Effect of age and sex on carcass characteristics and internal organ weights of scavenging chickens and helmeted guinea fowls

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\textbf{ABSTRACT}

The objective of the study was to determine the effect of age and sex on carcass characteristics and internal organ weights in scavenging guinea fowls and chickens. Ninety-six scavenging birds, purchased from farmers, were used comprising 48 guinea fowls and 48 chickens from communal farmers. Guinea fowls comprised 25 females and 23 males, with 21 growers and 27 adults. Chickens had 18 females and 30 males with 19 growers and 29 adults. Guinea fowls had heavier body weight and relative hot carcass and cold dressed weight than chickens and which increased with age. Breast and wing relative weights were higher in guinea fowls. Chickens recorded the higher weight of leg and drumstick than guinea fowls. The neck, feet and head weights were heavier in chickens except for the back which was similar to guinea fowls. Chickens had significantly higher abdominal fat than guinea fowls. Relative weights of the heart, liver, kidney, lung and gizzard were higher in chickens. Relative total intestinal weight and lengths of total intestines, small and large intestines were higher in chickens than in guinea fowls. Relative lengths of the intestines decreased with age. Chickens and guinea fowls could have different capacities to utilize scavengeable feed resources.

\textbf{Introduction}

The raising of traditional free range poultry is of great importance in smallholder communal production systems. Village poultry in Southern Africa includes chickens, guinea fowls, turkeys, geese and pigeons (Delany 2003). In most developing countries, poultry production is based mainly on scavenging systems which has been a traditional component of smallholder farmers in the developing world for centuries and is thought to continue in the future. Poultry production is by far the most common economic activity practised by 80% of the resource-poor households across Southern Africa (Mapiye et al. 2008). In most production systems, guinea fowls complement village chicken enterprises by utilizing spaces and feeds that are not accessible to chickens. They also produce more eggs than chickens, although they are poor in brooding them. Data on the interface and synergy between scavenging chickens and guinea fowls are scarce (Poulsen et al. 2000; Obike et al. 2011). Popularizing guinea fowls as a source of quality meat and cheaper animal protein is important (Singh et al. 2015).

Guinea fowl meat is highly acceptable in many communities making its adoption easy. One of the advantages over chickens is that guinea fowls are free from worrisome poultry diseases. In many tribes, guinea fowls play an important socio-cultural role as they are cheap to produce since they require less labour and management, greatly consume green feeds, have the ability to protect themselves from or evade predators, control ticks and other pests and are tolerant to most common poultry diseases. Guinea fowl meat is characterized by high protein content, low fat content and is, therefore highly priced as compared to chicken meat (Mareko et al. 2006; Tufarelli et al. 2007; Laudadio et al. 2012). Since resource-poor communities are adopting the rearing of the guinea fowls, it is important to promote them (Ogah 2013) by creating profitable enterprises through the understanding of its performance (Singh et al. 2015). Marketing of poultry meat is profitable when there is a production of various cut up parts, making it possible for different classes of consumers to purchase according to their requirements and affordability (Teye and Adam 2000). It is, therefore, important to determine if the adoption of guinea fowls is worthwhile in households in comparison with the conventional chickens. Information on the comparisons of growth, carcass and carcass portions in scavenging chickens and guinea fowls are scarce (Poulsen et al. 2000; Tadelle et al. 2000). Such comparisons enable policymakers and development agencies to develop informed strategies of improving smallholder poultry production systems. Therefore, the objective of the current study was to determine the interaction of age and sex on carcass characteristics and internal organs in helmeted guinea fowls and scavenging chickens. It was hypothesized that carcass and internal organ weights vary with sex and age of birds in guinea fowls and village chickens.
Materials and methods

Description of study site

The study was conducted in Wedza District communal area located in Mashonaland East Province, Zimbabwe. The district lies between longitude 31°00′E and latitude 32°00′E and 18°30′S and 19°15′S. The area is characterized by mixed crop and livestock production system under smallholder and semi-intensive farming. The area is located in Natural Region II which receives a mean annual rainfall of between 600 and 1000 mm and mean temperatures of 29°C. The soils in Wedza district are largely derived from granite, with categories on a typical catena recognized on the basis of soil moisture-holding capacity, waterlogging, weed burden and soil fertility. The natural vegetation in Wedza is dry Miombo woodland, with dominant tree species comprising *Brachystegia boehmii*, *B. spiciformis* and *Julbernardia globiflora* (Woittiez 2010). This type of woodland stretches over Mozambique, Malawi and Zimbabwe and varies in density from closed canopy to a savanna with scattered trees (Woittiez 2010). The dominant grass species found is thatchng grass (Gadzirayi et al. 2007). The major crops grown in the area include maize, groundnuts and sunflower (Zvinorova et al. 2013). Goats, cattle, poultry, sheep, donkeys and pigs are also common.

Birds sampling and slaughter

A total of 96 birds were used in the study. Forty-eight guinea fows and 48 chickens were purchased from different guinea fowl and chicken keepers in the area of study. Guinea fowls comprised 25 females and 23 males made up of 21 growing (11 females and 10 males) and 27 adults (14 females and 13 males). Chickens had 18 females and 30 males with 19 growers (7 females and 12 males) and 29 adults (11 females and 18 males). The birds used in the study were those which were left to roam freely and scavenge during the day and confined at night as described by Mwalusanya et al. (2002). The birds were occasionally given cereal grains such as maize and sorghum, and kitchen waste as a supplementary feed but farmers did not practise the measuring of quantities offered. Growing birds were aged between 4 and 8 months which were weaned at about 3 months of age when they would have gained the pace of adult birds. Adult birds were caught from the households at the end of the day when doing their last scavenging and slaughtered immediately between 1600 and 1800 h by the same person. The birds were slaughtered by cutting and dislocating cervical region using a sharp knife and left to bleed for 5 min (Ncobela and Chimonyo 2016). After bleeding, the carcass was scalded in hot water for a few minutes to allow for manual plucking of feathers. The birds were eviscerated. The head was removed between the occipital condyle and the atlas and the feet at the carpal joint. The carcass, head, feet and internal organs for each bird were placed in separate labelled polythene bags, placed in a cooler box filled with ice and transported to the University of Zimbabwe, Animal Science Department Laboratory for measurements.

Measurements

Measurements of the body weight (BW), hot carcass, head and feet were done using a mechanical top loading scale which weighs up to 5 kg in 20 g increments (Salter Model 250-65). The carcass was weighed again after 24-h refrigeration at 4°C to determine the cold carcass weight. The carcass was cut into breast, legs (including thigh and drumstick), wings, back and neck. The breast, legs, drumstick, thigh and wing were cut according to the method used by Golioni et al. (2003). The cut parts of economic importance comprised the wing, leg thigh, drumstick and breast. Carcass remainders were the back, neck, feet and head. Internal organs (heart, liver, lungs, kidneys, spleen, total intestines and gizzard) and abdominal fat were separated and weighed. Giblets were heart, liver, lungs, kidneys, spleen and gizzard. Weighing of the cut parts, carcass remainders and internal organs was done using a Mettler PE 2000 digital electronic scale with an accuracy of 0.1 g. The length of the intestines was measured using a flexible tape measure with an accuracy of 1 mm.

All the measurements taken from each carcass, except for the body weight and intestinal length, were expressed relative to the live body weight as g/kg BW. The intestinal length was expressed as cm/kg BW.

Statistical analyses

Analysis of variance was carried out to determine the effects of sex and their interactions on carcass characteristics and internal organ weights of chickens and guinea fowls using the PROC GLM procedure of SAS (2011). The model used was

\[
Y_{ijk} = \mu + P_i + A_j + S_k + (P \times A)_{ij} + (P \times S)_{jk} + (A \times S)_{ik} + (P \times A \times S)_{ijk} + \varepsilon_{ijk},
\]

where \(Y_{ijk}\) is the response variable (carcass and internal organ weights); \(\mu\) is the overall mean common to all observations; \(P\) is the effect of the \(i\)th species (\(i = \) chickens, guinea fowls); \(A\) is the effect of \(j\)th age (\(j = \) growing birds, adults); \(S\) is the effect of \(k\)th sex (\(k = \) male, female); \((P \times A)_{ij}\) is the effect of interaction between \(i\)th species and \(j\)th age; \((P \times S)_{jk}\) is the effect of interaction between \(j\)th species and \(k\)th sex; \((A \times S)_{ik}\) is the effect of interaction of \(j\)th age and \(k\)th sex; \((P \times A \times S)_{ijk}\) = effect of interaction of \(i\)th species and \(j\)th age and \(k\)th sex; \(\varepsilon_{ijk}\) is the random error with mean 0 and variance \(\sigma^2\).

Least square means were generated and separated using the LSMEANS and PDIFF options, respectively (SAS 2011).

Results

Body weight, hot carcass and cold carcass weights

Table 1 shows the summary statistics of the measurements taken from the scavenging chickens and guinea fowls. The coefficient of determination for the relative weight of the back and spleen was below 50%. Table 2 shows the levels of significance
for the carcass traits and internal organs measured in scavenging chickens and guinea fowls. Species and age had an effect on absolute body weight and proportional weights of the hot carcass and cold carcass relative to body weight. There was a three-way interaction of species, age and sex of bird on hot carcass, cold dressed and breast weight.

Body weight, hot carcass weight and cold dressed weight were significantly higher in guinea fowls than in chickens. A significant interaction of species × sex was detected for cold carcass weight where female chickens recorded the lowest significant interaction of species × sex was detected for cold carcass weight, where female chickens recorded the lowest body weight, hot carcass weight and cold dressed weight. Across both age categories, the sex of the bird had no influence on the relative back weight. The weights of the thighs were not different between males and females. Grower guinea fowls had significantly heavier thighs than their chicken counterparts. For adult birds, chicken had heavier thighs and drumsticks than guinea fowls. Growing chickens had higher (P < .05) drumstick weights than guinea fowls. Across age groups and species, guinea fowls (P > .05; Table 3). The hot carcass weight for mature female guinea fowls differed from that of growing chickens, growing male guinea fowls and adult male chickens. Cold carcass weight for growing female chickens was lowest and different (P < .05) from guinea fowls and adult chickens and growing male chickens. Mature male guinea fowls recorded the heaviest cold dressed weight which differed from all the classes of birds investigated except mature female guinea fowls.

### Table 1. Summary statistics for traits measured in the current study.

| Trait                  | Mean  | CV   | RMSE | R² value |
|------------------------|-------|------|------|----------|
| Body weight (g)        | 1271  | 12.5 | 158.8| 0.92     |
| Hot carcass (g/kg BW)  | 656.6 | 5.21 | 34.2 | 0.57     |
| Cold dressed (g/kg BW) | 638.7 | 7.58 | 37.0 | 0.53     |
| Wing (g/kg BW)         | 47.24 | 11.4 | 5.39 | 0.69     |
| Leg (g/kg BW)          | 111.4 | 10.7 | 11.9 | 0.69     |
| Thigh (g/kg BW)        | 61.40 | 12.4 | 7.64 | 0.58     |
| Drumstick (g/kg BW)    | 51.25 | 11.1 | 5.68 | 0.74     |
| Breast (g/kg BW)       | 161.9 | 11.5 | 18.6 | 0.83     |
| Neck (g/kg BW)         | 43.32 | 13.9 | 6.02 | 0.74     |
| Back (g/kg BW)         | 135.8 | 13.9 | 18.9 | 0.48     |
| Feet (g/kg BW)         | 39.99 | 15.7 | 6.27 | 0.85     |
| Head (g/kg BW)         | 37.82 | 12.2 | 4.61 | 0.86     |
| Abdominal fat (g/kg BW)| 23.82 | 13.7 | 2.42 | 0.76     |
| Gizzard (g/kg BW)      | 63.75 | 17.4 | 11.1 | 0.79     |
| Liver (g/kg BW)        | 20.80 | 20.5 | 4.26 | 0.75     |
| Heart (g/kg BW)        | 6.364 | 20.5 | 1.31 | 0.54     |
| Lungs (g/kg BW)        | 8.848 | 15.4 | 1.36 | 0.79     |
| Kidney (g/kg BW)       | 8.196 | 14.5 | 1.19 | 0.83     |
| Spleen (g/kg BW)       | 1.026 | 31.9 | 0.33 | 0.34     |
| Total intestine (g/kg BW)| 51.59 | 19.9 | 10.3 | 0.67     |
| Total intestine (cm/kg BW)| 104.3 | 13.6 | 14.1 | 0.87     |
| Small intestine (g/kg BW)| 84.80 | 19.9 | 10.3 | 0.67     |
| Large intestine (cm/kg BW)| 19.53 | 31.9 | 0.33 | 0.34     |

Note: CV, coefficient of variation; RMSE, root mean square error; R², coefficient of determination.

### Cuts of economic importance

Table 3 shows the relative breast weight for chickens and guinea fowls. For growing birds, male guinea fowls had a larger breast than their female counterparts, whereas no sex differences were detected for chickens. In adult birds, however, males and females had the same breast weight, with guinea fowls heavier than chickens. Table 4 shows the relative weights of the leg, back, thigh, drumstick and wings. Leg weight was highest in adult chicken and lowest in adult guinea fowls. The leg weight for growing chickens was lower (P < .05) than for adult chickens. For guinea fowls, however, adults had significantly lower leg weights than growing birds. Adult male chickens had higher (P < .05) leg relative weights than their female counterparts whereas adult male and female guinea fowls showed no differences (P > .05) (Table 4).

Relative back weight for adult guinea fowls was significantly heavier than in growers while in chickens, adults and growers were the same (P > .05) (Table 4). Across both age categories, the sex of the bird had no influence on the relative back weight. The weights of the thighs were not different between males and females. Grower guinea fowls had significantly heavier thighs than their chicken counterparts. For adult birds, chicken had heavier thighs and drumsticks than guinea fowls. Growing chickens had higher (P < .05) drumstick weights than guinea fowls. Across age groups and species,
sex of bird had no effect on the relative weight of the wings. The wing weights for grower and adult chicken were the same (P > .05). In guinea fowls, however, wing weight for adults was significantly lower than in growing birds.

**Abdominal fat and carcass remainders**

Table 5 shows the least square means of carcass remainders and abdominal fat in male and female chickens and guinea fowls across two age groups. The proportional weight of the abdominal fat was, as expected, low in grower birds. Among the growing birds, female chickens had the highest (P < .05) amount of abdominal fat. There was no difference in the amount of abdominal fat between adult male chickens and guinea fowls. Adult chickens had the highest abdominal fat. The relative weight of the neck, feet and head varied with species and age. The neck weight was heavier in chickens (P < .05) than in guinea fowls. Growing birds had heavier neck, feet and head weights than mature birds (P < .05). Significant differences among sexes were observed in the weight of the neck and feet as male birds recorded higher (P < .05) weights for both traits than female birds. An interaction of species x age was significant for neck weight. Neck weight was highest in growing chickens which was statistically similar (P > .05) to mature chickens, and lowest in mature guinea fowls which differed (P < .05) from growing chickens and mature chickens and guinea fowls.

**Internal organs**

Species and age had an effect (P < .05) on the proportional weight of liver, lungs, kidney and gizzard (Table 6). Compared to guinea fowls, chickens recorded higher weights for the liver, kidney, lungs and gizzard. A significant decrease in the proportional weights was observed in the heart, liver, kidney, lungs and gizzard (P < .05). There was a significant species x age interaction on the kidney weight. Male growing birds had the heaviest heart. Growing chickens recorded the heaviest kidney weight (P < .05). Mature guinea fowl kidney weight was the lowest and differed (P < .05) from the other three classes investigated. Kidney weight was observed to decrease with age in both poultry species. There was no significant difference between the kidney weight of mature chickens and young guinea fowls (P > .05). The spleen weight was not affected by neither age nor sex of bird.

### Table 3. Interaction of species × age × sex for hot carcass weight, cold dressed weight and large intestine length of scavenging chickens and guinea fowls.

| Trait                 | Sex            | Growing chickens | Adult chickens | Adult GF |
|-----------------------|----------------|------------------|----------------|----------|
| Trait                 | Growing GF     | Adult GF         | Adult GF       | GF       |
| Body weight (g)       | Female         | 878.8 ± 66.21 a  | 973.8 ± 61.47 a| 1416 ± 60.00 c| 1628 ± 48.58 c|
| Hot carcass (g/kg BW) | Male           | 905.0 ± 59.72 a  | 920.8 ± 55.71 a| 1557 ± 43.84 c| 1664 ± 54.76 c|
| Cold dressed (g/kg BW)| Female         | 586.5 ± 14.27 b  | 636.3 ± 13.24 b| 654.6 ± 12.92 b| 686.6 ± 10.47 ab|
| Breast (g/kg BW)      | Male           | 645.2 ± 12.87 b  | 631.4 ± 12.00 b| 652.0 ± 9.52 b  | 702.0 ± 11.80 ab|

Note: GF, guinea fowl.

### Table 4. Interaction of species, sex and age of bird on cuts of economic importance.

| Trait                | Sex            | Growing chickens | Growing GF | Adult chickens | Adult GF |
|----------------------|----------------|------------------|------------|----------------|----------|
| Trait                | Growing GF     | Adult GF         | Adult GF   | GF            | GF       |
| Leg                  | Female         | 112.8 ± 4.97 b   | 110.1 ± 4.61 b | 1266.6 ± 45.0 a | 89.6 ± 3.64 a |
| Back (g/kg BW)       | Male           | 114.9 ± 4.48 bc  | 120.1 ± 4.18 bc | 1277.3 ± 32.9 d | 91.3 ± 4.11 a  |
| Thigh (g/kg BW)      | Female         | 135.5 ± 7.86 abcd| 118.1 ± 7.30 a | 134.2 ± 7.12 acd | 155.8 ± 5.77 d|
| Drumstick            | Male           | 128.5 ± 7.09 abc | 120.2 ± 6.62 a | 137.9 ± 5.1 bc  | 147.3 ± 6.50 d|
| Wing                 | Female         | 36.7 ± 1.38 ab   | 66.3 ± 2.96 a | 67.8 ± 2.88 a  | 50.3 ± 2.34 a  |
| Leg                  | Male           | 57.8 ± 2.87 ab   | 70.4 ± 2.68 a | 68.8 ± 2.11 a  | 54.6 ± 2.63 ab|
| Drumstick            | Female         | 56.1 ± 2.37 a    | 46.9 ± 2.20 a | 57.5 ± 2.15 d  | 40.6 ± 1.74 a  |
| Drumstick            | Male           | 57.8 ± 2.14 a    | 53.6 ± 1.99 a | 57.7 ± 1.57 ad  | 40.6 ± 1.96 a  |
| Wing                 | Female         | 44.0 ± 2.26 a    | 53.5 ± 2.10 a | 42.2 ± 2.41 a  | 51.2 ± 1.65 b  |
| Wing                 | Male           | 45.7 ± 2.03 a    | 55.4 ± 1.91 a | 41.3 ± 1.49 a  | 47.5 ± 1.86 b  |

Note: GF, guinea fowl.

### Table 5. Interaction of species, sex and age of bird on carcass remainders.

| Trait                | Sex            | Growing chickens | Growing GF | Adult chickens | Adult GF |
|----------------------|----------------|------------------|------------|----------------|----------|
| Abdominal fat        | Female         | 24.2 ± 1.01 a    | 21.0 ± 0.94 a | 29.6 ± 0.92 a  | 26.6 ± 0.74 c|
| Feet (g)             | Male           | 20.9 ± 0.91 a    | 20.4 ± 0.85 a | 23.9 ± 0.67 b  | 22.2 ± 0.84 ab|
| Neck                 | Female         | 53.7 ± 2.62 d    | 34.2 ± 2.43 b | 41.1 ± 2.37 a  | 24.0 ± 1.92 a  |
| Head                 | Male           | 58.4 ± 2.36 a    | 38.1 ± 2.20 ab | 47.6 ± 1.73 d  | 24.1 ± 2.16 a  |
| Chest                | Female         | 47.3 ± 2.52 ab   | 40.4 ± 2.33 b | 47.1 ± 2.28 ad | 33.9 ± 1.91 a  |
| Chest                | Male           | 52.8 ± 2.43 a    | 45.7 ± 2.12 bc | 50.6 ± 1.78 ad | 31.9 ± 2.08 ab|

Note: GF, guinea fowl.

For each trait, least square means, within a trait, with different superscripts differ (P < .05).
Table 6. Interaction of species, sex and age of bird on weights (g/kg BW) of internal organs.

| Trait           | Sex       | Growing chickens | Growing GF | Adult chickens | Adult GF |
|-----------------|-----------|------------------|------------|---------------|----------|
| Liver           | Female    | 29.6 ± 1.78<sup>c</sup> | 21.1 ± 1.65<sup>b</sup> | 19.6 ± 1.61<sup>b</sup> | 15.1 ± 1.34<sup>a</sup> |
|                 | Male      | 28.5 ± 1.62<sup>c</sup> | 22.8 ± 1.50<sup>b</sup> | 20.3 ± 1.23<sup>b</sup> | 14.1 ± 1.51<sup>a</sup> |
| Kidney          | Female    | 11.5 ± 0.50<sup>c</sup> | 7.8 ± 0.46<sup>b</sup>  | 7.5 ± 0.45<sup>b</sup>  | 5.9 ± 0.36<sup>a</sup>  |
|                 | Male      | 11.3 ± 0.45<sup>c</sup> | 8.0 ± 0.44<sup>b</sup>  | 7.4 ± 0.33<sup>b</sup>  | 5.4 ± 0.41<sup>a</sup>  |
| Heart           | Female    | 7.0 ± 0.54<sup>abc</sup> | 7.0 ± 0.51<sup>abc</sup> | 6.1 ± 0.49<sup>abc</sup> | 5.2 ± 0.40<sup>a</sup>  |
|                 | Male      | 7.3 ± 0.49<sup>b</sup>  | 8.4 ± 0.46<sup>b</sup>  | 5.7 ± 0.36<sup>b</sup>  | 5.8 ± 0.45<sup>b</sup>  |
| Lungs           | Female    | 11.9 ± 0.57<sup>c</sup> | 8.5 ± 0.53<sup>b</sup>  | 8.8 ± 0.52<sup>b</sup>  | 6.2 ± 0.42<sup>d</sup>  |
|                 | Male      | 11.8 ± 0.52<sup>c</sup> | 9.7 ± 0.49<sup>b</sup>  | 8.7 ± 0.38<sup>b</sup>  | 6.6 ± 0.48<sup>a</sup>  |
| Gizzard         | Female    | 68.6 ± 4.63<sup>c</sup> | 51.4 ± 4.29<sup>c</sup> | 79.1 ± 4.19<sup>c</sup> | 57.6 ± 3.39<sup>b</sup> |
|                 | Male      | 75.3 ± 4.21<sup>cd</sup> | 38.8 ± 3.89<sup>b</sup> | 80.7 ± 3.06<sup>d</sup> | 56.1 ± 2.92<sup>ab</sup>|
| Spleen          | Female    | 0.99 ± 0.137<sup>bc</sup> | 0.90 ± 0.127<sup>b</sup> | 0.94 ± 0.124<sup>b</sup> | 1.05 ± 0.100<sup>a</sup>|
|                 | Male      | 1.16 ± 0.123<sup>a</sup> | 1.00 ± 0.115<sup>a</sup> | 1.11 ± 0.090<sup>a</sup> | 0.94 ± 0.118<sup>a</sup>|

Note: GF, guinea fowl; SI, small intestine; LI, large intestine.

<sup>abc</sup>For each trait, least square means, within a trait, with different superscripts differ (P < .05).

Table 7. Interaction of species, sex and age of bird on weights (g/kg BW) and length (cm/kg BW) of intestines.

| Trait           | Sex       | Growing chickens | Growing GF | Adult chickens | Adult GF |
|-----------------|-----------|------------------|------------|---------------|----------|
| Weight of intestine | Female    | 74.5 ± 4.33<sup>a</sup> | 48.3 ± 4.13<sup>b</sup> | 46.6 ± 4.20<sup>b</sup> | 45.7 ± 3.27<sup>b</sup> |
|                  | Male      | 66.0 ± 4.10<sup>c</sup> | 47.6 ± 4.12<sup>c</sup> | 45.4 ± 3.03<sup>c</sup> | 46.2 ± 3.69<sup>d</sup> |
| Intestine length | Female    | 139.7 ± 5.96<sup>c</sup> | 112.5 ± 5.59<sup>b</sup> | 95.5 ± 5.35<sup>b</sup> | 70.2 ± 4.33<sup>a</sup> |
|                  | Male      | 147.3 ± 5.39<sup>d</sup> | 118.1 ± 4.96<sup>d</sup> | 100.0 ± 3.91<sup>d</sup> | 68.0 ± 5.28<sup>d</sup> |
| SI weight        | Female    | 112.4 ± 4.84<sup>c</sup> | 89.4 ± 4.47<sup>b</sup> | 81.3 ± 4.35<sup>b</sup> | 53.2 ± 3.51<sup>a</sup> |
|                  | Male      | 124.2 ± 4.38<sup>c</sup> | 93.7 ± 4.03<sup>c</sup> | 84.8 ± 3.18<sup>b</sup> | 52.2 ± 4.29<sup>d</sup> |
| LI weight        | Female    | 27.3 ± 1.58<sup>bc</sup> | 23.1 ± 1.46<sup>b</sup> | 14.3 ± 1.42<sup>b</sup> | 17.1 ± 1.15<sup>a</sup>|
|                  | Male      | 23.1 ± 1.43<sup>b</sup> | 24.4 ± 1.31<sup>bc</sup> | 15.2 ± 1.04<sup>a</sup> | 15.8 ± 1.40<sup>b</sup>|

Note: GF, guinea fowl; SI, small intestine; LI, large intestine.

<sup>abc</sup>For each trait, least square means, within a trait, with different superscripts differ (P < .05).

Intestinal weight and length

Intestine weight and length of the total intestines and small intestines were significantly affected by species and age while the length of large intestines was affected by age. Chickens had heavier (P < .05) intestine weight and longer total intestines and small intestines than guinea fowls and these parameters including large intestine length decreased (P < .05) with age (Table 7). Species × age interaction had a significant effect on total intestines weight. The highest total intestinal weight was obtained from growing chickens and was significantly different from growing guinea fowls. There was no significant difference between the large intestine length of growing guinea fowls, mature chickens and mature guinea fowls. Sex had no effect (P > .05) on total intestine weight and length of total intestines, small intestine and large intestines.

Discussion

There were notable differences observed between chickens and the not so exploited guinea fowls in terms of their carcass characteristics and internal organs. Guinea fowls had heavier carcasses than chickens which are supported by CAB International (1987) who reported that guinea fowls have got a small skeletal frame and their carcasses yield a large amount of meat. Body weights for guinea fowls were less than 1.4 ± 0.09 kg in guinea fowls observed by Ogah (2013) in Nigeria and lower than Fulani chickens (1.8 ± 0.40 kg), as reported by Olawunmi et al. (2008). Guinea fowls had a relatively higher dressing out percentage than other conventional sources of meat which includes chickens due to their high meat-to-bone ratio. This suggests that guinea fowls can be adopted to complement chickens as a source of meat in households.

An increase in body weight and carcass weight with age conforms to Porwal et al. (2002) and Fajemilehin (2010), who reported that the body weight of guinea fowls increased with age. Pedersen (2002) reported high body weights for mature male and female indigenous chickens in Zimbabwe. No differences in body weight observed between males and females contradict earlier findings (Musa et al. 2006; Olawunmi et al. 2008). The similarity in body weight in both sexes observed could be due to the slow growth of the species which slows down the accumulation of weight. The significant effect of species × sex and species × age × sex interactions on hot carcass and cold dressed weight could be attributed to the contribution of feathers, head, feet and internal organs to the body weight before slaughter. The weight of carcass components is influenced by weight at slaughter as conditioned by differences in climatic, managerial conditions of rearing, differences in genetic makeup as well as the statistical manipulation of the data used to obtain the estimates. The difference in weight between males and females, a phenomenon called sexual dimorphism, is particularly marked in poultry species and poses several problems (Mignon-Grasteau et al. 1999) such as vulnerability of the larger sex to starvation and sibling competition for parental resources. Such differences lead to sex-biased deaths (Drummond et al. 1991). Baeza et al. (2001) reported that sex effect on body weight is observed in almost all domesticated avian species where males are generally than Yoruba indigenous ecotypes that weighed 0.8 ± 0.21 kg and lower than Fulani chickens (1.8 ± 0.40 kg), as reported by Olawunmi et al. (2008).
heavier than females. These differences between sexes, however, vary considerably between species.

Heavier wing and breast weights in guinea fowls than in chickens observed in this study could be influenced by the guinea fowls’ body weight at slaughter and ability of carcasses to yield high meat quantities. Lower weights for the leg and drumsticks in guinea fowls than in chickens might be due to the small skeletal frame of the guinea fowls. Guinea fowls are flight birds which may mean that they need larger wings and lighter legs to enable flying. The observed proportional breast weight increased with age agrees with Kokoszyński et al. (2011b) where higher weight was observed in 16-week-old than in 13-week-old guinea fowls. The high breast weights in males than in females are similar to earlier reports on hybrids of Ross-308 and Lohmann Meat broilers (Marcu et al. 2013). In contrast, higher breast cut in females than in males have been documented in Japanese quails (Vali et al. 2005; Kossak et al. 2014). Other reports have shown no significant differences between sexes on breast percent (Aksit et al. 2003; Genciev et al. 2008). Metabolic differences and the onset of fattening differences could explain these sex differences (Musa et al. 2006). Similarly, Merkley et al. (1980) reported that females had greater breast and back but smaller legs than males. The decrease in proportional weights of wing and drumstick with increasing age is due to allometric growth in the birds. Dissimilar growth patterns are shown by different body parts and traits (Alkan et al. 2011) as their growth rates vary (Koops and Grossman 1991). Kokoszyński et al. (2011b) reported similar findings for decreasing wing proportional weights with age between 13 weeks and 15 weeks of both sexes in guinea fowls.

The neck, feet and head were heavier in chickens which may be due to the genetic makeup of the species. Chicken legs were heavier than guinea fowls and this should have influenced the feet weight. Guinea fowls are fast runners and this could explain their lighter feet than chickens. Swatland (1994) reported that there is extensive variation in poultry body proportions across breeds. The weight of the back was similar between guinea fowls and chickens. Chickens and guinea fowls are both characterized by long bodies. A decrease in neck, feet and head with maturity is attributed to the allometric growth of the birds. Similarly, Kamińska (1986) reported a decrease in the proportion of head and feet to body weight in broilers where a head content decrease was noted during the first 7 days (from 13% to 9% of body weight) and further decreased to 2.5% total body weight at 12 weeks. Feet content in 2-day-old chicks of 6% decreased to around 4% in 12-week-old birds. Murawska et al. (2005) also reported a decrease in the head content of broilers in the first 6 weeks from 6.9% to 2.3%. Back weight increased with age, as also reported by Sogunle et al. (2006), where Harco cockerels increased percentage back weight to body weight from 3 to 9 weeks. This could be as a result of isometric growth of the body part in poultry. The higher neck weight in young and mature chickens than in guinea fowls observed may be due to species and genetic differences since the body weight of guinea fowls was heavier than chickens. The weight of the back was high in mature guinea fowls, which could be because guinea fowls have a long body with females observed to have longer bodies than males by Baffour-Awuah et al. (2000).

Guinea fowls accumulated less abdominal fat than chickens in the study since they are characterized by having lean meat. CAB International (1987) stated that guinea fowl meat has a low fat content of 4% as compared to chickens, beef (21%), lamb (25%) and pork (21%), which makes it appealing to health-conscious consumers in addition to it being white meat (Nahashon et al. 2006). High weights of liver in the chickens are related to the high abdominal fat content and make animals prone to metabolic disorders such as fatty liver diseases and sudden death in all types of animals including chickens (Skirvan et al. 2000). Liver, lung and gizzard relative weights were high in chickens than in guinea fowls due to variation in species morphology and genetics. Growing birds had a lower abdominal fat weight than mature birds which is similar to Blum and Leclercq (1977) who reported that the lowest abdominal fat content is observed in the lightest guinea fowls and Murawska et al. (2011) in Ross 308 broilers. Kokoszyński et al. (2011a) noted contradicting findings in game pheasants of decreasing abdominal fat content from 18 weeks (0.2 ± 0.05%) to 20 weeks (0.1 ± 0.05%) of age. Females had higher abdominal fat than males, also reported by Baeza et al. (2001). In that study, females had a higher percentage of abdominal fat in high growth rate and low growth rate lines of 3% than males (2.2%). A similar trend was reported by Kokoszyński et al. (2011a) in game pheasants and Kokoszyński et al. (2011b) in guinea fowls. Beg et al. (2016) reported that age and sex greatly influence fat as females deposited more fat than males and older birds had more fat than younger ones.

Decreases in relative weights of the liver, heart and gizzard and a constant spleen with age agree with Kokoszyński et al. (2011a) while they disagree on the heart which remained constant. The total inner edible organ (heart, liver and gizzard) weights expressed as percentages of cold carcass weights in partridges were observed to decrease from 14 to 18 weeks of age (Yamak et al. 2016). Kasperska et al. (2012) observed that relative weights of the liver, heart and gizzard decrease with age. Janiszewska et al. (1998) found that among the internal organs which experience changes in growth at different rates, the highest age-related changes occur in the gizzard weight. The low kidney weight in guinea fowls may be influenced by the guinea fowl body weight and allometric growth of the organ relative to body weight.

Chickens had heavier intestines weights and longer lengths for intestines and small intestines than guinea fowls since these species are different in morphology. Grower birds had higher weight of intestines and longer lengths of intestines, small intestines and large intestines similar to finding in broilers (Amerah and Ravindran 2008) where small intestines relative length decreased with age and Murawska et al. (2011) in game pheasants. Mobini (2011) reported similar findings that, with an increase in age, all the indices of relative values of intestinal parameters with relation to the Ross broilers’ body weight decreased in both sexes.

**Conclusions**

The body weight and relative hot carcass and cold dressed weights for guinea fowls were heavier than chickens and these parameters showed an increasing trend with age, and
males were heavier than females. Breast and wing weights were significantly heavier in guinea fowls with leg and drumstick significantly heavier in chickens. Carcass remainders were heavier in chickens except for the back which was similar in both poultry species. Chickens had significantly higher abdominal fat, heart, liver, kidney, lung and gizzard weights than guinea fowls. More abdominal fat content in females than in males, and adults than growing birds was observed. Relative total intestinal weight and lengths of total intestines, small and large intestines were higher in chickens than in guinea fowls. Adult birds had significantly shorter relative lengths (cm/kg BW) of the total intestines, small intestine, and large intestines were higher in chickens than in guinea fowls.

This study could not fully establish the capacities in which the chickens and guinea fowls utilize the scavengeable feed resources.

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References
Aksit M, Oguz I, Akbas Y, Altan O, Ozdogan M. 2003. Genetic variation of feed traits and relationships to some meat production traits in Japanese quail (Coturnix coturnix japonica). Arch Geflugelkd. 67(2):76–82.
Alkan S, Mendes M, Karabag K, Balcioglu MS. 2011. Allometric growth of body components in 11 generations selected Japanese quails of different lines. Arch Geflugelkd. 75(1):13–19.
Amerah AM, Ravindran V. 2008. Influence of method of whole-wheat feeding on the performance, digestive tract development and carcass traits of broiler chickens. Anim Feed Sci Technol. 147:326–339.
Baeza E, Juin H, Rebours G, Constantin P, Marche G, Letenier C. 2001. Effect of genotype, sex and rearing temperature on carcass and meat quality of guinea fowl. Br Poult Sci. 42:470–476.
Baffour-Awuah O, Ampofo E, Dodoo R. 2000. Predicting the live weight of sheep by using linear body measurements. Ghana J Agric Sci. 33:207–212.
Beg MAH, Islam KS, Aftabuzzaman M, Mahbub ASM. 2016. Effects of separate sex growing on performance and metabolic disorders of broilers. Int J Anim Resour. 1(1):19–26.
Blum JC, Leclercq B. 1977. Influence de l’alimentation de l’âge et du sexe sur la composition corporelle du pintadeau. La composition corporelle des volailles. Journée INRA, Nouzilly, France. p. 17–26.
CAB International. 1987. The technical centre for agricultural and rural cooperation. Manual of poultry production in the tropics. Aberystwyth: Cambrian News.
Delany ME. 2003. Genetic diversity and conservation of poultry. In: Muir WM, Aggrey SE, editors. Poultry genetics, breeding and biotechnology. Trowbridge: CABI Publishing, CAB International; p. 257–281.
Drummond H, Osornio JL, Torres R, Chavelas C, Larios HM. 1991. Sexual size dimorphism and sibling competition: implications for avian sex ratios. Am Nat. 138:623–641.
Fajemilehin SOK. 2010. Morphostructural characteristics of three varieties of grey breastfed helmeted guinea fowl in Nigeria. Int J Morphol. 28:557–562.
Gadzirayi CT, Mutandwa E, Mupangwa JF. 2007. Veld condition trend of grazing areas: why poor livestock production in the tropics? Rangelands. 29(1):17–21.
Genchev A, Mihaylova G, Ribarsi S, Pavlov A, Kabakchiev M. 2008. Meat quality and composition in Japanese quails. Trakia J Sci. 6(4):72–82.
Golonymts M, Panopoulou E, Rogdakis E. 2003. Growth curves for body weight and major component parts, feed consumption, and mortality of male broiler chickens raised to maturity. Poult Sci. 82(7):1061–1068.
Janiszewska M, Bochno R, Lewczuk A, Brzozowski W. 1998. Changes in the weight of body, parts of carcass and tissue components in broiler and laying chickens during the growing period. Acta Acad Agric Technol Olszt. 48:103–114.
Kamińska B. 1986. Comparative studies on the dynamics of growth in chicks [PhD dissertation]. Krakow: Biul. Inf. Iz.
Kasperska D, Kokoszyński D, Korytkowska H, Mistrzak M. 2012. Effect of age and sex on digestive tract morphometry of guinea fowl (Numida meleagris L.). Folia Biol. 60(1–2):45–49.
Kokoszynski D, Bernacki Z, Cisowska A. 2011a. Growth and development of young game pheasants (Phasianus colchicus). Arch Tierz. 54:83–92.
Kokoszynski D, Bernacki Z, Korytkowska H, Wilkanowska A, Piotrowska K. 2011b. Effect of age and sex on slaughter value of guinea fowl (Numida meleagris). JCEA. 12(2):255–266.
Koops WJ, Grossman M. 1991. Application of a multiphasic growth function to body composition in pigs. J Anim Sci. 69:3265–3273.
Kossak AS, Dim NJ, Momoh OM, Gambo D. 2014. Effect of sex on carcass characteristics and correlation of body weight and blood components in Japanese quails. IOSR-JAVS. 7(1):72–76.
Laudadio V, Nahashon SN, Tufarelli V. 2012. Growth performance and carcass characteristics of guinea fowl broilers fed micronized-dehulled pea (Pisum sativum L.) as a substitute for soybean meal. Poult Sci. 91(11):2988–2996.
Marique C, Mwale M, Mupangwa JF. Chimomyo M, Foti R, Mutenje MJ. 2008. A research review of village chicken production constraints and opportunities in Zimbabwe. Asian-Australasian J Anim Sci. 21(11):1680–1688.
Marcu A, Vacaru-Opris I, Marcu A, Danaila L, Dronca D, Kelciov B. 2013. The influence of genotype and sex on carcass characteristics at broiler chickens. Lucrari Stiintifice-Seria Zootehnie. 59:17–21.
Mareko MHD, Nsoso SJ, Thibelang K. 2006. Preliminary carcass and meat characteristics of guinea fowl (Numida meleagris) raised on concrete and earth floors in Botswana. J Food Tech. 4(4):313–317.
Merkley JW, Weinland BT, Malone GW, Chaloupka GW. 1980. Evaluation of five commercial broiler crosses. Eviscerated yield and component parts. Poult Sci. 59:1755–1760.
Mignon-Graesteau S, Beaumont C, Le Bihan-Duval E, Poivey JP, De Rochembeau H, Ricard FH. 1999. Genetic parameters of growth curve parameters in male and female chickens. Br Poult Sci. 40:44–51.
Molini B. 2011. Age dependent morphometric changes of different parts of small and large intestines in the Ross broilers. JAIVS. 5(5):456–463.
Murawska D, Bochner R, Michalik D, Janiszewska M. 2005. Age-related changes in the carcass tissue composition and distribution of meat and fat with skin in carcasses of laying-type cockerels. Arch Geflugelkd. 69:135–139.
Murawska D, Klczek K, Wawro K, Michalik D. 2011. Age-related changes in the percentage content of edible and non-edible components in broiler chickens. Asian Australas J Anim Sci. 24(4):532–539.
Musa HH, Chen GH, Cheng JH, Li BC, Melki DM. 2006. Study on carcass characteristics of chicken breed raised under the intensive condition. Int J Poult Sci. 5(6):330–333.
Mwalusanya NA, Katule AM, Mutayoba SK, Minga UM, Mtambo MMA, Olsen JE. 2002. Nutrient status of crop contents of rural scavenging local chickens in Tanzania. Br Poult Sci. 43(1):64–69.
Nahashon S, Adefope N, Amenyenu A, Lema M, Wright D. 2006. Growth and carcass characteristics of French Guinea broilers fed diets with varying concentrations of metabolizable energy. J Sustain Agr. 27(4):25–32.
Nahashon S, Adefope N, Amenyenu A, Wright D. 2005. Effects of dietary metabolizable energy and crude protein concentrations on growth performance and carcass characteristics of French guinea broilers. Poult Sci. 84:337–344.
Ncobela CN, Chimonyo M. 2016. Nutritional quality and amino acid composition of diets consumed by scavenging hens and cocks across seasons. Trop Anim Health Prod. 48(4):769–777.

Obike OM, Oke UK, Azu KE. 2011. Comparison of egg production performance and egg quality traits of pearl and black strains of guinea fowl in a humid rain-forest zone of Nigeria. Int J Poul Sci. 10(7):547–551.

Ogah DM. 2013. Variability in body shape characters in an indigenous guinea fowl (Numida meleagris L.). Slovak J Anim Sci. 46(3):110–114.

Olawunmi OO, Salako AE, Afuwape AA. 2008. Morphometric differentiation and assessment of function of the Fulani and Yoruba ecotype indigenous chickens of Nigeria. Int J Morphol. 26(4):975–981.

Pedersen CV. 2002. Production of semi-scavenging chickens in Zimbabwe [PhD dissertation]. Frederiksberg: Royal Veterinary and Agricultural University.

Porwal V, Singh B, Kumar D, Sharma RK, Pandey H. 2002. Genetic studies on growth and conformation traits of guinea fowl. Indian J Poul Sci. 37:179–180.

Poulsen J, Permin A, Hindsbo O, Yeifers L, Nansen P, Bloch P. 2000. Prevalence and distribution of gastro-intestinal helminths and haemoparasites in young scavenging chickens in upper eastern region of Ghana, West Africa. Prev Vet Med. 45:237–245.

SAS. 2011. Statistical Analysis System User’s Guide Version 9.2. Cary (NC): SAS Inst. Inc.

Singh MK, Singh SK, Sharma RK, Singh B, Kumar S, Joshi SK, Kumar S, Sathapathy S. 2015. Performance and carcass characteristics of guinea fowl fed on dietary Neem (Azadirachta indica) leaf powder as a growth promoter. Iran J Vet Res. 16(1):78–82.

Skřivan M, Skřivanová V, Marounek M, Tůmová E, Wolf J. 2000. Influence of dietary fat source and copper supplementation on broiler performance, fatty acid profile of meat and depot fat, and on cholesterol content in meat. Br Poul Sci. 41:608–614.

Sogunle OM, Soyooye EM, Fanimo AO. 2006. Age-related carcass component changes in cockerels. EPC 2006-12th European Poultry Conference; Sep 10–14; Verona, Italy. World’s Poultry Science Association (WPSA).

Swatland HJ. 1994. The conversion of muscle to meat. In: Swatland HJ, editor. Structure and development of meat animals and poultry. Lancaster: Technomic Publishing; p. 495.

Tadelle D, Alemu Y, Peters KJ. 2000. Indigenous chickens in Ethiopia: genetic potential and attempts at improvement. World Poultry Sci J. 56(01):45–54.

Teye GA, Adam M. 2000. Constraints to guinea fowl production in northern Ghana: a case study of the Damongo area. Ghana J Agric Sci. 33:153–157.

Tufarelli V, Dario M, Laudadio V. 2007. Effect of xylanase supplementation and particle-size on performance of guinea fowl broilers fed wheat-based diets. Int J Poul Sci. 6:302–307.

Vali N, Edriss MA, Rahmani HR. 2005. Genetic parameters of body and some carcass traits in two quail strains. Int J Poul Sci. 4(5):296–300.

Woittiez L. 2010. Non-timber forest and rangeland products to reduce food insecurity at times of extreme climatic events. A case study of Wedza communal areas, Zimbabwe [dissertation]. Wageningen: Wageningen University.

Yamak US, Sarica M, Boz MA, Ucar A. 2016. The effect of production system (barn and free-range), slaughtering age and gender on carcass traits and meat quality of partridges (Alectoris chukar). Br Poul Sci. 57(2):185–192.

Zvinorova PI, Halimani TE, Mano RT, Ngongoni NT. 2013. Viability of smallholder dairying in Wedza, Zimbabwe. Trop Anim Health Prod. 45 (4):1007–1015.