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The Effect of Different Diets on the White Worm (*Enchytraeus albidus* Henle, 1837) Reproduction

Devrim Memiş[1,*], M. Salih Çelikkale[1], Ertan Ercan[1]
[1] Istanbul University, Faculty of Fisheries, Department of Aquaculture, No: 200, 34470, Laleli, İstanbul, Turkey.

*Corresponding Author: Tel.: +90. 212 455 57 00 /16446; Fax: +90. 212 514 03 79;
E-mail: mdevrim@istanbul.edu.tr

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Abstract

In this study, white worms (*Enchytraeus albidus* Henle, 1837), which are used especially by aquarists and sturgeon breeders, were fed five different experimental diets, and then the numerical increase in their population was calculated. Four of the five diets were composed of carbohydrates, vegetables, fruits, and pelleted commercial trout feed, and the fifth was composed of a combination of all four of these. At the end of the study, the greatest numerical increase and best reproduction was found to have occurred with the commercial trout feed in pellet form. This study was completed in 91 days.

Key words: White worm, *Enchytraeus albidus*, different diets, culture

Introduction

Two conditions must be fulfilled for successful fish breeding: the fish must propagate, and the resulting fry must be nourished. The second requirement can be much more difficult to satisfy than the first. Every variety of fish exhibits a distinct feeding behavior. Because of this, it is necessary to identify the feeding behavior of the fish being studied, and the appropriate type and portion of feed must be determined. Dry feed (pellet, granule, flake foods etc.), pond feed (*Rotifera*, *Daphnia*, bosmina, cyclops, chironomids etc.), and live feed (soil worms, tubifexes, white worms etc.) were used in this study (Bailey and Standford, 1995).

White worms thrive worldwide in temperate climates in soil, fresh water, brackish water, and in marine littoral environments. There are about forty species among the various genera of white worms (Ivleva, 1969; Stephenson, 1972). White worms (*Enchytraeus albidus* Henle, 1837) are an excellent, easily produced form of live fish feed, and are particularly good for inducing fish to spawn. They are readily consumed by most fish and are also of a suitable size for very small fish as well as larger ones. White worms contain approximately 70% protein, 14.5% fat, 5.5% ash, 10% carbohydrates (Grene, 1999) by dry mass.

White worms are probably one of the most popular cultured live foods used by aquarists and more specifically by sturgeon breeders. Sturgeon culture was first made possible via the artificial fertilization and the rearing of larvae, followed by the development and cultivation of appropriate artificial feed and live feed. Eventually, many scientists and fish breeders succeeded in developing technologies for cultivating planktonic organisms (*Moina*, *Daphnia*, *Artemia*), oligochaeta, and cladocera (Milshtein, 1969; Vedrasco, 2002). Bogatova (1980) conducted research on the effects of providing different diets in alternation for the production of white worms.

In nature, benthic chironomid larvae and oligochaete constitute one of the basic food sources for juvenile sturgeon. Several authors have described the conditions of mass production of the oligochaete *Enchytraeus albidus* in sturgeon hatcheries. A farm that produces 2.5–3 billion juvenile sturgeon typically has about 1,000 wooden boxes which each contain 100–300 g of white worms that are fed once a week (Özdemir, 1982).

The secret to success in raising white worms is for producers to understand the worms' particular needs and fulfill them. The subject of this paper and the information presented herein have scientific significance for addressing problems related to the cultivation of live feed for sturgeon and ornamental fish around the world..

Materials and Methods

Diets for White Worms

5 different diets were used in this study. Their food content is shown in Table 1 below.

Table 1. Ingredients in the five different diets

Diets	Ingredients
1. Diet	Wheat, bread and milk
2. Diet	Apple, banana and date
3. Diet	Cabbage, spinach, potatoes, carrot
4. Diet	Trout pelled feed (pellet size: 2 mm)
5. Diet	1, 2, 3, 4 diets (mixed diet)

Preparing Diets

Diet 1: (Carbohydrate) One cup of boiled wheat, one slice of bread, and one cup of milk were combined and mashed together.

Diet 2: (Fruit) One apple, one banana and one date were combined and mashed together.

Diet 3: (Vegetable) One potato, one carrot, one cabbage leaf, and two spinach leaves were boiled and mashed together.

4. Diet: (Commercial pelleted trout feed) 2 mm-sized trout pellets were moistened with water and then used as dough.

5. Diet: (Mixture) Combination of commercial trout pellet feed and diets 1–4

One tablespoon of each diet food was mixed with one tablespoon of pelleted trout feed.

The Wooden Containers, Culture Medium and Feeding

The wooden boxes for containing white worms were 20 cm in diameter and 10 cm deep. Five wooden boxes were used in duplicate trials. These wooden containers were filled with soil (without artificial fertilizers or chemicals). Soil pH was found to range between 6.8–7.2., and room temperature was measured to be 20 ºC. Each container was filled with 300 g of soil. This mixed soil was ½ humus and ½ garden soils. The top of the container was covered with a flat board to prevent the soil surface from drying out, to protect against incoming light, and to keep predators out. 10 mature white worms were placed in the soil and covered with soil in each box. One teaspoon of food (4–5 g wet weight) of the appropriate type of feed was placed under the surface of the soil. After this, the food and worms were covered with more soil medium and then sprayed with water. Soil humidity was maintained at 22–26% throughout the process of white worm production (Vedrasco *et al*., 2002). White worms fed once a week with the experimental diets.

Counting of White Worms

At the beginning, 10 white worms were placed in every container. They were counted on the dates of 5 April 2002, 7 May 2002, 4 June 2002 in the experimental time interval. Data were presented of the mean of the two (duplicate) trials.

Significance levels were set at $p<0.05$. Differences in numerical increases among the experimental groups were statistically tested by ANOVA and the Tukey test (Zar, 1984).

Results

At the beginning of the study, 5 March 2002, 10 worms were placed in every box. Successive worm counts are shown in Figure 1.

The worms were counted periodically over the course of 3 months. Numerical increases can be seen for every diet in every time period. At the end of the study, the fourth group, which was fed pelleted trout feed only, showed the most intensive population increase. The mean numerical increase for this group rose from 10 individual worms initially to 342 by end of the study. The fourth group was followed by the first group fed with carbonhydrate (mean n=295), second group fed with fruits (mean n = 283 individuals), fifth group fed with mixture (mean n = 179 individuals), and third group fed with vegetables (mean n = 165 individuals) and (Figure 1) in terms of numerical increase. The following statistically significant differences ($p<0.05$, determined using the Tukey test), were found to have occurred among the five groups: the first and second groups differed from the third group; the third group differed from the first group, second and forth groups; the fourth group differed from the third group and fifth group; and the fifth group differed from the forth group.

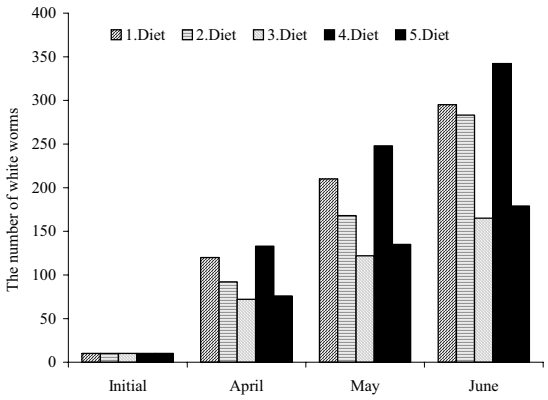

Figure 1. Periodically measured mean numerical increases of the 5 different groups, fed experimental diets throughout the experimental time interval.

Discussion

White worms are hermaphroditic, i.e., each individual has both male and female reproductive organs. Adults are self-fertile because the sperm and ova develop at different times. The worms exchange sperm cells during copulation with one another, and eggs are laid in transparent cocoons. Cocoons produced by young adults contained 9-10 eggs each, while cocoons produced mature adults contained 20–25 eggs each, and those produced by old worms contained 2–3 eggs each. The highest egg production observed was 35 eggs per cocoon. The average for the total population in culture was found to be 10 eggs per cocoon. White worm eggs hatch in 12 days, and worms begin reproducing in 20 days. Each individual can produce as many as 1000 eggs over its life span (Ivleva, 1969).

Enchytraeus albidus make one of the best sources of live feed for the young of sturgeon varieties such as benthic chironomids. White worms are cultured in hatcheries as a type of live prey for these fish. The maximum length of white worms is ~2.5 cm, and under the conditions in culture they can reach harvest size in 2 months (Anon., 1999).

Enchytraeus albidus reproduce normally at and above 8–10°C, with optimum growth and reproduction occurring between 15–21°C. Experimental results have shown that they die at temperatures above 30°C or below 0°C. Commercial worm farmers in the former USSR produce many tons of clean worms each year with a density of about 3 kg worms per square meter (Ivleva, 1969).

Several authors have described the mass production of the oligochaete (*E. albidus*) in sturgeon hatcheries. This is usually carried out in wooden boxes measuring 50 x 40 x 12 cm in size, filled with soil at humidity = 22–26%, pH = 6.2–6.8, and temperature = 18-20°C. It is first of all necessary to have a good-quality soil spread out in 9–10 cm layers, inoculated with a pure culture of worms, 200–250 g per square meter (40–50 g per box). This initial oligochaete population should be nourished with rye, brans, flour basters, potatoes, cabbage, beetroot, feading yeast, garden leaves, and other carbohydrate-rich vegetables. Processed foods are distributed in the boxes once per week at a dosage of about 6 times the biomass of the worms (dry weight). The expected production is 350–420 g of worm per square meter every week (Vedrasco *et al*., 2002).

In an experiment in which white worms were fed four different food syrups, with increases in weight and number being calculated periodically at fifteen-day intervals over the 90-day period of the experiment, Timur *et al*. (2003) reported that worms that were fed vegetable- and cereal powder-based diets containing casein attained higher levels of weight and reproductivity than those that were fed vegetable and cereal powder-based diets not containing casein.

White worms can consume just about anything organic. Producers of these worms feed them vegetable-based foods such as plant material, oatmeal, bread soaked in milk, wheat flour, cereal, mashed potatoes, and dozens of other similar foods. Worms can even eat flake or pelleted fish feed and dry dog and cat food, if they are soaked in water beforehand. In feeding trials, it has been shown that the very best food for worms is brewery wastes (a mix of grains, hops, and yeasts), bread crumbs, and oat groats (Ivleva, 1969; Anon., 2001). However, Timur *et al*. (2003) reported that brewery wastes containing food did not give rise to the best growth and reproduction rates and even led to declines in these rates when added to casein-containing vegetable- and cereal powder-based foods.

Bogatova (1980) reported that the best results in white worm production were obtained by implementing different diets in alternation.

It was observed in this study that the highest white worm population was reached by the fourth group (on a diet of pelleted trout feed only) out of the five. The fourth group attained a final population of 342 worms, averaged over two trials conducted in duplicate. The following performance results were observed with carbohydrate diets and then in the second group with fruit diets: The greatest numerical increase in worm population was attributed to the pelleted trout feed, which contained 45-47% protein and 12% fat. The least increase in number of individuals was observed in the third group, which was vegetable-based (Figure 1).

White worms are a viable alternative prey-type food for carnivorous fish. For this reason, white worms are essential for ornamental fish and sturgeon culture. This experimental study demonstrated that the commercial culture of white worms can easily be carried out by fish farmers in the future.

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