EXPERIÊNCIA DA INTRODUÇÃO DE TILÁPIA NAS FONTES GEOTÉRMICAS DO CAZAQUISTÃO

EXPERIENCE OF TILAPIA INTRODUCTION AT GEOTHERMAL SOURCES OF KAZAKHSTAN

ОПЫТ ВНЕДРЕНИЯ ТИЛАПИИ В ГЕОТЕРМИЧЕСКИЕ ИСТОЧНИКИ КАЗАХСТАНА

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RESUMO

Nos últimos anos, muita atenção tem sido dada ao uso de fontes geotérmicas na pesca. As perspectivas para esta área são enormes, pois abrem oportunidades para o gerenciamento de processos de criação de peixes, independentemente das condições climáticas. O principal objetivo do estudo foi uma análise abrangente dos processos tecnológicos de piscicultura. Uma das reservas promissoras para o aumento da produção de peixes é o uso racional de resíduos comerciais de água quente e fontes geotérmicas. O trabalho de pesquisa foi realizado em 2019 com base na fazenda TOO Tengri Fish, localizada a 270 quilômetros da cidade de Almaty. Os materiais foram coletados e processados de acordo com os métodos geralmente aceitos em ictiologia e piscicultura e subsequentemente analisados por meio de computador pessoal. Com base nos resultados do estudo, foram determinadas as primárias tecnológicas da criação de tilápia em SRA (sistema de recirculação da aquicultura) utilizando águas geotérmicas. Durante o estudo, foi realizado um trabalho para otimizar o regime hidroquímico. Os principais indicadores de criação de peixes e indicadores biológicos de crescimento e desenvolvimento de peixes da tilápia foram estabelecidos. Foi determinada a densidade ideal da tilápia em sistemas de recirculação da aquicultura usando água geotérmica e a temperatura em que a tilápia tem um ganho médio diário mais alto. A novidade do trabalho: um estudo abrangente da biologia e a adaptação de uma nova unidade de piscicultura industrial de tilápia e peixe-gato, realizado fora da área natural e que determinou a possibilidade de adaptar tilápia e peixe-gato a fatores extremos do ambiente aquático.

Palavras-chave: *fonte geotérmica, desgaseificação, caviar, larva, hidroquímica.*

ABSTRACT

Over recent years much attention has been paid to the fishery use of geothermal sources. The prospects for this area are enormous, as it opens up possibilities for managing fish-breeding processes, regardless of climatic conditions. The main objective of the research was a comprehensive study of the technological processes of growing. One of the promising reserves for increasing fish production is the rational fishery use of waste warm water and geothermal sources. Research work was carried out in 2019 based on the farm of "Tengri Fish" LLP, which is located 270 kilometers from Almaty. The collection and processing of materials were carried out according to generally accepted methods in ichthyology and fish farming, followed by their analysis on a PC. Based on the results of the research, technological primaries of growing tilapia in a RAS (Recirculating Aquaculture System) using geothermal waters were determined. During the research, work was carried out to optimize the hydrochemical regime. The main fish breeding and biological indicators for the growth and development of tilapia were established. The optimal stocking density of tilapias in recirculating aquaculture systems using geothermal waters and the temperature when tilapias have a higher average daily weight gain were found. The novelty of the research: a complex study of biology and adaptation of a new object of industrial fish farming of tilapia and clarium catfish has been carried out outside the range and determined the adaptation possibilities of tilapia and clarium catfish to extreme factors of the aquatic environment.

Keywords: *geothermal spring, degassing, caviar, larva, hydrochemistry.*

АННОТАЦИЯ

В последние годы большое внимание уделяется использованию геотермальных источников в рыбном хозяйстве. Перспективы этой области огромны, так как она открывает возможности для управления процессами разведения рыбы, независимо от климатических условий. Основной целью исследования было комплексное изучение технологических процессов выращивания. Одним из перспективных резервов для увеличения производства рыбы является рациональное использование промысловых отходов теплой воды и геотермальных источников. Исследовательские работы проводились в 2019 году на базе фермы ТОО «Tengri Fish», расположенной в 270 километрах от Алматы. Сбор и обработка материалов проводились в соответствии с общепринятыми методами в ихтиологии и рыбоводстве с последующим их анализом на ПК. По результатам исследования определены технологические праймериз выращивания тилапии в РСА (рециркуляционной системе аквакультуры) с использованием геотермальных вод. В ходе исследования проводились работы по оптимизации гидрохимического режима. Установлены основные рыбоводные и биологические показатели роста и развития тилапии. Найдена оптимальная плотность посадки тилапии в рециркуляционных системах аквакультуры с использованием геотермальных вод и температура, при которой у тилапии наблюдается более высокий среднесуточный прирост веса. Новизна исследования: комплексное изучение биологии и адаптация нового объекта промышленного рыбоводства тилапии и клариумного сома, проведенного за пределами ареала, и определившего возможности адаптации тилапии и клариумного сома к экстремальным факторам водной среды.

Ключевые слова: геотермальный источник, дегазация, икра, личинка, гидрохимия.

1. INTRODUCTION

Over the past decades, aquaculture has become one of the fastest-growing areas of food production and plays an increasingly important role in the economic development of many countries. In terms of development, aquaculture is ahead of fish caught in the oceans and seas and today provides more than 40% of total fish production (Mamontov, 2000). One of the promising reserves for increasing fish production is the rational fishery use of waste warm water and geothermal sources. Over recent years, in our country and abroad, much attention has been paid to the fishery use of geothermal sources (Gurkina *et al.*, 2019; Lefers *et al.*, 2020). The prospects for this area are enormous, as it opens up possibilities for managing fish-breeding processes, regardless of climatic conditions (Budiasa *et al.*, 2018; Leite *et al.*, 2018).

A promising direction in fish farming is the use of not only the potential of inland water bodies but also the rational use of waste warm water and geothermal sources. Geothermal sources located on the territory of the Republic of Kazakhstan are one of the water areas where the cultivation and cultivation of new aquaculture facilities with a high growth rate and valuable taste qualities are quite promising (Beisembayeva *et al.*, 2017; Syzdykov *et al.*, 2019).

Geothermal waters in different regions of

the country and at different levels of occurrence can vary significantly. The temperature of such waters also varies from 30-40 to 80-90 °C and higher. A common characteristic feature of geothermal waters can be considered the absence of a minimum amount of dissolved oxygen, high content of carbon dioxide, and mineral salts. However, in the process of filling the ponds and their operation, the chemical composition of the water may change. In particular, it is saturated with oxygen, and the carbon dioxide content is reduced. In determining the possibility of using geothermal waters for fish farming, in each specific case, their careful chemical analysis is necessary (Tetdoyev, 2009; Tosun, 2017).

The area of application of geothermal sources in the national economy is expanding more and more and requires economic and rational use, including in fish farming (Tetdoyev, 2009; Tetdoyev and Pliyev, 2009). The chemical composition of the new, previously unknown aquatic environment, will allow establishing the degree of tolerance, adaptive plasticity, as well as their growth and development potential at different stages of cultivation when breeding fish farming objects (Tetdoyev, 2009; Tetdoyev and Pliyev, 2009).

Geothermal waters in different regions and at different levels of occurrence can vary significantly. The composition of geothermal waters is characterized by a large amplitude of

fluctuation both in chemical composition and in the number of salts and gases dissolved in it. A common characteristic feature of geothermal waters can be considered the absence or minimum amount of dissolved oxygen, high content of carbon dioxide, and minerals. However, in the process of filling the ponds and their operation, the chemical composition of the water may change. In particular, it is saturated with oxygen, and the carbon dioxide content is reduced (Boronetskaya, 1993; Mamontov, 2000; Tetdoyev, 2009; Bolotov *et al.*, 2016).

Scientists of Russia have experience in growing traditional fish farming objects (carp, wild carp), as well as new aquaculture objects (tilapia). Research on the cultivation of tilapia in ponds using geothermal water was carried out based on the fish breeding department of the Mostovskaya greenhouse complex in the Krasnodar Territory (Mamontov, 2000; Tetdoyev, 2009). Studies have shown that the geothermal water of the Mostovskoye field belongs to sulfate-sodium waters, has a temperature of 75-800 °C. Mineralization of water is low (1-1.5 g/l). Geothermal water was pre-mixed with river water and then fed into fish ponds. The ratio of geothermal and river water varied depending on the season of the year. The temperature in the ponds was also regulated due to the intensity of water exchange (Tetdoyev, 2009). Russian scientists conducted experiments on growing carp using geothermal, weakly mineralized, carbonate-chloride-sodium water from deep wells with total salinity in hatcheries from 1.9 to 3.6 g/l, and in commercial fish plots up to 12.2 g/l (Pevnev, 2000; Korentovich *et al.*, 2017).

The new economic conditions in Kazakhstan over the past decade (2010-2020) put the fisheries industry in a rather difficult position, and therefore, the per capita consumption of fish products for this period reached only 4 kg, that is, 2.5 times less than the following consumption rate (14 kg per capita), which reduced the usefulness of protein nutrition. The principal, decisive factor for solving this issue will be, first of all, the development of aquaculture in the Republic of Kazakhstan, using available water resources and the introduction of new aquaculture facilities – fish with an intensive growth and development rate, crustaceans, mollusks, aquatic plants and other aquatic organisms (Master plan of commercial..., 2011).

Growing fish in industrial fish farms has several advantages over pond farming. No more than 0.01 m² of land and 0.005 m³ of water are spent on the production of 1 kg of products in

industrial fish farming, which is two orders of magnitude less than in pond fish farming. At the same time, a high yield of fish products is achieved – 100 kg or more from 1 m² of cage and pool area. One of the real ways to increase the economic efficiency of industrial fish farming is to grow more valuable fish species that have a reasonably high growth and development rate, unpretentiousness to the habitat and food, high fecundity, and high taste (Pruszyński and Pistelok, 1999; Shelton, 2002; Rothbard and Peretz, 2002; Zdanovich and Pushkar, 2007; Tetdoyev and Boronetskaya, 2008).

The main objective of the research is a comprehensive study of the technological processes of growing Nile tilapia at geothermal sources. In order to achieve the objectives, the following tasks had to be accomplished:

- to study the features of the hydrochemical regime of geothermal sources (thermal regime, gas and salt composition of water);

- study of the influence of technological factors (planting density, feeding level) on the growth and development of tilapia when kept in a water storage system using geothermal water.

The novelty of the research: a complex study of biology and adaptation of a new object of industrial fish farming of tilapia and clari catfish has been carried out outside the range and determined the adaptation possibilities of tilapia and clari catfish to extreme factors of the aquatic environment: lack of oxygen dissolved in water, high and low concentration of ions (pH), high concentration of minerals (Grande Burgos *et al.*, 2018; Billah *et al.*, 2020; Mansano *et al.*, 2020).

2. MATERIALS AND METHODS

Research work was carried out in 2019 based on the farm of “Tengri fish” LLP, which is located 270 kilometers from Almaty, near the village of Chunzha, on a plot of 15 hectares. This farm has two deep, self-flowing, artesian, geothermal wells. Previously, it was conducted hydrochemical studies of geothermal waters in order to determine the hydrochemical regime of water bodies for the subsequent planting of aquaculture objects in them – tilapia and Clari (African) catfish.

Aquaculture objects were grown at a planting density of 50-150 kg/m³ for African catfish and 30-50 kg/m³ for tilapia. Feeding was carried out with specialized Aller aqua aquaculture feeds

containing 45% protein, 15% fat, and 22% carbohydrate. The daily diet ranged from 10% for juveniles to 3% for marketable fish. Each month, fish were sorted to reduce planting density and uniform fish growth. The OxyGuard Handy Polaris Thermo Oximeter was used for daily monitoring of oxygen in the water. Water samples were taken to describe the complex hydrochemical regime in fish hatcheries. The studies were carried out in an accredited hydrochemical laboratory of the Scientific Analytical Center LLP.

To characterize the hydrochemical regime in fish hatcheries, water samples were taken. The studies were carried out according to standard methods. The control of the hydrochemical regime was carried out according to the following leading indicators (parameters) – oxygen content (O_2), carbon dioxide (CO_2), pH – medium, water temperature ($t\text{ }^{\circ}C$), as well as the content of nitrates (NO_3) and nitrites (NO_2) (Semyonov, 1977; Yudin, 1980). For ichthyologic studies, generally accepted research methods used in fish farming were used. The ichthyologic analysis includes the determination of linear dimensions, weight, fatness (Pravdin, 1966). The growth rate of the studied fish was carried out according to accepted methods (Chugunova, 1959; Privezentsev, 1991). Ichthyological studies were carried out every 7 days in order to determine the growth rate and calculate the daily diet.

3. RESULTS AND DISCUSSION:

3.1. The Features of the Hydrochemical Regime of Geothermal Sources

Geothermal waters in different regions of the country and at different levels of occurrence vary significantly. The composition of geothermal waters is characterized by a large amplitude of fluctuation both in chemical composition and in the number of salts and gases dissolved in it. A characteristic feature of geothermal sources can be considered the absence or minimum content of dissolved oxygen with a high content of carbon dioxide and minerals (Boronetskaya, 1993; Pevnev, 2000).

Studies on the cultivation of tilapia using geothermal waters were carried out based on the fish farm of "Tengry fish" LLP. This farm is located in the Almaty region, Uygur district, the village of Chunzha, for fish growing was used as a system of closed water supply systems with geothermal water. As this study shows, as well as data from foreign scientists (Boronetskaya, 1993; Pruszyński and Pistelok, 1999; Pevnev, 2000; Tetdoyev, 2009; Bolotov *et al.*, 2016; Korentovich

et al., 2017), the minimum salient oxygen content at high content of carbon dioxide and mineral salts can be considered a common characteristic feature of geothermal sources. Accordingly, in the waters of geothermal sources used in this study, the hydrochemical regime corresponded to the above data. Preliminary studies of water from geothermal sources indicate that the maximum permissible concentrations of carbon dioxide (80.1 mg/l) and total nitrogen (2.86 mg/l) are exceeded. Table 1 shows the hydrochemical parameters of water of geothermal sources, and in Figure 1, the proportion of chemical components present in the geothermal source.

The negative effect of a high concentration of carbon dioxide on the vital activity of fish is that fish, being in a depressed state, use oxygen dissolved in water worse. Moreover, not only the absolute content of oxygen and carbon dioxide (carbon dioxide) in the water is essential, but their ratio. For carp, for example, the ratio of O_2 and CO_2 approaching 0.02 is dangerous. With a low oxygen content and an unfavorable ratio of O_2 and CO_2 , fish use feed much worse. The critical carbon dioxide concentration varies for different fish species.

The high content of carbon dioxide leads to a decrease in pH, as a result of which prerequisites are created for limiting the transfer of blood oxygen in the gills. As a result, signs of asphyxia in fish develop. Nitrogen is less toxic to fish. However, fodder and vital products of fish continuously get into the fish's artificial keeping water, and in the process of their decomposition, a large amount of phosphorus and nitrogen is formed in the form of ammonia. This leads to the uncontrolled growth of algae and causes intoxication of the fish organism; chronic gill lesions occur. According to hydrochemical analyzes, the concentration of iron did not exceed the MPC. However, it should be noted that iron in the water of geothermal sources is presented as divalent, which, in turn, is toxic to caviar and juvenile fish.

In order to regulate and optimize the hydrochemical regime of the waters of the geothermal spring, it is necessary to reduce the carbon dioxide content. The removal of carbon dioxide in geothermal springs was carried out by the method of degassing – by aeration of water or by stripping. Aeration is carried out by forcing air into water. With this degassing method, the turbulent contact of air bubbles and water removes gases. In this research, a more effective degassing method is stripping. In a drip filter system, gases are stripped by physical contact

between water and a plastic aggregate (bio blocks) stacked in a column. The stripping process will remove carbon dioxide and nitrogen from the water, and the aeration well will allow ferrous iron to become ferric with subsequent conversion to iron oxide, which precipitates (Figure 2). As a result of regulation by the method of degassing the hydrochemical regime in the pools, it was found that the water indicators practically corresponded to the normative indicators (Table 2). As shown in Table 2, the effective operation of the degassing unit is reflected in a decrease in carbon dioxide concentration by 20 times from the initial one and increases the concentration of dissolved oxygen by two times.

As reflected in Figure 3, when using the degassing method, the level of dissolved oxygen in closed water supply plants almost reached the maximum level and averaged 6.27 mg/dm³. This was seen in the behavioral response of fish (tilapia). At the initial stage of the experiment, when using water from geothermal springs, after degassing, the fish behaved relatively passively, inactive, sluggishly took food, and for the most part, they were at the surface of the water. Subsequently, as the concentration of dissolved oxygen increased, the activities of the fish increased, willingly and actively took food and were dispersed over the entire basin. The highest activity was observed during the periods of July-August. The method of degassing effectively reduced the concentration of carbon dioxide (Figure 4). Figure 4 shows the dynamics of decreasing carbon dioxide concentration in the recirculating aquaculture system with the content of tilapias up to 71%. In this study, the pH dependence on carbon dioxide concentration is traced. According to V. V. Tetdoyev (2009) research, low pH is "favorable" for the presence of free carbon dioxide. When pH increases to 8, the balance shifts towards the formation of bicarbonate (HCO₃), resulting in a reduction in free carbon dioxide. This study notes a gradual increase in the pH value (Figure 5). As reflected in Figure 5, the pH of water in basins with tilapias was predominantly of a weakly alkaline environment.

Figure 6 reflects the general dependence of pH on carbon dioxide using geothermal waters while keeping tilapia in the recirculating aquaculture system. The inverse dependence of pH on the content of carbon dioxide becomes evident after drawing the trend lines: the higher the concentration of carbon is, the lower is the pH of the medium. A similar tendency can be observed for "the content of carbon dioxide – pH of the

medium" pair. In order to confirm that, the correlation ratio in these pairs of features was calculated. In the pair "carbon dioxide – concentration", it was $r = -0.448$, and in the pair "pH – ionic medium" $r = -0.04$. To determine the effect of the temperature on tilapia growth, in the process of growing the mint here circulating aquaculture system using geothermal waters, experiments with temperature regimes from 25 to 33 °C was conducted. The results of the experiment are represented in Table 3. The results of the experiment proved the advantages in the growth of tilapias, which had been kept at the temperatures of 29 °C and 30 °C. The tilapias kept in these temperature regimes have higher average daily weight gain rates, which indicates the high activity of fish and, consequently, feed digestion.

3.2. Influence of Technological Factors on Tilapia Growth and Development at Content in Recirculating Aquaculture System Using Geothermal Waters

The main task of the conducted research was to develop technological processes of tilapia rearing and cultivation in a recirculating aquaculture system with geothermal water supply. In the course of the research, tilapias (females) were evaluated and then divided into three groups – with stocking densities of 100, 200, and 300 pcs/m³, respectively. Live weight and body indices were used as the main criteria for a comprehensive evaluation of the investigated fish population. The evaluation was also carried out in terms of secondary sexual characteristics.

Reproductive qualities were checked based on the results of two successive spawnings. The first spawning was carried out with fish kept at a water temperature of 27-29 °C in the basins. As a result of observations, it was found that the females matured 35-40 days after spawning. The results of tilapia growing at different stocking densities are presented in Table 4. The results of the studies have shown (Figures 7, 8) that tilapias grown under conditions of high stocking density are inferior in growth rate, the highest growth rate is observed in the basins with the lowest planting density.

As it can be seen in Figures 7-8, the growth rate is directly proportional to the density of fish stocking in the basins, the optimal density for growing tilapia in the basins using recirculating aquaculture system with geothermal water supply is 100 pcs/m³. At the same time, with a denser stocking, tilapia size and weight indices are close to commercial fish, and only a decrease in working fecundity and relative fecundity is noted (Table 4).

In order to determine the reproductive quality of tilapias grown under conditions of keeping in recirculating aquaculture system basins with geothermal water supply, studies were conducted (Table 5). Productive qualities of tilapias were identified during the periods of two spawnings. Assessment of tilapias productive and reproductive qualities at a specific stocking density and spawning order revealed certain differences.

The results of the performed research showed that tilapias grown in recirculating aquaculture systems using geothermal waters at a high density of stocking reflect the tendency to depend on the density level. The measurements taken at optimal stocking of tilapias with a density equal to 100 pcs/m³ show that the fish had high fecundity rate rates compared to tilapias grown at stocking densities of 200 to 300 pcs/m³. When assessing the efficiency of cultivation, not only the gross yield of products was taken into account, but also their commercial and nutritional qualities, as well as the efficiency of use of the given feeds.

Expectedly, the highest growth rate was observed in the basin with the lowest stocking density (average weight 300 g). 98% of tilapia, which had been kept at a stocking density of 100 pcs/m³, was esteemed as a standard product. In the third variant of growing, with a stocking density of 300 pcs/m³, the average fish weight was about 196 g, with only 14% of the yield of standard production (above 250 g). Feed consumption is not more than 2.5 kg/kg weight gain.

Aquaculture is one of the fastest-growing areas of food production in the world market. Tilapia is one of the top contributors to the increase in aquaculture production. Tilapias are grown in more than 120 countries. The largest tilapia producers are China – 51% (897.3 thousand tons), Southeast Asian countries (Philippines, Indonesia, Thailand), Mexico, and Egypt. In Europe, tilapias are cultivated in Germany, France, Belgium, Czech Republic, Bulgaria, and some other countries.

Such a rapid spread of tilapia in world aquaculture and a significant increase in its production are associated with several valuable biological characteristics and economic benefits that are peculiar to these fish. (Boronetskaya, 1993; Pevnev, 2000; Shelton, 2002; Rothbard and Peretz, 2002; Tetdoyev, 2009; Tetdoyev and Pliyev, 2009; Boronetskaya and Privezentsev, 2011; Boronetskaya, 2012).

Tilapias are also of great interest in fish farming in Kazakhstan. In our country, the first studies related to the study of tilapia as a possible

object of domestic aquaculture have been launched quite recently. As researches have shown, the natural and climatic conditions of our country allow cultivating it in the southern regions of the republic. Also, a promising production base for tilapias is industrial fish farms that use natural and technical warm waters, including the use of geothermal sources.

The necessary condition ensuring the realization of the high genetic potential of tilapias in the knowledge of their requirements to the main water parameters – temperature, dissolved oxygen in the water and other water quality parameters, their adaptation capabilities. In this regard, the research tasks included, on the one hand, the study of the peculiarities of the hydrochemical regime of geothermal sources (thermal regime, gas and salt composition of water, etc.), and on the other hand – the study of the influence of technological factors (density of stocking, feeding level) on the growth and development of tilapia in the recirculating aquaculture system using geothermal water.

The work was carried out based on the fish farm of “Tengry fish” LLP. Several studies related to the influence of individual environmental factors were carried out in the conditions of the Research Center “Fish Industry”. When studying the technology of tilapia growing in recirculating aquaculture systems using geothermal waters, great attention was paid to studying their temperature regime. Temperature is one of the leading environmental factors determining the possibility and effectiveness of tilapia cultivation. The temperature regime in basins with geothermal water supply is practically in a controlled mode. The experience of cultivation of tilapias in conditions of keeping in ponds with geothermal water supply created essential problems in the winter period due to temperature decrease to 10-15 °C (Tetdoyev, 2009). Studies have shown that the closed water supply system provides reliable control of water quality and allows year-round reproduction and cultivation of fish.

One important indicator of water quality is the oxygen regime. Studies on tilapia growing in conditions of closed water supply using geothermal waters indicate that the oxygen regime was quite favorable for tilapia breeding. Assessing the environmental conditions for growing tilapias in conditions of closed water supply using geothermal waters, it can be concluded that they meet the requirements for tilapias. The ability to regulate several water quality indicators, in particular through degassing, will create the conditions to ensure the realization of highly

productive and reproductive qualities of these fish species.

Much attention was paid to the study of tilapia growth and development in the conditions of a recirculating aquaculture system using geothermal waters. In the course of the research, the reactions of tilapias to the technology of content (density of stocking) and, accordingly, its impact on growth and development and reproductive qualities were determined. Performed researches have shown high tolerance of tilapias to influence of adverse factors of environment, extensive adaptive possibilities and high productive qualities that confirms the possibility of cultivation of new object of aquaculture in Republic of Kazakhstan in the conditions of domestic industrial fish farms.

4. CONCLUSIONS:

1. To regulate and stabilize the hydrochemical regime of geothermal sources, degasation was carried out, as a result of which the level of dissolved oxygen reached an average of 6.27 mg/dm³; pH 7.56; concentration of carbon dioxide to 2.11 mg/dm³.

2. As a result of growing tilapias at different stocking densities, it was found that the optimal stocking density of tilapias in recirculating aquaculture systems using geothermal waters is 100 and 200 pcs/m³. At the given density of stocking, higher indicators of growth rate are observed – absolute weight gain was 1603.1 g and 1357.1 g, respectively, in comparison with a stocking density of 300 pcs/m³, where absolute weight gain was 1214.2 g.

3. It has been found that reproductive qualities of tilapias grown in recirculating aquaculture system using geothermal waters at planting density from 100 to 200 pcs/m³ are also higher in all parameters than those kept at planting density of 300 pcs/m³, concerning both the weight of producers and such indicators as fecundity, the mass of reproductive products, yield of larvae.

4. It has been found that at the temperature, 29-30 °C tilapias have a higher average daily weight gain and, accordingly, more efficient use of feeds.

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Table 1. Hydrochemical parameters of geothermal waters

No.	The name of indicators	Actual figures	Normative indicators
1	Dissolvedoxygen, mg / dm ³	2.5	>5
2	pHunits	7.7	6.5-8.5
3	General stiffness, mg-eq/dm ³	3.8	<7
4	Carbondioxidemg / dm ³	80.1	10-15
5	Hydrogensulfide, mg / dm ³	0.002	<0.003
6	Permanganateoxidation, mg / dm ³	0.301	5
7	Totalnitrogen, mg / dm ³	2.86	<1.5
8	Phosphorustotal, mg/dm ³	0.009	<2
9	Chlorides, mg / dm ³	69.2	<350
10	Irontotal, mg/dm ³	0.030	<0.3
11	Fluorine, mg / dm ³	0.068	0.5-1.5
12	Zinc, mg / dm ³	0.091	<0.01
13	Manganese, mg / dm ³	0.009	<0.1
14	Oilproducts, mg / dm ³	0.073	<0.1

Table 2. The hydrochemical regime in a recirculating aquaculture system with the use of geothermal waters with tilapia content (maintenance time six months)

Indicators	Month						Average index	Normative indicators
	March	April	May	June	July	August		
Oxygen, mg/dm ³	6.01	6.09	6.24	6.28	6.47	6.58	6.27	>5
pH, units	7.5	7.5	7.5	7.6	7.6	7.7	7.56	6.5-8.5
Carbondioxide, mg/dm ³	3.8	2.5	1.6	2.1	1.6	1.1	2.11	10-15
Iron (II), mg/dm ³	0.003	0.002	0.002	0.001	0.001	0.001	0.001	<0.3
Iron (III), mg/dm ³	0.114	0.115	0.114	0.112	0.111	0.111	0.112	
Nitrates, mg/dm ³	4.11	3.28	3.1	2.84	2.77	2.71	3.135	<3
Nitrites, mg/dm ³	0.024	0.021	0.013	0.011	0.009	0.010	0.014	<0.02
Phosphates, mg/dm ³	0.01	0.01	0.011	0.0094	0.009	0.009	0.009	<2

Table 3. The effect of the temperature on the growth and development of tilapia while growing them in the recirculating aquaculture system using geothermal waters

Indicators	Water temperature, °C		
	25	29	33
Average stocking weight, g		12.6±0.36	
Average fishing weight, g	89.7±1.6	92.4±1.2	91.6±1.5
Averagedailyweightgain, g	0.86	1.14	1.11
Consumption of feed, kg/kg of weight gain	1.8	1.8	1.8

Table 4. The results of growing Nile Tilapia under different conditions of keeping

Indicators	Feeding level, %	Stocking density, pcs/m ³		
		100	200	300
The initial weight of females, g		12.6±0.36		
The final weight of females, g	3.5	202±6.3	171±4.5	153±5.9
Absolute weight gain, g	3.5	1603.174	1357.142	1214.285
Average daily weight gain, g	3.5	1.06	0.88	0.78
Workingfecundity, pcs. eggs	3.5	603±24.9	490±31.8	400±33.1
Relativefecundity, pcs. /g	3.5	2.9	2.6	2.5

Table 5. Characteristics of reproductive qualities of tilapias growing in a recirculating aquaculture system using geothermal waters

Indicators	Spawning	
	1	2
Stocking density, 100 pcs/m ³		
Weightoffish, g. female	158±13.5	242±9.6
Weightoffish, g. male	198±10.4	306±10.7
Feed consumption, kg/kg weight gain	2.5	2.5
Absolute weight gain, g female	-	84±5.8
Absolute weight gain, g male	-	108±9.5
Average daily weight gain, g female	-	2.1
Average daily weight gain, g male	-	2.7
Fecundity: working, pcseggs relative, pcs/g	427±9.2	750±10.3
Weight of eggs, mg	3.2±0.09	3.5±0.12
Weight of fish larvae, mg	7.7±0.14	7.9±0.11
Larvalyield, %	83.0±1.25	85.2±1.1
Stocking density, 200 pcs/m ³		
Weightoffish, g. female	127±14.2	203±9.8
Weightoffish, g. male	154±12.2	250±10.4
Feed consumption, kg/kg weight gain	2.5	2.5
Absolute weight gain, g female	-	76±5.9
Absolute weight gain, g male	-	96±7.1
Average daily weight gain, g female	-	1.9
Average daily weight gain, g male	-	2.4
Fecundity: working, pcseggs relative, pcs/g	317±9.8	528±9.7
Weight of eggs, mg	3.1±0.1	3.5±0.14
Weight of fish larvae, mg	7.5±0.11	7.7±0.12
Larvalyield, %	80±1.6	81±1.5
Stocking density, 300 pcs/m ³		
Weightoffish, g. female	117±13.1	192±9.6
Weightoffish, g. male	144±11.3	201±10.5
Feed consumption, kg/kg weight gain	2.5	2.5
Absolute weight gain, g female	-	71±5.5
Absolute weight gain, g male	-	93±7.2
Average daily weight gain, g female	-	1.6
Average daily weight gain, g male	-	2.1
Fecundity: working, pcseggs relative, pcs/g	287±9.6	418±8.8
Weight of eggs, mg	2.9±0.1	3.3±0.12
Weight of fish larvae, mg	7.1±0.1	7.3±0.14
Larvalyield, %	78±1.2	80±1.4

Figure 1. Diagram of the parameters of the hydrochemical regime of geothermal waters of fish farm Tengry fish LLP

Figure 2. Experimental degassing unit

Figure 3. Dynamics of changes in the oxygen regime in the installation of closed water supply using geothermal waters with tilapia content for six months

Figure 4. Dynamics of changes in the concentration of carbon dioxide in the installation of closed water supply using geothermal waters with tilapia content for six months

Figure 5. Dynamics of pH change in a recirculating aquaculture system using geothermal water keeping tilapia for six months

Figure 6. The effect of carbon dioxide on the pH of water in a recirculating aquaculture system using geothermal water while keeping tilapia for six months

Figure 7. The tilapia growth rate in recirculating aquaculture system using geothermal waters with different stocking densities

Figure 8. Average daily weight gain of tilapia in recirculating aquaculture system using geothermal waters with different stocking densities