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CURRENT DEVELOPMENT ASPECTS IN UKRAINE'S ANIMAL BREEDING WITH THE CONSIDERATION OF THE IMPACT OF AGRARIAN CRISES

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Aim. To determine the consequences of the cyclic development in the agrarian sector and evaluate the shifts in the structure and the performance of the animal breeding branch due to the occurrence and course of the agrarian crises and inter-crisis periods, to substantiate the measures and practical actions for its restoration. **Methods.** Common scientific methods were applied, including historical and logical, dialectic and systemic analysis, theoretical generalization, analysis and synthesis, variation dynamics, comparison, grouping, indexing, and table methods. **Results.** The cyclic nature of the development in the agrarian sector was investigated; it was found that agrarian crises, starting with 1990 to 1999 which lasted 10 years, from 2000 to 2010 – 10 years, from 2011 to 2015 – 5 years, from 2016 to 2020 – 5 years, were the consequences of this process and their trough was a starting point to launch a new cycle. It was determined that the transition to new forms of economic activity was accompanied by the destruction of the material foundation of animal breeding, the arable areas under forage crops were reduced, the scientific requirements towards crop rotations were not followed, yet the transformational processes promoted the organization of animal farms of different organizational and legal forms. It was analytically proven that there was no restoration of animal breeding after the transformational crisis: the highest indices were registered in 2013 – 56.1 % from the level of the animal breeding production index in the basic year as compared to the lowest value of this indicator of 43.3 % in 2000. It was demonstrated that practically all the effective indices of animal breeding production tended to decrease, except the following ones: poultry meat production, the production volumes of which increased twice; the production of honey was increased by one-third; the performance of cows increased by 1.8 times. The russian aggression has induced the exacerbation of the crisis phenomena in the animal breeding industry, which will cause the manifestation of catastrophic risks in some sub-branches, like meat and milk animal breeding. We suggested the main directions of strategic post-war restoration of animal breeding restoration based on the intensive methods of enlarging the livestock of farm animals, modernization of industrial potential of animal breeding complexes, expansion of forage crop areas, recovery of the natural forage foundation, and increasing the capacities of producing concentrated fodder, the introduction of resource-saving and ecology-oriented technologies, digital instruments with the adherence to stable development principles and innovational provisions. **Conclusions**. It was determined that the livestock of most sub-branches of the animal breeding industry was not restored after the trough of the transformational crisis, and the indices of the pre-crisis state were not reached, except in poultry breeding. The descending trends, initiated in the

transformational period, reached such dynamics that they still go on in some main branches of animal breeding. The exception was found in poultry meat production, in which the count of birds decreased down to 82.2 % from the basic year, but the 2.36-fold gain in live weight was ensured, which promoted the approximately two-fold increase in the production volumes. It was found that the descending trend of milk production is permanent, and as of the end of the investigated period, only one-third of the 1990 index was produced in Ukraine (34.2 %). It was caused by the fact that the number of cows decreased more than five times during the investigated period, yet the index value of the annual yield of milk per one cow changed to the ascending trend, and at the end of the investigated period, the yield of milk increased 1.8 times – up to 5,155 liters. It was proven that in the years of crises, there was a decrease in the number of small and large agrarian milk-producing enterprises and an increase in the group of extralarge ones. No clear manifestation of regularities in the cyclic development was registered by the main indices of animal breeding because after slight rises, this branch remained on a low level, and since the peak of the agrarian crisis has had descending dynamics. It was substantiated that the main factors of shorter time periods in the crisis manifestation in animal breeding are as follows: global climate change, stronger initiatives on the introduction of climatically neutral technologies of production, adherence to ecological requirements and standards, development of different organizational forms of conveying the novel elaborations to agrarian producers and their scientific and consultative support, active state support, etc.

Key words: animal breeding, production index, production dynamics, cyclic development, agrarian crises, climatically neutral technologies, digitalization instruments, post-war period.

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INTRODUCTION

The relevance of the animal breeding industry for the economy of any country is determined by numerous factors, among which noteworthy is the fact that the products of animal origin are components of food safety, the increase in the consumption volume of which demonstrates the increase in the population's life quality. At the same time, global climate change impacts the resilience of animal breeding since it causes higher heat stress and greenhouse gas emissions, which conditions crisis phenomena in the industry. It requires the elaboration of preventive measures to minimize the negative impact of the crisis on the food safety of the country and the well-being of farm animals and poultry.

The system of preventive measures and practical actions regarding the flexible adaptation of animal breeding to climate change and the manifestation of other crisis-related effects based on the implementation of ecology-oriented and resource-saving approaches to the breeding technologies is considered by foreign researchers within the framework of sustainable development (Bonilla-Cedrez et al, 2023; Wawrzyniak, 2023).

The balanced development of the country's agriculture is achieved via a rational combination of plant production development (Shust et al, 2023) and animal breeding industry (Pavlenko and Vinichenko, 2017; Dankevych, 2014; Bohdanovych, 2015), which is a manifestation of the synergic effect for the purpose of enhancing the efficiency of the industrial activity of agrarian enterprises. It is explained by animal breeding being the largest consumer of plant cultivation products, namely, forage. It is known that almost one-third of globally produced cereals are used as fodder for farm animals and poultry (Bayram et al, 2023; Zhen et al, 2023). In addition, the animal breeding industry helps low-income strata of the population survive in hard-to-reach areas and is a valuable source of income for the rural population.

A relevant specificity of the animal breeding industry is its impact on preserving the biodiversity and genetic resources for food production and sustainable development of agriculture, which is confirmed by the fact that more than one-third of ruminants of the world is kept on the pastures in dry biomes. Thus, under the rational organization of production, the animal breeding industry may promote the fulfillment of relevant ecosystem functions, the circulation of nutrients, the binding of organic carbon in soil, and the preservation of agricultural landscapes.

At the same time, this ambiguous specificity of the animal breeding industry lies in its being a direct source of greenhouse gas emissions, mainly due to intestinal fermentation and manure, and an indirect source during fodder production (agricultural and forage crops). The functioning of animal breeding systems is accompanied by the release of large volumes of manure and by-products and the flow of nutrients into water and air.

Thus, the animal breeding industry develops under the impact of macro- and microenvironment factors, the combination of which defines its resilience and efficiency and conditions the manifestations of crisis-

related events and, thus, rises and troughs in production volumes and the corresponding changes in the effective indices of its development. Currently, all the described characteristics and conditions of animal breeding development have a high level of fluctuation and uncertainty, which conditions the specifics of its cyclicity manifestation and, thus, the elaboration of measures and actions, notable for a specific stage of development, which would promote stabilization and enhance positive tendencies. The main current task for the development of the agrarian sector of the economy, including the animal breeding industry, is reaching a sustainable increase, capable of meeting the current needs of the population for food and promoting the well-being of farm animals and poultry, as well as ensuring the growth and preservation of natural resources and ecosystems for the needs of future generations. Therefore, it is important to investigate the impact of agrarian crises on the changes in the structure and efficiency of the animal breeding industry to rationalize efficient measures for overcoming crisis phenomena.

The analysis of recent studies and publications. It is evident that higher variability and uncertainty in the functioning of the agrarian sector condition the need for scientific studies on the manifestation of agrarian crises and the elaboration of instruments for their study and monitoring in conditions of periodic imbalance in the agro-food system and its specific subsystems. Scientists have a higher interest in the study of the state and tendencies in the development of the investigated sector, the results of which are used for some conclusions. In the course of recent thirty years, until the full-scale russian aggression, there were four actual agrarian crises (Shust et al, 2023) that conditioned a considerable decrease in production volumes down to the level of the early 2010s, which requires the analysis of quantitative-qualitative changes in its structure, in plant production and animal breeding first and foremost, as well as in crisis years and inter-crisis periods, to find the points of post-crisis increase.

It should be noted that both foreign and domestic scientists study specific factors impacting the long-term component of the development of the animal breeding industry. For instance, in the research of the UN Food and Agriculture Organization (FAO), the strategic development of the animal breeding industry is considered based on the ramp-up of production volumes for the main types of products using the principles of sustainable development. The obtained results demonstrate that the animal breeding industry may make a direct or indirect contribution to each of the 17 Sustainable Development Goals, set in 2015 (SDG), but there is an urgent issue of decreasing the negative impact of the animal breeding industry on the biodiversity and environment (FAO, 2018). The same opinion is shared by domestic scientists (Holovachko et al, 2021; Lysenko, 2020), who see the overcoming of crisis phenomena in the animal breeding industry via the implementation of sustainable instruments and technologies.

The generalization of the study results of different scientists demonstrates that they have identified the factors, conditioning the manifestation of the risk in specific branches of the animal breeding industry and their consequences. However, there are not enough studies that would generalize the manifestations of the crisis and its consequences based on the study of its impact on the efficiency indices of the industry development, the balanced state of the industry structure, and the development of the food production industry. For instance, in the animal breeding industry, the main factors conditioning the crisis-related manifestations are the catastrophic shortening in the number of livestock, the decrease in the performance of animals and quality of products, due to which a long-term stagnation in the industry induced a decrease in the efficient indices and its attractiveness for investments and a shortening of animal breeding production volumes and the deterioration of food safety of the country, as a whole (Izhboldina et al, 2021). It is clear that under a sharp decrease in the purchasing power of the country's population, there is a distorted situation in terms of adhering to the requirements of food safety, which also promotes the ongoing negative tendency in the development of animal breeding and its strengthening.

We believe that the consequences of the COVID-19 pandemic for the animal breeding industry are currently not estimated because most studies mainly consider the failures in the functioning of production-sale chains in the industry and economic losses, but their impact on food safety and stability of the socioeconomic situation has not been studied (Rahman et al, 2023; Balagtas et al, 2021). However, the COVID-19 pandemic also triggered the decrease in the efficiency of the animal breeding industry and the shortening of investments required for the improvement of ecologic, social, and economic indices in the industry.

However, the most destructive effect on the development of the domestic animal breeding industry and exacerbation of crisis phenomena was made by the russian aggression. According to the preliminary estimates, the

losses of cattle are estimated at USD 1.7 billion. The experts note that the largest losses due to the decrease in the livestock numbers are observed in the production of milk and eggs, which amount to USD 254.2 million and USD 159.7 million, respectively. At the same time, the losses regarding other cattle and animal breeding products due to the decrease in animal herds, including pigs, cattle, poultry, sheep, goats, wax and honey from bees, amount to USD 210.5 million. The animal breeding industry has also suffered considerable losses due to the decrease in the efficiency of the animal breeding sector, which amounted to USD 1.1 billion (Top Lead Company, 2023; KSE, 2022). These losses were caused by killing, stealing, or injuring a large number of cattle, which may lead to a deficit in some animal-derived products. Thus, the war in the country has conditioned the exacerbation of risks in the animal breeding industry, the level of which is catastrophic in some regions.

The results of the study conducted by the FAO on the losses in agriculture due to the war based on the survey among the rural farmholds in Ukraine, demonstrate a decrease in the volumes of animal breeding production by USD 192.5 million due to a reduction in the number of animals. In addition, the experts stated that the consequences of war induced a decrease in the performance of farm animals and poultry that was registered as 2.7 % for poultry and 12 % for cattle, which resulted in a loss of income of USD 212.6 million (FAO, 2022). We believe that the expert evaluations in the agrarian sector of economy are significant, but they may be considered preliminary assessments, since the war is still going on, and there is no possibility to determine actual losses in the occupied territories. The war in this country will have a considerable negative effect on the future development of the animal breeding industry and demand the consolidation of resources for post-war restoration.

The stability of the development in the animal breeding industry is also affected by international factors since the global manifestations of crisis-related phenomena will impact the possibilities of the domestic animal breeding industry to restore in the aspect of procuring pedigree animals. The results of foreign investigations prove that the crisis has covered the animal breeding industry in the entire world which will pinpoint the issue of providing the global population with the products of animal origin. For instance, according to expert opinions, the global demand for cattle will have reached USD 20 billion by 2026, the tempo of annual increase in which is 0.3 % starting with 2017. In 2021, the leading countries, importing farm animals, were the USA, the import volumes of which were almost USD 3 billion, Germany, Italy, and the Netherlands. It is noteworthy that the global cattle population is expected to reach almost 2 billion animals by 2026, and the tempo of the annual growth is 0.5 % on average, starting with 1966 (Global Livestock Trends, 2022).

The crisis has currently been noted for the development of the animal breeding industry in France, which is a leading country in this sector. In the recent decade, the country has experienced a deterioration in the level of food safety in terms of animal products since almost 30 % of the total volume of meat and meat products consumed in the country are imported. At the same time, France lost 800 thousand cows in seven years. Therefore, they consider the offers about the instruments of state support for farmers' income, the acquisition of farms, and the provision of additional benefits for them because the annual inflation rate for food products reached very high values – 9.6 %. In addition, the country pays great attention to decreasing the risk of diseases among farm animals and poultry and allocates EUR 20 million for preventive measures.

It should be noted that from 2005 to 2020, the number of specialized animal farms in Europe decreased by 45 %, and the number of mixed farms – by 60 % (PigUA.info, 2023). It is obvious that this situation was conditioned by a number of factors – not crises merely but also adherence to ecological requirements, including strategic goals for the decarbonization of European animal breeding. Most European countries have introduced or are currently introducing the strategies of decarbonization of animal breeding (Perissi and Jone, 2022), which is met with different farmers' reactions. For instance, the Netherlands, a country with a powerful animal breeding industry in Europe with over 100 million animals (cattle, poultry, and pigs), the largest meat exporter in the EU, considers unconventional measures to achieve compliance with the European ecological requirements. For instance, the country has developed a proposal which envisages a reduction in livestock by 30 %, which is the most radical plan of its kind in Europe (The Guardian, 2021). With this purpose, they suggested scenarios that envisage forcing farmers to sell the rights for emissions and even their land to the state if the farm management does not comply with the requirements of the European Climate Law (European Climate Law, 2021). Considering the orientation of Ukraine to the European community, it is important to take into account the adopted require-

ments that will have an evident negative effect on the development of the animal breeding industry, which might exacerbate the crisis phenomena. Therefore, there is a need for the elaboration of a roadmap for the consistent transformation of animal breeding branches to comply with ecological requirements and adopt the relevant program documents on different levels of executive management.

The generalization of the study results of foreign and domestic researchers and international organizations allowed for a conclusion about the high variability and uncertainty of the environment of the animal breeding industry, which requires complex studies on its current state and the identification of the factors causing and enhancing the crisis-related phenomena.

The aim of the study is to determine the consequences of impairing the equilibrium in the structure of the agricultural sector of the economy as a result of the emergence and course of agricultural crises and the transition to a new model of agricultural production and their impact on changing the structure and performance of the animal breeding industry and to substantiate measures and practical actions aimed at its restoration with the consideration of ecological requirements, the limitations of dynamic growth and the need to achieve a balanced socio-ecological and economic development of the sectoral structure and the agro-food system.

METHODS OF STUDIES

A number of general scientific and specialized methods of research were used in the study. In particular, such general scientific methods as dialectic and systemic analysis and theoretic generalization were used along with the specialized methods: the method of dynamic rows – to analyze the variability of the production index and the performance of agrarian sector, including animal breeding industry; analysis and synthesis – to study, summarize, and systematize the manifestations of positive changes and negative consequences, related to the primary production, including animal breeding industry, through the peaks of agrarian crises and inter-crisis periods, to identify the problems, which occurred due to the aggression of the russian federation; economic-statistical method (grouping, comparison, indexing, tabular) – to process statistics data, visualize it and describe the phenomena and processes under investigation; variation dynamics – to determine the scale, periods, and variations in the fluctuation of the indices of gross agricultural output, including animal breeding; theoretical generalization – to systematize the results of the studies and to prepare substantiated conclusions.

The study on the impact of agrarian crises on the changes in the structure and performance in the animal breeding industry included the following stages: Stage I – the analysis of the variability of the production index in animal breeding in 2009–2021, based on which the descending and ascending trends will be determined along with the points of the lowest decrease (crisis trough) and maximal increase. The estimation of the tempo of the change in the gross animal breeding production volumes for the corresponding year was made compared to 1990 (accepted as the basic 100 %). It should be noted that the building of the dynamic row by the index of animal breeding production volume and the tempo of its change compared to 1990 and the previous period was done at the level of agriculture and food industry. Stage II was the determination of the efficient indices of the animal breeding industry development, which helped determine the impact of the crisis on the efficacy of the primary production and food industry; stage III – a complex study of the changes in the structure of the products of animal breeding industry and the efficacy of this production to determine the directions of the impact of agrarian crises. The informational foundation for the study was the data of the State Statistics Service of Ukraine.

THE RESULTS OF THE STUDIES

In the years of crisis, there were structural changes in the animal breeding industry in the process of restoring industrial potential after the transformational crisis. The peak of the transformational crisis was notable for a considerable decrease in livestock, poultry, and bee colonies (**Table 1**).

The restoration of the livestock should have happened after passing the trough of the transformational crisis, but the pre-crisis state was not reached in any branch of the animal breeding industry. For instance, as for cattle, in the basic year, the cattle livestock was estimated as 24,623.4 thousand animals; at the peak of the crisis — 10,626.5 thousand animals (43.1 % compared to 1990), and at the end of 2021 — 2,644.0 thousand animals (10.7 % compared to the basic year). The data obtained may be presented as follows: the ratio for the number of livestock in 1990 : 1999 : 2021 is 43.1 : 10.7 compared to the basic year. In terms of different branches of animal breeding: the livestock of cows in the dynamics in 1990, 1999, and 2021 was as follows: 8,372.0 : 5,431.0 : 1,544.0 thousand animals, which is

a ratio of 64.8 : 18.4 % compared to 1990; the livestock of pigs: 19,426.9 : 10,072.9 : 5,608.8 thousand animals – 51.8 : 28.9 % compared to the basic year; the livestock of sheep and goats: 8,418.7 : 1,884.7 : 1,094.3 thousand animals – 22.4 : 13.0 % compared to the basic year; the livestock of horses: 734.8 : 698.1 : 180.8 thousand animals – 94.6 : 24.6 % compared to the basic year; the livestock of rabbits: 6,308.2 : 5,600.3 : 4,370.6 thousand of animals – 88.8 : 69.3 % compared to 1990; the livestock of poultry: 246,104.2 : 126,079.8 : 202,243.1 thousand of birds – 51.2 : 82.2 % compared to the basic year; the number of bee colonies: 3,515.1 : 2,856.5 : 2,686.0 thousand of bee colonies – 81.3 : 76.3 % compared to the basic year.

Table 1. Structure and dynamics of the cattle and poultry livestock: as of the end of the year, thousands of animals

Species	1990: note	1998	1999 –	2000	2009	2010	2011
Cattle	24623.4	11721.6	10626.5	9423.7	4826.7	4494.4	4425.8
Including cows	8378.2	5840.8	5431.0	4958.3	2736.5	2631.2	2582.2
Pigs	19426.9	10083.4	10072.9	7652.3	7576.6	7960.4	7373.2
Sheep and goats	8418.7	2026.0	1884.7	1875.0	1832.5	1731.7	1739.4
Horses	738.4	721.3	698.1	701.2	443.4	414.2	395.7
Rabbits	6308.2	5673.4	5600.3	5557.1	5620.6	5354.7	5642.7
Poultry	246104.2	129474.0	126079.8	123722.0	191446.4	203839.8	200760.6
Bees, thousands of colonies	3515.1	2974.3	2856.5	2849.3	3150.5	2921.5	2890.9
							Source: composed and estimated according to the data
Tempo of change in the production volumes, %	100.0	46.2	44.9	43.3	51.1	51.8	51.9

Note. Source: composed and estimated according to the data of the State Statistics Service of Ukraine for the cor-

Table 2. Structure and dynamics of animal breeding production

Kind of products	1990: note	1998	1999	2000	2009	2010	2011
Meat (in slaughter weight), thousand tons	4357.8	1706.4	1695.3	1662.8	1917.4	2059.0	2143.8
Milk, thousand tons	25508.3	13752.7	13362.2	12657.9	11609.6	11248.5	11086.0
Eggs, millions	16286.7	8301.4	8739.7	8808.6	15907.5	17052.3	18689.8
Fleece, tons	29804	4600	3800	3400	4111	4192	3877
Honey, tons	50858	58899	55451	52439	74051	70873	70311
							Productivity of farm animals
Average annual yield of milk from one cow	2863	2219	2358	2359	4049	4082	4174
Average annual yield of fleece from one sheep	3.4	2.9	3.0	3.0	3.6	3.4	3.4
							Note: animal breeding production
Tempo of change in the production volumes, %	100.0	46.2	44.9	43.3	51.1	51.8	51.9

Note. Source: composed and estimated according to the data of the State Statistics Service of Ukraine for the cor-

The main factors which conditioned the reduction of the livestock are as follows: "withering away" of the old-fashioned forms of production organization and physical destruction of the material foundation of animal breeding as a result of its division into shares; a reduction in the raw resources of the cooperative animal breeding due to the division of land plots and their privatization to meet the needs of small farmers; the reduction and termination of industrial-economic relations between agricultural and food processing enterprises; a higher imbalance in the prices for raw materials of animal origin and industrial material and technical resources, concentrated fodder, and zoovet-erinary maintenance, provided to animal breeding complexes, commercial dairy farms, and forage stor-ing premises; an increase in the unprofitableness of the

2014	2015	2016	2019	2020	2021	1999: in % till 1990	2020 in % till 1999	2021 in % till 2020
3884.0	3750.3	3682.3	3092.0	2874.0	2644.0	43.1	27.0	92.0
2262.7	2166.6	2108.9	1788.5	1673.0	1544.0	64.8	30.8	92.3
7350.7	7079.0	6669.1	5727.4	5876.2	5608.8	51.8	58.3	95.5
1371.1	1325.3	1314.8	1204.5	1140.4	1094.3	22.4	60.5	96.0
316.8	305.8	291.5	224.2	202.0	180.8	94.6	28.9	89.6
5141.3	5042.9	4940.4	4522.9	4504.7	4370.6	88.8	80.4	97.0
213335.7	203986.2	201668.0	220485.8	200651.9	202243.1	51.2	159.1	100.8
2699.6	2590.0	2487.1	2633.2	2594.4	2686.0	81.3	90.8	103.5
of the State Statistics Service of Ukraine for the corresponding years								
55.8	53.7	52.6	53.6	52.3	49.9	–55.1	7.4	–2.4

responding years.

2014	2015	2016	2019	2020	2021	1999: 1990	2020: 1999	2021: 2020
2359.6	2322.6	2323.6	2492.4	2477.5	2433.8	38.9	146.1	98.2
11132.8	10615.4	10381.5	9663.2	9263.6	8713.9	52.4	67.8	94.1
19587.3	16782.9	15100.4	16677.5	16167.2	14071.3	53.6	185.0	87.0
2602	2270	2072	1734	1573	1497	127.5	41.4	95.2
66521	63615	59294	69937	68028	68558	109.0	122.7	100.8
(liters; kg)								
4508	4644	4735	4976	5129	5155	82.4	217.5	100.5
3.0	2.9	2.8	2.6	2.7	2.9	88.2	90.0	107.4
(1990 as 100 %)								
55.8	53.7	52.6	53.6	52.3	49.9	–55.1	7.4	–2.4

responding years.

manufacturing of animal products, etc. The descending trends, initiated in the transformational period, reached such dynamics that they still go on in all directions of animal breeding.

The analysis of the dynamics in the breeding of cattle and poultry demonstrated that in terms of the live weight of farm animals in 1990, 1999, and 2021, the breeding ratio was 6,465.0 : 387.8 :3,329.8 thousand tons or 36.9 : 51.5 % compared to the basic year. These included: cattle: 3,248.1 : 1,093.8 : 475.1 thousand tons – 33.7 : 14.6 %; pigs: 2,097.8 : 929.5 : 971.2 thousand tons – 44.3 : 46.3 %; goats and sheep: 99.3 : 37.5 : 24.6 thousand tons — 37.8 : 24.8 %; horses: 19.2 : 17.9 : 12.1 thousand tons — 93.2 : 63.0 %; horses: 19.2 : 17.9 : 12.1 thousand tons — 93.2 : 63.0 %; rabbits: 60.5 : 29.2 : 21.4 thousand tons — 48.3 : 35.4 %; poultry: 940.1 : 279.9 : 1,825.4 thousand tons — 29.8 : 194.2 %. Therefore, our estimates demonstrated that the only direction of animal breeding where the index of 1990 became twice higher was poultry breeding. Despite the decrease in the poultry count down to 82.2 % from the basic year, there was a 2.36-fold gain in live weight due to a balanced diet, i.e., the increase in productivity.

The results of the dynamics of the animal breeding industry in Ukraine and the performance of farm animals (**Table 2**) showed that after the transformational decline, there was some improvement in meat production (up to 55.8 %) and a considerable increase in egg production (up to 86.4 %). At the same time, even at the peak of the crisis, there was more than one-quarter more fleece (an increase of 27.5 %), yet it was followed by a sharp decline (down to 39.4 %); there was also an increase in honey yield (a gain of 9 %), and the ascending trend for honey was maintained by the end of the investigated period (an increase by one third). The descending trend of milk production is permanent, and as of the end of the investigated period, only one-third of the 1990 volume was produced in Ukraine (34.2 %). A similar trend was found for the average annual yield of fleece from one sheep (down to 85.3 %). However, the decline in the average annual yield of milk from one cow at the peak of the transformational crisis changed to the ascending trend, and at the end of the investigated period, the yield of milk increased 1.8 times – up to 5,155 liters. This was a result of the perennial work on enhancing the performance of cows and improving the quality structure of the herd by scientifically substantiated selective breeding work, the use of modern potential of genetic resources, and the increase in the share of highly productive animals in the herd.

Considering the decrease in the number of cows more than five times in the investigated period, noteworthy are the changes in the structure of milk farms by their size (**Table 3**). The statistical data allow for tracing the changes in terms of economic subjects for 10 years (2011–2021).

The estimates in the Table demonstrate that during this period, there was more than a two-fold reduction in the number of enterprises that bred cows. The highest losses were observed in the group of smallest enterprises, which kept up to 50 animals – 2.8 times (about 536 enterprises); large losses were registered for the group of small agrarian enterprises (50–99 animals) – 2.2 times (about 203 enterprises), and middle-sized enterprises (100–499 animals) – 1.9 times (about 716 animals), but their share increased from 37.7 to 42.5 %. A similar contradictory tendency was observed in the group of large agrarian enterprises (500–999 animals) – their number decreased 1.5 times, down to 150 enterprises, but their share increased up to 8.9 %. And only a group of extralarge enterprises (over 999 animals) had a quantitative, 1.6-fold (about 81 enterprises) and relative (up to 4.8 %) increase. Thus, with the reduction in the number of enterprises keeping cows, there is a rapid decrease in the group of small enterprises, an almost twofold decrease in the number of large ones, but there is a relative and quantitative increase in the extralarge ones. Actually, there was a territory-wise (convergent) concentration of large and extralarge enterprises with a reduction in small and even medium-sized ones.

There were also evident changes in the structure of enterprises, breeding poultry, which started with the general twofold decrease in their number in 2011–2021 (down to 316 enterprises). However, this tendency was most evident in the example of small agricultural enterprises (down to 4,999 animals): their number decreased almost four times (down to 100) and almost twice in relative terms (the share was 31.6 %). A similar tendency was manifested in the group of medium-sized poultry-breeding enterprises (5,000–49,999 birds): their number decreased by 1/6 (down to 91), but the share increased almost twice – up to 28.8 %. The same tendency was observed in the group of large poultry-breeding enterprises (over 50,000 birds): their number decreased almost by 40 % (down to 125), but the share increased almost one and a half times – up to 39.6 %. The general conclusion is as follows: in crisis periods, there was a sharp decrease in the number of small and

medium-sized poultry-breeding enterprises, but the reduction of large poultry-breeding structures occurred with a slower tempo, thus resulting in a territorial (convergent) concentration of enterprises, producing poultry meat and eggs.

Therefore, the analysis of the development of the animal breeding industry under the transformational and agrarian crises and inter-crisis periods in terms of industry branches and specific products helped determine the specificities of their functioning and production performance in dynamics. No clear manifestation of regularities in the cyclic development was registered by the main indices of animal breeding because after slight rises, this branch remained on a low level, and because the peak of the agrarian crisis had descending dynamics.

As for the perspective of the post-war restoration of animal breeding branches, it is reasonable to consider a rapid decline in the production caused by catastrophic consequences of the russian aggression on the occupied and liberated territories. Yet the drop in animal breeding production, in this case, is not related to the cyclic development of the agrarian sector, it is artificially induced by the russian aggression. It allows for the assumption that agriculture, including the animal breeding industry, is likely to actually follow the same route but under different circumstances, i.e., after an evident positive rise in 2021 (the index of the gross production of agriculture was 104.8 %, according to the updated data) and a rapid decline in production in 2022 (the gross output in the industry decreased by more than a quarter compared to the previous year (Lupenko, 2023) or amounted to 77.5 % compared to 1990, there will be a gradual transition to the post-war ascending trend of development. It should be noted that in 2023, experts predicted a decline in animal breeding production by 2.2 % compared to the previous year. Such insignificant indices of the production decline can be explained by the fact that the experts accepted 2022 as the comparison basis when low values of these indices were reached (Lupenko, 2023).

The abovementioned allows us to make an assumption that the restoration of the agrarian resource potential of Ukraine, including animal breeding, in the post-war volumes and its ramp-up will take a considerable amount of time, and the results of its usage after the rapid decline of 2022–2023 will be characterized by a global ascending trend. However, it does not exclude

Table 3. Grouping of agricultural enterprises by the number of cows as of the end of the year

Number of agricultural enterprises	2011: peak		2015		2021: peak			
	Enterprises							
	units	%	units	%	units	%	%	%
Enterprises with the livestock – total	3591	100.0	2614	100.0	1686	100.0	72.8	64.5
Of these, had animals								
up to 5	491	13.7	269	10.3			54.8	
6–20	591	16.4	411	15.7			69.5	
21–49	420	11.7	305	11.6	536	31.8	72.6	54.4
50–99	459	12.8	326	12.5	203	12.0	76.0	62.3
100–199	664	18.5	470	18.0			70.8	
200–299	338	9.4	292	11.2			86.4	
300–399	216	6.0	186	7.1			86.1	
400–499	135	3.8	104	4.0	716	42.5	77.0	68.1
500–999	226	6.3	187	7.2	150	8.9	82.7	80.2
over 999	51	1.4	64	2.4	81	4.8	125.5	125.5

Note. Source: composed and estimated according to the data of the State Statistics Service of Ukraine for the corresponding years.

local declines due to different unfavorable circumstances: deterioration of natural climatic conditions, higher turbulence in the environment, reaching the peak of the economic and then agrarian crises, etc.

DISCUSSION

The results of our study allow for isolating the specificities of the manifestation of agrarian crises in the national economy and its impact on the development of the animal breeding industry, the incidence of which is manifested in shorter periods and is impacted by numerous global challenges, including climate change, digitalization, etc. The results of our study correlate with the conclusions made by domestic researchers (Petrukha et al, 2022; Shyan, 2013; Shust et al, 2023), in the aspect of the manifestation of crisis phenomena in the agrarian sector of the economy, their impact on the branches of plant production (Shust, 2023), the methodological approaches to their study, the duration, etc. It is evident that the changes in the characteristics of agrarian crises in the main branches of agriculture, including animal breeding, are caused by the turbulence in the world economy in two recent decades and the national specificities in their development.

At the same time, the results of this study became the generalization of the determined regularities in the impact of specific technological and economic factors on the efficient indices of dairy production and its risks (Lutsenko et al, 2021; Varchenko et al, 2019) The study of the factors forming the competitiveness of the domestic pig breeding industry via the prism of technical, technological, and economic parameters (Ibatulin et al, 2019; Ibatulin and Varchenko, 2019) helped systematize those, affecting the exacerbation of crisis phenomena in pig breeding. The obtained results of the study on the development of poultry breeding are confirmed by the conclusions on the availability of competitive advantages of the industry in the internal and external markets, the specificities of quality parameters, and the possibilities of forming considerable volumes of supplies (Lupenko et al, 2020).

The exacerbation of crisis phenomena in animal breeding occurred due to the war in the territory of our country, which accrues relevance to taking efficient management measures and actions on macro- and microlevel in creating the prerequisites for the stabilization of the losses in the livestock and poultry and ensuring the conditions of simple restoration. In the future, there will evidently be a more complicated strategic task of extended restoration of the animal breeding industry, the implementation of which will take place on the foundation of domestic specificities and modern global trends of its development.

The publications, dedicated to the problems of food provision under agrarian crises, clearly define the factors, conditioning the instability of their development and the instruments to overcome them. Among the most impactful factors that have now and will in the future have an effect on the development of the animal breeding industry, there are global climatic changes and digitalization. The introduction of the digitalization instruments in the investigated industry is considered by both domestic and foreign researchers within the framework of so-called smart livestock farming, envisaging the application of novel technological achievements to improve the ability for extended restoration of the number of farm animals and poultry, sustainable functioning, and enhancing the social, ecological, and economic efficiency in animal breeding industry (Syniavina et al, 2021; García et al, 2021; FAO, 2020). It would allow the manufacturers of animal breeding products to minimize and neutralize climatic risks. It should be noted that the model of smart animal breeding provides for the monitoring of specific animals and introducing reasonable methods and technologies for keeping them, which are considered within the concept of the Internet of Things (IoT). The results of the study demonstrate that IoT ensures the economy of time and industrial resources, provides remote access of the farmer and other interested persons to the data about the state of animals, and identifies the producer and product in the supply chains in agriculture, based on the BlockChain technology (BC) (Alshehri, 2023; Khan et al, 2023). Thus, the technology of smart animal breeding is based on the managers' use of IoT-BC-SLF technologies, which would enable the synergic effect via the improvement of conditions of the organization and management on the farm, the improvement of quality and safety of the products, ensuring the well-being of animals, which, in a combination, will provide for the social, ecological, and economic stability of the animal breeding production.

It is obvious that the creation of the IoT network in the manufacturing of animal breeding products under higher temperatures on the premises would ensure the arrangement of the corresponding conditions for animals and poultry via the activation of the system of cooling or ventilation (Lovarelli et al, 2020; Iwasaki et al; Idoje et al, 2021).

The management technology for animal breeding farms with the IoT eliminates the unpredictability of

the maintenance conditions since it allows for obtaining information about the location, temperature, blood pressure, and heart rate of animals and sending it in real time to the farmers' gadgets via the battery-run monitors on the collar or the tag (Wolfert et al, 2017). The Internet of Things can be used to trace the physiological state, movement, and behavior of animals and control the sanitary and hygienic conditions in the premises and the process of feeding (Javaid et al, 2022; Mansour, 2022).

A current relevant element in the development of animal breeding is blockchain technology and non-contact probing, which ensure the safety and quality of products in the meat supply chains, form the arrays of information about the livestock in terms of age and gender parameters of animals and poultry, help determine the location of an animal in real time, etc. and transmit the obtained information in the networks (Yin, 2023; Walter et al, 2017; Tedeschi et al, 2021). It is noteworthy that the animal breeding industry is one of the least digitalized in the 21st century, but it can benefit from the implementation of digital instruments, which will promote enhancing the efficiency of the manufacturing of animal breeding products and the sustainability of the industry.

At the same time, in some branches of the industry, for instance, in dairy farming, the use of artificial intelligence has already been used along with robots for cow milking, which promotes the efficiency of milk production and the reasonable adoption of decisions by the farm management. It should be noted that artificial intelligence is the foundation for the so-called Digital Twin (DT) technology (Mishra and Sharma, 2023), which is a digital copy of the intellectual environment of cattle that is constantly updated, which helps decrease the production costs. Among the instruments that can be used for automatic tracing of the location of specific animals, noteworthy are the Global Positioning System (GPS), the Radio Frequency IDentification (RFID), artificial intelligence, and Machine Learning (ML).

Thus, the perspective development of animal breeding in Ukraine should be considered on the basis of a wide application of digital instruments, which demands from domestic producers the provision of country-wide Internet access and promotion of the culture of using digital instruments among managers and employees of animal farms, etc. The application of the abovementioned digital innovations for the monitoring and evaluation of the well-being of animals, the implementation of specific technological processes, the analysis and forecasting of the indices of diseases for some farms, and the economic indices of the development is a good perspective. Still, these methods are complicated, they require investments in equipment, hardware, and software, as well as the training of management and employees of farms.

A special factor to be considered in the post-war restoration of the animal breeding industry is compliance with ecological requirements and achieving the conditions of climatically neutral development. The researchers state that the agro-food systems are responsible for one-third of the global anthropogenic greenhouse gas (GHG) emissions, 57 % of which are related to the manufacture of products of animal origin (Xu et al, 2021). Considering the ever-increasing global population, the demand for food products of animal origin will be higher, which will cause an increase in production volumes and, thus, GHG emissions.

On the level of animal farms, the GHG emissions are mainly related to keeping the farm animals and poultry (the by-products — manure, feces, urine, and digestion of ruminants), which condition the emissions of methane, nitrogen dioxide, and carbon dioxide. According to the estimates, the animal breeding industry is responsible for the emission of 39 % of total methane and 65 % of nitrogen dioxide. For instance, methane is formed due to the digestion of animals and large volumes of manure accumulated in farms and kept without any compliance with scientific and ecological requirements (Yaroshchuk, 2018). According to the data of the National Center for GHG Inventory, in 2021 in Ukraine, the GHG emissions amounted to 341.5 million tons of CO_2-equivalent, and the share of agriculture was 14 % (the National Center for GHG Inventory, 2021). As per experts, before the full-scale russian invasion, agriculture was characterized by an increasing dynamics of GHG emissions for the last decade, which demonstrates that there were no direct evident changes regarding the implementation of climatically neutral technologies in agricultural production. Obviously, the implementation of measures and practical actions regarding the international obligations of the country, along with the realization of strategic national and regional programs in the area of mitigating the consequences of climate change and adaptation to them, are urgent tasks. Still, they have become more complicated due to the occurrence of new ecological threats caused by the war. However, the measures in decarbonization and development of biogas production

retain their urgency in the animal breeding industry (Scientific Report, 2022), namely, objective assessment of the branches of the animal breeding industry on the level of the entire production cycle, outlining direct and indirect emissions; organization of the biogas production using the by-products of the animal breeding industry; implementation of efficient rates of the ecology tax which would stimulate the producers to introduce ecology-oriented technologies in animal breeding, as well as the processing and storing of the by-products.

There are attempts in the foreign and Ukrainian practices to develop approaches for agricultural producers to acquire carbon-neutral status and initiatives for reporting and certification (Nekhai, 2022; Rissman et al, 2020; Ridoutt, 2021; Dagle et al, 2017). At the same time, the specific feature of the animal breeding industry, especially dairy and meat production and sheep breeding, lies in the formation of methane (CH_4) emissions along with carbon dioxide. It should be noted that researchers refer methane to short-time climatic factors, the lifetime of which in the atmosphere is only 12 years (Myhre G. et al., 54), and the long-term contribution of which into global warming is relatively small (Allen et al, 2018; Lynch and Pierrehumbert, 2019). Therefore, there is a need for an objective assessment of the impact of different emissions of greenhouse gases on climate to decrease the negative attitude of society to animal breeding as the main pollutant of the environment. A relevant role in the spreading of climatically neutral technologies in the manufacturing of animal breeding products is played by the change in the population's behavior in food consumption, which may become the instrument for a considerable reduction in global GHG emissions. It is obvious that currently, consumers feel a shortage of information about ecological problems, especially in the aspect of the formation of food wastes and the impact of their choice of purchases on the environment. In addition, there is a need to improve public opinion regarding climate change, to spread objective information and communication; these are key conditions for the provision of consumers with the possibility of accepting the required changes in their decision about the purchase.

The next factor to be considered in the strategic program of the post-war restoration of domestic animal breeding is the activation of the innovational activity. It will become possible due to the higher efficiency of the national system of agricultural innovations, the main directions of which should be focused on generating, spreading, and applying the knowledge and innovations based on the long-term partner relations of subjects in the state sector, agrobusiness, and the society. In this aspect, it is important to create favorable conditions for enhancing the efficiency of scientific studies, first of all, via the diversification of the sources of financing, enhancing the level of innovations in the research base, modernization of the directions of scientific research in the animal breeding industry, including global climate changes, the introduction of sustainable technologies in the manufacture of animal breeding products, etc. The foreign practice shows that one of the directions may be the creation of national and regional innovational agricultural networks, which are considered to be the networks of technological research, including universities, state and private research institutions and companies, targeting the elaboration of new products or business concepts (Möller et al, 2005; Hurmelinna-Laukkanen et al, 2022; Rubach et al, 2017; Hoholm and Olsen, 2012). It should be noted that the innovational networks in the leading countries of the world are efficient in the elaboration of measures and practical actions to decrease the negative impact of the industrial activity of the animal breeding industry on the environment. Under these conditions, it is important to streamline the activity of scientific research institutes and agrarian universities in the domestic practice towards conducting interdisciplinary studies on the mobilization of the internal potential of animal farms in their adaptation to climate, war, and other risks which will ensure the preservation of their ability to perform the industrial activity and form positive conditions for the positive dynamics of such indices as the number and performance of farm animals and poultry and the production volumes.

CONCLUSIONS

There was no restoration of the animal breeding industry in Ukraine after the transformational crisis: the highest indices were registered in 2013 – 56.1 % from the level of the animal breeding production index in the basic year as compared to the lowest value of 43.3 % in 2000. It was demonstrated that practically all the effective indices of animal breeding production tended to decrease, except the following ones: poultry meat production, the production volumes of which increased twice; the production of honey was increased by one-third; the performance of cows increased by 1.8 times. Therefore, the restoration of the animal breeding industry may be solved via intensive methods, envisaging the increase in the number of livestock and poultry with the corresponding building of the material

and technical foundation, the expansion of the areas under forage crops, the restoration of the natural fodder base, and the expansion of concentrated fodder production capacity, the introduction of resource-saving and ecology-oriented technologies, digital instruments, and innovational solutions with the adherence to the sustainable development principles.

After the institutional crisis, the restoration of the food industry (the production index of 37.4%) was the fastest — in 2005, the production index was 101.4 %, then the drop in the production index below the basic level was registered in 2015, with the production index of 95.2 % and in 2021 — 99.3 %. The worst years in terms of economic indices were 2014–2016 — the cost-effectiveness of the entire activity and the income were below zero. In the year when the russian aggression started, the dynamics of economic indices was declining, which demonstrated the exacerbation of the crisis in the food industry.

A close association between the animal breeding industry and plant production requires the search for their optimal development as interdependent and intersupplemental branches on the level of specific agricultural enterprises, which would allow for the formation of the synergic impact on the creation of conditions for the economic growth of agriculture and food industry. We believe that the tendency towards the decrease in the indices of the development of the animal breeding branches in Ukraine will be observed in future compared to the basic period and 2021, preceding the aggression, and the tempo of the post-war restoration will depend on the factors, among which we would like to highlight the efficiency of the instruments of state support for the agrarian sector of economy, enhancing the investment attraction of the industry, financial provision for the measures and practical actions on effective overcoming of war consequences in the occupied and front-line regions, the efficacy of the anti-crisis management of agricultural enterprises, the willingness of producers to actively implement digital instruments, innovational climate-neutral technologies, ensure the quality and safety of meat supply chains, etc.

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Сучасні аспекти розвитку тваринництва України із урахуванням впливу аграрних криз

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Мета. Вивчити наслідки циклічного розвитку аграрного сектора й оцінити зрушення в структурі та результативності галузі тваринництва внаслідок виникнення та перебігу аграрних криз і міжкризових періодів, обґрунтувати заходи та практичні дії щодо її відродження. **Методи.** Застосовано загальнонаукові методи, зокрема, історико-логічний, діалектичного й системного аналізу, теоретичного узагальнення, аналізу й синтезу, а також варіативної динаміки, порівняння, групування, індексний, табличний. **Результати.** Досліджено циклічний характер розвитку аграрного сектора, і зокрема тваринницької галузі та встановлено, що аграрні кризи, починаючи з 1990 р. по 1999 р. тривалістю 10 років, з 2000 р. по 2010 р. – 10 років, 2011 р. по 2015 р. – 5 років, з 2016 р. – 2020 р. – 5 років, є результатом цього процесу, а їх «дно» є відправною точкою для започаткування нового циклу. Виявлено, що при переході до нових форм господарювання було зруйновано матеріальну базу тваринництва, скорочено посівні площі під кормовими культурами, порушені наукові вимоги до сівозмін, однак трансформаційні процеси сприяли організації тваринницьких підприємств різних організаційно-правових форм. Аналітично доведено, що відновлення тваринництва після трансформаційної кризи не відбулося – найвищі показники було зафіксовано у 2013 р. –

56,1 % від рівня індексу виробництва продукції тваринництва у базовому році, порівняно з найнижчим значенням цього індикатора 43,3 % у 2000 році. Доведено, що практично всі результативні показники виробництва продукції тваринництва мали тенденцію до зниження, за винятком: вирощування м'яса птиці, обсяги виробництва якого збільшилися вдвічі; отримано меду на третину більше; продуктивність корів зросла в 1,8 рази. Російська агресія спровокувала поглиблення кризових явищ у галузі тваринництва, що зумовить прояв катастрофічних ризиків в окремих підгалузях, таких як м'ясне та молочне скотарство. Запропоновано основні напрями стратегічного повоєнного відновлення розвитку галузі тваринництва на основі інтенсивних методів нарощення поголів'я сільськогосподарських тварин, модернізації виробничого потенціалу тваринницьких комплексів, розширення площ кормовими культурами, відтворення природної кормової бази і збільшення потужностей з виробництва концентрованих кормів, впровадження ресурсоощадних та екологоорієнтованих технологій, цифрових інструментів із додержанням принципів сталого розвитку та інноваційного забезпечення. **Висновки.** Виявлено, що у більшості підгалузей тваринництва не відбулося відновлення поголів'я після проходження «дна» трансформаційної кризи та не вдалося досягти показників докризового стану, за винятком птахівництва. Низхідні тренди, які було започатковано у трансформаційний період, набули такої динаміки, що продовжуються і дотепер у основних галузях тваринництва. Винятком є галузь м'ясного птахівництва, у якій поголів'я птиці зменшилося до 82,2 % від базового року, однак забезпечено приріст живої ваги в 2,36 рази, що й сприяло збільшенню обсягів виробництва продукції майже вдвічі. Встановлено, що низхідний тренд з виробництва молока має постійний характер і наприкінці досліджуваного періоду у країні було вироблено лише третину від показника 1990 р. (34,2 %). Це зумовлено тим, що поголів'я корів скоротилося більш як уп'ятеро за досліджуваний період, однак значення показника середньорічного удою молока від однієї корови змінилося на висхідний тренд і наприкінці досліджуваного періоду надій зріс у 1,8 рази – до 5155 л. Доведено, що у кризові роки відбувається зменшення кількості малих і великих сільгосппідприємств з виробництва молока, а кількісно збільшується група надвеликих. За основними показниками розвитку тваринництва не встановлено чіткого прояву закономірностей циклічного розвитку, оскільки галузь після незначних підйомів, так і залишилася на низькому рівні, а з піку другої аграрної кризи взагалі набула спадної динаміки. Обґрунтовано, що основними чинниками скорочення часових періодів прояву кризових явищ у галузі тваринництва є: глобальні кліматичні зміни, посилення ініціатив щодо впровадження кліматично нейтральних технологій виробництва продукції, додержання екологічних вимог та стандартів, розвитку різних організаційних форм доведення інноваційних розробок до сільгоспвиробників і наукового та консультативного їх супроводу, дієвої державної підтримки,тощо.

Ключові слова: тваринництво, індекс продукції, динаміка виробництва, циклічний розвиток, аграрні кризи, кліматично нейтральні технології, інструменти цифровізації, повоєнний період.

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