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Regulation of the Duration of Spawning Cycles of Catfish in Industrial Aquaculture

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Abstract

This article is devoted to the study of the qualitative and quantitative characteristics of the African Catfish *Clarias gariepinus* eggs produced at different durations of the inter-spawning interval. Eggs were produced artificially using sex hormones. In industrial aquaculture, the African Catfish *Clarias gariepinus* does not reproduce naturally. Therefore, the problem of obtaining high-quality eggs that will be used for in-vitro fertilization is urgent. To implement artificial spawning of fish in industrial aquaculture, it is necessary to correctly choose the effective hormonal stimulator and empirically select its dose. Sex hormones are involved in regulating the duration of the inter-spawning interval and affect the quality of eggs produced both for fertilization and for food purposes. The pituitary gland of the African Catfish *Clarias gariepinus* and surfagon were used as gametogenesis stimulators. The aim of the work was to study the optimal duration of the inter-spawning interval and the effect of hormonal inducers used to stimulate artificial spawning in industrial aquaculture. The use of the catfish pituitary gland in fresh or acetonated form as a hormonal stimulator provided higher-quality eggs, compared to the synthetic hormonal drug - surfagon. Stimulation with acetonated pituitary injections reduced the inter-spawning interval of the African Catfish *Clarias gariepinus* to three months, and the use of surfagon prolonged the inter-spawning interval to four months. Reducing the duration of the inter-spawning interval is important for the production of the African Catfish *Clarias gariepinus* eggs for food purposes. Studies have shown that reducing the optimal duration of the inter-spawning interval negatively affects the quality of the produced eggs and their quantity. This research was financially supported by a grant from the Russian Foundation for Fundamental Research, project No. 18-016-00127.

Keywords: aquaculture, African Catfish *Clarias gariepinus*, eggs, inter-spawning period, sex hormones, oocytes.

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1. Introduction

Clarias Gariepinus catfish is a promising object of industrial aquaculture. It attracted the attention of fish farmers due to its record growth rate, excellent taste quality, and ability to metabolize feed efficiently. In terms of the rate of biomass growth, the African catfish surpasses all objects of industrial aquaculture, both in Russia and abroad (Germany, Hungary, Japan, France, USA, etc.) [1, 2].

The natural habitat of this catfish is Africa, the American continent and countries with warm climates. This is a thermophilic fish. The most favorable temperature for the African catfish is in the range of 25-28°C. [3, 4].

The biological characteristics of the African Catfish Clarias Gariepinus relative to environmental conditions make it possible to grow it both in RAS and in conditions of basin keeping. The optimal pH range is 6.3 - 7.5. Catfish Clarias Gariepinus - can live not only in fresh, but also in brackish waters. This species does not have high demands on the oxygen content, the oxygen level during its cultivation should be at least 5 mg/l. By the nature of its nutrition, the African catfish belongs to polyphagia. The life span of the African catfish is about 8 years. During this time, the fish can gain a mass of about 60 kg. [5, 6].

Sexual maturation of female species occurs at the age of 8-9 months, but at this age, females produce little eggs. The gonado-somatic index in nine-month-old females ranges from 7 to 9% [7–9].

Sexual maturation of males occurs at a later time and stretches up to 1.5-2 years. This process depends on the temperature of the habitat and the feeding conditions of the fish. The African Catfish Clarias Gariepinus has multi-portion spawning and is capable of producing eggs and spawning several times a year [10, 11].

Special attention in fish reproduction technology is given to the selection of males and females for the first spawning. Under the conditions of fish factory breeding, this group is usually the most numerous in a brood stock when producing offspring. There is no consensus on the breeding value of first-time spawning fish. The importance of this issue is currently increasing due to the transition to an industrial method of conducting the industry, as well as with the expansion of work on artificial breeding of African catfish in aquaculture [12–14].

The problem of the duration of inter-spawning intervals in industrial aquaculture is poorly studied. When breeding African catfish, you often have to deal with the poor quality of the reproductive cells of males and females. This is especially often manifested during the first spawning or with an insufficiently long spawning interval of repeated

spawning [15]. In the conditions of industrial breeding, this problem is relevant for all types of fish with multi-portioned spawning. At present, it is practically not studied. One of the important aspects of solving the problem of the quality of the reproductive products in fish with multi-portion spawning is the correct selection of hormonal inducers that ensure gonad maturation [16–18]. Without gametogenesis inducers, the African Catfish Clarias Gariepinus does not reproduce in industrial aquaculture. Our practical experience indicates the importance of choosing the optimal inducer of gametogenesis for obtaining high-quality reproductive cells for fish reproduction [19, 20].

In fish farming, a wide range of drugs are used as gametogenesis stimulants for the African Catfish Clarias Gariepinus. In domestic fish farming, a suspension of freshly obtained or acetonated pituitary gland is most often used, and from synthetic preparations – Surfagon.

The aim of the work was to study the optimal duration of the inter-spawning interval and the effect of hormonal inducers used to stimulate artificial spawning in industrial aquaculture.

2. Methods and Equipment

The research was conducted on the basis of Ulyanovsk State Agrarian University, in the laboratory of Experimental Biology and Aquaculture of the Department of Biology, Veterinary Genetics, Parasitology and Ecology. Females African Catfish Clarias Gariepinus aged 18 months were selected as the objects of the study.

Six experimental groups each consisting of 10 fish have been formed from the mature females for carrying out the experiment. The first and second experimental groups were operated in a two-month spawning interval. In the first group, the pituitary gland was used as a hormonal stimulator, and in the second group - Surfagon.

The third and fourth experimental groups were formed from females operated in the three-month inter-spawning interval. Females of the third group were injected with the pituitary gland, and the fourth group was injected with Surfagon.

The fifth and sixth groups included females that were operated in the four-month inter-spawning interval. In the fifth group, hormonal stimulation of ovogenesis was performed with a pituitary drug, in the sixth group, Surfagon was used.

The dose of fresh or acetonated pituitary gland was 0.5 mg/kg weight of females. Synthetic Surfagon was used in the concentration of the active substance 10 mcg/ml in a single dose of 1.5 ml/kg of fish weight.

The study of reproductive indicators of female Catfish Clarias Gariepinus was carried out according to generally accepted methods in fish farming.

3. Results

The aim of the study was to determine the optimal timing of the inter-spawning period of females when using them in reproductive technologies or for obtaining food caviar. It was also necessary to give a comparative assessment of the effectiveness of hormone inducers for shortening the inter-spawning interval.

At the first stage of the work, the rate of maturation of female oocytes and the number of mature eggs were studied, depending on the type of hormonal stimulator. Females of the experimental groups were kept at a temperature of 260 °C during the inter-spawning period, which was stipulated by the conditions of the experiment. After the experimentally planned inter-spawning period, 1st, 3rd, 5th experimental groups for oocyte maturation were stimulated with a pituitary suspension, and females of 2nd, 4th, 6th groups were hormonally induced with synthetic Surfagon.

The results of our preliminary studies and literature data indicate that the minimum inter-spawning interval of female African Catfish Clarias Gariepinus is at least 60 days.

Maturation of female oocytes under the influence of hormonal stimulators differed significantly in duration in all experimental groups. The longest period of female oocytes maturation was observed in the 2nd and 4th experimental groups and amounted to 18 and 15 hours, respectively. In the 1st experimental group, the maturation of female oocytes under the action of the pituitary gland was 14 hours after the injection.

A faster maturation of the reproductive products was noted among the females with the spawning period of 3 and 4 months, under the influence of hormonal stimulants. In the 5th experimental group, female oocytes matured within 10 hours. A comparative analysis of the effectiveness of hormonal inducers showed that maturation of female oocytes in experimental groups under the influence of the pituitary gland occurred faster than in groups that were stimulated by Surfagon drug. The research results are shown in Figure 1.

Upon maturation of female oocytes in each group, intra-group polymorphism was observed. Generalized study results of the oocyte maturation features are given in Figure 2.

Each of the experimental groups was characterized by specific features. According to the number of matured females in the experimental groups, differences depending on the duration of the spawning period and the type of inductor were observed.

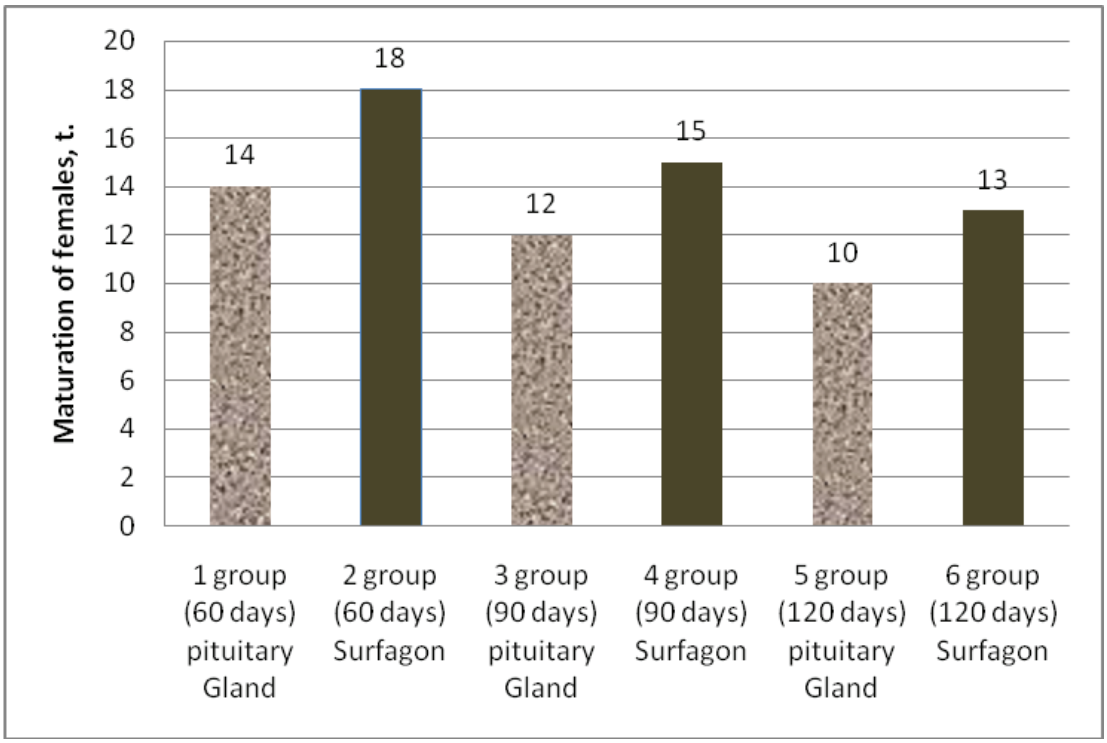

Figure 1: The duration of female oocytes maturation depends on the type of hormone inducer and the duration of the inter-spawning period.

Studies have shown that the smallest proportion of matured female oocytes was in the groups with the shortest (two-month) inter-spawning period. In the first group, under the influence of the pituitary gland, the number of females with matured oocytes was 50 percent of the number of injected ones. In the second experimental group, under the influence of Surfagon, oocytes matured only in 30% of females.

In females with a three-month inter-spawning period in the 4th experimental group, where hormonal stimulation was performed with Surfagon, oocyte maturation after hormonal stimulation reached 80%. In the 3rd experimental group, oocyte maturation was observed in 100% of individuals against the background of pituitary injections (Figure 2.).

In the 5th and 6th groups, with a four-month inter-spawning period, when using the pituitary gland and Surfagon, oocyte maturation was observed in 100% of females (Figure 2.).

At the next stage of the work, a quantitative and qualitative assessment of caviar obtained as a result of hormonal stimulation was carried out. The research results are presented in Table 01. and Figure 3.

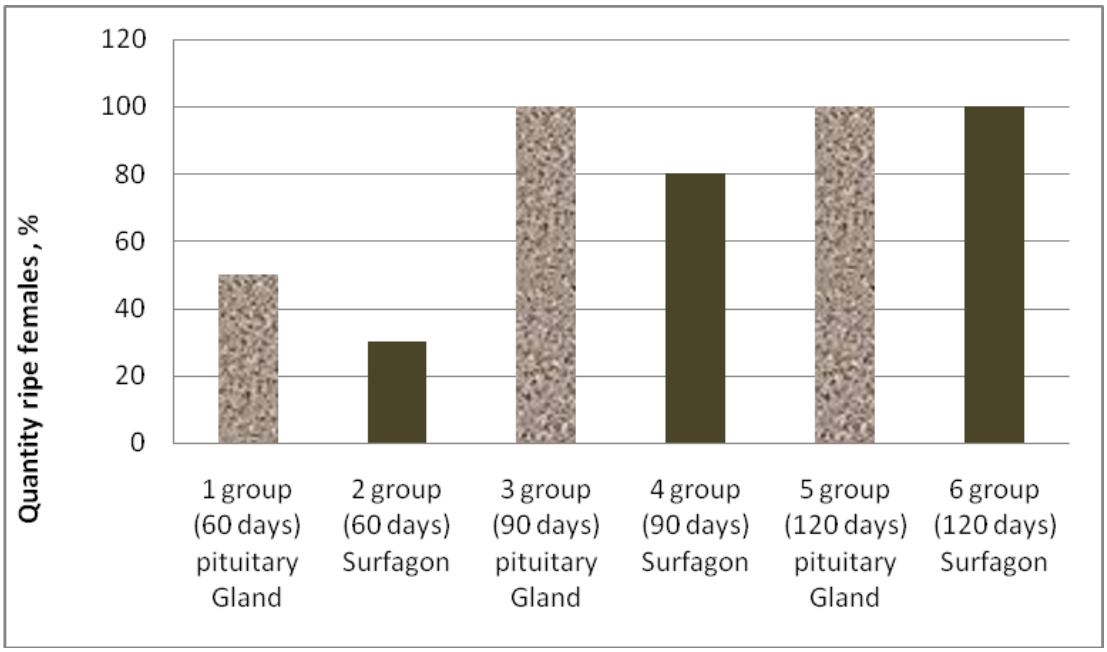

Figure 2: The number of females with matured oocytes depending on the spawning interval and the type of inductor

Table 1: Quantitative and qualitative characteristics of caviar depending on the duration of the inter-spawning period and the type of hormone inducer

Indicators	Average weight of females, g	The average weight of eggs	The average weight of egg, mg	Stages of eggs maturity	Visual assessment of eggs
1 group (60 days)	1735 ±15.12	65.1 ±3.15	1.311±0.0021	IV	immature
2 group (60 days)	1700 ±15.75	40.5±2.60	1.216±0.0030	IV	immature
3 group (90 days)	1692 ±16.07	250.3±7.24	1.595±0.0015	V	good quality
4 group (90 days)	1741 ±17.51	182.5±5.71	1.384 ± 0.001	IV- V	immature
5 group (120 days)	1730 ±15.75	305.2±11.4	1.605±0.0023	V	good quality
6 group (120 days)	1685 ±15.75	268.3±10.8	1.590 ± 0.001	V	good quality

When evaluating the quality and quantity of caviar obtained under the influence of hormonal stimulators of gametogenesis, it was found that there are differences in these indicators in all experimental groups.

The lowest values of the quantity and quality of eggs were obtained in the 1st and 2nd experimental groups with a two-month inter-spawning interval. On average, 65 g of eggs were obtained from females of the first group (Figure 3. A). During visual assessment, the eggs were characterized as immature; the average weight of eggs did not exceed 1.311 ± 0.0021 mg. and was assessed as IV stage of maturity according

to Kiselevich scale. Quantitative and qualitative indicators of eggs of the 2nd females group were low, the amount of eggs was 40 g. and the eggs themselves had IV stage of maturity according to Kiselevich and were assessed as immature.

Differences in quantitative and qualitative characteristics of eggs were observed in females of the 3rd and 4th experimental groups with a three-month inter-spawning interval. In the 3rd group of females, hormonally stimulated by Surfagon, an average of 182 g of good quality eggs, of V maturity stage were obtained (Figure 3. B).

In the 4th group of females, hormonally stimulated by Surfagon, an average of 182 g of eggs were obtained from 1 female. Both mature and immature oocytes were observed in the resulting portion of eggs. According to the Kiselevich scale, the eggs corresponded to the IV - V stage of maturity. The average weight of eggs in the third group exceeded this indicator in 1st, 2nd, 4th groups ($P < 0.001$).

In females of the 5th and 6th experimental groups with a four-month spawning interval, the quantitative and qualitative characteristics of eggs were higher than in the other experimental groups.

In the 5th group, an average of 305±11.4 g of eggs were obtained from each of the females, the gonadosomatic index was 19% (Figure 3c), in the 6th group, the gonadosomatic index was less and amounted to 16.7% against the background of Surfagon. In this group, an average of 268.3±10.8 g of eggs was obtained from the female. According to the results of the assessment, eggs in the fifth and sixth groups had high-quality characteristics and corresponded to the V stage of maturity according to Kiselevich.

3(a). 1 experienced group 3 (b) 3 experienced group 3(c). 5 experienced group

Figure 3: The number of eggs obtained from females with a two-month (a), three-month (b) and four-month (c) inter-spawning interval.

4. Discussion

Studies of the maturation rate of female oocytes and the number of mature eggs depending on the type of hormonal stimulator showed that the smallest proportion of mature females was in the groups with the shortest (two-month) inter-spawning period. 100% maturation of reproduction cells was observed in the 3rd experimental group of females with a three-month inter-spawning period against the background of pituitary gland use. In groups with a four-month inter-spawning period when using both the pituitary gland and Surfagon, oocyte maturation was observed in 100% of females.

Quantitative and qualitative assessment of eggs demonstrated differences for these indicators in all experimental groups. In the experimental groups with a two-month inter-spawning interval, the lowest quantity and quality values were obtained. Among the females with a three-month inter-spawning interval, the best indicators were demonstrated by females with pituitary gland hormonal stimulation. The highest quantity and quality indicators of eggs in comparison with the rest of the experimental groups were shown by females with a four-month inter-spawning interval, but higher quality eggs were observed in groups stimulated by the pituitary gland. An increase in the number of eggs in this group was accompanied by an increase in the maturity coefficient.

5. Conclusion

Analysis of research results revealed the dependence of indicators of eggs quality and reproductive characteristics of female Catfish Clarias Gariepinus on the timing of the inter-spawning interval and the gametogenesis hormone inducer used.

The results of hormonal stimulation of females depending on the duration of inter-spawning intervals show that the first and second experimental groups with a two-month inter-spawning interval during this period do not have time to recover from the eggs spawn and show low quantitative and qualitative characteristics of eggs, compared with other experimental groups. Such differences allow us to conclude that it is not advisable to use females in the two-month inter-spawning interval due to low fertility of females and poor quality of eggs. This is explained by the fact that the two-month inter-spawning period is clearly insufficient for the full completion of the processes of resorption of non-spawn oocytes remaining from the previous spawning, and for the formation of a new portion of full-fledged eggs.

When using the pituitary gland, the three-month spawning interval allows the female reproductive system to fully recover after the spawn of the next eggs portion. The

temperature of 26°C during the inter-spawning period and 28-30°C during the spawning period has a positive effect on the maturation of females under the influence of pituitary injections and ensures high quality of eggs.

The use of the synthetic hormonal drug Surfagon in hormonal stimulation requires a longer inter-spawning period in order to obtain high-quality, mature eggs of females. This period is four months.

The results of the research allow us to conclude that when using pituitary injections, the inter-spawning interval can be reduced without compromising the qualitative and quantitative characteristics of the eggs up to three months. If the drug Surfagon is used for hormonal stimulation of artificial spawning, the inter-spawning period should be prolonged to 4 months.

The use of a two-month inter-spawning period does not allow either using the pituitary gland or Surfagon to obtain a sufficient amount of mature eggs suitable for use in the reproductive process and for food purposes.

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