

REPRODUCTIVE BIOLOGY OF THE CHANNEL CATFISH (*ICTALURUS PUNCTATUS* RAF.) REARED IN HEATED WATER

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Abstract

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Size and age at which the channel catfish reared in the conditions of a thermal power station cooling lake have reached sexual maturity were studied. The fish were reared in net cages situated in the cooling lake. The water temperature during the winter months does not fall under 10°C, which allows the fish to feed during the autumn-winter period and to generate growth. The established body weight of the one-summer old catfish is 100.5 g for males and 81.2 g for females. For the one-year old catfish, the body weight was 163.4 g for males and 133.2 g for females. Differentiation of the gonads was clearly pronounced as early as at age of one-summer. The GSI was 0.19% for the females and 0.016% for the males. By the age of one year, the ovaries doubled in size with an average weight of 0.21g, and the testes of 0.03 g. The GSI had values of 0.21% for the females and 0.04% for the males. The maturity stage of the ovary and the testis was determined as stage II. For the two-summer old catfish (16-17 months of age), an average body weight of 958.9 g for the males and 894.8 g for the females was established. The GSI was 1.68% for females and 0.15% for males. The ovary was in the III-IV stage of maturity and their predominant fraction consisted of early vitellogenic follicles. At an age of 18-19 months, the ovary was in the IV stage of maturity, and the vitellogenic follicles were the main fraction in the ovary. The spawning takes place during mid May-early June, and the fish that reached the age of two years, is with an average body weight of 1007.8 g for the males and 985.2 g for the females, and can participate successfully in the reproduction process. The values of the absolute (7 583 eggs) and relative (8700 eggs/kgbody weight) fecundity for the two-year old matured channel catfish were lower than those typical for the older sexually mature fish. The weight and diameter of the eggs were 0.0071 g and 2.12 mm, respectively.

Key words: channel catfish, first maturity, fecundity, egg size

Introduction

American channel catfish *Ictalurus punctatus* (Rafinesque, 1818) is broadly distributed around the world including tropical and temperate fresh and shallow marine waters. It was first introduced from the United States to Soviet Union in 1972-1979. In Bulgaria it was introduced in 1979 from Krasnodar region of Russia. Commercial catfish rearing is performed only in one place in the country under the conditions of a Thermal Power Station cooling lake in fish cages. As of this moment the annual production of fish for consumption is about 400 t, which is marketed on both internal and external markets, mainly in the form of live or frozen fish.

In the last few years together with its rearing in the aquaculture the channel catfish has become a popular put-and-take

fish species in some recreational water bodies in Bulgaria. Commercially-produced catfish has been introduced into many private or public waters (ponds, small reservoirs and sandpits) for recreational fishing. The fish that is introduced in those reservoirs are two-year old weighing about 0.8-1.0 kg and according to witnesses when conditions are fit they can spawn. Catfish reproduction can be a major problem in the recreational water reservoirs. Its propagation can lead to congestion, stunt, increased occurrence of diseases, and increased likelihood of oxygen depletion. Another problem is that the channel catfish is an alien species for the Bulgarian ichthyofauna and its uncontrolled stocking and reproduction in the inland reservoirs would endanger the fish biodiversity.

The aim of this study is to survey the size and age at which the channel catfish reach sexual maturity when reared in

heated water in a commercial fish farm before its stocking in recreational water bodies.

Materials and Methods

Subject of this survey were 39 one-summer old fishes, 26 one-year old fishes, 34 two-summer old fishes and 22 two-year old fishes. Fish are reared throughout the year in fish cages based in Ovcharitsa dam-lake (South-East Bulgaria). One-summer old fish are reared at density of 600 ind.m⁻³ and the two-summer old fish at density of 35 ind.m⁻³. Fish are fed with pellets containing 32% protein. The annual water temperature dynamic in the dam-lake is presented in Figure 1.

Weight and length of the fish studied are measured with electronic scale to the nearest of 0.01g and 0.01 cm. The gonadosomatic index (GSI, %) was calculated as the ratio of ovary weight to fish weight. Ovary samples fixed in alcohol-formaldehyde-acetic acid (AFA) solution were used to determine the egg follicle weight to the nearest of 0.0001 g, and the egg diameter to the nearest of 0.0001 cm by using a microscope and ocular micrometer.

The absolute fecundity, i.e. the number of egg follicles present in the ovaries just prior to spawning, was determined by counting the number of egg follicles in 1 g of ovary and then multiplying by the total ovary weight. The relative fecundity was calculated by dividing the absolute fecundity by the fish weight.

For the histological examination of the ovary and testes samples were taken in October and May, fixed in 4% neutral buffered formalin, dehydrated, embedded in paraffin, sectioned at 5 µm, and stained with haematoxylin and eosin. Histological observations were performed at either 200x or 400x total magnification. Digital images were taken with an Olympus DP-10 camera. The developmental stage of testis

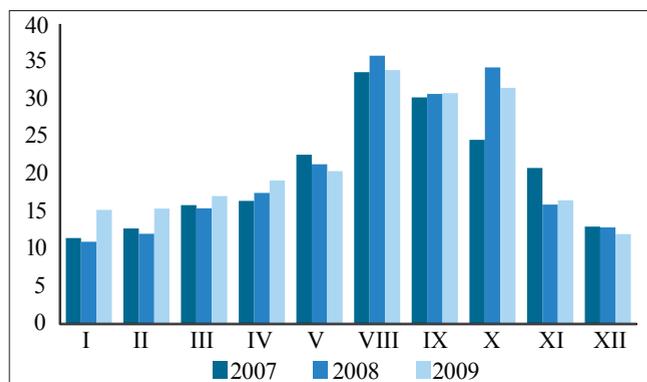


Fig. 1. Water temperature dynamic in Ovcharitsa dam-lake (South-East Bulgaria)

and ovaries was determinate according to Grizzle (1985) and Koshelev (1984)

Results

Body weight and length

Under the rearing conditions described the one-summer old catfish reached body weight of 100.4±46 g for males, and 81.2±37 g for females (Table 1). Their length was 17.4±2.4 cm and 16.4±2.4 cm, respectively. For one-year old fish was established body weight of 163.4±52 g for males, and 133.2±39 g for females, and body length of 20.3±2.4 cm and 19.1±1.7 cm respectively. The two-summer old catfish reached body weight of 958.9±172.10 g for males, and 894.8±142.90 g for females (Table 1). Their length was 39.2±1.51 cm and 38.6±2.08 cm respectively. For two-year old catfish body weight of the males was 1 007.8 g±111.42, and 985.2±144.18 g for females, and the body length was 45.45±3.09 cm and 43.72±37.50 cm respectively.

Gonadosomatic index (GSI, %)

Ovary weight of the one-summer-old catfish was 0.12±0.06 g, and the testes weight was 0.02±0.01 g (Table 2). GSI, % was 0.19±0.004 for female fish and 0.016±0.003% for males. At one year of age the ovary weight was twice as big - 0.21±0.10 g, and the testes weights 0.03±0.05 g. GSI, % had values of 0.23±0.07% for female fish and 0.04±0.06% for males. The ovary of two-summer old fish was with an average weight of 12.76±4.55 g, and the testes of 1.24±0.46 g (Table 2). The GSI, % was 1.68±0.62% for females and 0.15±0.06% for males, respectively. At age of two years the ovary weight was almost twice as big as the one of the two-summer old fish and had an average weight of 22.64±27.87 g. Same applies for the testes weight – it had values of 2.62±3.41 g for the two-year old fish. The GSI% had values of 2.97±3.63% for females and 0.35±0.44% male.

Gonad development

The ovary of the one-summer and one-year old fish were determined as being in early maturity stage II, showing immature ovaries, and developing young previtellogenic oocytes. The oocytes of phase B₁ и B₂ are predominant, and in the ovary of the one-year old females are met rarely oocytes of phase B₃. In the testes the spermatocytes were predominant.

First vitellogenic oocytes in the ovary were observed in 16-17 month-old fish, i.e. in two-summer old catfish. The maturity stage of the ovary was III-IV, as a predominant fraction were outlined the oocytes of phase D₃-D₄, i.e. vacuolated oocytes. Oocytes with accumulated yolk granules were rarely observed. At age of 18-19 months, the ovary passes into

the IV maturity stage, and the vitellogenic follicles were the main fraction in it. The testes were in the III-IV maturity stage in 16-17-month old fish, and reached the IV stage in fish at age of 18-19 months. The V maturity stage - ovulation, are observed in the ovary during mid May-beginning of June, during which the two-year old fish was ready to participate in the reproduction. Atretic vitellogenic follicles are observed in the ovary during the late June-August, i.e. the ovary is in the VI-II maturity stage in 25-26- month-old fish.

Fecundity

It was found in our investigation that the ovarian follicles number (absolute fecundity) in two-year old females weighing 892.67 ± 183.35 g was 7 583.67 pcs. (Table 3), and the relative was 8 702.83 pcs. per kg body weight.

Egg follicle weight and diameter

The egg follicle weight in the ovary of the two-year old females had an average value of 0.0071 g, as it varies from

Table 1
Body weight (g) and length (cm) of the investigated catfish (*I. punctatus* Raf.)

	One-summer-old fish				One-year-old fish			
	males n=20		females n=19		males n=12		females n=14	
	BW, g	SL, cm	BW, g	SL, cm	BW, g	SL, cm	BW, g	SL, cm
x	100.05±45.55	17.41±2.44	81.26±36.67	16.36±2.44	163.42±52.03	20.33±2.40	133.21±39.01	19.11±1.68
min	46.0	13.5	42.0	13.5	94.0	17.5	90.0	17.0
max	198.0	21.5	172.0	21.7	257.0	24.0	226.0	23.0
	two-summer-old fish				two-year-old fish			
	males n=10		females n=24		males n=12		females n=10	
	BW, g	SL, cm	BW, g	SL, cm	BW, g	SL, cm	BW, g	SL, cm
x	958.9±172.10	39.17±1.51	894.8±142.90	38.60±2.08	1007.83±111.42	45.45±3.09	985.2±144.18	43.72±37.50
min	721	37.5	644.0	35.0	848	39.5	730	37.5
max	1414	42.5	1087.0	42.0	1170	52.1	1190	48.0

Table 2
Testes (TW,g) and ovary weight (OW, g) and GSI, % of the investigated catfish (*I. punctatus* Raf.)

	One-summer-old fish				One-year-old fish			
	TW, g n=11	GSI,%	OW, g n=11	GSI,%	TW, g n=12	GSI,%	OW, g n=14	GSI,%
	x	0.02±0.01	0.016±0.003	0.12±0.06	0.19±0.04	0.03±0.05	0.04±0.06	0.21±0.10
min	0.008	0.012	0.04	0.11	0.005	0.004	0.086	0.122
max	0.034	0.022	0.25	0.28	0.175	0.176	0.48	0.321
	two-summer-old fish				two-year-old fish			
	TW, g n=10	GSI,%	OW, g n=24	GSI,%	TW, g n=12	GSI,%	OW, g n=14	GSI,%
	x	1.24±0.46	0.15±0.06	12.76±4.55	1.68±0.62	2.62±3.41	0.35±0.44	22.64±27.87
min	0.64	0.07	4.18	0.49	0.78	0.10	1.47	0.19
max	2.32	0.26	22.66	2.98	12.16	1.59	77.33	8.79

Table 3
Absolute and relative fecundity of two-year old female catfish (*I. punctatus* Raf.)

	BW, g	SL, cm	Egg number in 1 g ovarian mass	Absolute fecundity	Relative fecundity
x	892.67	40.60	134.33	7583.67	8702.83
SD	183.35	4.25	23.78	3185.83	3400.67
min	700	36	106	3710	3372
max	1130	48.3	168	12218	12507

0.0033 to 0.023 g (Table 4). The eggs diameter had average value of 2.12 mm, varying from 1.0 to 2.8 mm.

Discussion

The use of heated water from geothermal and industrial sources for aquaculture purposes has grown in the past two decades. Heated water is being used for fish farming in countries around the world (Fridliefsson, 1998). Approximately thirty facilities in the western United States rear aquatic species including channel catfish, tilapia *Oreochromis* spp., striped bass *Morone saxatilis*, fresh water prawns *Macrobrachium rosenbergii*, and tropical ornamental fish by use of geothermal water (NREL, 1998).

Reared in the cooling lake of the Thermal Power Plant, where the water temperature in winter does not drop below 10°C, channel catfish feeds during the autumn - winter period and gains growth, which allows reaching market size of over 1000 g after two-summer age. With such weight, usually in early spring months it is stocked as a put-and-take fish into recreational reservoirs within the country.

Temperature is the primary environmental influence on channel catfish spawning (Davis et al., 1986, Lang et al., 2003). The spawning season of channel catfish usually begins in May and lasts through early summer (June). Spawning activity is reported to begin when minimum water temperatures remain between 21 and 30°C (Busch, 1985; Huner and Dupree, 1984) but spawning can drop drastically at temperatures below 21°C or above 30°C (Lee 1981). Such temperature conditions can be expected in inland small, shallow ponds or reservoirs, which are used for recreational fishery. With continuous climate warming in recent years the likelihood for channel catfish to spawn in more inland water reservoirs increases.

The age and size at which channel catfish reach sexual maturity vary greatly. Usually it becomes sexually mature at 2 to 4 years of age and between 28 and 76 cm in size (Grizzle, J. 1985; Trautman, 1981). Our study established that by the

beginning of the third growing season, the two-year old fish is mature and ready to spawn during late spring (May-June). This is confirmed by Pacoli et al. (1990), who by using the ELISA and Western blot techniques found for the first time vitellogenin in the blood of 12 months old catfish. Its concentration in the blood does not vary significantly while fish reach age of 18 months in December. The vitellogenin level is increased significant from 0.40 mg/ml, when the fish were 16 months old in October to 3.77 mg/ml in December.

In recreational reservoirs containing other fish, such as sunfish or other carnivorous fishes, survival of spawned eggs, fry and fingerling will usually be low, because of predation by the other species. However, if the pond conditions are favorable, the survival rate can be good and result in overcrowding.

Another factor limiting its propagation are the significantly lower values of the ovary and testes weight in two-year old (May) channel catfish compared with those in older spawners (3 400-3 500 g). In May the testes of the spawners weights 8.9 g (GSI,%=0.25%), and the ovary 423 g (GSI,%=12.44%) respectively, i.e. they have a 7-times higher levels for the testes and 16-times higher values for the ovary compared with those in two-year old fish

Despite the reproduction availability, the fry, which could be obtained from these fish, would be fewer. The fecundity of two-year old fish is lower in comparison with this of the older spawners, where the absolute fecundity is 32 994 pcs., and the relative - 9 704 eggs per kg body weight. Zaikov and Zlatev (1987) established that the working fecundity of female channel catfish weighing 1 030 g to 1 780 g ranged from 11 520 to 4 640 eggs. The relative working fecundity values range 6 500-4 367 spawning eggs per kg body weight. For older female spawners the weight and the diameter of the egg follicles is significantly higher than in the two-year old females, respectively - 0.0109 g and 2.5867 mm.

The established fecundity in this study is lower than the one indicated by other authors. Channel catfish females produce a

Table 4
Egg follicle weight (g) and diameter (mm) of two-year old female catfish (*I. punctatus* Raf.)

Egg weight, g n=30							
Individual n=6	1	2	3	4	5	6	Average n=180
x	0.0056±0.0120	0.0109±0.0010	0.0070±0.0014	0.0074±0.0007	0.0044±0.0007	0.0076±0.0070	0.0071±0.0022
min	0.0033	0.008	0.0038	0.0058	0.003	0.0058	0.0033
max	0.0074	0.0123	0.0088	0.0089	0.0064	0.0088	0.0123
Egg diameter, mm							
x	2.0433±0.1478	2.2000±0.1722	2.2667±0.2023	2.2733±0.2243	1.8467±0.1978	2.0800±0.2524	2.12±0.2500
min	1.7	1.9	1.5	1.9	1.4	1.0	1.0
max	2.3	2.5	2.7	2.8	2.3	2.4	2.8

relatively large number of eggs – 10 000 – 20 000 per female and between 6000-8000 eggs per kg of body weight (Becker 1983). This can be explained with the rearing conditions and especially with the food quality. The study established that for the surveyed ages the amount of peritoneal fat tissue in the abdominal cavity is significant. For the two-summer old fish weighting 614-1190 g its share is 11.8-15.6%, and for two-year old with weighting of 730-1414 g it reaches 8.8-14.9%. This fact results most likely from the unbalanced diet during the rearing and most probably had affected the fecundity and the formation of the gonads. This is confirmed by our previous studies (Hubenova et al., 1993), where we have established spermatogenesis disturbance in sexually matured males due to spawner's unbalanced feeding.

In conclusion two-year old channel catfish reaches an average weight of 1 007g for males and 985 g for females, is mature and ready to spawn during late spring (May-June) by the beginning of the third growing season. The absolute (7583 egg follicles) and relative (8702 egg follicles/kg body weight) fecundity and the follicle egg weight (0.0071 mg) and diameter (2.12 mm), are lower than those characteristic for older sexually matured spawners.

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