Short Communication

Method to estimate feed intake from pasture in broilers and laying hens

Methode zur Abschätzung der Futteraufnahme von Broilern und Legehennen im Auslauf

Carina Lorenz, T. Kany and M.A. Grashorn

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Introduction

A main prescription in organic poultry production is that birds must have access to a free range area which has to be covered with vegetation (directives (EG) No 834/2007 and (EG) No 889/2008). Access to free range must be given at least half of life time span for meat-type chicken (broilers) and all over the production period for laying hens. Access may only be restricted due to unfavorable climatic conditions (e.g. heavy rain and snow, very low temperature). For both broilers and laying hens 4 m² (= 2,500 birds/hectare) have to be provided if birds are kept in solid houses.

In general, it is expected that birds have a distinct feed intake in free range (e.g. grass, herbs, spices, stones, insects, worms etc.) which contributes to their supply with nutrients (BLAIR, 2008). HORSTED et al. (2007a, b) assumed that the ingestion of plant particles of high quality reduces the intake of compound feed without affecting laying performance, by this reducing feed costs. Thus, this intake of plant particles can be regarded as a valuable feed supplement (FÖLSCH et al., 1999). Nevertheless, according to WALKER and GORDON (2003) and PONTE et al. (2008) information on the nutritive value of feed ingested from pasture is still limited. It can be expected that feed intake in the pasture depends on bird specific factors (genotype, size, age, rearing conditions etc.) and on condition of the pasture (plant populations, vegetation period, soil characteristics etc.) (HÖRNING et al., 2002).

Most studies on feed intake in pasture have been conducted in laying hens. HORSTED et al. (2006) and ANTELL and CISZUK (2006) estimated the feed intake of grass/clover as 10–35 g dry matter (DM) per hen and day. In a recent study (TREI et al., 2013), 57 g DM intake from pasture per hen and day has been reported. For broilers LORENZ and GRASHORN (2012) estimated that about 10–15% of total feed intake may come from pasture.

In most studies feed intake in the pasture was determined by estimation from changes in vegetation cover (HORSTED et al., 2007b; JONDREVILLE et al., 2010; TREI et al., 2013) and by analysis of crop contents (AMAKALOMU et al., 2004; ANTELL and CISZUK, 2006; HORSTED et al., 2007b; KOSMIDOU et al., 2010). The disadvantage of these methods is that feed intake is calculated either on the basis of rather defective estimations or by the contents of a very small section of the GIT of the birds. Therefore, it seems more promising to determine the amount and the composition of the contents of the pre-intestinal part (crop, proventriculus, gizzard) of birds.

The objective of this research has thus been to develop a method to determining total feed intake and composition of ingested feed in broilers and laying hens kept in free range. The method was then applied to analyse the effects of genotype, age, daytime and feeding regime on feed intake of broilers and laying hens from the pasture.

Animals and Methods

The method was developed with broilers and then adapted and transferred to laying hens. The experiments had been conducted at the Research Farm of Agriculture, Unterer Lindenhof, University Hohenheim, Stuttgart, Germany, and had been approved by the Animal Welfare Commission of the University (No. S303/11 and S339/12).

Animals

In total, 144 broilers of three different genotypes were used in the first experiment: fast growth (Ross 708; FG), medium growth (Isa 757; MG), slow growth (Isa 657; SG). Of each genotype 24 birds of mixed gender were assigned to one group (in total 72 birds) and were fed on conventional (N = 72) or organic diets (N = 72) with access to free range (5 m² per bird) from d 35 of life. Birds were kept in two compartments in a house with a winter garden. The pasture was a permanent grassland consisting of grass (perennial ryegrass, common meadow grass, etc.), clover (mainly white clover) and herbs. The experiment was conducted in springtime. Access to the pasture was from 7 a.m. to 7 p.m. Light went on at 6 a.m. and the whole lighting period was 16 h. All birds were fed ad libitum a mash compound feed and the nutrient contents of diets were adjusted to requirements of SG birds (starter: CP 18.5%, Met 0.35%, Lys 0.97%, AMEN 11.9 MJ/kg; grower: CP 17.2%, Met 0.33%, Lys 0.89%, AMEN 12.2 MJ/kg; finisher: CP 16.0%, Met 0.31%, Lys 0.81%, AMEN 12.5 MJ/kg). Grit was offered for free choice.
For the second experiment 120 laying hens were used: 60 “young” Bovans (30 weeks of age) and 60 “old” Lohmann Brown (65 weeks of age). Laying hens were taken from a conventional free range farm and during the experiment were kept in the same house as the broilers. Hens had access to the free range (4 m²/hen) from 7 a.m. to 9 p.m. Lighting inside of the house was 14 h (5 a.m. – 7 p.m.). Mash feed (CP 15.1%, Met 0.37%, Lys 0.73%, Ca 3.98%, total P 0.56%, AMEn 11.3 MJ/kg) and water were provided ad libitum. Furthermore, grit (3 mm) was available in the winter garden.

**Slaughtering**

Broilers were slaughtered in the morning at 10 a.m. Of each genotype and diet 4 birds (2 male and 2 female) were slaughtered weekly from the 7th to the 12th week of life without feed withdrawal (24 birds per week). Slaughtering of hens was in the morning (10 a.m.), at noon (1 p.m.) and in the afternoon (4 p.m.) to consider daytime variations in feed intake. Slaughtering was in the second and fourth week of the experiment, with 30 hens per day and time of day.

Immediately after catching, broilers as well as hens were electrically stunned for 8 seconds and killed by cutting neck blood vessels. Immediately after neck cutting, the esophagus was clamped with a cable fixer in order to avoid a loss of the crop content. Birds must be treated very calmly and gently before death to prevent a vomiting of the crop content.

**Sampling**

After slaughtering birds were transferred to supine position and the thorax was opened by cutting ribs and coracoid on the left side with scissors. The chest was opened and crop, proventriculus and gizzard were removed (Figure 1) and samples were transferred to plastic boxes and stored in a freezer (–18°C) for further investigations.

**Separation of the contents**

Prior analyses, samples of crop, proventriculus and gizzard were thawed overnight at 10°C. Before opening the crop, contents of the esophagus were pushed to the crop. Crop, proventriculus and gizzard were opened with a scalpel and contents were visually separated into five fractions: feed, litter, grit, pasture and other objects like feathers or insects (Figure 2). The term pasture comprises grass as well as clover, grass seed and other plant particles. Weights of litter, grit and pasture were determined. Feathers and insects were counted and the amount of feed was calculated by subtracting the content of all other fractions from the weight of the whole content.

The method will be described in detail for the crop, the gizzard was analyzed in the same way. The proventriculus was not considered as it was mainly empty. After opening the crop, it was turned inside out and the content was collected in a bowl. All rests of the content were flushed with water from the inner surface. The crop was dried with a paper towel and reweighed to calculate whole crop content. Crop contents were then diluted with water to separate single components from each other.

If the crop contained a lot of mash feed the water was very muddy and the individual components could not be seen. Then, an intermediate step was needed. For this, the content of the bowl was passed through a sieve (mesh width: 1 to 2 mm) and some solved feed ingredients could be washed out under running water. After that, plants from pasture, litter, feathers and insects swam at the water surface and could be separated with forceps. Small plant components or seeds were separated by using another sieve (diameter approx. 5 cm, mesh width: 0.5 to 1 mm). Grass and litter were pressed with forceps or fingers to squeeze the water, which would result in too high weights. Thereafter, respective fractions were weighed. In the next step feed was separated from grit. Feed dissolved in water was poured off carefully, while grit remained at the bottom of the bowl. This process was repeated until water was quite clear and only grit was visible at the bottom. The grit was then transferred to a sieve (diameter: 5 cm, mesh width: 0.5 to 1 mm) in order to separate the remaining water and was weighed.

In gizzards sometimes the plant particles were crushed thoroughly by the grit. Thus it was not possible to select the particles with forceps entirely. In this case, plant particles were skimmed off with a sieve. In order to prevent a distortion of the results no feed particles should be skimmed off.
During the whole analysis it is very important to avoid the entry of undesirable components or the loss of sample material to get reliable results.

**Determination of correction factors to calculate the real fresh mass of contents**

Due to rinsing the crop and gizzard with a lot of water, too much water remained in the fractions as it could not be squeezed completely. To get the fresh substance of the single components, a correction of the ascertained values had to be done. For this, a preliminary experiment was conducted with 20 hens. Crop and gizzard were removed and treated as described above. Samples of pasture, grit and litter were weighed and dried at room temperature until the bound water had evaporated. It is important that the samples should not be dried too long, as only fresh matter was wanted and not dry matter. After drying samples were weight once more and the proportional decrease in weight was calculated. The average weight loss was used in the quantitative analysis as a correction factor for the ascertained weights of plant particles and grit.

**Analysis of nutrient contents**

Nutrient contents of crops and gizzards of laying hens have been analyzed according to NAUMANN and BASSLER (1993). Besides the water content, contents of crude protein, crude ash, crude fiber, calcium and phosphorus were determined in a random sample of 30 young and 30 old hens.

**Statistical analyses**

The JMP® SAS version 8.0 program was used for statistical analyses (SAS Institute Inc., Cary, NC, USA). Prior analysis the residuals of the traits were tested for normal distribution. As all criteria significantly deviated from the Gaussian distribution data were subjected to a non-parametric analysis of variance with effects genotype and diet (Wilcoxon-Mann-Whitney Test) for the broiler experiment and with effects of slaughtering and genotype and diet (Kruskal-Wallis test) for the laying hens experiment. As all criteria significantly deviated from the Gaussian distribution data were subjected to a non-parametric analysis. As all criteria significantly deviated from the Gaussian distribution data were subjected to a non-parametric analysis of variance with effects genotype and diet (Wilcoxon-Mann-Whitney Test) for the broiler experiment and with effects of slaughtering and genotype and diet (Kruskal-Wallis test) for the laying hens experiment. Results on crop and gizzard analyses were used to estimate the content and the composition of daily feed intake in laying hens (Table 6). Crop and gizzard contents were distinctly higher in old than in young hens. The higher total content in old hens was mainly caused by the higher proportion of feed. The proportion of grit was not different between hens, whereas, younger hens showed a distinctly higher pasture proportion.

**Results**

During separation of crop and gizzard contents it was observed that a part of the added water during rinsing could not be squeezed. This amount was quite high for pasture and litter and low for grit (Table 1). Differences between crop and gizzard were minor. The calculated correction factors were therefore used to correct weight fractions in crop and gizzard.

<table>
<thead>
<tr>
<th>Crop/gizzard</th>
<th>Content</th>
<th>Bound water</th>
<th>Correction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
<td>pasture</td>
<td>33.1%</td>
<td>0.669</td>
</tr>
<tr>
<td>Gizzard</td>
<td>pasture</td>
<td>30.8%</td>
<td>0.692</td>
</tr>
<tr>
<td>Both</td>
<td>grit</td>
<td>10.4%</td>
<td>0.897</td>
</tr>
<tr>
<td>Both</td>
<td>litter</td>
<td>38.0%</td>
<td>0.620</td>
</tr>
</tbody>
</table>

**Discussion**

Determination of feed intake in the pasture is mainly of interest in organic broiler and egg production to estimate the contribution of this intake to the nutrient supply of birds. Estimation of feed intake from the pasture by observation of grazing behavior of birds or by calculating differences in plant cover between areas used by birds and control areas (HORSTED et al., 2006; ANTELL and CISZUK, 2006; JONDEVILLE et al., 2010) is not effective due to the high error probability. A more appropriate way is to analyze the contents of the GIT. In several studies authors analyzed the contents of crops (AMAKALOMU et al., 2004; HORSTED et al., 2007b; HORSTED and HERMANSSEN, 2007; KOSMIDOU et al., 2010) after slaughtering of laying hens. This results probably in more reliable values. In these experiments the calculated contents of clover varied between 0.20 and 5.80 g

<table>
<thead>
<tr>
<th></th>
<th>FG</th>
<th>MG</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed (%)</td>
<td>93.5a</td>
<td>82.4b</td>
<td>84.8b</td>
</tr>
<tr>
<td>Grit (%)</td>
<td>1.1</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Pasture (%)</td>
<td>1.0b</td>
<td>2.0ab</td>
<td>5.9a</td>
</tr>
</tbody>
</table>

FG = fast growth, MG = medium growth, SG = slow growth

a,b,c means within a line with differing superscript are significantly different (P < 0.05)
Conclusions

In conclusion, the described method is a suitable procedure to determine the feed intake of broilers and laying hens in free range systems. For reliable values determination of crop and gizzard contents at least at three points during a day is necessary. Crop and gizzard contents and their composition depend on production course (meat, egg), genotype, age of birds and daytime. Preliminary results indicate a pasture proportion of about 10–15% and 20–25% of total feed intake of broilers and laying hens, respectively. Assuming a dry matter content of pasture of 20%, the respective dry matter contents of pasture in crops and gizzards results in 18.8 and 13.7 g in young and old hens, respectively. Assuming a dry matter content of pasture of 20%, the respective dry matter contents are 3.6 and 2.7 g. These values are somewhat lower than the values reported by AMAKA LOMU et al. (2004), ANTELL and CSIZIK (2006), HORSTED et al. (2007b) and KOSMIDOU et al. (2010) due to overestimation of the pasture proportion by crop only analysis.

Summary

Information on feed intake of broilers and laying hens in free range systems is of interest to estimate nutrient supply...
of birds. Up to now feed intake from pasture is estimated either from changes in vegetation cover or from analyses of crop contents. But, it is assumed that the composition of GIT contents will result in more accurate estimates. Therefore, a method was developed to estimate feed intake from pasture in broilers and laying hens by analyzing crop and gizzard contents. In total, 144 broilers of different genotypes (FG – fast growth, MG – medium growth, SG – slow growth) were used to develop the method. Validation of the method was done on 180 young and old laying hens. The paper describes in detail the developed methodology with pointing to crucial points. The method requires a correction system to calculate the real fresh matter of fractions of crop and gizzard contents and a sample collection at least at three days times (morning, noon, afternoon).

Significant differences both in contents and composition of contents of crop and gizzard were observed for different broiler genotypes. Slow growing broilers showed the lowest of contents of crop and gizzard were observed for different genotypes. Langsam wachsende Broiler wiesen den ge- ringsten Inhalt, aber den höchsten Anteil an pflanzlichen Bestandteilen auf. Bei älteren Legehennen wurde mehr Kropf- und Muskelmageninhalt ermittelt, während der Anteil an pflanzlichen Bestandteilen aus dem Auslauf bei jungen Hennen höher war. Der analysierte Proteingehalt des Kropf- und Muskelmageninhaltsumsatzes konnte mit dem Proteingehalt der Futter- und Pflanzenfraktionen sowie der Aufnahme an tierischem Protein (z.B. Insekten) erklärt werden. Die Menge an Frischmasse pflanzlicher Bestand- teile in Kropf und Muskeln betrug bei jungen Hennen 18,8 und bei alten 13,7 g. Dies entspricht etwa 3,6 bzw. 2,6 g Trockenmasse. Es wurde der Schluss gezogen, dass die entwickelte Methode ein geeignetes Verfahren zur Be- stimmung der Nahrungsaufnahme von Broiler und Lege- hennen in Freilandhaltungen darstellt.

**Stichworte**

**Zusammenfassung**
Method zur Abschätzung der Futteraufnahme von Broilern und Legehennen im Auslauf


Die Zusammensetzung der Kropf- und Muskelnalimentar- Inhalte unterschied sich signifikant zwischen den Broiler-

**Key words**
Broiler, laying hen, free range, feed composition, crop, gizzard

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Correspondence: Carina Lorenz, Prof. Dr. M.A. Grashorn, Dept. of Poultry Science (470C), University of Hohenheim, 70593 Stuttgart, Germany; e-mail: carinalorenz@yahoo.de, michael.grashorn@uni-hohenheim.de

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