EFFECTIVE POPULATION SIZE FOR DIFFERENT TECHNOLOGIES OF POULTRY GENE POOL MAINTENANCE

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Despite military operations, the poultry industry has a huge impact on Ukraine's food security. This is achieved through the production of sufficient quantities of various types of poultry meat and table eggs, which are the most affordable components of the daily food basket of Ukrainians. In order to provide producers (micro, small, and medium-sized farms) with genetic resources for poultry, it is necessary to involve domestically bred breeds through a state program, strengthen integration with large industrial complexes, and attract investment. The research was conducted at the experimental base of the State Research Station for Poultry Farming of the Institute of Animal Husbandry of the National Academy of Agrarian Sciences of Ukraine using genetic resources of chickens of various productivity types from the collection of the national gene pool of Ukrainian poultry breeds. Current paper represents results of scientific research focused on comprehensive analysis of the economic efficiency of maintaining the gene pool of chickens of different productivity types. Based on the results of a comparative analysis, taking into account the effective population size (N≥200 heads), the number of poultry groups using different technological equipment (number of group cages from 14 to 20) is justified. Indicators were calculated for the use of standard premises (12x72; 12x84; 12x96 and 18x72; 18x84; 18x96 m) and the minimum number of gene pool groups of chickens of different productivity directions using domestically produced cage equipment (OKPB-2 type) was established, ranging from 24 (laying hens) to 17 (broilers) to 49 to 34 groups, respectively. The number of cages in the corresponding poultry houses that need to be used to complete the gene pool groups of poultry is, respectively, from 216-324 to 296-444 (for OKPB-2 type equipment) and 272-408 and 376-564 (TBR-2 type). Obtained data can be used in the future for calculations and determining directions for improving the economic efficiency of maintaining the gene pool of chicken breeds of different productivity directions.

Keywords: gene pool, chickens, husbandry technology, cage equipment, effective population size.

ЕФЕКТИВНА ЧИСЕЛЬНІСТЬ ПОПУЛЯЦІЙ ЗА РІЗНИХ ТЕХНОЛОГІЙ УТРИМАННЯ ГЕНОФОНДУ ПТИЦІ

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Галузь птахівництва, незважаючи на військові дії, має величезний вплив на формування продовольчої безпеки України. Це досягається за рахунок виробництва в достатній кількості м'яса різних видів птиці та харчових яєць, які є найбільш доступною складовою щоденного харчового кошику українця. Для забезпечення виробників (мікро-, малі- та середні господарства населення) генетичними ресурсами птиці необхідно залучати породи вітчизняної селекції за рахунок державної програми, посилення інтеграції з великими промисловими комплексами та залучення інвестиції. Дослідження проведено на експериментальній базі Державної дослідної станції птахівництва Інституту тваринництва Національної академії аграрних наук України за використання генетичних ресурсів курей різного напряму продуктивності з колекції національного генофонду птиці української селекції. В роботі представлено результати наукових досліджень спрямованих на комплексний аналіз економічної ефективності утримання генофонду курей різного напряму продуктивності. За результатами порівняльного аналізу, з урахуванням ефективної чисельності популяцій (N≥200 голів), обґрунтовано кількість груп птиці за використання різного технологічного обладнання (кількість групових кліток від 14 до 20 шт.). Розраховано показники, щодо використання типових приміщень (12х72; 12х84; 12х96 та 18х72; 18х84; 18х96 м) та встановлено мінімальну кількість генофондових груп курей різного напряму продуктивності із використанням кліткового обладнання (тип обладнання ОКПБ-2) вітчизняного виробництва, відповідно від 24 (яєчні кури) – 17 (м'ясо-яєчні) до 49 – 34 груп. Кількість кліток у відповідних пташниках, які необхідно залучати для комплектування груп генофонд птиці становить, відповідно від 216-324 до 296-444 (для обладнання типу ОКПБ-2) та 272-408 і 376-564 (типу ТБР-2). Отримані дані в подальшому можливо використовувати для розрахунків та визначення напрямів покращення економічної ефективності утримання генофонду порід курей різного напряму продуктивності.

Ключові слова: *генофонд, кури, технологія утримання, кліткове обладнання, ефективна чисельність*

Introduction. Agriculture is the foundation and one of the main industries that ensures food security in the country. Sustainable development of the industry requires the integration of science and business on the platform of innovative bioeconomy in the crisis economic and legal conditions of Ukraine (Volodin S. et al., 2023; Hlushkov O., Lazakovych I., 2025; Shelenko D., Madryha D., 2025) through the introduction of environmentally friendly technologies, reduction of environmental impact, and optimization of logistics (Karkach P. et al., 2023; UlychV., 2021).

Poultry farming is a sub-sector of animal husbandry that produces about 70% of animal protein (meat from various types of farm poultry and edible eggs). The share of poultry meat (99% of which is broiler chicken) of various types in the total production of meat (in live weight) of farm animals is about 58.5% (State Statistics Service of Ukraine,

2020). Therefore, these products are the most affordable and basic in the food basket of Ukrainian citizens and, accordingly, influence the formation of food security, despite regional characteristics (Savchenko T., 2023; Hryvkivska O., Krasnorutskyi O., 2023).

According to data from the State Statistics Service of Ukraine (2025), poultry farming combines two powerful sectors. First, there are specialized enterprises that produce about 50% of table eggs and about 90% of broiler chicken meat. The second part consists of small and medium-sized private farms. Specialized enterprises are fully focused on the use of foreign genetic resources and technologies, which make the poultry industry the most automated in the world (Nikolyuk O., et al., 2023; Shevchenko A. et al. 2023).

Global innovations do not always work in micro, small, and medium-sized enterprises, where there are difficulties with automated microclimate, balanced feeding, and veterinary and sanitary safety. There is also a major problem with high-quality genetic resources, as there have been no poultry breeders in the country over the past decade aimed at meeting the needs of the population. (Ladyka V. et al., 2023; Voytenko S., Vasylieva O., 2018).

We should underline that despite the seemingly satisfactory situation with gross poultry production in Ukraine, the majority of it is produced by agricultural holdings and large specialized poultry enterprises, which have recently been focusing mainly on exports (Voloshchuk K., Lisevych N., 2019; Yatsiv, S., 2021). The share of private households in the production of both meat and eggs is decreasing every year. At the same time, as global experience shows, the development of small businesses in rural areas (including backyard and farm poultry farming) is more important for the sustainable development of rural areas, as it increases employment and improves the well-being of the rural population, supports the viability of rural settlements, and develops their infrastructure (Avercheva N., 2022).

Global experience also suggests the most promising area of activity for backyard and farm poultry farms, in which they will not compete with large producers, namely the production of so-called "niche" poultry products (organic, farm eggs and chicks, etc.) (Katerynych O. et al., 2023; Lykhach V. et al., 2022; Shelenko D., Madryha D., 2025).

However, in order to realize the potential of small poultry farms, it is necessary to establish a steady supply of day-old chicks that meet the conditions for keeping and feeding in such farms and are most suitable for the production of the above-mentioned products, since currently most of the poultry in private and commercial farms in Ukraine consists of low-yielding non-purebred poultry or industrial high-yielding crossbred poultry that is not adapted to the aforementioned conditions (Polehenka M., 2019; Shulskyy M., Ramskyy I., 2024).

Unfortunately, in modern conditions, the economic component of conservation and rational use of genetic resources of both animals and poultry comes to the fore (Ruban S., Danshyn V., 2019).

At the same time, for the effective development of breeding enterprises, it is necessary not only to preserve and rationally use the best domestic genetic resources and the global gene pool of animals and poultry, but also to modernize the instruments of state support for breeding farms, strengthen integration with large industrial complexes, farms, and private peasant farms (Ibatullin M., Khakhula B., 2021; Ryabukha H., 2019; Savchenko T., 2022).

Therefore, the aim of our research was to conduct a comparative analysis, taking into account the effective population size and the number of gene pool groups of chickens of different productivity types under different husbandry technologies.

Materials and methods. Current study was conducted at the State Research Station for Poultry Farming of the Institute of Animal Husbandry of the National Academy of Agrarian Sciences, in the Department of Innovative Development of Poultry Farming and at the experimental farm "Preservation of the National Gene Pool of Agricultural Poultry". The object of the research is the technological parameters of keeping chickens of egg, egg-meat, and meat-egg productivity, which are preserved as a gene pool.

The effective population size (Ne) was calculated:

$$Ne = (4N_m * N_f)/(N_m + N_f),$$

where N_m is the number of males; N_f is the number of females.

It was used normative data on chicken stocking density (floor space per head, cm^2) on the floor (Departmental standards for technological design of poultry farms (VNTP-APK-04.05, 2005) and technological parameters of cage equipment manufacturers - OKPB-2 (manufacturer: JSC "Nizhynsilmash Plant") and TBR-2 (manufacturer: JSC "Tekhna"), which is used at the experimental farm "Preservation of the National Gene Pool of Agricultural Poultry". Usually calculations use typical room sizes (12x72; 12x84; 12x96; 18x72; 18x84; 18x96) that are partially involved in the technological processes of breeding and keeping chickens of various productivity directions at the DDSP IT NAAS.

Research results. The main task in maintaining gene pool units (populations, breeds, etc.) is to create a system that allows for the long-term preservation of maximum genetic diversity. At the same time, the effective population size (N) indicator comes to the fore in order to control the level of genetic heterogeneity and the risk of genetic diversity loss.

Theoretically, this allows for the development of strategies and programs for the conservation and rational use of the gene pool, and in practice, it reduces genetic drift and controls the genetic integrity of the population.

It is believed (Frankham et al., 2014) that about 50 individuals are sufficient to protect against a decline in viability, such as protection against inbreeding. About 300 females and 50-60 males are sufficient to preserve genetic diversity.

According to our calculations, when keeping 300 females and 60 males on the floor, the effective population size for chickens of different productivity types is 200 heads (Table 1).

Unfortunately, there are restrictions on the groups of birds that can be kept in cages, primarily related to stocking density, floor space, and other technological parameters (feeding front, watering, etc.). Therefore, we have made calculations for cage equipment that has been used for some time to keep parent flocks of adult chickens of various productivity types.

In OKPB-2 cages (manufactured by JSC "Nizhynsilmash Plant"), a value of N at a level of about 200 birds can be achieved by keeping chickens of egg, egg-meat, and meat-egg productivity in the following quantities: 504 hens and 56 roosters (14 cages); 450 hens and 60 roosters (15 cages); 360 hens and 60 roosters (15 cages). At the same time, the N value for all groups of poultry is 202, 212, and 206 birds, respectively.

Similar indicators for TBR-2 equipment (manufactured by JSC "Tekhna"), are as follows for egg-laying, egg-meat, and meat-egg chickens: 551 hens and 57 roosters (19 cages); 475 hens and 57 roosters (19 cages); 380 hens and 59 roosters (20 cages). The N indicator for poultry groups is 207, 204, and 204 heads, respectively.

Table 1.

Effective population size (N) under different systems of maintaining the gene pool of chickens of different productivity types

No	Productivity direction	Analogues	Type of maintenance	Livestock, heads		Effective number (N)
				male	female	
1	Egg-laying	Birkivska Barvysta	On the floor	60	300	200
	Egg-laying and meat-producing	Poltavska Gliniasta		60	300	200
	Meat-producing and egg-laying	White Hercules		60	300	200
2	Egg-laying	Birkivska Barvysta	OKPB-2	56	504	202
	Egg-laying and meat-producing	Poltavska Gliniasta		60	450	212
	Meat-producing and egg-laying	White Hercules		60	360	206
3	Egg-laying	Birkivska Barvysta	TBR-2	57	551	207
	Egg-laying and meat-producing	Poltavska Gliniasta		57	475	204
	Meat-producing and egg-laying	White Hercules		59	380	204

Floor space is one of the determining factors in keeping different types of poultry and productivity. For keeping laying hens (for example, Birkivska Barvysta) on the floor, 1667 cm^2 is required. The corresponding indicators for egg-meat chickens are 1818 cm^2, and for meat-egg chickens – 2222 cm^2 (Table 2).

According to the norms of VNTP – APK-0.4 – 0.5 (2005), the floor space of cage equipment per head of chickens of different productivity directions is, respectively, 600, 720, and 870 cm² (egg-laying, egg-meat, and meat-egg). For the OKPB-2 cage equipment available in Ukraine, the corresponding figures are 600, 706, and 857 cm², respectively. For similar equipment, TBR-2, the corresponding figures are 600, 686, and 873 cm², respectively.

Accordingly, the number of chickens of different productivity, which is given in Table 1, must be 14 (laying hens) and 10 (broilers) for OKPB-2 and TBR-2 cages, respectively, in order 1, in order to maintain an effective number of gene pool groups of poultry in OKPB-2 type battery cages, it is necessary to use 14 (laying hens) and 15 (egg-meat and meat-egg) cages. For the TBR-2 type of equipment, the corresponding figures are 19 (laying and egg-meat) and 20 (meat-egg) cages.

Table 2.

Floor space and number of cages for different systems of keeping the gene pool of chickens of different productivity directions

No	Productivity direction	Analogues	Type of maintenance	Floor space per head, cm²:	Number of cells
1	Egg-laying	Birkivska Barvysta	On the floor	1667	-
	Egg-laying and meat-producing	Poltavska Gliniasta		1818	-
	Meat-producing and egg-laying	White Hercules		2222	-
2	Egg-laying	Birkivska Barvysta	OKPB-2	600	14
	Egg-laying and meat-producing	Poltavska Gliniasta		706	15
	Meat-producing and egg-laying	White Hercules		857	15
3	Egg-laying	Birkivska Barvysta	TBR-2	600	19
	Egg-laying and meat-producing	Poltavska Gliniasta		686	19
	Meat-producing and egg-laying	White Hercules		873	20
4	Egg-laying	Birkivska Barvysta	VNTP	600	-
	Egg-laying and meat-producing	Poltavska Gliniasta		720	-
	Meat-producing and egg-laying	White Hercules		870	-

The results of a comparative analysis of cage equipment that can be used to keep gene pool flocks of chickens of different productivity types are shown in Table 3.

Table 3.

Equipment that can be used to maintain a gene pool of chickens of various productivity types

Indicators	OKPB-2 type	TBR-2 type
Number of tiers	2	2
Dimensions of the battery with feed dispenser, mm,		
- width	1600	1920
- height	1900	1907
Dimensions of cages, mm:		
- довжина- length	2400	1830
- depth	1000	1050
- height	655	653
Total cage area, cm^2	24000	19215
Number of cages in a poultry house, m:		
12x72[1] /18x72[2]	216 / 324	272 / 408
12x84[1] / 18x84[2]	256 / 384	328/ 492
12x96[1] / 18x96[2]	296 /444	376 / 564

Notes: [1] - the room houses 3 cage batteries; [2] - the room houses 4 cage batteries.

The basis is two-tier cage batteries, but manufacturers have the option of creating three-tier batteries. The OKPB-2 equipment has a larger total cage area – 24,000 cm² compared to 19,215 cm² – due to its greater length (+170 mm) and shallower depth (-50 mm). It is the size of the cages that determines the number of bird families when keeping a breed or population. These are shown in the previous table (Table 3).

A standard poultry house measuring 12x96 m can accommodate 296 cages (OKPB-2) compared to 376 (TBR-2). For a poultry house measuring 18x96, the corresponding figures are 444 (OKPB-2) and 564 (TBR-2).

Based on our calculations (Table 2), taking into account the minimum number of cages for keeping separate groups of birds, we have determined the total number of gene pool units in standard poultry houses (Table 4).

Table 4.

Number of gene pool groups of chickens of different productivity types in poultry houses with different types of equipment

No	Number of cages in a poultry house, m:	Productivity of chickens from the gene pool flock					
		equipment type OKPB-2			equipment type TBR-2		
		Egg-laying	Egg-laying and meat-producing	Meat-producing and egg-laying	Egg-laying	Egg-laying and meat-producing	Meat-producing and egg-laying
1	12x72[1]	24	22	17	29	27	20
2	12x84[1]	28	26	20	35	32	24
3	12x96[1]	33	30	23	40	37	28
4	18x72[2]	36	32	25	44	41	30
5	18x84[2]	43	38	30	52	48	36
6	18x96[2]	49	44	34	61	56	42

Notes: 1 - the room houses 3 cage batteries; 2 - the room houses 4 cage batteries.

According to our calculations, a 12x72 poultry house using OKPB-2 cage equipment can accommodate 24 gene pool populations, groups, breeds, etc. of egg-laying chickens (the Ukrainian equivalent of Birkovskaya Barvysta). The corresponding indicators for egg-meat (Poltavska Gliniasta) and meat-egg (White Hercules) productivity are 22 and 17 storage facilities. When using TBR-2 type equipment, the corresponding indicators are 29, 27, and 20 gene pool units of different productivity types.

Thus, a comparative analysis of the existing cage equipment was carried out and the number of cages for keeping a gene pool flock of chickens of different productivity (from 14 to 20) was established, taking into account the effective population size (N≥200 heads).

Discussion. Currently, despite the state of war, Ukraine is a powerful producer of poultry products and satisfies both domestic and foreign markets. The industry produces a wide range of high-quality poultry products, which allows it to have a constant impact on the formation of stable food security in the country. Unfortunately, to meet the genetic resource needs of enterprises (egg-laying hens and broiler chickens), only poultry breeders that meet their own needs operate in the country.

Despite high production rates of food eggs and meat from various types of farm poultry, the population does not have the opportunity to form and improve its own material and technical base and ensure breeding products. Therefore, along with highly specialized enterprises, micro, small, and medium-sized farms have enormous potential that needs to be realized. It is precisely for this sector of the economy that a state program

is needed, which, together with increased integration with large industrial complexes, will attract investment and increase the gross production of poultry products.

Preserving the gene pool is not an economic but a strategic direction in the economy. Almost every country has its own "special" gene pool of plants and animals, which is part of the nation's identity. Unfortunately, especially for countries with "transitional" economies, the economic component of genetic resource conservation is paramount. Given the low profitability, and in most cases the negative value of this indicator, indigenous breeds and varieties lose out to their highly productive "relatives."

Preserving the gene pool, and especially its reproduction, research, and dissemination, is losing its economic appeal, leading to the destruction of breeds, populations, and so on. For example, there are currently no officially operating breeding enterprises for various types of domestic poultry in Ukraine. Our research emphasizes the need to comply with the relevant quantitative indicators when keeping poultry using modern equipment. Unfortunately, a decrease in the number of individuals in poultry groups will lead to gene drift, reduced heterogeneity, and disruption of the genetic structure.

Thus, the data we have obtained are the basis for further calculations aimed at improving or refining the technology of keeping and preserving the gene pool using various keeping technologies.

Conclusions.

1. Based on the results of a comparative analysis, taking into account the effective population size (N≥200 heads), quantitative indicators for maintaining gene pool groups of poultry using different technological equipment (number of group cages from 14 to 20) were calculated.

2. A comprehensive use of technological indicators for keeping poultry (stocking density, floor area, cage sizes, etc.) is provided for selecting a strategy for preserving the gene pool of chickens of different productivity types.

3. Calculated indicators have been established for the use of standard premises for keeping the optimal number of gene pool groups of chickens of different productivity directions using domestically produced cage equipment.

4. Basic data on calculations for maintaining the poultry gene pool are presented to improve further research on improving the economic efficiency of maintenance by improving technological solutions.

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