

## Lateral profile of the pigs' teat line of different Ukrainian breeds

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A quantitative analysis of the lateral profiles of five Ukrainian pig breeds (n=584), listed in the State Books of Pedigree Animals, showed that the teat line's complete symmetry was found only in the Poltava meat breed. The large black one is characterized by insignificant (6%) asymmetry, and among species of the Ukrainian meat breed, Ukrainian spotted steppe and Mirgorod breeds of asymmetry cases were noted on average 20-30%. The analysis revealed that the structure of the pigs' teat line with asymmetry is characterized by dominant-enantiomorphic proportional structuring, which ensures the population stability of breeds in the changing environment. We established that the teat line's left-dominant structure prevails both in boars and in sows of different breeds in the case of dominance inversion that demonstrates the ability for evolutionary adaptation self-organization of multi-component living systems under environmental factors. The evolutionary hypothesis's conclusions, which consider lateralization as a natural evolutionary process, an adaptive specialization of bilaterally arranged organisms, have been confirmed. There was assumed the possibility of improving selection in pig breeding by increasing the effect of heterosis in selecting couple pairs with laterally differentiated teat lines.

**Keywords:** obstetrics, boars, sows, lateral profiles of the teat line.

## Introduction

The milk production of sows is a crucial physiological and technological characteristic that determines pig breeding efficiency. According to modern biological concepts, pigs have multiple udders, consisting of 6-8 pairs of mammary glands, lying on the white line's sides from the radial cartilage to the pubic region. Lactation is the mammary gland's function: the formation and accumulation of milk with periodic excretion during the suckling of piglets (Naumov, 1982; Hladii et al., 2015; Sudyka & Sudyka, 2018; Animal ..., 2016). In the breeding practice, the number of naturally developed teats of the pigs' mammary gland is called the teat line, which has a bilateral structure (Instruktsiia z bonituvannia svynei, 2003). For a long time, the selection of highly productive pigs of modern breeds has traditionally been based on the generally accepted model of harmonic body structures; i.e., with a symmetrical arrangement of the teat on the left and right requirements have been selected for breeding animals (Instruktsiia z bonituvannia svynei, 2003; Voitenko, 2004; Pivinska, 2005; Voitenko, 2007; Knjazev & Nikitin, 2010; Nikitin & Knjazev, 2011; Khalak et al., 2020). Today, there are no consistent explanations why, with such a long term of artificial selection aimed at choosing species with full pairs of teats for reproduction, in the majority of both commercial and breeding herds, animals with an asymmetrical teat line are still present? Over the past decades, an increased scientific interest in functional asymmetry issues with a bilateral structure has been revealed. Interdisciplinary barriers complicate the consideration of complex fundamental problems of livestock production, including mono- and dimorphism of the structure of paired organs. Genetic and environmental influences in the formation and various manifestations of functional interhemispheric asymmetry are not clear. Many scientists consider its significance to be the leading one in forming functional asymmetry of different organs and systems in bilateral organisms (Ljashhenko & Bessalova, 2006; Aleksandrov, 2014). The mechanisms of this phenomenon are interpreted ambiguously. The conclusion about the presence of functional interhemispheric asymmetry of the brain in

animals has been discussed to date (the leading influence on the functional level of development of paired organs has been shown in clinical medicine) (Aleksandrov, 2014). The main principle in control of body functions using brain structures and the formation of a dominant system in them, introduced by A.A. Ukhtomsky in 1923, were developed and supplemented by Russian scientists in subsequent years with the theory of functional systems, biocybernetic principles of auto control (polarity, multilevel duplication, direct and reverse positive and negative connections) (Geodakjan, 1993; Orlov et al., 2004; Aleksandrov, 2014). According to foreign researchers, it has been established that the number of pairs of pigs' teats can vary from 4 (8 teats in the wild boar *Sus scrofa*) to 10 (20 teats) in the domestic pig *S. domesticus* (Knjazev & Nikitin, 2010). Various literature sources indicate the presence of up to 40% of species that can have unpaired (represented by only one teat) pairs, i.e., an asymmetric teat line (Nikitin & Knjazev, 2011). However, it remains unclear how widespread is the lateral dimorphism of the teat line in wild pigs, the dynamics of the lateral profile among different breeds of pigs, and the geographical features of the lateral profile. The literature contains only incomplete data on the presence of a monomorphic or dimorphic structure of the pigs' udder of certain breeds and populations (Knjazev & Nikitin, 2010; Nikitin & Knjazev, 2011).

Pig breeders and several researchers consider deviation from the teat line's symmetry an exterior defect is traditionally considered to be the most proportional criterion of good health and high productivity symmetrical structure of pigs as bilaterally organized animals (Instruktsiia z bonituvannia svynei, 2003; Knjazev & Nikitin, 2010). This is reflected in the requirements for selecting breeding pigs in the State Studbooks of Ukraine (Voitenko, 2004; Pivinska, 2005; Voitenko, 2007). There are no theories of lateralization of the animal organism which can consistently explain the phenomenon as a whole, although scientists have proposed numerous hypotheses of its origin (genetic, cytogenetic, pathological, ecological, chemical, neurohumoral). The biological significance of the constant manifestation of the asymmetric structure of the mammary gland of pigs (which is quantitatively recorded when assessing the conformation by counting the active teats of the teat line) has not been clarified. **The purpose** of our research was to study the level of lateral symmetry-asymmetry of the teat line of breeding pigs of Ukrainian breeds and the dynamics of changes in the lateral profile of the functional asymmetry of populations bred under different conditions.

## Materials and methods

The analytical part of the work was carried out by comparing the exterior data on the number of teats in the main boars – producers and main sows included in the State books of breeding animals: Ukrainian meat (Volume 1, 2008), Poltava meat (Volume 1, 2005), Mirgorodskaya and large black (Volume 2, 2007) and Ukrainian spotted steppe breed (Volume 3, 2009). The analysis was carried out on five breeds, which are mainly characterized by domestic selection. The geographic localization of the surveyed populations in different Ukraine regions is presented in Table 1; 14 breeding farms took part in the work. We developed and tested a method for constructing and comparing lateral profiles of the teat line of different sex and age groups of pigs was developed and practically tested; we carried out a quantitative analysis of the ratio of symmetrical and asymmetric teat lines in breeding pigs of five breeds was carried out according to the data entered in the State books of breeding animals (Vol. 1, 2, 3); we also carried out a quantitative analysis of the ratio of the lateral dominance of the right or left side of the udder in pigs of five breeds, considered the sex distribution; we also performed a comparison of the lateral profile of the populations of pigs of different breeds towards to the time interval from the creation (approval) of the breed. We carried out a quantitative analysis of the lateral profiles of the teat line's functional asymmetry in pigs of the Mirgorod breed in the conditions of an operating farm compared with animals included in the State herd book. The statistical analysis of data on lateral differentiation of the pigs' teat line of different sex and age groups of five breeds was carried out. The analysis of literature data and the actual results of studying the lateral profiles of breeding pigs was carried out. A hypothesis of the biological significance of the teat line's functional asymmetry and the dynamics of its structuring in different populations was suggested.

**Table 1.** Localization of the studied breeding stock of different breeds of pigs in the regions of Ukraine

Pig breeds	Breeding farm location and farm number *
1 Mirgorodskaya breed	No1 – Poltava region
2 Ukrainian spotted steppe breed	No2 – Kherson region
3 Large black breed	No3 – Sumy region
	No4 – Donetsk region
	No 5 – Donetsk region
	No6 – Khmelnytsky region
4 Poltava meat breed	No7 – Sumy region
	No 8 – Lugansk region
	No 9 – Lviv region
	No 10 – Poltava region
	No 11 – Dnipropetrovsk region
5 Ukrainian meat breed	No 12 – Odessa region
	No 13 – Kyiv region
	No 14 – Kherson region

Note: \* - serial number of the breeding farms surveyed in this work (from now on).

The experimental part of the work was carried out under the conditions of farm No. 1 (Poltava region) for breeding the Mirgorod pig breed, which today is a disappearing local population. In the conditions of an operating farm (2015-2016), quantitative indicators of the teat line's lateral profile were recorded in animals of the main herd and the young animals tested. In the course of our research, we used analytical, structural-functional, comparative, and statistical methods.

The generalized data were processed using statistical methods using the MSeXel2010 software package (Lakin, 1999) with the determination of the probability coefficient (Student's *t*) (for values  $P < 0.01$  - \*;  $P < 0.001$  - \*\*).

## Results and Discussion

Analysis of the teat line lateralization profiles in breeding pigs according to the chronological vector (Table 2) showed the ambiguity of the results in different breeds at the same terms of selection.

**Table 2.** Distribution of pigs with different terms of selection into groups according to the structure of lateral symmetry – asymmetry of the teat line (n = 584)

Pig breeds	Number of farms	Number of examined animals	Breed approval year	The nature of the lateral differentiation of the teat line of the examined species*
Large black breed	2	60	End of 19th century (brought to Ukraine in 1947)	Bilateral symmetry
Poltava meat breed	6	137	1993.	Lateral asymmetry in 20%
Ukrainian meat breed	4	179	1993	
Ukrainian spotted steppe breed	1	160	1926-1934	
Mirgorodskaya breed	1	48	1940	Lateral asymmetry in 30%

**Note:** \* - bilateral symmetry - an equal number of functional teats on the right and left side of the udder; lateral asymmetry - unequal number of functional teats on the udder's right or left side (incomplete pairs).

There is a single instructional document in Ukraine that provides the requirements for selecting pigs into reproduction groups and focuses on maintaining the bilateral symmetry of the teat line in both breeding boars and sows (Instruktsiia z bonituvannia svynei, 2003). All animals listed in the breeding registers have passed through a long selection process according to exterior indicators and productive qualities. However, comparatively young breeds (Ukrainian and Poltava meat breeds) formed in very similar climatic and economic conditions had identical initial breeds in their pedigrees. In 20 years after approval, Ukrainian and Poltava meat breeds demonstrate a different structure of teat line lateralization: complete symmetry of the mammary gland structure in Poltava meat and 20% asymmetry Ukrainian meat breed.

**Table 3.** Lateral structure of the teat line profiles of pigs of Ukrainian breeds (n = 584)

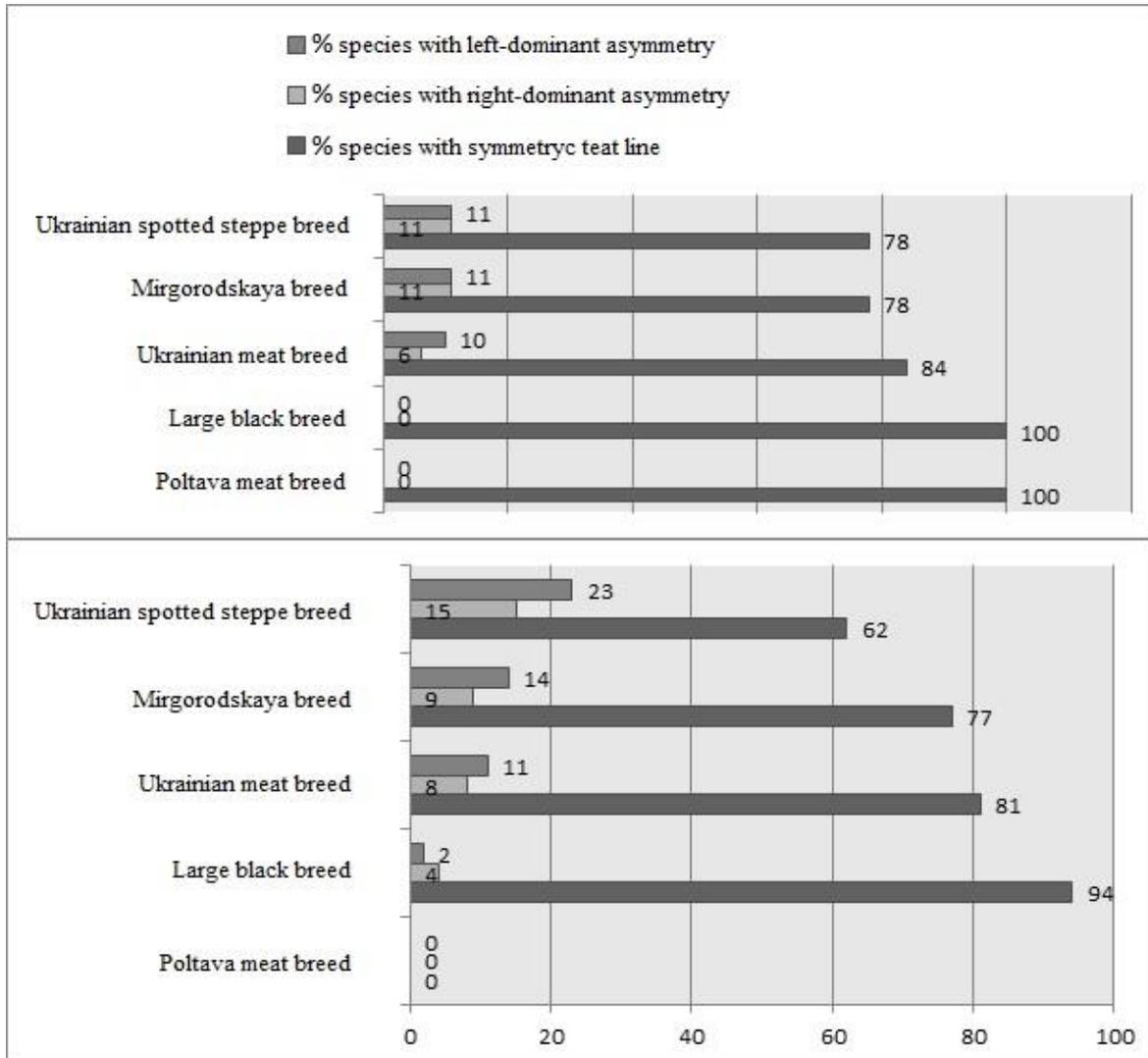
Pig breeds	n	Symmetrical teat line (L=R)		Asymmetrical teat line (L≠ R)	
		goals	%	goals	%
<b>Boars-producers</b>					
Large black breed	14	14	100.00	0	0.00
Poltava meat breed	15	15	100.00	0	0.00
Ukrainian meat breed	51	43	84.31	8	15.69
Mirgorodskaya breed	9	7	77.78	2	22.22
Ukrainian spotted steppe breed	72	56	77.78	16	22.22
Total, goals /%	161	135	83.85±5.05*	26	16.15±5.05*
<b>Sows</b>					
Poltava meat breed	122	122	100.0	0	0.00
Large black breed	46	43	93.48	3	6.52
Ukrainian spotted steppe breed	88	71	80.68	17	19.32
Ukrainian meat breed	128	99	77.34	29	22.66
Mirgorodskaya breed	39	24	61.54	15	38.46
Total, goals /%	423	359	84.87±6.69**	64	15.13±6.69**

The complete bilateral symmetry of large black boars confirms the long-term influence of selection on the teat line pairing but contradicts the Mirgorod breed data, which lasted for a similar period (Table 2).

As a result of the animals' selection process for 65 years, the Mirgorod breed has an average of 30% of the species with asymmetric teat lines in the population. The next stage of the analysis was the detailing of the data on the prevalence of

asymmetry in the organization of the pigs' teat line of the main herd (structured by sex) in the breeds included in the State herd books (Table 3).

The analysis (Table 2) has shown that in males and females with similar average values, a different picture of the asymmetry of the teat line in the section of different breeds is presented: from complete symmetry to the level of asymmetry in sows of the Mirgorod breed equal to 38.46% (CV = 86.055;  $td = 8.416$ ;  $P < 0.001$ ). A subsequent study of the data to identify the dominant side of the teat line differentiation, i.e., the more developed side of the udder with many active teats, showed a left-dominant tendency, mainly observed among females (Fig. 1).



**Fig. 1.** The structure of the lateral profiles of the teat line differentiation of pigs of different breeds: at the top - the main boars - producers, at the bottom - the main sows

The results of our analysis showed that the paired organ (mammary gland of pigs) is characterized by lateral dimorphism, i.e., one of the sides is dominant, the other subordinate one. This conclusion is consistent with several studies by other authors in studying the function of different systems of paired organs in mammals (Orlov et al., 2004; Geodakan, 2005; Ljashhenko & Bessalova, 2006). The dominant organ is larger and morphologically better developed, which was confirmed in our previous studies of the paired gonads of female cattle (Sidashova & Sahlo, 2014; Sidashova, 2017).

The structuring of the data on species with the teat line's asymmetry (Table 4) showed the lateral organization's proportionality of the anatomical structure of the udder with signs of enantiomorphism in animals of different sex. The significance of the phenomenon of enantiomorphism and polarity in the organization of complex multi-component structures in biology has not yet been sufficiently studied, but several literary sources emphasize its crucial importance in the evolutionary processes of adaptation of living organisms to a changing environment (Geodakjan, 1993; Orlov et al., 2004). Our previous studies on the functional asymmetry of the ovaries of cows - donors of preimplantation embryos and heifers - recipients (Sidashova & Sahlo, 2014; Sidashova, 2017; Roman et al., 2020) confirmed the prevalence of functional asymmetry of paired mammalian organs with the enantiomorphism as an adaptive mechanism of interaction between species and the entire population with the environment.

According to researchers who conducted experiments on laboratory animals, the central nervous system becomes the coordinator of these processes, in which the dominant concepts are the essential principle of temporal organization in the morphological development of paired organs (Aleksandrov, 2014). These findings have been experimentally proven in clinical medicine when studying women's reproductive function (Orlov et al., 2004). Our analysis data confirm the conclusions of other

research conducted on females of different animal species (Sidashova & Sahlo, 2014; Sidashova, 2017; Roman et al., 2020). In 1956, research by scientists from the Poltava Institute of Pig Breeding proved a large dynamic asymmetry of the pig's uterus with a complex dynamic profile of lateralization (Martynenko, 1956). The author experimentally established a significant difference in the increase in the morphological development of the pig's uterus's left horn during the non-pregnancy period and its higher contractile function.

The left-dominant organization of the asymmetry of paired organs in sows confirms the structural patterns of the organization of mammary gland morphology in a population of animals that are under pressure from environmental stressors, among which there may be the intensification of production processes in pig breeding, climate, or microclimate change (Geodakan, 2005; Denysiuk, 2008). Based on data from clinical studies in medicine, we can note the predominant role of the right hemisphere of the brain (hence, the organs of the left side) under stress and in the processes of adaptation to changed environmental factors (Aleksandrov, 2014).

**Table 4.** Features of the lateral structure of the pigs' udder of different sex with an asymmetric of the teat line (n=90)

Pig breeds	Number of species with asymmetry, goals	The dominance of lateral udder differentiation in species of different sex, %			
		Boars		Sows	
		R>L*	L>R**	R>L	L>R
1 Large black breed	3	Bilateral symmetry		67	33
2 Poltava meat breed	0	Bilateral symmetry		Bilateral symmetry	
3 Ukrainian meat breed	37	38	62	38	62
4 Ukrainian spotted steppe breed	33	50	50	41	59
5 Mirgorodskaya breed	17	50	50	40	60

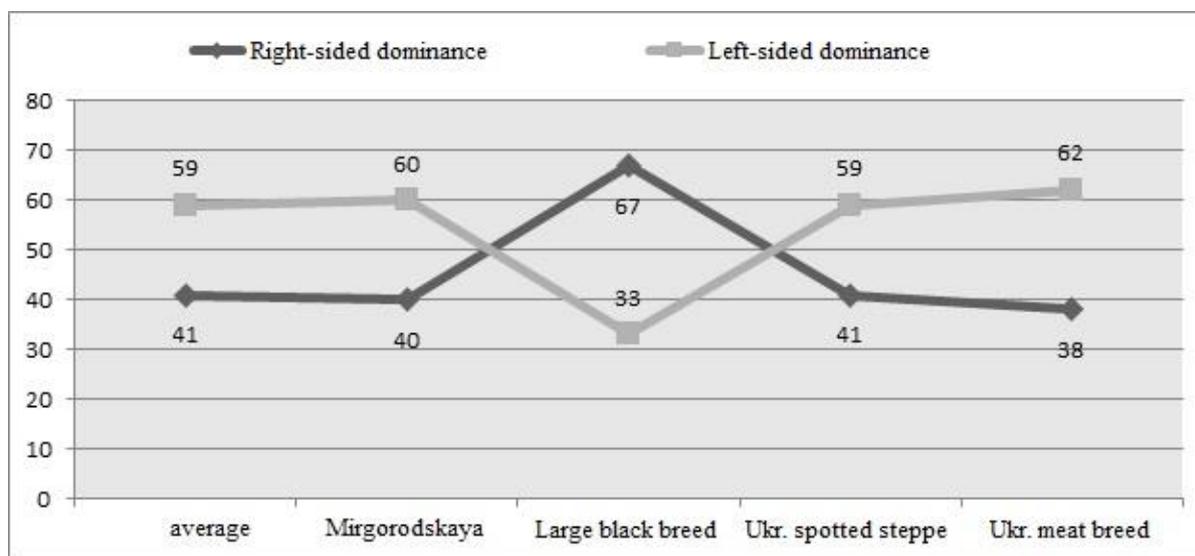
Note: \* - right - dominant teat line-R>L; \*\* - left-dominant-L>R

Graphic image (Fig. 2) of lateral dominance among sows of different breeds born in the farms with different climatic and technological conditions illustrates the harmonic proportional character of the asymmetry. This is approaching universal proportions "Golden section" if the ratio of lowest to highest as 1:0,613 that we established on large statistical samples of the research cows (Sidashova & Sahlo, 2014; Sidashova, 2017; Roman et al., 2020).

The structural mechanism of the enantiomorphic ratio of left and dominant right asymmetry of the teat line in sows of different populations shows the influence of the information principle of the "racking structure" (Fig. 2) or coherent systems that increase the evolutionary stability of the biological system as a whole, evolving in a changeable environment (Geodakjan, 1993).

The available theoretical assumptions and actual prerequisites allowed us to make reasonable speculation about the dominant-asymmetric structure of paired organs (mammary gland), which determined the formation of the udder's morphology and function of pigs' teat line.

The consideration of functional asymmetry in the organization of the pigs' udder of different populations, presented in our study by the profiles of lateralization of the teat line of boars and sows of five Ukrainian breeds, can characterize the biological mechanisms of adaptation of animals at the level of micro populations (herds) in the process of interaction with the changing environment. The revealed regularities of the enantio-dominant organization of the dynamics of lateral profiles of the teat line confirm the isomorphic structure of lateral specialization in the development of the udder in males and females belonging to the same breed and between different sex of different micropopulations (breeding herds) of pigs.



**Fig. 2.** The profile of the organization of the structure of the teat line in sows with an asymmetric number of active udder teats (Mirgorod, Large black, Ukrainian spotted steppe, and Ukrainian meat breeds, in % of the registered species)

Recently, breeding has placed increasing importance on genotype assessment, taking as a basis that the value of animals is concentrated in their homozygosity since this makes it possible to obtain offspring with standard traits that will be stably transmitted (Nebylytsia, 2018). The data obtained by us show fluctuating asymmetry in the indicators of an essential external feature that determines the level of sows' milkiness and the survival of suckling piglets. This indicates the action of more complex biological processes in the microevolution of pig populations, which should be taken into account when developing requirements for the breeding process.

The regularities of the structural organization of the teat line of pigs with the asymmetry of the udder structure can be an essential additional resource of heterosis, especially in small local breeds (Denysiuk, 2008; Denysiuk, 2013).

The next experimental stage of our study confirmed the regularity of the structured proportional ratio of the number of animals of different sex and age groups with asymmetric development of the teat line in the conditions of the existing farm of the Mirgorod breed (Table 5).

**Table 5.** Structuring of the lateral organization of the teat line in Mirgorod pigs in different periods of the breeding herd (n=132)

Research year	Main sows			Boars-producers		
	Total investigated, goals, n	The structure of the teat line lateralization, %		Total investigated, goals, n	The structure of the teat line lateralization, %	
		Symmetric L=R	Asymmetric L≠R		Symmetric L=R	Asymmetric L≠R
2016	39	61.54	38.46	9	77.78	22.22
2017	49*	67.35	32.65	35	65.38	34.62

Note: basic and verifiable sows in a farm.

The investigation of the main stock of the Mirgorod breed confirmed the preservation of laterality in the morphological organization of the udder structure in breeding pigs, even under the condition of several decades of a selective selection of animals for reproduction, focused on the symmetry of the teat line. If we rely on the genetic hypothesis of the formation of unpaired teats in pigs (Knjazev et al., 2002), such a comprehensive selection should have led to the complete elimination of genes carrying signs of asymmetry population, which did not happen. Moreover, the data show the following increase in udder asymmetry in the herd after a nine-year observation period: in boars, the number of species with teat line asymmetry increased by 12.40%. The mechanism of enantiomorph-dominant organization of the lateral structure of the udder was evident during the same period, the decrease in asymmetry in a group of sows 5.81%. This reveals the effect of adaptive "tracking system" accommodation of the local populations of small Ukrainian breeds of animals to environmental factors, including the pressure of artificial selection. The small number of samples did not allow for processing biometric data correctly.

The analysis confirmed the conclusions made based on our previous studies (Sidashova et al., 2015; Sidashova, 2017) regarding the dynamic and proportional organization of the functional asymmetry of the anatomical structure of the udder in pigs obtained during purebred breeding. Studies of Ukrainian scientists reveal data on the critical state of the limited population of the Mirgorod breed (Tsybenko et al., 2015). However, the teat line's lateral organization shows the presence of structural biological reserves of adaptability of this unique breed.

Thus, the results obtained analytically show that for bilaterally organized animals, the lateralization of paired organs is a natural process representing an organism's adaptive specialization to environmental conditions. The modern theory of evolution states that the basic premise of the selection effectiveness is genetic diversity in the population in terms of characteristics necessary for the life support of the organism or production tasks (Voroncov, 1980; Denysiuk, 2013). The biological regularities showed that only sex-and laterality-dimorphic traits evolve, i.e., asymmetric ones, while monomorphic (symmetric) ones are stable.

The controversial hypothesis put forward by Russian researchers (Knjazev et al., 2002) about the pathogenetic nature of teat line asymmetry requires a broader statistical consideration. According to the authors, in the genome of a domestic pig (on the example of the Kemerovo breed), there are genes whose recessive alleles can cause disorders of prenatal development of piglets, leading to an uneven – asymmetric arrangement of the teats. According to other authors (Geodakjan, 1993; Geodakan, 2003), the formation of the lateral profile of the central systems of animals' paired organs occurs in a developing fetus in utero as a result of brain hypoxia, as a consequence of the influence of adverse environmental stressors on the mother's body.

For theoretical substantiation in our research of the methodological approach to the study of the prevalence of asymmetry in the populations of Ukrainian pig breeds, we used and expanded the application of the evolutionary concept (Geodakjan, 1993), which was based on the hypothesis of deepening the asymmetry of living systems in the process of evolutionary movement. Since asymmetry is associated with evolution, the maximum values of asymmetry should be expected in intensively evolving species, including farm animals and pigs of modern specialized meat breeds. Therefore, it can be assumed that in specialized pig lines and hybrid populations, the lateralization of paired organs will increase, which requires detailed study.

The analytical and experimental data obtained by us on five Ukrainian breeds of pigs indicates a stable (for a long time) phenotypically expressed dominance of the asymmetry of the left side of the teat line (taking into account the phenomenon of inversion of dominance). The data of the analysis of the lateral profile of the teat line of five breeds showed the effect of the evolutionary mechanism of adaptogenesis of domestic pigs' population in conditions of increased stress of environmental stressors, taking into account the impact of intensification and technological modernization of the pig industry.

## Conclusions

As a result of the quantitative analysis of the differentiation of the pigs' teat line, five Ukrainian breeds, listed in the State book of breeding animals. We found that Poltava meat breed is characterized by bilateral symmetry, a large black one – slight asymmetry (6%) and Ukrainian meat Ukrainian spotted steppe, and Mirgorod breeds differ by on average 20-30% of species

with the lateral asymmetry of the teat line. Among breeds with large topographic asymmetry, several reliable patterns of right-left differentiation of mammary gland development among different sex and age groups were established for the first time. Reliable regularities of the lateral structural organization of the asymmetric development of the pigs' teat line have been established, which in statistical terms tended to a proportional universal ratio of the smallest part to the largest one 1:0.613. The presence of inversion of the dominance of the teat line's asymmetry among different pigs breeds as a manifestation of the adaptability of populations to the influence of environmental stressors of the technological processes has been analytically established. We found that the studied breeds are characterized by left dominance in the teat line structure with the manifestation of signs of enantiomorphism in the groups of males and females.

The presented method of assessing the lateral profile of the pigs' teat line makes it possible to improve the methods of selecting parent couples using the additional effect of heterosis in groups with different lateral specialization of the morphological structure of the mammary gland. Prospects for further research are studying the features of the formation of lateral profiles of pigs' paired organs of different breeds and populations, taking into account the universality of the principles of organization of the body's bilateral structure.

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