PREDICTED AND REALISED IMPROVEMENT DURING THREE YEARS OF SELECTION FOR SHELL QUALITY

Voraussagungen der Verbesserung und reale Tatsachen der letzteren während dreifährigen Selektion für die Qualität der Eierschale

Amélioration prédite et réalisée au cours de trois ans de sélection pour la qualité de la coquille de l'oeuf

W. F. van TIJEN *
A. R. KUIT *

Introduction

It is beyond doubt that the economics of the production of consumption eggs is to an important extent influenced by the quality of the shell. Clearly the latter should be strong enough to withstand the stress of normal transport in order to minimize the amount of breakage.

The following report deals with an experiment in which it has been tried to improve the shell quality by selection for this trait. The estimation of the heritabilities in our material supported the supposition that the possibility of success should not be excluded.

Basically the project was set up to find the answer to the question what happens when the normal selection procedure is replaced during a number of generations by a strong selection pressure on shell quality traits in order to improve shell strength.

The results of this selection experiment as far as the change of means and the frequency distributions in the strains are concerned have been published elsewhere (VAN TIJEN, 1973). The paper to be presented here deals with the selection pressure used and the response which was obtained as a result thereof.

Material and methods

The experiment was carried out with two groups of laying hens, a White Leghorn and a Rhode Island Red strain. Before the experiment started these strains had been bred as closed groups for at least 15 years with a mild selection

* Spelderholt Institute for Poultry Research, Beekbergen, The Netherlands.

pressure on egg number, egg weight, shell quality and internal quality during the last 5 years. Inbreeding in the latter period (1961-1966) did not amount to more than one percent per generation.

In 1967 these groups were each divided into genetically equal substrains, hereafter designated as WS, WP, RS and RP, which were in the following three years bred for shell quality and for productivity respectively. The selection took place after a comparatively short period of production at 38 weeks of age. The egg quality was determined at the age of 30 weeks.

The final production data — total number of eggs and laying percentage — were determined at the age of 72 weeks, while a second measurement of the egg quality was taken at the age of 60 weeks.

The measurements were performed on samples of four eggs per hen as much as possible. In addition to shell quality, shape index and internal quality — height of thick albumen and blood- and meatspots — were determined.

The shell quality was measured in three different ways:

a) shell thickness in 0.01 mm measured at two places at the waist;

b) the specific gravity of the whole egg;

c) the shell stiffness — deformation of the shell under a load of 500 gms — measured in 0.001 of a mm. (A lower figure is the indication of a better shell.)

From these three measurements an index for the shell quality was calculated, in which each was represented for an equal part.

The production strains were also selected on the basis of an index, in which four traits were represented: production for 50 %, egg weight for 30 % and shell- and internal quality each for 10 %. The mothers of the next generation were selected on the basis of their own performance, the fathers on the basis of the performance of their full sisters.

The results after three years of selection merit the conclusion that the improvement of shell quality by means of selection is very well possible. It was found however that this improvement was gained at the cost of productivity.

An aspect which was not taken into consideration and which will be dealt with in this paper is the confrontation of the response to be expected as a result of the selection pressure with the real progress which has been made.

The expected response resulting from a given selection pressure expressed as selection differential is found by multiplying the latter with the heritability of the trait in question ($R = h^2 S$).

The heritability estimates of the differ traits by the method of the variance component analysis as described by LERNER (1958) and FALCONER (1960).

For unequal numbers of mothers per father and daughters per mother a correction was applied which among others is described by KING and HENDERSON (1954).

By equating the mean squares to the expected values the estimation of the necessary variance components and from these h^2_s and h^2_d were were obtained. The mean value of these two estimates was taken as h^2_i, the heritability of the phenotypic values of the individuals.

The fathers however have been selected on the basis of the performance of their full sisters. Therefore the part of the expected response which is due to the selection of the sires is found by multiplying the selection differential with h^2_f, the heritability of the means of the full sib families. The latter estimate is related to h^2_i by the following formula:

$$h^2 = \frac{n\,r}{1 + (n - 1)\,t}\, h^2_i$$

in which n is the average number of individuals per full sib family, r is 0.5 and t is the correlation of the phenotypic values of members of the families.

It seemed to be justified to average the estimates over the three years under discussion, because no trend could be detected. These averages of h^2_f and h^2_i were used to predict the cumulative response to be expected as a result of the selection of the sires ($R_1 = h^2_f S_1$) and of the dams ($R_2 = h^2_i S_2$). The mean of R_1 and R_2 was calculated to obtain the expected progress during three years of selection, which was compared with the actual gain made.

RESULTS AND DISCUSSION

The results are presented in the form of two tables. Table 1 presents the heritabilities which were derived from the variance analysis $\frac{h^2_s + h^2_d}{2}$, averaged over the years 1967, 1968 and 1969. The estimates of the family-means (h^2_f) as well as those of the phenotypic values of the individuals (h^2_i) are given.

In the majority of the cases the estimate of h^2_f is larger than that of h^2_i. The data agree well with those of other authors given in the literature, with a low heritability for production percentage, a high one for egg weight and an intermediate one for the shell quality traits.

TABLE 1

HERITABILITIES FOR PRODUCTIVITY AND SHELL QUALITY TRAITS (AVERAGE 1967-1969)

Strain \ Trait	Prod. perc. 38 wks.	Egg weight 30 wks.	Def.	Shell quality 30 wks. Thickness	Spec. gravity
			h^2_f		
R S	0.28	0.58	0.45	0.47	0.38
R P	0.22	0.62	0.52	0.62	0.62
W S...	0.27	0.49	0.48	0.50	0.41
W P...	0.27	0.60	0.48	0.59	0.51
			h^2_i		
R S	0.14	0.63	0.30	0.38	0.30
R P	0.09	0.61	0.30	0.45	0.51
W S...	0.12	0.65	0.40	0.48	0.37
W P...	0.16	0.67	0.45	0.60	0.52

TABLE 2

EXPECTED CUMULATIVE RESPONSE VS PROGRESS MADE DURING THREE GENERATIONS OF SELECTION FOR SHELL QUALITY RESP. PRODUCTIVITY

Trait	S-group		P-group	
	Exp. response	Progress made	Exp. response	Progress made
	Rhode Island Reds			
Production % 38 wks.	0.8	2.3	2.1	5.9
Egg weight 38 wks.	0.6	— 0.4	3.8	3.7
Deformation 30 wks.	— 1.9	— 4.9	— 0.6	— 2.5
Shell thickness 30 wks.	2.3	2.7	1.1	0.5
Spec. gravity 30 wks.	3.6	5.5	1.3	0.5
	White Leghorns			
Production % 38 wks	0.2	3.3	3.7	5.1
Egg weight 38 wks.	0.6	1.6	3.0	3.6
Deformation 30 wks.	— 1.7	— 3.5	— 0.5	— 2.2
Shell thickness 30 wks.	3.0	4.0	1.0	2.1
Spec. gravity 30 wks.	4.6	4.7	1.0	0

These estimates have been used to arrive at the data of Table 2, in which the expected cumulative response ($R = h_2 S$) over the years 1967-1970 for the five traits have in each group been compared with the actual progress made.

From the data it is apparent that the realised progress in most cases exceeds the expectation.

One would be inclined to equalise the progress due to selection and the expected response, ascribing the difference between expected and actual response entirely to environmental causes. In view of the standard error of the estimated heritabilities the above procedure is not justified. The results could possibly be refined to derive an average environmental effect by considering the S- and the P-group of a strain together, ascribing the mean of the differences between actual progress and expected response to non-genetic causes. This is dangerous however, in view of the fact that we are not dealing with randombred controls but with groups in which selection has been practised. It is therefore preferred to present the data as such with the following comments.

Production percentage

The realised progress exceeds the expected response to a considerable extent both in the S- and in the P-groups. Because of the low heritability, especially h^2_1, we have strong reasons to assume that the largest part of the difference between expected and realised response should be ascribed to environmental causes.

Egg weight

The heritability for this trait is fairly high. The progress made is somewhat higher than the expectation, but in general the two values agree fearly well. The environment has not played so large a role in the progress of this trait in the three years under discussion.

Egg quality traits

One of these traits, the deformation, can be compared with the production percentage. The actual progress is clearly higher than expected on the basis of the estimated heritabilities. In the case of the shell thickness and the specific gravity the differences between the values of the expected and the realised response are pretty well in agreement with each other. These traits can — as far as this aspect is concerned — more or less be compared with egg weight.

Thus it can be assumed that in general — as far as these five traits are concerned — the production percentage and the shell deformation are to a larger extent influenced by the environment than egg weight, shell thickness and specific gravity.

SUMMARY

A White Leghorn and a Rhode Island Red strain were each divided into two genetically equal parts, which were for three generations selected for productivity and shell quality respectively.

The response to be expected for production percentage, egg weight and three shell quality traits was compared with the actual progress made. The realised gain in productivity and one of the shell quality traits (deformation) considerably exceeded the expectation. For egg weight and the two other shell quality traits (shell thickness and specific gravity) the prediction was fairly well in agreement with the actual gain.

The results merit the supposition that the production percentage and the shell deformation are to a larger extent influenced by the environment than egg weight, shell thickness and specific gravity.

ZUSAMMENFASSUNG

Je ein Stamm Weisse Leghorn und Rode Island Red wurden beide in zwei genetisch gleiche Teile geteilt, welche in den darauffolgenden drei Generationen für Produktivität bzw. Schalenqualität selektiert wurden.

Die zu erwartende Reaktion für Produktions-Prozentsatz, Eigewicht und drei Merkmale für die Schalenqualität wurde mit dem wirklich erzielten Fortschritt verglichen. Die realisierten Fortschritte in Produktivität und einer der Schalenqualitäts-Merkmale (Deformation) übertraffen die Erwartungen beträchtlich. Für das Eigewicht un die zwei anderen Schalenqualitäts-Merkmale (Schalendicke und spezifisches Gewicht) stimmte die Voraussage mit dem wirklichen Fortschritt ziemlich gut überein.

Die Ergebnisse bieten Grund zur Annahme, dass der Produktions-Prozentsatz und die Schalen-Deformation in grösserem Masse durch die Umwelt beeinflusst werden als Eigewicht, Schalendicke und spezifisches Gewicht.

RESUME

Une souche de Leghorn Blanc ainsi qu'une de Rhode Island Red étaient toutes les deux divisées en deux parts génétiquement égales qui, pendant trois générations, étaient sélectionnées pour la productivité, respectivement la qualité de la coquille.

La réaction prédite pour pourcentage de production, poids de l'oeuf et trois caractères de la qualité de la coquille était comparée avec le progrès actuellement fait. L'avancement réalisé pour productivité et un des caractères de la qualité de la coquille (déformation) était considérablement au-delà de la prédiction. Pour le poids de l'oeuf et les deux autres caractères de la qualité de la coquille, la prédiction et l'avancement réalisé étaient assez bien en rapport l'un avec l'autre.

Les résultats motivent la supposition que le pourcentage de la production et la déformation sont plus influencés par le milieu que le poids de l'oeuf et l'épaisseur de la coquille.

REFERENCES

FALCONER, D. S. (1960): *Introduction to quantitative genetics.* Oliver and Boyd, Edinburgh and London.

KING, S. C., and HENDERSON, C. R. (1954): Variance components in heritability studies. *Poult. Sci.*, 33, 147-154.

LERNER, I. M. (1958)): *The genetic basis of selection.* John Wiley and Sons Inc., New York. Chapman and Hall Ltd., London.

VAN TIJEN, W. F. (1973): The consequences of selection for shell quality. *Ann. Gén. Sél. Anim.*, 5, 403.