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# **The Use of Parthenogenetic Clones to Create Highly Heterogeneous Hybrids of the Silkworm (*Bombyx mori* L.)**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors EAL and BAM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BAM and UTD managed the analyses of the study. Author IBR managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Since the entire world's sericulture, to achieve maximum heterosis is based on the feeding of hybrids of only the first generation, therefore, operations for the preparation of pure hybrids are of particular importance. In Uzbekistan, the Sericulture Research Institute has developed new biotechnologies specifically to solve this problem, and genetically modified breeds and parthenogenetic clones have been created on their basis. The unfertilized eggs are thermally activated at  $t = 46^{\circ}\text{C}$  for 18 minutes, and the reducing division of meiosis in the germ cells of the silkworm is hampered. As a result, the eggs remain with a diploid set of chromosomes and develop as zygotes. Since silkworm females are heterogamous by sex chromosomes, only female parthenogenetic clones develop from thermally activated eggs. Clonal-breed hybrids, characterized by increased viability of caterpillars – 93,5-98,0% (in the control – 90,0%), the high cocoon shell ratio – 22,1-23,8% (in the control – 22,5%), increased egg-bearing capacity - 622-639 pcs (in the control - 630 pcs), metric number of thread - 3344-4065 units (in the control - 3321), the synchronicity of caterpillar development, uniformity of cocoons, ease of preparation. The

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technology of thermal activation of unfertilized silkworm eggs for parthenogenetic development is not particularly difficult, therefore clones can reproduce the required number of generations and in an unlimited number of individuals. The second component for hybridization can be males of almost any breed. Clones, due to their genetic constancy, do not need breeding and breeding selection, they do not need to be divided by gender, because they are represented by only one female sex, and have high combinational ability and amicable development.

*Keywords: Silkworm; breed; hybrid; parthenogenetic clone; heterosis; marked by sex; female; male; caterpillar; cocoon; eggs.*

## 1. INTRODUCTION

Sericulture is the first branch of animal husbandry that switched to the feeding of first-generation interbreed hybrids to use the effect of heterosis.

Heterosis is the property of first-generation hybrids to surpass the best of their parents in viability, fertility, and other characteristics.

An obstacle to obtaining the maximum effect from heterosis is the very technical solution for the production of pure  $F_1$  hybrids that are not polluted by parental forms. In order to prepare hybrid silkworm eggs, it is necessary to divide by sex before the departure of the butterflies, in order to then cross the females of one breed with the males of another. This is a technically difficult task and requires precise gender separation of a large amount of breeding material. The method currently used at eggs of silkworm enterprises to separate females from males by weight differences of cocoons is inaccurate and time-consuming. On average, the proportion of hybrid eggs is only 35-40%, and the remaining 60-65% are the second generation of the maternal form. Consequently, the advantages of hybridization in sericulture are used by no more than 30%.

The problem can be solved by genetic methods.

One of the methods is the use of parthenogenetic clones in hybridization.

Cloning in the silkworm is based on the artificial launch of this type of initial egg development, which would ensure full continuity of the natural characteristics of the parent to the offspring. Method of activation of unfertilized silkworm eggs to complete parthenogenetic development of the ameiotic type [1].

Its essence is as follows. The unfertilized silkworm eggs extracted from the abdomen of

females, as well as the newly laid fertilized ones, are at the metaphase stage of the first division of maturation. If at this stage the unfertilized eggs are immersed for 18 minutes in water heated to 46°C, then they can be forced to develop as fertilized. Heating in hot water destroys the spindle of the metaphase of the first reduction division of maturation. A new spindle in the egg arises after some time, but this is already the spindle of the second division of maturation, and in this case, the chromosomes undergo only equational division. There is no reduction in the number of chromosomes at all, and the original diploid set of chromosomes ( $28 \times 2 = 2n$ ) is preserved in the crushing nucleus, and then in the nuclei of all embryo cells. This is the so-called zygotic or amniotic parthenogenesis, in which the complex transformation of the genotype during the divisions of egg maturation (meiosis) is extremely simplified and reduced to the degree of simple equal-hereditary division, or mitosis. The eggs activated in this way develop normally, and only females appear from them, strictly repeating the genotype and all the features of the progenitor mother. Simple heating of unfertilized eggs in water allows you to get the necessary number of parthenogenetic butterflies, always some females.

Parthenoclones are used in science for different purposes. For example, the use of clones to study the nature of motor activity [2]. It is proved that traditional methods of breeding in combination with methods of cloning, obtaining polyploid forms and elimination of lethal are suitable for creating an open parthenozygotic population of silkworms optimal for solving problems of sericulture [3-6], it was also possible to prove the possibility of using parthenoclones in breeding and for hybridization [7-9]. As the mother breed for the preparation of hybrids, a female parthenoclone is used, consisting of females with strictly the same heredity. This gives the following advantages in the breeding and production of silkworm eggs.

1. F<sub>1</sub> hybrids obtained from crossing parthenoclone females with males of any breed differ from conventional hybrids in greater endurance and alignment in all respects.
2. The parent breed (parthenoclone), which is original for hybridization, does not need to be divided by sex, since it consists entirely of females.
3. Breeding work at all its stages completely disappears, since all parthenoclonal females are genetically the same.
4. The sorting of cocoons at eggs of silkworm plants completely disappears, due to their genetically determined structural uniformity.
5. In the case of hybridization of clones with sex-labeled breeds, hybrids are produced with 100% purity of preparation, and, this means, the maximum manifestation of heterosis in viability and yield of silk thread.
6. All individuals of parthenoclones at all stages of development of the silkworm are distinguished by synchronicity in development, which is of exceptional value in sericulture, where millions of caterpillars undergo simultaneous reproduction and it can be very difficult to achieve parallelism in the development of individuals of the same breed or hybrid.
7. Heat treatment of eggs to activate parthenogenetic development leads to partial disinfection of eggs from bacterial pathogens.

All this points to the real prerequisites for the creation and application of parthenogenetic ameiotic clones for the industrial hybridization of the silkworm. This is reflected in a number of scientific papers [10-13]. Silkworm egg production enterprises receive cocoons, from which only female butterflies will obviously fly out. The second component for hybrids can be males of almost any breed labeled by gender.

All economically valuable indicators of clones remain unchanged from generation to generation, therefore, only the component breeds should be improved by traditional breeding selection.

The use of new breeding methods accelerates the breeding process. One of these methods is the selection of silkworm individuals at the caterpillar and butterfly stages based on

motor activity. In a number of works [2,14,15] it was found that phenotypic polymorphism in motor activity has a genetic basis, and the mating rate of butterflies correlates with the viability of caterpillars and the weight of the cocoon. This means that selection based on motor activity can successfully replace or complement traditional methods of selective selection.

The purpose of this study is to create pure hybrids in a less laborious and more accurate way, namely, by crossing parthenogenetic female butterflies with male butterflies of labeled and unlabeled breeds.

## 2. MATERIALS AND METHODS

The research was carried out in the laboratory of "Genetics and breeding of the silkworm" of the Sericulture Research Institute in the period from 2020 to 2022. As material for the study, parthenogenetic clones and breeds contained in the world collection of the silkworm SRIS were used: 9PC, APC, S-14, Ya-120, MG [16].

9PC, APC – parthenogenetic clones, S-14, MG – genetically modified breeds with sexual dimorphism in the color of the serous shell of eggs in the breed (S-14 eggs of males-light, females-dark) in the color of the skin caterpillar covers (in the MG breed, females are patterned, males are white-capped), Ya-120 is a common breed.

Incubation and feeding of caterpillars of all lines and breeds were carried out in full accordance with the experimental feeding methodology approved for white-window breeds. In accordance with the same methodology, all data obtained as a result of egg storage and incubation, caterpillar feeding, and cocoon weighing were collected and statistically processed [17].

When feeding all the breeds and lines used in the project, the method of selection by motor activity was used [18-20].

According to the method of selection by motor activity, when working with breeds, the most mobile individuals are selected for feeding at the moment of the caterpillars' revival, and the most mobile and active males are selected at the moment of the butterflies' cocoons.

## 2.1 Reproduction of Parthenogenetic Clones

Reproduction of parthenogenetic clones was carried out according to the method of B. L. Astaurov [1].

The contents of the butterfly are squeezed out of the severed abdomen and the fingers squeeze under the stream of water through the seal sieve. The eggs, passing through the sieve, fall to the bottom of the exposed glass vessel.

1. The washed eggs are scattered in a thin layer on filter paper and stored at a temperature of 16-17°C for 10-12 hours.
2. The eggs are placed in a cotton bag tied so that hot water freely washes all the eggs. Heating is carried out in the water at a temperature of 46°C and lasts 18 minutes. Warmed eggs are immediately transferred for 5-6 minutes to water at room temperature (25°C)
3. Warmed and cooled eggs are scattered in a thin layer on filter paper and dried.
4. Dried eggs are transferred to a room with a temperature of 16-17°C and humidity of 90-95%, where they are stored for 3 days.
5. After this time, the eggs are transferred to a room with a temperature of 25°C and undergo the usual estivation.

After microanalysis, the eggs are poured into non-emulsified parchment bags and placed in a refrigerator for storage until the next feeding.

## 2.2 Breeding Work with the Component Breeds of S-14, MG, Ya-120 Clonal-breed Hybrids

The work with the breeds was carried out according to the "Basic methodological provisions of breeding work with silkworms" [17], which were amended taking into account the genetic characteristics of sex-labeled breeds and parthenoclonal.

Along with the traditional selection choice, the selection of the motor activity of individuals of the silkworm was used.

## 2.3 Creation of Clonal-breed Hybrids

Clonal-breed hybrids were created according to the following scheme:



Eggs of clonal-breed hybrids were incubated and the caterpillars were fed in 3 repetitions of 200 caterpillars each. In the process of feeding, the main reproductive, biological, and technological indicators were taken into account.

A total of 6 hybrid combinations have been created. Each hybrid is prepared in an amount of 60-100 clutches.

All quantitative results were subjected to biometric processing by the Plokhinsky N. A. method [21]. A parametric statistical criterion was used - the Student's t-criterion built on the basis of the parameters of this set of  $X$  and  $S^2x$  and representing the functions of these parameters, which was due to the need to calculate the sample characteristics of the average value and the indicators of variation. The compared samples were taken from normally distributed aggregates

## 3. RESULTS AND DISCUSSION

In 2020, 2021, and 2022, the eggs of the APC and 9PC clones were incubated and the caterpillars were fed in 8 repetitions of 220 caterpillars each. Their biological parameters are shown in Table 1.

As can be seen from Table 1, parthenoclonal are medium to window and rocks - the weight of the cocoon varies by years, from 1,27g and 1,56g, and the weight of the shell from 228mg to 326mg. The viability of the caterpillars is quite high (83,0-96,0) and is at the control level - 90,0%, and the viability of the APC - 92,0-96,0% exceeds the control. The content of raw silk of cocoons of 18,0% - 21,3% is characteristic of female silkworms, and clones, as is known, are represented by only one sex - female, so the content of raw silk of the control - 22,0% of the bisexual breed is slightly higher.

The data in Table 1 also indicate that the variations in biological traits are small, which confirms the homogeneity of parthenogenetic clones. Constancy (a remarkable property in a complete nature) is an obstacle to the selection, since, starting from the first parthenogenetic generation, genotypic variability and, at the same time, the possibility of selection are excluded. In our work, the improvement of basic biological indicators can only occur due to strict compliance with the necessary hygrothermal conditions and improvement of feed quality.

**Table 1. Biological indicators of parthenogenetic clones**

Lines	Years	Viability of caterpillars		Cocoon weight		Shell weight		Content of raw silk	
		X, %	C <sub>v</sub>	X, g	C <sub>v</sub>	X, mg	C <sub>v</sub>	X, %	C <sub>v</sub>
APC	2020	95,3±3,3	9,8	1,53±0,06	3,5	325±9,1	6,2	21,2±0,8	3,2
	2021	96,0±3,0	7,0	1,56±0,03	3,2	326±7,0	5,0	21,0±0,3	3,2
	2022	92,0±2,9	8,8	1,44±0,06	4,0	274±6,1	4,5	19,0±0,4	3,0
9PC	2020	83,0±2,4	9,0	1,27±0,03	4,8	228±8,2	5,9	18,0±0,3	8,4
	2021	94,1±1,2	6,9	1,50±0,03	3,5	320±6,9	5,2	21,3±0,3	4,0
	2022	89,1±2,0	8,1	1,50±0,03	4,0	282±7,2	5,0	19,9±0,3	5,3
Ipakchi-1 (control)	average	90,0±7,1	12,0	1,80±0,04	6,7	396±9,5	8,0	22,0±0,9	7,5

### 3.1 Breeding of Silkworm Lines with Improved Viability of Caterpillars and Silkworm Cocoons from Component Rocks MG, Ya-120, S-14 Clonal-breed Hybrids

To create new breeding, and improved the viability of caterpillars and silkworm cocoons, lines of component breeds of clonal-breed hybrids, from the "Catalog" [16] of the silkworm of the SRIS, the breeds S-14 (labeled by sex at the egg stage MG, (labeled by sex at the caterpillar stage) Ya-120 (unlabeled).

In 2020, 2021, and 2022, silkworm eggs of these breeds were incubated and the caterpillars were fed in 8 repetitions of 220 caterpillars each. Selection is carried out annually according to the viability of caterpillars and the content of raw silk cocoons, their biological indicators are given in Table 2.

Table 2 clearly shows that the reproductive indicators of the studied breeds have changed for the better under the influence of selection, and are at the level of control. For example, the number of normal eggs in the clutch of the Ya-120 breed is from 623 pieces in 2020 to 735 pieces in 2022. The mass of normal eggs in the clutch increased in the S-14 breed from 266mg in 2020 to 318mg in 2022. Over the three years of selection, egg recovery has improved in all breeds. Thus, in the S-14 breed, in 2020 the percentage of egg revitalization was 92.4%, in 2022 95.7%, in the Ya-120 breed in 2020 – 97.1%, in 2022 98.1%. However, despite the fact that the reproductive properties have improved in almost all indicators over the three years of selection, relatively high coefficients of variation in the number of eggs in the clutch, in the mass of normal eggs, and in the renewal of eggs give grounds for continuing work to stabilize reproductive traits.

**Table 2. Reproductive indicators and egg vivacity of the studied breeds by year**

No	Breeds	Years	Number of eggs in a clutch, pcs		The mass of normal egg, g		Mass of 1 egg, mg		Egg revival, %	
			$\bar{X} \pm S^2x$	C <sub>v</sub>	$\bar{X} \pm S^2x$	C <sub>v</sub>	$\bar{X} \pm S^2x$	C <sub>v</sub>	$\bar{X} \pm S^2x$	C <sub>v</sub>
1	MG	2020	626±9,0	18,2	310±7,9	13,3	0,500±0,003	5,4	96,9±0,5	3,3
		2021	594±7,6	13,3	309±3,5	11,8	0,520±0,003	5,9	96,4±0,4	2,8
		2022	745±4,5	10,2	385±2,9	10,8	0,517±0,003	5,0	97,7±0,4	2,0
2	Ya-120	2020	623±6,5	10,0	322±8,0	11,3	0,517±0,002	3,7	97,1±0,4	3,2
		2021	541±8,7	15,2	278±4,7	15,2	0,573±0,003	6,5	94,8±0,7	4,2
		2022	735±5,7	9,5	390±3,4	9,0	0,531±0,003	6,7	98,1±0,3	3,0
3	S-14	2020	529±6,7	16,7	266±4,0	2,4	0,503±0,003	4,6	92,4±0,4	4,1
		2021	356±7,1	22,6	186±3,8	23,2	0,522±0,005	5,3	85,9±0,9	3,9
		2022	574±5,7	13,7	318±3,0	13,7	0,556±0,004	4,3	95,70,7	3,0
4	Ipakchi1 (control)	average	630±7,0	14,1	32,0±4,6	13,0	0,508±0,004	4,2	98,0±0,7	4,0

**Table 3. Biological parameters and coefficients of variation of the studied breeds**

No	Lines	Years	Viability of caterpillars, %		Cocoon weight, g		Shell weight, mg		Content of raw silk, %	
			$\bar{X} \pm S^2x$	$C_v$	$\bar{X} \pm S^2x$	$C_v$	$\bar{X} \pm S^2x$	$C_v$	$\bar{X} \pm S^2x$	$C_v$
1	MG	2020	90,0±2,5	13,0	1,57±0,02	5,5	362±0,7	6,9	23,2±0,3	6,9
		2021	95,0±0,8	3,4	1,93±0,02	5,3	431±4,9	4,8	22,3±0,2	5,0
		2022	90,7±2,7	9,6	1,40±0,02	6,1	324±3,8	4,1	23,1±0,2	5,1
2	YA-120	2020	89,9±2,1	2,6	1,54±0,02	6,6	371±4,0	3,0	24,1±0,2	3,5
		2021	95,0±0,8	3,8	1,86±0,02	5,1	448±5,9	6,0	22,4±0,2	3,7
		2022	92,3±1,1	3,0	1,48±0,02	6,9	351±3,7	3,8	23,7±0,2	3,3
3	S-14	2020	84,2±3,0	15,2	1,26±0,02	6,6	3073,5	3,3	24,4±0,2	4,1
		2021	93,3±1,0	4,9	1,67±0,02	5,1	387±6,0	6,9	23,2±0,2	4,5
		2022	90,0±2,5	9,0	1,30±0,02	6,8	319±5,3	6,1	24,5±0,2	4,0
4	Ipakchi1 (control)	average	96,0±7,1	12,0	1,80±0,014	6,7	396±9,5	8,0	22,0±0,9	7,5

As can be seen from Table 3, the viability of the caterpillars taken into the work of the breeds remained quite high for three years and ranged from 84,2% to 95,0% and was at the control level – 90,0%. It should be noted that the viability of the caterpillars of the sex-labeled rocks S-14 (84,2%-93,3%), MG (90,0-95,0%) was at the level of viability of the unlabeled rock Ya-120 (89,9-95,0%). Sex-labeled breeds differ from the usual ones by the presence of chromosomal rearrangement in their genomes. Therefore, these breeds react more sensitively to any changes in the conditions of detention. As is known [10,11] under good experimental conditions, the biological characteristics of sex-labeled rocks are at the same level as that of normal material, but in unstable conditions, the material with genetic changes behaves somewhat worse. The spread of the coefficients of variation in the viability of caterpillars from 3,4 to 15,2 of the sex-labeled breeds indicates a large variability of such an indicator as the

viability of caterpillars and indicates the possibility of further selection on this basis. The coefficients of variation in the viability of the unlabeled breed Ya-120 are significantly lower – from 2,6 to 3,8. This indicates the stability and balance of its genome on this trait.

The coefficients of variation of biological characteristics of the studied breeds in 2020 and 2022 were low (Table 3). This indicates that the annual rigorous selection aimed at improving the main economic and valuable indicators has led to the consolidation and stabilization of the biological characteristics of breeds.

### 3.2 Creation of Clonal-breed Hybrids

In 2020, 2021, 2022, all hybrids were fed with mixtures in three repetitions of 200 caterpillars each. Clutches with the best reproductive indicators were selected for feeding (Table 4).

**Table 4. Reproductive indicators of the studied hybrids**

No	Breeds	Years	Number of normal eggs in, pcs	The mass of normal egg, mg	The mass of 1 egg, mg
1	APC x MG	2020	565	-	-
		2021	589	287	0,488
		2022	626	302	0,483
2	APC x Ya-120	2020	594	-	-
		2021	595	257	0,472
		2022	639	323	0,506
3	APC x S-14	2020	582	-	-
		2021	589	290	0,493
		2022	637	308	0,483
4	9PC x MG	2020	577	-	-
		2021	566	253	0,473
		2022	634	320	0,505

No	Breeds	Years	Number of normal eggs in, pcs	The mass of normal egg, mg	The mass of 1 egg, mg
5	9PC x Ya-120	2020	540	-	-
		2021	500	231	0,472
		2022	637	319	0,501
6	9PC x S-14	2020	572	-	-
		2021	570	221	0,470
		2022	622	304	0,488
7	Ipakchi1 x Ipakchi2 (control)	average	630	320	0,508

Table 4 demonstrates that the hybrids of APC x S-14, APC x Ya-120, APC x MG were the best in terms of reproductive parameters during the 3 years of research. Interestingly, the components of 2 of these hybrids are sex-labeled S-14 and MG breeds with changes in genomes.

For clarity, data on the number of normal eggs in the clutches of hybrids before and after selection are shown in Fig. 1

Fig. 1, clearly shows that, how the number of eggs in the clutches of clonal-breed hybrids has changed after 3 years of selection. The best hybrids in the number of normal eggs in the clutch were APC x Ya-120 (639 pcs), APC x S-14 (637 pcs), 9PC x Ya-120 (637 pcs). The increase in the number of eggs in the clutches of hybrids

occurred in accordance with the increase in the number of eggs in the clutches of breeds (Table 3).

As can be seen from the Table 5, over all the years of the study, the viability was quite high (from 87.2 to 98.0%). The caterpillars developed well, smoothly, molted together and quickly ascended to the cocoons. This behavior is typical for caterpillars of clonal-breed hybrids and it is very valuable in practical sericulture.

At first glance, the indicators do not seem very high. However, it is necessary to keep in mind other advantages of clonal-breed hybrids, which were indicated in the "Introduction", and above all – the purity of preparation.

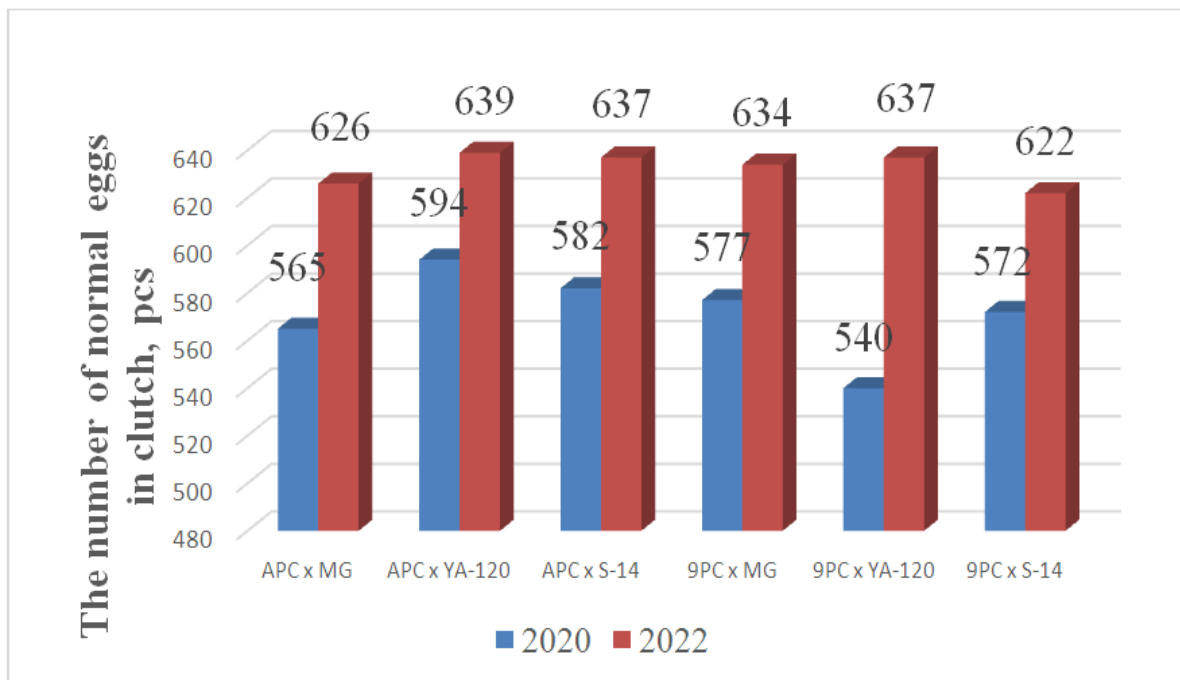


Fig. 1. The number of normal eggs in the clutches of hybrids before and after selection

**Table 5. Biological indicators of clonal-breed hybrids by the years**

No.	Hybrids	Year	Viability of caterpillars, %	Average weight		Content of raw silk, %
				cocoon, g	shell, mg	
1	APC × MG	2020	87,2	1,67	379	22,4
		2021	96,6	1,87	424	22,8
		2022	98,0	1,45	322	22,3
2	APC × Ya-120	2020	95,0	1,63	358	22,0
		2021	94,8	1,69	408	21,6
		2022	93,5	1,44	318	22,1
3	APC × S-14	2020	95,7	1,62	385	23,8
		2021	94,0	1,85	407	22,2
		2022	94,5	1,65	369	22,3
4	9PC × MG	2020	94,3	1,54	341	22,1
		2021	97,2	1,91	421	22,0
		2022	93,7	1,73	370	21,7
5	9PC × Ya-120	2020	93,7	1,65	369	21,4
		2021	97,1	1,96	418	21,3
		2022	93,7	1,65	382	23,2
6	9PC × S-14	2020	94,0	1,60	373	23,3
		2021	95,5	1,84	394	21,6
		2022	97,3	1,65	363	22,4
7	Ipakchi1×Ipakchi2 (control)	average	90,0	1,85	416	22,5



**Table 6. Technological indicators of clonal-breed hybrids**

No	Hybrids	Year	The mass of 1 dry cocoon, g	Output, %		Metric number of thread	* NBFL, m	The total length of the thread, m
				Raw silk	Silk products			
1	APC × MG	2019	0,689	46,96	50,90	3880	648	654
		2020	0,702	44,93	48,79	3448	1067	1067
		2021	0,686	41,74	47,01	3436	942	1042
2	APC × Ya-120	2019	0,742	41,88	47,68	3636	908	1108
		2020	0,918	44,07	47,84	3333	800	1300
		2021	0,569	44,30	49,07	4065	883	1133
3	APC × C-14	2019	0,610	47,33	50,10	3448	1050	1275
		2020	0,867	46,21	48,22	2994	1058	1158
		2021	0,629	42,92	48,11	3906	725	1183
4	9PC × MG	2019	0,682	45,26	50,01	3649	858	1275
		2020	0,802	41,72	46,31	3300	775	1150
		2021	0,713	44,10	49,22	3356	867	1108
5	9PC × Ya-120	2019	0,754	44,19	47,84	3558	1100	1150
		2020	0,772	42,66	48,50	3257	833	1150
		2021	0,708	41,12	47,50	3344	717	1150
6	9PC × S-14	2019	0,700	42,48	46,62	3650	1108	1183
		2020	0,835	44,56	49,31	2958	1083	1108
		2021	0,708	45,56	50,36	3704	1008	1175
7	Ipakchi1×Ipakchi2 (control)	average	0,706	43,09	48,05	3321	1000	1150

Note : Non-breakable filament length

The best in biological indicators were hybrids: APC × C-14, APC × MG, and 9PC × S-14. It is noteworthy that one of the components of the noted hybrids is the sex-labeled S-14 and MG breeds.

Technological indicators of clonal-breed hybrids were also collected.

The data in the Table 6 indicate that clonal-breed hybrids are characterized by good technological properties. Attention is drawn to the high metric numbers of hybrids APC × MG – 3333-4065 units, 9PC × Ya-120 – 2958-3704 units, the long thread length of APC × Ya-120 – 1108-1300m, APC × C-14– 1158-1275m. Such high technological indicators once again testify to the benefits of introducing clonal-breed hybrids into the industrial sericulture.

Separate studies on the use of silkworm parthenoclones were conducted in Ukraine a few years ago [22-25], and clones obtained by the so-called "surgical" way are produced in many countries of the world [26]. But only so far in Uzbekistan, for the first time, clonal-breed hybrids of the silkworm are beginning to be introduced into industrial sericulture.

#### 4. CONCLUSION

Based on the conducted research, the following conclusions can be drawn:

1. Reproduction of parthenoclones for three years proved the genetic stability of clones in all indicators – the coefficients of variation do not exceed 9.8 units.
2. The use of traditional selection for three years at all stages of development of the silkworm (egg, caterpillar, cocoon, butterfly) led to a change in the indicators of breeds-components S-14, MG, Ya-120 clonal-breed hybrids for the better.
3. The indicators of clonal-breeds of hybrids changed in accordance with changes in the indicators of the component breeds, the egg content in the clutch increased in all hybrids and reached a maximum in the hybrid APC×S-14 (637 pcs), the viability of caterpillars improved in hybrids, the highest indicator in the hybrid APC×MG (98,0%), content of raw silk of hybrids ranges from 21,7 to 23,2%.
4. The economic efficiency of the introduction of clonal-breed hybrids consists in facilitating breeding work, in the possibility of creating 100% pure hybrids, in

simplifying the sorting of cocoons upon admission.

5. The clonal-breeds of hybrids, unlike domestic and foreign analogs, for the first time in the history of sericulture can be introduced into industrial production.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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