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Research Article

## FEATURES OF THE EATING BEHAVIOR OF PRUSSIAN CARP *Carassius gibelio* Bloch, 1782 DEPENDING ON THE EFFECT OF THE ELECTROSTATIC FIELD

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### Abstract

The article presents the results of a study of the influence of the electrostatic field of different output voltages on the feeding behavior and motor activity of the crucian carp *Carassius gibelio* Bloch, 1782 under conditions imitating the benthic type of nutrition. Were formed two experimental (with the influence of ESP voltage 1.2 and 2.5 kV) and one control (without external influence) groups of fish. Two studies were carried out with different duration of experiments: 8 (experiment 1) and 15 (experiment 2) minutes. In the first experiment, significant differences in the behavior of fish were established for the indicators of total feeding time and diet under the influence of an ESP with a voltage of 1.2 kV. Similar calculations were carried out to study the significance of differences in the behavior of fish in the control and experimental groups in experiment 2 under the influence of ESP voltage of 1.2 kV and 2.5 kV. In this case, differences in the behavior of fish were established for the indicator of the time of group movement at an ESP of 1.2 kV. The motor activity of fish in the experimental groups under the influence of ESP is lower than in the control. When exposed to an ESP of 1.2 kV, groups of fish prefer to be on the “forage spot”, which is indicated by the highest average value of the diet; in two series, three of them ate all parts of the proposed feed (1 experiment). When fish is exposed to an ESP of 2.5 kV, it can be noted that the diet does not change significantly, but the motor activity of fish increases. In study no. 2 (15 minutes), the moment of satiety is pronounced, the fish could not swallow more food items than they needed, and they can digest. The group took an exploratory interest in the new setting.

Keywords: crucian carp, electrostatic field, video surveillance, physical activity, food activity, diet.

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Научная статья

## ОСОБЕННОСТИ ПИЩЕВОГО ПОВЕДЕНИЯ КАРАСЯ СЕРЕБРЯНОГО *Carassius gibelio* (Bloch, 1782) ОТ ВЛИЯНИЯ ЭЛЕКТРОСТАТИЧЕСКОГО ПОЛЯ НА

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### Аннотация

В статье представлены результаты исследования влияния электростатического поля разного выходного напряжения на пищевое поведение и двигательную активность карася серебряного - *Carassius gibelio* Bloch, 1782 в условиях, имитирующих бентосный тип питания. Были сформированы две опытные (с воздействием электростатического поля (ЭСП) напряжением 1.2 и 2.5 кВ) и одна контрольная (без внешнего воздействия) группы рыб. Проведено два исследования с разной продолжительностью опытов: 8 (опыт 1) и 15 (опыт 2) минут. В первом опыте установлены достоверные различия в поведении рыб для показателей - суммарного времени питания и рациона питания, под воздействием ЭСП напряжением 1.2 кВ. Аналогичные расчеты были проведены для исследования значимости различий в поведении рыб контрольной и опытной групп в опыте 2 под воздействием ЭСП напряжением 1.2 кВ и 2.5 кВ. В данном случае, различия в поведении рыб установлены для показателя времени группового движения при ЭСП 1,2 кВ. Двигательная активность рыб в опытных группах под воздействием ЭСП ниже, чем в контроле. При воздействии ЭСП 1.2 кВ группы рыб предпочитают находиться на “кормовом пятне”, на что указывает самое высокое среднее значение рациона, в двух сериях их трех особи съели все части предложенного корма (1 опыт). При воздействии на рыб ЭСП 2,5 кВ можно отметить, что рацион существенно не изменяется, однако повышается двигательная активность рыб. В исследовании № 2 (15 минут), момент насыщения ярко выражен, рыбы не могли заглотить больше кормовых объектов, чем им нужно, и они могут переварить. Группа проявляла исследовательский интерес к новой обстановке.

Ключевые слова: карась, электростатическое поле, видеонаблюдение, двигательная активность, пищевая активность, рацион.

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Introduction. At present, much attention is paid to the study of food procuring activity and the electroreceptor sensory system in fish [8, 13, 15, 20, 24, 26, 27]. The first work in the field of electroreception and electroorientation of fish began in Russia under the leadership of V.R. Protasov (Institute of Evolutionary Morphology and Ecology of Animals - IEMEZH). In the monograph of this scientist “Bioelectric fields in the life of fish” [6, 21] data on the so-called weakly and strongly electric fish, on the mechanisms of their perception of magnetic and electric fields and their significance in the life of underwater inhabitants were given. These studies laid the foundation for a new direction in biological science - electroecology.

Numerous electrophysiological studies of peripheral and central mechanisms associated with the electrolocation system revealed specific features of the topology of the central departments responsible for location [12, 16, 10], elucidated mechanisms for detecting stationary and moving objects [4, 5], as well as the principles of operation of an electrolocation system in the presence of electrical interference [2, 3, 10, 16, 22, 23, 25].

Through the efforts of domestic scientists, the mechanisms of the operation of electroreceptors and the regularities of the functioning of the electrosensory systems of cartilaginous and teleost fishes have been studied and identified, the influence of electric fields on non-electric species of fish and other aquatic animals has been considered. In the last two decades, the effect of the electromagnetic field on various aquatic organisms has been actively studied [1, 23].

In the Yaroslavl State Agricultural Academy, since 2017, studies have been carried out to study the behavior of fish and other aquatic organisms with the effect of ESP on them [11, 20, 24, 25, 26].

The aim is to consider the effect of an electrostatic field (the output voltage of which varied in the range from 1.2 to 2.5 kV) on food reactions and the diet of prussian carp under conditions that mimic the benthic type of nutrition.

Studies were carried out by the method of periods.

Materials and methods. For the experiment, a sample of prussian carp was presented (body length ranged from 7.1-9.4 cm, body weight - 10.0-20.2 g, age 2+). To generate the electrostatic field, an experimental setup was used, which was a rectangular aquarium (with a volume of 7 liters and a bottom area of 780 cm<sup>2</sup>, the thickness of the

water layer was 7 cm) with electrodes superimposed on the end walls, the distance between them was 20 cm. Copper electrodes were connected through high-voltage wires to a high voltage source (gas-light transformer TG 1020 220 - 10000 V). The voltage at the electrodes of the experimental setup is regulated using a laboratory autotransformer (LATR), which made it possible to reduce or increase the output voltage to the desired one in the range from 1.2 to 2.5 kV.

The movements of the fish were recorded using a video camera, which was installed at a height of 1.2 m above the center of the aquarium [26].

The behavioral reactions of the fish were recorded and assigned to the following two groups: - feeding behavior (feeding time of one fish, total feeding time of a group of fish and diet, feeding rate); - motor activity (time of immobility, time of single movement, time of group movement).

The results were statistically processed using the Excel application. Figure 1 - The process of feeding a group of fish in the experiment

A - fish in the starting compartment of the aquarium; B - the starting compartment is open; B - search and consumption of food by fish

1 - starting compartment of the aquarium, 2 - specimens of crucian carp, 3 - electrodes, which are superimposed on the end walls of the installation, 4 - feed spot, 5 - shutter

Experiment 2. The duration of the experiment was 15 minutes. The food was given in the amount of 50 parts per group of fish. The food is the same.

At the end of experiment 1 and experiment 2, the fish were removed from the aquarium with a net, and the remains of food were collected for calculating the ration. During the experiment, the following parameters were recorded [9]:

diet - the amount of food particles eaten during the observation period, granules;

feeding time - the duration of the search for and capture of food particles by fish in the “feeding spot”, sec.

- the feeding time of one fish (the time spent by an individual to search for and consume a food particle),

- feeding time of two fish (duration of feeding simultaneously

two fish on one spot),

- total feeding time, calculated as the sum of feeding times of the 1st and 2nd fish;

feeding rate (ratio of ration to total feeding time), ind./sec.;

swimming time (movement of fish outside the “feeding spot”, the fish does not make attempts to feed), sec., where they were allocated:

- the time of immobility (none of the fish makes forward movements),

- single movement time (fish move separately),

- time of group movement (all two individuals move in a group).

#### Results and discussion

The results given in Table 1 showed the extent to which the behavioral food-procuring and motor reactions of fish are able to respond to the effect of electrostatic fields of different voltages (Table 1).

When analyzing under the influence of an ESP with a voltage of 2.5 kV, it was found that the indicators of feeding behavior and motor activity of fish in the control group and the experimental group did not differ, that is, the ESP did not have a statistically significant effect on the behavior of crucian carp. Differences in the behavior of fish were established only for the indicators of the total feeding time and diet during experiments under the influence of an ESP with a voltage of 1.2 kV.

Table 1 - Analysis of the parameters of the feeding behavior of fish under the influence of the electrostatic field in experiment 1 and experiment

Index	Group	1 series	2 series	3 series	M ± m	σ
the feeding time of one fish, sec	K	0	244	41	95 ± 92.4	130.65
	O (1.2 kB)	314	88	139	263 ± 83.8	118.3
	O (2.5 kB)	133	22	0	51.66 ± 50.4	71.29
	K	0	354	135	163 ± 126.3	178.65

		O (1.2 кВ)	79	242	123	148±59.6	84.32
		O (2.5 кВ)	133	145	167	148.3±12.2	17.24
feeding time of two fish, sec	1 experiment	K	0	6	6	4 ± 2.4	3.46
		O (1.2 кВ)	20	90	61	57.0 ± 24.87	35.17
		O (2.5 кВ)	6	8	0	4.7 ± 2.94	4.16
	2 experiment	K	0	7	23	10±8.3	11.78
		O (1.2 кВ)	31	72	29	44±17.16	24.27
		O (2.5 кВ)	93	33	32	52.7±24.70	34.93
total feeding time, sec	1 experiment	K	0	250	47	99 ± 93.9	132.86
		O (1.2 кВ)	334	178	200	237.3 ± 59.70*	84.44
		O (2.5 кВ)	139	30	0	56.3 ± 51.72	73.15
	2 experiment	K	0	361	158	173±128.0	180.96
		O (1.2 кВ)	110	314	196	206.7±72.42	102.42
		O (2.5 кВ)	226	178	199	201±17.01	24.06
diet, granules	1 experiment	K	0	10	5	5 ± 3.5	5
		O (1.2 кВ)	10	8	10	9.3 ± 0.26*	1.15
		O (2.5 кВ)	7	7	0	4.7 ± 2.86	4.04
	2 experiment	K	0	16	15	10.33±6.3	8.96
		O (1.2 кВ)	13	6	11	10.0±2.55	3.61
		O (2.5 кВ)	10	5	10	8.3±2.04	2.89
feeding rate, ind./sec	1 experiment	K	0	0.004	0.106	0.036 ± 0.0	0.06
		O (1.2 кВ)	0.029	0.044	0.050	0.0 ± 0.01	0.01
		O (2.5 кВ)	0.050	0.233	0	0.1 ± 0.09	0.12
	2 experiment	K	0	0.044	0.094	0.046±0.0	0.047
		O (1.2 кВ)	0.118	0.019	0.056	0.1±0.04	0.05
		O (2.5 кВ)	0.044	0.028	0.050	0.0±0.01	0.01
the time of immobility, sec	1 experiment	K	0	62	35	32.33 ± 22.0	31.08
		O (1.2 кВ)	60	71	40	57.0 ± 11.11	15.72
		O (2.5 кВ)	20	0	468	162.7 ± 187.11	264.62
	2 experiment	K	170	225	19	138±75.4	106.66
		O (1.2 кВ)	215	84	51	116.7±61.34	86.74
		O (2.5 кВ)	141	341	47	176.3±106.17	150.15
single movement time, sec	1 experiment	K	0	20	253	91 ± 99.5	140.65
		O (1.2 кВ)	33	137	232	56.7 ± 50.56	71.50
		O (2.5 кВ)	130	0	12	47.3 ± 50.80	71.84
	2 experiment	K	216	98	435	249.66±120.9	171.00
		O (1.2 кВ)	97	241	181	173.00±51.15	72.33
		O (2.5 кВ)	281	100	199	193.30±64.09	90.63
time of group movement, sec	1 experiment	K	480	398	192	356.6 ± 104.9	148.38
		O (1.2 кВ)	387	272	208	289.0 ± 64.14	90.70
		O (2.5 кВ)	330	480	0	270.0 ± 173.64	245.56
	2 experiment	K	514	577	446	512.33±46.3	65.51
		O (1.2 кВ)	588	575	668	610.3±35.61*	50.36
		O (2.5 кВ)	478	459	654	530.3±76.03	107.52

Similar calculations were carried out to study the significance of differences in the behavior of fish in the control and experimental groups in experiment 2 under the influence of ESP voltage of 1.2 kV and 2.5 kV. In this case, differences in the behavior of fish were established only for the indicator of the time of group movement at an ESP of 1.2 kV.

The discussion of the results.

Experience 1. The obtained data on the study of feeding behavior and motor activity of crucians show that the average time of group movement of the group of crucians in the control was  $356.6 \pm 104.9$  s - this is the highest result of the obtained ones.

It can be noted that the individuals in the 1st replicate of the control group did not perform single movements at all outside the “feeding spot”. Fish spent a lot of time on activity not related to the search for and obtaining food (ration of 0 pcs.). The opposite situation was with individuals from the third replication of the experimental group

(about 2.5 kV), there was no search behavior: the time of immobility was 468 s, the fish practically did not make translational movements (ration of 0 pcs.).

In the experimental group (O 2.5 kV) from the second repetition, the search behavior was virtually absent: the feeding time of the 1st fish was 22 s, the total feeding time was 30 s (the lowest indicators). Throughout the experiment, the fish approached the “forage spot” (the time of group movement is 480 s), grabbed several particles and left it (diet 7 ns.). These individuals are characterized by the absence of a defensive reaction in the fish: the individuals began to feed immediately after leaving the starting compartment.

The average value of the diet of the experimental group (O 2.5 kV)  $9.3 \pm 0.26$  pcs - the highest result of the obtained. Individuals from the 1st and 3rd replicates of this group found that they captured the entire proposed diet. At the same time, the values characterizing the feeding time were higher than other experimental groups (the average feeding time of the 1st fish,  $263 \pm 83.8$  s, the average feeding time of 2 fish,  $57.0 \pm 24.87$  s). Upon reaching a certain degree of saturation, the motor activity of fish decreased and, accordingly, the time spent in immobility increased [10].

Experience 2. Comparative analysis of indicators given in table 1 showed to what extent ESP is able to influence food reactions, diet and motor activity of prussian carp. The average time of group movement of individuals in the experiment (O 1.2 kV) was  $206.7 \pm 72.42$  s - this is the highest result from the obtained ones. It can be noted that this indicator varies from 0 seconds (in the 1st replicate control) to 361 seconds (in the 2nd replicate control).

Despite the fact that in the second experiment the fish were offered 40 more feed pellets, they were able to consume:  $10.33 \pm 6.3$  pcs. - in control,  $10.0 \pm 2.55$  pcs. - in the experiment (O 1.2 kV) and  $8.3 \pm 2.04$  pcs. - in the experiment (about 2.5 kV). As mentioned above, this can be facilitated by the achievement of a feeling of satiety and a larger number of granules of an individual are not able to absorb, in all the agility of the study, both in the control and in the experimental groups, rejection of food particles was noted, then their repeated capture.

It should be noted that significant differences were established in the behavior of fish for the indicator of the time of group movement when exposed to the experimental group when exposed to an ESP with a voltage of 12 kV. ( $610.3 \pm 35.61$  s). The study lasted almost 2 times longer than the first experiment (15 minutes).

The control group (without ESP) has the highest average value of the time of a single movement ( $249.66 \pm 120.9$  s), which can be explained by rapid movements around the perimeter of the aquarium and competition for food and advantageous position.

We do not take into account the indicator “feeding rate”, as in the control and experimental groups it is reduced to zero.

Conclusions. 1. The motor activity of fish, which is characterized by the indicator “swimming time”, when individuals move outside the “feeding spot” in the experimental groups of the first experiment (8 minutes) under the influence of ESP is lower than in the control. A decrease in motor activity in the experimental groups is possible if the fish have reached the “degree of satiety”, which leads the fish to immobility. The experimental group under the influence of an electrostatic field with a voltage of 1.2 kV showed the highest average value of the diet; in two series, three of them ate all parts of the proposed food.

2. In experiment 2, practically all indicators of feeding behavior in the crucian carp of the control group stabilized at a higher level in comparison with the experimental group under the influence of an ESP voltage of 2.5 kV.

Differences in the behavior of fish for the indicator of the time of group movement when exposed to the experimental group under the influence of an ESP with a voltage of 1.2 kV were established. ( $610.3 \pm 35.61$  s). The group of fish not only actively moved, but also willingly studied food objects, repeated rejection of food particles of the compound feed was observed.

3. Prussian carp is classified as passive fish - benthophages, when food saturation occurs, food and physical activity sharply decreases. In study # 2 (15 minutes), the satiety point was pronounced, the fish could not swallow more pellets than they needed, and they could digest.

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of the environment on the activity of peptidases in chironomid larvae - potential food objects of benthophagous fish.

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