

Larval viability in hybrids of mulberry silkworm strains marked by sex at the egg stage

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Abstract

This article presents research findings on the viability of larvae obtained from crosses between mulberry silkworm (*Bombyx mori* L.) strains that are marked by sex at the egg stage. The study demonstrates that hybrids produced from genetically modified sex-marked lines exhibit a pronounced heterosis effect in larval survival. Completely pure hybrid combinations show the highest levels of viability, which ultimately enhances cocoon yield and improves the overall efficiency of sericultural production systems.

Keywords: *Bombyx mori* L, sex-marked strains, pure hybrids, larval viability, heterosis, female, male

Introduction

Uzbekistan has achieved significant scientific achievements of global importance in the field of sericulture. In particular, great progress has been made in cloning and genetic modification of the mulberry silkworm (*Bombyx mori* L.) [1-2]. Based on these achievements, this study aims to increase cocoon productivity by selecting specialized genetically modified breeds that allow for the production of completely pure hybrid offspring. In these strains, eggs can be separated into dark-colored female eggs and light-colored male eggs using special technical means, which allows the two sexes to be raised on different farms. As a result, batches of cocoons delivered to egg factories do not require gender sorting, and the hybrids obtained from them have 100% genetic purity.

The main goal of this study is to create highly heterozygous mulberry silkworm hybrids that can fully demonstrate their genetic potential due to the purity of hybrid egg production, while reducing the overall cost of egg production. The world collection of sexed mulberry silkworms at the Uzbek Sericulture Research Institute currently contains twelve sexes [3, 4]. Several of these breeds have been and are still used in breeding programs and to create hybrids for various practical purposes.

The use of sexed breeds in crossbreeding leads to the formation of completely pure hybrids. Hybrid eggs obtained from such breeds consistently exhibit strong heterosis in larval viability and silk production, while requiring minimal material and labor resources for their production. Therefore, hybrid eggs obtained from sexed breeds are very valuable, provide significant biological advantages, and bring direct economic benefits to egg factories [5].

Materials and Methods

The study was conducted at the Silkworm Breeding Laboratory of the Uzbek Sericulture Research Institute (NIISH) within the framework of the research project AL-4721035212, titled "Development of Pure High-Heterosis Hybrids of the Mulberry Silkworm Through the Use of Sex-

Marked Strains at the Egg Stage," during the period 2023–2025. After ranking the collection strains according to key biological characteristics, five strains carrying gene translocations W2W2, W3W3, and W5W5 onto the W sex chromosome were selected for investigation. These strains included S-5, S-10, S-12, S-13, and S-14. The selected strains differed in their egg-color-determining genes: strains S-5 and S-13 (W2W2) produced light yellow eggs, strain S-12 (W5W5) produced brown eggs, while strains S-10 and S-14 (W3W3) produced dark brown eggs. The larvae of all sex-marked strains were characterized by white coloration, with some showing distinctive masks or semicircular markings. The cocoons of these strains were white, exhibited fine to medium grain texture, and varied in shape, ranging from elongated and oval to forms with and without constrictions.

All experimental procedures involving sex-marked strains and their hybrid combinations were conducted in accordance with the "Fundamental Methodological Guidelines for Breeding Work with the Mulberry Silkworm" [6], with particular attention paid to the genetic characteristics of sex-marked lines. Hybridization was carried out between strains producing rounded cocoons and those producing elongated cocoons. As a result, the hybrid cocoons demonstrated an intermediate oval-elongated form, which is considered optimal for reeling efficiency on modern cocoon-reeling machinery.

Results

The hybrids obtained from sex-marked silkworm strains were reared over a three-year period (spring seasons of 2023, 2024, and 2025), with each hybrid combination tested in three replications of 200 larvae. The larval viability values are presented in Table 1. Throughout all three years of evaluation, the hybrids demonstrated consistently high survival rates, indicating the presence of a strong heterosis effect associated with sex-marked parental lines.

Table 1: Larval viability (%) of new hybrids over three years (Spring 2023–2025)

No.	Hybrid combination	Year	Viability (%)	
			average	% to Control
1	S-5 x S-12	2023	97,3	103,5
		2024	96,2	100,2
		2025	96,2	100,7
2	S-5 x S-13	2023	97,5	103,7
		2024	97,2	101,3
		2025	97,3	101,9
3	S-10 x S-12	2023	98,0	104,3
		2024	96,2	100,2
		2025	96,3	100,8
4	S-10 x S-13	2023	97,2	103,4
		2024	96,8	100,8
		2025	97,0	101,6
5	S-12 x S-5	2023	96,2	102,3
		2024	94,4	98,3
		2025	95,7	100,2
6	S-12 x S-10	2023	95,6	101,7
		2024	95,5	99,5
		2025	97,2	101,8
7	S-12 x S-14	2023	97,1	103,3
		2024	96,3	100,3
		2025	96,5	101,0
8	S-13 x S-5	2023	96,0	102,1
		2024	94,0	97,9
		2025	95,7	100,2
9	S-13 x S-10	2023	95,2	101,2
		2024	97,0	101,0
		2025	97,3	101,9
10	S-13 x S-14	2023	97,8	101,0
		2024	97,0	101,0
		2025	97,3	101,9
11	S-14 x S-12	2023	97,1	103,3
		2024	96,7	100,7
		2025	96,8	101,4
12	S-14 x S-13	2023	97,6	103,8
		2024	97,0	101,0
		2025	97,1	101,7
13	Ip-1 x Ip-2 (Control)	2023	94,0	100,0
		2024	96,0	100,0
		2025	95,5	100,0

Larval viability is one of the critical factors determining cocoon yield under industrial rearing conditions, as it directly influences the preservation of the larval population. A greater number of larvae capable of tolerating environmental fluctuations, disease challenges, and variable mulberry leaf quality ultimately results in increased silk output and a higher cocoon yield per box of eggs [7]. As seen in Table 1, nearly all hybrid combinations showed superiority over the control group across all years of testing, confirming the high heterotic response derived from sex-marked parental strains.

Even the lowest recorded viability—94.0% in the S-13 x S-5 hybrid—remains suitable for commercial-scale hybrid production. The best-performing hybrids in 2025 included S-5 x S-13 (97.3%), S-13 x S-10 (97.3%), and S-13 x S-14 (97.3%), making them the most promising candidates for industrial sericulture.

High larval viability in hybrids is an important biological advantage that directly contributes to increased cocoon yield; however, this trait is not the only benefit of the newly developed hybrid combinations. An equally significant advantage lies in the economic efficiency achieved by

eliminating the labor-intensive process of separating male and female cocoons based on weight differences. When hybrids with 100% genetic purity are used, the need for such sorting operations disappears entirely, resulting in substantial reductions in production costs. This makes the implementation of these pure hybrids not only biologically advantageous but also economically justified for large-scale sericulture enterprises.

Conclusions

Twelve hybrid combinations were developed using sex-marked mulberry silkworm strains. These hybrids currently demonstrate the following performance indicators: the number of normal eggs per laying ranges from 528 to 596, larval viability ranges from 95.7% to 97.3%, cocoon weight varies between 1.63 and 1.90 g, and cocoon shell ratio ranges from 22.9% to 24.2%.

All twelve hybrid combinations exhibited a clear heterosis effect in larval viability. Among them, the hybrids S-5 x S-13, S-13 x S-10, and S-13 x S-14 reached the highest viability value of 97.3%.

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