# Heat production of two different lines and their reciprocal crosses.

# Producción de calor en does lineas diferentes, y en sus cruzas reciprocas.

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## Introduction

A number of alternative equations are available for predicting daily feed intake of the laying pullet. Multiple regressions on body weight, weight gain and egg-mass output of food-consumption showed a correlation with observed feed-intake of 0.82 - 0.90 (Mc DONALD 1977).

BENTSEN (1980) indicated that 10-20 % of variance in feed efficiency between lines remains unexplained.

More than 50 % of the daily ME intake is used for maintenance requirement. Therefore it is of practical importance to investigate if residual variance in feed-consumption can be explained by genetic differences in energy metabolism.

## Material and Methods

The heat production of two brown layer-lines and their reciporcal crosses were measured by indirect calorimetry. After 24 and 36 hours of starvation hens were placed in an open-circuit-respirometer. The 12 chambers had a capacity of 30 l each and were ventilated by 2.5 l/min fesh air. The ambient temperature was maintained at 22 + 1°C. After an equilibration period of 30 minutes, ten minutes outputs of $CO_2$ production and $O_2$-consumption of 600 hens were taken.

A constant fraction of the airstream was directed through drying tubes (CA $SO_4$) to Beckmann LB-2 ($CO_2$) and OM-11 ( $O_2$) gas analysers.The amount of $CO_2$ produced and $O_2$ consumed can be calculated by multiplying the volume of ventilated air by the $CO_2$-surplus and $O_2$ deficit of the air leaving the respiration chambers.

Heatproduction was estimated by the formula:

$$H(kJ) = 16.18\ O_2(l) + 5.02\ CO_2(l)$$

(ROMIJN + LOKHORST 1961)

Volumes for the gas determinations were computed at standard temperature and pressure (STP).

Metabolic rate shows a marked diurnal variation (LUNDY et al. 1978) therefore measurements were made at the same time 8-10 a.m. and 8-10 p.m.

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The lighting cycles (17L:7D) in the calorimeters was synchronous with that in the holding rooms.

## Results and Discussion

The following two analyses of variance (HARVEY 1976) were used for day and night measurements:

Night: $\log y_{ijk} = \mu + L_i + F_j + (LxF)_{ij} + b_i(\log W) + e_{ijk}$

Day: $\log y_{ijkl} = \mu + L_i + F_j + A_k + (LxF)_{ij} + (LxA)_{ik} + b_i(\log W) + e_{ijkl}$

where:

- $\log y$ = log of heat production (H)
- $\mu$ = the mean log H for all subclasses
- $L_i$ = the effect of the i th line
- $F_j$ = " " " " j th feather-loss score
- $A_k$ = " " " " k th activity
- $(LxF)_{ij}$ = the effect of interaction of i th line with j feather-loss score
- $(LxA)_{ik}$ = the effect of interaction of i th line with k activity
- $b_i(\log W)$ = the log of body weight in the i th line;
- $e_{ijkl}$ = residual error

The respiratory quotients after 24 and 36 hours of starvation are 0.73 ± 0.04 and 0.71 ± 0.04 and indicate that hens reached postabsorptive status.

The same relation between body weight and heat production was found for all line-combinations: $H_{Day} = 20.11\ W^{0.68}$ kJ/h $H_{Night} = 14.96\ W^{0.53}$ kJ/h. Breed differences in heat production are published by FARELL (1974) and LUNDY et al. (1977). OTA and MC NALLY (1969) and HOUSTON (1962) observed a significant higher energy metabolism of Leghorn hens than heavy breeds.

In this investigation highly significant differences in starvation heat production in the night of 2 kJ/h were found between pure lines (Table 1).

In our study heterosis in egg-mass output is correlated with heterosis in energy metabolism in a desired direction.

Table 1: LSQ-estimates of the different line combinations

| line | number of observations | Heatproduction (kJ/h) in the night |
|---|---|---|
| AA | 152 | $24.32^{a} \pm 1.02$ |
| AB | 147 | $22.45^{b} \pm 1.02$ |
| BA | 148 | $22.18^{b} \pm 1.02$ |
| BB | 150 | $22.23^{b} \pm 1.03$ |

During days the following activities in the respiration chamber were taken account of:resting (1) standing (2) and nesting behaviour with (4) and without oviposition (3). V. KAMPEN (1976) found differences in energy metabolism of 9 % between standing and sitting birds. In our investigation only an increase of 4 % between acticity 1 and 2 was measured (Table 2).

Table 2:

| activity | n | LSQ-Estimates of Heatproduction (kJ/h) |
|---|---|---|
| 1: resting | 171 | $27.79 \pm 1.01$ |
| 2: standing | 282 | $28.82 \pm 1.02$ |
| 3: nesting behaviour without oviposition | 36 | $40.92 \pm 1.10$ |
| 4: nesting behaviour and oviposition | 101 | $42.46 \pm 1.05$ |

According to BESSEI (1977) oviposition costs a extra heat loss of 6.7 $kJ/kg^{3/4}$. This result is in good agreement with our value showing an increment in heat production whilst oviposition of 14 kJ/h at an average body weight of 2.3 kg.

The experiment of WOOD-CUSH (1970) established a relationship between nesting and ovarian functions. So 99 % of nestings are preceded by ovulation during the previous 24 h. Nesting behaviour without oviposition i.e. internal laying, is measured as activity 3.

The significant line by activity interactions in starvation heat production during day-time show the same tendency than the night-measurements.

Resting and quietly standing hens of line BB need 1-1.5 kJ/h less energy than birds of line AA. The difference of 40-50 kJ/day in netto-energy-requirement could explain the 4-5 g higher feed intake of line AA.

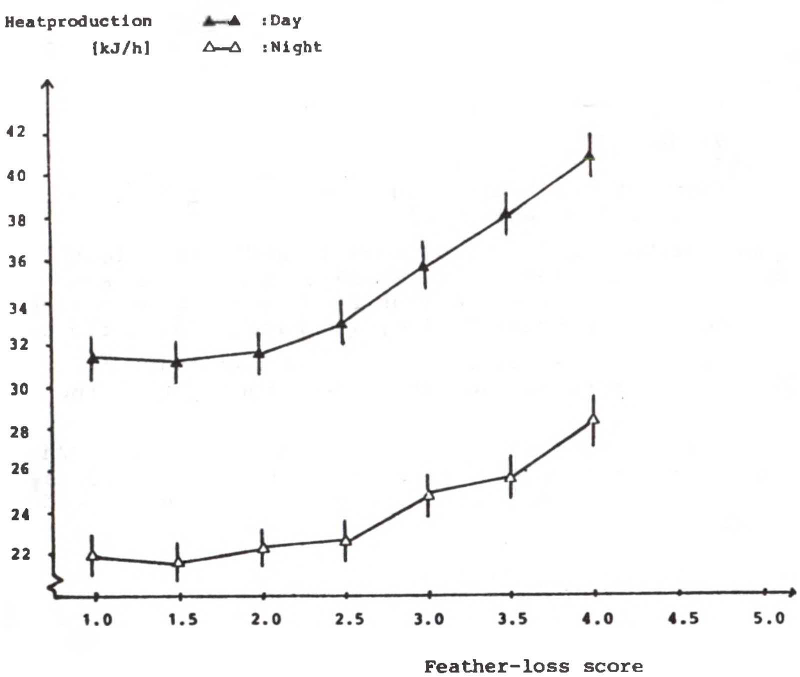
Table 3
LSQ-Estimates of line by activity interactions in energy metabolism

| activity | Heatproduction (kJ/h) | | | |
|---|---|---|---|---|
| | AA | AB | BA | BB |
| 1 | 28.67[a] ± 1.02 | 28.55[a] ± 1.01 | 27.33[ab] ± 1.02 | 26.95[b] ± 1.04 |
| 2 | 29.52 ± 1.03 | 28.54 ± 1.04 | 28.23 ± 1.03 | 28.47 ± 1.02 |
| 3 | 41.18[a] ± 1.10 | 40.20[a] ± 1.11 | 36.19[b] ± 1.07 | 46.04[c] ± 1.01 |
| 4 | 41.43[a] ± 1.03 | 43.22[b] ± 1.05 | 43.40[b] ± 1.05 | 42.16[ab] ± 1.08 |

The influence of feather damage on maintenance requirement were investigated by HUGHES (1980) and TAUSON (1980). Throughout the experimental programme a scoring system for feather was used where score 1 denotes complete feather cover and 5 total bare body surface. The increase in heat production with feather-loss is demonstrated in Fig. 1

Fig. 1

Influence of plumage condition on starvation metabolism



Defeathering of neck only (feather-loss score 1.5-2) has no influence on starvation metabolism. This is in good agreement with the result of TULLED (1980) where only the artificial defeathering of neck plus breast region led to a significant increase in heatproduction.

The observed differences in energy metabolism between score 1 and 4 was 11 kJ/h at daytime and 8 kJ/h in the night, which means ~ 240 kJ/day. If we assume that 1 g feed contains 11 kJ ME, birds with feather score 4 need about 20 g more feed than birds with a good plumage. This agrees very well with the results of EMMANS (1979) and WILLEKE and KOCOGLU (1980) who found a difference, between good and poor feathered hens, in daily feed intake of 15 and 16 g, respectively.


## Summary

The heat production of two brown egglayer-lines and their reciprocal crosses were measured by indirect calorimetry after 24 and 36 hours of starvation. Activity in the respiration chambers and plumage condition were taken into account. The relation between body weight and energy metabolism of 600 hens is given by following regression equations for day and night measurements:
$H_{DAY}=20.11\ W^{0.68}$ kJ/h $H_{NIGHT}=14.96\ W^{0.53}$ kJ/h.
The starvation heat production of the linecombinations in the night is:
AA: 24.32 ± 1.02 kJ/h; AB: 22.45 ± 1.02 kJ/h; BA: 22.18 ± 1.02 kJ/h; BB: 22.23 ± 1.03 kJ/h. Highly significant differences were found between pure lines.
During days significant line by activity interactions in energy metabolism appear to be present.
Heat production increases with bare bodysurface.



## Resumen

La producción de calor en dos lineas que huevos de cáscara marrón, y en sus cruzas reciprocas, fue medida por calorimetria indirecta luego de 24 y 36 horas de ayuno. Se tomaron en consideración la actividad en las cámaras de respiración y las condiciones del plumaje.
Le relación entre peso del cuerpo y metabolismo energético de 600 gallinas, puede expresarse por medio de las siguientes ecuaciones, para las mediciones diurnas y nocturnas:

$$H_d = 20.11\ W^{0.68}\ \text{kj/h}$$
$$H_n = 14.96\ W^{0.53}\ \text{kj/h}$$

Para los distintos genotipos, la producción de calor en condiciones de ayuno, durante la noche, es la siguiente:

AA = 24.32 ± 1.02 kj/h AB = 22.45 ± 1.02 kj/h
BB = 22.23 ± 1.03 kj/h BA = 22.18 ± 1.02 kj/h

Se encontraron diferencias altamento significativas entre las lineas puras. Durante el dia, la interacción linea x actividad fue significativa, para el parámetro metabolismo energético. La producción de calor aumenta cuando el porcentaje de superficie con plumaje disminuye.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