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Prospects for growing juveniles and rearing fingerlings of pikeperch (*Sander lucioperca*) in cages in the conditions of fish farming of Almaty region

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Abstract

This article presents the results of scientific research on the growing juveniles and the rearing fingerlings of pikeperch in cages. The conditions for growing larvae, juveniles, and fingerlings of pikeperch are described, and the dynamics of hydrochemical indicators of temperature, active reaction of the aquatic environment, oxygen content in water, and the state of the natural food supply in the experimental pond are presented. The data of a comparative analysis of fish-cultivation and biological indicators for three stages of growing larvae, juveniles and six stages of growing fingerlings of pikeperch in cages are presented. Prospective planting densities of fish planting material for pikeperch have been determined. The data on the use of live and artificial feed for feeding pikeperch are presented.

Keywords: pikeperch aquaculture, larvae, juveniles, fingerlings, pond cages technology, breeding and biological indices of fish

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INTRODUCTION

Stable fish consumption in the world is one of the ways to get the protein needed by the human body. Lack of commercial fish can be offset by the development of aquaculture. The total volume of aquaculture production in the world is growing and progressing.

According to FAO, aquaculture is now present in the economies of 202 countries and territories, with 194 countries producing heavily in recent years. For two decades, 89 percent of the world's aquaculture production has come from China. (FAO, 2018).

Kazakhstan has a large number of water bodies (the total area of water bodies of Kazakhstan, excluding the Caspian Sea, is about 5 million hectares) on which it is possible to produce environmentally safe fish products. To ensure food security of the Republic of Kazakhstan among other branches of agricultural production, a special place is given to fisheries, in particular, aquaculture (Isbekov and Alpeisov 2014, Koishybayeva et al. 2018).

According to FAO, per capita fish consumption increased from 9.0 kg in 1961 to 20.2 kg in 2015, an annual increase of an average of one and a half percent. According to preliminary calculations, in 2016 this figure reached 20.3 kg, and in 2017 – 20.5 kg. Currently, the consumption of fish in Kazakhstan is 11 kg/year, with 14.6 kg/year recommended by the Institute of Nutrition of the AMS of Kazakhstan (FAO 2018).

For the successful development of commercial fish farming in a market economy, it is necessary to revise the technological methods of growing valuable aquaculture objects in order to ensure their profitability. In this situation, it is extremely important to develop and implement effective technologies for industrial cultivation of valuable fish species. Solving the issues of ensuring the sustainability and stability of the development of fisheries, effective production management on the basis of the introduction of modern scientific developments will help to find ways to achieve the task of increasing the efficiency of fish farms in Kazakhstan. The development of industrial fish farming will significantly reduce the fishing pressure on many natural reservoirs. In addition, intensive breeding technologies will improve the use

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efficiency of water bodies in Kazakhstan (Isbekov et al. 2018).

Pikeperch (*Sander lucioperca*) a genus of pikeperch Sander. Pikeperch is common in the basins of the Baltic, Black, Azov, Caspian and Aral seas. In Kazakhstan the pikeperch lives in reservoirs of the Ural-Caspian basin, the Small Aral Sea. Acclimatized in Balkhash-Alakol (including Kapshagai reservoir) and Zaisan-Irtysh (including in the canal named after K. Satpayev) basins, as well as in the Talas and Nura rivers (Isbekov et al. 2018). Due to the availability of suitable spawning and feeding areas for both immature and mature fish acclimatization was successful (Isbekov et al. 2019). The range of its habitat has expanded rapidly, and now the pikeperch is fully naturalized and has become an object of fishing.

Pikeperch reaches the sexual maturity in age 3+, and commercial weight in 4-6 year of live. As for many fish, pikeperch spawning is closely related to the regime of hydrometeorological conditions, mainly to water temperature. Spawning usually occurs in the end of the third decade of March and the beginning of April (depending on natural and climatic conditions). The perch spawns at the same time. The fecundity of pikeperch ranges from 11,6 to 2206,0 thousand eggs (Abilov et al. 2016, Mitrofanov et al. 1989).

Pikeperch is usually considered in fish science as an additional fish in carp ponds, or as an object of pasturable aquaculture. Recently, pikeperch attracts the attention of fish farmers in terms of its use as an object of industrial breeding. The research undertaken in Europe are an evidence of this growing attention (Khrustalev et al. 2009, Ljubobratović et al. 2016, Policar et al. 2013, Szkudlarek and Zakęś 2007, Tamash et al. 1985, Zakęś 1999).

Pikeperch is a commercially valuable object of aquaculture. The urgency of the problem of pikeperch breeding in Kazakhstan has increased significantly in recent years. The main reason for this was a sharp drop in natural stocks of pikeperch, associated with anthropogenic impact on the ecosystems of natural reservoirs and intensive industrial fishing as a result of increased market demand for delicatessen food products of this fish (Badryzlova et al. 2019). Reduction of stocks of pikeperch in fishery reservoirs of Kazakhstan was also caused due to an excessive commercial pressure on the population of this species in all reservoirs of Kazakhstan because of its export to western Europe. On the other hand, the increased demand for pikeperch on the world market causes an increasing interest of domestic entrepreneurs to preserve and increase the stocks of this fish in natural water bodies. In this regard, an alternative way, widely used in world practice, is the pikeperch breeding in the aquaculture conditions in Kazakhstan.

This article presents the results of scientific research on the growing of larvae, juveniles and rearing fingerlings of pikeperch in cages. To date, work on the industrial breeding of pikeperch stock material in cages in fish farms in Kazakhstan has not been carried out.

Fig. 1. The arrangement of the set of cages used for the rearing of pikeperch juvenile

MATERIAL AND METHODOLOGY

In 2018, the research on the development of technology for growing larvae, juveniles and rearing fingerlings of pikeperch was carried out in cages at the experimental site of the fish farm LLP “Halyk balyk” (Almaty region, VI zone of pond fish farming). Material for the study was the larvae, juvenile and fingerlings of pikeperch.

Analytical determination of hydrochemical parameters was carried out in accordance with generally accepted GOSTs (ST RK GOST R 51592 (2003)) and methods for classification of waters according to the scheme of Alekin (1970) were used.

To assess the influence of the dynamics of abiotic environmental factors, temperature and oxygen were monitored twice a day and the level of pH once a day. The content of nutrients in water was determined by express tests (Sera, Germany).

Below experiment design was based on the literature available data (Minayev 2008, Radko et al. 2011, Tamash et al. 1985, Tereshenkov and Korolev 1997).

Growing pikeperch larvae in cages installed in the pond. The sieves installed in cages were used for pikeperch larvae rearing in the pond (**Fig. 1**). The number of larvae planted in experimental cages was determined by volumetric method. Rearing of pikeperch larvae was carried out in three stages and each stage in two variants. Each variant of the experiment was carried out in two repetitions.

The stock density of pikeperch larvae was 10 and 5 thousand pcs/m^3 at I stage, 4 and 2,5 thousand pcs/m^3 at II stage, 2 and 1,5 thousand pcs/m^3 at III stage, in the first and second variant respectively. Selection of juveniles for the II and III stages of the experiment was carried out from those grown at the previous stage. Each stage lasted 10 days.

Small forms of zooplankton caught from specialized “forage ponds” were used as live food during the growing of pikeperch larvae (**Fig. 2**). Feeding was carried out by

Fig. 2. Straining zooplankton through a sieve and feeding pikeperch juveniles in cages with live feed

small forms of zooplankton (rotifers, juveniles of cladoceran and copepod crustaceans). The amount of zooplankton in cages was maintained at the maximum level. As the larvae grew, the size of the live feed was also increased. Starting from the 8th day of rearing, the starter artificial food began to be entered gradually to the diet of larvae. The starter food for pikeperch juveniles was developed by Kazakh Research Institute of Processing and Food Industry. The feeding frequency was 6 times a day in the first 10 days, and 4 times a day in subsequent days. Larvae were offered with live food by 50% and 25 % and 10% of their total biomass during the stage 1 and stage 2 and stage 3, respectively. The daily rate of feeding with starter food ranged from 3% at the beginning up to 10% of larvae biomass at the end of experiment.

Growing of pikeperch juveniles in cages installed in the pond. Pikeperch juveniles of average weight of 90 mg were stocked in cages installed in the fry pond of 0,2 hectares area with a 10-day water exchange. Breeding of fingerlings was carried out in 6 stages, each lasted 20 days. In each stage, two variants of stock density was set. The stock density of each variant in each stage are given in **Tables 3**-**8**. At the end of each stage, fish measurements, sorting and replacement of cages were carried out. Cleaning of cages was carried out every three days. The experiment was carried out in two repetitions.

At the beginning of breeding of pikeperch juveniles in cages, the diet consisted of live food (large *Daphnia magna*), which was caught from “forage ponds”, as well as larvae and juveniles of forage fishes. Cultivation of *Daphnia magna* in “forage ponds” was carried out according to the technology developed and applied earlier. The larvae of forage fishes (*Pseudorasbora parva*, *Cobitidae, Abbottina rivularis*), were obtained by natural reproduction in separate “forage pond”. The zooplankton caught in “forage ponds” was filtered through appropriate sieves in order to remove the largest organisms and predatory insects. The number of zooplankton in cages was maintained at the maximum level. The percentage share of zooplankton and forage larval fish in the food of pikeperch juveniles is given in the Result section for each stage separately.

Table 1. Dynamics of hydrochemical indicators of the environment in the experimental pond

Month	Decade	Value of indicators		
		Temperature (^{0}C)	pH	mg O_2/l*
April	I	14.1	7.6	5.6
	II	15.7	7.8	5.8
	III	16.9	8.0	6.0
May	I	17.8	7.9	6.4
	II	19.5	7.4	5.9
	III	21.3	7.5	6.5
June	I	22.1	7.2	6.3
	II	22.8	7.5	6.2
	III	23.6	7.3	6.7
July	I	25.4	7.1	6.1
	II	26.8	7.9	6.8
	III	27.0	8.1	5.9
August	I	25.9	7.6	6.2
	II	25.1	8.2	6.4
	III	23.8	8.0	6.8

* values of oxygen content measured in pond water in the morning hours

Matured manure was introduced along the shoreline of experimental ponds at the dose of 2 t/ha in order to intensify the development of natural forage base.

The method of expert assessment was used to assess the effectiveness of rearing of pikeperch juveniles in cages. Determination of breeding and biological indices were carried out according to the methods given by Kozlov et al. (2006). Collection and processing of hydrobiological samples were carried out according to the methods existing during hydrobiological studies (Abakumov 1983, Sharapova and Falomeeva. 2006).

Statistical processing of the material was carried out using computer programs (Hajinezhad et al 2019, Lakin 1990).

RESEARCH RESULTS

Characteristics of hydrochemical indices of ponds. The dynamics of hydrochemical indices in the experimental pond in the 2018 season is presented in **Table 1**. The water temperature values in the ponds were within the permissible values for pikeperch. Fluctuations ranged from 14.1^{0}C in the first decade of April, to 27.0^{0}C in the third decade of July.

The content of oxygen dissolved in water during the fish breeding season ranged from 5.6 – 6.8 mg/l; the lowest value of this indicator was noted in early April, the highest at the end of the season. The oxygen content in the morning hours in the water did not fall below 5,5 mgO^2/l and was within the limits of biotechnical standards for carp fish ponds used for growing pikeperch fingerlings. The value of pH in the experimental pond during the fish breeding season ranged from 7.2 – 8.2. There was no stable regularity of pH change in the pond.

The State of the Natural Forage Base of the Experimental Pond

The zooplankton of the experimental pond was represented by 66 taxa from three main groups, where 32 taxa were rotifers, 16 cladocerans and 18 copepod

Table 2. Results of experimental rearing of pikeperch larvae and juveniles in cages in LLP «Halyk Balyk»

Indicator	I variant	II variant
1 stage (larvae)		
The survival rate of juveniles (%)	42.3	53.6
Number of growing larvae. (thousand pcs)	4.2	2.7
Initial length (mm)	5.0	5.1
Final length (mm)	10.2	13.5
Absolute linear growth gain (mm)	5.2	8.4
Initial weight (mg)	2.0	2.0
Final weight (mg)	6.0	7.0
Absolute growth gain (mg)	4.0	5.0
Average daily growth gain (mg)	0.4	0.5
2 stage (larvae)		
The survival rate of juveniles (%)	52	61
Number of growing juveniles, (thousand pcs.)	2.08	1.525
Initial length (mm)	10.2	13.5
Final length (mm)	15.3	19.7
Absolute linear growth gain (mm)	5.1	6.2
Initial weight (mg)	6.0	7.0
Final weight (mg)	20.0	26.0
Absolute growth gain (mg)	14.0	19.0
Average daily growth gain (mg)	1.4	1.9
3 stage (juvenile)		
The survival rate of juveniles (%)	59	68
Number of growing juveniles, (thousand pcs.)	1.18	1.02
Initial length (mm)	15.3	19.7
Final length (mm)	26.0	29.8
Absolute linear growth gain (mm)	11.3	10.1
Initial weight (mg)	20.0	26.0
Final weight (mg)	88.0	97.0
Absolute growth gain (mg)	68	71
Average daily growth gain (mg)	6.8	7.1

crustaceans. The productivity of zooplankton of the pond corresponded to the low-feed class of oligotrophic type. The mean biomass of benthos 12.3 g/m^2 was recorded in the summer months. Benthic biomass values increased from June to August.

In terms of phytoplankton biomass, the pond correspond to middle trophic class and represented β-mesotrophic type of reservoir in June, and to moderate class and α-mesotrophic type in July and August according to the trophic scale (Kitayev 2007).

Results of Growing of Pikeperch Larvae in Cages Installed in the Pond

The results of rearing of pikeperch larvae fed zooplankton and starter feed for 30 days are presented in **Table 2**. As can be seen from **Table 2**, the values of all indicators of pikeperch juvenile in the variant II of the experiment were higher than in the variant I. In pikeperch juveniles with lower planting density, the better breeding and biological indices were obtained: the survival rate of juveniles was higher by 11.3%, the absolute linear growth gain by 3.2 mm and the absolute weight gain by 1 mg, respectively.

The mean weights of the larvae selected for the second stage of the experiment were 6 mg and 7 mg for variants I and II respectively.

The values of all indicators were higher in the variant II comparing to the values obtained in variant I at the second stage. The survival rate was higher by 9%,

Table 3. Breeding and biological indices of pikeperch juveniles, grown in cages at the first stage of rearing

Indicators	Measurement unit	Variant I	Variant II
Planting density	pcs/m^3	1000	500
	kg/m^3	0.090	0.045
Mean initial weight	g	0.09 ± 0.02	0.09 ± 0.02
Mean final weight	g	0.40 ± 0.037	0.83 ± 0.09
Absolute growth gain	g	0.31	0.74
Average daily growth gain	g	0.0155	0.037
The survival rate	%	71	79
Fish productivity	kg/m^3	0.22	0.29
Final planting density	kg/m^3	0.284	0.328

Table 4. Breeding and biological indices of pikeperch juveniles grown in cages at the second stage of rearing

Indicators	Measurement unit	Variant I	Variant II
Planting density	pcs/m^3	500	200
	kg/m^3	0.200	0.166
Initial weight	g	0.40 ± 0.037	0.83 ± 0.09
Final weight	g	0.95 ± 0.092	1.57 ± 0.098
Absolute growth gain	g	0.55	0.74
Average daily growth gain	g	0.0275	0.037
The survival rate	%	89	93
Fish productivity	kg/m^3	0.24	0.14
Final stock density	kg/m^3	0.423	0.292

absolute linear growth gain by 1.1 mm, absolute weight gain by 5 mg.

The mean weights of the larvae selected for the third stage of the experiment were 20 mg and 26 mg for variants I and II, respectively.

At the third stage, the values of all indicators were higher in the variant II than in the variant I of the experiment. The survival rate was higher by 9%, the absolute linear growth gain by 1.2 mm, the absolute weight gain by 3 mg.

Results of Growing of Pikeperch Juveniles in Pond Cages

At the beginning of the first stage of growing pikeperch juveniles in cages (in the period from May 31 to June 20), the stock densities were 1000 pcs/m3 and 500 pcs/m3 in the first and second variant, respectively. Breeding and biological indices of pikeperch juveniles obtained at the end of the first stage of rearing are presented in **Table 3**. Absolute growth of pikeperch juveniles was 2.39 times greater in variant II when compared to results of variant I. The same applies to other breeding and biological indices; the survival rate was higher by 11.27%, the fish productivity of cages - by 31.82%, and the final planting density by 15.49%.

At the beginning of the second stage of growing pikeperch juveniles (in the period from June 21 to July 10), the stock densities in respective variants were 500 pcs/m^3 and 200 pcs/m^3. The feeding ration of live food was 70% of zooplankton (medium-sized Daphnia) and 30% of larvae of forage fishes. Breeding and biological indices of pikeperch juveniles at the end of second stage of rearing are presented in **Table 4**. The value of absolute growth gain and survival rate was greater in variant II by 34.55% and by 4.49%, respectively. However, larger values of fish productivities of cages (by

Table 5. Breeding and biological indices of pikeperch fingerlings grown in cages at the stage III of rearing

Indices	Measurement unit	Variant I	Variant II
Planting density	pcs/m^3	250	120
	kg/m^3	0.238	0.188
Initial weight	g	0.95±0.092	1.57±0.098
Final weight	g	2.84±0.108	4.29±0.129
Absolute growth gain	g	1.89	2.72
Average daily growth gain	g	0.0945	0.136
The survival rate	%	90	95
Fish productivity	kg/m^3	0.43	0.31
Final planting density	kg/m^3	0.639	0.489

Table 6. Breeding and biological indices of pikeperch fingerlings grown in cages at the stage IV of rearing

Indices	Measurement unit	Variant I	Variant II
Planting density	pcs/m^3	250	120
	kg/m^3	0.710	0.515
Initial weight	g	2.84±0.108	4.29±0.129
Final weight	g	4.53±0.132	8.14±0.231
Absolute growth gain	g	1.69	3.85
Average daily growth gain	g	0.0845	0.1925
The survival rate	%	94	98
Fish productivity	kg/m^3	0.40	0.45
Final planting density	kg/m^3	1.065	0.957

71.43%) and the final stock density (by 44.86%) were recorded in the cages of the 1st variant.

At the beginning of the third stage of growing pikeperch fingerlings (in the period from July 11 to July 30) the stocking densities of fingerlings were 250 pcs/m^3 and 120 pcs/m^3. The life food consisted of zooplanktom 50% and 50% of juveniles of forage fish. Breeding and biological indices of pikeperch fingerlings at the end of third stage of cultivation in cages are presented in **Table 5**. Similarly to the second stage, the value of absolute growth gain and survival rate were greater (by 43.92% and 5.56%, respectively) in the variant II, but larger values of fish productivity of cages (by 38.71%) and the final stock density (by 30.67%) were recorded in the cages of the variant I.

At the beginning of the fourth stage of growing pikeperch fingerlings in cages (in the period from July 31 to August 20), the stock density of fingerlings was 250 pcs/m^3 and 120 pcs/m^3 in the first and the second variant, respectively. The diet consisted of 30% of Daphnia sp. and 70% of forage fish. Breeding and biological indices of pikeperch fingerlings at the end of fourth stage are presented in **Table 6**. At the end of this stage, the values of absolute growth gain, survival rate and fish productivity of cages were higher in the second variant, by 127.81%, 4.26% and by 12.50%, respectively. However, the final stock density was higher by 11.29% in the first variant.

At the beginning of the fifth stage of growing of pikeperch fingerlings in cages (in the period from August 21 to September 10), the stock density of fingerlings was 120 pcs/m^3 and 50 pcs/m^3 in the first and second variant, respectively. The diet consisted only of juvenile coarse fish offered at the rate of 20% of juveniles biomass. The value of the absolute growth gain and the survival rate were higher in the second variant by 3.35% and 1.05%, respectively. However, larger fish productivity in cages (on 123.53%) and the final stock density (to 60.94%) were recorded in cages of the first variant. Breeding and biological indices of pikeperch fingerlings at the end of the fifth stage are presented in **Table 7**.

Table 7. Breeding and biological indices of pikeperch fingerlings grown in cages at the fifth stage of rearing

Indices	Measurement unit	Variant I	Variant II
Planting density	pcs/m^3	120	50
	kg/m^3	0.544	0.407
Initial weight	g	4.53±0.132	8.14±0.231
Final weight	g	7.81±0.275	11.53±0.329
Absolute growth gain	g	3.28	3.39
Average daily growth gain	g	0.1640	0.1695
The survival rate	%	95	96
Fish productivity	kg/m^3	0.38	0.17
Final planting density	kg/m^3	0.890	0.553

Table 8. Breeding and biological indices of pikeperch fingerlings grown in cages at the sixth stage of rearing

Indices	Measurement unit	Variant I	Variant II
Period of rearing	days	20	20
Planting density	pcs/m^3	50	25
	kg/m^3	0.391	0.288
Initial weight	g	7.81±0.275	11.53±0.329
Final weight	g	15.23±0.412	21.36±0.499
Absolute growth gain	g	7.42	9.83
Average daily growth gain	g	0.3710	0.4915
The survival rate	%	100	100
Fish productivity	kg/m^3	0.37	0.25
Final planting density	kg/m^3	0.762	0.534

At the beginning of the sixth stage of growing of pikeperch fingerlings in cages (in the period from September 11 to September 30), the stock densities were 50 pcs/m^3 and 25 pcs/m^3 in the first and the second variant, respectively. The diet consisted only of forage fish offered at the ratio of 10% of the juveniles biomass. Breeding and biological indices of pikeperch fingerlings at the end of sixth stage are presented in **Table 8**. The higher values of absolute growth gain (by 32.5%), fish productivity of cages (by 48.0%) and the final stock density (by 42.7%) were found in cages of the first variant.

Fish stock material of pikeperch, grown during the experiment, was moved to experimental cages in a fry pond. Three groups were set; cage stocked with 1185 pcs of fingerlings with an average weight of 0.61 g; and cage stocked with 783 pcs of average weight 1.26 g; and 1968 pcs of average weight of 0.87 g. Total stock density was 9840 pcs/ha. During the autumn harvest, 802 pcs of pikeperch fingerlings with an average weight of 29.84 g ± 1.54 g (C_V = 25,8%) were caught. The survival rate of fingerlings was 40.75%, and the pond productivity was 116 kg/ha.

DISCUSSION

At the earliest stages of life, pikeperch juveniles feed on zooplankton (cladoceran and copepod crustaceans, rotifers), then, upon reaching a length of 20-25 mm, on mysids, freshwater hoppers, shrimps, chironomids larvae and caddis warms, pupae of mosquitoes, occasionally - larvae of fish. The transition to a predatory lifestyle usually occurs at a body length of 50 mm. Adult pikeperch is a predator and feeds on fish juveniles, particularly roach, bream, carp, perch, partly dace, rudd, bleak, goldfish, spotted stone loach, striped perch, gobies, sometimes mysids, freshwater hoppers, shrimps. The greatest activity of feeding was observed from May to October, during the winter feeding rate falls down (Isbekov et al. 2018).

The rearing of pikeperch larvae is an important technological stage not only for the pond fish farming system, but fist of all for the stocking of natural water bodies, since the stocking of fertilized pikeperch eggs on the nest or ungroomed larvae has a very low efficiency. he commercial return is 0.4-1.0%. Therefore, it is advisable to grow larvae to a viable stage for at least 10-12 days.

When conducting research on the rearing of pikeperch larvae to a viable stage, the aim was to study the survival and growth rate of pikeperch larvae reared in cages at different stock densities, using starting artificial feeds.

As a result of the conducted research, that the stock density of pikeperch juveniles in cages plays an important role. Lower stock density generally results in better breeding and biological indices.

It was also determined that at growing pikeperch juveniles in cages to an average weight of 0.8 g, the best stock density was 500 pcs/m^3, to an average weight of 0.95 (1.00) g – 500 pcs/m^3, to 2.84 (3.00) g – 250 pcs/m^3, to 8.14 (8.00) g – 120 pcs/m^3, to 15.23 (15.00) g – 50 pcs/m^3.

The data on the breeding of larvae, juveniles and combined breeding of pikeperch fingerlings in cages installed in carp ponds were obtained for the first time in the Kazakhstan. This research proved that carp ponds can be a source of additional valuable production in the practice of fish farming in Kazakhstan.

CONCLUSION

The results of the research on the breeding of pikeperch fingerlings in cages from grown juveniles in the conditions of fish farms in Kazakhstan are promising.

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