

EFFECTIVENESS OF INDIVIDUAL AND FAMILY SELECTION FOR THE BODY WEIGHT IN *DROSOPHILA MELANOGASTER*¹

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Summary. A two-way selection for the body weight in *Drosophila melanogaster* has been performed using individual and family selection under stable environmental conditions. Individual selection lasted for 51 generations and family selection — for 50 generations.

Results obtained in the both types of selection, individual and family, were different. The most effective appeared to be family selection, in which the obtained progress was more systematic and resulted in a marked differentiation between the families selected for a high body weight, control and those selected for a low body weight.

A significant asymmetry in the response to selection has been achieved between the lines selected for a high and low body weight of insects. In both, individual and family selection, more effective was selection for a high body weight.

Theoretical considerations concerning prediction of selection results do not always prove correct in practice, because they are influenced by too many factors. It would be very expensive, long-lasting and in most cases impossible to carry out experiments on farm animals with the aim of testing different selection methods.

Among many species of laboratory animals one of the most popular is the fruit fly *Drosophila melanogaster* (Robertson 1956, Knothe 1965, Lerner 1969, Chvostova et al. 1978). Selection for many different features was conducted on the fruit fly; selection for the insect size has been the subject of breeders' interest.

The purpose of the present paper was the study on a two-way selection for the body weight in *Drosophila melanogaster* using individual and family selection under stable environmental conditions.

MATERIAL AND METHODS

The studies were carried out on *Drosophila melanogaster* reared at the Department of Genetics of the Agricultural and Teacher's University in Siedlce. The rearing conditions and the nutrient medium used were the same as those in the paper by Socha (1984).

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Individual selection was performed in three stages, and family selection — in two stages. There were intervals between the stages of selection.

Stage I. To determine the effectiveness of selection for a high body weight three simultaneous rearings (replications) were carried out in 1-l Erlenmeyer flasks. Ten females and ten males constituted the beginning of each generation (for each replication). Seven days after, the flies of the parental generation were removed. Then, about 80 pupae were isolated from each rearing. On the 14th day of rearing the progeny was examined. As the pupae hatched in individual tubes, they were segregated according to their sex and individually weighed to an accuracy of 1 mg on the electronic Sartorius microscopes of 4431 type. Among them 10 heaviest females and 10 heaviest males were selected for further rearing.

The experiments, which had to determine the effectiveness of selection for a low body weight were carried out in a similar way as above, with the only difference that the lightest, not the heaviest, insects were selected for further rearing.

Three control groups were simultaneously maintained in 3-l jugs, with no selection among them. The beginning of each generation were randomly selected 50 females and 50 males. Fifty pairs in the control rearing had to prevent matings of relatives. Selection at that stage of studies was performed through 20 generations. Through the subsequent 7 generations, the flies in both control and selected rearings were randomly selected. The control of the body weight was performed for generations 24-26.

Stage II. Selection was made in a similar way as at stage I, with small changes. At that stage it was decided to reduce the period of time, which the insects — parents of the future generation came from. The flies, hatched before the 13th day of the established generation, were removed from the flasks. Then, pupae were isolated from each rearing. On the 15th day of rearing the progeny hatched from isolated pupae was examined. In rearings selected for a high body weight (H) and low body weight (L) a choice was made according to the direction of selection. Control rearings (C) were limited to the same number of insects as in the experimental groups (10 pairs in each replication). Selection at that stage was performed in generations 28-47. Through the next 5 generations the insects were chosen and mated randomly within each experimental and replication group.

Stage III. Individual selection in generations 53-63 was continued according to the same principles as at stage II.

FAMILY SELECTION

Stage I. Before the beginning of the selection experiment the sterility of females hatched during night was checked by a test. It was performed on 100 females hatched during night in the rearings of the Department of Genetics and taken in the morning, not later, however, than 12 hours after removal of hatched insects on the previous day. After 11 days it was checked, whether there were larval forms, pupae or imago

in the flasks. It was found that during 12 hours after hatching no female was fertilized. The test confirmed the possibility of selecting virgin females directly from the rearing (Strickberger 1962) without the necessity of pupae isolation.

In view of the fact that results of the earlier studies (Socha 1984) indicated a large fluctuation of the female body weight, caused not only by somatic development, but also by ovary development, exclusively the male body weight was taken into account while selecting families. The females were also weighed to obtain additional information, but that had no influence on the decision of their selection.

The rearing was started from 60 insect pairs, the progeny of individual pairs consisted of complete siblings. Insects hatched before the 14th day were segregated according to sex, counted and weighed (collectively). On the basis of the obtained results 20 heaviest families (HS), 20 lightest (LS) and 20 families with an average body weight (CS) were selected. Division made on the basis of the male body weight formed the following groups: with 20 families in each, which gave the beginning to selection for a high (HS) or low body weight (LS) and with 20 control families (CS). Next day, i.e. on day 15 after the establishment of the rearing 2 insect pairs were taken from each HS family to form new families which were selected for high body weight in the subsequent generations. Regarding the lightest families (LS), two pairs of insects were taken from a new family, later selected for a low body weight. One pair of insects was taken from each of the remaining 20 families to form new families, which constituted a control group. In order to prevent inbreeding increase in rearing families a rotation system of matings of Falconer was used (after Sławiński 1981). In the subsequent generations 20 families (out of 40) were selected from each HS and LS groups according to the previously accepted criterion. Selection of families at that stage was performed through 25 generations. Then, in the groups, where selection was performed, it was given up for the period of 5 generations and insects within their groups were reproduced maintaining rotation mating system.

Stage II. In generations 31-55 selection was continued according to the same principles as at stage I of the selection. After the selection expired it was given up for 6 generations, and insects within their groups were reproduced maintaining the rotation mating system.

STATISTIC CALCULATIONS

Data concerning the body weight of males and females in mass selection were treated separately for each sex and using a two factor analysis of variance in a double cross classification (Oktała 1972) according to the model:

$$x_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ijk}$$

where μ — mean value of a feature, α_i — effect of replication, β_j — effect of generation, $(\alpha\beta)_{ij}$ — effect of interaction, e_{ijk} — error.

Results of family selection were processed according to the same model of the analysis of variance, α_i meaning the effects of individual families (HS, LS or CS).

Phenotypic relationships between the body weight of females and males in family selection were worked out according to the method given by Ruszczyk (1978).

In order to see trends in the subsequent generations we used average means formed in the following way: having a number of means (for instance, male body weight) in n subsequent generations $\bar{x}_1, \bar{x}_2, \bar{x}_3, \dots, \bar{x}_n$, transformations were performed

$$\bar{x}_2 = \frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3}{3}, \bar{x}_3 = \frac{\bar{x}_2 + \bar{x}_3 + \bar{x}_4}{3}, \dots, \bar{x}_{n-1} = \frac{\bar{x}_{n-2} + \bar{x}_{n-1} + \bar{x}_n}{3}$$

giving a number of moving means $\bar{x}_2, \bar{x}_3, \dots, \bar{x}_{n-1}$.

The value of response to selection was determined by estimating a cumulated phenotypic advance h^2 (Žuk 1979), which was a ratio of a sum of advances in all the generations (ΣG) and selection difference (ΣDS).

$$h^2 = \frac{\Sigma G}{\Sigma DS}$$

A standardized cumulated breeding (phenotypic) advance was also estimated by advance values in all the generations. Standardization consisted in subtraction in each generation of the corresponding advance values (in the control families in family selection) from a cumulated advance in the experimental groups obtained during that time (ΣG_s). After dividing ΣG_s by ΣDS we obtained a standardized coefficient of realized heritability (h_s^2).

$$h_s^2 = \frac{G_s}{DS}$$

The coefficient of realized heritability was also estimated as a regression coefficient (h_r^2) of the ΣG on ΣDS in the subsequent generations of selection (Hill 1972).

RESULTS AND DISCUSSION

Individual and group (families) results of insect weighing have revealed marked differences in the body weight of males and females, and for that reason results were treated separately for each sex.

INDIVIDUAL SELECTION

In individual selection for a high and low body weight (designated H and L, respectively) against the control group (C) showed no significant differences between replications and in this connection they were treated together.

In Figs 1-4 the body weights of insects are expressed in moving means, which permitted to discover the main trends manifested by individual groups of selected

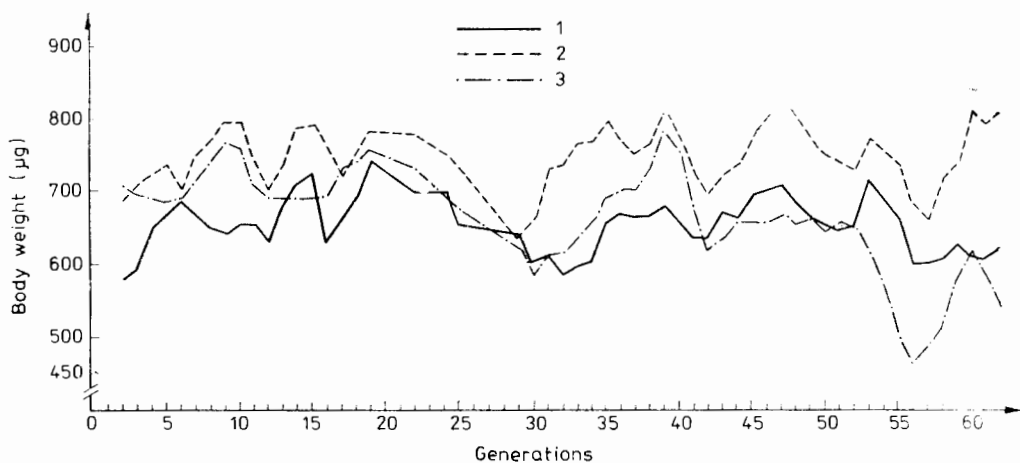


Fig. 1. Movable means of the male body weight of *D. melanogaster* in individual selection
 1 — control rearings, 2 — rearings selected for high body weight, 3 — rearings selected for low body weight

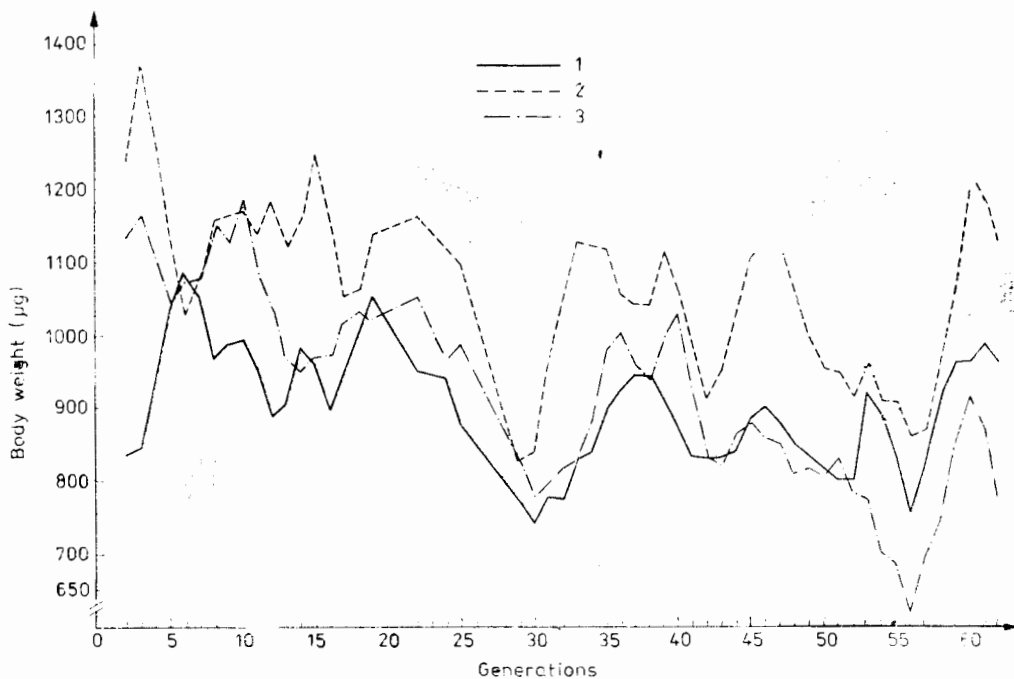


Fig. 2. Movable means of the female body weight of *D. melanogaster* in individual selection
 1 — control rearings, 2 — rearings selected for high body weight, 3 — rearings selected for low body weight

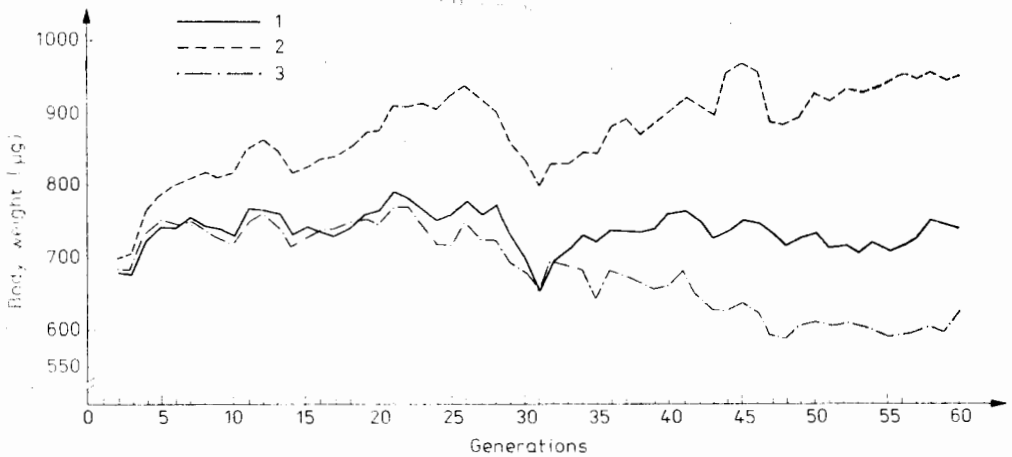


Fig. 3. Movable means of the male body weight of *D. melanogaster* in family selection
 1 — control families, 2 — families selected for high body weight, 3 — families selected for low body weight

flies. Curves in Figs 1 - 4 were drawn taking into account division into different types of selection (individual selection — Figs 1 and 2, family selection — Figs 3 and 4 (and sexes) males — Figs 1 and 3, females — Figs 2 and 4).

In individual selection fluctuations in the body weight were observed in the experimental H and L rearings. Large fluctuations were also noted in the control C

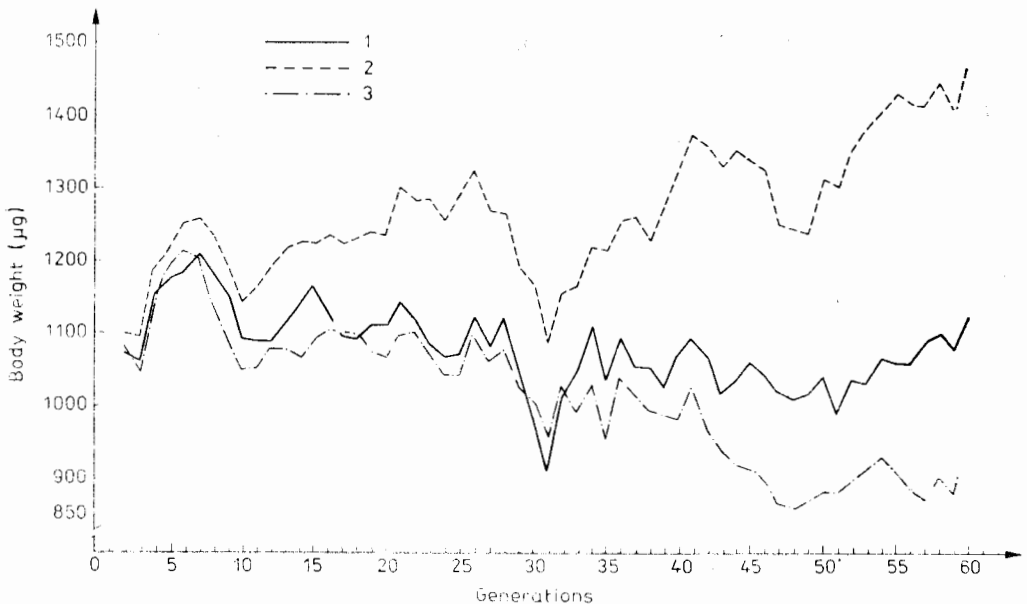


Fig. 4. Movable means of the female body weight of *D. melanogaster* in family selection
 1 — control families, 2 — families selected for high body weight, 3 — families selected for low body weight

rearings. It is difficult to explain the reasons of such state of things, but they were probably related to the influence of the environment, despite the fact that throughout the entire experiment the efforts were made to maintain stable temperature, lightening and feeding. The observed large identity of the increase and decline in the values of the studied characters in all the groups seems to support that suggestion.

Table 1. Realized heritability (h^2), realized standardized heritability (h_s^2) and realized heritability (h_r^2) calculated as regression of ΣG on ΣDS in individual selection of *Drosophila melanogaster*

| Generations | Heritability | Heritability coefficients | | | |
|-------------|--------------|---|-------|---------------------------------------|-------|
| | | rearings selected for high high body weight | | rearings selected for low body weight | |
| | | females | males | females | males |
| 1 - 20 | h^2 | 0.07 | 0.06 | 0.00 | -0.03 |
| | h_s^2 | 0.02 | -0.04 | 0.08 | 0.08 |
| | h_r^2 | -0.02 | 0.05 | 0.05 | -0.02 |
| 28 - 47 | h^2 | 0.09 | 0.14 | 0.06 | -0.01 |
| | h_s^2 | 0.09 | 0.17 | 0.05 | -0.05 |
| | h_r^2 | 0.08 | 0.09 | -0.03 | -0.05 |
| 53 - 63 | h^2 | 0.20 | 0.20 | 0.12 | 0.45 |
| | h_s^2 | 0.03 | 0.18 | 0.31 | 0.47 |
| | h_r^2 | 0.25 | 0.19 | 0.01 | 0.01 |

As a result of the performed individual selection in generation 1 - 20, 28 - 47 and 53 - 63 a phenotypic advance (measured by the value of realized heritability) for a high body weight has been achieved. Heritability realized in individual selection is presented in Table 1. The lowest advance was at the first stage of selection, the highest one — at the third stage. At the first stage of selection the insects were taken from a group of different age and for that reason a small effectiveness of selection could result from a smaller precision of the estimated selection value. One of the basic factors, which determine selection success is the correctness of the selection value estimate (Lerner 1969, Falconer 1974, Schwark 1977, Žuk 1979). If selection was made from the group with a large age range, then the phenotypic estimate of individuals only to a small degree rendered their selection value. The body weight of insects, besides genetic factors, were influenced by monogenetic factors, in this case caused by the insects' age.

FAMILY SELECTION

In family selection for the body weight in females a larger effectiveness was obtained in generations 31 - 35 as compared to that obtained in generations 1 - 25 in males, and vice versa.

Coefficients of realized heritability in family selection are presented in Table 2. On the basis of the obtained heritability coefficients it should be concluded that the body weight in the fruit fly is little heritable.

REALIZED HERITABILITY

Coefficients of realized heritability for the periods, in which an advance has been achieved, ranged from 0.07 to 0.20 (Tables 1,2). In the selection for a low body weight, except gene ratios 53 - 63 in individual selection, heritability was still lower.

Authors of other works, who estimated heritability of the animal body weight, obtained very different results. The heritability coefficient of *Drosophila melanogaster* body weight determined by Martin (1959) was 0.2, whereas that estimated by De Fries and Touchberry (1961b) for *Drosophila affinis* body weight was equal to 0.06.

Table 2. Realized heritability (h^2), realized standardized heritability (h_s^2) and realized heritability (h_r^2) calculated as regression of ΣG on ΣDS in family selection of *Drosophila melanogaster*

| Generations | Heritability | Heritability coefficients | | | |
|-------------|--------------|--|-------|---------------------------------------|-------|
| | | Families selected for high body weight | | Families selected for low body weight | |
| | | females | males | females | males |
| 1-25 | h^2 | 0.09 | 0.16 | 0.03 | -0.02 |
| | h_s^2 | 0.10 | 0.13 | 0.00 | 0.02 |
| | h_r^2 | 0.07 | 0.15 | 0.03 | -0.03 |
| 31-55 | h^2 | 0.20 | 0.14 | 0.07 | 0.06 |
| | h_s^2 | 0.11 | 0.09 | 0.17 | 0.11 |
| | h_r^2 | 0.12 | 0.10 | 0.09 | 0.09 |

The body weight of farm animals belongs to intermediately and highly heritable characters and according to different authors ranges from 0.2 to 0.7 (after Žuk 1979 and Radomska 1982).

In the earlier studies the body weight of insects was estimated on the basis of the length of the thorax and wings. The heritability of these characters estimated by Robertson (1956, 1957) was 0.3 - 0.5 and 0.4, respectively. It should, however, be remembered that the length of the thorax and wings is not in the line with the body weight (Sheldon 1963).

Only the construction of electronic microscales permitted to weight insects precisely and then to estimate the body weight parameters.

EFFECTIVENESS OF SELECTION FOR A HIGH AND LOW BODY WEIGHT

A large differentiation, particularly in the first periods of selection, occurred between heritability of a high and low body weight. When estimating standardized realized heritability, the body weight of insects in selected rearings was compared to that in the control rearing. The phenotypic advance achieved in H (in HS families) and L (in LS families) rearings was additionally compared to the body weight in the C rearings (in CS families). In the case of the body weight increase in the C

(or CS) lines the advance obtained in the H (or HS) lines was reduced by that increase, whereas in the L (or LS) lines it was increased by the same value. The standardized realized heritability in most cases influenced the increase of the realized heritability coefficients of a low body weight, which meant that the control lines slightly increased their body weight in individual periods.

Results obtained by most of authors, who carried out selection in opposite directions, showed asymmetry of response. The experiments of Hetzer and Harvey (1967), who performed two-way selection throughout 10 generations for the thickness of pork fat showed a higher heritability of the pork fat thickness reduction. Menzi and Lortscher (1964), selecting hens for a high weight of eggs obtained h^2 equal to 0.45, and in the case of this kind of selection for a low weight of eggs they obtained h^2 equal to 0.71. Nestor et al. (1983), performing selection of quails through 5 generations in two directions — a high and low egg-laying ability, estimated heritability, which was 0.069 and 0.353, respectively. Benoff and Renden (1983) obtained a higher effectiveness of selection in the direction of a low body weight, when selecting dwarf hens for a high and low body weight. Pingel et al. (1984) selecting ducks for a high and low feed intake obtained a larger effectiveness for a low intake.

Selection works carried out on mice by Mac Arthur (1949), Falconer (1953, 1960), Legates and Farthing (1962), Sutherland et al. (1968), Hayes and Eisen (1979), Hyde and Sawyer (1980) confirmed a higher effectiveness of selection towards a reduction of the character value. The reasons, which brought about such an asymmetry were varied. One of them could be inbreeding depression. Under the influence of inbreeding the average body weight decreased, which involved a decrease in the response tempo in plus and thereby — an increase of response to selection in a negative direction. The effectiveness of selection depends to a large degree on the frequency of genes determining a given character in the initial population. The lower is that frequency, the more easily a desirable advance is obtained. A low body weight is a character, which can unfavourably influence the organism of mice and natural selection may act against that character (Falconer 1974).

One of few works revealing asymmetry in the opposite direction were experiments by Von Butler et al. (1984). They selected mice in opposed directions and obtained a larger effectiveness for a high body weight. The authors see the reasons of asymmetry in different frequencies of genes before starting selection. A higher fecundity of individuals with a lower body weight caused a larger spread of genes of that character in the initial population. In fact, mice with a high body weight had their first litters larger, but their general life fecundity was lower in comparison to mice with a low body weight. That caused a larger portion of genes determining the value of that character. Selection for a high body weight has brought about a significant frequency increase in genes of "high body weight" in comparison to the opposite direction of selection, which was the cause of the observed asymmetry.

In some selection works, including those on fruit flies, no response asymmetry was detected. Kask and Vorob'eva (1981) performed selection throughout 60 generations for an increased and reduced wing length. They did not find any signi-

ficant asymmetry in their experiments. Asymmetry was not revealed, either, in one of Robertson's experiments (after Falconer 1974) in the response to selection for the thorax length of the fruit fly.

Sheldon (1963), while selecting fruit flies for the body weight, obtained significant asymmetry in the selection response. More effective appeared to be selection for a high body weight. The mentioned author sees the reasons of asymmetry in differentiated survival of insects. From general observations it follows that their survival decreased in the lines with a low body weight (particularly in one of them). But the author did not notice changes in the survival of the opposed lines. He mentioned, however, that those observations were very general and were not the subject of detailed studies.

Robertson (1955) making selection for the length of abdomen and wings found that insects with a longer abdomen and longer wings are characterized by a better survival.

The author of the present paper found no differentiation in individual selection with regard to female fecundity between the H and L lines (Socha 1987), whereas in family selection the fecundity markedly decreased in the HS families. Fecundity of females under family selection for the body weight indicates that insects with a higher body weight were characterized by a lower fecundity and insects with a lower body weight were more fertile. Assuming that insects in the initial population were characterized by such a regularity, the gene frequency of a low body weight was higher in comparison with the frequency of genes conditioning high body weight in the initial population. That would be in agreement with the already cited hypothesis of Von Butler et al. (1984).

EFFECTIVENESS OF SELECTION AMONG MALES AND FEMALES

Differences in the body weight of males and females revealed in the present paper are supported by earlier studies of De Fries and Touchberry (1961b), Druger (1962), Sheldon (1963), Kearsey and Kojima (1967), Trudy (1981), Kammerer and Young (1983). A larger variation in the body weight of females was obtained in the studies of Fries and Touchberry (1961a), Sheldon (1963), Kammerer and Young (1983).

Differentiation in the body weight of males and females obtained in the experiments presented in this paper could be one of the reasons of varied effectiveness of selection for each sex. In the selection for a low body weight, except stage III of individual selection, the effectiveness of selection was higher among the females. In the selection for a high body weight results between individual stages were differentiated. In some periods the effectiveness of selection was higher among the females, whereas in others it was the opposite. Sheldon (1963) conducting selection for a high and low body weight in fruit fly obtained a larger advance for a high body weight among the females. Regarding selection for a low body weight this author achieved no advance in females of one of the lines, while another line of females had the body weight similar to that of the initial generation. Only slight advance was

obtained by that author in one of the lines among the males. In another line the males had the body weight slightly lower, but it was difficult to speak about advance.

Authors of other works, who performed selection in opposed directions, including Hyde and Sawyer (1980) — for the aggressiveness of mice, Dunnington et al. (1981) — for cholesterol content in the blood of mice, Pingel et al. (1984) — for the effectiveness of feed intake by ducks, found a smaller differentiation in the effectiveness of selection between sexes than between directions of selection.

EFFECTIVENESS OF INDIVIDUAL AND FAMILY SELECTION

One of the objectives of the present paper was a possibility of comparing the effectiveness of individual and family selection. From an analysis of diagrams of moving means of the body weight it follows that the most effective was family selection, in which selection advance was more systematic and selection benefits were maintained in the next generations. During that selection there occurred a marked differentiation of HS, LS and CS families. In individual selection differentiation also became evident between the H, L and C rearings, but it was not so pronounced as under family selection. The direction of changes in the body weight (except males in the LS families in generations 1 - 25) always conformed to the direction of selection (Fig. 3 and 4). In individual selection changes in the body weight, particularly in the L rearings were not always in conformity with the direction of selection (Figs 1 and 2).

A larger systematism in the selection response observed during family selection also caused the obtaining of more probable coefficients of realized heritability. As a matter of fact, they were not high, but more similar to each other irrespective of the method of their estimation. Only in two cases, negative values, very close to zero, were obtained. In the groups selected individually the stability of these coefficients was much smaller, which probably resulted from large fluctuations of that character values in individual generations.

In order to compare additionally the effectiveness of two selection methods, Table 3 contains cumulated selection differences and means of selection differences per generation, whereas Figs 5 - 8 present selection response in the form of relative body weights in the selected groups in relation to the control. Table 4 presents regression coefficients of body weights on generations with the division into individual and family selection, as well as with the division into females and males.

The obtained mean selection differences were larger in most of the generations in individual selection. Selection response, however, was higher in the selection of families, where individual groups of families became markedly differentiated. A higher effectiveness of family selection is also supported by the estimated regression coefficients. In family selection only in one case regression was not in agreement with the direction of selection, while in individual selection as many as 5 regression coefficients did not conform to the direction of the conducted selection. In family selection the regression coefficients for most of the generations were statistically significant, whereas in individual selection only two regression coefficients were statistically significant.

Table 3. Selection differences (in μg) in individual and family selection of *Drosophila melanogaster*

| Genera- tion | Individual selection | | | | | Genera- tion | Family selection | | | | |
|-----------------|----------------------|--|---------|---|---------|-----------------|------------------|--|---------|---|---------|
| | para- meter | rearings selected for high body weight | | rearings selected for low body weight | | | para- meter | families selected for high body weight | | families selected for low body weight | |
| | | males | females | males | females | | | males | females | males | females |
| 1-20 | Σ RS* | 1565.6 | 3771.6 | 1331.8 | 2556.1 | 1-25 | Σ RS | 1372.5 | 2269.7 | 1091.1 | 1916.8 |
| | \bar{x} RS** | 77.8 | 188.6 | 66.6 | 127.8 | | \bar{x} RS | 54.9 | 90.8 | 43.6 | 76.7 |
| 28-47 | Σ RS | 1253.8 | 2135.3 | 1063.2 | 1617.3 | 31-55 | Σ RS | 1213.6 | 1773.4 | 1123.6 | 1695.2 |
| | \bar{x} RS | 62.7 | 106.8 | 53.2 | 80.9 | | \bar{x} RS | 48.6 | 70.9 | 44.9 | 67.8 |
| 53-63 | Σ RS | 514.2 | 1033.0 | 473.2 | 853.0 | | | | | | |
| | \bar{x} RS | 46.7 | 93.9 | 43.0 | 77.6 | | | | | | |

* cumulated selection difference

** mean selection difference per generation

Gallego and Lopez-Fanjul (1983), performing individual and within-family selection for the reduction of set a number in the fly, obtained the same effectiveness with the both methods. Similar results were previously obtained by Clayton et al. (1957), who selected flies for the number of the abdomen setae using a mass and family selection, and with the both methods similar results were obtained. Von Butler et al. (1984), selecting mice for the body weight, obtained a higher effectiveness in individual than in family selection. Selection of families in two groups constituted 82% and 61% effectiveness of individual selection, respectively. Kownacki (1982) conducted selection of mice, using in one population selection on the basis of individual production, but in the other — on the basis of this character value in the offspring. He found that an estimate and selection of mice on the basis

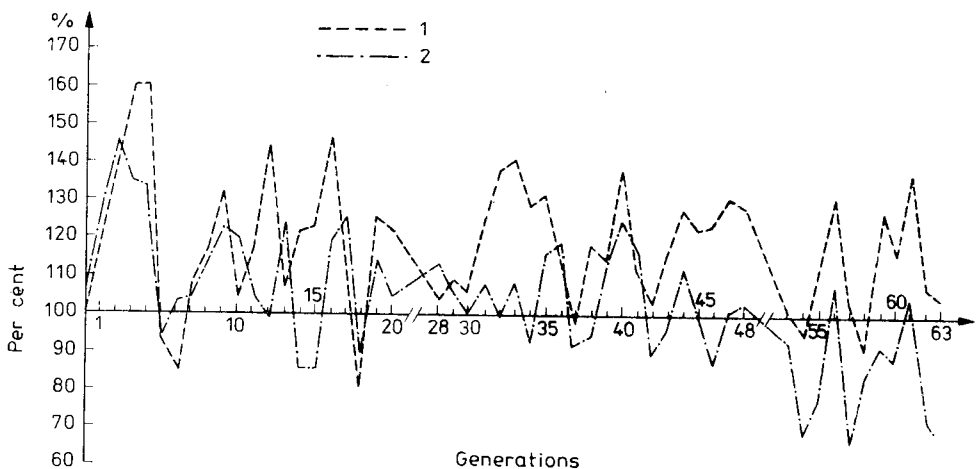


Fig. 5. Response to selection of males in individual selection expressed by relative body weights of insects in relation to the control rearings.

1 — families selected for high body weight, 2 — families selected for low body weight

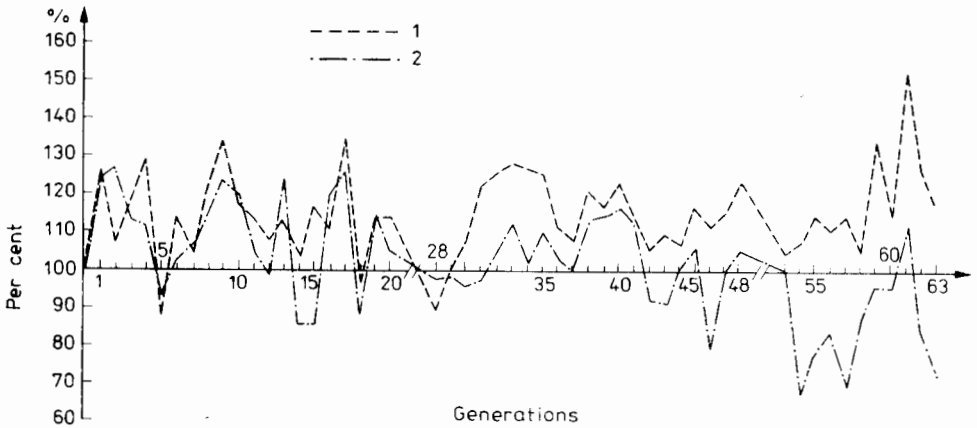


Fig. 6. Response to selection of females in individual selection expressed by relative body weights of insects in relation to the control rearings

1 - families selected for high body weight, 2 - families selected for low body weight

of individual productivity gave better results in comparison with those on the basis of their offspring. A considerably more effective individual selection for the body weight of mice could result from the fact that this character in mice is characterized by a higher heritability in relation to the fly body weight.

The heritability of the fruit fly body weight in the present experiment did not exceed 0.20, except the last stage of individual selection for a low body weight, where

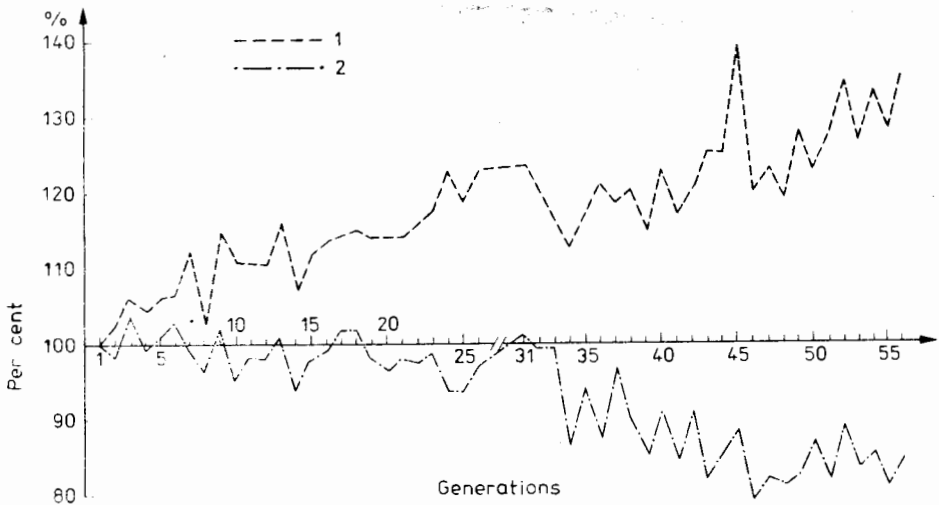


Fig. 7. Response to selection of males in family selection expressed by relative body weights of insects in relation to the control families

1 - families selected for high body weight, 2 - families selected for low body weight

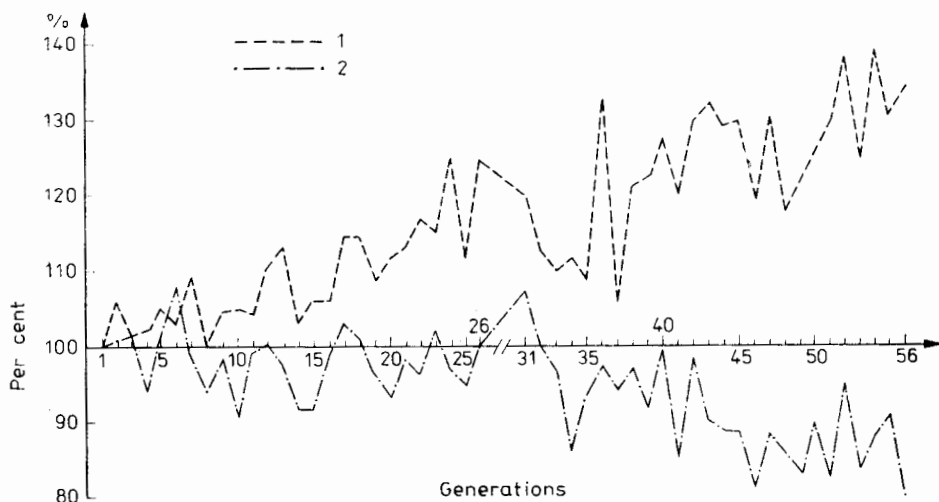


Fig. 8. Response to selection of females in family selection expressed by relative body weights of insects in relation to the control families

1 — families selected for high body weight, 2 — families selected for low body weight

it was higher. Similar results were previously obtained by other authors (Martin 1959, De Fries et al. 1961b, Sheldon 1963).

Despite a low realized heritability of the character, the body weight in the fruit fly is under genetic control. This is indicated by results of family selection, conducted exclusively on the basis of the male body weights. The body weights of females were

Table 4. Coefficient of the body weight regression on generations (in μg) in individual and family selection of *Drosophila melanogaster*

| Generations | Individual selection | | | | Generations | Family selection | | | |
|-------------|--|---------|---------------------------------------|---------|-------------|--|---------|---------------------------------------|---------|
| | rearings selected for high body weight | | rearings selected for low body weight | | | families selected for high body weight | | families selected for low body weight | |
| | males | females | males | females | | males | females | males | females |
| 1-20 | 4.361 | -3.150 | 1.971 | -6.377 | | | | | |
| 28-47 | 5.642* | 8.103 | 2.500 | 1.309 | 1-25 | 8.267* | 6.480* | 1.411 | -2.512 |
| 53-63 | 8.282 | 29.391* | -1.973 | 10.309 | 31-55 | 4.608* | 8.944* | -4.077* | -5.994* |

* significance at the level of 0.05

only controlled, but did not constitute a criterion of selection. The choice of method appeared to be correct. Despite an indirect selection of females on the basis of that character registered in brothers, the obtained selection differences among the females were in agreement with the direction of the performed selection in all generations. A similar and in some cases even higher advance in comparison to males was also obtained in females.

Table 5 presents correlations and regression between the body weight of males and females. These are coefficients for full sibs estimated for separate periods of selection (generations 1 - 25 and 31 - 55) and for intervals in selection (generations 26 - 30 and 56 - 61). In all the cases, positive, statistically significant correlation coefficients, which provided basis for estimation of regression coefficients, were obtained.

Table 5. Relationship between the body weight of females and males in family selection of *Drosophila melanogaster*

| Generation | Sex (variable independent) | Families selected for high body weight | | Families selected for low body weight | | Control families | |
|------------|----------------------------|--|------------|---------------------------------------|------------|------------------|------------|
| | | correlation | regression | correlation | regression | correlation | regression |
| 1-25 | males | 0.710* | 1.640 | 0.640* | 1.583 | 0.738* | 1.819 |
| | females | 0.710* | 0.308 | 0.640* | 0.259 | 0.738* | 0.300 |
| 26-30 | males | 0.741* | 1.619 | 0.763* | 1.622 | 0.631* | 1.089 |
| | females | 0.741* | 0.339 | 0.763* | 0.359 | 0.631* | 0.366 |
| 31-55 | males | 0.695* | 1.275 | 0.458* | 1.647 | 0.682* | 1.466 |
| | females | 0.695* | 0.379 | 0.458* | 0.325 | 0.682* | 0.318 |
| 56-61 | males | 0.605* | 1.430 | 0.650* | 1.594 | 0.779* | 1.652 |
| | females | 0.605* | 0.256 | 0.650* | 0.265 | 0.779* | 0.367 |

The obtained correlation and regression coefficients of the body weights of males and females, as well as results of family selection, indicate a large relationship of the body weight within families between males and females, which is also an evidence of a large influence of genetic factors on the value of that character.

CONCLUSIONS

The most effective appeared to be selection of families, in which the obtained selection advance was more systematic and the estimated regression coefficients of the body weight to generations in most cases were statistically significant.

2. Heritability realized for the periods, in which selection advance was obtained, ranged from 0.07 to 0.20.

3. Selection for a high body weight appeared to be effective in all the periods with the both selection methods. This is supported by realized heritability of that character and coefficients of the body weight regression to generations.

4. Effectiveness of selection for a low body weight was differentiated. In the first periods of individual and family selection no selection advance was obtained. A significant reduction of the body weight of the insects was obtained at the third stage of individual selection and at the second stage of family selection.

5. The asymmetry of the effectiveness of selection for a high and low body weight could result from different frequency of genes determining the opposed forms of these characters in the initial population and from a difficulty in the overcoming

barriers of homeostasis maintaining the stability of the character having the optimal value for the existence of species.

6. A high interrelationship was found between the body weight of males and females from the same families. For all periods of rearing the correlations were positive, statistically significant and ranged from 0.46 to 0.78.

7. Large fluctuations (between generations) in the values of the character, which was the purpose of selection, indicate a significant influence of the environmental factors on the result of selection experiments. Results of the experiment are also markedly influenced by the precision of selection, which in the case of characters with a low heritability is a basic factor, which determines (alongside environmental influences) results of selection.

REFERENCES

1. Benoff F. H., Renden J. A. (1983). Divergent selection for mature body weight in dwarf White Leghorns. I. Growth and reproductive responses to selection. *Poultry Sci.*, 62 (10): 1931 - 1937.
2. Butler von J., Willeke H., Pirchner F. (1984). Two-way within-family and mass selection for 8-week body weight in different mouse populations. *Genet. Res.*, 43: 191 - 200.
3. Chvostova V. V., Golubovskij M. D., Koročkin L. J. (1978). *Drosophila v eksperimentalnoj genetike*. Izdatelstvo Nauka, Novosibirsk.
4. Clayton G. A., Morris J. A., Robertson A. (1957). An experimental check on quantitative genetic theory. II. The long-term effects of selection. *J. Genet.*, 55: 152 - 170.
5. De Fries J. C., Touchberry K. W. (1961a). A "maternal effect" on body weight in *Drosophila*. *Genetics*, 46: 1251 - 1266.
6. De Fries J. C., Touchberry K. W. (1961b). The variability of response to selection inter-line and intraline variability in a population of *Drosophila affinis* selected for body weight. *Genetica*, 46: 1519 - 1530.
7. Druger M. (1962). Selection and body size in *Drosophila pseudoobscura* at different temperatures. *Genetics*, 47: 209 - 222.
8. Dunnington E. A., White J. M., Vinson W. E. (1981). Selection for serum cholesterol, voluntary physical activity, 56-day body weight and feed intake in random bred mice. *Can. J. Genet. and Cytol.*, 23 (3): 533 - 555.
9. Falconer D. S. (1953). Selection for large and small size in mice. *J. Genet.*, 51: 470 - 501.
10. Falconer D. S. (1960). Selection of mice for growth on high and low planes of nutrition. *Genet. Res.*, 1: 91 - 102.
11. Falconer D. S. (1974). *Dziedziczenie cech ilościowych*. PWN Warszawa.
12. Gallego A., López-Fanjul C. (1983). The number of loci affecting a quantitative trait in *Drosophila melanogaster* revealed by artificial selection. *Genet. Res.*, 42: 137 - 139.
13. Hayes J. F., Eisen E. J. (1979) Environmental maternal influences on body composition in mice selected for body weight. *Theor. and Appl. Genet.*, 55(5): 209 - 223.
14. Hetzer H. Q., Harvey W. R. (1967). Selection for high and low fatness in swine. *J. Anim. Sci.*, 26: 1244 - 1251.
15. Hill W. G. (1972). Estimation of realised heritabilities from selection experiments. *Biometrics*, 28: 767 - 780.
16. Hyde J. S., Sawyer T. F. (1980). Selection for agonistic behavior in wild female mice. *Behav. Genet.*, 10 (4): 349 - 359.
17. Kammerer C. M., Young S. S. Y. (1983). Directional selection for body weight in constant and variable environments in *Drosophila melanogaster*. *Heredity*, 50 (3): 237 - 251.

18. Kask V., Vorobéva O. (1981). Otor v model'nykh populacijach drozofily. Genet. selekcija v ESSR. 3 — Kongr. Est. Resp. o-va genetikov i selekcionerov. Tallin. Tez. dokl.: 19 - 20.
19. Kearsay M. J., Kojima Ken-Ichi. (1967). The genetic architecture of body weight and egg hatchability in *Drosophila melanogaster*. Genetics, 56: 23 - 37.
20. Knothe A. (1965). Zwierzęta laboratoryjne w pracach badawczych nad doskonaleniem zwierząt domowych. Zwierzęta laboratoryjne, 3: 73 - 85.
21. Kownacki M. (1982). Selection of animals on the basis of performance test and progeny test. Z. Tierzüchtung Züchtungsbiol., 99 (3): 213 - 221.
22. Legates J. E., Fartning B. R. (1962). Selection for growth and maternal performance in mice. J. Animal. Sci., 29: 974 (Abstr.).
23. Lerner M. (1969). Genetyczne podstawy selekcji zwierząt. PWRiL, Warszawa.
24. Mac Arthur J. W. (1949). Selection for small and large body size in the house mouse. Genetics, 34 (2): 194 - 209.
25. Martin G. A. (1959). Selection for body weight in *Drosophila melanogaster*. Ph. D. Thesis. Purdue University.
26. Menzi M., Lörtscher H. (1964). Ein Selektionsexperiment in entgegengesetzter Richtung. Z. Tierz. Zücht — Biol. 80: 267 - 277.
27. Nestor K. E., Bacon W. L., Lambio A. L. (1983). Divergent selection for egg production in *Coturnix coturnix japonica*. Poultry Sci. 62 (8): 1548 - 1552.
28. Oktaba W. (1972). Metody statystyki matematycznej w doświadczalnictwie. PWN, Warszawa.
29. Pingel H., Klemm R., Wolf A. (1984). Die Effektivität der direkten Selektion auf die Schlachtkörperqualität bei Enten. Wiss. Z. Karl-Marx-Univ. Leipzig. Math — natur. wiss. R. 33 (3): 325 - 329.
30. Radomska M. J. (1982). Metody i kierunki doskonalenia zwierząt. PWN, Warszawa.
31. Robertson F. W. (1955). Selection response and the properties of genetic variation. Cold Spr. Harb. Symp. quant. Biol., 20: 166 - 177.
32. Robertson F. W. (1956). The use of *Drosophila* in the experimental study of animal breeding problems, Anim. Breed. Abstr., 24: 218 - 224.
33. Robertson F. W. (1957). Studies in quantitative inheritance. XI. Genetic and environmental correlation between body size and egg production in *Drosophila melanogaster*. J. Genet., 55: 428 - 443.
34. Ruszczyk Z. (1978). Metodyka doświadczeń zootechnicznych. PWRiL, Warszawa.
35. Schwark H. J. (1977). Der Einfluss der Züchtung auf die Erhöhung der Effektivität der Tierproduktion. Ökonomische Aufgaben und Massnahmen zur weiter Intensivierung beim Übergang zur industriemässigen Tierproduktion. Leipzig, 2: 329 - 345.
36. Sheldon B. L. (1963). Studies in artificial selection of quantitative characters. II Selection for body weight in *Drosophila melanogaster*. Aust. J. Biol. Sci., 16 (2): 516 - 539.
37. Sławiński T. (1981). Zasady hodowli zwierząt laboratoryjnych. PWN, Warszawa.
38. Socha S. (1984). Variation of the body weight and fecundity in subsequent generations of unselected population of *Drosophila melanogaster*. Genetica Polonica, 24 (5): 387 - 395.
39. Socha S. (1987). Plenność samic *Drosophila melanogaster* selekcjonowanych na masę ciała. Genetica Polonica (in press).
40. Strickberger M. W. (1962). Experiments in Genetics with *Drosophila*. John Wiley and Sons. Inc. New York, London.
41. Sutherland T. M., Biondini P. E., Haverland C. H. (1968). Selection under assortative mating in mice. Genetical Research, 11: 171 - 178.
42. Trudy F. C. M. (1981). Genetic variation in varying environments, Genet. Res., 37: 79 - 93.
43. Zuk B. (1979). Metody genetyki populacji w hodowli zwierząt. PWRiL, Warszawa.

SKUTECZNOŚĆ SELEKCJI INDYWIDUALNEJ I SELEKCJI RODZIN NA MASĘ CIAŁA U *DROSOPHILA MELANOGASTER*

Streszczenie

Przeprowadzono dwukierunkową selekcję na masę ciała u *Drosophila melanogaster*. Stosowano selekcję indywidualną i selekcję rodzin w stałych warunkach środowiskowych. Selekcja indywidualna trwała 51 pokoleń, natomiast selekcja rodzin przez 50 pokoleń.

Rezultaty uzyskane w wyniku selekcji indywidualnej i selekcji rodzin były znacznie zróżnicowane. Efektywniejszą okazała się selekcja rodzin, ponieważ osiągnięty postęp hodowlany był bardziej systematyczny niż w selekcji indywidualnej.

Stwierdzono znaczącą asymetrię reakcji na selekcję między liniami owadów selekcyjonowanych na wysoką i niską masę ciała. Zarówno w selekcji indywidualnej jak i w selekcji rodzin skuteczniejszą okazała się selekcja na wysoką masę ciała.

ЭФФЕКТИВНОСТЬ ИНДИВИДУАЛЬНОЙ СЕЛЕКЦИИ И СЕЛЕКЦИИ СЕМЕЙ НА МАССУ ТЕЛА У *DROSOPHILA MELANOGASTER*

Резюме

Произведена двунаправленная селекция на массу тела у *Drosophila melanogaster*. Применена индивидуальная селекция и селекция семей в постоянных условиях окружающей среды. Индивидуальная селекция осуществлялась на протяжении 51 поколения, а селекция семей — на протяжении 50 поколений.

Результаты, полученные при индивидуальной селекции и селекции семей, были неоднородны. Более эффективной оказалась селекция семей, при которой достигнутый генетический прогресс был более систематическим, вследствие чего дифференциация семей, селекционированных на высокую и низкую массу тела насекомых была отчетлива. Как при индивидуальной селекции, так и при селекции семей, более эффективной была селекция на высокую массу тела.