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Caecal abnormality in a layer hen (Gallus gallus forma domestica) not accompanied by deficits in digestive performance or egg productivity

Stephanie K. Courtney Jones
University of Wollongong, skcj542@uowmail.edu.au

Adam J. Munn
University of Wollongong, amunn@uow.edu.au

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Keywords

Caecal malformation, nutrition, organogenesis, poultry, physiology

Disciplines

Medicine and Health Sciences | Social and Behavioral Sciences

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Caecal abnormality in a layer hen (*Gallus gallus* forma domestica) not accompanied by deficits in digestive performance or egg productivity.

Stephanie K. Courtney Jones [1] and Adam J. Munn [*1]

[1] Institute of Conservation Biology and Environmental Management, School of Biological Sciences, University of Wollongong, Wollongong, NSW 2500, Australia

Phone, +612 4221 4459; amunn@uow.edu.au

[*] To whom all correspondence should be directed

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Abstract

We report a case of a layer hen (*Gallus gallus* forma domestica) with deviation in the morphology of the caecum, and unique opportunity to investigate the digestive performance of the animal compared with normal hens. In a study investigating digestive and reproductive performance, an atypical caecal arrangement was found in a hen that was unremarkable in regards to body mass, digestive performance and egg productivity in comparison to other hens fed a similar diet. Examination of the gastrointestinal tract revealed a singular tubular outgrowth from the ileo-caecal junction, rather than the typical paired outgrowths. The single caecal duct bifurcated into two separate blind ended sacs. Similar caecal deviations have been described in adult and juveniles, but no indications of animal performance were reported in these cases. We conclude that if the presence of an abnormal caecal arrangement reduces digestive abilities they were not obvious, and some compensatory mechanism/s may exist. Alternatively, the abnormal caecal arrangement of our hen might function adequately, such that no compensation in feed intakes or reduced egg productivity was required or observed.

Introduction

Caecal abnormalities in poultry are not common, with the reported incidences being as low as n= 6 in 13,483 birds and n = 3 in 35,000 birds (see Grewal et al., 1976; Grewal and Brar, 1989). Documented cases have typically been seen in birds associated with other maladies (Grewal et al. 1976). However, in cases where no other malady is obvious, the consequences to animal nutrition of these caecal malformations are uncertain. We report a unique opportunity to investigate a case of deviation in morphology of the caecum in a layer hen (*Gallus gallus* forma domestica) that was discovered during an investigation into the digestive and production performance of layer hens in response to different diets (Courtney Jones et al. *In press*). As such, we were able to compare post-hoc the nutritional and production performance of the single layer hen displaying caecal abnormality with that of normal hens.

Materials and methods

Animals

All hens used in this project were aged > 18 months in production (estimated age of two years), and we followed their performance in response to increased dietary fibre content in a related study (Courtney Jones et al. *In press*). For the purposes of the comparison described here, our single abnormal hen (discovered during post-mortem evisceration) was part of a larger treatment group offered a high-fibre diet balanced with corn oil to match energy contents of a standard low-fibre layer diet.

Throughout acclimation and experimental periods, birds were weighed once weekly to monitor body condition. Birds were held in the Ecological Research Centre (ERC) at the University of Wollongong (34°25'S, 150°54'E). Upon introduction to the ERC, birds were treated for internal and external parasites using Piperazine Solution (Piperazine anhydrous: 172 5g L-1; Inca (Flight) Co. Pty Ltd, St Mary's, NSW, Australia) and Pestene-Insect Powder (Sulfur: 50g kg^{-1}, Rotenone: 10g kg^{-1}; Inca (Flight) Co. Pty Ltd, St Mary's, NSW, Australia), and birds were treated fortnightly henceforth. During the acclimation period, birds were housed in groups for two weeks followed by a further ten days of acclimation to individual housing conditions and adjust to the control and experimental diets (see Diet Composition and Feeding Trials). Throughout the experimental period, birds were individually housed in standardised stainless steel mesh cages (0.6 m wide x 0.6 m deep x 0.5 m high) equipped with collection trays lined with waxed paper for excreta collection. Each cage was equipped with plastic self-feeders for food and water; throughout the entire study food and water were offered ad libitum. Birds were housed at temperatures between temperature of 22 – 25°C with air humidity 50 – 60% and a 14 h: 10 h light : dark regimen, using full-spectrum UV fluorescent bulbs.

Diet Composition and Feeding Trials

Prior to the experimental period, birds were fed a standard commercial layer pellet diet (‘Back Yard Layer’ - The Vella Group, Plumpton, NSW, Australia), containing 8.37% fibre as fed (fibre type not defined). Animals were then assigned randomly to the experimental diet, in this case a diet high in fibre (16% Neutral detergent fibre; see Courtney Jones et al. *In press* for full details). Birds were acclimated to a high fibre experimental diet with a transition period over 5-days that introduced the experimental diet incrementally (at 0%, 30%, 50%, 70%, 100%) to the low-fibre layer pellet diet. The control and experimental diets were obtained from the Poultry Research Foundation of the University of Sydney, Camden, New South Wales, Australia (see Table 1). Fibre for the experimental diets was sourced from wheat bran. All diets were analysed to determine proximate chemical composition (Table 1).

Body Mass, Feed Intake, Egg Production and Apparent Metabolisability

Body mass, food intake and eggs laid were measured daily; all masses were measured in grams, with the exception of body mass being measured in kilograms. Feed remaining and spilt food were collected quantitatively and stored in a dry air tight room (see Sample Analysis). After the 14 day experimental period, birds were euthanased to measure morphometric differences.

The intake of dietary components (Dry Matter Intake) was calculated as [(Feed offered – Feed Remaining and Spilt)*%Dry Matter]. The apparent and energy metabolisabilities (%) of the dietary components were calculated as:

[((Dry Matter Intake – Dry Matter Output)/Dry Matter Intake)] * 100 and [((Dry Matter Energy Intake – Dry Matter Energy Output)/Dry Matter Energy Intake)] * 100 respectively, where Intake and Output were measured as g per chicken day^{-1} (Robbins, 1993).

Dissections and Morphometry

Animals were euthanased using isofluorane overdose followed by cervical dislocation. Immediately following euthanasia, macroscopic dissections and measurements of organ size were conducted.

Sample Analysis

Daily samples of food offered, food remaining, food spilt and faecal output were collected and weighed to determine wet mass. Faecal samples were stored frozen (-20°C). Faecal samples from each day were then later thawed and sub samples (approximately 25% wet mass) along with sub-samples of food offered were prepared (approximately 25% wet mass) for analysis by air drying in an oven at 103°C for 48h (Robertson and Van Soest, 1981) to determine dry masses.

The dried samples of feed offered were ground using a Wiley Mill through a 1 mm mesh (Arthur Thomas Co. Scientific Apparatus, Philadelphia, USA). Ash content of the dried, ground feed offered were determined by dry ashing 0.5 g samples in a Thermolyne

Muffle Furnace (Model 62700; Dubuque, Iowa, USA) at 550°C for 12 h. Organic matter of food stuffs was calculated as the Dry Matter content – Ash Content.

The Neutral Detergent Fibre (NDF; comprised of mainly cellulose, hemicellulose and lignin) and Acid Detergent Fibre (ADF; comprised of mostly cellulose and lignin) of the three diets offered were determined using reagents and procedures as described by Van Soest et al. (1991); before neutral detergent digestion, duplicate 0.5 g sample bags were washed in acetone to remove any soy bean products from the extract samples. Using a sequential filter bag technique, to reduce any unintentional loss of samples during the procedure, and ANKOM Fibre Analyser (Model 220, ANKOM Technology Corp., Fairport New York, USA), the soluble cell contents (calculated as Dry Matter – Neutral Detergent Fibre), hemicellulose (NDF – ADF) and cellulose contents (ADF – lignin) in the three diets were determined by the difference. NDF and ADF were not adjusted for ash content and are presented on a %DM basis only.

The energy content of the dried, ground feed and faeces were determined via the combustion of duplicate ca. 0.5 g sub samples in a bomb calorimeter (Gallenkamp, Model CB-375; Gallenkamp and Co. Ltd, Loughborough, UK); a standard of benzoic acid was used for calibration. Nitrogen content of feed was determined by total combustion of duplicate 0.2 g samples in a Leco CHN-1000 elemental analyser (Leco Inc. St Joseph, Michigan, USA).

Results

We describe here an atypical caecal arrangement found in a hen that was otherwise unremarkable with regard to body mass, digestive performance (apparent dry matter metabolisability) and egg productivity (output and mass) when compared with other hens fed similar diet. At evisceration the hen was 2.0 kg and was free from any other obvious abnormalities. This is the first report of an abnormal caecal arrangement found in a mature, otherwise healthy hen, and the first description of such an anomaly where digestive performance and egg production were quantified.

Following euthanasia of the bird, examination of its gastrointestinal tract revealed an atypical singular tubular outgrowth from the ileo-caecal junction, rather than the typical paired outgrowths (Fig. 1). This singular tubular outgrowth, referred henceforth as the caecal duct, bifurcated distally 60.3 mm from the ileo-caecal junction, and opened distally to form two blind sacs, henceforth referred to as the paired caeca. These paired caeca shared common mesentery with adipose tissue. Further, a small sacculation was present at the junction of the caecal duct and the paired caeca (Fig. 1). Of the paired caeca, one was longer and heavier (henceforth referred to as caecum 1) in comparison with the other (caecum 2). Caecum 1 was 64.3 mm in length (from the point of bifurcation), and had diameters of 10.4 mm, 7.0 mm and 6.2 mm at the blind sac, mid-point (body) and proximal section (immediately adjacent to the ileo-caecal junction), respectively (average diameter was 7.9 mm). Caecum 2 was 60.8 mm in length, and had diameters of 7.5 mm, 7.0 mm and 6.8 mm at the blind sac, mid-point (body) and proximal section (immediately adjacent to the ileo-caecal junction), respectively (average diameter 7.1 mm). Of note, the blind sac of caecum 1 arched and widened to bulge at the apex, but the caecum 2 blind sac was straight and bluntly rounded at the blind end (Clench and Mathias, 1995). We also observed a twist in the caecal duct immediately adjacent to the ileo-caecal junction.

Discussion

Similar caecal deviations have been described in adult chickens (e.g. Grewal *et al.*, 1976; Peckham 1965), and in younger birds, including a 20-week White Leghorn pullet (Grewal *et al.*, 1980) and in a 7-week old broiler (Mishra and Panda, 2010), but no indications of animal performance were reported in these cases. Mishra and Panda (2010) noted that the paired caeca of their broiler shared an extensive inter-caecal mesenteric fold and capillary bed; however, this was not observed in our case study. Further, Grewal *et al.*, (1980) noted complete aplasia of the left caecum, and on the right caecum a groove of the free surface dividing the caecum into two separate structures terminating at the apex with two blind-ended structures. In our case study, there was distinct singular proximal duct (tube), and which possessed a short groove proximally on the free surface, but which did not extend distally (Fig. 1). Furthermore, Grewal *et al.* (1976) noted that their 20-week old pullet with an aplastic left caecum was lethargic and with a pale comb, but the bird was also infested with jejunal round worms. We found no such malady in our mature hen.

Our hen was up to 18-months production (or 2 years old) and exhibited no abnormalities of egg production or egg quality (egg number and mass) during our 28-day feeding trial (Fig. 2). Furthermore, our hen showed no obvious deviations in feed intake, apparent metabolisability of dry matter (%) or body mass changes when compared to all other hens offered the same diet (a high-fibre mash, balanced for energy and protein, matching contents a low-fibre, standard layer hen mash; Courtney Jones *et al*., *In press*). Thus, if the presence of an abnormal caecal arrangement reduced the digestive abilities of our hen they were not obvious, and some compensatory mechanism/s may have existed. Alternatively, the abnormal caecal arrangement of our hen, with its long singular duct and short terminally paired caeca, might function adequately, such that no compensation in feed intakes or reduced egg productivity was required (Fig. 2). Of note, Mishra and Panda (2010) reported that the histological characteristics of an abnormal caecal duct were similar to that of the ileum. Given that the ileum generally has a higher absorptive capacity for various nutrients compared with the caeca, it is possible that similar morphological characteristics allowed the abnormal caecum of our hen to compensate for lost nutrition (Mishra and Panda 2010), but we were unable to conduct histological analyses in this case.

The single caecal duct seen here may be indicative of an error during organogenesis during embryogenesis (Romanoff, 1960). Given similar deviations in caeca morphology have been reported previously, this may indicate that errors in organogenesis may be more frequent than previously thought in *Galliformes*, and in particular in domesticated species. It is suspected that intensive breeding may result in such abnormalities, suggesting that domestic chickens could be a useful model for investigating organogenesis of digestive structures. Notably, the dimensions of our chicken's deviated caeca were approximately double those observed in normal caecal arrangements for duct diameters of caecal material. For example, the typical diameter of the caeca at the opening at the ileo-caecal duct for the normal hens in our study were 7.6 ± 1.6 mm and 8.4 ± 1.8 mm for the right and left caecum, respectively. In contrast, the diameter of the caeca at the opening at the ileo-caecal duct for our chicken's deviant caeca was 11.6 mm. In addition, caecal-body diameters 60 mm distal to the ileo-caecal duct in normal chickens were 5.5 ± .07 mm and 6.3 ± 1.9 mm for the right and left caeca, respectively, compared with a diameter of 12.9 mm in the deviant caecum; 60 mm was the length at which the deviant caecum's common duct bifurcated (Fig. 1). Furthermore, the entire caecal empty-wet mass of normal chickens fed the same diet was 7.7 ± 0.4 g, compared with 6.6 g for the entire empty wet-mass of the deviant caecum. As such, the comparable dimensions of the deviant caecum relative to a normal paired caeca may have compensated for the complete aplasia of one caeca, and may explain why no deficits of health or production were noted in that chicken.

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Acknowledgements

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Figure Captions

Figure 1: Aplasia of the left caeca; with only the right caeca present, bifurcation at the blind end.

Figure 2: Comparison of mean body mass (g), body mass change (g), daily dry matter intake (g d^{-1}), apparent dry matter metabolisability (%), total number of eggs and egg mass (g) of a single layer hen with caecal abnormality (Individual), compared with the group means from n= 5 hens fed the same diet, but with no gross caecal-abnormalities (High Fibre Balanced; see Table 1 for details).

Table 1: Ingredients and proximate nutrient composition of the experimental diets used in this experiment; Low Fibre = standard layer mash, and High Fibre Balanced was diluted with wheat bran to increase fibre contents, and was balanced with corn oil to match the Low Fibre diet metabolisable energy contents.

% ingredients as fed	Low Fibre	High Fibre Balanced
Wheat – Feed	72.5	44.6
Soybean Meal 48	15.2	13.2
Wheat Bran	-	25.0
Corn Oil	2.1	7.1
Salt	0.14	0.17
Sodium Bicarbonate	0.21	0.17
DL Methionine	0.08	0.08
Lysine HCl	0.02	0.00
Limestone	8.8	8.8
Dicalcium Phosphate	0.77	0.77
Vitamin Premix	0.20	0.20
Chemical composition		
Dry Matter (%)*	92.1	92.0
Organic Matter (%)*	90.9 ± 0.1	86.7 ± 0.0
Nitrogen (%)*	3.1	3.0
Crude Protein (%)*	19.2	18.5
Gross Energy (kJg^{-1} DM as fed)*	16.4 ± 0.2	18.5 ± 0.8
Metabolisable Energy (kJd^{-1} DM)	11.5 ± 1.2	12.2 ± 0.7
Neutral Detergent Fibre (%)*	8.5±0.5	15.6 ± 0.5
Acid Detergent Fibre (%)*	3.0±0.01	5.9 ± 0.2

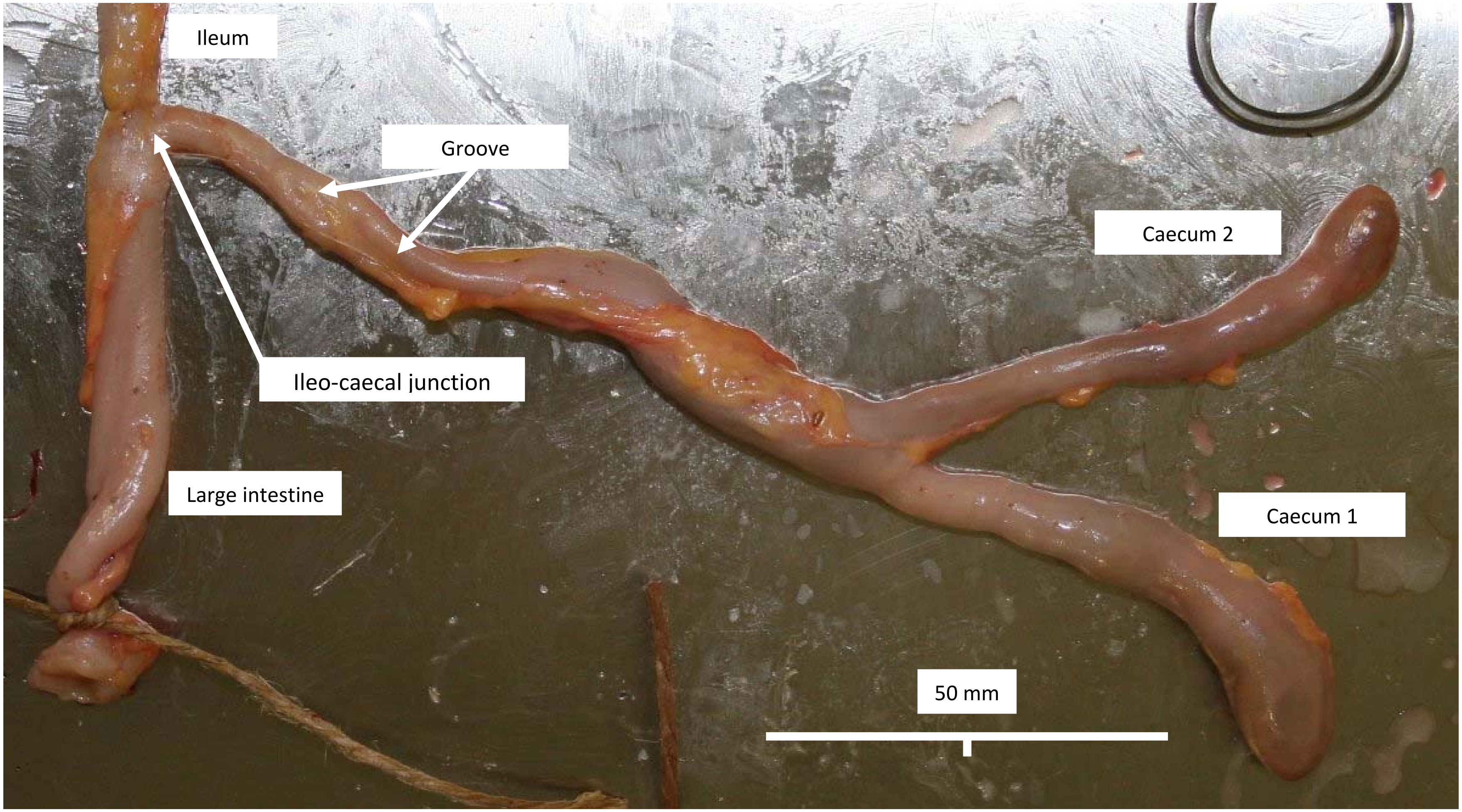
Ileum
Groove
Caecum 2
Ileo-caecal junction
Large intestine
Caecum 1
50 mm

Fig. 1

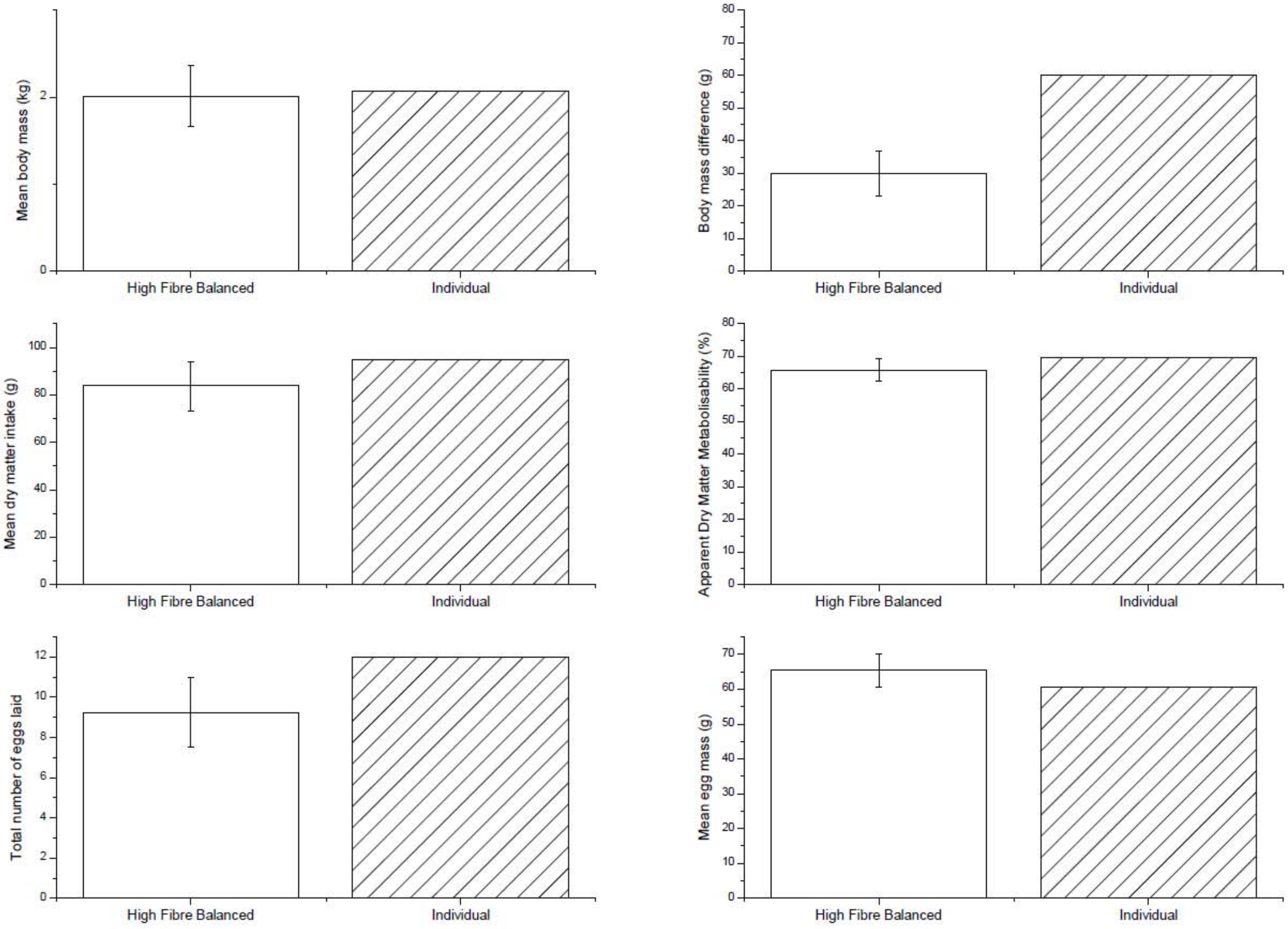
Mean body mass (kg)
0
2
High Fibre Balanced
Individual
Body mass difference (g)
0
10
20
30
40
50
60
70
80
High Fibre Balanced
Individual
Mean dry matter intake (g)
0
20
40
60
80
100
High Fibre Balanced
Individual
Apparent Dry Matter Metabolisability (%)
0
10
20
30
40
50
60
70
80
High Fibre Balanced
Individual
Total number of eggs laid
0
2
4
6
8
10
12
High Fibre Balanced
Individual
Mean egg mass (g)
0
10
20
30
40
50
60
70
High Fibre Balanced
Individual

Fig. 2