Evaluation of the effectiveness of feeding fish using electro-optical devices in fish farms of the Volgograd region

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Abstract. For intensive fish farming on fish farms, the food supply is a decisive condition. But the fodder base of reservoirs is not an unlimited resource, and compound feed is becoming more expensive and not always available. One of the solutions to this problem can be attracting flying insects to the surface of water bodies. Light traps of various models are increasingly used to attract insects at twilight and at night. The experiment used an experimental mobile electro-optical installation for the destruction of flying insects with an optical converter of the ultraviolet spectrum, a structure to which a high-frequency electric voltage is applied and a screen for collecting insects. The light trap attracts different species of insects, which also differ in their food value for fish. Nevertheless, natural food provides a good supplement with sufficient amounts of essential nutrients and energy. As a result of the obtained experiment, a species analysis of arthropods attracted by a light trap was carried out. The most active ones were representatives of the order Diptera, from the families of chironomids (bell mosquitoes) and midges (river midge). Representatives of the leafhopper family from the order of Hemiptera (bugs) also showed high activity. Chironomids are an important component of food for larvae and fry of fish, especially carp species. The proposed installation can operate in a mixed discrete mode, actively attracting flying insects without affecting them by high voltage, which contributes to the intensification of the development of food organisms.

1. Introduction
The most important indicator of the effectiveness of pond fish culture is the stocking density of fish. Moreover, an increase in stocking density should not lead to a decrease in the final individual mass of cultured fish. The recommended stocking density is related to the proportion of natural feed in the diet of cultured fish. The composition and quantity of artificial and natural feed should correspond to the biological and physiological needs of the fish, taking into account the age, weight, fatness and breeding conditions. Thus, when growing the most widespread carp culture in Russia, the recommended share of natural feed is: for producers 60-70%, underyearlings - 20-25% and commercial carp - 15-20%. The accumulated experience of fish farming shows that when feeding juveniles of carp, the stocking density is 80-100 thousand pieces / ha. Such a load on the ecosystem of the pond leads to a rapid depletion of the natural food base and places increased demands on artificial food. Currently, various methods are used to prevent a decrease in the individual mass of fish by improving feeding methods and, in particular, stimulating the natural food base of ponds. Their productivity largely depends on the development of the natural food base of ponds, since it is living food organisms in terms of the composition and structure of nutrients that most closely correspond to the digestive system of juvenile fish [1]. Among the living organisms available as natural food for fish, insects are the most important.
2. Materials and methods

Currently, there are various ways to improve the natural food base of ponds due to flying insects, for example, creating a workshop for cultivating bell mosquitoes at a fish farm, the larvae of which, chironomids, are a valuable food resource for fish at all stages of its rearing. However, this method is associated with significant material costs and is very laborious, therefore, to attract mosquitoes to the ponds, the authors of works [2, 3, 4] suggest using optical radiation with a wavelength in the range of 320-380 nm. According to the data presented in these works, due to the attraction of mosquitoes to the sources of optical radiation, the biomass of chironomid larvae in ponds increases 4 ... 10 times, and in the food lump of fish food of animal origin was 3 times more. In addition, in the experimental pond, in comparison with the control pond, the mobility of fish at twilight and at night sharply increased, the fish in the zone of action of electro-optical converters actively eats attracted insects. All this leads to a significant improvement in the epizootic situation in ponds.

These results unambiguously indicate that the technology of feeding fish with flying insects attracted to the source of electro-optical radiation is a very promising way to increase the efficiency of pond fish farming.

To test the efficiency of the optical light converter and determine the species composition of attracted insects, a field experiment was carried out on the territory of the Volgograd region. For the experiment, an experimental setup was developed and created [5], the block diagram of the setup is shown in Figure 1.

![Figure 1. Schematic diagram of an installation with an optical light converter](image)

The setup was installed in the water area of the Sukhaya gully of the Volgograd reservoir on a pontoon behind the coastal reed thickets. The experimental setup was a prototype of a mobile electro-optical setup for the destruction of flying insects [6] and included an optical converter of the ultraviolet spectrum of radiation for attracting flying insects in the dark. In front of the source of optical radiation, a structure of two metal grids, separated by a dielectric insert, was installed. A high voltage was applied to the grids from a storage battery through a multiplier. A screen with an area of 0.5 m² was installed under the radiation source for collecting insects.

3. Nutritional value of insects attracted by an electro-optical converter

It is known that electro-optical radiation attracts mosquitoes and many other species of flying insects at night, which can also be used to feed fish.

The nutritional value of insects varies greatly. This variability is due to the large variety of species, as well as the stage of the insect's life cycle. However, despite significant fluctuations in the composition of elements, most insects, as food for fish, provide a sufficient amount of energy, protein,
amino acids, mono- and polyunsaturated fatty acids.

Insects contain trace elements such as copper, iron, magnesium, manganese, phosphorus, selenium and zinc.

The calorie content of insects is in the range of 293-762 kilocalories per 100 grams of dry weight. The protein content varies from 13 to 77% of dry weight. The amount of protein in insects is high, and its digestibility by fish is 76-98%. In the adult stages of development, insects have more protein than other stages.

Fats are the main source of energy for fish. Edible insects are high in fat, rich in polyunsaturated fatty acids and often contain essential linoleic and α-linolenic acids.

4. Obtained results

The species composition of insects, their number and the intensity of flight to the radiation of the optical converter varies greatly depending on the geographic location of the farm, the month during the season and the time of day.

Active flight of insects to light usually occurs at a temperature of at least 15 °C. At the same time, representatives of 11 orders of insects fly to the light: Diptera, caddisflies, mayflies, beetles, bugs, butterflies, Hymenoptera, Homoptera, Retinoptera, Cockroaches, Orthoptera. The greatest flight in calm warm weather is observed after sunset in the period from 22 to 23 hours in the Volgograd region. The productivity of flight during the night can reach up to 100 g / m², and the total weight of insects attracted to light per season on a 1 ha pond area can reach 1000 kg. The feeding ratio of insects consumed by cultivated fish ranges from 5 to 9, on average – 7 [7].

Insects, attracted by the ultraviolet light source, were caught between the high-voltage grids, electrocuted, and dropped onto the screen. After the end of the experiment, the insects from the screen were collected in a sealed container, after which the insects were counted and their systematic affiliation was determined.

The species composition of insects attracted by the optical light converter during the experiment is presented in Table 1.

| Systematic group                                      | Number of copies, pcs. | Number of copies,% |
|-------------------------------------------------------|------------------------|--------------------|
| Class arachnids                                       | 2                      | 0.27               |
| Insects class                                         | 752                    | 99.73              |
| Detachment Hemiptera (bugs)                           | 134                    | 17.77              |
| Rowing family                                         | 14                     | 1.86               |
| Pluta family                                          | 1                      | 0.13               |
| Family of leafhoppers                                 | 121                    | 16.05              |
| Vesnyanka squad                                       | 20                     | 2.65               |
| Diptera squad                                         | 563                    | 74.67              |
| Sciaris family (flower midges)                        | 16                     | 2.12               |
| Sciarida family (mushroom gnats)                      | 12                     | 1.59               |
| Family of midges (species of river mide)              | 234                    | 31.03              |
| Family of mides (species of the mide silvery)         | 1                      | 0.13               |
| Chironomid family (bell mosquitoes)                   | 230                    | 30.5               |
| Family of squeaky mosquitoes                          | 70                     | 9.28               |
| Coleoptera squad (beetles)                            | 32                     | 4.24               |
| Family of ladybugs (7-spot ladybug species)           | 1                      | 0.13               |
| Whirligig family                                      | 10                     | 1.33               |
| Ground beetle family (genus ground beetle)            | 1                      | 0.13               |
| Family of stafffilinids                               | 20                     | 2.65               |
| Mayfly squad                                          | 1                      | 0.13               |
| Total                                                 | 754                    | 100                |
An analysis of the results of the experiment shows that the use of ultraviolet emitters to attract at nighttime is quite effective, while the overwhelming number of attracted insects belong to the order Diptera, mainly the river midge and bell mosquitoes. It is these species of insects, adults (adult insects) and their larvae, that have the greatest food value for fish of the cyprinid family at the stages of development of larva and fry [2].

It is characteristic that in mosquitoes the larvae are more nutritious than adults. More than 200 species of fish feed on mosquitoes and their larvae in nature. Chironomids - bell mosquito larvae contain up to 57% protein and about 14% fat. The belling mosquitoes attracted by the source of optical radiation actively swarm and at the same time the females are fertilized. Female mosquitoes lay eggs on the surface of aquatic vegetation, and under favorable conditions, after 2-3 days, larvae - chironomids - appear from the laid eggs, which, getting into the water, serve as food for fish [4].

It should be noted that the electro-optical device [6] can operate in a mixed discrete mode, that is, a high voltage on the insect striking element - the grid, is supplied not constantly, but discretely, according to a certain algorithm. The proposed mode of operation not only ensures a more rational use of the battery, but also the active attraction of flying insects without being hit by high voltage. Such a mode of operation of the electro-optical installation can be considered as a method of intensifying the development of zoobenthos organisms food for fish, in particular chironomids, whose share in the food balance of cultivated fish can reach 15%.

5. Conclusion

Thus, it can be concluded that the use of technologies for attracting flying insects for feeding fish is quite promising for implementation in fish farms in the Volgograd region and southern Russia.

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