

*Izmailova A.*

*Chief Veterinary Officer, Veterinary Center "TOTEM",  
Russia, Khabarovsk*

**LETHAL AUTOSOMAL RECESSIVE JEB MUTATION IN DRAFT HORSE BREEDS OF  
RUSSIA AND THE USA: PATHOLOGICAL AND GENEALOGICAL ANALYSIS OF RISKS  
TO CLOSED POPULATION WELFARE AND THE BIOETHICS OF GENE POOL  
PRESERVATION**

**Keywords:** *Junctional Epidermolysis Bullosa, population welfare, animal welfare, gene pool conservation, Belgian Brabant, Soviet Draft Horse, American Cream Draft Horse*

**Abstract**

*The article examines the genetic and bioethical aspects of the lethal autosomal recessive mutation Junctional Epidermolysis Bullosa (JEB), observed in populations of draft horse breeds in Russia and the United States that historically share a common influence of European (Belgian) bloodlines. Based on a comparative analysis of the Soviet Draft Horse and the American Cream Draft Horse, the study explores the latent threat to the preservation of valuable breeding lines and the impact of JEB-associated alleles on the integrity of the breeding nucleus. It is noted that, under conditions of small population size and limited genetic diversity, the absence of a targeted program for systematic genetic testing and optimized breeding management in Russian horse breeding contributes to the deposition and genetic drift of abnormal alleles within the breed, whereas foreign breeding programs actively employ preventive genetic screening practices. The conducted study emphasizes the need to promote the principles of responsible breeding and to implement genetic monitoring tools as a priority component of effective breeding management — an approach of direct importance for the sustainable welfare of national breeds and alignment with international standards of animal welfare and bioethics.*

**INTRODUCTION: Junctional epidermolysis bullosa (JEB)**

**Related terms:** equine epitheliogenesis imperfecta, hereditary junctional mechanobullous disease, red foot disease, hairless foal syndrome; epitheliogenesis imperfecta neonatorum

**JEB** is a monogenic lethal genodermatosis characterized by the formation of subepidermal blisters and erosions resulting from structural insufficiency of the basement membrane of the skin and mucous membranes. The clinical presentation in newborn foals includes generalized blistering, multiple deep erosions of the mucous membranes and skin, degradation of the hoof horn, and a high susceptibility to severe secondary infections (Fig. 1). The prognosis for the classical form is unfavorable: the vast majority of foals die during the fetal–neonatal period or are euthanized on humane grounds within the first week of life [4].

Morphologically, junctional epidermolysis bullosa (JEB) in horses is characterized by dermoepidermal separation at the level of the lamina lucida due to defective adhesion involving laminin-332 (laminin-5), specifically its  $\gamma 2$  chain, and disrupted hemidesmosome formation. On the molecular level, JEB is caused by pathogenic mutations in genes encoding components of the basement membrane extracellular matrix, most notably LAMA3 and LAMC2. In certain draft breeds,

a frameshift insertion mutation in LAMC2 (c.1368insC) has been identified as causative, leading to the loss of functional  $\gamma 2$  subunit of laminin-332, a structural glycoprotein essential for anchoring filaments of the epithelial basement membrane. [13]



**Figure 1.** *Clinical features of junctional epidermolysis bullosa in affected foals. Extensive loss of skin on the lower limbs and joints is evident (A, B), accompanied by ulceration of the gingival mucosa (C) and sloughing of the hooves (D). Images reproduced from Milenkovic et al. (2003).*

The main challenge in identifying and eliminating the pathology within the affected population lies in the autosomal recessive inheritance pattern of the mutation, which results in characteristic asymptomatic carriage among heterozygous JEB individuals. According to OMIA, equine JEB is classified as LAMC2-related junctional epidermolysis bullosa, with OMIA ID: 001678–9796, and is included in the list of confirmed monogenic disorders diagnosed in draft horse breeds. [14,11]

Diagnosis involves clinico-pathological verification (biopsy with morphological and immunohistochemical assessment) and DNA typing through targeted PCR testing and sequencing of the LAMC2 fragment (and LAMA3 for Saddlebreds), enabling the screening of breeding animals and the implementation of monitoring programs in at-risk populations. [16]

#### Pathological and Genealogical Considerations

Junctional epidermolysis bullosa in foals was first described in Belgian draft horses and was subsequently identified in other European heavy draft breeds—French, Italian, and Romanian—historically influenced by the introduction of Belgian bloodlines. [13,10,7]

Similarly, despite the development of the American Cream Draft and the Russian Heavy Draft populations occurring on different continents, their evolutionary processes exhibit comparable genetic and chronological features.

In the United States, the origin of the American Cream Draft traces back to the mare Old Granny (1911), which conferred the breed's distinctive cream-colored phenotype, followed by line selection, with one of the leading sires being the half-blood Belgian stallion Silver Lace No. 9. The breed was officially recognized in 1950. [15]

In the USSR, systematic breeding efforts were undertaken to develop a massive, dry-muscled, and resilient Draft Horse. This was achieved by improving local utility horse types through absorption crossbreeding and subsequent inbreeding of the resulting hybrids. The program began with the intensified importation of Belgian Brabants in 1889 at the Khrenovsky Stud, then considered the leading facility of its time, with the breeding program later transferred to the Pochinkovsky State Stud. Several Belgian stallions—specifically Bozhe, Jasmine, Orizon-de-Bogerden, Cléron Remi, Emerald, and Emigrant—served as the progenitors of the main extant lines, significantly shaping the breed's future genetic profile. On 14 July 1952, the Soviet Draft Horse was officially recognized by the Ministry of Agriculture. [6]

In both cases, the influence of Belgian bloodlines contributed to the development of a large, well-proportioned exterior and a desirable conformation, while simultaneously introducing alleles associated with JEB — a pattern observed in the contemporary genetic monitoring of the American Cream Draft and traceable in the historical and genealogical records of Soviet Draft Horse breeding.

In other words, JEB represents a clinically and molecularly well-characterized hereditary disorder, the latent carriage of which in Draft Horse populations generates hidden population-level risks, ultimately leading to degradation and loss of the breeding core. A comparative analysis of the genetic pools of the Soviet Draft Horse and the American Cream Draft from a pathophysiological perspective has not been previously conducted, conferring substantial practical and prognostic value. This study enables an assessment of the likelihood of introgression of Belgian alleles and is aimed at formulating scientifically grounded preventive recommendations for veterinary-genetic management programs tasked with preserving this unique national breed.

**OBJECTIVE OF THE STUDY:** to conduct a comparative analysis of genetic risks associated with the lethal autosomal recessive mutation causing junctional epidermolysis bullosa (JEB) in the populations of the Soviet Draft Horse and the American Cream Draft; to assess the consequences of the presence of JEB-associated alleles for breeding management and population welfare; and to offer practical recommendations on genetic monitoring and breeding bioethics applicable to domestic conditions.

## **MATERIALS, METHODS, AND STUDY OBJECTS**

### Population and Sample Description

The study focuses on two draft horse populations with evolutionarily parallel influences from Belgian bloodlines: the Soviet Draft Horse and the American Cream Draft. The study sample encompasses the total population metrics for each breed and includes registered breeding individuals with verified pedigrees and official registry records — the IPS "KONI-3" Database of the All-Russian

Scientific Research Institute of Horse Breeding named after Academician V.V. Kalashnikov, and the complete studbook of the American Cream Draft Horse Association (ACDHA) covering 1901–2023. Unidentified crossbreeds and isolated private records without documented verification were excluded. [9,1]

The *Soviet Draft Horse* is a rare domestic breed (residual population  $\approx 400$  individuals), with the main gene pool concentrated in three historical state studs and several private farms (Table 1). The genealogical composition of the population comprises seven paternal lines and 17 maternal groups, with the Omul and Franco Van Saint Martens lines being the most numerous (Table 2). The phenotypic characteristics of modern representatives of the breed clearly reflect the influence of Belgian Brabant bloodlines in shaping a large, massive draft horse with a strongly developed exterior and robust conformation (Figure 2).

**Table 1. Major State Studs and Farms Preserving the Breeding Core of the Soviet Draft Horse**

<i>Name of Breeding Farm</i>	<i>Historical Name</i>	<i>Year of Establishment</i>	<i>Location</i>	<i>Breeding stock size (2023/25)</i>
ANO "Pochinkovsky Stud"	Pochinkovsky Stud No. 23	1652	Nizhny Novgorod Region, village of Pochinki	$\approx 120$ heads
JSC Agro-Breeding Plant "Perevozsky"	Perevozsky Stud No. 151	1918	Nizhny Novgorod Region, Perevozsky District, settlement of Tsentralny	92 heads
FSUE "Mordovsky Breeding Stud"	Mordovsky Stud No. 27	1931	Republic of Mordovia, Ichalkovsky District, village of Obrochnoe	$\approx 150$ heads
KFH Krasilnikova N.N.	Most Prominent Private Farm	1992	Ivanovo Region, city of Vichuga	22 heads

**Table 2. Genealogical Lines and Groups of the Soviet Draft Horse (2021)**

<i>Category</i>	<i>Name of group/line</i>	<i>Share/Number</i>	<i>Note</i>
Male lines (total 7)	Omul	30,2 %	Largest male line
	Fenomen	17,7 %	Third most numerous line
	Franco Van Saint Martens	21,9 %	Large genealogical group
	Other male lines	30,2 %	Remaining four lines of smaller size
Families	Roulettes	—	Female line
	Orchids	—	Female line
Subfamilies	Rozhitsy	—	Female group
	Znamenki	—	Female group
Families Genealogical groups of mares	—	17 groups	Total for the breed



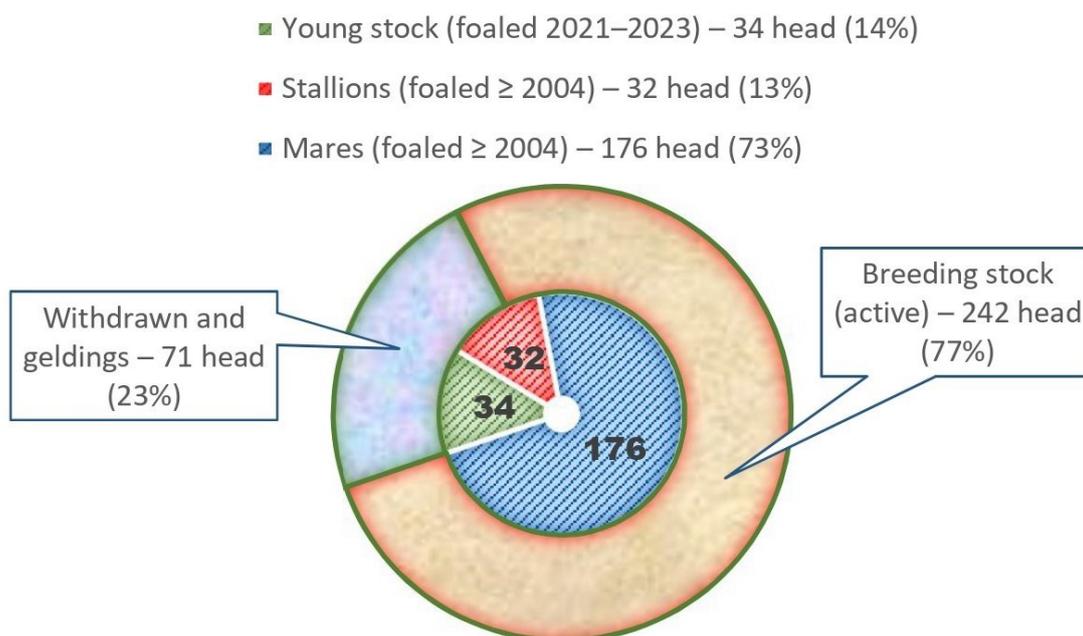
**Figure 2.** *Comparative demonstration of phenotype: right — Soviet Draft Horse (Pochinkovsky line, stallion Veresk, owned by A. Izmailova); left — Belgian Brabant (imported from the Netherlands, mare Erza Van Waardzicht, owned by A. Izmailova).*

The American Cream Draft is classified as an endangered breed and is represented in the studbook of the *American Cream Draft Horse Association* (ACDHA) by a total of 870 individuals ever registered since 1901. Historically, the breed numbered approximately 200 animals during 1950–1957. By the year 2000, 222 individuals were recorded, and according to registry data from 1992 to 2004, the number reached 341 horses. In subsequent years, the population has continued to grow by an average of 10–30 new horses annually but still remains critically low, comprising fewer than 500 living animals [1].

As of early 2024 (foaled  $\geq$  2004), the age–sex distribution of the breed includes a total of 313 registered horses (Fig. 3), including non-breeding individuals such as geldings — 71 head (23% of the total population) — and 242 members of the breeding nucleus, with the following composition:

- Mares of reproductive age (foaled  $\geq$  2004) — 176 head (73% of the active population);
- Breeding stallions (foaled  $\geq$  2004) — 32 head (13%);
- Young replacement stock (foaled 2021–2023) — 34 head (14%).

### DEMOGRAPHIC STRUCTURE OF THE AMERICAN CREAM DRAFT HORSE POPULATION (N = 313)



**Figure 3.** Age and sex structure of the American Cream Draft population: proportion of the breeding nucleus and its distribution by category (mares, breeding stallions, replacement young stock).

The percentage of each category within the breeding nucleus was calculated using the following formula:

$$P_C = \frac{N_C}{N_t} * 100\%$$

where:

- $P_C$  — is the percentage of the breeding nucleus represented by category C (mares, stallions, replacement young stock, etc.);
- $N_C$  — is the number of individuals in category C;
- $N_t$  — is the total number of breeding animals.

Modern data indicate that among more than 70 known monogenic disorders, even rare mutations can significantly reduce the viability of offspring and the genetic stability of small populations, particularly under conditions of genealogical isolation and a high level of inbreeding. In the context of JEB, this underscores the necessity of considering the LAMC2 mutation not in isolation but as part of a broader system of risks for breeds with a narrow gene pool. Models of recessive allele distribution demonstrate that even a single inclusion of carriers into the breeding nucleus increases the likelihood of fixation of the defective allele in the absence of directed selective control and genetic monitoring programs. [8]

The ethical dimension of breeding practice aimed at preventing hereditary pathologies that cause suffering and death of offspring must be implemented already at the stage of mating planning.

This implies adherence to the principles of preserving population welfare and health through responsible selection of breeding animals based on genetic risk assessment.

Thus, within its breed registry, the ACDHA conducts pedigree verification and DNA typing programs, including mandatory monitoring of the Junctional Epidermolysis Bullosa (JEB) mutation. Testing for JEB (as well as Polysaccharide Storage Myopathy Type 1) is offered by Animal Genetics Laboratory (USA, Florida) as a standard service for this breed (Fig. 4). The proportion of breeding animals and offspring tested for key genetic criteria is approaching 100%.



 **Animal Genetics** Generated on: 11/26/2024

3382 Capital Circle NE  
Tallahassee, FL 32308 **Genetic Testing Report**  
2024 Captain-KH filly

---

**Subject Horse**

<b>Name:</b> 2024 Captain-KH filly	<b>Lab Reference #:</b> 834458
<b>Breed:</b> American Cream Draft Horse	<b>Sample Date:</b> 06/27/2024
<b>Phenotype:</b> champagne	<b>Research Date:</b> 09/29/2024
<b>Sex:</b> Filly	<b>American Cream Draft Horse Association:</b> x
<b>Birth:</b> --/--/2024	

**Sire**

<b>Sire:</b> Captain
<b>Breed:</b> American Cream Draft Horse
<b>Phenotype:</b>

**Disorder Results(2 of 4)**

ACDHA - JEB1	<b>N/N</b>	Clear: Horse is negative for the JEB1 gene mutation.
ACDHA - PSSM1	<b>n/P1</b>	At Risk: Horse has one copy of the PSSM Type 1 gene mutation and may exhibit signs of the disorder.

**Figure 4.** Official ACDHA genetic test report showing a JEB negative result (filly JD's Windy, foaled 2024, Reg. No. 00878, owner: A. Izmailova)

## RESULTS AND DISCUSSION

### Genetic profile of the ACDH population and JEB screening outcomes [1]

The current American Cream Draft Horse population is characterized by an extremely low frequency of the lethal autosomal recessive JEB mutation, which is widespread among Belgian Draft Horses — a breed historically used to improve working capacity during the formation of the American Cream Draft. Belgian ancestry accounts for 25.98% of all cross-references in the studbook (226 out of 870 total ACDHA registrations, 1901–2023).

Analysis of JEB testing records (including both direct laboratory results and pedigree-based confirmations for pure lines) for ACDHA-registered horses over the period 2004–2023 showed (Table 3):

- 97.44% of horses possess the N/N genotype (no mutation detected);
- 2.56% (8 individuals) were identified as heterozygous carriers (N/J or JEB carrier);
- no homozygous “positive/affected” animals were recorded.

**Table 3. Distribution of genotypes based on JEB testing results in American Cream Draft horses (2004–2023).**

<i>JEB Test Result Categories</i>	<i>Number of Animals</i>	<i>% of Tested Population</i>
JEB N/N – negative, non-carriers	186 animals	97,44 %
JEB N/N by parentage – pedigree-confirmed N/N	119 animals	(included in the overall proportion of JEB-negative animals)
JEB N/J – carriers, heterozygotes	8 animals	2,56 %
JEB positive / affected – homozygotes, affected	0 cases	0 %

All detected JEB carriers belong to older mares (foaled 2005–2013) and to geldings and stallions that have been fully removed from breeding. (Table 4) As a result, since 2019, no new cases of JEB carriage have been recorded in the ACDHA registry, representing a reliable indicator of 100% elimination of the genetic defect from the breed population and serving as a clear example of responsible breeding management.

Table 4. Sample of all laboratory-confirmed JEB heterozygotes (carriers) according to the ACDHA registry data.

<i>Horse Name</i>	<i>Date of Birth</i>	<i>Sex</i>	<i>JEB Test Result</i>
Helt's Betsy's Bronze – 646	June 21, 2006	Mare	JEB (N/J)
H-N-J's Dick's Creamy Supreme – 618	May 9, 2005	Mare	JEB (N/J)
Shadow Box Farm Lemon Meringue – 744	April 29, 2013	Mare	JEB (N/J)
Sparkling Cream of Wheat Lola-Bella – 749	March 1, 2008	Mare	JEB (N/J)
Shadow Box Farm I-KI-LE-OLA – 708	August 10, 2010	Stallion	JEB (N/J)
Rush Creek Nick – 730	May 19, 2010	Gelding	JEB (N/J)
Rush Creek Bud – TR00178	April 25, 2012	Stallion	JEB (N/J)
SR Max's Baby George – 794	June 15, 2019	Gelding	JEB (N/J)

Decline in the Number of Soviet Draft Horse Mares (Percentage by Year)

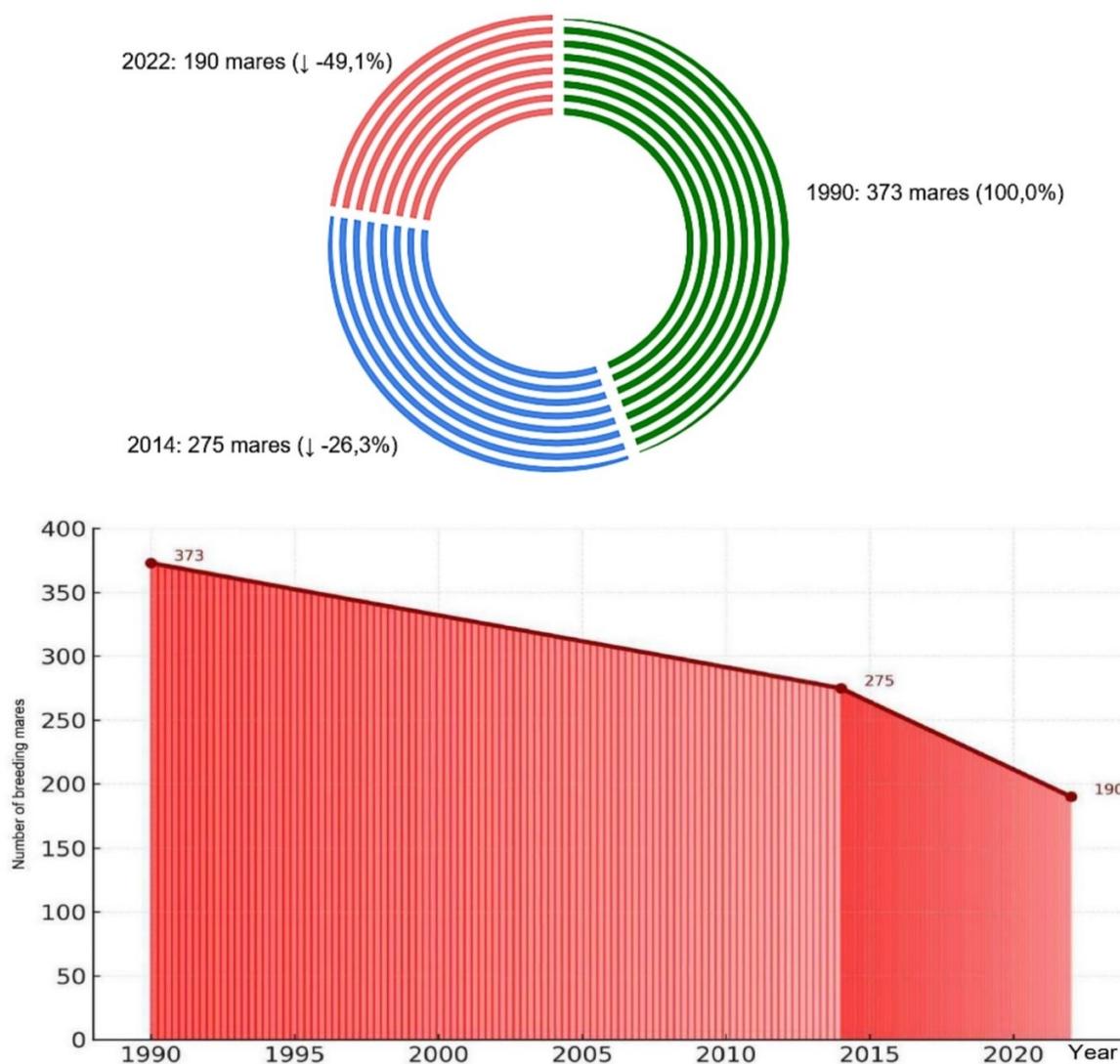


Figure 5. Dynamics of the breeding nucleus population of the Soviet Draft Horse (1990–2022).

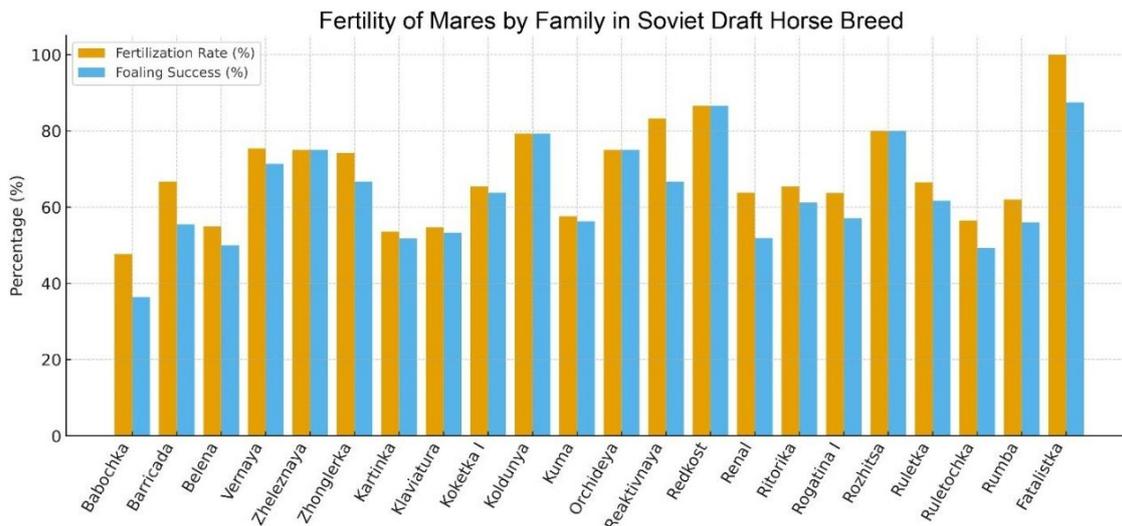
## Soviet Draft Horse population status and reproductive genetics

As the study demonstrated, despite the seemingly routine nature of the situation for non-commercial breeds existing outside the consumer mainstream, the genetic status of the Soviet Draft Horse is indeed critical. In 1990, there were 373 registered broodmares, decreasing to 275 in 2014 [5]. By 2022, the breeding nucleus had declined to fewer than 190 purebred mares, indicating an annual reduction of approximately 10 ( $\pm 1$ ) individuals (Fig. 5). If current trends persist, by 2036 the population could fall below 50 broodmares, representing an irreversible genetic and demographic collapse of the breed. Against a backdrop of 98.2–100% inbred individuals and only 4.9–7.7 fertile years per mare [2]—defining the natural aging threshold of the population—the ongoing decline in Soviet Draft Horse numbers is accompanied by negative markers of reproductive dysfunction such as mare infertility (embryo resorption), abortion, stillbirth, and the birth of non-viable foals, collectively signaling fatal disturbances during early embryonic or fetal development.

The presented histogram and heat map (Fig. 6) illustrate the fertility of Soviet Draft Horse mares by maternal families, considering two indicators: conception rate and successful foaling rate [10]. Initial evaluation of the data indicates that a significant portion of families exhibits low foaling rates despite conception rates close to the norm. For instance, the minimum foaling rate is 36.4% (family “Babochka”), meaning that in this group only every third impregnated mare produces a live foal per year.

A more detailed examination of the heat map reveals the following pattern: of 22 maternal families, only six show a foaling rate above 75%, and none reach 90%, while the majority fall within the 50–70% range. This trend aligns with the typical effects of recessive lethal mutations, such as JEB in Draft Horses, where the pairing of two heterozygous parents can result in up to 25% of embryos being homozygous for the defective allele and non-viable. Therefore, the observed gap between conception and foaling rates is highly likely to reflect embryonic losses rather than suboptimal management or feeding conditions.

The histogram data further complement this picture, highlighting substantial discrepancies between conception and foaling rates across maternal families. This underscores the need for comprehensive genetic screening of the Soviet Draft Horse to identify carriers of autosomal recessive mutations, primarily JEB, inherited from Belgian ancestors. The data visualization serves as a predictive tool, enabling the identification of groups with critically low foaling rates, which has direct practical implications for breeding management and for preventing the fixation of deleterious alleles.



Fertility and Foaling Indicators by Mare Family (Soviet Draft Horse)

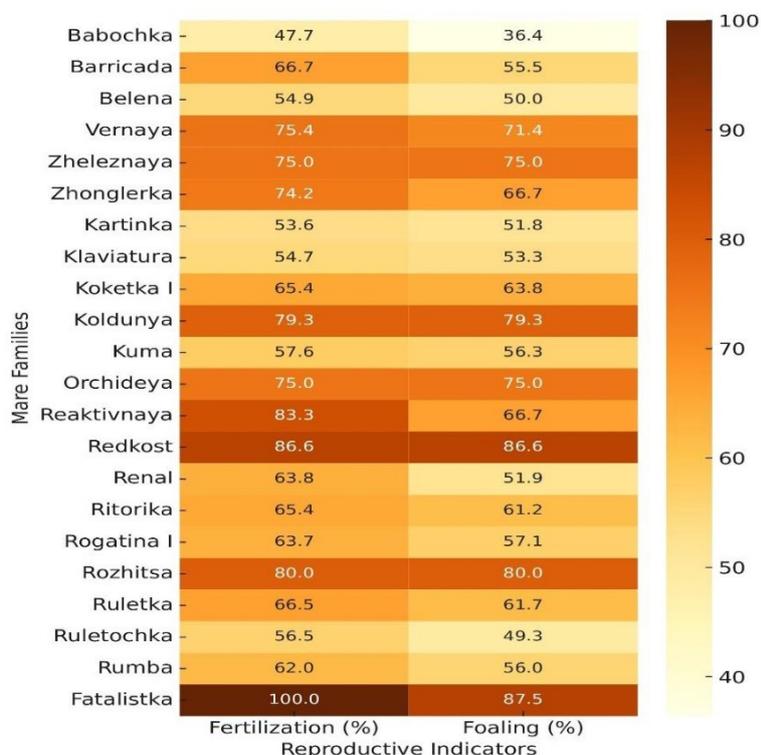


Figure 6. Fertility of Soviet Draft Horse mares by maternal families.

A parallel analysis of domestic and international approaches demonstrates that the implementation of genetic screening and targeted selection of breeding animals ensures the stability of the gene pool while preserving the diversity of breed lines. Genetic isolation, a limited effective population size, and the absence of molecular control create conditions for a self-accelerating collapse, in which each successive generation carries a higher mutational load than the previous one. For small populations, where every individual possesses high breeding value, the establishment of systematic genetic monitoring represents both an ethical and strategic measure. Strengthening population genetic resilience through ethically grounded selection secures the long-term preservation of the breeding core, reduces the likelihood of inadvertent fixation of deleterious alleles, and enhances the predictability of breeding outcomes.

Thus, genetic oversight of breeding operations serves simultaneously as a scientific, practical, and ethical safeguard of the population, confirming the integration of contemporary principles of responsible breeding into livestock practice as an essential component of breeding management.

## CONCLUSIONS AND PRACTICAL RECOMMENDATIONS

1. The analysis of the current status of the Soviet Draft Horse indicates a critical reduction in population size and a pronounced decline in reproductive potential. Under conditions of persistent inbreeding and the absence of molecular-genetic oversight, these factors pose a tangible risk of demographic and genetic collapse. The contraction of the breeding core, short duration of mares' fertile periods, and significant reproductive losses point to systemic disruptions empirically associated with the expression of recessive lethal mutations.

2. Comparison with the practices employed in the American Cream Draft Horse demonstrates that the implementation of mandatory DNA diagnostics and rigorous selection policies has effectively eliminated the lethal allele from the population, even within a closed breeding system: no homozygous animals have been identified, heterozygous carriers have been completely excluded from breeding, and the proportion of JEB-free individuals reaches approximately 98%. This experience provides a conceptual framework for genetic risk management applicable to Russian Draft Horse breeds.

3. The findings presented here demonstrate for the first time that the observed patterns allow the reduction in reproductive performance of the Soviet Draft Horse to be interpreted not as a consequence of husbandry factors, but as a reflection of deep-seated genetic processes characteristic of small, highly inbred populations. The established link between the frequency of reproductive failures and the probable carriage of recessive lethal alleles, such as JEB, underscores the need to shift breeding priorities from a purely phenotype- or line-based approach to comprehensive molecular monitoring programs.

4. This approach aligns with international standards of animal breeding bioethics. In the long term, the implementation of regular molecular screening, certification of breeding animals according to carrier status, and the development of an open genetic registry may constitute key conditions for the preservation of the Soviet Draft Horse as a functional, biologically viable, and culturally significant national breed.

## REFERENCES:

1. ACDHA All Registrations 1900-10072023 (2024) //American Cream Draft Horse Association URL: <https://www.acdha.org/blank-5>
2. Alekseeva, E.I., Borisova, A.V. Breeding methods in small populations using the example of the Vladimir and Soviet Draft horse breeds. // Proceedings of Saint Petersburg State Agrarian University. Section: Agricultural Sciences. Veterinary Medicine and Animal Science. — 2019. — Issue 56. — pp. 118–123. — DOI: 10.24411/2078-1318-2019-13118.
3. Alekseeva, E.I., Borisova, A.V. Characteristics of mare families in the Soviet Draft breed. // Proceedings of Saint Petersburg State Agrarian University. Section: Agricultural Sciences. Veterinary Medicine and Animal Science. — 2020. — Issue 59. — pp. 96–104. — DOI: 10.24411/2078-1318-2020-12096.

4. Baird J. D., Millon L. V., Dileanis S., Penedo M. C. T., Charlesworth A., Spirito F., Meneguzzi G. Junctional epidermolysis bullosa in Belgian draft horses // Proceedings of the American Association of Equine Practitioners. – 2003. – Vol. 49. – P. 122–126.
5. Borisova, A.V., Trufanov, V.G. 65 Years of the Soviet Draft Breed. // Horse Breeding and Equestrian Sports. — 2017. — No. 5. — pp. 15–17. — (World of Draft Horses / Horse Breeding) ISSN 0023-3285.
6. Budyonny, S.M. The Book of the Horse. Vol. 1. // Main Directorate of Horse Breeding and Stud Farms. — Publisher: Selkhozgiz, Moscow, 1952. — pp. 155–175.
7. Cappelli K., Brachelente C., Passamonti F., Flati A., Silvestrelli M., Capomaccio S. First report of junctional epidermolysis bullosa (JEB) in the Italian draft horse // BMC Veterinary Research. – 2015. – Vol. 11. – Article 55.  
DOI: 10.1186/s12917-015-0374-0.
8. Finno C. J., Spier S. J., Valberg S. J., Penedo M. C. T. Equine genetic diseases: linking genotype to phenotype // Equine Veterinary Journal. – 2016. – Vol. 48, No. 5. – P. 562–575. DOI: 10.1111/evj.12568.
9. IPS “KONI-3”. Database of breeding horses, Federal State Budgetary Scientific Institution “All-Russian Research Institute of Horse Breeding named after Academician V.V. Kalashnikov.”  
URL: <https://base.ruhorses.ru>
10. Georgescu S., Costache M., Vlaicu R., Dinescu S. A method for Junctional Epidermolysis Bullosa (JEB) detection in Romanian Draft Horses // Scientific Papers, Series D, Animal Science. – 2008. – Vol. 51. – P. 127–132.  
URL: <https://doiserbia.nb.rs/Article.aspx?id=1450-91560802127G>
11. Khrabrova, L.A. Hereditary defects in horses: diagnostics and prevention // Horse Diseases. VetPharma (4), 2014. – pp. 86–96.
12. Kurskaya, V.A. Soviet Draft Horse: Current Status of the Breed. // Association “Rosplemkonzavod”, 2021.  
URL: <https://rpkz.org/avtorskie-teksty/vera-kurskaja-sovetskij-tjazhelovoz-sovremennoe-sostojanie-porody.html>
13. Milenkovic D., Chaffaux S., Taourit S., Guérin G. A mutation in the LAMC2 gene causes the Herlitz junctional epidermolysis bullosa (H-JEB) in two French draft horse breeds // Genetics Selection Evolution. – 2003. – Vol. 35, No. 2. – P. 249–256.  
DOI: 10.1186/1297-9686-35-2-249.
14. Nicholas, F. W., Tammen, I. Epidermolysis bullosa, junctionalis, LAMC2-related (Horse). – OMIA:001678-9796: Online Mendelian Inheritance in Animals (OMIA): University of Sydney, 2022. <https://doi.org/10.25910/2AMR-PV70>  
URL: <https://omia.org/OMIA001678/9796/>
15. Siford, J. History of the American Cream Draft Horse // S&J Stable, 2018  
URL: <http://www.sjstable.com/american-cream-draft-horse-history.html>
16. UC Davis Veterinary Genetics Laboratory. Junctional epidermolysis bullosa (JEB1) in Belgian Draft Horses. – Davis, CA: University of California, Davis, 2021.  
URL: <https://vgl.ucdavis.edu/test/jeb-belgian>