

## Application of comprehensive integrated indices of breeding boars in DanBred breeding programmes

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**Abstract.** Breeding programs for pigs involve a comprehensive assessment of productive and reproductive traits in purebred lines through the use of individual breeding indices, which allows for an effective increase in the genetic potential of both crossbred animals for industrial production and subsequent generations of breeding stock. This approach differs from traditional methods that are limited to evaluating individual traits and slow down genetic progress. The aim of the study was to determine the feasibility of using an individual integral evaluation of boars and to establish the influence of their age and individual breeding index on reproductive and productive qualities. The study involved 304 Duroc sows, which were inseminated with semen from four boars differing in age, belonging to either the breeding nucleus or the reproductive group, and their comprehensive breeding value index, calculated according to the DanBred system (at least 130 points for the “breeding nucleus” and 105 points for the “reproductive group”). It was found that the individual comprehensive index and age of the boars significantly affected the reproductive performance of the sows. The best results in reproductive indices (sow reproductive quality index – 84.8; viability – 99.1%; reproductive index – 34.8; litter uniformity – 0.90) were obtained from sows inseminated with semen from young boars (12-18 months) with high indices. Older boars or those with lower breeding value indices showed poorer results. It was also established that young boars with high indices demonstrated better semen quality (ejaculate volume – 332.6 ml; concentration – 499.2 million/ml; motility – 8.7 points), although older boars produced more insemination doses per ejaculate (32.8). These findings confirm the feasibility of implementing boar index evaluation technology to improve the efficiency of breeding programs in Ukrainian pig production

**Keywords:** breeding programs; reproductive qualities; pig farming; cluster evaluation; semen quality

### INTRODUCTION

Optimisation of the reproductive ability of pigs is an important prerequisite for achieving sustainable and economically efficient pork production. In the field of artificial insemination in pigs, the role of breeding boars is undoubtedly key, as they are an integral factor in the genetic potential of breeding enterprises and in raising pigs for fattening in commercial farms. Therefore, understanding and improving the reproductive capacity

of boars is important for maintaining high-quality pork production and adapting to market demands.

Artificial insemination is the most common assisted reproductive technology in animal husbandry. This process begins with obtaining fresh ejaculate from selected boars, which are kept in specially equipped facilities (i.e., a breeding station) that also have a laboratory where semen quality is evaluated, and the ejaculate is

#### Article's History:

Received: 19.05.2025

Revised: 25.08.2025

Accepted: 30.09.2025

#### Suggested Citation:

Karatieieva, O. (2025). Application of comprehensive integrated indices of breeding boars in DanBred breeding programmes. *Ukrainian Black Sea Region Agrarian Science*, 29(3), 71-81. doi: 10.56407/bs.agrarian/3.2025.71

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processed into artificial insemination doses. Afterward, all obtained data are entered into specialised programs and automatically processed, and based on them, breeding programs are developed (Althouse, 2024). Commercial pig farming is systematic and focused on processing breeding data. Both integrated and independent systems include software packages that allow the collection and monitoring of a wide range of performance indicators, including reproductive parameters. Based on these data, comprehensive breeding indices are formed for each animal. Based on this breeding index, animals are individually selected for mating. An example of such data processing can be seen in enterprises that work with a software package within the DanBred pig breeding system. Each week, an individual breeding index is calculated for every breeding animal. This cluster index reflects the expected breeding and economic value of the animal, considering all key breeding traits: meat traits – live weight and its absolute, average daily, and relative gains, meatiness coefficient, and meat yield; fattening traits – age at reaching 100 kg live weight, fattening duration, feed cost per unit of production, and feed conversion index; reproductive traits – prolificacy, piglet weight at birth, litter weight at weaning, number of functional teats, viability, and piglet survival. For breeding boars, a number of semen productivity indicators are also taken into account – average volume of filtered ejaculate, sperm concentration, sperm motility, number of insemination doses, fertilising ability, ejaculation index, and others (DanBred, n.d.).

In addition, A. Lykhach *et al.* (2023) studied the relationship between behavioural manifestations and semen productivity of boars of modern and local breeds, which can be used as a basis for cluster evaluation and the formation of individual indices in breeding programs. During the individual selection of boars for breeding work, both in pedigree and commercial herds, particular importance is given to qualitative semen indicators – ejaculate volume and its storage ability. Although these indicators are strictly individual for each boar, breed-specific features of semen productivity, which are important in the organisation of artificial insemination, should also be taken into account. The hereditary potential of a breeding boar is also of great importance, in particular the total number of sperm, their motility, semen concentration, and ejaculate volume. Thus, the breeding index is formed based on a set of sub-indices (clusters), each of which reflects the genetic value of a certain trait. Weighting the clusters according to their economic significance makes it possible to form an integrated overall breeding value index, which is the criterion for selecting breeding stock (Tsheten & Penjor, 2024). According to J. Gu *et al.* (2023), methods

of comprehensive cluster selection have improved animal breeding by increasing the accuracy of predicting breeding values, especially for traits that are difficult to measure and have low heritability, as well as shortening generation intervals. In addition, the authors proposed a method of selecting pigs based on a relatedness index, which determines the ideal individual with information about useful genotypes for the target trait. Thus, the basis for evaluating selection decisions is the useful genotypic similarity between the candidate and the ideal individual. That is, the relatedness index can overcome the need to establish genetic reference groups and continuously determine the phenotype.

Also, according to V.I. Khalak & B.V. Gutyj (2023), the issue of finding effective breeding methods for integrated evaluation of pig productivity traits, taking into account their genotype and interbreed differences in some complex indicators or integral indices, remains relevant, as this will simplify the selection and mating process. According to H. Reyer *et al.* (2024), morphological characteristics of sperm and so-called “stress tests” are more informative for assessing reproductive performance, based on which one of the main clusters of sperm quality – the sperm motility index – is calculated. Assessment of sperm motility, as part of the integral index, helps to evaluate fertilisation ability and sperm resistance to environmental changes. Sperm motility under stress conditions varies between normal and abnormal sperm groups, as well as during sperm aging. When evaluating boar semen, these data can help not only in compiling a comprehensive breeding index but also in predicting the fertilisation potential of the ejaculate by assessing sperm resistance to thermal stress, which can also be assessed as a separate index. Testing sperm motility after prolonged exposure to +38°C simulates the duration of sperm in the female reproductive tract. This makes it possible to draw conclusions about their fertilisation ability and functional metabolism. The stress test at low temperatures, i.e., +6°C, models an optimal storage regime that limits bacterial growth and can also affect semen quality. Testing sperm motility using index evaluation makes it possible to detect even small differences between high-quality ejaculates, and the sperm quality index, based on various measurements and assessments, accurately reflects the requirements of artificial intelligence and contributes to fertility prediction.

As breeding experience showed, the transmission of hereditary potential from the breeding herd to commercial herds occurs mainly through male individuals, i.e., boars. Accordingly, the success of breeding improvement of the herd is ensured by the correct individual selection of a boar based on a set of integral qualities.

This prompted interest in studying the influence of integral cluster indices on the productive qualities of breeding boars. Considering that a successful combination of parental pairs in breeding work has a fundamental impact on the breeding and productive qualities of their offspring, the purpose of the study was to demonstrate the effectiveness of using an integrated evaluation of Duroc boars, taking into account their age, individual breeding value selection index, and usage.

## MATERIAL AND METHODS

The study was conducted on a commercial farm in Denmark using Danish-bred Duroc pigs during the period 2022-2023. Animal handling procedures fully complied with European legislation (Council Directive 98/58/EC, 1998; Nalon & Stevenson, 2019). The research

protocol was approved by the bioethics committee in accordance with good clinical practice standards for the protection and humane treatment of experimental animals. A total of 304 Duroc sows were included in the study and inseminated with semen from four different boars. Semen was collected using an automated semen collection system – IMV Collectis (France) and evaluated using a portable CASA-type mobile analyser for rapid assessment of motility, concentration, and sperm morphology directly at the animal. The boars differed in several parameters: membership in the nucleus breeding herd or reproductive group, age category (12-18 months vs. over 18 months), and their comprehensive breeding value index. All animals were maintained under identical feeding and housing conditions. The experimental design and formation of groups are presented in Table 1.

**Table 1.** Grouping Scheme of Experimental Pigs

| Index                 | Boar Class               |                       |                          |                       |
|-----------------------|--------------------------|-----------------------|--------------------------|-----------------------|
|                       | Reproductive group       |                       | Nucleus herd             |                       |
|                       | No. 1<br>18 months and ≥ | No. 2<br>12-18 months | No. 3<br>18 months and ≥ | No. 4<br>12-18 months |
| Total Index, points   | 105                      | 125                   | 130                      | 140                   |
| Number of sows (head) | 85                       | 75                    | 70                       | 83                    |

**Source:** compiled by the author

Boars were evaluated using a comprehensive integral breeding index, which was calculated by a computer program within the DanBred pig breeding system. According to the breeding data calculations, the integral breeding index should be at least 130 points for nucleus herd boars and at least 105 points for boars of the reproductive group. The program takes into account the individual characteristics of boars and sows, and automatically selects sows for each specific boar, which resulted in a different number of sows included in the study. Sows were evaluated for maternal qualities using reproductive performance evaluation indices. To determine the comprehensive indicator of sows' reproductive traits, the formula by V.A. Kovalenka was used (Stavetska & Piotrovych, 2015):

$$CIRT = 1.1X_1 + 0.3X_2 + X_3 + 0.35X_4, \quad (1)$$

where *CIRT* is a comprehensive indicator of reproductive traits;  $X_1$  – litter size, heads;  $X_2$  – maternal milk yield, kg;  $X_3$  – number of piglets at weaning, heads;  $X_4$  – litter weight at weaning, kg.

For the calculation of the Selection Index of reproductive traits of sows, the formula of D.A. Baranovskyi (Stavetska & Piotrovych, 2015) was used:

$$SRQI = 6X_1 + \frac{9.34X_2}{X_3}, \quad (2)$$

where *SRQI* is a selection index of reproductive traits in sows;  $X_1$  – number of piglets at birth, heads;  $X_2$  – litter weight at weaning, kg;  $X_3$  – weaning age, days.

For the determination of the viability index, the algorithm by V.P. Kovalenko was used as the basis (Harmatiuk, 2022):

$$V_i = X_1 / X, \quad (3)$$

where  $V_i$  is a viability index;  $X_1$  is an individual litter size of the sow, heads;  $X$  – an average number of piglets at birth, heads.

The methodology of V.P. Kovalenka was used for calculating the reproductive traits index (Harmatiuk, 2022):

$$RQI = A + 2 \times B + 35\sigma, \quad (4)$$

where *RQI* is a reproductive quality index;  $A$  – litter size, heads;  $B$  – number of piglets at weaning, kg;  $\sigma$  – an average daily gain of one piglet from birth to weaning, g; 35 – constant coefficient.

V.P. Kovalenka's algorithm forms the basis for calculating the litter uniformity index (Harmatiuk, 2022):

$$LU = (X_{max} - X_{min}) / X, \quad (5)$$

where *LU* is a litter uniformity;  $X_{max}$  – maximum live weight of a piglet in the litter at birth, kg;  $X_{min}$  – minimum live weight of a piglet in the litter at birth, kg;  $X$  is an average live weight of a piglet in the litter at birth, kg.

In addition, using evaluation indices, an index assessment of boar sperm productivity was conducted. The ejaculation index was calculated based on the formula by A.V. Kvasnytsky (Sheremeta & Opanasenko, 2012).

$$E_i = n_{cd} / t_E, \quad (6)$$

where  $E_i$  is an ejaculation index;  $n_{cd}$  – number of semen doses obtained from one ejaculate;  $t_E$  – duration of the ejaculation reflex in the boar, minutes.

The sperm productivity index of boars was calculated using the algorithm by H.D. Sviatovets (Melnyk *et al.*, 2022):

$$SPI = (O \times K \times A) / 10, \quad (7)$$

where  $SPI$  is a sperm productivity index of boars, billion;  $O$  – ejaculate volume, ml;  $K$  – sperm concentration in the ejaculate, billion/ml;  $A$  – sperm motility, points; 10 – number of ejaculates evaluated.

## RESULTS AND DISCUSSION

With a short production cycle, rapid cash turnover, the implementation of modern feeding and housing technologies, and the use of contemporary animal breeding programs, pig farming has high potential and opportunities for efficiently increasing meat production. The growth in profitability of the pig farming sector is largely driven by the use of highly productive lines, breeds, and crosses in the breeding process, both within purebred breeding and through crossbreeding and breed-line hybridization. The quality of breeding stock largely depends on the hereditary potential of appropriately matched parental forms – sows and, primarily, boars (von Keyserlingk *et al.*, 2024). Calculations of reproductive performance data for sows (Table 2), inseminated by different boars, confirmed that the individual selection index of the boars has a direct impact on the reproductive qualities of the sows.

**Table 2.** Reproductive qualities of sows depending on the class and age of boars

| Index                             | Boar Class               |                       |                          |                       |
|-----------------------------------|--------------------------|-----------------------|--------------------------|-----------------------|
|                                   | Reproductive group       |                       | Nucleus herd             |                       |
|                                   | No. 1<br>18 months and ≥ | No. 2<br>12-18 months | No. 3<br>18 months and ≥ | No. 4<br>12-18 months |
| Overall index, points             | 108                      | 136                   | 131                      | 139                   |
| Number of Sows, heads             | 83                       | 71                    | 69                       | 81                    |
| Farrowing rate, %                 | 62.4                     | 84.6                  | 60.8                     | 86.4                  |
| Number of piglets at birth, heads | 9.0±0.15                 | 10.5±0.28             | 8.8±0.13                 | 11.4±0.15*            |
| Birth weight of piglet, kg        | 1.20±0.02                | 0.97±0.04             | 0.88±0.04                | 1.1±0.05              |
| Milk yield, kg                    | 57.0±3.4                 | 55.4±2.0              | 53.4±2.7                 | 56.6±3.4              |
| At 35 days weaning                |                          |                       |                          |                       |
| Number of piglets, heads          | 7.8±0.32                 | 8.2±0.58              | 7.0±0.05                 | 7.9±0.44              |
| Total Litter weight, kg           | 64±2.1                   | 60.8±3.4              | 59.0±5.1                 | 63.2±4.8              |
| Piglet weight, kg                 | 8.85±0.27                | 8.70±0.21             | 8.0±0.18                 | 8.3±0.47              |
| Survival rate, %                  | 64.4±1.8                 | 68.3±4.6              | 84.7±3.5***              | 69.7±7.1              |

**Note:** \* –  $P < 0.05$ ; \*\* –  $P < 0.01$ ; \*\*\* –  $P < 0.001$

**Source:** compiled by the author

Breeding boars were evaluated based on an integral comprehensive breeding value index, which was at least 130 points for the segment – breeding nucleus, and for boars of the reproductive group, it had to be no less than 105 points. Analysis of the obtained results showed that the studied sires met the established requirements for this indicator. At the same time, the highest index among boars in the reproductive group was recorded in boar No. 2 which was 136 points, while among animals of the breeding nucleus, the best result was demonstrated by boar No. 4 which was 139 points, which, according to the integral index, corresponded to the requirements of the reproductive group class. These same production groups were also characterised by the highest farrowing rates which were 84.6% and 86.4%, respectively. Among sows of the breeding

nucleus group, the highest reproductive performance was demonstrated by those inseminated with semen from a boar with a breeding value index of 136 points. Their litter size was 10.5 piglets, and piglet survival to weaning was 68.3%, which exceeded the respective indicators of the first group (9.0 piglets and 64.4%). At the same time, due to lower litter size, sows inseminated with semen from an older boar over 18 months with a selection index of 108 had higher results for indicators such as piglet birth weight, litter weight at birth, and, accordingly, total litter weight and average live weight of one piglet at weaning.

Analysis of the reproductive ability of sows established that the highest comprehensive integral index was observed in animals of the breeding nucleus in the fourth group – 139 points. Sows of this group had

significantly better reproductive performance compared to other experimental groups. In particular, the number of piglets at birth was at the level of  $11.4 \pm 0.15$  piglets, which was statistically significant compared to the indicators of other groups by 15-23% ( $P \leq 0.05$ ). Regarding piglet birth weight, sows of the fourth group were second only to sows of the first group, in which this indicator was 1.20 kg and was 0.1 kg higher. In contrast, in the second and third groups, birth weight was lower compared to the fourth:  $0.97 \pm 0.04$  kg and  $0.88 \pm 0.04$  kg, respectively, versus  $1.1 \pm 0.05$  kg in the fourth group. A similar trend was observed for milk production: sows of the fourth group, despite high litter size, were second only to animals of the first group of the "breeding nucleus" class, which, however, had lower litter size indicators. The suckling period at the enterprise lasts up to 35 days of age. During this time, the number of weaned piglets

in the third and fourth groups was 7.0 and 7.9 head, respectively, which corresponded to survival rates of 84.7% ( $P \leq 0.001$ ) and 69.7%, respectively. The average weight of one piglet at 35 days among sows of the first segment was significantly lower compared to animals of breeding use, although the difference was not statistically confirmed. In addition, the conducted studies showed that the class and age of the boar significantly affect the maternal qualities of sows (Table 3). In particular, evaluation by the *RQI* in the breeding nucleus class established that the advantage was observed in sows inseminated with semen from boar No. 3 with a comprehensive breeding value index of 131 points. In contrast, in the "reproductive group" class, the opposite trend was observed: the highest indicators were recorded in sows inseminated with semen from a young boar No. 4 with the maximum comprehensive index – 139 points.

**Table 3.** Maternal qualities of sows based on reproductive evaluation indices depending on the class and age of boars

| Index                                  | Boar Class               |                        |                          |                        |
|----------------------------------------|--------------------------|------------------------|--------------------------|------------------------|
|                                        | Reproductive group       |                        | Nucleus herd             |                        |
|                                        | No. 1<br>18 months and ≥ | No. 2<br>12-18 months  | No. 3<br>18 months and ≥ | No. 4<br>12-18 months  |
| Overall index, points                  | 108                      | 136                    | 131                      | 139                    |
| CIRT, points                           | $64.8 \pm 3.88$          | $62.4 \pm 2.74$        | $61.7 \pm 4.93$          | $65.9 \pm 4.21$        |
| SRQI, points                           | $70.6 \pm 2.13$          | $79.4 \pm 4.02$        | $68.1 \pm 4.84$          | $84.8 \pm 4.48^{**}$   |
| Viability index, %                     | $65.8 \pm 7.04$          | $72.2 \pm 6.18$        | $59.4 \pm 2.56$          | $99.1 \pm 5.08^{***}$  |
| Reproductive performance index, points | $31.9 \pm 2.31$          | $33.06 \pm 2.08$       | $31.1 \pm 1.44$          | $34.8 \pm 1.85$        |
| Litter uniformity                      | $0.19 \pm 0.003$         | $0.33 \pm 0.008^{***}$ | $0.36 \pm 0.005^{***}$   | $0.90 \pm 0.003^{***}$ |

**Note:** \* –  $P < 0.05$ ; \*\* –  $P < 0.01$ ; \*\*\* –  $P < 0.001$ ; CIRT is a comprehensive indicator of reproductive traits; SRQI is sow reproductive quality index

**Source:** compiled by the author

At the same time, the comprehensive indicator of reproductive qualities in the experimental groups showed no significant differences and ranged between 61.7 and 65.9 points. Analysis of the *SRQI* revealed a wider variation among the groups, from 68.1 to 84.8 points. In the "reproductive group" class, higher *SRQI* values were observed in sows inseminated with semen from young boars aged 12-18 months and received 79.4 points, which exceeded the same indicator in sows mated with older boars (70.6 points). Similarly, in the "breeding nucleus" class, higher values of this index were recorded in sows inseminated with young sires which was 84.8 points. These animals exhibited the highest *SRQI* among all experimental groups, significantly surpassing other groups ( $P \leq 0.01$ ). The viability index of piglets across the studied groups showed a similar trend, indicating its dependence on both the comprehensive breeding value index and the age of the boar. However, the viability index was not associated with the production class of the sire; the highest value

was recorded in group 4, where the boar had an individual comprehensive index of 139-99.1%, which significantly exceeded the values of other groups by 27.7-42.4% ( $P \leq 0.001$ ). Conversely, the lowest viability index was observed in sows from the reproductive group inseminated by an older boar with the lowest individual breeding value index which was 59.4%. In the "breeding nucleus" class, a similar dynamic was observed: sows inseminated with semen from young boars with higher indices demonstrated a higher piglet viability index which was 72.2%, whereas the use of older sires with lower individual indices resulted in only 65.8%.

The sow reproductive performance index showed minimal variability, ranging from 31.1 to 34.8 points, following the overall trend of dependence on boar age and individual comprehensive index. The highest values were recorded in sows of groups No. 2 and No. 4, while groups No. 1 and No. 3 had slightly lower scores. It is also important to note significant differences in litter uniformity. The highest score of 0.90 was observed



in sows of group No. 4, which statistically exceeded the corresponding indicators of other groups ( $P \leq 0.001$ ). The lowest litter uniformity was found in sows of group No. 1 which has got only 0.19 points. In breeding programs and the individual selection of boars for both pedigree and commercial herds, semen quality, its quantity, and storability are of particular importance. All these indicators have pronounced individual variability; however, there are also interbreed differences in semen quality, which must be considered when implementing artificial insemination (Karpovsky *et al.*, 2020). Genetic factors also play a crucial role, including total ejaculate volume, total sperm count, sperm concentration, and semen density. In this regard, the effect of the individual comprehensive

breeding value index and boar age on semen production characteristics was studied. Among boars belonging to the "breeding nucleus" class, the mean ejaculate volume of  $332.6 \pm 30.2$  mL was significantly higher, which exceeded that of boars from group No.1 –  $299.4 \pm 24.3$  mL ( $P \leq 0.05$ ) (Table 4). In the "reproductive group" class, the advantage was observed in boar No. 4 –  $257.6 \pm 25.1$  mL, although the difference compared to boar No. 1 was not statistically significant. The lowest ejaculate volume of  $229.4 \pm 24.3$  mL was recorded in boar No. 3, which belonged to the older age category, significantly lower than the values in group No. 1 ( $P \leq 0.01$ ). A high level of variation was observed in sperm concentration, which ranged from 312.3 to 499.2 million/mL.

**Table 4.** Effect of boar class and age on semen productivity parameters

| Index                                    | Boar Class           |                     |                       |                  |
|------------------------------------------|----------------------|---------------------|-----------------------|------------------|
|                                          | Reproductive group   |                     | Nucleus herd          |                  |
|                                          | No. 1                | No. 2               | No. 3                 | No. 4            |
|                                          | 18 months and $\geq$ | 12-18 months        | 18 months and $\geq$  | 12-18 months     |
| Overall Index, points                    | 108                  | 136                 | 131                   | 139              |
| Average Volume of Filtered Ejaculate, ml | $299.4 \pm 24.3$     | $332.6 \pm 30.2^*$  | $229.4 \pm 23.6^{**}$ | $257.6 \pm 25.1$ |
| Sperm Concentration, million/mL          | $404.5 \pm 35.5$     | $499.2 \pm 28.4^*$  | $312.3 \pm 52.2^{**}$ | $457.6 \pm 18.8$ |
| Sperm Motility, points                   | $7.5 \pm 1.9$        | $8.7 \pm 2.5$       | $7.1 \pm 3.1$         | $8.0 \pm 1.1^*$  |
| Number of Semen Doses, pcs               | $32.8 \pm 5.6$       | $27.7 \pm 1.7^{**}$ | $24.4 \pm 10.2$       | $29.6 \pm 2.8^*$ |

**Note:** \* –  $P < 0.05$ ; \*\* –  $P < 0.01$ ; \*\*\* –  $P < 0.001$

**Source:** compiled by the author

Among the studied population, regardless of production class, the highest values were observed in young boars aged 12-18 months with high individual comprehensive indices:  $499.2 \pm 28.4$  million/mL in boar No. 2 and  $457.6 \pm 18.8$  million/mL in boar No. 4. In contrast, older boars No. 1 and No. 3 showed lower sperm concentration values of  $404.5 \pm 35.5$  and  $312.3 \pm 52.2$  million/mL, respectively ( $P \leq 0.01$ ). Sperm motility also demonstrated a dependence on the age of the animals: young boars under 18 months exhibited higher scores have got 8.7 points in boar No. 2 ("reproductive group") and 8.0 points in boar No. 4 ("breeding nucleus") ( $P \leq 0.05$ ). Older boars (over 18 months) had lower motility scores which have got 7.5 and 7.1 points, respectively. The cumulative criterion for semen quality is the number of insemination

doses obtained from a single ejaculate. By this indicator, unlike the previous ones, boar No. 1 of the "reproductive group" class had an advantage – 32.8 doses, which significantly exceeded the corresponding values of other groups ( $P \leq 0.01$ ). Similar values were noted in boars No. 2 and No. 4 – 27.7 and 29.6 doses, respectively, with varying degrees of statistical significance. Additionally, boars were evaluated for their fertilising ability (Table 5). The highest level of this indicator was found in young boars No. 4, which also had the highest comprehensive index 86.4%. High fertilisation ability was also observed in young boars of the "reproductive group" class, specifically No. 2 and valued at 84.6%. In contrast, older boars, regardless of breeding purpose, showed lower values of 62.4% and 60.8%, respectively.

**Table 5.** Influence of boar class and age on fertilising ability

| Index                             | Boar Class           |                 |                      |                   |
|-----------------------------------|----------------------|-----------------|----------------------|-------------------|
|                                   | Reproductive group   |                 | Nucleus herd         |                   |
|                                   | No. 1                | No. 2           | No. 3                | No. 4             |
|                                   | 18 months and $\geq$ | 12-18 months    | 18 months and $\geq$ | 12-18 months      |
| Overall Index, points             | 108                  | 136             | 131                  | 139               |
| Sows, heads                       | 83                   | 71              | 69                   | 81                |
| Fertility rate, %                 | 62.4                 | 84.6            | 60.8                 | 86.4              |
| Number of Piglets at Birth, heads | $9.0 \pm 0.18$       | $10.5 \pm 0.32$ | $8.8 \pm 0.21$       | $11.4 \pm 0.11^*$ |

**Note:** \* –  $P < 0.05$ ; \*\* –  $P < 0.01$ ; \*\*\* –  $P < 0.001$

**Source:** compiled by the author

A similar age-related pattern was also observed for sow prolificacy. Sows inseminated with semen from younger boars exhibited higher prolificacy – 11.4 and 10.5 piglets – compared to 9.0 and 8.8 piglets in sows inseminated by older boars. Modern high-tech and profitable pig production requires comprehensive, objective, and reliable evaluation of both genetic traits and the reproductive capacity of boars. This process begins at an early age with selection and targeted rearing, as well as assessment based on individual growth performance, sexual behaviour, expression of mating reflexes, and semen production characteristics

(Balogun & Stewart, 2021). Therefore, the need arises to complement traditional methods of semen quality evaluation with more advanced approaches involving a comprehensive assessment of boars using various evaluation indices. Analysis and calculation of the ejaculation index revealed that the best values were characteristic of young boars under 18 months of age in Groups 2 and 4 – those animals with the highest individual integral breeding value indices, regardless of their breeding status or category (Table 6). The ejaculation index values were  $4.20 \pm 0.024$  ( $P \leq 0.001$ ) and  $4.06 \pm 0.017$  ( $P \leq 0.001$ ), respectively.

**Table 6.** Assessment of Boars of Different Classes and Ages Based on Index Values

| Index                             | Boar Class               |                        |                          |                        |
|-----------------------------------|--------------------------|------------------------|--------------------------|------------------------|
|                                   | Reproductive group       |                        | Nucleus herd             |                        |
|                                   | No. 1<br>18 months and ≥ | No. 2<br>12-18 months  | No. 3<br>18 months and ≥ | No. 4<br>12-18 months  |
| Overall index, points             | 108                      | 136                    | 131                      | 139                    |
| Ejaculation Index                 | $3.97 \pm 0.077$         | $4.20 \pm 0.024^{***}$ | $2.91 \pm 0.032^{***}$   | $4.06 \pm 0.017^{***}$ |
| Semen Productivity Index, billion | $276.4 \pm 5.76$         | $345.1 \pm 8.92$       | $233.4 \pm 4.98^{***}$   | $379.2 \pm 5.68^{***}$ |

**Note:** \* –  $P < 0.05$ ; \*\* –  $P < 0.01$ ; \*\*\* –  $P < 0.001$

**Source:** compiled by the author

Conversely, older boars (over 18 months) showed significantly lower ejaculation index values are  $3.97 \pm 0.077$  and  $2.91 \pm 0.032$  with a statistically proven difference ( $P \leq 0.001$ ). A similar age-related dependence was observed for the sperm production index. Boars younger than 18 months recorded the highest values of 345.1 billion and 379.2 billion sperm cells, respectively – with a highly significant advantage ( $P \leq 0.001$ ). In older boars, this indicator was considerably lower – 276.4 billion and 233.4 billion, respectively ( $P \leq 0.001$ ). According to V.I. Khalak *et al.* (2024), innovations in breeding were necessary to obtain animals that were both productive and adapted to a wide range of local conditions and diverse systems. Breeding strategies to advance agroecological systems are similar across animal species. However, current practices differ for ruminants, pigs, and poultry. Ruminant breeding remains an open system, where farmers continue to select their own breeds and strategies. In contrast, pig and poultry breeding is largely dominated by international breeding companies that supply farmers with hybrid animals. Therefore, breeding strategies must be adapted for different species. Pig breeding programs using artificial insemination have greatly benefited from the integration of advanced techniques and the application of cluster-based integral assessment of boar potential. While traditional selection methods are based solely on the sire's phenotype – such as growth rates and conformation – modern selection increasingly relies on comprehensive indices supplemented by phenotypic traits.

Cluster indices serve as critical indicators of boar reproductive capacity. They help identify individuals with high fertility and detect potential fertility problems at an early stage, enabling proactive strategies in breeding programs (Vaishnav *et al.*, 2025).

Pig breeding programs such as DanBred have significantly expanded the number of traits used for boar selection. This system allowed ranking of breeding stock based on two groups of indices – comprehensive integral breeding value indices. The first group of cluster indices focused on growth and terminal line traits, based on growth performance and sperm production indicators. The second group was concentrated mainly on maternal line development, evaluating sow reproductive traits and considering litter size and its main characteristics (González-Díéguez *et al.*, 2020). Semen quality is a key biomarker for assessing boar reproductive capacity, encompassing a wide range of parameters such as morphology, motility, sperm concentration, and ejaculate volume. These parameters collectively reflected the functional competence of spermatozoa, enabling the identification of ejaculates that do not meet minimum quality requirements. Although most biomarkers have limited informativeness individually, they provided data on quantitative and qualitative sperm characteristics and serve as the basis for forming complex integral or cluster indices of sperm production. S. Jang *et al.* (2022) noted that most commercial pigs in swine production result from crossing maternal-line sows with pooled semen from terminal

sires. Therefore, it was reasonable to assume that the true genetic value of most commercial boars for reproductive traits remains unknown. These animals represented a population subjected to limited selection for male reproductive traits, requiring cluster-based integral assessment of each sire across a set of characteristics, combined with semen pooling based on similar cluster index scores.

S.P. Turner *et al.* (2024) recommended that commercial pig breeding programs based on integrated selection indices should also incorporate new phenotyping methods and genetic methodologies that expand the range of welfare traits. Specifically, separate individual welfare indices should be developed to exert selection pressure on welfare traits, improving animal well-being and contributing to economic and environmental benefits. Additionally, one of the sub-indices within a cluster index may include an inbreeding index, which helps prevent inbreeding issues in breeding herds. The effective size of these herds or populations is generally small, increasing the risk of reduced adaptability and viability in pigs (Kramarenko *et al.*, 2023). Inbreeding index data enabled new approaches to breeding programs and help avoid negative inbreeding consequences. As noted by R. Ausejo-Marcos *et al.* (2024), analysis all components of the overall integral index were essential for understanding its relationship with fertility and prolificacy, providing insights into reproductive success and assisting the industry in distinguishing among boars used in breeding programs. Integrating this information into a simplified form – through cluster aggregation – is necessary for better ejaculate quality assessment. H.H. Salgado *et al.* (2021) developed a new feeding behaviour index that integrates multiple components of pig feeding behaviour during fattening, consolidating these into a single parameter and accounting for changes over time. This index better illustrates individual feeding patterns, identifies the impact of production factors on feeding behaviour and growth, and improves productivity. Moreover, this index may serve as one of the components or sub-indices of an individual comprehensive breeding value index. Other researchers have indicated that genomic information on purebred animals before selection allows better prediction of commercial performance. They work with large datasets based on imaging, sensors, and sound data, complicating animal selection processes. Therefore, it is recommended to use integral indices that include behavioural and welfare indicators (Howard, 2019).

In the studies by S. Kramarenko *et al.* (2019), analysis of microsatellite locus polymorphism in meat-type pigs revealed associations between specific alleles and reproductive traits, an important prerequisite for

forming selection indices. The authors emphasised the effectiveness of genetic markers for evaluating boar breeding value and recommended integrating them into breeding programs using comprehensive breeding value indices. A statistically significant effect of boar breed on stillbirth rates was also established. Specifically, offspring of Duroc boars exhibited substantially higher stillbirth rates (15.0%) compared to other breeds (10.0-10.1%). These results confirmed the importance of considering boar breed characteristics when calculating comprehensive breeding value indices aimed at improving piglet viability and reducing reproductive losses in commercial breeding programs. Chinese researchers S. Ye *et al.* (2020) suggested including a breed fixation index based on allele composition in the integral index evaluation of boars, which can be useful for distinguishing breeds, lines, or specific crosses. Consequently, predicting breeding value using cluster assessment based on individual comprehensive integral indices holds potential for improving selection efficiency, reducing costs, and creating a platform that integrates approaches to enhance pig productivity, advance biological discoveries, and increase the economic profitability of the industry.

## CONCLUSIONS

The reproductive performance of sows is influenced by the individual comprehensive breeding value index and the age of the boars. The highest fertility rate (86.4%), litter size at birth (11.4 piglets), and number of weaned piglets (7.9 piglets) were observed in sows inseminated with semen from boars with the highest individual integral indices in the “nucleus breeding” production class. Meanwhile, the highest piglet survival rate (68.3%) was recorded in sows inseminated with semen from young boars of the “reproductive group” with an individual breeding value index of 136. Overall, for most reproductive traits, sows inseminated with semen from young boars aged 12-18 months demonstrated superior performance. A clear relationship was confirmed between the age and class of the boar, as determined by the comprehensive breeding value index, and the maternal traits of sows according to reproductive assessment indices. Specifically, the highest values for most reproductive indicators were observed in sows inseminated with semen from young boars aged 12-18 months with the highest individual comprehensive index. SRQI values included 84.8 points, piglet viability index was 99.1%, reproductive traits index was 34.8 points, and litter uniformity was 0.90 points. Conversely, the use of older boars or animals with lower individual integral indices was associated with decreased reproductive performance in sows.



The influence of age and the individual comprehensive selection index of boars on semen productivity indicators was confirmed, regardless of their breeding purpose. In particular, young boars with high individual integral selection indices showed higher values of ejaculate volume is 332.6 ml, sperm concentration is 499.2 million/ml, and sperm motility is 8.7 points. At the same time, the number of semen doses obtained from a single ejaculate was higher in older boars, amounting to 32.8 doses. A correlation was also established between the age, individual integral breeding value index of boars, and both fertility and litter size in sows. Sows inseminated with semen from young boars had higher values for these traits is 86.4% fertility and 11.4 piglets per litter. A clear trend of the effect of age and the comprehensive selection index of boars on semen quality parameters was confirmed. Young boars with high

comprehensive indices exhibited higher ejaculate index values – 4.20 and 4.06 points, respectively, as well as sperm productivity index values is 345.1 billion and 379.2 billion spermatozoa. In contrast, boars older than 18 months had lower values for these indices, indicating an age-related decline in semen quality.

## ACKNOWLEDGEMENTS

The author expresses gratitude to the management and specialists of the commercial enterprise in the Kingdom of Denmark for providing the opportunity to conduct research under the enterprise's conditions.

## FUNDING

None.

## CONFLICT OF INTEREST

None.

## REFERENCES

- [1] Althouse, G.C. (2024). Contaminant toxicity of concern for boars and semen used in assisted reproduction programs. *Animal Reproduction Science*, 269, article number 107519. doi: [10.1016/j.anireprosci.2024.107519](https://doi.org/10.1016/j.anireprosci.2024.107519).
- [2] Ausejo-Marcos, R., et al. (2024). Spermogram, kinetics, flow cytometric characteristics and DNA damage degree in boar ejaculates: Summarization and clustering. *Veterinary Sciences*, 11(9), article number 420. doi: [10.3390/vetsci11090420](https://doi.org/10.3390/vetsci11090420).
- [3] Balogun, K.B., & Stewart, K.R. (2021). Effects of air exposure and agitation on quality of stored boar semen samples. *Reproduction in Domestic Animals*, 56(9), 1200-1208. doi: [10.1111/rda.13975](https://doi.org/10.1111/rda.13975).
- [4] Council Directive 98/58/EC "Concerning the Protection of Animals Kept for Farming Purposes". (1998, July). Retrieved from <https://eur-lex.europa.eu/eli/dir/1998/58/oj>.
- [5] DanBred. (n.d.). Retrieved from <https://dbcorpstaging.wpengine.com/our-dna/>.
- [6] González-Díéguez, D., Tusell, L., Bouquet, A., Legarra, A., & Vitezica, Z.G. (2020). Purebred and crossbred genomic evaluation and mate allocation strategies to exploit dominance in pig crossbreeding schemes. *G3: Genes, Genomes, Genetics*, 10(8), 2829-2841. doi: [10.1534/g3.120.401376](https://doi.org/10.1534/g3.120.401376).
- [7] Gu, J., Zhang, Z., Xu, Y., Qadri, Q.R., Zhang, Z., Wang, Z., Wang, Q., & Pan, Y. (2023). Molecular design-based breeding: A kinship index-based selection method for complex traits in small livestock populations. *Genes*, 14(4), article number 807. doi: [10.3390/genes14040807](https://doi.org/10.3390/genes14040807).
- [8] Harmatiuk, K.V. (2022). *Methods for increasing pig productivity in modern conditions in southern Ukraine*. (PhD dissertation, Odesa State Agrarian University, Odesa, Ukraine).
- [9] Howard, J. (2019). *The use of Big Data in a modern swine breeding program now and in the future*. Retrieved from <https://blog.steakgenomics.org/2019/06/bif-2019-use-of-big-data-in-modern.html>.
- [10] Jang, S., Ros-Freixedes, R., Hickey, J.M., Chen, C.Y., Herring, W. O., Misztal, I., & Lourenco, D. (2022). Using large-scale whole-genome sequence data for single-step genomic predictions in maternal and terminal pig lines. *bioRxiv*. doi: [10.1101/2022.11.11.516229](https://doi.org/10.1101/2022.11.11.516229).
- [11] Karpovsky, V., Usenko, S., & Shostya, A. (2020). Influence of prooxidant-antioxidant homeostasis on the functional activity of boars' sperm with corrections of mineral nutrition. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 16(6). doi: [10.31548/dopovidi2020.06.015](https://doi.org/10.31548/dopovidi2020.06.015).
- [12] Khalak, V.I., & Guttyj, B.V. (2023). Productive qualities of young pigs of the Large White breed of diverse genealogical lines and interbreed differentiation according to some integrated indicators. *The Animal Biology*, 25(1), 27-31. doi: [10.15407/animbiol25.01.027](https://doi.org/10.15407/animbiol25.01.027).
- [13] Khalak, V.I., Guttyj, B.V., & Bordun, O.M. (2024). Some innovations in pig farming and their zootechnical assessment. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 7(2), 50-54. doi: [10.32718/ujvas7-2.07](https://doi.org/10.32718/ujvas7-2.07).
- [14] Kramarenko, A., Luhovyi, S., Karatieieva, O., & Kramarenko, S. (2023). Risk factors associated with stillbirth of piglets in Ukrainian Meat breed sows. *Scientific Horizons*, 26(10), 19-31. doi: [10.48077/scihor10.2023.19](https://doi.org/10.48077/scihor10.2023.19).

- [15] Kramarenko, S., Lugovoy, S., Lykhach, A., Kramarenko, A., Lykhach, V., & Slobodanyk, A. (2019). Effect of genetic and non-genetic factors on the reproduction traits in Ukrainian Meat sows. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Agricultural Sciences*, 21(90), 3-8. doi: [10.32718/nvlvet-a9001](https://doi.org/10.32718/nvlvet-a9001).
- [16] Lykhach, A., Lykhach, V., Barkar, Y., Shpetny, M., & Kucher, O. (2023). Dependence between behavioural acts and sperm parameters of boars of modern and local breeds of Ukraine. *Journal of Animal Behaviour and Biometeorology*, 11(1), article number ee2023008 doi: [10.31893/JABB.23008](https://doi.org/10.31893/JABB.23008).
- [17] Melnyk, V., Karatieieva, H., Kravchenko, H., & Kogut, E. (2022). [Hematological and biochemical blood indicators of young gilts after estrus synchronization](#). *Scientific Papers. Series D. Animal science*. LXV(1), 289-294.
- [18] Nalon, E., & Stevenson, P. (2019). Protection of dairy cattle in the EU: State of play and directions for policymaking from a legal and animal advocacy perspective. *Animals*, 9(12), article number 1066. doi: [10.3390/ani9121066](https://doi.org/10.3390/ani9121066).
- [19] Reyer, H., Abou-Soliman, I., Schulze, M., Henne, H., Reinsch, N., Schoen, J., & Wimmers, K. (2024). Genome-wide association analysis of semen characteristics in Piétrain boars. *Genes*, 15(3), article number 382. doi: [10.3390/genes15030382](https://doi.org/10.3390/genes15030382).
- [20] Salgado, H.H., Méthot, S., Remus, A., Létourneau-Montminy, M.P., & Pomar, C. (2021). A novel feeding behavior index integrating several components of the feeding behavior of finishing pigs. *Animal*, 15(7), article number 100251. doi: [10.1016/j.animal.2021.100251](https://doi.org/10.1016/j.animal.2021.100251).
- [21] Sheremeta, V.I., & Opanasenko, O.S. (2012). [Assessment of the reproductive capacity of breeding boars based on the ejaculation index](#). *Taurida Scientific Herald*, 78(2), 134-138.
- [22] Stavetska, R.V., & Piotrovych, N.A. (2015). [Influence of genotype of buds on reproductive quality of sows](#). *Animal Husbandry Products Production and Processing*, 1, 65-70.
- [23] Tsheten, G., & Penjor, T. (2024). [Determinants of repeat breeding in sows and gilts at the National piggery development centre in Bhutan: A retrospective study](#). *Bhutan Journal of Animal Science*, 8(1), 90-102.
- [24] Turner, S.P., Camerlink, I., Baxter, E.M., D'Eath, R.B., Desire, S., & Roehe, R. (2024). Breeding for pig welfare: Opportunities and challenges. In *Advances in pig welfare* (pp. 429-447). Cambridge: Woodhead Publishing. doi: [10.1016/B978-0-323-85676-8.00003-1](https://doi.org/10.1016/B978-0-323-85676-8.00003-1).
- [25] Vaishnav, S., Saini, T., Ahmad, S.F., Gaur, G.K., Mehrotra, A., & Chauhan, A. (2025). Breeding management in commercial pig farms. In *Commercial pig farming* (pp. 29-46). London: Academic Press. doi: [10.1016/B978-0-443-23769-0.00003-8](https://doi.org/10.1016/B978-0-443-23769-0.00003-8).
- [26] von Keyserlingk, M.A., Hendricks, J., Ventura, B., & Weary, D.M. (2024). Swine industry perspectives on the future of pig farming. *Animal Welfare*, 33, article number e7. doi: [10.1017/awf.2024.2](https://doi.org/10.1017/awf.2024.2).
- [27] Ye, S., Song, H., Ding, X., Zhang, Z., & Li, J. (2020). Pre-selecting markers based on fixation index scores improved the power of genomic evaluations in a combined Yorkshire pig population. *Animal*, 14(8), 1555-1564. doi: [10.1017/s1751731120000506](https://doi.org/10.1017/s1751731120000506).

## **Застосування комплексних інтегральних індексів кнурів-плідників в програмах розведення системи DanBred**

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**Анотація.** Програми розведення свиней передбачають комплексну оцінку продуктивних і репродуктивних ознак у чистопородних лініях за допомогою індивідуальних племінних індексів, що дозволяє ефективно підвищити генетичний потенціал як помісних тварин для промислового виробництва, так і наступних поколінь племінного поголів'я. Такий підхід відрізняється від традиційних методів, які обмежуються оцінкою окремих ознак і уповільнюють генетичний прогрес. Метою дослідження було визначити доцільність використання індивідуальної інтегральної оцінки кнурів та встановити вплив їх віку та індивідуального селекційного індексу на репродуктивні та продуктивні якості. У дослідженні брали участь 304 свиноматки породи Дюрок, яких запліднювали спермою чотирьох кнурів різного віку, що належали до племінного ядра або репродуктивної групи, та їхнім комбінованим індексом племінної цінності, розрахованим за системою DanBred (не менше 130 балів для «племінного ядра» та 105 балів для «репродуктивної групи»). Було встановлено, що індивідуальний комплексний індекс та вік кнурів значно впливали на репродуктивну продуктивність свиноматок. Найкращі результати за репродуктивними показниками (індекс репродуктивної якості свиноматок – 84,8; життєздатність – 99,1 %; репродуктивний індекс – 34,8; однорідність приплоду – 0,90) були отримані від свиноматок, запліднених спермою молодих кнурів (12-18 місяців) з високими показниками. Старіші кнури або кнури з нижчими показниками племінної цінності показали гірші результати. Також було встановлено, що молоді кнури з високими показниками демонстрували кращу якість сперми (об'єм еякуляту – 332,6 мл; концентрація – 499,2 млн/мл; рухливість – 8,7 балів), хоча старші кнури давали більше доз для запліднення на еякулят (32,8). Ці результати підтверджують доцільність впровадження технології оцінки показників кнурів для підвищення ефективності селекційних програм в українській свинарській галузі

**Ключові слова:** селекційні програми; репродуктивні якості; свинарство; кластерна оцінка; якість сперми