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**INBREEDING DEPRESSION OF SIMMENTAL CATTLE IN THE SYSTEM OF
GENETIC AND ENVIRONMENTAL FACTORS ASSESSMENT**

**ИНБРЕДНАЯ ДЕПРЕССИЯ СИММЕНТАЛЬСКОГО СКОТА
В СИСТЕМЕ ОЦЕНКИ ГЕНЕТИЧЕСКИХ И СРЕДОВЫХ ФАКТОРОВ**

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The article is devoted to the problems of inbreeding depression minimization in a herd of Simmental cattle. The author analyses the data received during the experimental research of the evaluation of the intensity of Simmental calves growth using different degrees of inbreeding, including in-and-inbreeding, bottom crossing, top-cross inbreeding, in-breed-line-crossing. The results of the experiment showed that at bottom crossing, top-cross inbreeding, in-breed-line-crossing the influence of genetic factors on live weight from birth to 6 months in bulls increases to 73.7-75.8%, also in 7, 8, 9 and 10 months heifers with $F_x=25.0\%$ left behind heifers with $F_x=0.781\%$ and 24.8, 31.0, 41.7 and 43.2 kg, respectively ($p<0.1-0.05$). Mating of inbred cows with outbreed bulls and outbreed cows with inbred bulls does not give the unambiguous results, however it can be assumed that the method of bottom-crossing can be applied to the large stud bulls only, while top-breeding and top-cross breeding can avoid serious consequences only in mating cases when a cow has a high live weight. The genetic variability of live weight from the generation to 6 months was above heifers – from 1.588 to 16.428 kg; environmental variability was above in bull calves from the second month of cultivation (from 2.106 to 4.915 kg). This can be the proof of the fact that the inbred bull calves needed the intensive feeding.

Key words: genetic factors, in-and-inbreeding, bottom crossing, top-cross inbreeding, in-breed-line-crossing, inbreeding depression, Simmental cattle.

В работе рассмотрены проблемы снижения инбредной депрессии на примере тёлочек и бычков симментальской породы. Были проанализированы данные, полученные в ходе исследований интенсивности роста при использовании различных степеней инбридинга, в том числе ин-энд-инбридинга, боттомкроссинга, топкроссбридинга, инбредлайнкроссинга. Результаты исследований позволили утверждать, что при боттомкроссинге и топкроссбридинге влияние наследственных факторов на живую массу у бычков от рождения до 6 месяцев увеличивалось до 73,7-75,8%, а тёлки со степенью инбридинга $F_x=25,0\%$ в 7, 8, 9 и 10 месяцев превосходили тёлочек с $F_x=0,781\%$ на 24,8, 31,0, 41,7 и 43,2 кг соответственно ($p<0,1-0,05$). Спаривание инбредных коров с аутбредными быками и наоборот не дало убедительных однозначных результатов, однако было сделано предположение, что степень боттомкроссинга может быть применима только на лучших крупных быков-производителей, а при топбридинге и топкроссбридинге избежать негативных прогнозов можно лишь в случаях подбора родительских пар, когда высокую живую массу имеют тёлки и/или коровы. У тёлочек от рождения до 6 месяцев генетическая изменчивость живой массы была выше – от 1,588 до 16,428 кг; у выращиваемых бычков была выше паратипическая изменчивость – со второго месяца (от 2,106 до 4,915 кг). Это может быть доказательством необходимости улучшенного кормления и содержания для бычков.

Ключевые слова: генетические факторы, ин-энд-инбридинг, топ-кросс-инбридинг, боттомкроссинг, инбредлайнкроссинг, инбредная депрессия, симментальская порода.

Introduction. As opposed to domestic breeding, the use of genetic parameters is accepted in the world practice and many scientists write about it [1, 2, 4, 7, 9-11]. At the same time an integral part of research in the analysis of genetic parameters in the foreign works is the study of the problems of inbreeding [3, 5, 8, 14]. These and other aspects of

genetic selection of cattle disclose the article quoted in the list of references [6, 12-13]. Due to the active use of artificial insemination this question is relevant in many countries.

The purpose of research: to study the importance of genetic and environmental factors in minimizing inbreeding depression on live weight of Simmental cattle.

Methods and research materials. To solve the problems of minimization of inbreeding depression we carried out a research in the farm "Fatnevo", Bolhov area of the Orel region. For improving of Simmental herd in this sector Simmental and Red-and-White Holstein bulls of JSC "Orel" for stock breeding have been mainly used in recent years. In the study of the heifers growth intensity the control group was presented by animals obtained by method of close inbreeding, in the study of the growth rate of calves the control group was presented by animals obtained by in-and-inbreeding (i.e. in a few generations) and complex inbreeding. The animals were of the same age. The coefficient of inbreeding was calculated as Wright. The statistical analysis was carried out in the computer program "Microsoft Excel".

Results and discussion. The previously conducted research has shown that in the inbred population of Simmental and Red-and-White Simmental-Holstein cattle of farm "Fatnevo" the greatest live weight at birth had heifers obtained by close inbreeding (32.5 kg), but heifers (n=30) obtained by the top-cross inbreeding (i.e. using inbred fathers raising IV-IV and V-V), also gave higher live weight – 31.2 kg (table 1). By the end of the first month of growing the greatest live weight had heifers obtained by close inbreeding and distant inbreeding: live weight from 1 to 12 months increased from 57.0 and 53.5 to 268.0 and 266.0 kg, respectively. And by 7, 8, 9 and 10 months heifers with $F_x=25.0\%$ left behind heifers with $F_x=0.781\%$ and 24.8, 31.0, 41.7 and 43.2 kg, respectively ($p<0.1-0.05$).

Table 1 – The live weight of Simmental heifers from the birth to 12 months in the inbred groups on farm of "Fatnevo"

Forms of inbreeding	n	Parameters	Live weight on the months, kg												
			Birth weight	1 month	2 month	3 month	4 month	5 month	6 month	7 month	8 month	9 month	10 month	11 month	12 month
close inbreeding $F_x=25.0\%$	2	M	32,5	57,0	84,5	108,0	125,0	133,0	149,0	172,0	196,5	224,5	241,0	253,5	268,0
		$\pm m$	0,5	5,0	8,5	12,1	14,0	11,1	14,0	18,1	16,5	8,51	9,0	11,6	12,1
		$C_v, \%$	2,1	12,4	14,2	15,7	15,8	11,7	13,3	14,8	11,9	5,3	5,2	6,4	6,3
in-and-inbreeding	8	M	28,2	45,1	64,2	86,0	98,1	110,4	124,4	138,1	150,6	167,7	190,0	205,6	221,6
		$\pm m$	0,2	2,1	3,3	4,1	2,5	2,1	3,6	2,9	2,8	4,1	4,7	4,3	4,4
		$C_v, \%$	2,5	13,3	14,6	13,4	7,1	5,3	8,1	5,9	5,2	6,9	7,0	5,9	5,6
distant inbreeding (III-IV и IV-IV)	6	M	28,8	53,5	77,8	96,2	112,3	124,5	139,2	147,2	165,5	182,8	197,8	215,8	266,0
		$\pm m$	0,3	2,7	4,9	2,5	5,0	7,3	10,6	10,4	10,0	9,8	10,4	10,1	10,2
		$C_v, \%$	2,8	12,5	15,6	6,3	10,9	14,4	18,6	17,2	14,8	13,1	12,9	11,5	9,4
bottom crossing	35	M	29,9	50,9	70,0	86,6	100,9	111,4	121,5	132,4	147,0	162,2	178,3	194,7	211,5
		$\pm m$	0,3	1,0	1,8	2,2	2,8	3,3	4,0	4,8	5,3	5,4	5,5	5,6	5,7
		$C_v, \%$	5,2	12,0	15,3	14,8	16,4	17,5	19,6	21,5	21,2	19,6	18,1	16,9	15,9
top-cross inbreeding	30	M	31,2	51,2	71,8	89,7	101,9	113,9	125,7	139,2	155,1	174,0	190,6	205,4	221,0
		$\pm m$	0,4	1,0	1,6	1,6	1,9	2,3	3,1	4,0	4,4	5,0	6,0	6,4	6,5
		$C_v, \%$	7,7	10,4	12,0	10,0	10,1	11,2	13,5	15,9	15,4	15,9	17,2	17,1	16,2
in-breed-line-crossing and in-cross-breeding	6	M	29,2	47,2	68,0	88,8	102,7	107,3	111,3	117,7	130,8	152,5	173,8	190,8	217,0
		$\pm m$	0,4	1,9	2,7	2,3	2,6	4,3	6,7	9,4	13,0	15,6	14,4	13,6	13,7
		$C_v, \%$	3,3	9,9	9,6	6,4	5,9	9,8	14,8	19,5	24,4	25,1	20,4	17,4	15,5
All inbred group in herd	87	M	30,1	50,4	70,7	88,9	102,4	113,2	124,1	135,9	151,2	168,8	185,8	201,4	218,7
		$\pm m$	0,2	0,7	1,1	1,2	1,4	1,7	2,2	2,7	3,0	3,2	3,4	3,5	3,6
		$C_v, \%$	6,6	12,2	14,3	12,5	13,2	14,1	16,7	18,4	18,4	17,8	17,1	16,0	15,3

Afterwards, the animals of these groups were able to put on live weight by 18-month necessary for normal fertilization, and heifers obtained by bottom crossing (i.e. by fertilization of inbred mothers with semen of outbreed bulls) at 12 months gave the worst index – total 211.5 ± 5.7 kg, which gave way to heifers with $F_x=25.0\%$ 56.5 kg ($p<0.001$).

Among inbred herds of bull calves the group obtained by top-cross inbreeding ($n=28$) – 29.9 ± 0.2 kg was different at birth (table 2), although there was no significant difference in all groups. From 2 to 4 months animals obtained by mating inbred mothers and outbreed fathers (the increase was from 48.3 to 86.6 kg) forged over growth rate in the herd, but by 5 and 6 months the group obtained from the use of inbred fathers semen – 99.1 ± 2.5 and 113.6 ± 3.0 kg showed the greatest live weight again, which exceeded the animals in the control group at 13.2 and 18.3 kg, respectively ($p<0.001$). The live weight variation in the groups and months was not stable and may be evidence of a strong dependence of the individual inbred bulls on feeding and keeping.

Table 2 – The live weight of Simmental bull calves from the birth to 5 months in the inbred groups on farm of "Fatnevo"

Forms of inbreeding	n	Parameters	Live weight on the months, kg					
			Birth weight	1 month	2 month	3 month	4 month	5 month
in-and-inbreeding	8	M	29,7	45,1	61,5	80,2	85,9	95,3
		$\pm m$	0,1	1,8	3,1	3,7	1,5	2,7
		σ	0,43	5,08	8,79	10,53	4,15	7,67
		$C_v, \%$	1,45	11,27	14,29	13,12	4,84	8,05
distant inbreeding (III-IV и IV-IV)	7	M	29,4	45,9	64,4	84,9	96,0	103,9
		$\pm m$	0,49	4,15	6,65	7,10	7,89	9,93
		σ	0,2	1,6	2,5	2,7	3,0	3,7
		$C_v, \%$	1,68	9,06	10,32	8,37	8,22	9,56
bottom crossing	19	M	29,5	48,3	67,4	86,6	96,1	105,6
		$\pm m$	0,2	1,1	2,1	3,0	2,4	3,3
		σ	1,09	4,75	9,37	13,01	10,57	14,33
		$C_v, \%$	3,71	9,85	13,90	15,01	11,00	13,56
top-cross inbreeding	28	M	29,9	48,1	66,7	84,5	99,1	113,6
		$\pm m$	0,2	0,8	1,4	1,9	2,5	3,0
		σ	1,13	4,05	7,27	10,13	13,02	15,80
		$C_v, \%$	3,78	8,43	10,90	11,99	13,14	13,91
in-breed-line-crossing and in-cross-breeding	10	M	29,3	46,2	62,9	83,2	96,3	104,8
		$\pm m$	0,1	1,2	2,4	2,4	3,5	4,7
		σ	0,46	3,87	7,46	7,64	11,10	14,99
		$C_v, \%$	1,56	8,37	11,86	9,18	11,53	14,31
All inbred group in herd	72	M	29,6	47,3	65,6	84,5	96,2	107,5
		$\pm m$	0,1	0,5	1,0	1,2	1,4	1,8
		σ	0,97	4,51	8,29	10,65	11,69	15,28
		$C_v, \%$	3,28	9,53	12,64	12,61	12,15	14,22

However, the study of correlations between live weight of calves (table 3) has testified that the influence of genetic factors on the growth rate increases with the mating of inbred mothers and outbreed bulls and vice versa (73.7%). This may be confirmation of inbreeding depression reduction. In-breed-line-crossing and in-cross-breeding are also able to reduce inbreeding depression against live weight in bulls due to the complex forms of inheritance when mating animals of different breeds and lines.

Table 3 – Influence of genetic and environmental factors on the live weight of calves Simmental

Forms of inbreeding	n	Parameters	Correlations between live weight in different periods of breeding (at birth to 6 months)						Influence of genetic and environmental factors, %	
			at birth - 1 month	1 month - 2 month	2 month - 3 month	3 month - 4 month	4 month - 5 month	5 month - 6 month	$r_w \cdot 100$	$(1-r_w) \cdot 100$
			Bull calves							
in-and-inbreeding (control group)	8	r	0,695	0,953	0,888	-0,616	0,728	0,956	60,1	39,9
		$\pm m_r$	0,840	0,040	0,055	0,094	0,082	0,035		
distant inbreeding (III-IV и IV-IV)	7	r	0,099	0,886	0,915	0,734	0,789	0,924	72,5	27,5
		$\pm m_r$	0,119	0,055	0,048	0,081	0,073	0,046		
bottom crossing	19	r	0,166	0,930	0,967	0,862	0,894	0,936	73,7	26,3
		$\pm m_r$	0,102	0,044	0,030	0,061	0,054	0,042		
top-cross inbreeding	28	r	0,007	0,887	0,825	0,886	0,888	0,941	73,7	26,3
		$\pm m_r$	0,001	0,055	0,068	0,055	0,055	0,040		
in-breed-line-crossing and in-cross-breeding	10	r	0,248	0,992	0,811	0,634	0,917	0,947	75,8	24,2
		$\pm m_r$	0,116	0,015	0,070	0,092	0,048	0,039		
All inbred group in herd	72	r	0,025	0,924	0,883	0,828	0,885	0,945	74,8	25,2
		$\pm m_r$	0,120	0,046	0,056	0,067	0,056	0,039		
Heifers										
in-and-inbreeding (control group)	8	r	-0,142	0,979	0,959	0,915	0,869	0,907	74,8	25,2
		$\pm m_r$	0,107	0,022	0,030	0,044	0,053	0,046		
distant inbreeding (III-IV и IV-IV)	6	r	-0,099	0,981	0,794	0,838	0,955	0,981	74,2	25,8
		$\pm m_r$	0,107	0,021	0,066	0,06	0,032	0,021		
bottom crossing	34	r	0,201	0,908	0,876	0,868	0,933	0,950	78,9	21,1
		$\pm m_r$	0,106	0,040	0,055	0,055	0,053	0,030		
top-cross inbreeding	28	r	0,344	0,893	0,772	0,886	0,846	0,932	77,9	22,1
		$\pm m_r$	0,100	0,045	0,071	0,055	0,055	0,045		
in-breed-line-crossing and in-cross-breeding	6	r	-0,094	0,974	0,782	0,254	0,883	0,973	62,9	37,1
		$\pm m_r$	0,110	0,024	0,067	0,105	0,055	0,024		
All inbred group in herd	88	r	0,281	0,916	0,845	0,866	0,909	0,947	79,4	20,6
		$\pm m_r$	0,110	0,043	0,054	0,054	0,045	0,035		

The genetic variability of live weight from the generation to 6 months was above heifers – from 1.588 to 16.428 kg (table 4); however, environmental variability was above in bull calves from the second month of cultivation (from 2.106 to 4.915 kg). This can be the proof of the fact that the inbred bull calves needed the intensive feeding.

Table 4 – The genetic and environmental variability of the live weight in the inbred groups of Simmental young animals of "Fatnevo"

Inbred group in herd	n	Parameters	Variability of the live weight, kg						
			at birth	1 month	2 month	3 month	4 month	5 month	6 month
Bull calves	72	σ_G	0,726	3,373	6,201	7,966	8,744	11,429	15,332
		σ_e	0,246	1,145	2,106	2,705	2,969	3,881	4,915
		σ_P	0,972	4,518	8,307	10,671	11,713	15,31	20,247
Heifers	88	σ_G	1,588	4,875	8,019	8,829	10,743	12,688	16,428
		σ_e	0,412	1,265	2,081	2,291	2,787	3,292	4,262
		σ_P	2,001	6,140	10,100	11,120	13,531	15,981	20,690

Conclusions on the results. Summarizing the results of this study it should be noted that in the selection of Simmental cattle according to the growth rate the results depend to a greater degree not on inbreeding variants but on compatibility of the individual parental pairs. Inbreeding for several generations and complex inbreeding

remain highly undesirable, as when it appears inbreeding depression shows its maximum. Mating of inbred cows with outbred bulls and outbred cows with inbred bulls does not give the unambiguous results, however it can be assumed that the method of bottom crossing can be applied to the large stud bulls only, while top-breeding and top-cross breeding can avoid serious consequences only in mating cases when a cow has a high live weight. The uncontrolled use of inbred mating is unacceptable, though moderate congeniality when mating does not lead to a significant inbreeding depression in growth intensity of heifers and steers. The cases of incest in breeding of Simmental cattle are permitted only at the presence of the outstanding qualities of the paired parents. The bottom crossing and top-cross inbreeding, in-breed-line-crossing and in-cross-breeding allow strengthening the influence of genetic factors at a live weight of calves from birth to 6 months. In general, the conducted investigations enable to weaken the negative effects of inbreeding of dairy and beef cattle of Orel region.

In the system of the minimization of the inbred depression in Simmental herds by the live weight should be considered the sex of calf, the form of inbreeding, the environmental factors (i. e. to balance fodders for the heifers and bull calves separately) and the periods of cultivation. This will make it possible to strengthen the intensity of an increase in the live weight.

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