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CULTIVATION OF DIPTEROUS (*DIPTERA* LINNAEUS, 1758) INSECTS, SUCH AS FRUIT FLIES, SYNANTHROPIC FLIES LARVAE AND CHIRONOMIDS LARVAE FOR FISH FEEDING (REVIEW)

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Purpose. *To analyze a selection of professional literature and summarize the information on the specifics of cultivation of fruit fly, synanthropic flies larvae (maggots) and Chironomids larvae (bloodworms) for use in fish feeding. To consider the features of their biology, as well as opportunities and prospects for their use as forage objects in aquaculture.*

Findings. *This work contains a brief review of the main biotechnological steps of cultivation of the above-mentioned dipterous insects for the subsequent fish feeding. The study presents features of the production features of different species of such families as Drosophila, synanthropic flies and chironomids. The presented cultivation technologies for these three families, both in small quantities for the needs of private individual and large quantities for the needs of legal entities. The optimal conditions for the development of these insects as well as the basic principles for feeding them to fish are presented. Data on the nutritional value of fruit flies, synanthropic flies and chironomids larvae are presented.*

Practical significance*. This work gives recommendations on compliance with the veterinary and sanitary requirements for the cultivation of these forage organisms. The summarized information will be useful for researchers who are exploring ways to optimize fish feeding as well as for aquarists. The cultivation technology for fruit flies, synanthropic flies and chironomids larvaeoptimal both for fish farms of different types of aquaculture and private individuals is presented. Obtaining zoohumus as a valuable cultivationby-product provides the opportunity for additional revenue and integrated development.*

Keywords: *Drosophila (Drosophilidae), larvae of synanthropic flies, larvae of chironomids (Chironomidae), fish feeding, aquaculture, aquarium, fed organisms, zoohumus.*

КУЛЬТИВУВАННЯ ДВОКРИЛИХ (*DIPTERA* LINNAEUS, 1758) КОМАХ — ДРОЗОФІЛ, ЛИЧИНОК МУХ ТА ХІРОНОМІД — ДЛЯ ГОДІВЛІ РИБ (ОГЛЯД)

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Мета. *Проаналізувати масив спеціальної літератури та узагальнити отриману інформацію щодо специфіки культивування дрозофіли (Drosophilidae), личинок синантропних мух (опаришів) та хірономід (мотиля) для використання їх в годівлі риб. Розглянути особливості їхньої біології, а також можливості і перспективи використання в якості кормових об'єктів в аквакультурі.*

Результати. *Дана робота містить короткий огляд основних біотехнологічних ланок культивування вищезазначених двокрилих комах з метою наступного згодовування рибам. Розглянуто особливості продукційних характеристик різних видів представників родин дрозофіл, синантропних мух та хірономід. Представлені технології культивування цих трьох родин як у малих кількостях для потреб фізичних осіб, так і у великих — для потреб юридичних осіб. Викладено оптимальні умови для розвитку даних комах, а також основні засади їх згодовування рибам. Наведено дані стосовно поживної цінності дрозофіл, личинок синантропних мух та хірономід. Надано рекомендації стосовно дотримання ветеринарно-санітарних вимог при культивуванні цих кормових організмів.*

Практична значимість. *Масив узагальненої інформації буде корисним для науковців, які досліджують шляхи оптимізації годівлі риб, та акваріумістів. Представлена технологія культивування дрозофіл, личинок синантропних мух та хірономід оптимальна для рибницьких господарств різних типів ведення аквакультури та фізичних осіб. Отримання зоогумусу в якості цінного побічного продукту культивування надає можливість отримання додаткового прибутку та інтегрованого розвитку.*

Ключові слова: *дрозофіли (Drosophilidae), личинки синантропних мух, личинки хірономід (Chironomidae), годівля риб, аквакультура, акваріумістика, кормові організми, зоогумус.*

КУЛЬТИВИРОВАНИЕ ДВУКРЫЛЫХ (*DIPTERA* LINNAEUS, 1758) НАСЕКОМЫХ — ДРОЗОФИЛ, ЛИЧИНОК МУХ И ХИРОНОМИД — ДЛЯ КОРМЛЕНИЯ РЫБ (ОБЗОР)

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Цель. *Проанализировать массив специальной литературы и обобщить полученную информацию о специфике культивирования дрозофил (Drosophilidae), личинок синантропных мух (опарышей) и хирономид (мотыля) для использования их в кормлении рыб. Рассмотреть особенности их биологии, а также возможности и перспективы использования в качестве кормовых объектов в аквакультуре.*

Результаты. *Данная работа содержит краткий обзор основных биотехнологических звеньев культивирования вышеупомянутых двукрылых насекомых с целью последующего скармливания рыбам. Рассмотрены особенности продукционных характеристик различных видов представителей семейств дрозофил, синантропных мух и хирономид. Представлены*

технологии культивирования этих трех семейств как в малых количествах для нужд физических лиц, так и в больших — для нужд юридических лиц. Изложены оптимальные условия для развития данных насекомых, а также основные принципы их скармливания рыбам. Приведены данные о питательной ценности дрозофил, личинок синантропных мух и хирономид. Даны рекомендации по соблюдению ветеринарно-санитарных требований при культивировании этих кормовых организмов.

Практическая значимость. *Массив обобщенной информации будет полезным для ученых, исследующих пути оптимизации кормления рыб и аквариумистов. Представленная технология культивирования дрозофил, личинок синантропных мух и хирономид оптимальна для рыбоводных хозяйств различных типов ведения аквакультуры и физических лиц. Получение зоогумуса в качестве ценного побочного продукта культивирования предоставляет возможность получения дополнительной прибыли и интегрированного развития.*

Ключевые слова: *дрозофилы (Drosophilidae), личинки синантропных мух, личинки хирономид (Chironomidae), кормление рыб, аквакультура, аквариумистика, кормовые организмы, зоогумус.*

PROBLEM STATEMENT AND ANALYSIS OF LAST ACHIEVEMENTS AND PUBLICATIONS

Dipteran is one of the largest orders of insects, which consists of more than 240 thousand species of mosquitoes, black flies, midges, gadflies, flies, botflies, etc., but only less than a half of them is thoroughly researched by scientists.It should be emphasized that in ecological sense, medical and economic values they are one of the most important groups of insects [1-3]. Important features of an order of Dipteran are the presence of one pair of wings (the second pair of wings are represented by balancer) and complete metamorphosis. Going forward, we will consider the following representatives of this order, which are widely used in aquaculture, due to their high nutritional value (primarily high protein content): fruit flies, flies larvae (maggots) and chironomids larvae (bloodworms).

STUDY RESULTS AND THEIR DISCUSSION

Family of fruit flies (*Drosophilidae*) is well known to mankind, and its members belong to the suborder of brachyceran (*Brachicera*) Dipteran (*Diptera*) insects. Among them the most well-known species, which is widelyused in human activities is a common fruit fly or vinegar fly (*Drosophila melanogaster*). It was referred to the genus *Drosophila* morphologically, while modern genetic studies refer it to the genus *Sophophora* [1,4]. *Drosophila funebris* is morphologically close to a common fruit fly. It differs from a common fruit fly in larger size (3–4 mm). In addition to *Drosophila funebris*, surprisingly similar species are *Drosophila histrio* and *Drosophila trivittata* [5, 6]. Common fruit fly is a small gray or yellowish-gray fly, with transverse black rings across the abdomen, with a body length of 1.5 to 3 mm. Its body consists of the head, thorax (prothorax, mesothorax and metathorax) and abdomen [7]. Sexual dimorphism is strongly marked. The female weighs about 1.5 mg, while the male weighs 0.8 mg [5, 7, 8]. *Drosophila melanogaster* in its development passes three stages, common for all *Dipterous* insects: eggs, larvae and imago, that is, it is characterized by a complete metamorphosis [1, 9].

Cultivation of fruit flies is relatively simple and does not require significant costs. Usually, on the Ukrainian market, there are two most common species – *Drosophila*

melanogaster and *Drosophila hydei*, and there may be other above-mentioned species [6, 9, 10]. However, the method of their cultivation is common, and the nutritional value is almost the same (table 1):

Table 1. **Nutritional value of fruit flies of species *Drosophila melanogaster* and *Drosophila hydei***

Nutrient	Species	
	D. melanogaster	*D. hydei*
Humidity, %	74	71
Dry matter, %	1.7	2.1
Chitin, %	3.4	4.3
Protein, %	17.8	18.3
Lipids, %	5.3	6.2
Ash, %	1.7	1.7
kcal	5.12	5.12
The ratio of Ca to total P, %	27.8	49.6
Na, %	0.42	0.42
Mg, %	0.08	0.08
K, %	1.06	1.06
Cu, %	18	18
Fe, ppm	1.38	1.38
Zn, ppm	171	171
Mn, ppm	39	39
Se, ppm	0.07	0.07

The main difference between them is the size of the adult and the duration of the life cycle. *D. hydei* is the biggest one, the size of imago is around 3 mm, whereas *D. melanogaster* reaches a smaller size of about 1.5 mm. *D. melanogaster* passes the way from the egg to the larva and then to the adult fly in about two weeks (depending on the temperature and nutrient medium), and just hatched individuals can be eaten in 24 hours. *D. hydei* develops more slowly, his cycle takes about 30 days [7, 8, 11, 12]. Mostly flightless *Drosophila* are useed (wingless forms), which can be bought at reptiles suppliers, in dedicated companies, and in some pet stores. Wingless forms (vestigial) are more convenient for cultivation, because it reduces the chance of their spread around the room, but the winged forms are convenient in that they themselves are able to move from the container for cultivation to the aquarium, where fish eat them. Flightless forms have underdeveloped wings, so these individuals cannot fly, only crawl. However, they can jump and are not afraid of heights. This is a pure line, that is, in future generations will be born only "wingless" fruit flies, however, if wild individual appear in such a culture, its descendants will be winged [13, 14]. In the cultivation of flies, there is a need for their cold treatment (placing container for cultivation in the refrigerator) or ether treatment. Ether treatment is carried out as follows: cotton wool or cloth soaked in it is applied to the hole in the container, which is kept on its side, so that the flies do not fall on the feed, which they can stick to. Tapping on the walls, the flies are poured into the lower part of the container. After that, they are swept away with a

feather into a new container [13–15]. General requirements for any method of cultivation of fruit flies are: optimum temperature is 20-24°C. Elevated temperature (above 30°C) leads to sterility, and at a temperature below 18°C the life cycle slows down; humidity of 70-80%; a constant flow of air; change of lighting (day/night); it is necessary to make sure that the imago is able to sit on the land, because they often drown. For this purpose, a crumpled sheet of paper is perfect; if a black mold appeared in the container with insects, the entire colony should be destroyed. Green or blue mold in small quantities will not harm the colony. Cider vinegar can be used as a mold inhibitor; as the culture matures, small (difficult to see with the naked eye) ticks may appear and cause growth retardation, and subsequently the death of flies. It is recommended to use anti-tick paper, which is usually sold in rolls. The sheet, placed in a container for cultivation should prevent the appearance of ticks; when the producing capacity decreases, the substrate must be added or the temperature and humidity must be adjusted; the culture is replaced with a new one after a few months of cultivation; amount of about 20 flies per a volume of 500 ml is optimal. If placing more, there may be a shortage of food and hatch of abnormally small larvae. For a volume of 3 liters the maximum allowable amount of imago is 3000 [1, 5, 13–16]. Following items can be used as the substrate for the cultivation of fruit flies: pieces of apples, pears, bananas, dried fruits, jams, sweet cereals cooked on water (pearl barley, millet, rice) [7, 10, 11]. In case of preparation of a large amount of substrate, its excess can be frozen and used later if necessary [1]. The main recipes of nutritious (water in all recipes can be effectively replaced by ¼ beer, it accelerates the reproduction of fruit flies) substrates are:

1) water — 1l, wheat farina or wheat flour – 110 g, baker's yeast — 30 g, agar or gelatin — 10 g, sugar or beet juice — 30 g, nipagin or monomycin — 5 ml. The yeast should be stirred in water and slightly boiled, then agar-agar, sugar and cereals should be added. Then the mixture is made dense so that it is not too liquid, but rather easily poured into a container for cultivation. After cooling to 60°C nipagin or monomycin or 100 ml of the alcoholic solution methyl hydroxide is added. Then it is cooled to a gel state and sprayed with a suspension of yeast;

2) water — 1 l, wheat farina or wheat flour — 38 g, baker's yeast — 60 g, raisins — 40 g (or 50 ml of molasses), agar-agar or gelatin — 10–12 m, propionic acid — 0.8 ml. The yeast should be stirred in water and slightly boiled, then all other ingredients are added and simmered for 1.5 hours. The mixture is then cooled to 60°C and propionic acid is added and mixture is poured into a container for cultivation. After hardening, it is necessary to spray it with a spray suspension of yeast;

3) water — 500 ml, carrots — 400 g, honey or sugar — 70 g, baker`s yeast — 5 g. Chopped carrots are mixed with other ingredients until smooth. Larvae acquire orange color and improve the color of fish;

4) water — ½ cup; sugar — ½ tablespoon (30 g); milk powder — 1 tablespoon; soluble mashed potatoes – 4-6 tablespoons; baker`s yeast – 5-15 granules (Harvey Peterson nutrient substrate). First, dissolve the sugar in warm water. Then pour the milk powder and stir well. Add soluble mashed potatoes, its amount will depend on the level of humidity for the culture, and on its ventilation. If the amount of mashed potatoes is insufficient the environment will be too wet, in this case, it will be difficult to get flies. If adding too much mashed potatoes the environment will dry, the fruit flies will not breed.

5) oat flakes — 100 g, corn flour — 40 g, raisins — 3 tablespoons, sugar — 3 tablespoons. Raisins are chopped in a coffee grinder, mixed with oat flakes. The mixture is boiled in a small amount of water to obtain a mushy mass. When it is cooled, about 25 g of grated yeast or half as dry yeast is added.

6) water — 1 cup, vinegar — 1 cup, solution of mashed potatoes — 1 cup, brewers' yeast — ½ cup, banana — 1, grapefruit juice concentrate — ½ cup, applesauce — 400 ml, honey or molasses — 1/8 cup. It is necessary to boil, stirring, a banana, concentrate, mashed potatoes and honey or molasses. After cooling the mixture to 60°C, the remaining components are introduced into it: water, vinegar, yeast and applesauce (Power Mix nutrient substrate) [1, 12, 16, 17].

The four main methods of cultivation of flying and non-flying *Drosophila* are following:

1) Cultivation in the jar. A jar of capacity of 2–3 liters, covered with a plastic lid is used. In a lid it is necessary to make an opening with the closing device. The advisable substrate layer should not exceed 1–5 cm. The culture of *Drosophila* is placed there it can be obtained independently. After filling a jar with a substrate it is left open for a while. Usually after 2–3 days it is possible to find adult insects that fly to the smell of rotting fruit. After the culture is placed into the substrate and the jar is closed,15–20 cm long capron bag is put on its lid, which is tightened on the jar neck with a rubber ring. The mesh size of capron should be no more than 0.5 mm. Humidity in such an incubator should not be excessive, so the device closing the window in the lid should be open. After 5–7 daysflies or larvae can be used for fish feeding. For this purpose, the hole on the lid should be opened when capron bag is on the jar neck. Then the incubator is several times shaken, fruit flies fly over the substrate and of the walls and get into the bag. When the required number of flies is in the bag, the opening in the lid is closed. Tapping on the bottom of the bag with a finger, the flies are driven into its upper part, and the lower part of the bag is twisted and removed from the jar. Together with the collected insects, it is placed under cold water and moistened abundantly. They get wet and under the influence of water temperature fall into a temporary stupor. In this form, they are transferred to the aquarium with tweezers. Another way of fish feeding in the cultivation of *Drosophila* in banks provides 2 holes in the lid. One opening necessary for gas exchange should be closed with gauze or nylon fabric with a mesh size of not more than 0.5 mm. In the second hole hose or glass tube is inserted, which opposite end is fixed in the hole in the lid of the aquarium. If this "tunnel" is not very long, fruit flies will constantly crawl into the aquarium through it, and fall to the surface of the water, feeding the fish. Yields from one jar of 3l capacity is 100–300 flies per 2–3 days;

2) cultivation in containers. Small flat containers are used. A cotton swab can be used as a lid. Fabric screen fixed with wire is more suitable for large containers. It is also convenient to use special plastic containers for keeping insects. Such containers are sold with holes covered with thin paper. They are well ventilated and easy to clean, so they can be used several times. Adults lay eggs directly into the nutrition substrate, where the larvae develop. Often the larvae crawl on the inner surface of the lid, and they can be easily shaken out into the aquarium. It shoul be noted that they fly quickly in different directions when opening a container. After 10–15 days after placing the breeders, harvesting can be begun. If the nutrient substrate is dry, the flies can be simply shaken out of the container. But if it remains liquid, it is necessary to remove the lid of the container, thereby allowing the fruit flies to crawl out of hiding;

3) cultivation in test tubes — glass or plastic test tubes 30–40 mm wide and 100 mm high, closed with cotton and gauze or foam plugs are convenient;

4) cultivation in plastic bottles — their upper part is cut off, and closed with fine-porous nylon mesh [1, 12, 13, 18].

Fish Feeding With Fruit Flies. Many species of aquarium fish eagerly consume insects that have fallen to the surface of the water. For some fish species, such as butterflyfish, or pantodon (*Pantodon buchholzi*) or Banded Archerfish (*Toxotes jaculatrix*), they are the main element of nutrition [8, 11].Other species for successful spawning require winged insects, for example, the CongoTetra (*Phenacogrammus interruptus*) and long-finned Tetra (*Brycinus longipinnis*) [14, 18]. For some species of fish, this kind of food even stimulates fertility, for example, in representatives of the genus *Carnegiella*. Larvae of *Drosophila* is a favorite food for tropical fish, but as the main feed they cannot be used because in large quantities they cause digestive problems. If the fish do not eat the moving food, the drosophile is put for a few minutes in the freezer, and then added to the aquarium. Uneaten individuals stay on the water surface for 2–3 hours, then get wet and sink to the bottom [4, 6–8].

Synanthropic Flies Larvae (Maggots). The life cycle of flies, which are used for the cultivation of larvae are in general similar to that for all of *Diptera* order insects (tab. 2) [23–25].

Table 2. **Life cycle of blow flies (*Calliphoridae* and *Sarcophagidae*) at 27°C and 50% relative humidity**

Species	Number of generations	The duration of the development stage						
		hours					days	
		egg	larva			pro pupa	pupa	total to imago
			1	2	3			
Sarcophada cooley	29	—	24	18	48	96	9	16
Sarcophaga shermani	28	—	24	18	48	96	9	16
Sarcophaga bullata	18	—	26	18	54	112	12	17
Phormia regina	23	16	18	11	36	84	6	11
Protophormia terranovae	27	15	17	11	34	80	6	11
Lucilia sericata	29	18	20	12	40	90	7	12
Eucalliphora lilaea	27	22	22	14	36	92	6	13
Cynomyopsis cadaverina	17	19	20	16	72	96	9	18
Calliphora vomitoria	5	26	24	48	60	360	14	23
Calliphora vicina	5	24	24	20	48	128	11	18
Calliphora terranovae	4	25	28	22	44	144	12	20

Fly larvae or maggots is a popular name for the larvae of synanthropic (found especially comfortable conditions next to the human) flies of the superfamily *Oestroidea* which are used inanimal breeding, crop production, and medicine [2, 19, 20]. The representatives of this superfamily are members of *Diptera* order (*Diptera*) of insects from *Brachycera* suborder. More than 12,000 species of them are known and found around the world [1, 3, 21]. Larvae of three families of flies are usually used for

cultivation: flesh fly sarcophagids (*Sarcophagidae*) — larva is up to 25 mm long, trade name is "Gordin"; muscid flies (*Muscidae*), most often it is a house fly (*Musca domestica*); blowflies (*Calliphoridae*) most common among which is: common greenbottle (*Lucilia caesar*). The larva is the smallest among other, pink, brand name is "pinky"; seabirdbluebottle (*Calliphora uralensis*) or *Calliphora terraenovae*. The larva is about 10 mm long, a trade name is "maggot"; bluebottle fly (*Calliphora vomitoria*), larva is 12-15 mm long [11, 14, 22, 23].

Cultivation of synanthropic flies larvae in large (in specialized premises) and small (in conditions close to home) quantities has almost no differences, it uses the process of rotting food residues. It is enough to place several pieces of meat or other food residues in a warm room, where flies are inside, so that in a week it is possible to collect larvae suitable for feeding fish [22, 23, 25]. The main technical requirements for the premises for the cultivation of fly larvae are following: temperature regime: 23–25°C constantly,temperature fluctuations effect negatively on the size of larvae, 30–32°C leads to their adaptation in a number of generations and further reduction (4–5 days) in the duration of biological population development; humidity should be 50–70%; air exchange in the room is necessary, as ammonia, which is released by larvae is toxic and unpleasant; darkened lighting [23, 26]. The quality of fly larvae depends on three factors: food (the best is protein-rich food); stages of development (early stage: the larva is soft and not large, but long stored; optimal: the larva is large and well stored; late: the larvae are dry and pupate quickly); family and species of flies [1, 27, 28]. Laboratory populations of imago survive the whole year without passing diapause (the state of physiological inhibition of metabolism and stopping forming processes). The life span of fertilized imago is 20–25 days. The most intense oviposition they give the first 10–15 days after mating. Nutrition of flies imago includes water, proteins and carbohydrates [1, 29]. Water is placed in a cultivating container in any flat vessel with a relatively large surface, and changed as contamination occurs. It is advisable to use special waterer in the form of glassware with a narrow neck with a wick of filter paper or tissue. Special attention should be paid to the extreme sensitivity of flies to water and feed shortages; in their absence, they quickly die [30, 31]. As adult feed required for the maturation of eggs, any meat, fish, liquid (on cotton swabs) or dry milk, etc is suitable. As a carbohydrate food, flies are fed with sugar (lump or sand), bread or other carbohydrates. Conspicuous is the fact of sharp reduction in the life span of flies when feeding flies with only protein feed, as well as the different nutritional value of different carbohydrates. Data on the life expectancy of flies and their fertility, depending on the different types of food are shown in table 3 and 4 [22–24, 32].

Table 3. **Life expectancy of *Calliphoridae* females at different protein meals**

Substrate	The number of flies	Life expectancy, days
The proteins of cattle meat and glucose	35	50.3
Blood peptone and glucose	35	24.1
Egg albumin and glucose	35	25
Egg albumin without glucose	35	4.3
Alanine and glucose	35	19.8
Alanine and globulin of cattle meat	35	4.0
Valine and glucose	20	23.7

Table 4. **Life expectancy of *Calliphoridae* females at different carbohydrates meals**

Substrate	Daily average % of death	Average life expectancy (days)	Average female fertility (number of eggs)	% sterile females
Mannose	0.65	79.0	131	8.7
Maltose	0.86	82.0	140	14.7
Levulose	0.90	56.4	120	17.2
Glucose	1.28	50.3	194	8.4
Sucrose	1.23	41.0	34	51.5
Raffinose	1.54	37.7	62	35.0
Galactose	2.0	18.9	17	76.5
Mannitol	2.0	24.0	15	54.6

Cultivation of synanthropic flies larvae in large quantities is possible in two ways:in special cabinets, the most common way. The larvae is transferred into a special growing cabinets, fed with mince made of organic waste. The larvae are characterized by high energy of growth, they are well fed, growing 300-350 times per day. They have so – called external digestion of food; they secrete juice rich in enzymes on the food substrate, which is digested under the influence of enzymes, and then, like a pump, pass this substrate through theirselves. Within 4 days they grow to adulthood. Then they are separated from the substrate, cleaned and placed to the dryer. An empty substrate is placed in tight bags and closed. During the day, under the influence of a large number of anaerobic bacteria, it burns out at a temperature of 60-70°C and turns into a very valuable organic fertilizer, called zoohumus; in cages; this method was first tested on *Calliphora terraenovae* on a variety of organic waste (fish, meat), as well as pig manure and poultry manure; itwas developed in the 70s in the State research Institute of animal husbandry [20, 22, 23, 38]. Basic requirements and technical requirements for the cultivation of flies in cages: the volume of the cage is 0.5 m^3, height is not more than 50 cm, depth is 60 cm, length is 170 cm; it is necessary to provide a sufficient number of places in the cage at the rate of 2–3 cm^2 per individual, which is provided by the installation of 10 curtains (made of dense material) in the upper part of the cage at a distance of 10–15 cm from each other, a width of 20 cm each; the duration of life of flies in the cages is 20 days; ratio of sexes is 1:1; density of settlement in cages is 25 cm^3 per individual; the average number of eggs from one female during its life is 600; the average number of eggs from one female per day is 30; average egg yield per 1m^3 per day is 6 00 000 (60 g) [1–3, 22, 23, 32]. Placing pupas into the cage is carried out in a pencil box 50 cm long, 10 cm wide, 7 cm high. The hole above the pencil box is covered with a lid. After the release of flies pencil box is used to obtain the ovipositions [33, 34]. To prevent flies from crawling under the bait in a pencil box during egg laying, the bait is covered with gauze on top, and flies fly away from it when it is shaken. The bait is fish pieces moistened with Baker's yeast and 2% solution of ammonium carbonate [27, 30, 31]. For watering insects in cages metal or plastic cuvettes are installed (length — 50 cm, width — 10 cm, height — 7 cm) , filled with heat-treated sand in 5 cm layer. The sand is covered with double folded gauze. A glass tube with a rubber hose and a pinchcock connected to the vessel filled with water are placed to a cuvette. The flow of water into the cuvette is regulated by the pinchcock [22, 23, 33, 34]. For feeding insects with sugar and dry milk two more cuvettes as large

as waterer are put to the cage; the feed is given once for the entire period of detention of insects (for one fly a day: 2 mg of sugar, 1 mg of milk) [31]. Cultivation of flies in cages is carried out in three cycles with several cages in each. Settling cages with pupae is carried out consistently, on Mondays with calculation of the amount of flies in each cycle within 21 days [22]. The cages of the first cycle are inhabited by pupae.Waterers, curtains, feeders with food are placed there. For the first 7 days, the development of flies, their mating, puberty and laying 1–2 ovipositions occur in cages. From 8 to 15 days inclusively, flies of the first cycle are the most productive and give the most amazing ovipositions. From 15th to 21th day they gradually lose their fertility, and most of them die. So on 21st day all the cages of the first cycle are taken out in the room for disinfection, where the scalding destroys the remains of flies. Cages and their parts are disinfected and prepared for the next pupae settling [22, 32]. Cages of the second cycle are enrolled on the 7th day, and those of the third cycle — on 15th day, after laying cages of the first cycle, on mondays. Thus, every day in the insectarium there are cages with developing cultures, the most productive and aging flies (tab. 5) [22, 29].

Table 5. **The yield of eggs of synanthropic flies daily, in % of the total number of eggs**

Cages	Day				
	1–7	8–15	15–21	21–28	28–35
The first cycle	10%	70%	20%	10%	70%
The second cycle	–	10%	70%	20%	10%
The third cycle	–	–	10%	70%	20%

In spring and summer, it is possible to expect an increase in the life expectancy of flies and the timing of intensive egg laying. In this case, it is rational to put into operation the fourth cycle, but also with intermediate settling in 7 days after the third cycle. In general, the settling of cycles should be timed to a certain day of the week [22, 23, 29]. The life duration and fertility of flies largely depend on the conditions of development of the larval phase, so the formation of the stock swarm should begin with the cultivation of larvae. When growing larvae to replenish the stock swarm, they are isolated on the 7–8th day in the pre-pupal stage (that is, larvae that have stopped feeding and prepared for the pupal phase, weighing at least 110 mg). It is not recommended to use larvae grown for commercial purposes to replenish the stock swarm, where the main requirement of the technology is to obtain the maximum biomass of larvae without taking into account their biological maturity and usefulness. For the purpose of reproduction, eggs of flies are placed on fish waste in metal containers 15–18 cm deep with the edges bent on top (inside) at the rate of 150 mg on 1 kg of fish waste. The growth rate of larvae with a sufficient supply of feed and a temperature of 28–30°C are shown in tab. 6 [26, 27, 34, 35].

The cultivation of commercial larvae can be carried out in metal containers, which volume depends on the possibilities of mechanization. However, the working layer (height of the container loading with waste) should not exceed 15 cm. Containers for the cultivation of larvae are placed in a conveyor or rack cultivator, covered with a casing, into the which space warm air is supplied from the heater with simultaneous exhaust ventilation.

Table 6. **Growth rates of larvae of synanthropic flies with a sufficient supply of feed and a temperature of 28-30°C**

Stage of development	Weight, mg
Egg	0,07–0,1
Larva 1 day	0.13
Larva 2 days	1.12
Larva 3 days	6.3
Larva 4 days	17.6
Larva 5 days	77.0
Larva 6 days	96.0
Larva 7 days	106.0
Larva 8 days	115.0
Prepupa 9 days	97.2
Pupa 10-12 days	76.4

When placing 0.5 g of eggs per 1 kg of fish waste, it is fully processed by the 5th day of larval development and all the contents of containers with larvae is transferred to a mesh or slatted conveyor, through which holes the larvae migrate in the containers or trays that are installed under the conveyor belt [1, 20, 22, 23]. The first 4 days larvae are small, and their need for food is insignificant, so they can be contained in a small bowl with a small amount of food. During this period, the larvae separated from the substrate can be used for feeding fish of the earliest age groups [25, 27, 29, 35]. Starting from the 4th day, the larvae are transferred to permanent cultivation tanks, where the estimated amount of fish or meat waste is laid. The most intensive growth of larvae ends on the 6th day after hatching from egg. In the future, the growth rate is significantly reduced, and feed consumption increases. Unproductive energy use for respiration and metabolism increase. At the age of 5–6 days, the larvae have already formed protein-fat body. The crude protein content in this period is 15–18% in live larvae and 52–60% in dry matter of larvae [28, 36, 37]. With a lack of food, larvae actively migrate from the substrate and can be isolated on a mesh conveyor when illuminated from above by incandescent lamps. Larvae can be transported by a stream of water where they do not die within 30-36 hours. On 7–8th day after the termination of nutrition, the larvae with a substrate are transferred to the net machine, where they can be easily separated from the residues of fish waste, as thwy crawl down through the holes of the lattice. At this time, they are calculated and placed in separate containers, adding to them a small amount of dry feed or bran, where the transition to the stage of the pupa occurs. Pupae that have reached 3–4 days of age (dark brown) are used for settling cages of the next cycle [1, 22, 23]. To calculate the plant for cultivation of commodity larvae the following control figures can be used: the rate of settling eggs — 0.5 g per 1 kg of fish waste; the temperature in the room for the cultivation of larvae — 28–30°C; biomass yield of larvae — 300 kg per 1 ton of waste; the protein content in the dry matter of the larvae — 50%; period of larvae cultivation — 5 days [22, 23, 29, 30].

Settling containers for obtaining pupae should be carried out two weeks before the expected date of settlement of the cycle. By this time, 9-day larvae develop from eggs, which in the pupa phase will wait for 5 days in a separate bowl, before entering the

cage. Flies will begin to appear from pupae of this age in the cage on the day of their settlement [1, 22, 23]. For settling for the reconstruction of the stock swarm is very important to take the eggs from the most productive and sanitary satisfactory cages, possibly from fresh egg layings. It is best to re-take the ovipositions 2–3 hours after removal of the main ovipositions, which is usually a mixture of ovipositions, accumulated within 24 hours (or 12 hours in the case of double removal of ovipositions). When re-selecting from the ovipositions larvae and pupae develop more similar to each other, which contributes to the simultaneous hatching and mating imago [20, 22, 23, 32]. To calculate the reproduction plant for stock swarm the following control figures can be used: yield of pre-pupae from 1 g of eggs —10 000 ind.; amount of fish or meat waste for the cultivation of 10,000 prepupae — 7 kg: the height of the layer of fish waste in containers — 15 cm; the output of the flies from the prepupae — 80%; the period of larvae growing up to the matured pupa phase is 14 days [22, 23, 30].

Cultivation of larvae of flies in small quantities is usually carried out in the following 8 ways:

1) on bread. Cut the crust on a fresh loaf of bread and remove the crumb. Then pour a little water with fish or meat blood and leave in a place where flies are gathered for 12 hours. Next, the bread is placed in a plastic bag. After 2–3 days the larva is ready for feeding fish;

2) on a salted fish. The gutted fresh fish is put for 8–10 hours in a saturated solution of table salt, then the fish is wiped, rinsed with clean water and wiped dry with a cloth and left in the place where flies are gathered for 12 hours, necessarily in the shade. Then the fish is removed and put in a bowl with a lid with holes. The closed vessel is left to stand at room temperature. The larva hatches in 2–3 days. It is removed from the vessel, and the fish is thrown away. Larvae are fed with minced fresh salted fish. In 1–2 days the grown-up larvae are removed again, poured with wheat farina or bran mixed with crude sawdust, and placed in a cool place;

3) on buried meat or fish. A piece of meat or fish is buried shallow in the ground. In 5–6 hours, removing the top layer of soil, the largest individuals should be collected with tweezers, rinsed in soapy water and put on the paper. Dried larvae are sprinkled with wheat farina adding cheese and placed in jars. Small holes are made in a lid for access of air;

4) on boiled egg. Egg is boiled, a small piece of a shell with a film is removed from it and placed in a shadow. The rotten egg exudes an aroma, pleasant for flies, so very soon it turns into a miniature "incubator" for larvae. Until the contents of the egg is over, the larvae do not leave the shell. It is only needed to extract, process and move them into the cold;

5) on a raw egg. A hole in each egg is made using thin object; then it is left in an open space, where flies often appear. After a few days a lot of larvae can be obtained from each egg;

6) on fish and sawdust. Sawdust from deciduous breeds of a tree is poured into a container, and a thin layer of bran is placed above. Then the mixture is poured with hot water and all the ingredients mixed. In this container the crude fish with the cut open belly is put and in the morning it is placed there where flies most often appear. In the evening it is placed in a warm place. For 2–3 dayslarvae begin to appear from eggs laid by flies;

7) in the bottle. Take a clean bottle with a capacity of 2l, gently cut a small holes of

about 3 cm on the top. Chicken guts (intestines, stomach, etc.) or pieces of pork or chicken meat are thrown to the bottom through these holes. It is hung in a sunny area. Then it is left in this position for four days;

8) in liver. Take a small piece of veal or pork liver (not more than 0.5 kg. Make shallow transverse incisions so that blood flows from both sides. Put the liver on a strong hook and hang it at a high distance. Leave for five days, then remove it and put in a deep container with sawdust (bucket with a lid is perfect), and wait a little longer. After 2 days you mature larvae can be collected [1, 8, 11, 20, 30–34].

Colouring of synanthropic flies larvae. It should be noted that larvae can change their color depending on the nutrition. They become white after protein (although this is their main color), from the yolk they acquire yellowness, and become red from a special food dye rhodamine. To add red color, mashed beets or cherry juice is used. Yellow is obtained with carrots, egg white, green color from parsley, mint and other herbs. Larvae acquire a dazzling white color, if they are fed a mixture of chalk and flour. There are special dyes for larvae, that give them different colors and are safe for fish, for example,"Sudan–3 " and "Sudan-4". For coloring larvae only fat-soluble food dyes can be used, safe for fish and humans [1, 32, 33, 38].

Aromatization of synanthropic flies larvae. If adding vanilla sugar, cinnamon, aniseed oil, garlic, mint to the sawdust, the larvae acquire an attractive smell, which is not only more pleasant to fishermen, but also attracts the attention of fish [34, 38].

Feeding fish with synanthropic flies larvae is possible in live (fresh or thawed), boiled and dried states. The nutritional value of larvae and pupae of house flies (*Musca domestica*) in living form is given in table 7 [25, 35-37].

Table 7. **Nutritional value of larvae and pupae of house flies (Musca domestica) in living state**

Indicator	Stage of development	
	Larva	Pupa
Energy, MJ/kg	20.10	20.42
Crude protein, %	60.38	76.23
Crude lipids, %	14.08	14.39
Ash, %	10.68	7.73

The dried flies' larvae are on sale in the form of the whole larvae which swell after soaking or ground, in the form of a brown powder. By its nutritional value, 1 kg of dried fly larvae is equivalent to 3 kg of live flies. The nutritional value of flour from dried fly larvae is shown in the table 8 [23, 25, 29, 37].

Treated by drying the biomass of the larvae is retained for 3–4 years with no loss of useful properties. It is convenient to use it as an additive to feed or a feed. In the dried state, the larvae biomass does not lose most of its original properties. Long-term storage of dried whole larvae, comparing to meat, bone and fish meal, is caused by the fact that fats and other nutrients contained in them are protected from oxidation by the chitin shell. It is convenient to grind dried larvae into flour of the necessary fraction, if needed, before feeding. This flour is a safe source of protein, which can be used to replace other sources of protein, which can increase productivity in the cultivation of fish.

Table 8. **Nutritional value of flour from dried synanthropic flies larvae**

Nutrient	Content
Moisture,%	10
Crude lipids, %	24.2
Crude protein, %	54.3
Chitin, %	10.0
Melanin,%	8.0
Dietary fibre, %	7.0
Ash, %	5.06
Metabolizable energy, kcal / 100 g	596
Mineral composition	
Fe, mg/kg	30.03
Cu, mg/kg	4.20
Zn, mg/kg	130.07
P, mg/kg	7.03
Ca, mg/kg	18.0
Na, mg/kg	342.0
Mg, mg/kg	158.3
Aminoacid composition	
Lysine, %	4.0
Methionine, %	1.61
Cysteine, %	0.43
Histidine, %	2.1
Arginine, %	3.01
Threonine, %	2.23
Serine, %	2.3
Proline, %	1.5
Glycine, %	3.01
Alanine, %	2.83
Valine, %	2.03
Isoleucine, %	3.35
Leucine, %	4.21
Tyrosine, %	5.05
Phenylalanine, %	4.22
Glutamic acid, %	9.3
Aspartic acid, %	4.37

Storage of synanthropic flies larvae. On 7–8 days they should be fed to fish or stored, otherwise they pupate. It is possible to collect larvae with hands in gloves or to sift a substrate through a sieve. Larvae should be placed in containers with fresh

(necessarily wet) sawdust and placed in the refrigerator. Freeze makes they go into hibernation and their further developmentrapidly slows. At a temperature of +4 to +2°C, the larva will be stored for about 30 days [1, 31, 32, 38]. Preparation for long-term storage (for more than 2–3 months) involves drying larvae. For this purpose, flour or small sawdust is used. The larvae should be mixed with sawdust, packed in a sealed container and put in the freezer, where the temperature should not be below -5°C. It should be noted that once thawed larvae will not survive after re-freezing. In addition, thawed larvae can "revive" for quite a long time [33–36, 38].

Veterinary and sanitary conditions for the cultivation of synanthropic flies larvae. It should be followed faithfully, because they, like mites and fleas can be dangerous for pets and humans, given that they are cause diseases, called miases (parasitic diseases from the group of entomoses in the tissues and cavities of the human and animals' body). Therefore, it is always necessary to follow personal hygiene, wash hands and use gloves [1, 20, 32, 33]. In addition, containers, cages and parts of their equipment (curtains, boxes, feeders, etc.) are periodically treated with boiling water and dried in a separate room. The shelves, where cages are established or cabinets and floors of the insectarium, should be periodically washed with water using a hose. However,it is not allowed to store and use of disinfectants, washing powders, various reagents in the insectarium [8, 11, 33, 34].

Chironomidae larvae or bloodwormsare young insects from the superfamily of *Chironomids* or nonbiting midges, or lake flies (*Chironomidae* or *Tendipedfdae*) [1, 39]. The chironomids belong to a huge family (over 7046 species), distributed worldwide; the southernmost and northernmost localities of *Diptera* (in Antarctica and Arctic) belong to them. In Arctic, they constitute the dominant group of insects [1, 20, 40]. Like the whole group of *Diptera*, chironomids develop with complete metamorphosis, successively passing the stage of eggs, larvae, pupae and winged insect or imago [40, 41]. As a rule, in the population number of males is 10-15% more than females [1, 2, 42]. Females lay the oviposition in water and it sinks to the bottom or is fixed on plants with the help of a string. In water, the jelly-like mass of the oviposition swells and the eggs are in the mucous membrane. The number of eggs in a laying varies depending on the size of the females; the bigger it is, the more it lays eggs. Egg length is 375 mc; a width is 150 microns on average. Females of *Chironomus thummi* lay about 900 eggs at once, and *Chironomus plumosus* — up to 1200–1500 eggs. Egg lying is a tiny jelly-like formation, with translucent yellow, brown or black oblong eggs [1, 43, 44]. After leaving the eggs, the chironomids larvae remain in the mucous mass of the ovipositions for some time (for example, *Chironomus thummi* for 10–20 hours, and *Chironomus plumosus* for 2–5 days). Leaving a laying, they pass to a pelagic way of life that lasts 3–5 days then settle to a bottom where their further development occurs, up to a stage of a pupa. The chironomids spend most of their lives in the larval stage, from 2 weeks to 2 years. Their larvae are the most important component of aquatic ecosystems [42, 45, 46]. Depending on the living conditions and species, the larvae of chironomids have different sizes; *Chironomus plumosus* reaches a length of 30 mm and a mass of 90 mg before passing to the pupal stage, and *Chironomus thummi* weighs 1.2 mg at the age of 5 days, and 3.5 mg at 10 days. Before beginning the pupal stage (approximate age is 15 days), the average mass of chironomids larvae is about 7 mg [45–48].

Cultivation of chironomids larvae in large quantities or their mass plant breeding

was developed by the O. Konstantinov in the Saratov branch of the Fisheries Research Institute. It requires the use of 2 premises: to create and maintain a swarm of mosquitoes breeders and for the cultivation of larvae. Each of them should not have bright lighting; constant air temperature of 18–20°C, good ventilation and heating, supplied water is necessary. Optimal humidity is about 70% [1, 49, 50]. The initial culture of mosquitoes breeders is cultivated from a small number of eggs or larvae, and then maintained by artificial breeding. Mosquitoes lay eggs in enameled cuvettes, standing on the floor and filled with clean water. The height of the cuvette is 4-5 cm, an area is 0.1 m^2, a layer of water is 2–3 cm. Mosquito egg layings are replaced from the cuvettes with tweezers and transferred for incubation in faience cups with water (0.5–1 cm). Loading of eggs for incubation is not more than 400–500 units per 1 cm^2 of the bottom of the cup, which corresponds to about one laying. At a temperature of 18-20°C the development of eggs lasts 50–70 hours [44, 47, 51]. Before the end of incubation, as can be seen from the appearance of the first larvae, 85–90% of egg layings are transferred to another workshop. The remaining 10–15% of ovipositions are left in the first workshop to reproduce the culture of mosquitoes breeders [1, 45, 50]. The substrate for growing larvae can be prepared from fine (without relatively large residues of plants and sand) silt collected in water bodies. First, it is sterilized at a temperature of not less than +56 – +60°C. It can just be treated with boiling water, which is poured away after the silt sets. At the next stage, pure water is added to it in such an amount to achieve the consistency of sour cream [43, 45, 51]. In the second workshop, the eggs are distributed in cuvettes half filled with liquid sludge. Their height is 2.5–3 cm, and the area is 0.25 m^2. 50–60 thousand eggs are placed per 1 m^2 of soil surface, which corresponds to 100-150 ovipositions. After their placement, the cuvettes are installed in several tiers, on special frames. The space between them is 3–4 cm. In one frame there are 30–40 cuvettes [40, 41, 50]. Larvae after hatching begin to feed immediately, feeding on the mucus from the oviposition and feed that is placed to the cuvette. The fodder yeast is the best feed; they are put in an amount of 100 g per 1 m^2 of soil, even before placing in the ovipositions to the cuvettes. Before application, they are soaked in water to obtain a semi-liquid dough, and then thoroughly mixed with silt [1, 50]. On prepared in advance nutrient medium larvae are grown for 10–12 days and only 3–4 days before removal of grown products a second portion of yeast is added, but in dry form, spraying them on the soil surface at the rate of 30–40 g/l. If the air temperature in the room exceeds 18–20°C, it is not advisable to add a large amount of feed, as this will lead to the development of putrefactive processes with the release of methane and hydrogen sulfide. In this case, it is better to add food every 3–4 days, and the dose should be gradually increased according to growth of larvae. Terms and rates of adding fodder yeast are presented in table 9 [44, 50, 51]

Table 9. **Terms and rates of adding application of fodder yeast during the cultivation of chironomids larvae**

Day after placing oviposition	Amount of yeast, g/m^2
1	5
4	15
7	30
10	45
13	45

Before adding feed, excess water from the soil should be removed, but it should not be allowed to dry. The last feed is added three days before sampling larvae. When the larvae have reached a state close to the pupal stage, the entire contents of the cuvette are moved to aperforated cage mounted in the washing tank. The cage is driven (by motor or manually), so fine silt particles pass through the mesh (0.7–0.8 mm) and settle to the bottom of the tank. When the silt is removed from the cage, the remaining larvae are transferred to a bag of silk mill gauze, washed in clean water, and then fed to fish or frozen. Silt, settled on the bottom of the tank, is used again to fill the cuvettes [1, 2, 39, 44, 50]. The average daily biomass of chironomid larvae is 2–3 kg per 200–300 m^2 of cultivated area, or 10 g/m^2. The consumption of yeast by 1 kg of chironomids larvae is 500–700 g. The rest, 10–15% of the ovipositions in the first workshop, are also distributed before hatching the larvae on the cuvettes filled with liquid silt, which are then installed in several tiers, in the frames. Larvae are fed with yeast according to the same standards as in the second workshop. However, before the pupa stage, they are not removed from the soil, but they have an opportunity to turn into pupae, and then into adults. Under favorable conditions, the pupal stage begins on 12–13 days after the hatching and lasts 2–3 days. After its completion, the mosquitoes leave the cuvettes and reach sexual maturity in 20–30 hours, begin to swarm, mate and lay eggs. Each oviposition consists of mucus and eggs (averages to 400–500 pieces). Mosquitoes lay eggs both in the light and in the dark. Therefore, the care of the imago is reduced to maintaining a constant temperature in the room within 18–20°C, to prevent the penetration of foreign odors and smoke, and to keep clean the cuvettes filled with water, which are intended for ovipositions [1, 20, 39, 44, 50, 52].

Cultivation of chironomids larvae in small quantities involves the following sequence of actions: prepare a bucket, plastic barrel or other container of any size. It is very convenient to breed them in a small aquarium, for example with a capacity of 20-30 litres, where larvaeare visible through the glass and they will be easier to remove. In addition, barrel with a capacity of 200 would be a good choise; it is possible to collect up to 80 larvae per day. But, if it is black, it can get very hot on the sun and when thw weather is hot it should be moved into the shade; a favorable environment for the development of chironomids larvae are algae at the bottom of the barrel or moss; it is very important to fill the container for growing bloodworms, not with tap water, but with rain water or melted snow, in extreme cases with filtered water; after preparing the water, put the container in the sun, so that micro-algae began to grow there, which serve as food for chironomids larvae; wait until the mosquitoes lay a large number of brown eggs, where the larvae will develop in the future in the water of this container; after the appearance of bloodworms in the container, wait until they will have antennae, then they can be fed to the fish [1, 53–56]. It is important to collect larvae in the tank regularly to prevent the development of mosquitoes or their transformation into pupae. The larvae should be caught by net with a fine mesh. For more convenient washing larvae it is possible to use a bucket with water in addition.

Fish feeding with chironomids larvae. It is unacceptable to bury bloodworms into the ground of aquarium, where they die and begin to rot, spoiling the water. Despite the high value and efficiency in the preparation of breeders for spawning, bloodworms should not be used in large amounts. They are very high in calories, so they should not be feed to fish daily, it can lead to obesity, toxicosis, infertility and other diseases. It is best to give it 2–3 times a week, notmore often. Early fish fry can be fed with bloodworms, shopped with a sharp blade into small pieces. After feeding all uneaten

bloodworms must be removed from the water, since their residues spoil the water. That is why when feeding chopped chironomids larvae, it is necessary to change water in the aquarium regularly [1, 8, 58, 59]. The nutritional value of chironomids larvae is determined by the high content of proteins, carbohydrates and minerals. Proteins have a complete amino acid profile. Thus, essential amino acids, which are the criterion of feed value of the protein, reach more than 41.17%.The ash residue contains a significant amount of phosphorus and iron, see table 10 [45, 49, 50, 57].

Table 10. **The nutritional value of the chironomids larvae per 100 g**

Nutrient	Content
Energy, kcal/g	4.5
Ash, %	0.9
Proteins, g	62.5
Lipids, g	2.9
Carbohydrates, g	29.7
Vitamins, mg	
A	0.231
E	0.287
B_1	0.18
B_2	0.483
B_{12}	0.154
Amino acids, % of protein	
Arginine	4.75
Histidine	2.38
Tryptophan	2.06
Methionine	1.48
Cysteine	1.05
Tyrosine	3.16
Lysine	7.95
Alanine	6.9
Valine	3.72
Aspartic acid	10.2
Threonine	5.28
Isoleucine	5.3
Serine	5.29
Leucine	7.19
Glutamic acid	13.35
Proline	6.3
Phenylalanine	6.62
Glycine	5
γ-aminobutyric	2.06

Continuation of the table. 11

Nutrient	Content
Trace elements, mg/%, wet weight	
Fe	925
Al	460
Cu	185
Mn	121
Ti	60
Ag	0.5

Chironomids larvae are divided into several groups by size (large, medium, small, especially small) and by place of their harvesting (factory, estuaries, rivers) [1, 57]. Chironomids larvae for aquarium fish are very nutritious and quite versatile food, widely used. They are used as food alive, frozen, dried and freeze-dried. Alive and frozen bloodworm has the greatest nutritional value [58, 59]. Freshly caught bloodworms are not usedfor feeding fish. It is necessary to sustain them for 3–4 days to clean the intestine, which can contain pathogenic flora of the reservoir; during this time the degree of possibility of fish infection decreases significantly. For this purpose, the larvae are placed in a 5% solution of salt for 10 minutesevery 3 days. At least 3 days, twice a day it is washed in running water. During this period, the water where the larvae are located must be changed periodically. Also, it is desirable to disinfect them with kanamycin, methylene blue (400 mg/l during 5 min), rivanol, ozone or antibiotics. Before using for feeding or freezing, they are thoroughly washed [1, 14, 57, 60]. When buying chironomids larvae, first of all it is necessary to pay attention to their color: they should be bright red, glossy. Pink or light orange color indicates the immaturity of larvae, they have insufficient hemoglobin in the hemolymph, so they are inactive, not very nutritious and also die quickly. If it is, on the contrary, very dark, burgundy or cherry color, it is a sign of old age, long time of storage, so the larvae will not be stored for a long time, so there is a high probability to poison fish with such larvae. Too light, carrot or dark color and uneven size (ranging from 1–2 to 7 mm) may indicate that the larvae are from estuaries, that is, were collected in salty bays. They are characterized by a very thick chitin cover, which reduces their nutritional value, in addition, there is evidence of a relatively high content of harmful substances in them. In addition, their transportation to other regions of the country for sale, requires a long time and storage in conditions, mostly far from optimal. All this calls into question the suitability of the chironomids larvae from estuary for feeding fish. In addition to color, when buying, attention should be paid to the mobility of larvae: fresh and high-quality chironomids larvae actively fold into rings in response to irritation [1, 3, 8, 61]. Bloodworms are fed to fish by placing them in a floating feeder with the holes in the bottom; they slowly fall into the aquarium through the holes [11]. In addition, poisoning with chironomids larvae extracted from bad water bodies is widespread. Their waters mainly contain high concentrations of highly toxic elements (heavy metals, insecticides, herbicides, fungicides, chlorinated hydrocarbons and many others). Chironomides accumulate in their tissues a significant amount of these substances. Eating larvae, fish absorb toxic compounds. After feeding with such larvae there are signs of acute or chronic poisoning with nonspecific symptoms. Often, along with poisoning, there may be inflammation of the intestine, then fish generally refuse to feed and die [1, 57, 58, 60]. First of all, the

liver is affected, and other vital organs of the fish (intestine, spleen, kidneys, brain, nervous system, sense organs), depending on the composition and concentration. Depending on the type and amount these poisons pose different danger to fish. Often there are chronic poisoning, which weaken the body of fish, and the latter become prone to various diseases. At the same time, the ability of chironomids larvae to absorb toxins from water is used to treat sick fish. For example, to 1 liter of water 2 g of the drug is added (in particular the 10% solution of Concurat) , which is used to expel worms and various other parasites found in the intestines of the fish. Chironomids larvae are left in solution until they die from the drug (a few minutes). Then they can be immediately fed the fish to expel parasites or they can be frozen. At the same time, it is worth remembering that the accumulated poison of the drug in the cold is not destroyed, this also applies to all poisons and toxins absorbed by larvae from reservoirs with sewage [1, 46, 54, 55].

Veterinary and sanitary requirements for the cultivation of chironomids larvae: in some countries, it is prohibited to extract or cultivate chironomid larvae, especially in Southeast Asia (Singapore, Malaysia, etc.); cleaning and disinfection of chironomids larvae is a mandatory requirement; use containers where chemicals were not stored to avoid death or fish caused by chironomids; mosquitoes are carriers of diseases dangerous to humans and animals (encephalitis, West Nile virus, malaria,helminths) [1, 52, 58, 61].

CONCLUSION AND PERSPECTIVES OF FURTHER DEVELOPMENT

Representatives of insects from the order of Dipterans (*Diptera*) such as fruit flies (*Drosophilidae*), synanthropic flies and chironomids (*Chironomidae*) larvae are promising forage organisms in aquaculture, in particular in feeding young fish and as additional ingredients in animal feed due to a number of their biological features. They contain amino acids and vitamins necessary for fish, and can also be used for the transfer of veterinary drugs when fed. However, it is worth emphasizing that for their cultivation it is desirable to use the stock cultures obtained in specialized conditions, because when using such organisms obtained from natural reservoirs there is a great risk of poisoning fish with pollutants. Moreover, given their lipid composition, these organisms cannot act as the main feed, but due to the high content of easily digestible protein, they have a positive effect on the growth and development of fish. In addition, for many species of aquarium fish, they are an essential component of the diet. In general, the populations of fruit flies and larvae of synanthropic flies and chironomids are characterized by high producing capacity and tolerance to environmental conditions, which causes the ease and economic feasibility of cultivation. However, the latter requires strict compliance with veterinary and sanitary requirements.

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