



ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor (RJIF): 8.4
IJAR 2024; 10(3): 16-19
www.allresearchjournal.com
Received: 22-12-2023
Accepted: 26-01-2024

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Reduction of the larval period of silkworm *Bombyx mori* L. and leading biological indexes

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Abstract

This article is devoted to the analysis of selection and research works of Uzbek breeders aimed at reducing the larval period of silkworms. The experiments involved 6 domestic species of Uzbekistan breeds, 4 selection systems and industrial hybrids F1 in 4 different combinations. As a result of selection work on experimental material over the years, a reduction in the larval period by 2.4-3.1 absolute days was achieved. Although shortening the larval period is somewhat difficult in breeds that mount large cocoons, it has been proven that the larval period can be significantly shortened in breeds with small and medium cocoons. At the same time, experiments have established that industrial hybrids, imported from abroad, have a stable 23-day larval period. From these data, we can draw conclusions about the possibility of reducing the larval period based on selection and providing the industry with new highly productive breeds and hybrids that grow and develop at a rapid pace.

Keywords: Silkworm, larva, cocoon, hatchability, selection, hybrid, breed, selection system

Introduction

The spectrum of selection traits in silkworm breeding is so wide that it covers all stages of silkworm development. These include the egg productivity of the mother butterfly, the degree of egg hatchability, viability and incidence of caterpillars, the mass of mounted cocoons, the percent of cocoon shell and filature of these cocoons, which are important technological parameters. Each of these traits has its own heredity and intercorrelation with other traits. In the last 10-15 years, seeds of industrial hybrids F1 have been brought to our country from China and bred under industrial conditions. If you look at the results, cocoons yield from one box of silkworm eggs does not exceed 45-50 kg. However, it must be admitted that their cocoons, from a technological point of view, meet the requirements of the modern silk industry. In the process of breeding imported silkworms, one can observe that, firstly, Chinese hybrids consume less food than our local hybrids, and secondly, their larval period is very short, and they begin to mount a cocoon after 23-24 days. Based on this, there is no doubt that the study of the larval period of local breeds and hybrids created in Uzbekistan, and its reduction through selection, is an urgent scientific and practical task. Currently, in our silk industry there is a need for highly productive breeds of silkworms that grow and develop quickly. It should be separately emphasized that in the currently operating sericulture clusters, modern automatic spinning machines are installed, which are almost 100% adapted for processing hybrid cocoons imported from China. If we strive for complete zoning of silkworm seeds in the republic, then first of all it is necessary to create breeds and hybrids that produce cocoons similar to Chinese breeds and hybrids and meet the requirements for technological indicators for silk of 3A class. However, most of the domestic breeds and hybrids created to date are large-cocoon breeds, the cocoons of which are not suitable for the automatic spinning machines mentioned above.

A certain level of results has been achieved in carrying out breeding work on numerous selection traits of silkworm by our republican and foreign scientists.

Akhmedov N. (1998) ^[1] conducted a number of scientific research works to study the natural factors affecting the silkworm in the process of shortening its life cycle and accelerating larvae hatching from eggs. In this regard, the researchers suggested that firstly it is important to determine the period of seeds hatching. Environmental factors can influence the growth and development of silkworms, as well as the amount of mulberry leaves they are fed.

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Some research has been carried out aimed at breeding larvae at high temperatures and increasing the frequency of feeding. N. Chernetsova (1966) [2]; N.G. Bogoutdinov (1981) [3] in their studies established that it is possible to accelerate the growth of larvae and increase the productivity of cocoons by maintaining optimal temperature and relative humidity in the conditions of silkworm production, as well as feeding larvae at different periods during the development cycle (7 times per during the day, 2 times at night).

In the research of R. Gunchaum (2017) [4], a new generation was obtained as a result of the selection of two silkworm breeds with low and high viability, bred by artificial feeding, in which an extension of the larval period of caterpillars and a decrease in cocoon yield and silk quality were observed.

Indian researchers conducted research to study the biology of silkworm belonging to the Mcon-1 breed in laboratory conditions. In these studies, the third period of embryonic development of eggs, i.e., the period of hatching was 8.6 days, the larval period of caterpillars was 23.7 days, the period of mounting cocoons of caterpillars was 2.3 days, the pupal stage was 10 days, and the period of moth was 4.6-5.9 days. Female larvae have been found to live longer than males. During the overall life cycle of larvae, the sex ratio was 1:1.3 (T.S. Gurjar, 2018) [5]. Similar articles (Nasirillaev B.U., Umarov S.R., Zhumaniyozov M.S., Khudzhamatov S.K. 2019; 2022) [6, 9], (Khudjamatov, S., Nasirillaev, B. U. 2022) [9], (Nasirillaev, B., Khudjamatov, S., Abdigodirov, M., & Faizullaeva, Kh. 2022) [9] and (Khudjamatov, S., Nasirillaev, B., & Rajabov, N. 2023) [10]. As can be seen from this brief review, insufficient selection work aimed at reducing the larval period of breeds and hybrids has been carried out.

Material and methodology of the study: Selection experiments were carried out in special silkworm nurseries of the laboratory “Silkworm breeding, ecology and prevention of chemical poisoning” of the Scientific Research Institute of Sericulture in optimal hydrothermal

conditions. The similar nutritional and agrotechnical paratypic factors were created for populations of experimental breeds. Mulberry leaves of the same quality brought from the institute mulberry plantations were used as fodder. Varieties Guzal, Marvarid, Gulshan, Nafis, Parvoz 1, Parvoz 2 and selection lines Line 42, Line 101/1, Line 500, Line 501 available in the laboratory “Silkworm breeding, ecology and prevention of chemical poisoning” of the Scientific Research Institute of Sericulture were taken for experiments during which their embryonic and postembryonic viability was determined in each generation. In silkworm breeds and systems with different characteristics, egg layings were first of all sorted. During the spring larvae breeding season, each oviposition of the selection breeds and systems was individually placed in the hatchery. Spring incubation was carried out according to the method of P.K. Kovalev. According to this method, the seeds are kept for a day at room temperature, and then placed in an incubator at a temperature of 24 °C and a humidity of 75-80%. After the beginning of whitening in the third period of embryonic development (blastokinesis) of the seeds, the temperature is increased to 25 °C and the humidity to 75-80%.

Results

The purpose of the study is a comparative study of the larval period of local breeds and systems of silkworms and leading economic traits.

The scientific problem under study is that when creating local breeds and hybrids, in most cases, attention is paid to the indexes of cocoons productivity and larval viability of the breeding material. However, today's sericulture industry requires scientists to create breeds and hybrids that are productive, quickly growing and developing, as well as quickly starting to mount cocoons. Therefore, we conducted a comparative analysis of larvae life expectancy and the indicators of leading biological traits obtained during the study. Table 1 presents the indicators of the larval period and the leading selection characteristics of selection breeds and lines of silkworms by years.

Table 1: Duration of the larval period and leading biological indicators of selection breeds and systems 2021-2023, spring

Breeds and lines	Years	Duration of larval period, day	Eggs hatching, %	Viability of larvae, %	Morbidity, %	Cocoon weight, g	Percent cocoon shell, %
Parvoz 1	2021	26,3	94,9	88,9	3,3	2,0	23,8
	2022	26,03	95,8	89,2	6,2	2,08	22,9
	2023	25,6	86,3	93,9	5,5	2,20	23,8
Parvoz 2	2021	26,0	97,4	91,7	2,4	1,75	23,8
	2022	25,5	91,9	87,8	6,20	1,90	23,3
	2023	25,2	86,9	90,6	4,2	2,01	24,3
Gulshan	2021	25,0	85,3	89,7	2,5	1,80	22,6
	2022	24,0	92,7	93,0	2,6	1,81	21,9
	2023	23,8	94,4	91,5	3,0	1,96	22,1
Nafis	2021	25,2	85,3	90,5	2,45	1,90	21,8
	2022	24,1	94,0	92,7	2,3	1,85	21,6
	2023	24,1	96,4	92,9	2,6	2,06	21,0
Guzal	2021	26,7	97,3	90,0	2,8	2,05	23,4
	2022	25,3	90,9	92,1	3,3	2,12	22,2
	2023	25,5	96,4	92,8	3,2	2,30	23,0
Marvarid	2021	26,3	97,9	89,9	2,7	2,08	23,2
	2022	25,0	93,6	88,3	5,5	2,08	23,2
	2023	25,2	94,7	94,1	1,7	2,35	21,8
L-500	2021	27,0	95,0	92,5	1,4	1,37	22,3
	2022	25,5	87,8	91,0	3,3	1,49	23,2
	2023	23,9	96,9	94,1	2,6	1,74	22,7

L-501	2021	27,0	96,3	88,5	1,8	1,32	21,7
	2022	26,3	87,9	88,3	3,7	1,43	21,7
	2023	24,6	95,5	89,8	3,9	1,78	23,2
L-42	2021	26,7	96,0	93,3	0,87	1,61	22,4
	2022	26,0	94,3	89,6	4,4	1,7	21,8
	2023	23,0	94,7	91,3	4,1	1,98	22,2
L-101/1	2021	26,0	95,3	88,4	2,93	1,89	23,6
	2022	25,0	90,7	86,5	6,3	1,89	23,7
	2023	24,7	84,7	94,5	2,57	2,11	23,4
Foreign breed (Japan) oblong	2021	25,0	98,0	94,3	1,01	1,31	22,7
	2022	25,0	96,0	92,9	0,57	1,55	22,4
	2023	29,0	87,0	89,9	3,3	1,09	19,3
Foreign breed (China) round	2021	25,0	97,3	93,4	2,8	1,34	22,3
	2022	24,0	95,2	92,8	1,6	1,46	21,6
	2023	30,0	91,6	94,4	2,1	1,14	22,8

Analyzing the data in Table 1, it can be seen that the larval stage of the experimental breeds and lines decreased in 2022 and 2023 in comparison with 2021. This situation is clearly observed in Parvoz 1, Parvoz 2 and Gulshan breeds. Among the new selection lines in the «Line 500» and «Line 501» lines, this figure was reduced from 27 days to 23.9-24.6 days, or 2.4-3.1 absolute days.

Now we turn our attention to changes in other breeding characteristics of the breeds and systems mentioned above. The achievement of research work, along with a reduction in the larval period, is an increase in the indexes of larval

viability, mass and percent cocoon shell as a result of selection in these breeds and lines. This situation, of course, is the basis for recommending the introduction into production of Parvoz 1, Parvoz 2 breeds and the Line 500, Line 501 lines as fast-growing productive breeds.

We will analyze new hybrid combinations in the same way we analyzed breeds and lines. Therefore, the three-year indicators of the larval period and selection traits of new hybrids in two different combinations and domestic as well as foreign comparative hybrids are presented in Table 2.

Table 2: Duration of the larval period and leading biological indicators of industrial hybrids 2021-2023, spring.

Hybrids	Years	Duration of larval period, day	Eggs hatching, %	Viability of larvae, %	Morbidity, %	Cocoon weight, g	Percent cocoon shell, %
Uzbekistan 5	2021	24,3	91,6	94,8	2,4	2,37	22,9
	2022	24,0	79,0	90,8	2,6	2,16	20,9
	2023	23,0	69,0	90,1	3,6	2,55	21,0
Foreign hybrid	2021	23,0	98,0	94,4	2,3	1,63	22,4
	2022	23,0	99,3	96,4	1,65	1,67	21,0
	2023	23,0	98,7	95,6	1,67	1,76	22,0
Parvoz-1 x Foreign	2021	-	-	-	-	-	-
	2022	25,0	88,7	95,7	0,44	1,92	21,7
	2023	23,0	95,3	92,3	3,9	2,04	21,8
Parvoz-2 x Foreign	2021	-	-	-	-	-	-
	2022	25,0	86,3	92,5	4,1	1,86	22,3
	2023	23,0	92,0	91,7	5,06	2,04	21,5

Based on the analysis of the hybrids presented in Table 2, we consider that it is worth special noting that the imported industrial hybrid had a stable 23-day larval period for three years. This situation certainly indicates that there was continuous selection of the paternal and maternal components of this hybrid. The indicators of the larval period of our new obtained hybrids Parvoz 1 x Foreign and Parvoz 2 x Foreign are not bad; as of 2023, these hybrids, like Chinese hybrids, begin to mount cocoons on the 23rd day, and this is considered the result of selection work.

The data in this table also includes egg hatchability and larval viability. It can be seen that the new hybrid combinations Parvoz 1 x Foreign and Parvoz 2 x Foreign do not have very high egg hatchability and larval viability and demonstrate contradictory results over three years. But it should be noted that in 2023, when the larval period of both hybrids was 23 days, the egg hatchability was 95.3% and 92.0%. And the larval viability over these two years ranged from 91.7 to 95.7%.

If we focus attention on the analysis of productivity indicators of cocoons and the larval period, it was difficult

to develop a clear pattern of how long the larval period lasts and, accordingly, the change in cocoon mass. Because the Foreign hybrid, which lived the shortest of all, i.e. quickly grew, developed and mounted cocoons, had relatively good larval viability, but at the same time their cocoon mass was significantly lower (1.63-1.76 g). On the contrary, along with the shortening of the larval period of our new local hybrids, the larval viability slightly decreased, but the cocoon mass increased (1.86-2.04 g).

Conclusions

The larval stage of the silkworm has not been deeply studied in comparison with other breeding or economic traits. There is almost no information about the nature of heredity of this trait and the extent to which it is related to other traits. There are certain reasons for this: temperature and relative humidity play a direct role in making the larval period short or long. Based on this, optimal temperature and humidity conditions were identically created for the selection material in this study, differences were observed in the duration of the larval period in the population of 6 species of local

breeds, two species of foreign breeds, as well as four species of new selection lines. This means that the duration of larval period is a genetic trait transmitted from generation to generation, and this trait is realized differently in different genotypes. In addition, as a result of three years selection, changes in this trait from generation to generation can become the scientific basis for creating breeds and hybrids that begin to mount cocoons quickly and in a short period of time. As a result of selection works on genotypes with the shortest larval period, a shortening of this period can be observed in almost all breeding material. This indicator remained stable at the same level only in large-cocoon breeds. However, annual selection in populations of new systems with high variability has shown the results. If we analyze the industrial hybrids F1, we have witnessed that the foreign hybrid that participated in the experiments had a stable larval period of 23 days for three years. The most important thing is that the eggs hatchability and the larval viability of this hybrid were higher every year than that of local hybrids. In our hybrid combinations, both the larval period and the larval viability showed different results each year. So what does this indicate? This situation indicates that the selection of foreign breeds and hybrids for the larval life cycle was carried out in parallel with other economic traits. When carrying out breeding work aimed at reducing the larval period, it is necessary to conduct complex selection work on traits associated with this trait.

Preliminary results show the need to reduce the larval period and increase the productivity and viability of cocoons while maintaining this trait when creating silkworm breeds and hybrids in Uzbekistan in the future.

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