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Behavioral activity as a predictor of heat production in laying hen

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The analysis assumes that a difference of heat production (HP) between the light and dark periods is due to behavioral activities (BA) such as standing, eating, sitting etc. The increase of HP during the light period derived from eating activities and general movements; the increment of heat included energy expenditure by eating activity as well as the true calorigenic effect of food. The most commonly practiced methods of measuring HP in chicken is direct or indirect calorimetry as well as heart rate methods. The calorimetry method is very complex and expensive, and often restrict the free movements of the chicken. Therefore, a convenient method for estimating HP of laying hen in the field is very essential to easy understanding and evaluation of energy utilization efficiency in egg production.

Generally, it can be said that the locomotor activity of the domestic fowl is a behavioral trait, and BA can be detected either by the measurement of time spend for behaviors such as standing time (STN), eating time (ETN) etc. or by the detection of number of body movements as activity count (ACT). The Actigraph (Ambulatory Monitoring Inc., USA) may measure BA of laying hens quantitatively, where movements of various activities can be detected as ACT due to the three dimensional function of the Actigraph. Once the quantitative relationship between BA and HP of a hen can be recognized, HP can be estimated from the quantitative measurement of BA at any environment. Therefore, the increment of HP for food intake (FI) would also be calculated separately and perfectly.

However, in order to estimate HP in the free-living conditions without the respiratory chamber, simultaneous measurements of HP and BA were done to establish BA as a predictor of HP in the laying hen, which is the main objective of this study. In addition, the accuracy of the estimated HP expressed by the ACT was compared with that of the STN. This study contains a series of four experiments to evaluate and justify the reliability of BA to predict HP in each 6 to 8 laying hens under different environmental conditions (25-33℃, 12-16 lighting hour).

In this study, the number of body movements were measured by the Actigraph (AMI., USA) as ACT per min. STN, ETN and laying- were measured by the infra-red beam switches. An open circuit indirect calorimetry was used to measure HP from the difference between oxygen concentration of 10 min in-let air and 50 min exhausted air from the respiration chamber, and HP was calculated by the first response method. The data of HP, STN and ETN were collected and stored by a personal computer PC-9801 as per one min. The data of HP, ACT, STN, and ETN were analyzed as per hour. FI per lighting hour (g/(LR/h)) was calculated from the daily FI. In order to estimate HP predicted by BA, the effects of ACT (count/h), STN (min/h), FI (g/(LR/h)), Ta (℃), body weight (Bwt) (kg) and Age (wk) etc. on HP (kJ/kg $^{0.75}$/h) were analyzed as the multiple regression equations depending on the significance of each factor.

FI decreased with the increase of Ta. HP was also decreased with the increase of Ta. BA

changed depending on the levels of feeding, Ta and LR. Accordingly, the level of HP was also changed with the varying level of BA. BA increased significantly ($P<0.01$) during the dark periods at 29 and 33℃ compared with that at 25℃. The hens were restless under higher Ta during the dark periods and took rest in standing position rather than sitting, therefore, a slight increase of HP occurred during this time. BA increased with the increase of LR, and the increase of BA was significant at 16L: 8D in comparison with that at 12L : 12D. Simultaneously, HP was also increased with the increase of LR, but the increase of HP was not significant.

The data of all the experiments were analyzed as combined multiple regression equations in order to estimate HP predicted by BA. The combined multiple regression equations were as follows:

$$HP\ (kJ/kg^{0.75}/h) = 5.00/104 \times ACT + 2.92 \times FI - 0.41 \times Ta - 16.12 \times Bwt + 0.77 \times LR + 0.15 \times Age + 23.46 \quad \text{(a)}$$

$R = 0.90^{**}$, $R^2 = 81\%$, $n = 360$, Prediction error (PE) $= \pm 11\%$, $^{**}\ P < 0.01$.

Where, ACT was expressed by (count/h), FI (g/(LR/h)), Ta (℃), Bwt (kg), LR (h) and Age (wk). From the equation (a), the contribution rate of ACT, FI, LR, Ta, Bwt and Age to HP were 59%, 10%, 7%, 3%, 1% and 1%, respectively. Similarly, when the multiple regression equation was analyzed by the factor STN instead of ACT, the equation was as follows:

$$HP\ (kJ/kg^{0.75}/h) = 0.19 \times STN - 0.63 \times Ta + 3.18 \times FI - 22.02 \times Bwt + 0.27 \times Age + 42.0 \quad \text{(b)}$$

$R = 0.86^{**}$, $R^2 = 75\%$, $n = 360$, PE $= \pm 13\%$, $^{**}\ P < 0.01$.

Where, STN was expressed by (min/h), Ta (℃), FI (g/(LR/h)), Bwt (kg) and Age (wk). Here, the contribution rate of STN, Ta, FI, Bwt and Age to HP were 51%, 11%, 3%, 3% and 7%, respectively. The effect of LR to HP was not significant in the equation (b). Therefore, the factor LR was removed from this equation. It is noted that the above equations were analyzed by the use of data per hour and hence, estimation of the daily HP would be calculated by multiplying 24 hours.

From the combined multiple regression equation (a) and (b), the contribution rate of BA to HP when expressed by the ACT and STN were the highest among all other factors, and the contribution rate of ACT and STN to HP was 59% and 51%, respectively. Therefore, BA would be a good predictor of HP in the laying hen, where the information of the factors such as FI, LR, Ta, Bwt, age etc. would be required during the precise prediction of HP by BA. The correlation coefficient (R) of the multiple regression equation (a) was approximately 81% which was bigger than that of the equation (b) as 75%. The prediction error (PE) of the multiple regression equation (a) and (b) were 11% and 13% when expressed by the ACT and STN, respectively. From the results of the multiple regression equations (a) and (b), the prediction of HP was performed more accurately by the ACT rather than the STN. HP predicted by STN was lower than that by ACT due to the fact that the hens increased quiet STN significantly during the dark periods at the higher Ta, where the increase of HP was very little.

The level of BA varied depending on the level of FI, LR, Ta and other factors such as Bwt, age etc. Consequently, the level of HP was also differed with the varying level of BA. Thus, the energy expenditure of BA may be differed with the varying environmental conditions. The actual energy cost of BA will vary between individuals due to a number of factors such as Bwt, age, strain etc. Therefore, it can be suggested that during the prediction of HP by BA, the factors such as age,

strain etc. should be homogeneous, if possible.

Key words: heat production (HP), activity count (ACT), standing time (STN), food intake (FI), feeding level (FL), ambient temperature (Ta), lighting regime (LR)