

## *Ichthyofauna of the Iskar River Section Affected by the Hydropower Cascade „Middle Iskar”*

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**Abstract.** The study aimed to assess the impact of a cascade of 5 small hydropower plants on the composition and structure of the recent fish communities in the affected area of Iskar River. The field surveys cover the river sections up- and downstream the 5 dams, the dam lakes and the fish passes of the dams. Fifteen fish species were recorded in the dam lakes. Limnophylous and eurytopic species predominate the communities. The high species richness and the presence of large-size fishes can be considered as an indirect indication of relatively stable conditions in the dam lakes. Eleven fish species were found in the studied river stretches. The ecological status of these river sections assessed by standardized fish indices were determined as Good and High. Both the abundance and size-age composition of some type-specific species correspond to “Favorable” conservation status. Totally 8 fish species were recorded to migrate up- and downstream through the fish passess. The most intensive upstream migration was found at the end of May when 2 to 5 species migrated through different dams.

**Key words:** HPPs, Fish communities, Iskar River, Dams, Fish passes, Ecological state.

### **Introduction**

The effects of construction and operation of hydropower facilities over the fish communities in rivers are widely discussed because of their widespread and increasing numbers as renewables. The main reported impacts are related to the hydro-morphological pressure: barrier effect (river fragmentation and breaking the migration corridors), change of hydrological and morphological features (depths, current velocities, sediment’s granulometry etc.), water abstraction (LUCAS & MARMULLA, 2000; LUCAS & BARAS, 2001; STEINMETZ & SUNDQVIST, 2014, VASSILEV *et al.*, 2016; UZUNOVA *et al.*, 2017, etc.). Although the general impacts of the small hydropower plants (HPPs) on the river fish communities are well known the specific effects are quite variable depending on the river

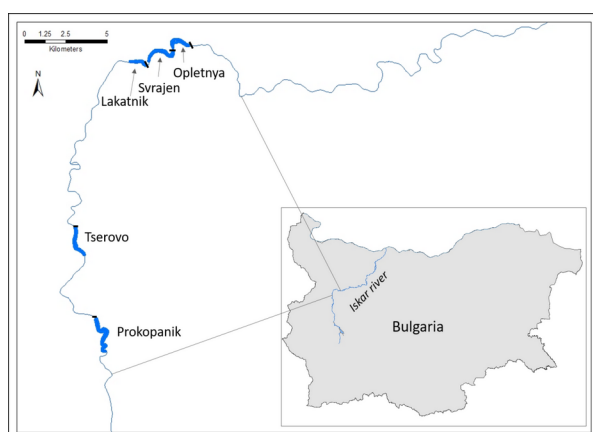
typology, fish zone, types of the HPP (run-of-the-river hydroelectrics or diverted), constructive features of the facilities and some further pressures.

The aim of this study was to establish the current state of fish community in a semi-mountain river zone after construction of a cascade of 5 small run-of-the-river HPPs and to check the use of the fish passes at the dams of HPPs by fishes for upstream migrations. So far no data on these issues have been published for this hydroelectric facility, and for Bulgaria they are too scarce as a whole.

### **Material and Methods**

*Study area.* Iskar River is the longest right Danube tributary on Bulgarian territory and the only one which crosses the Balkan

Mountain through a gorge 84 km long. Along the gorge, its middle course is a high-flow, fast-flowing river. The “Middle Iskar” HPP cascade is built in the middle part of the Iskar’s gorge. The cascade covers about 30 km along the river including 5 HPPs (downstream): “Prokopanik”, “Tserovo”, “Lakatnik”, “Svrajen” and “Opletnya” (Fig. 1). The distance between the HPPs “Prokopanik” and “Tserovo” is about 6 km, those between “Tserovo” and “Lakatnik” – about 16 km while the 3 HPPs “Lakatnik”, “Svrajen” and “Opletnya” are immediately adjacent consecutively. Two tributaries inflow in the Iskar River close to the cascade area. The Batuliyska River inflows upstream the Prokopanik dam lake and the Gabrovnitsa River inflows downstream the Opletnya HPP.



**Fig. 1.** Location of the hydropower cascade and the surveyed HPPs.

Study was carried out in 2017 and 2018 comprising spring, summer and autumn seasons. The surveys cover three types of habitats within the studied area: 1) dam lakes of the HPPs; 2) free sections of the Iskar River between the HPPs and these situated immediately upstream and downstream the cascade and 3) fish passes at the dams along with surveys on the passage of fish upstream through the fish passes. Fish were sampled using different methodology and tools relevant to both the concrete task and the habitat features as follows:

- In the dam lakes fish were sampled by multimesh gillnets and fish traps which were put during the night time. The processing of fish samples *in situ* included: species identification of the caught fish, measuring their individual total length (TL) and determination of the number and the total weight of each species;

- In the targeted free river sections multihabitat fish sampling with electricity was performed by wading according CEN EN 14011 in accessible zones using backpack electrofishing devices. The accessible river section between the HPPs „Lakatnik” and „Svrajen” is quite short and does not allow to find two separate sampling sites (one – downstream „Lakatnik” and other – upstream „Svrajen”) and that’s why there is only one site. No sampling sites were also found between the HPPs „Svrajen and „Opletnya” since there is no free river section at all (the dam lake of HPP “Opletnya” begins immediately downstream the fish pass of HPP “Svrajen”). The processing of fish samples *in situ* included: species identification of the caught fish, measuring their individual total length (TL) and determination of the number and the total weight of each species;

- In the fish passes fish were sampled using electrofishing. Fish caught in the different sections of each fish pass (lower, middle and upper) after species identification and determination of the individual length were counted and released in the river or in the dam lake;

- For checking upstream fish migrations through fish passes specially constructed fish trap (Fig. 2A) was put against the upper exit of the fish pass (Fig. 2B). After several trial catches the fish traps were then put only during the night time. The processing of fish samples *in situ* included: species identification of the caught fish, measuring their individual length (TL) and determination of the number of each species.

The ecological state of the surveyed river sections was assessed by Biological Quality

Element (BQE) Fish using the intercalibrated Type-specific Bulgarian Fish Based Index (TsBFI) (Adapted method for BQE Fish in rivers of national types R2, R4, R7, R8 Type specific Bulgarian Fish Based Index (TsBFI), 2016) in 5 grades as defined by the Ordinance H-4/2012. Furthermore the status of type specific and indicator species was assessed according the approach used in the National System for Monitoring of Biological Diversity (National System For Monitoring of Biological Diversity, 2014).



**Fig. 2.** Fish trap for studying the upstream fish migrations through the fish passes. Upper – general view; Lower – working position.

### Results and Discussion

Fifteen fish species of 5 families were found in the dam lakes of the cascade, most of them native for the studied area according the historical data (DRENSKI, 1921; PASPALEV

& PESHEV, 1958). The species composition in different dam lakes was almost the same (Table 1). Roach *R. rutilus* characterizes with higher abundance in the fish communities of dam lakes sharing about 60% of fish caught. It is remarkable however the presence of Vimba bream which is considered as a rheophylous migrating species.

Four species are considered alien for the studied area: *L. gibbosus* and *P. parva* are alien species in Bulgarian ichthyofauna, reported first for the Danube and adjacent wetlands; currently widespread all over the country, mainly in standing waters and slow-flowing rivers; *C. gibelio* is considered native in the Lower Danube region. It was considered an invader upstream along the tributaries although in the middle stream of the Iskar its status (native/alien) is unclear; *A. brama* is a native species for Bulgaria but it is not typical for the middle stream of the Iskar River. Most likely it was translocated in the Middle Iskar dam lakes. A special case is with the Carp *C. carpio*, considered a native species in the Danube basin but currently in the Middle Iskar it is probably presented by stocked culture form instead a wild form presented in the past.

A total of 11 fish species of 3 Families were found in the surveyed free river sections (Table 2). The fish communities there were predominated by few rheophylous species although some eurytopic and even limnophylous species are presented.

The same three alien fish species were found in the river sections but presented with very low abundance (Table 2).

Ecological state of the surveyed river sections has been determined according the indicative ichthyological parameters as High or Good (Table 3) but the assessment of the section downstream the HPP “Lakatnik” should be considered only as approximate because of the big depth and the fast current the zone where standard electrofishing by wadding could be applied is very restricted. Standard sampling with electricity was also inapplicable downstream the HPP “Svrajen”. The highest values of the index TsBFI were calculated for the

longest free river section between the HPPs “Prokopanik” and “Tserovo” (Table 3).

**Table 1.** Species composition of the fish communities in the dam lakes of surveyed HPPs. Legend: \* - alien species for the region.

Family Species	Dam lakes				
	Prokopanik	Tserovo	Lakatnik	Svrajen	Opletnya
Esocidae					
<i>Esox lucius</i> Linnaeus, 1758	+	+	+	+	+
Centrarchidae					
<i>Lepomis gibbosus</i> (Linnaeus, 1758)*	+	+	+	+	+
Cyprinidae					
<i>Abramis brama</i> (Linnaeus, 1758)*		+	+	+	+
<i>Alburnus alburnus</i> (Linnaeus, 1758)	+	+	+	+	+
<i>Barbus petenyi</i> Heckel, 1852	+	+	+	+	+
<i>Carassius gibelio</i> (Bloch, 1782)*	+	+	+	+	+
<i>Cyprinus carpio</i> Linnaeus, 1758	+	+	+	+	+
<i>Gobio gobio</i> (Linnaeus, 1758)	+	+	+	+	+
<i>Pseudorasbora parva</i> (Temminck & Schlegel, 1846)*	+	+	+	+	+
<i>Rhodeus amarus</i> (Bloch, 1782)	+	+	+	+	+
<i>Rutilus rutilus</i> (Linnaeus, 1758)	+	+	+	+	+
<i>Squalius cephalus</i> (Linnaeus, 1758)	+	+	+	+	+
<i>Vimba vimba</i> (Linnaeus, 1758)		+	+		+
Percidae					
<i>Perca fluviatilis</i> Linnaeus, 1758	+	+	+	+	+
Siluridae					
<i>Silurus glanis</i> Linnaeus, 1758		+	+	+	

**Table 2.** Composition of the fish communities in the river sections along the studied area. Legend: Pr – Prokopanik, Ts – Tserovo, La – Lakatnik, Op – Opletnya, DL – dam lake, HPP – Hydropower Plant, (Up) – upstream, (D) – downstream; Ab – abundance: N – ind./ha, B – kg/ha. Legend: \* - alien species for the region.

Family Species	Ab	Pr DL (Up)	Pr HPP (D)	Ts DL (Up)	Ts HPP (D)	La DL (Up)	La HPP (D)	Op HPP (D)
Fam. Cyprinidae								
<i>Alburnoides bipunctatus</i> (Bloch, 1782)	N	860	680	833	3045	2160	1067	3400
	B	3.900	6.360	6.042	12.727	11.840	4.667	15.000
<i>Alburnus alburnus</i>	N		80		750		400	75
	B		0.960		3.545		0.733	0.225
<i>Barbus petenyi</i>	N	720	1720	1708	1454	7820	133	2375
	B	9.420	44.400	57.250	19.954	11.160	1.333	24.975
<i>Carassius gibelio</i> *	N		120	125	23			
	B		5.880	1.083	0.045			
<i>Gobio gobio</i>	N	200	320	167	636	160	600	375
	B	2.200	5.600	2.208	3.590	0.560	2.867	3.700
<i>Pseudorasbora parva</i> *	N			42			67	
	B			0.375			0.467	
<i>Rutilus rutilus</i>	N		640	750	68			
	B		1.600	13.167	0.068			
<i>Rhodeus amarus</i>	N		40				267	
	B		0.120				0.200	



Family Species	Ab	Pr DL (Up)	Pr HPP (D)	Ts DL (Up)	Ts HPP (D)	La DL (Up)	La HPP (D)	Op HPP (D)
<i>Squalius cephalus</i>	N	520		750	909	880	1200	300
	B	7.900		44.083	10.727	11.040	14.000	9.975
Fam. Centrarchidae								
<i>Lepomis gibbosus</i> *	N		80					
	B		2.320					
Fam. Cobitidae								
<i>Cobitis elongatoides</i>	N							50
Bacescu & Mayer, 1969	B							0.250

**Table 3.** Ecological state of the surveyed Iskar River sections according TsBFI.

Site – river section	Value of TsBFI	EQR	Ecological state
Upstream DL “Prokopanik”	50	0.71	Good
Downstream HPP “Prokopanik”	74	1	High
Upstream DL “Tserovo”	68	1	High
Downstream HPP “Tserovo”	57	0.83	High
Upstream DL “Lakatnik”	50	0.71	Good
Downstream HPP “Lakatnik”	64	0.97	High
Downstream HPP “Opletnya”	63	0.96	High

In most of the surveyed river sections the numbers, the biomass and the size structure of some common type-specific and indicator fish species, such as: *S. cephalus*, *B. petenyi*, *A. bipunctatus* and *G. gobio*, correspond to “Favorable” ecological state. High abundance and biomass, as well as the good age structure of *A. bipunctatus* and *B. petenyi* are remarkable as far as they are an indicator species for this river zone and furthermore *B. petenyi* is a species enlisted in the Annex 2 of the Habitat Directive.

The conservation status of *B. petenyi* in the river section downstream the HPPs “Lakatnik” was assessed as “Unfavorable” according the parameters Abundance, Biomass and Age structure. Although as mentioned above the results for this river section are only approximate this is an expected result taking in account the modified habitat of this species there.

The most intensive upstream fish migrations through the *fish passes* were recorded in May-June when as it is well known the most intensive spawning occurs (KARAPETKOVA & ZHIVKOV, 1995) but upstream movements occurred until the end of August even outside the spawning period

(Table 4). During the period 27.05-01.06 upstream fish migrations were recorded through the fish passes of all 5 dams but of different intensity (presented as *fish specimens per night*). As one can see (Table 4), the highest number of migrating species occurred at the both “Lakatnik” and “Opletnya” dams while only one species *B. petenyi* was recorded to migrate through the fish pass at the HPP “Tserovo”. The highest intensity of migration through the fish pass was recorded at the HPP “Opletnya” and the lowest one – at the HPP “Svrajen. Later the intensity of the upstream migration of fish sharply decreased and only single specimens of 2-3 species were found to move upstream through the fish passes at the three lower dams (Table 4).

The biggest proportion amongst the fishes migrating upstream through all the fish passes shared *B. petenyi* (39 – 100%), *A. bipunctatus* (1,7 – 24%) and *S. cephalus* (1,5 -32%).

Fish were found in the *fish passes* throughout the period from May to August and as the water temperature drops in the autumn all they leaved this habitat. The quantitative features of fish into the fish passes were surveyed during the period of

most intensive upstream fish migration (27.05-01.06.2018 r.). In three out of five surveyed fish passes fish were sampled twice – before and after checking of the upstream migration. In the other 2 of them sampling by different reasons was performed only after finishing the checking and removal of the fish trap. During the sampling some solid waste (plastic and

wooden debris) blocking the fish pass were removed.

The highest species richness was recorded in the fish pass of HPP “Lakatnik” (Table 5) including typical rheophlyous species (i.e., *A. bipunctatus*, *B. petenyi*) but also some limnophylous and eurytopic species, such as: *A. alburnus*, *C. gibelio*, *G. gobio*, *L. gibbosus*, *R. amarus*, *R. rutilus*, *S. cephalus*.

**Table 4.** Intensity of the upstream movements of fishes through the fish passes as *fish specimens per night* during the studied period.

	Dam	Prokopanik	Tserovo	Lakatnik	Svrajen	Opletnya			
	Number of <i>specimens per night</i>								
	Date	27.05-01.06	27.05-01.06	27.05-01.06	10-11.06	29-31.08	27.05-01.06	10-11.06	
Species									
<i>A. bipunctatus</i>		4		1		3	91		
<i>A. alburnus</i>				5	4		1		
<i>B. petenyi</i>		47	35	23	1	6	1	5	
<i>B. barbus</i>							285	2	
<i>G. gobio</i>				8			1		
<i>L. gibbosus</i>		1							
<i>S. cephalus</i>		1		19	1	5	1	6	
<i>V. vimba</i>				3				2	
Total number		53	35	59	2	15	2	8	
							386	3	

**Table 5.** Number of fishes found in the fish passes. legend: 1 – at the evening (before putting the fish trap); 2 – on the next morning (after the removal of the fish trap).

HPP	Prokopanik		Tserovo		Lakatnik		Svrajen	Opletnya
Sampling	1	2	1	2	1	2	2	2
Species	Fish number							
<i>A. bipunctatus</i>	7		52	98	25	10	199	35
<i>A. alburnus</i>	11	1	10	454	346	69		
<i>B. petenyi</i>	33	4	212	76	42	18	293	26
<i>C. gibelio</i>					30			
<i>C. nasus</i>							1	
<i>G. gobio</i>					16	10		
<i>L. gibbosus</i>		5	12	1				
<i>P. fluviatilis</i>		1						
<i>R. amarus</i>					8			
<i>R. rutilus</i>			4	57	9			
<i>S. cephalus</i>		2	6		77	51	19	1
<i>V. vimba</i>				2	10	8	10	1
Total number	51	13	296	688	563	166	522	62

After the sampling and removing of fish from the fish pass before the fish trap putting, the next morning in the fish pass were recorded 6 species the most abundant being rheophylic and highly mobile species, such as: *A. alburnus* (64%), *A. bipunctatus* (16%) and *B. petenyi* (9%).

Only in the fish pass of HPP "Opletnya" was found the typical migrating species *Chondrostoma nasus* even if presented only with single specimens against with the high proportions of both the *B. petenyi* (65%) and *A. bipunctatus* (28%).

As the water temperature drops in the autumn all the fishes leave the fish passes.

As can be seen by the obtained results, the species typical for standing and/or slow flowing waters predomined in the species composition of fish communities in the dam lakes what is an expected result taking in account the hydrological features. Most of the recorded species are native inhabitants of this part of the Iskar River but the hydromorphological modifications create more favorable conditions for the limnophylous and eurytopic species. The populations of some of these species which are atypical for the Iskar gorge area probably developed after their introduction here for recreational fishing or as a result of unintentional translocation when stocking with game species.

Currently the alien species for the area share about 18% of the total fish community abundance, with Prussian carp sharing the highest propotion (12,7%) and the Stone morocco – the lowest (< 1%) what suggests that the expectations for the rapid development of invasive alien species in the dam lakes of the cascade are not justified so far.

The diversity of the species composition and and the presence of big-size fishes (such as: Carp, Prussian carp, Perch, Pike and Wels catfish) could be cosidered as an indirect sign for stable environmental conditions in the dam lakes.

The fish communities in the surveyed free river sections are predominated by

native species typical for this section of the Iskar River (DRENSKI, 1921; PASPALEV & PESHEV, 1958; KARAPETKOVA, 1994). The comparison with the available historical data (DRENSKI, 1921; PASPALEV & PESHEV, 1958) shows reducing of the species richness of native fish community in the area of the Iskar Gorge along the years together with appearance of some new species. However the absence of recent published data does not allow evaluate the specific impact of the "Middle Iskar" hydropower cascade among the complex of anthropogenic pressures and impacts in this area. Eventually despite the presences of some species indicative for dam influence (such as, *R. rutilus*) and of 3 alien species in the river fish communities they obviously play negligible role in the community structure because of their very low abundance. This result refutes some predictions for significant increase of the importance of these species in the native river communities within the area of the cascade.

The Good and High ecological state of the surveyed river sections determined by BQE Fish and the Favorable conservation status of the type-specific species suggest relatively little impact of the HPP facilities on the fish communities in the river sections between the dam lakes if these river sections are more than 5 km long as well as on these upstream and downstream the cascade when there are less affected tributaries like the rivers Batuliyska and Gabrovnitsa.

Twelve species occurred in the fish passes in the spring-summer period represent a wide range of ecological guilds – from typical rheophylous to more or less eurytopic. Although the obtained results give a reason to conclude that during the night fish from the river actively colonize the fish pass moving upstream only part of them mainly typical rheophylous species realize effective upstream migration passing successfully from the lower to the upper water level of the dams. The rest of species most probably use the fish passes as temporary habitat and stepping stone bio-

corridor until the end of summer. The seasonal dynamics of the migration obviously is related to the reproductive behavior of river fishes. Although the rheophylous and mobile species predominate in the composition of migrating fishes in all fish passes of the cascade both the species composition and the intensity of migration are quite different in the different fish passes. The available data do not allow us yet to speculate concerning the reasons for the different features of the upstream movements of fish through the fish passes of the “Middle Iskar” HPP cascade. Therefore further investigations on these issues are very recommendable.

### Conclusions

Different fish communities composed mainly of native species are formed corresponding to the two main types of habitats (dam lakes and river zones) in the Iskar river section affected by the hydropower cascade “Middle Iskar”. The two communities are not strongly isolated but clearly distinguish by the dominating species complexes. The influence of the dam lakes’ fish communities over the river one is manifested through spreading of species only in restricted river sections both up-and downstream.

The fish passes are a transient habitat used temporary by river fish species during the spring-summer period when upstream movements of fish occur. Rheophylous and some eurytopic species use successfully the fish passes for upstream migrations which are most intensive during the spawning period but occur also later in summer. Significantly wider range of species (incl. more eurytopic species) uses the fish passes as temporary habitats and stepping stone bio-corridor moving upstream. Impaired function of the fish passes occurs when floating plastic waste and/or wooden debris block the upstream exit or the submerged orifices of the fish pass.

Currently no indications of worsening neither of the ecological state of the “free”

river sections longer than 5 km between the HPPs and both up- and downstream the “Middle Iskar” hydropower cascade determined through standard fish based indices nor of the status of type-specific species inhabiting there. A certain importance for maintaining good ecological state of the Iskar River sections up- and downstream the hydropower cascade probably have the good condition of the tributaries. Negative effect of dam construction over the rheophylous species occurs only in highly modified zones immediately downstream the dams in case of cascade construction where no enough long river sections exist.

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### References

- Adapted methodology for BQE Fish in the rivers of national types R2, R4, R7, R8 „Type-specific Bulgarian Fish Based Index (TsBFI)“. 2016. Available at: [[bd-dunav.org](http://bd-dunav.org)] (In Bulgarian).
- DRENSKI P. 1921. [Fish fauna and the fishing in the Iskar River]. – *Natural science and geography*, 2&3: 49-58. (In Bulgarian).
- KARAPETKOVA M. 1994. [Vertebrates]. - In: Russev B. (Ed.), *Limnology of the Bulgarian Danube tributaries*. MOEW, Bulgarian Academy of Sci., pp. 175-186 (In Bulgarian).
- KARAPETKOVA M., M. ZHIVKOV. 1995. [*Fishes in Bulgaria*]. Sofia, Gea-Libris, 247 p. (In Bulgarian).
- LUCAS M.C., E. BARAS. 2001. *Migration of Freshwater Fishes*. Blackwell Publishing, Ltd: Oxford, 420 p.



- LUCAS M. C., G. MARMULLA. 2000. An assessment of anthropogenic activities on and rehabilitation of river fisheries: current status and future direction. - In: Cowx I.G. (Ed.), *Management and Ecology of River Fisheries*, pp. 261-278. Fishing News Books, Blackwell Science Ltd, Oxford.
- National System For Monitoring of Biological Diversity. 2014. *Methodology for monitoring of fishes. Approach for monitoring of fishes in rivers*. Available at: [[eea.government.bg](http://eea.government.bg)] (In Bulgarian).
- Ordinance H-4 from 14.09.2012 for characterization of the surface waters. MOEW. (In Bulgarian).
- PASPALEV G., TS. PESHEV. 1958. [Contribution to the study of the ichthyofauna in the Iskar River]. - *Annual of the Sofia University, Faculty of Biology, Geology and Geography*, XLVIII(1): 1-39 (In Bulgarian).
- STEINMETZ M., N. SUNDQVIST. 2014. Environmental Impacts of Small Hydropower Plants - A case study of Boras Energy och Miljö's Hydropower Plants. Master's Thesis within the Industrial Ecology Programme. Chalmers University of Technology, Gothenburg, Sweden: 143 p.
- VASSILEV V., E. UZUNOVA, D. KISLYAKOV, R. TSONEV, H. TAULOW, I. NASHEIM. 2016. [Assessment of the complex impact of the HPPs on the ecosystems and the ecological state of the rivers]. Sofia, REC-Bulgaria. 102 p. (In Bulgarian).
- UZUNOVA E., L. RASHKOVA, I. HRISTOV. 2017. *Approaches to restoring river continuity. Fish passes: Biological bases, monitoring and legal framework*. WWF Bulgaria, Sofia: 98 p. ISBN: 978-954-8552-09-7 (In Bulgarian).

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