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Changes in Postweaning feed Efficiency As a Result of Selection for increased Preweaning and Postweaning Growth Rate in Mice

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Story in Brief

Growth performance to six weeks of age and feed efficiency between 21 and 42 days were determined for mice from three types of selection lines after 11 generations of selection. The three types of selection lines were: unselected control lines (CL), lines selected for increased weaning weight at 21-days of age (WWL) and lines selected for increased rate of gain between 21 and 42 days of age (ADGL). The WWL required more feed per unit of gain between 21 and 42 days of age than the CL, whereas the ADGL required less feed per unit of gain than the CL.

Both the WWL and ADGL significantly exceeded the CL in 21-day weight, 42-day weight, 21-42 day average gain and 21-42 day average daily feed consumption. The WWL were heavier at 21 days than the ADGL, but were lighter at 42 days of age, and gained slower from 21-42 days of age. Although the ADGL consumed more feed per day, they had a sufficiently larger rate of gain from 21-42 days of age that they required 1.3 grams less feed per gram of gain than did the WWL.

Introduction

One of the major factors in feeding farm animals profitably is to minimize total cost per unit gain. A large component of this total cost is the amount of feed required per unit gain of body weight. Although feed efficiency is a very important trait, it has generally not been measured or selected for in most performance testing and selection programs used by the livestock industry. This is primarily because of the difficulty and expense of determining feed efficiency on an individual basis. Some measurement of growth rate has been one of the principle traits involved in most livestock breeding programs designed to improve the genetic capability of the population for increased productivity. Fortunately, most research results, both with livestock and laboratory species, have shown a favorable genetic relationship between increased growth rate and feed efficiency. Thus, to some extent, increased growth rate resulting from selection should also be accompanied by an improvement in feed efficiency.

A laboratory organism, such as mice, can be very useful in terms of ascertaining the genetic interrelationships that exist between various performance traits. Such experiments with mice can involve a larger number of animals under more carefully controlled environmental conditions for less total cost than is possible with the livestock species. In addition, the shorter generation interval of mice (3 months) allows the experiment to be conducted in a much shorter time. The basic knowledge obtained from such experiments concerning the genetic interrelationships that exist for the economically important performance traits will aid in the development of more effective breeding programs to improve the total performance level of the livestock species.

The components that directly effect efficiency of gain are average daily gain and average daily feed consumption. It is the relationship of these components, with each other and with other performance traits, that must be studied to define the response of efficiency of gain to selection for increased growth performance. The objectives of this study were to determine the correlated change in feed efficiency as a result of selection based on preweaning and postweaning growth rate and to determine the phenotypic relationships that exist among some of the growth performance traits and postweaning feed efficiency in these selection lines.

Materials and Methods

A selection study with mice is currently underway to specifically measure the direct and correlated responses to selection for preweaning and postweaning rate of gain. This study consists of six selection lines

(three being selected for increased weaning weight at 21 days of age and three being selected for increased postweaning rate of gain between 21-42 days of age) and two unselected control lines. Each line consists of 20 litters in each generation. A more complete design of the selection study is presented in Okla. Agr. Exp. Sta. Miscell. Pub. 87:184.

The present study reports the growth performance and feed efficiency data after 11 generations of selection. Performances were similar in lines of the same type and thus the data were averaged and/or pooled within each type of selection line. Data are presented and compared by type of selection line: Unselected control lines (CL), weaning weight lines (WWL) and postweaning average daily gain lines (ADGL).

Mice were fed *ad. lib.* on standard Purina Lab Chow pellets. Mice of the same sex from the same line were placed in cages at 21-days of age. It was attempted to have 4 mice in each cage, but this was not possible in all cases. Most cages had 3 or 4 mice per cage. A few had 2 mice per cage and occasionally it was necessary to have only 1 mouse in a cage. The growth performance and feed efficiency for the single mouse cages were quite similar to the multi-mouse cages of the same selection group, thus their data were included in the analysis. The total number of mice and cages for each selection group are presented in Table 1.

Total feed consumption was measured for each cage of mice between 21-42 days of age. The postweaning period of 21-42 days in mice is a period of rapid growth rate and would be somewhat comparable to the feeding phase of the livestock species. All feed was carefully sifted to

Table 1. Average Performance by Type of Selection Line After 11 Generations of Selection

	Control Lines	Weaning Wt. Lines	21-42 Day ADG Lines	Pooled Stand. Dev.
No. Cages	80	133	126	
No. Mice	291	463	429	
21-Day Weight (gms.)	9.9[1]	12.2[2] (23.23%)[4]	11.3[3] (14.14%)	1.106
42-Day Weight (gms.)	23.4[1]	27.0[2] (15.38%)	31.4[3] (34.19%)	1.648
21-42 Day ADG (gms./day)	0.64[1]	0.71[2] (10.94%)	0.96[3] (50.00%)	0.056
21-42 Day Daily Feed Consumption (gms.)	3.94[1]	4.64[2] (17.77%)	5.09[3] (29.19%)	0.493
21-42 Day Feed Efficiency (gms. of feed/gm. of gain)	6.22[1]	6.70[2] (7.72%)	5.38[3] (−13.50%)	0.666

[1,2,3] Means on the same line with different superscripts were significantly different ($P<.01$).
[4] Parenthetical percentages are the deviation from the control group expressed as a percentage of the control.
[3] Author omitted.

eliminate fine material from the pellets in order to minimize feed waste. Feed consumption, and consequently feed efficiency, were determined on a cage basis. Since the number of mice per cage varied, the data were analyzed on an average per mouse per cage basis.

The data were analyzed and summarized for males and females, separately. The comparisons between selection lines were very similar for both sexes; and thus, the data were averaged over both sexes for presentation of the results.

Results and Discussion

The mean performances for each of the three selection groups after 11 generations of selection are presented in Table 1. Both the weaning weight lines (WWL) and postweaning average daily gain lines (ADGL) exceeded the control lines (CL) for 21-day weight, 42-day weight, 21-42 average daily gain and 21-42 day average daily feed consumption. The WWL had a significant decrease in feed efficiency as compared to the CL, whereas, the ADGL showed a significant improvement in feed efficiency. The WWL had significantly heavier weaning weights at 21-days of age than the ADGL, but were lighter at 42 days of age and gained more slowly from 21-42 days. Although the ADGL consumed more feed per day on the average than the WWL, they gained sufficiently faster from 21-42 days of age such that 1.32 fewer grams of feed were required per gram of gain.

The phenotypic correlations between traits within each selection group are presented in Table 2. Within all three selection groups, the positive correlation coefficients for 21-day weight and 21-42 day daily feed consumption with feed efficiency indicate an antagonistic relationship. Heavy weaning weights and increased daily feed consumption tend to be associated with an increased feed requirement per unit of gain. The negative correlation between 21-42 day ADG and feed efficiency indicates a favorable relationship. Increased 21-42 day average daily gain tends to be associated with improved feed efficiency. The correlations indicate a stronger relationship between feed consumption and feed efficiency than between 21-42 day average daily gain and feed efficiency. As would be logically expected, the best feed efficiency would be expected among the most rapidly gaining animals that have lower feed consumption rates.

Selection for 21-day weaning weight and selection for postweaning average daily gain apparently has resulted in some alteration in the relationships among 21-42 day average daily gain, daily feed consumption, and feed efficiency such that the feed efficiency performance was markedly different in the three groups after 11 generations of selection.

Table 2. Phenotypic Correlations Between Certain Performance Traits within Each Type of Selection Line

	21-Day Wt.	42-Day Wt.	21-42 Day ADG	21-42 Day Daily Feed Cons.
42-Day Wt.:				
CL[3]	0.752[1]			
WWL[3]	0.647[1]			
ADGL[3]	0.666[1]			
21-42 Day ADG:				
CL	0.006	0.650[1]		
WWL	0.086	0.812[1]		
ADGL	−0.082	0.677[1]		
21-42 Day Daily Feed Consumption:				
CL	0.286[1]	0.596[1]	0.235	
WWL	0.310[1]	0.451[1]	0.356[2]	
ADGL	0.386[1]	0.394[1]	0.141	
21-42 Day Feed Efficiency:				
CL	0.508[1]	0.019	−0.563[1]	0.678[1]
WWL	0.235	−0.160	−0.385[2]	0.719[1]
ADGL	0.409[1]	−0.039	−0.456[1]	0.811[1]

[1] Correlations significantly different from 0 at the .01 probability level.
[2] Correlations significantly different from 0 at the .05 probability level.
[3] CL, WWL and ADGL refer to the control lines, weaning weight selection lines and 21-42 average daily gain selection lines, respectively.

Part of the difference in feed efficiency between the groups may be due to the nature of the gains within the groups. In the WWL there was a significant correlation between average daily gain and daily feed consumption, suggesting that the higher gaining animals ate more feed. The fact that there were more nutrients passing through the G. I. tract possibly increased the likelihood of more nutrients being absorbed than required for maintenance, thus increasing gain. In the ADGL there was no significant correlation between average daily gain and daily feed consumption. This could mean that the higher gaining animals within the group did not especially eat more feed than the lower gaining animals but had a better ability to absorb what nutrients were present, thus exceeding their maintenance requirements to gain weight.

Since daily feed consumption had an adverse effect on feed efficiency that was apparently of larger magnitude than the beneficial effect of increased average daily gain, it might be expected that increased average daily gains caused by increased feed consumption would result in poorer feed efficiency. It would also be expected that increased gains due to increased feed absorption would result in better feed efficiency.

Another part of the differences in feed efficiency could be due to the differences that exist in 21-day weight. The correlations between 21-day weight and feed consumption suggest that an increase in 21-day weight would also increase daily feed consumption. The WWL were the heaviest at 21-days, and thus, their postweaning feed efficiency should be more adversely effected. Increased 21-day weight could also possibly increase maintenance requirements, and consequently have an adverse effect on postweaning feed efficiency.

These data clearly indicate that selection for increased postweaning rate of gain has significantly improved efficiency of gain. On the other hand, increasing weaning weight through selection has been accompanied by an apparent reduction in feed efficiency. Further study of basic biological components such as the body composition of the weight changes and nutrient absorption rates will be necessary to more clearly explain the relationship between feed efficiency and the growth performance traits.