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THE DEVELOPMENT OF TECHNOLOGY FOR CULTIVATION OF THE BLACK SOLDIER FLY

BARKAR V. P., HOLUB Y. A.
Department of Industrial Entomology, ITI "Biotechnica", Odesa, Ukraine
e-mail: eva.golub.1979@ukr.net

Summary. The analysis of the patterns of growth and development of the black soldier fly when grown in reservoirs of different sizes was carried out. It was found that the period of development of the black soldier fly from the week old stage to the beginning of pupal emergence in both variants of the experiment was 19 days, and the percentage of increase in the average weight of 200 pupae varied greatly from 2851,1% on the 10th day of rearing to 90,3% on the 25th day in the control and from 1832,1% on the 5th day to 112,5% on the 25th day in the experimental tank; the weight of one pupa during this period of development increased from 0,002 to 0,24 gr. in the control variant and from 0,002 to 0,27 g in the experimental tank.

Keywords*: technology of cultivation, Hermetia illucens L., patterns of development, artificial cultivation, biological parameters.*

Today, the issue of organic waste processing is relevant, and the use of insect larvae and especially some species of Diptera is becoming a promising area of biotechnology [1–2]. In this case, the black soldier fly (*H. illucens*) is of great scientific and practical interest, whose larvae are capable of efficiently processing organic waste of various types: organic portions of solid biological components, sewage sludge and waste from meat and fish processing, fruits, vegetables, and kitchen waste [3].

The method of waste destruction using the larvae of the *H. illucens* is unlike any other method of disposal. When using this method, organic residues are not subject to mandatory mechanical grinding. The fly larvae grind them into almost identical small particles in the process of eating and digestion, and as a result, the volume of waste is significantly reduced (up to 70–80%), and the waste itself is a highly valuable and environmentally friendly, complete fertilizer for plants (vermicompost) [4]. In addition, the larvae of *H. illucens* are a very valuable source of food for poultry and animals [5, 6, 7]. This is primarily due to their high nutritional value. Larvae grown on organic waste

contain proteins (≈40%) and fats (≈40%). In the fatty acids, lauric acid accounts for 50%, as well as calcium, phosphorus, and iron [8–9].

The usual distribution area of the *H. illucen* species is characteristic of the subtropics [10]. However, it is known that this species is also cultivated in Western Europe with a temperate climate [11, 12]. These are countries with predominantly warm climates where the fly is bred in open-air enclosures. However, recently, research has been conducted on the prospects of breeding the fly in artificial conditions and, as a result, the possibility of its use in regions with more severe climatic conditions. This is possible if optimal artificial conditions are created where *H. illucens* can function, develop and reproduce normally.

It is now known that in Ukraine, unlike the United States and Western Europe (Netherlands, Germany, Italy), where the study of adaptation and breeding of the Black Lion fly has been going on for decades, there has been no commercial cultivation of the fly until now. And research on this issue is at an early stage [13]. In particular, such work is currently being carried out at the Research Department of Industrial Entomology of the ITI "Biotechnology" of the National Academy of Sciences of Ukraine. In previous studies, a special tank for artificial conditions of fly cultivation was developed and created.

The analysis of the current state of research on creating optimal artificial conditions under which *H. illucens* can function, develop and reproduce most effectively has shown that abiotic factors have a significant impact on the growth, development and vital processes of larvae. It was found that the optimal conditions for breeding an adult black soldier fly are air humidity at 60–70%, air temperature at not lower than +26...+30 ºC [3, 14–15]. More stringent cultivation conditions increase the life cycle of insects and reduce the viability of larvae [16–17].

The purpose of the study was to investigate the patterns of growth and development of the black soldier fly when reared in tanks of different sizes.

The experiment was conducted in 2 variants: 1) control – larvae were reared in a standard tank, where 900 g of substrate (mill worm waste + water in a ratio of (1: 1) were placed 2000 larvae of one week of age with a total weight of 4 g with an average weight of 0,002 g; 2) larvae were kept in a developed model of the tank for rearing larvae and collecting pupae (the area of which is four times larger than the control variant). On a similar substrate to the control in the amount of 3500 g were placed 8000 larvae of one week of age with a total weight of 16 g with an average weight of 0,002 g.

The following biological and technological parameters were determined during the research:

average weight of older larvae, g; developmental period (from egg to pupa), days; weight of feed used, g;

The average weight of older larvae was determined every 5 days. To do this, 200 individuals were taken from each tank from 5 points with tweezers when larvae rose to the surface of the substrate in search of food. Each sample was placed on a sieve and rinsed with settled water, after which excess moisture was removed from the surface of the larvae with filter paper. The larvae were weighed and the average weight of the larvae from each sample was calculated separately and the arithmetic mean was determined.

During the experiment, it was found that the period of development of the black soldier fly from the larvae of a week old to the beginning of the emergence of pupae in both variants of the experiment was 19 days; the percentage of increase in the average weight of 200 larvae, both in the control and experimental tanks, had a wide range of fluctuations depending on the period of rearing (Fig. 1).

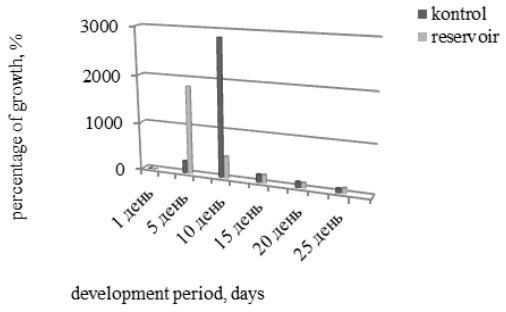


Fig. 1. Percentage of increase in average weight of 200 black lion fly larvae.

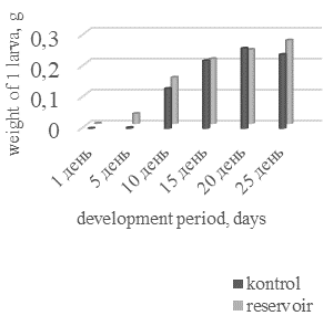


Fig. 2. The average weight of 1 larva of larvae in the process of growing

For example, in the control variant, the maximum percentage of larval growth was recorded on day 10 of cultivation – 2851,1 %, a decrease in weight gain was observed on day 25–90,3 %, in the experimental tank the peak of growth was observed on day 5 of cultivation – 1832,1 %, and similarly to the control on day 25 there was a tendency to decrease this indicator – 112,5 %. The weight of one larva during the specified period of development increased from 0,002 to 0,24 g in the control variant and from 0,002 to 0,27 g in the experimental tank (Fig. 2).

The need for feeding was determined visually by the appearance of the environment, or by larvae that rose to the surface of the substrate in search of food. To control the amount of feed consumed for larval rearing during the period of development from egg to pupae, it was pre-weighed before feeding (Table 1).

Table 1. Amount of substrate used for rearing black soldier fly larvae

Parameter	Container	Period of growing, days						Total amount of substrate, kg
		1 day	5 day	10 day	15 day	20 day	25 day	
Amount of substrate, kg	Control	0,9	0,25	0,3	0,25	0,3	-	2,0
	Reservoir	3,5	1,0	1,5	1,0	1,0	-	8,0

Thus, 2 kg of feed was consumed for rearing larvae during the period of development from egg to pupa in the control variant, while the substrate consumption per experimental tank was four times higher and amounted to 8 kg.

In summary, when growing *H. illucens* larvae in tanks of different sizes, no significant differences in the patterns of their growth and development were observed. The one difference was that with the increase in the surface area of the tank there was a difference in the intensity of larval development. For example, the peak of growth in the experimental variant occurred 5 days earlier than in the control variant. This may be explained by the fact that an increase in the tank area, and hence the migration activity of insects at the initial stage of their development, leads to an intensification of metabolism. Later on, a decrease in larval mobility delays this period, but due to higher rates, the final result is almost the same. These results need further investigation.

References

1. Stetsyshyn P.O., Pindus V.V., Rekunenko V.V. et al. Fundamentals of organic production: a textbook. For students of agrarian higher educational institutions. 2nd edition, amended and supplemented – Vinnytsia: Nova Knyha, 2011. 552 p.
2. Papadoyianis E.D. Insects offer a promising solution to the protein bottleneck. Feed Technology Update, 2007. Vol. 2 (6). P. 158.

3. Alvarez L. The Role of Black Soldier Fly, Hermetia illucens (L.) (Diptera: Stratiomyidae) in Sustainable Waste Management in Northern Climates. Electronic Theses and Dissertations, 2012. P. 402.
4. Serebryansky D. N. Advantages and problems of the business of breeding larvae of the Black Soldier fly (Hermetia illucens). URL: http://www.nasadki.net/index/ dostoinstva_i_problemy_biznesa_po_razvedeniju_lichinok_mukh_chernaja_lvinka_hermetiai llucens /0-594
5. Vlasova, O. A. Processing of organic waste by larvae. Strategic potential of advanced development and research, 2021. P. 217–227.
6. Pat. № 2 654 220. Russia. IPC (2016. 01). Method for processing organic waste by larvae of Hermetia illucens flies to produce animal protein and vermicompost Babaev, N. A., Bastrakov, A. I., Sokolov, I. V.; applicant and patentee Biogenesis LLC No. 2017109420, filed 21.03.2017, published 17.05.2018 Bulletin No. 14.
7. Elwert C., Knips J., Katz P. A novel protein source: maggot meal of the black soldier fly (Hermetia illucens) in broiler feed. 11. Tagung Schweine- und Geflügelernährung, November 23-25, 2010, Institut für Agrar- und Ernährungswissenschaften, Universität Halle-Wittenberg, Lutherstadt Wittenberg, Germany, 2010. P. 140–142.
8. St-Hilaire et al. Fish offal recycling by the black soldier fly produces a foodstuff high in Omega-3 fatty acids. World aquaculture. Soc, 2007. Vol. 38 (2). P. 310–311.
9. Baker D. H., Batal A. B., Parr T. M., Augspurger N. R., Parsons C. M. Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second- and third-weeks post hatch. Poultry Science, 2002.Vol. 81. P. 485–494.
10. Tomberlin J.K., Adler P.H., Myers H.M. Development of the black soldier fly (Diptera: Stratiomyidae) in relation to temperature. Environmental Entomology, 2009. 3 (38) P. 930–934. https://doi.org/10.1603/022.038.0347.
11. Tomberlin J.K., Sheppard D.C. Factors influencing mating and oviposition of black soldier flies (Diptera: Stratiomyidae) in a colony. Journal of Entomological Science, 2002. 37. P. 345–352.
12. Markina T.Y. New approaches to quality control for cultures of insects for rearing. Biosystems Diversity, 2016. Vol. 24.1 P. 164–172. doi:10.15421/011620.

13. Markina T.Y., Benkovskaya G.V. Mechanisms of homeostasis maintenance in laboratory populations of insects. Russ J Ecol, 2015. 46. P. 365–369. DOI:10.1134/S1067413615040128
14. Holmes L. Role of Abiotic Factors on the Development and Life History of the Black Soldier Fly, Hermetia illucens (L.) (Diptera: Stratiomyidae). Master's thesis University of Windsor. ON, Canada, 2010. P. 168.
15. Harnden L. M., Tomberlin J. K. Effects of temperature and diet on black soldier fly, Hermetia illucens (L.) (Diptera: Stratiomyidae), Development Forensic Sci Int, 2016. P. 109–116. doi: 10.1016/j.forsciint.2016.05.007
16. Markina, T. Y., Bachynska, J. O., Molchanova, O. D., Barkar, V. P. Influence of keeping temperature on biological parameters of Hermetia illucens l. (Diptera: stratiomieidae) under conditions of piece cultivation. Biodiversity, Ecology and Experimental Biology, 2021. 23(2), P. 87–93.
17. Sapronova, J. A., Sverguzova, S. V., Shaikhiev, I. G., Starostina, I. V., Danshina, E. P. Bio composting of waste: influence of various factors on the biological cycle of Hermetia illucens. Rational use of natural resources and processing of technogenic raw materials: fundamental problems of science, materials science, chemistry and biotechnology, 2020. P. 397–403.