriniformes* in ponds of diverse Syrdarya river shows 49 species, 18 species belongs to the class *Trematoda*, *Cestoda* class represents 13 species, class *Acanthocephala* 4 species and the class *Nematoda* 14 species. Analysis of biological properties and ecological specialty of *Cypriniformes* parasitic worms allows three types of helminth communities: 25 species parasitizing *Cypriniformes* as definitive hosts; 19 species parasitizing as intermediate hosts and 6 species parasitizing as a reservoir (paratenetic) hosts. *Dioctophyme renale* was registered first time in roach for the water bodies of the Syrdarya river. Ordinary carp, in our research, according to as host a new host *Nematode* of the *Raphidascaris acus* larvae. On the basis of factual data the environmental factors of the quantitative and qualitative composition of cyprinids helminthofauna in the northeast of Uzbekistan is reported.

Keywords: Helminths, trematode, cestode, nematode, acanthocephale, parasite fauna, ecology, taxonomy

INTRODUCTION

Helminths are certainly one of the most popular objects of study of the fauna of the Syrdarya River Basin. The Syrdarya River Basin is a natural geographic complex cross-border area, in which there is a variety of environmental conditions ponds. Currently, the Syrdarya basin has a high number of large reservoirs complexes that use hundreds of thousands hectares of area. Reservoirs are a new type of water bodies, characterized by specific and ecological conditions **(Majumder et al., 2015; Casey *et al.*, 2014; Jahantab *et al.*, 2014).** Due to intensive human activities related to the use of water resources, substantial qualitative and quantitative changes of biocenosis and the fish community has undergone. This inevitably of parasitic fish diseases leads to a decrease in the number of valuable species and the deterioration of the epizootic situation reservoirs. Parasitic diseases of fish not only cause significant economic losses associated with a decrease in fish productivity, but they are dangerous also to human health **(Lopes *et al.*, 2011; Osmanov 1975a).** Information on the fauna of fish helminthes in the region are reflected in various studies (**Artamoshin *et al.*, 1990; Osmanov, 1975a; Karimov, 2007).** To date, data from previous researchers significantly out of date, confirmed recent resumption of studies helminthes of fauna of the region **(Safarova et al., 2014; 2015)**. Based on the above it is actually a detailed study to ichthyic-parasitological of the current state of helminthes communities of their distribution within the various pools. The purpose of this study was to study of the helmintho-fauna of fish of the order of *Cypriniformes* in artificial and natural waters.

MATERIAL AND METHODS

Stationary studies were conducted in the period 2009-2014 in the water bodies of the Syrdarya basin (the Syrdarya River, the Chirchik River, Aydar-Arnasay lake system, Tuyabuguz reservoir and fish farms, "Balikchi", "Damachi" and "Tashkent fish farm"), in Syrdarya, Tashkent and Djizakh region. Collection and study of helminths of fish were conducted using appropriated methods described by **Jenkins *et al.* (1965)** and **Bykhovskaya-Pavlovskaya and Shcherbina (1985)**. In the study 2527 individuals of 15 species of *Cypriniformes* (*Cyprinidae* – 12, *Cobitidae* – 3) were analyzed. Besides, we carried out incomplete dissections of 1407 fish individuals and prepared 1561 temporary and permanent whole mounts. The cameral treatment and identification of *Trematoda* species was carried out at the Laboratory of General Parasitology of the Institute of Gene Pool of Plants and Animals of Uzbek Academy of Sciences. Helminth species were identified by using the Reference Guide of Freshwater Fishes **(Tonguthai, 1997; Ieshko *et al.*, 2012; Shigin, 1986; Khokhlova, 1986)** and the Catalogues **(Pugachev, 2002)**. The studies were conducted using a microscope type Olympus CK 2 (Olympus, Japan). The preparations were examined under the microscope LOMO MBI-3 and MBI-4 (Carl Zeiss, Germany), while the drawings were produced using the drawing tubes RA-4 and RA-5.

RESULTS AND DISCUSSION

Results of study detected, that the helminths of *Cypriniformes* from the basin of the Syrdarya (within Uzbekistan) currently present 49 species: 18 species of class *Trematoda*, 13 of *Cestoda*, 14 of *Nematoda* and 4 of *Acanthocephala* (Table 1). Class *Trematoda* represented in the studied basin 18 species belonging to the 5 orders and 9 families. The most numerous representatives were from order *Strigeida*. For class *Cestoda* representatives of the four orders – *Caryophyllida*, *Pseudophyllida*, *Proteocephalida* and *Cyclophyllida* were detected in the investigated region. There are 13 species found for *Cypriniformes*. The most widespread are the families *Caryophyllaeidae* (Leuckart, 1878) and *Dilepididae* (Fuhrmann, 1907) with four species each.

Table 1 Taxonomic composition of helminths parasitizing *Cypriniformes* in the studied region

Class	Order	Family	Species
Trematoda	Sanguinicolida	Sanguinicolidae	*Sanguinicola inermis* Plehn, 1905
	Clinostomida	Clinostomidae	*Clinostomum complanatum* Rud., 1819
	Fasciolida	Gorgoderidae	*Phyllodistomum elongatum* Nybelin, 1926
		Orientocreadiidae	*Orientocreadium siluri* Bychowsky et Dubinina, 1954
		Allocreadiidae	*Allocreadium isoporum* Looss, 1894; *A. transversale* Rudolphi, 1802
		Monorchidae	*Asymphylodora kubanicum* Issaitschikoff, 1923
	Strigeiida	Diplostomidae	*Diplostomum spathaceum* (Rud., 1819); *Tylodelphys clavata* (Nordmann, 1832); *Bolboforus confusus* (Krause, 1914); *Hysteromorpha triloba* Rudolphi, 1819; *Conodiplostomum perlatum* Ciurea, 1911; *Ornithodiplostomum scardinii* (Schulman, 1952); *Posthodiplostomum cuticola* Nardmann, 1832; *P. brevicaudatum* Nordmann, 1832
		Strigeidae	*Apharyngostrigea cornu* Zeder, 1800; *A. sogdiana* Pavlowsky et Anitschkov, 1923
	Bucephalida	Bucephalidae	*Rhipidocotyle campanula* Dujardin, 1845
Cestoda	Caryophyllidea	Caryophyllaeidae	*Caryophyllaeus laticeps* Pallas, 1781; *C. fimbriceps* Annenkova-Chlopina, 1919; *Biacetabulum appendiculatum* Szidat, 1937; *Khawia sinensis* Hsü, 1935
	Pseudophyllidea	Amphicotylidae	*Bathybothrium rectangulum* Bloch, 1782
		Bothriocephalidae	*Bothriocephalus opsariichthydis* Yamaguti, 1934
		Ligulidae	*Ligula intestinalis* Linnaeus, 1758; *Digramma interrupta* Cholodkovsky, 1914
	Proteocephalidea	Proteocephalidae	*Proteocephalus torulosus* Batsch, 1786
	Cyclophyllidea	Dilepididae	*Paradilepis scolecina* Rudolphi, 1819; *Gryporhynchus cheilancristrotus* Wedl, 1955; *G. pusillus* Nordman, 1832; *Dilepis unilateralis* Rudolphi, 1819
Nematoda	Trichocephalida	Capillariidae	*Capillaria tomentosa* Dujardin, 1843
	Dioctophymida	Dioctophymidae	*Dioctophyme renale* Goeze, 1782
	Spirurida	Rhabdochonidae	*Rhabdochona denudata* Dujardin, 1845; *R. gnedini* Skrjabin, 1946
		Desmidocercidae	*Desmidocercella numidica* Seurat, 1920
		Gnathostomidae	*Gnathostoma hispidum* Fedtschenko, 1872
		Camallanidae	*Camallanus truncatus* Rudolphi, 1814
		Philometridae	*Philometra ovata* Zeder, 1803; *Ph. abdominalis* Nybelin, 1928; *Ph. intestinalis* Dogiel et Bychowsky, 1934
	Ascaridida	Anisakidae	*Contracaecum spiculigerum* Rudolphi, 1809; *C. microcephalum* Rudolphi, 1819; *Porrocaecum reticulatum* Linstow, 1890; *Raphidascaris acus* Bloch, 1779
Acanthocephala	Neoacanthocephala	Neoechinorhynchidae	*Neoechinorhynchus rutili* Müller, 1780
	Echinorhynchida	Pomphorhynchidae	*Pomphorhynchus laevis* Müller, 1776
		Echinorhynchidae	*Acanthocephalus lucii* Müller, 1776; *A. anguillae* Müller, 1780

Other orders were represented by one or two common helminths species of *Cypriniformes*. Worthy of note are the findings of *Dioctophyme renale* Goeze, 1782 larvae III in *Cypriniformes* in the studied region. Previously this species were reported in many fish inhabiting water bodies along the Amydarya River and in the lower reaches of the Syrdarya River **(Spasskii, 1987; Osmanov, 1975 a,b)**. The greatest diversity of species of worms turned Syrdarya River waters (39), followed by the Chirchik River (15). The lowest number of helminths was recorded in the Aidar-Arnasay lake system (AALS), where only eight helminth species were found: 3 *Trematodes*, 2 *Cestodes* and 3 *Nematodes*. In our opinion, this is connected with peculiar ecological conditions in different water bodies (Table 2). Ten helminth species were found in the fish farms. At the same time prevalence and intensity of invasion varies widely.

Among of the registered helminths often frequently recorded pathogen species were *Sanguinicola inermis* Plehn, 1905, *Diplostomum spathaceum* Rudolphi, 1819, *Tylodelphys clavata* Nordmann, 1832, *Khawia sinensis* Hsü, 1935, *Bothriocephalus opsariichthydis* Yamaguti, 1934, *Ligula intestinalis* Linnaeus, 1758 larvae, *Digramma interrupta* Rudolphi, 1810 larvae and *Raphidascaris acus* Bloch, 1779 larvae. The poor diversity of the parasite fauna in *Cypriniformes* in landlocked water bodies and an almost complete absence of a number of specific parasites are undoubtedly associated with the process of acclimatization, where natural processes of the formation of respective groups of considered helminth hosts were disturbed.

Table 2 Distribution of helminths of *Cypriniformes* in the north-east of Uzbekistan (2009 – 2014)

Species	Mid-course of the Syrdarya River (n=600)			Chirchik River (n=547)			Aidar-Arnasay lake system			Fish farms (n=564)		
	A	B	C	A	B	C	A	B	C	A	B	C
Sanguinicola inermis Plehn, 1905	1.8	14.8	0.27	-	-	-	-	-	-	-	-	-
Clinostomum complanatum Rud., 1819	-	-	-	2.0	15.5	0.31	-	-	-	2.1	16.1	0.34
Phyllodistomum elongatum Nybelin, 1926	-	-	-	-	-	-	-	-	-	1.0	14.8	0.15
Orientocreadium siluri Bychowsky et Dubinina, 1954	-	-	-	1.0	26.8	0.29	-	-	-	-	-	-
Allocreadium isoporum Looss, 1894	0.83	31.6	0.26	0.91	33.4	0.30	-	-	-	-	-	-
A. transversale Rudolphi, 1802	2.0	16.5	0.33	-	-	-	-	-	-	-	-	-
Asymphylodora kubanicum Issaitschikoff, 1923	1.1	26.5	0.31	-	-	-	-	-	-	-	-	-
Diplostomum spathaceum (Rud., 1819)	2.6	14.4	0.38	2.1	17.4	0.38	1.5	19.0	0.30	1.9	17.0	0.33
Tylodelphys clavata (Nordmann, 1832)	1.5	21.8	0.32	-	-	-	-	-	-	-	-	-
Bolboforus confusus (Krause, 1914)	-	-	-	2.9	14.0	0.41	-	-	-	-	-	-
Hysteromorpha triloba Rudolphi, 1819	-	-	-	-	-	-	0.49	30.7	0.15	-	-	-
Conodiplostomum perlatum Ciurea, 1911	-	-	-	-	-	-	2.5	14.0	0.36	-	-	-
Ornithodiplostomum scardinii (Schulman, 1952)	-	-	-	2.0	18.6	0.37	-	-	-	-	-	-
Posthodiplostomum cuticola Nardmann, 1832	2.5	15.1	0.37	-	-	-	-	-	-	-	-	-
P. brevicaudatum Nordmann, 1832	-	-	-	1.64	20.7	0.34	-	-	-	-	-	-
Apharyngostrigea cornu Zeder, 1800	-	-	-	2.1	18.0	0.39	-	-	-	-	-	-
A. sogdiana Pavlowsky et Anitschkov, 1923	2.1	16.0	0.34	-	-	-	-	-	-	-	-	-
Rhipidocotyle campanula Dujardin, 1845	1.5	20.6	0.31	-	-	-	-	-	-	1.2	24.2	0.30
Caryophyllaeus laticeps Pallas, 1781	1.2	11.0	0.13	-	-	-	-	-	-	-	-	-
C. fimbriceps Chlopina, 1919	12.3	6.0	0.74	-	-	-	-	-	-	10.4	6.5	0.67
Biacetabulum appendiculatum Szidat, 1937	3.0	6.0	0.18	-	-	-	-	-	-	-	-	-
Khawia sinensis Hsü, 1935	2.5	6.6	0.16	2.4	6.7	0.15	-	-	-	2.5	6.6	0.16
Bathybothrium rectangulum Bloch, 1782	-	-	-	20.0	4.2	0.84	-	-	-	20.0	4.2	0.84
Bothriocephalus opsariichthydis Yamaguti, 1934	4.1	5.4	0.22	4.4	5.1	0.22	-	-	-	-	-	-
Ligula intestinalis Linnaeus, 1758	9.3	7.1	0.66	11.5	6.4	0.73	38.3	1.6	0.63	11.5	6.3	0.73

Digramma interrupta Cholodkovsky, 1914	17.6	4.2	0.74	16.8	4.3	0.80	-	-	-	9.5	6.4	0.61
Proteocephalus torulosus Batsch, 1786	23.0	2.9	0.68	-	-	-	27.8	1.8	0.51	9.9	4.2	0.42
Paradilepis scolecina Rudolphi, 1819	7.8	4.6	0.36	-	-	-	-	-	-	-	-	-
Gryporhynchus cheilancristrotus Wedl, 1955	15.3	5.0	0.76	-	-	-	-	-	-	-	-	-
G. pusillus Nordman, 1832	8.1	6.2	0.51	-	-	-	-	-	-	-	-	-
Dilepis unilateralis Rudolphi, 1819	4.3	5.2	0.22	-	-	-	-	-	-	-	-	-
Capillaria tomentosa Dujardin, 1843	15.3	5.0	0.77	-	-	-	-	-	-	-	-	-
Dioctophyme renale Goeze, 1782	8.8	6.5	0.57	-	-	-	8.7	6.2	0.54	-	-	-
Rhabdochona denudata Dujardin, 1845	8.8	6.3	0.55	7.3	6.9	0.50	-	-	-	-	-	-
R. gnedini Skrjabin, 1946	15.8	3.0	0.48	-	-	-	-	-	-	-	-	-
Desmidocercella numidica Seurat, 1920	8.1	6.1	0.49	-	-	-	-	-	-	-	-	-
Gnathostoma hispidum Fedtschenko, 1872	-	-	-	-	-	-	-	-	-	11.3	5.2	0.59
Camallanus truncatus Rudolphi, 1814	15.8	3.2	0.51	-	-	-	-	-	-	-	-	-
Philometra ovata Zeder, 1803	15.3	4.6	0.71	-	-	-	-	-	-	-	-	-
Ph. abdominalis Nybelin, 1928	15.3	3.5	0.54	-	-	-	-	-	-	-	-	-
Ph. intestinalis Dogiel et Bychowsky, 1934	10.3	4.2	0.43	-	-	-	-	-	-	-	-	-
Contracaecum spiculigerum Rudolphi, 1809	13.1	3.5	0.47	-	-	-	-	-	-	-	-	-
C. microcephalum Rudolphi, 1819	9.3	5.5	0.51	-	-	-	25.9	1.9	0.51	-	-	-
Porrocaecum reticulatum Linstow, 1890	5.1	5.8	0.30	-	-	-	-	-	-	-	-	-
Raphidascaris acus Bloch, 1779	13.0	3.5	0.46	-	-	-	10.1	5.4	0.55	11.8	3.8	0.45
Neoechinorhynchus rutili Müller, 1780	5.3	5.5	0.29	13.5	3.7	0.50	-	-	-	-	-	-
Pomphorhynchus laevis Müller, 1776	10.0	2.4	0.24	-	-	-	-	-	-	-	-	-
Acanthocephalus lucii Müller, 1776	6.8	3.3	0.23	-	-	-	-	-	-	-	-	-
A. anguillae Müller, 1780	5.5	4.3	0.23	-	-	-	-	-	-	-	-	-

A – prevalence (%); B – intensity; C – abundance

Obtained data on the quantitative composition of helminth fauna of the *Cypriniformes* and their biological characteristics make it possible to allocate three types of communities: helminths parasitizing *Cypriniformes* as definitive hosts; helminths parasitizing *Cypriniformes* as intermediate hosts and helminths parasitizing *Cypriniformes* as a reservoir (=paratenetic) hosts. The distribution of indicated helminth communities in the region depends on a number of well-known biotic and abiotic factors. The first type includes 25 helminth species: 7 *Trematodes*, 7 *Cestodes*, 11 *Nematodes* and 4 *Acanthocephalans* (Table 3). Fish are infected here mainly through the digestive tracts of hosts, as well as directly by a free-swimming nematode larvae (*Capillaria tomentosa* Dujardin, 1843) and penetration of trematode cercariae (*Sanguinicola inermis* Plehn, 1905) through the cover of cypriniform fish. But the life cycle of *Capillaria tomentosa* is studied insufficiently. Possible participation of *Oligochaeta* in the life cycle of these *Nematodes* in experiments requires additional studies **(Moravec, 1994)**.

There is no uniform opinion regarding the participation of different categories of hosts (both intermediate and paratenic) in the recorded *Nematodes* of the family *Anisakidae* Skrjabin et Karokhin, 1945: *Raphidascaris acus* (Bloch, 1779), *Porrocaecum reticulatum* (Linstow, 1890), *Contracaecum spiculigerum* (Rudolphi, 1809) and *C. microcephalum* (Rudolphi, 1819) **(Faltýnková *et al.*, 2014; Mozgovoy and Kosinova, 1963)**. Nevertheless, we find acceptable data as **(Faltýnková *et al.*, 2014)** considering Cypriniformes as second intermediate hosts of *Raphidascaris acus*.

Table 3 Biological characteristics of helminths of *Cypriniformes* in the studied region

Helminths	Number of species	Hosts			
		Intermediate hosts		Reservoir	Definitive
		First	Second		
Trematoda					
Bucephalidae	1	Mollusks	*Cypriniformes*	-	*Cypriniformes* and other fish
Sanguinicolidae	1	Mollusks	-	-	*Cypriniformes* and other fish
Allocreadiidae	2	Mollusks	-	-	*Cypriniformes* and other fish
Gorgoderidae	1	Mollusks	-	-	*Cypriniformes* and other fish
Monorchidae	1	Mollusks	-	-	*Cypriniformes* and other fish
Orientocreadiidae	1	Mollusks	-	-	*Cypriniformes* and other fish
Clinostomidae	1	Mollusks	Fish	-	Birds
Diplostomidae	8	Mollusks	Fish	-	Birds
Strigeidae	2	Mollusks	Fish	-	Birds
Cestoda					
Caryophyllaeidae	4	*Oligochaetes*	-	-	*Cypriniformes*
Amphicotylidae	1	Cyclops	-	-	*Cypriniformes*
Bothriocephalidae	1	Cyclops	-	-	*Cypriniformes*
Ligulidae	2	Cyclops	*Cypriniformes*	-	Birds
Proteocephalidae	1	Cyclops	-	-	*Cypriniformes*
Dilepididae	4	Cyclops	-	-	Birds
Nematoda					
Capillariidae	1	-	-	-	*Cypriniformes* and other fish
Dioctophymidae	1	*Oligochaetes*	*Cypriniformes*	-	Mammalians
Rhabdochonidae	2	*Oligochaetes*	-	-	*Cypriniformes*
Desmidocercidae	1	-	-	*Cypriniformes*	Birds
Camallanidae	1	Cyclops	-	-	*Cypriniformes*
Philometridae	3	Cyclops	-	-	*Cypriniformes*
Gnathostomatidae	1	Cyclops	-	*Cypriniformes*, Amphibians	Mammalians
Anisakidae	4	*Oligochaetes* and *Copepoda*	*Cypriniformes*, Dragonflies	*Cypriniformes*	Birds, Predatory fish
Acanthocephala					
Neoechinorhynchidae	1	*Ostracoda*	*Megaloptera*, *Hirudinea*	-	*Cypriniformes*
Echinorhynchidae	2	*Amphipoda*	-	-	*Cypriniformes* and other fish
Pomphorhynchidae	1	*Amphipoda*	-	-	*Cypriniformes* and other fish

This study also reports a corresponding view for the species of *Porrocaecum* and *Contracaecum*. The second type is characterized by the fact that some species of *Cypriniformes* are the second intermediate hosts for nineteen helminth species: 12 *Trematodes*, 2 *Cestodes* and 5 *Nematodes*. Definitive hosts (predatory fish, fish-eating birds and mammalians) are infected consuming *Cypriniformes* fish infected by helminth larvae.

Participation of *Cypriniformes* as paratenic hosts in the transmission of the considered helminths is in many respects questionable. Nevertheless, *Cypriniformes* were previously noted as paratenetic hosts **(Dorovskikh and Stepanov, 2014).** According to our findings, they are noted for two *Nematoda* species of the genera *Desmidocercella* and *Gnathostoma*, which should be assigned to the third type. Our results also confirm that *Cypriniformes* in the studied region promote the circulation of a number of *Cestoda*, *Trematoda*, *Nematoda* and *Acanthocephala* species in predatory fishes, birds and mammalians (Table 3).

Distribution of helminths of *Cypriniformes* in some parts of the Syrdarya River basin is not equivalent. The optimal conditions for the functioning of the communities of helminths obviously represented in the reservoirs of the middle reaches, where 49 species of parasites were recorded. In the 60 years of the last century, in this region have been reported 20 species of helminths **(Osmanov 1975b)**. In other parts of the Syrdarya significantly fewer species were noted, 25 – in the lower reaches **(Artamoshin *et al.*, 1990)** and 10 – in the headwaters **(Spasskii, 1987; Gehring *et al.*, 2014)**.

CONCLUSION

Results of this research show that the qualitative and quantitative distribution of *Cypriniformes* helminths in water bodies of the basin of the Syrdarya River is very uneven. The greatest diversity of species is characterized by well warmed water bodies in coastal parts of the river. There are optimal conditions for the development of *Cypriniformes* parasites that attract birds and mammals involved in the circulation of helminths. The life cycle of *Capillaria tomentosa* is studied insufficiently. Possible participation of *Oligochaeta* in the life cycle of *Nematodes* require additional studies. Species diversity of *Cypriniformes* helminths in the investigated region is rich enough and stable functions in water biocenosis. The parasitic worms include 49 species of *Cypriniformes*: 18 species of *Trematoda*, 13 of *Cestoda*, 14 of *Nematoda* and 4 of *Acanthocephala*. Among the species mentioned most common pathogenic representatives are those of the family *Sanguinicolidae*, *Diplostomidae*, *Bothriocephalidae*, *Ligulidae* and *Anisakidae*, whith a negative effect on the development of hamper the fishing industry. This fact dictates conduct of involves constant monitoring of ichthyo-parasitological situation in specific natural and artificial water bodies of Uzbekistan.

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