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Selection of Weaning and Adult Weight to Increase Growth of Deutch Democratic Yokohama (DDY) Mice

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ABSTRACT

This study aims to determine the increase of the growth of Deutch Democratic Yokohama (DDY) strain mice through a selection program from generation 0 (G0, n = 323), generation 1 (G1, n = 367) to generation 2 (G2, n = 386). The variables used for the selected program were weaning weight (WW) and adult weight (AW). For WW, the selection was made on the best 50% WW, and for the AW, the selection was carried out by choosing the best eight males and the best 32 females, using the value of genetic parameters and breeding values. Based on the study, WW increased from G0 to G1 and G1 to G2 of 12.63% and 12.05%, respectively. The increase in AW from G0 to G1 and G1 to G2 was 7.85 % and 17.78%, respectively. The conclusion was that it was possible to increase weaning weight and adult weight by selecting the program.

Keywords: Adult weight, Mice, Mus musculus, Selection, Weaning weight

Introduction

Mice are rodents needed as a medium for research needs such as the medical field, animal feed, and scientific research. The various advantages of the mice include easy maintenance management. They are suitable as a medium applied to various scientific research, especially in universities, institutions, medical and food-related studies. Nugroho (2018) added that one of the mammals whose genetics is similar to humans is the mouse, so it is widely used for research, including genetic manipulation and gene engineering. Good quality mouse seeds based on the line according to research needs are needed but their development in terms of growth is not yet available. The increase in livestock growth is done by improving the genetic quality of mice and improving the environment. One of the efforts that can be done is to improve the genetic quality of livestock on livestock growth, namely the selection program on weaning weights of mice and adult weights of mice.

The environment can be improved through feed quality, management, and breeding programs to increase livestock productivity. Crossing and selection are activities to improve genetic quality through breeding programs (Dewi and Wardoyo, 2018). Evaluation of the genetic quality of livestock in the breeding program can be carried out by estimating individual breeding values in terms of the basis for carrying out selection activities. Breeding value reflects the genetic ability of individual livestock on a given trait relative to its position in a population (Tribudi *et al.,* 2021). Traits that have economic value can be increased by selection activities and the mating system of the desired traits to improve the genetic quality of livestock. Various economic value characteristics include fertility, vitality, growth speed, birth weight, weaning weight, feed efficiency, the value on the carcass, and weight and quality of fur (Karnaen, 2008).

Weaning weight has a positive correlation with the adult weight of mice. It is effective as a selection criterion. If a selection is carried out on one trait, in that case, it can show other traits, so the selection program can be carried out to increase optimal growth. Weaning weight shows the parent's performance to its offspring, so with the selection on weaning weight, it is expected to be able to choose the good performance from their parents. In contrast, the adult weight was used as a reference for the implementation of selection because it showed the performance of the offspring to be used. Weaning weight is genetically related or correlated with sexual maturity body weight. A positive correlation value can be used as a reference; with the higher weaning weight, the higher sexual maturity body weight, so the selection to increase the weaning weight can indirectly increase the sexual maturity body weight (Wibowo, 1984).

Research using mice of the DDY strain on the selection of weaning weights and adult weights from G0 to G2 shows an update because it has never been done before. Research on the selection of birth weight and weaning weight in DDY strain mice were carried out to study the possibility of increasing weaning weight and adult weight as a result of selection. By increasing weaning weight and adult weight through a selection that is expected to be useful for the implementation of breeding programs, especially in increasing the growth of mice. The study also to assesses the genetic potential of mice as experimental animals that can be seen through the growth of body weight.

Materials and Methods

Research material

The research tool in this study was a digital scale brand Camry 100 g. The research material used in the study was DDY strain mice. White DDY strain mice were obtained from the Bogor Veterinary Research Center which has good physical conditions, is agile, and is often used for research in various fields. DDY strain mice reared in G0, G1 and G2 were 323, 367, and 386, respectively, commercial animal feed type AD 1 with crude protein content around 19%.

Research methods

Mice were reared until weaning age (21 days) and weaning weight was weighed and the best 50% weaning weight was selected for males and females. Selection of adult weight (35 days) was carried out by weighing the weight of adults and taking 8 males and 32 females. The mating system for mice was carried out with a ratio of male and female of 1: 4. Implementation of the selection on DDY strain mice can be seen in Figure 1.

Calculation of correction factor and body weight adjustment

Weighing and recording of weaning and adult weights of DDY strain mice and recording of sex, birth type arranged according to lineage. Body weight data obtained, namely weaning weight data and adult weights of DDY strain mice were adjusted using a correction factor based on the research location.

Calculation of the estimated value of heritability

Estimation of heritability value in the study using the paternal half-sib correlation method. The variance component in calculating the estimated number of inheritance (heritability) using analysis of variance Completely Randomized Design One Way Classification, for the mathematical model can be written as follows:

$Y_{ik} = \mu + \alpha_i + e_{(i)k}$

Explanation :

Y_{ik} = observation of the kth individual on the ith male; μ = population mean; α_i = male influence to i; $e_{(i)k}$ = uncontrolled deviation stemming from environmental and individual genetic effects (Hardjosubroto, 1994).

The estimated heritability value is calculated by the following equation:

$h^2 = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$ or $h^2 = 4t$; and the standard error of heritability value is calculated by the following equation:

$$SE(h^2) = 4\sqrt{\frac{2(1-t)^2[(1+(k-1)t)]^2}{k(k-1)(S-1)}}$$

(Becker, 1992)

Calculation of estimated genetic correlation value

Estimation of genetic correlation based on paternal half-siblings using the one-way analysis of covariance method according to the recommendations of Becker (1992) and Sulastri *et al.* (2019) uses the following equation:

$r_G = \frac{4c\hat{o}v_s}{\sqrt{4^{\sigma}_{s(x)}4^{\sigma}_{s(y)}}}$; and the standard error of the genetic correlation value is calculated according to the following equation:

$$S.E\ (r_G) = \frac{1-r_G^2}{\sqrt{2}} \times \sqrt{\frac{S.Eh^2_{(x)}(S.Eh^2_{(y)}}{h^2_{(x)}h^2_{(y)}}}$$

Keterangan: r_G = Genetic correlation ; $\sigma^2{}_s(x)$= The male variance component in the trait x; $\sigma^2{}_s(y)$ = Components of the variety of males in the trait y; $c\hat{o}v_s$= Components of various traits that are related between males; $S.Eh^2_{(x)}$ = standard error of heritability value of x; $S.Eh^2_{(y)}$ = standard error of heritability value of trait y; $h^2_{(x)}$ = heritability on trait x; $h^2_{(y)}$ = heritability on trait y.

Calculation of breeding value

The calculation of individual breeding values according to Hardjosubroto (1994) are:

$NP = h^2 (P - \overline{P}) + \overline{P}$

Explanation:

NP = Breeding value; h^2 = heritability; $\overline{P}$ = mean performance in the population of individuals being measured; P = individual performance.

Calculation of selection response in each generation

Calculation of direct and indirect selection responses to determine the response to the selection of the population in DDY strain mice used the recommendation of Hardjosubroto (1994) with the following equation:

Direct selection response

$R = ih^2\sigma_P$;

Explanation:

R = Selection response value; h^2 = heritability value; σ_P= standard deviation; i = selection intensity.

Indirect selection response

$CR_{2.1} = i\sqrt{h1}\sqrt{h2}\, r_G \sigma_p$

Explanation :

$CR_{2.1}$= Indirect selection response; i = selection intensity ; h^2 = Heritability ; h1 = heritability of trait 1; h2 = second trait heritability; r_G = Genetic correlation between traits 1 and 2; σ_P= Standard deviation of the trait 2.

Results and Discussion

Weaning weight

Weaning weight is one of the criteria used in the selection criteria for DDY strain mice. The following are the measurement results along with the increase in the weaning weight of DDY strain mice in Table 1.

The average weaning weight in mice from this study increased in weaning weight from G0 to G2. The bodyweight of mice at weaning age is 10 to 12 g/tails; 18 to 20 g/tails or 7,69 g per tails (Nugroho, 2018). Based on the results of the study, the weaning weight of DDY strain mice was by the literature.

Genetic influences affect weaning weight in addition to parental or maternal factors affecting weaning weight but with increasing age of run into decreases (Elieser *et al.,* 2016). Weaning weight is influenced by maternal genetics including mother's milk production and breastfeeding behavior. Therefore, cattle that have good mothering ability can be known from the weaning weight of their offspring so that it can be used and can be used as a criterion for implementing parental selection (Prihandini *et al.,* 2011).

Adult weight

Adult weight is a selection criterion in DDY strain mice. The adult weights of the DDY strain mice can be seen in Table 2.

Mice reached adulthood at the age of 35 days. Adult male mice have a body weight of about 20 g to 40 g and in female mice 18 g to 35 g (Smith and Mangkoewidjojo, 1988). Based on the results of the study, the measurement of adult weight in DDY strain mice was by the literature. Sex adult body weight is influenced by weaning weight so that high weaning weight will increase sex adult weight (Wibowo, 1984). Nutritional factors affect individual body weight gain. Nutrients are nutrients also called nutrients contained in feed and then enter the body as feed consumption (Mardiati and Sitasiwi, 2016).

Increase in body weight

Selection can increase the average body weight of the population which can be known based on the weaning weight and adult weight of the increasing mice. The following is the average increase in weaning and adult weight in generations G0, G1, G2 in DDY strain mice, which are listed in Table 3.

Based on the research in Table 3, the average weaning weight and adult weight from G0 to G2 always increased. The increase in weaning weight and adult weight as a result of research that occurred in DDY strain mice was due to a selection process by selecting selected livestock for each generation so that it could improve its performance, namely body weight gain.

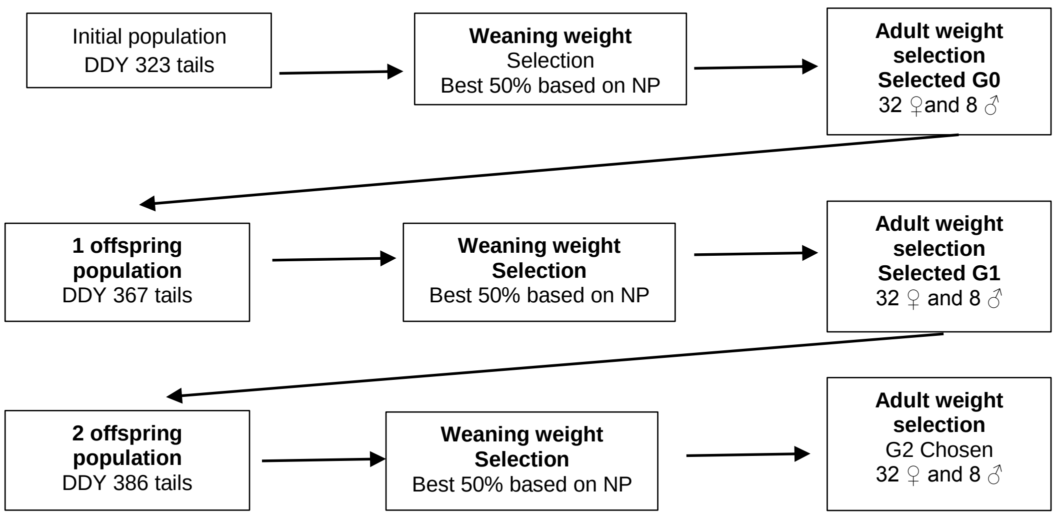

Figure 1. Stages of Selection Implementation.

Table 1. Weaning weight of DDY strain mice

Bodyweight (g)	P0	G0*	PG1	G1*	PG2	G2*
Mean	12.20	13.93	13.97	15.69	16.80	17.58
St deviation	2.64	2.06	2.52	1.91	1.54	1.07

P0 = Initial population; G0* = mice selected in the 0th generation; PG1 = first-generation population; G1* = mice selected in the 1st generation; PG2 = second-generation population; G2* = mice selected in the 2nd generation.

Table 2. Adult weights of DDY strain mice

Body weight	P0 (g)	G0* (g)	PG1 (g)	G1* (g)	PG2 (g)	G2* (g)
Mean	24.58	26.23	26.29	28.29	31.68	33.32
St deviation	2.76	2.08	2.11	1.97	1.67	1.09

P0 = Initial population; G0* = mice selected in the 0th generation; PG1 = first-generation population; G1* = mice selected in the 1st generation; PG2 = second-generation population; G2* = mice selected in the 2nd generation.

Table 3. Increase in weaning and adult weights of DDY strain mice

Age	G0 (g)	G1 (g)	Increase		G1 (g)	G2 (g)	Increase	
			g	%			g	%
Weaning	13.93	15.69	1.76	12.63	15.69	17.58	1.89	12.05
Adult	26.23	28.29	2.06	7.85	28.29	33.32	5.03	17.78

G0 = mice selected in the 0th generation; G1 = mice selected in the 1st generation; G2 = mice selected in the 2nd generation.

The frequency of genes contained in traits in a group of individuals in the population can be changed by selection and culling (Sulastri *et al.,* 2019). Improvement of genetic quality through a selection program will be effective if the response to the nature of production carried out by the selection process will have a high value (Istiqomah, 2010). The selection that is carried out continuously will affect changes in the phenotype of livestock and increase following a straight line (Hardjosubroto, 1994). Based on the results of the study, the weaning weight data always increased accompanied by an increase in the adult weight of the DDY strain mice.

Heritability

The calculation of heritability estimates in mice was carried out using data from paternal half-siblings, following the results of the calculation of the estimated heritability values listed in Table 4.

Table 4. Estimation of heritability values of weaning weight and adult weight of DDY mice

Variable	G0 (g)	G1 (g)	G2 (g)
Weaning weight	0.56±0.30	0.48±0.26	0.40±0.23
Adult weight	0.53±0.35	0.47±0.31	0.36±0.26

G0 = mice selected in the 0th generation; G1 = mice selected in the 1st generation; G2 = mice selected in the 2nd generation.

Based on the results of the study, it was found that the estimated heritability of weaning weight for DDY strain mice at G1 was 0.48±0.26. The estimated value of heritability of weaning weight obtained from the study can be interpreted that 48% being influenced by additive gene variance and 52% being influenced by dominant variance, epistatic variety, and environment. Heritability values of 0 to 0,1 are low; 0,1 to 0,3 is classified as moderate; and more than 0,3 is considered high (Hardjosubroto, 1994). Based on the research data, the estimated heritability value of the weaning weight of the DDY strain mice can be categorized as high.

The estimated heritability value of the adult weight of DDY strain mice in G1 is 0.47±0.31 which means that 47% is influenced by additive gene variance and 53% is influenced by dominant variety, epistatic variety, and environment. The estimated heritability value of adult weight in DDY strain mice in this study was high and the estimated heritability value decreased from G0 to G2. Estimation of heritability values can indicate the progress of selection. A high heritability value can indicate that the presence of additive gene action is important for a trait and the best interbreeding to produce the desired offspring, but a low heritability estimate can indicate that there is a low correlation between genotype and phenotype and if superior individuals are used in These traits for breeding purposes will produce offspring that are not as good as those obtained based on heritability for high traits (Lasley, 1978). Selection and mating is an effort to improve the genetic quality of livestock to maintain the purity of livestock and improve the genetic performance of offspring. Selection is an activity to get individuals who have the desired genes in the next generation by maintaining the best genes owned by individuals for reproductive activities (Istiqomah, 2010).

Genetic correlation

The results of the calculation of the estimated genetic correlation value between weaning weight and adult weight can be seen in Table 5.

Table 5. Estimation of the genetic correlation value of weaning weight and adult weight of DDY strain mice

Generation	DDY Mice genetic correlation value (g)	Explanation
G0	0.58±0.29	Positif
G1	0.47±0.36	Positif
G2	0.43±0.49	Positif

G0 = mice selected in the 0th generation; G1 = mice selected in the 1st generation; G2 = mice selected in the 2nd generation.

Based on the results of the study, the estimation of the genetic correlation value on weaning weight and adult weight of DDY strain mice was categorized as positive. Wibowo (1984) added that the genetic correlation value in male mice was 0.42131 and female mice was 0.76714±0.0998. The results of the study based on the estimated genetic correlation of weaning weight and adult weight in DDY strain mice were classified as positive.

If a trait has increased and affects other properties, it can be interpreted that the correlation value is positive. Thus, having the same gene if it causes the appearance of two or more traits will cause a genetic correlation (Warwick *et al.,* 1990). With heritability, it shows that parents pass on traits to their offspring and genetic correlations describe the close relationship between genes in the presence of additives that affect two or more traits (Soeroso *et al.,* 2009). To determine the basis of the selected trait, it is necessary to have heritability values, economic values, and costs (Karnaen, 2008). Therefore, the selection made on weaning weights can be an effort to improve the genetic quality of weaning weights and the correlated trait, namely adult weight. mature. Thus, it can be interpreted that improving weaning weight through a selection process will improve adult weight in DDY strain mice.

Breeding value (BV)

The estimation of the breeding value was carried out based on the weaning weight data and the adult weight was carried out to select the selected parents. Selection of DDY strain mice on weaning weight was carried out based on the highest 50% NP to select selected parents. The selection of DDY strain mice on adult weight was carried out by selecting 8 males and 32 females. The estimation of breeding values based on weaning weight and adult weight in DDY strain mice are listed in Table 6 and Table 7.

Table 6. Estimation of weaning weight breeding values of DDY mice

NP weaning weight	G0 (g)	G1 (g)	G2 (g)
Highest NP male	18.55	17.78	18.89
Female highest NP	16.87	24.50	20.66
Lowest NP male	11.44	13.53	17.64
Female lowest NP	10.99	13.75	17.73

G0 = mice selected in the 0^{th} generation; G1 = mice selected in the 1^{st} generation; G2 = mice selected in the 2^{nd} generation.

Table 7. Estimation of adult weight breeding values of DDY mice

NP adult weight	G0 (g)	G1 (g)	G2 (g)
Highest NP male	30.33	36.90	42.02
Female highest NP	35.03	42.775	41.10
Lowest NP male	27.80	32.72	41.30
Female lowest NP	29.79	31.77	40.00

G0 = mice selected in the 0^{th} generation; G1 = mice selected in the 1^{st} generation; G2 = mice selected in the 2^{nd} generation.

Breeding value is the total genetic ability of livestock on a certain trait so that the breeding value leads to the value of an animal in a breeding program for a trait (Salem and Hammoud, 2016). Seedlings from livestock or individuals with high breeding values are selected to be selected in the next generation rather than seeds from livestock with low breeding values (Lande *et al.,* 2019).

Selection response

The selection response was based on the selection that had been made on DDY strain mice. The selection was carried out on the DDY strain mice with the weaning weight of the DDY strain mice aged 21 days and adult weights at 35 days. Based on the results of the study, the value of the direct selection response on weaning weights of DDY strain mice was 0.92 g/generation, 0.72 g/generation, and 0.34 g/generation while the selection response value for adult weight was 1.51 g/generation, 1.35 g/generation, and 0.58 g/generation. The value of the direct selection response of weaning weight and adult weight in DDY strain mice decreased to G2. Based on the results of the study, the indirect selection response value of DDY strain mice were 0.90 g/generation and 0.64 g/generation, respectively. The value of the indirect selection response of weaning weight and adult weight in DDY strain mice decreased to G2.

Continuous selection can affect livestock populations by increasingly losing genetic diversity and phenotypic variety, thus the selection response decreases so that there is no selection response and the phenotypic graph shows a horizontal line called the plateau condition (Hardjosubroto, 1994). Genetic diversity and heritability values are useful in the implementation of selection programs. Implementation of an effective selection if the genetic diversity is wide and the population has high heritability values (Syukur *et al.,* 2011).

Conclusions

Based on the results of the study, the following conclusions can be obtained: 1) With the selection of weaning weight and adult weight in DDY strain mice, the weaning weight and adult weight of DDY strain mice can increase from G0 to G2, 2) The estimated heritability of weaning weight in DDY strain mice obtained from the results of the study in G0 to G2 was positive and high, 3) The estimation of the genetic correlation value in DDY strain mice at G0 to G2 which is classified as positive can be interpreted that the selection of weaning weight in DDY strain mice can increase the adult weight of DDY strain mice.

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