

Growth performance, body measurements, carcass composition and some internal organ characteristics in young Pekin ducks

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Abstract

The aim of the study was to compare the bodyweight and body measurements, carcass composition, and characteristics of major visceral organs in male and female Pekin ducks. A total of 80 hybrid SM3 Heavy ducks were kept in a conventional building and fed complete commercial diets *ad libitum*. The male and female were weighed individually at one day old and their bodyweight and body measurements were determined at 21, 35 and 49 days of rearing. On day 49, 20 males and 20 females were chosen for slaughter. After slaughter, the carcasses and visceral organs were collected. No significant differences were observed between males and females in bodyweight (1 d, 58.6 vs 56.3 g to 49 d, 3518 vs 3433 g) and feed conversion ratio (FCR) (0–49 d, 2.44 vs 2.49 kg/kg gain). At 35 days old males demonstrated a significantly longer body and shanks and, at 49 days old a significantly longer body than females. The sex of ducks had no significant effect on the percentage of wings, muscles from breast and legs, skin with subcutaneous fat, abdominal fat and carcass remainder. The neck content was significantly greater in male carcasses than female ones. The contents of proventriculus, liver, and spleen in the bodies of males and females were similar. Gizzard percentage was significantly greater in males, and heart percentage was significantly greater in females. Due to their high bodyweight, good FCR, and favourable carcass composition, SM3 Heavy male ducks are more useful as broiler duck than females.

Keywords: carcasses, digestive system, growth, Pekin duck, sex

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Introduction

Because of their rapid growth rate, Pekin ducks are ideally suited to meat production. The birds are raised mainly for tasty meat; hence the main goal of breeding ducks is on improving meatiness (Kokoszynski & Bernacki, 2011; Xie *et al.*, 2014). Commercial SM3 Heavy ducks are hybrids that were born to parents that were imported from Great Britain and were approved for distribution in Poland in 2013 (Wencek *et al.*, 2014). Carcasses from the SM3 Heavy hybrid live up to consumer expectations of duck meat, owing to their good muscling, in particular the large amount of breast muscle and relatively low content of skin with subcutaneous and abdominal fat (Kokoszynski *et al.*, 2016). Pekin duck bodyweight and slaughter value were investigated by Kokoszynski & Korytkowska (2003), Bernacki *et al.* (2006; 2008), Biesiada-Drzazga *et al.* (2012), Sari *et al.* (2013) and Oh *et al.* (2015). Sari *et al.* (2013) reported that male and female Pekin ducks had the highest daily weight gains between 28 and 42 days old, though males are significantly heavier than females from six weeks of growth. Kokoszynski & Korytkowska (2003) observed the highest weight gains in Pekin males and females between 35 and 49 days of rearing. In a study by Adamski & Bernacki (2002), the bodyweight and measurements, chest circumference and shank length in male and female Pekin ducks increased most between 21 and 35 days, trunk length between 21 and 28 days, and sternum length between 28 and 35 days old. The growth and development of muscle, adipose and bone tissue could be evaluated based on the dissection results. In a study by Kokoszynski *et al.* (2016), the carcasses of 49-day-old Pekin broiler ducks of both sexes contained more breast muscle (16.9–17.7%) than leg muscle (12.7–13.6%). The development of ducks is also reflected in the weight and dimensions of their visceral organs. The structure and metric traits of the digestive system and other visceral organs of ducks, depending on genotype, age, sex, diet and season of the year, were investigated, among others, by Farhad (2009), Downing (2010), and Wasilewski *et al.* (2015). Because the growth and development traits of SM3 Heavy

hybrid ducks had never been studied in Poland, this motivated the authors to conduct this research. Since a small number of studies had determined the effect of sex on meat traits and the development of visceral organs in ducks, the present study aimed to compare bodyweight and measurements in young Pekin males and females, and to determine dressing percentage, carcass composition and major visceral organs development.

Materials and Methods

A total of 80 one-day-old sexed SM3 Heavy Pekin ducks (1 : 1 sex ratio) were used in the study. Throughout the study, the birds were kept in a conventional building in four pens with an area of 12 m², each with 10 males and 10 females and were reared for 49 days. The birds were fed complete commercial waterfowl diets *ad libitum*. Table 1 shows data on the ingredient and chemical compositions of the commercial diets fed to the ducks during the rearing period. Fresh drinking water was available throughout the study.

Table 1 Composition of the diets for male and female ducks

Ingredient (g/kg as fed)	Starter	Grower/finisher
	1-21 d	22-49 d
Maize	334.2	437.9
Ground wheat	250.0	250.0
Wheat meal	20.0	25.0
Soya bean meal (465 g CP/kg)	275.0	173.0
Sunflower meal (390 g CP/kg)	15.0	20.0
Rape seed meal (347 g CP/kg)	10.0	10.0
Corn DDGS (280 g CP/kg)	30.0	30.0
Soya oil	33.0	26.0
Limestone	12.9	9.9
Monocalcium phosphate	10.6	7.4
Sodium chloride	2.7	2.4
Sodium bicarbonate	1.0	1.4
DL-methionine	0.5	1.0
L-lysine	0.1	1.0
Vitamin-mineral premix ^A	5.0	5.0
Chemical composition of diets (g/kg as fed)		
DM	908.2	892.8
CP	206.5	176.9
Crude fat	57.4	49.6
Crude fibre	44.5	35.3
Crude ash	49.1	41.7
N-free extracts	550.7	589.3
ME (MJ)	12.9	12.2

^A1 kg of vitamin-mineral premix provided; retinol 10 000 IU, cholecalciferol 2500 IU, α -tocopherol 20.00 mg, thiamine 0.5 mg, riboflavin 5.00 mg, niacinamide 20.00 mg, pyridoxine 1.0 mg, cobalamin 0.02 mg, folic acid 0.5 mg, menadione 2.5 mg, choline chloride 200.00 mg, Fe 45.00 mg, Mn 62.5 mg, Zn 50.00 mg, Cu 5.00 mg, Se 0.25 mg, I 1.3 mg. DDGS: distiller's dried grains with solubles, DM: dry matter, CP: crude protein

From 1 to 21 days old, the males and females received a complete commercial diet containing 20.65% crude protein (CP) and 12.9 MJ metabolizable energy (ME) per kg feed. From 22 to 49 days they were fed a complete diet containing 17.69% CP and 12.2 MJ ME. The chemical composition of the diets was determined in the Department of Animal Nutrition laboratory at UTP University of Science and Technology in Bydgoszcz, Poland. The CP and energy content of the diets conformed with the Nutrient Requirements for Animals (Rutkowski, 2005). The study was approved by the Ethical Committee (Approval no 27 of 2012) in Bydgoszcz, Poland.

One-day-old ducklings were weighed individually with Precisa 5/12 electronic scales (Medicat, Zurich, Switzerland) to the nearest 0.1 g, after which they were weighed at 21, 35 and 49 days old using electronic crane scales (Jotafan, Krakow, Poland) to the nearest 1 gram. The body measurements of birds were determined at 21, 35, and 49 days old.

The birds were tape-measured with an accuracy of 1 mm for body length (between the first cervical vertebra and posterior superior tuberosity of the ischium), length of trunk (between shoulder joint and posterior superior tuberosity of the ischium), length of shank (between tarsal joint and posterior area of the fourth toe at its base), length of keel (from the anterior to the posterior edge of the keel), and chest circumference (behind wings through anterior edge of the keel and middle thoracic vertebra).

At 49 days of rearing, 20 males and 20 females (five males and five females from each pen, that is, 40 birds in total with bodyweight close to the mean weight of each sex) were selected and subjected to slaughter, defeathering and evisceration. The intestines were removed during the evisceration process. The lengths of the small intestine, caeca, and colon were tape-measured with an accuracy of 1 mm. The total length of the intestine and its parts was converted to 100 g of the pre-slaughter weight. In addition, the gizzard (without digesta), proventriculus (without digesta), liver (without gallbladder), heart, and spleen were removed and weighed, and their percentage in pre-slaughter weight was calculated. The carcasses were dissected into breast muscles, leg muscles, neck without skin, wings with skin, skin with subcutaneous fat, and abdominal fat. The remainder of the carcass was collected after dissection. It contained the skeleton and some skeletal muscles.

The numerical data were analysed statistically with the Statistica program (2002). The arithmetic mean and standard error (SE) were calculated for various traits, and significant differences between means were verified with one-way analysis of variance. The following linear model was used:

$$y_{ij} = \mu + a_i + e_{ij}$$

where: y_{ij} is the value of the analysed trait
 μ is the overall mean of the analysed trait
 a_i is the effect of i^{th} sex
 e_{ij} is the random error

Results

The average bodyweights and standard error were 58.6 ± 0.1 g for males and 56.3 ± 0.1 g for females and the weight increased with age (Table 2). The body measurements of the male and female hybrids

Table 2 Mean and standard error (SE) bodyweight and measurements in Pekin ducks

Trait	Age (days) - sex					
	21		35		49	
	Male	Female	Male	Female	Male	Female
Bodyweight (g)	830 ± 9.5	793 ± 7.8	225 ± 11.1	2216 ± 10.7	3533 ± 9.4	3432 ± 11.4
Body length (cm)	27.9 ± 0.1	27.6 ± 0.1	42.2 ^a ± 0.1	40.3 ^b ± 0.1	46.3 ^a ± 0.1	43.9 ^b ± 0.1
Trunk length (cm)	17.6 ± 0.1	16.9 ± 0.1	27.5 ± 0.1	27.0 ± 0.1	27.6 ± 0.1	27.2 ± 0.1
Chest circumference (cm)	19.9 ± 0.1	19.5 ± 0.1	30.5 ± 0.1	30.2 ± 0.1	37.0 ± 0.1	36.5 ± 0.1
Keel length (cm)	5.4 ± 0.1	5.3 ± 0.1	10.2 ± 0.1	10.0 ± 0.1	13.6 ± 0.1	13.2 ± 0.1
Shank length (cm)	6.9 ± 0.2	2.1 ± 0.1	9.2 ^a ± 0.1	8.6 ^b ± 0.1	9.3 ± 0.1	8.8 ± 0.1

^{a,b} Row means with different superscripts differ significantly at $P < 0.05$

increased up to 49 days old, which suggests that the males and females did not stop growing. Compared with females, males demonstrated significantly longer bodies (the trunk with the neck) and shanks at 35 days old, and again at 49 days. In terms of trunk length, keel length and chest circumference, non-significant differences were observed between males and females (Table 2).

The daily weight gains were higher in males than in females (Table 3). The highest daily weight gains in males and females were noted between 22 and 35 days old, and the lowest until 21 days of growth. Compared with females, males consumed less feed to 21 days old. However, they showed a poorer feed conversion ratio (FCR) per kg of the weight gain over that period. Between 22 and 35 and between 36 and 49 days old and throughout the rearing period (1–49 days old) males consumed more feed than females. Males demonstrated poorer FCR than females between 22 and 35 days old and better FCR between 36 and 49 days and throughout the rearing period (Table 3).

Table 3 Mean and standard error (SE) bodyweight gains and feed consumption and feed conversion ratio in Pekin ducks

Trait	Age (days)			
	1–21	22–35	36–49	1–49
Bodyweight gain in males (g/day)	36.7 ± 0.1	102.1 ± 0.1	91.0 ± 2.9	70.9 ± 2.9
Bodyweight gain in females (g/day)	35.1 ± 0.7	101.6 ± 1.3	86.9 ± 3.8	68.9 ± 3.8
Feed intake per male (kg)	2.07	2.82	3.57	8.46
Feed intake per female (kg)	2.09	2.79	3.53	8.41
Feed conversion ratio in males (kg/kg)	2.68	1.98	2.80	2.44
Feed conversion ratio in females (kg/kg)	2.84	1.96	2.90	2.49

According to Table 4, the average body weight of 49-day-old males selected for dissection was higher than that of females ($P > 0.05$). Dressing percentage in the males and females was high and exceeded 70%. Females showed a higher dressing percentage ($P > 0.05$) than males. The carcasses from 49-day-old males contained significantly ($P < 0.05$) more neck compared with female carcasses. The percentages of wings, breast muscles, and leg muscles were non-significantly ($P > 0.05$) higher in male carcasses than female ones. A reverse relationship was established for the proportion (%) of abdominal fat, skin with subcutaneous fat, and the carcass remainder (Table 4).

Table 4 Mean and standard error (SE) bodyweight, dressing percentage and proportion of components in carcass from 49-day-old Pekin ducks

Trait	Male	Female
Body weight before slaughter (g)	3518 ± 19.3	3433 ± 18.3
Carcass weight (g)	2465 ± 15.7	2418 ± 11.4
Dressing percentage (%)	70.1 ± 0.2	70.4 ± 0.2
Neck (%)	7.3 ^a ± 0.1	6.6 ^b ± 0.1
Wings (%)	12.6 ± 0.2	12.2 ± 0.3
Breast muscles (%)	18.0 ± 0.4	17.6 ± 0.4
Leg muscles (%)	13.5 ± 0.4	13.2 ± 0.3
Skin with subcutaneous fat (%)	24.1 ± 0.5	24.9 ± 0.7
Abdominal fat (%)	0.5 ± 2.4	0.7 ± 2.1
Remainders of carcass (%)	24.0 ± 0.5	24.8 ± 0.2

^{a,b} Row means with different superscripts differ significantly at $P < 0.05$

In terms of the length of the intestine and the digestive organs, no significant differences were found between male and female SM3 Heavy ducks (Table 5). The relative total lengths of the intestine, small intestine and caeca were greater in females than in males. However, males were characterized by a greater relative length of colon than females. The percentage of proventriculus and liver in the body of 49-day-old males was similar to that in females, with no significant differences. The gizzard percentage was significantly higher in males than in females, while the opposite was true for the heart percentage. The spleen percentage in the body of 49-day-old birds was the same in males and females (Table 5).

Table 5 Mean and standard error (SE) relative intestinal length and proportion of some visceral organs in live weight in 49-day-old Pekin ducks

Trait	Male	Female
Intestine (cm/100 g BW)		
Small	6.31 ± 0.11	6.34 ± 0.10
Caeca	1.15 ± 0.01	1.16 ± 0.01
Colon	0.35 ± 0.01	0.34 ± 0.01
Total intestine	7.81 ± 0.11	7.84 ± 0.12
Proportion in bodyweight (%)		
Gizzard	3.04 ^a ± 0.07	2.77 ^b ± 0.06
Proventriculus	0.25 ± 0.01	0.24 ± 0.01
Liver	1.56 ± 0.04	1.67 ± 0.09
Heart	0.44 ^a ± 0.01	0.49 ^b ± 0.01
Spleen	0.05 ± 0.01	0.05 ± 0.01

^{a,b} Row means with different superscripts differ significantly at $P < 0.05$
 BW: bodyweight

Discussion

As in the current experiment, Sari *et al.* (2013) and Damaziak *et al.* (2014) found the bodyweight of Pekin ducks increased with age. The average bodyweight of both males and females determined at 49 days old was high. The bodyweight of the ducks examined at 49 days old was consistent with the recorded performance results of SM3 Heavy hybrids in Poland (Wencek *et al.*, 2016). Lower bodyweights in 49-day-old male and female Pekin ducks were reported by Mazurowski *et al.* (2015). In a study by Wasilewski *et al.* (2015), 49-day-old SM3 Heavy males and females weighed 2952.2 and 2857.2 g, respectively. Similarly, as in the studies by Biesiada-Drzazga *et al.* (2012) and Sari *et al.* (2013), males were heavier than females throughout the rearing period. Unlike the current study, these two experiments reported a significant effect of the sex on the bodyweight of ducks from six weeks old. The increased difference in body weight between male and female ducks from 35 to 49 days old may be indicative of more intensive growth of the males than females at a later age. Hong *et al.* (2014) reported that the higher bodyweight gains in Pekin males than females after four weeks old, with similar feed consumption, could be because of the effect of androgenic hormones on protein metabolism and growth rate of skeletal muscles in males. The highest daily weight gains of the male and female SM3 Heavy ducks in the current experiment were noted between 22 and 35 days old, which is consistent with the results of earlier studies on Pekin ducks of both sexes (Kokoszynski & Korytkowska, 2003; Bernacki *et al.*, 2006; Kowalczyk *et al.*, 2012). In a study by Biesiada-Drzazga *et al.* (2011), the mean daily weight gains of Star 53 HY (Pekin) ducks from 1 to 49 days old were 61.3 g for males and 48.9 g for females, of which the difference in BW was lower compared with the male and female Pekin ducks evaluated in the current study in the same period. Lower daily weight gains in Pekin ducks of both sexes between 1 and 49 days old were also reported by Kokoszynski and Korytkowska (2003) and Bernacki *et al.* (2006), who maintained ducks under similar environmental and feeding conditions.

At 49 days old, the ducks showed a shorter body but longer shanks and greater chest circumference, compared with hybrid ducks of similar body weight in an experiment by Kokoszynski (2011). This may suggest that the conformation of Pekin ducks varies according to their origin and the direction of breeding in pedigree flocks. The birds demonstrated poorer FCR (feed conversion ratio), compared with broiler ducks

investigated by Erdem *et al.* (2015), and better than in an experiment reported by Bernacki *et al.* (2008) with Pekin-type hybrid ducks. Feed conversion per kg meat (total breast and leg muscles) obtained from 49-day-old SM3 Heavy ducks (after conversion) was 10.89 kg in males and 11.29 kg in females, which is much lower than reported by Kowalczyk *et al.* (2012), where Pekin ducks of both sexes (line A55) needed as much as 19.11 kg of feed per kg meat at the same age. Kokoszynski (2011) reported that feed conversion per kg meat (total breast and leg muscles) in 49-day-old Star 53 HY hybrid ducks averaged 11.19 kg in males and 11.10 kg in females. The same study observed much poorer feed conversion per kg meat in Pekin duck hybrids obtained from genetic reserve parents. In seven-week-old ducks from the same study, the mean feed conversion per kg meat was 16.88 kg in males and 19.09 kg in females.

The percentage of eviscerated carcass with neck in the pre-slaughter weight of the ducks (dressing percentage) was higher in 49-day-old Star 53 HY ducks (69.3% in males, 65.3% in females) evaluated by Biesiada-Drzazga *et al.* (2011). Kokoszynski (2011) reported the dressing percentage of 49-day-old ducks as 69.8% in males and 72.7% in females. In turn, Witak (2008) found much lower dressing percentages in male (61.7%) and female (60.9) Pekin ducks aged 49 days, compared with the birds studied in the current experiment. Murawska *et al.* (2008) observed a higher dressing percentage in heavier ducks, which is associated mainly with a lower percentage of offal components (head, feet, inedible viscera) and giblets.

Muscle tissue is the most valuable component in the carcass of all animals. The weight of muscles in the poultry carcass is essentially determined by the weight of breast muscle and leg muscle, as reported by Kokoszynski & Korytkowska (2003), Gorska *et al.* (2014) and Kokoszynski *et al.* (2015). In this study the breast muscle accounted for 15.0 to 18.0% of the weight of carcass with the neck, which is less than reported by Kokoszynski (2011), where the proportion of breast muscle in 49-day-old Pekin ducks was 19.6% in males and 19.4% in females. This may indicate that the ducks were subjected to different selection pressures in terms of the percentage of breast muscles, which are the most valuable part of the carcass.

As reported by Biesiada-Drzazga *et al.* (2011), leg muscles accounted for 9.9 (in females) to 12.1% (in males) of eviscerated carcass in 49-day-old Pekin ducks, which is less than in the birds studied in the current experiment (13.5% in males and 13.2% in females). In an experiment by Biesiada-Drzazga *et al.* (2011) and Kokoszynski *et al.* (2016), similarly to the current study, male carcasses had higher leg muscle content compared with female carcasses. In terms of the percentage of wings in the carcass, the males and females were similar to those investigated by Kowalczyk *et al.* (2012). Ducks, especially the Pekin type, are characterized by high body fat. The content of skin with subcutaneous fat in the carcasses of male and female Pekin ducks ranges from 23.7 to 28.1% on average and may exceed 30% (Kokoszynski & Bernacki, 2011; Kowalczyk *et al.* 2012; Kokoszynski *et al.*, 2015). In the current study, the proportion of skin with subcutaneous fat was at an intermediate level, i.e. 24.1 and 24.9% in males and females, respectively.

The digestive system grows at different rates in different poultry species. In seven-day-old ducks, the small intestine is 1.6 times longer than in turkey poults, which weigh almost half as much at the same age (Konarkowski, 2006). According to Wu *et al.* (2012), the relative development of the intestine is greatest during the first week of age and decreases as birds age. In Pekin ducks the morphological and functional development of the digestive tract is terminated after 7 weeks old (Watkins *et al.* 2004). In the current study, the ducks of both sexes did not differ significantly in the percentages of the length of different intestinal parts, which contradicts Downing (2010) who showed that the sex of birds has an effect on relative intestinal length (cm/100 g live weight). The proportion of different intestinal parts in the SM3 Heavy males and females evaluated in the current study is similar to that in male and female Pekin hybrid ducks investigated by Wasilewski *et al.* (2015). This was likely associated with good uniformity of the examined ducks in terms of body weight.

Like in the study by Wasilewski *et al.* (2015), the male ducks showed a greater proportion of gizzard than the females. As reported by Kokoszynski *et al.* (2017), the high proportion of gizzard in the body of birds may be indicative of good muscle growth, which has a positive impact on the particle size of digesta and nutrient absorption. The results of the current experiment support this statement. Heavier males with a greater proportion of gizzard in the body were characterized by better feed conversion (as reflected in lower FCR) compared to females. The proportion of proventriculus, liver and spleen was similar in both sexes. Meanwhile, Downing (2010) observed that the proportion of liver in the body was higher in males than in females, which disagrees with the current findings. Murawska *et al.* (2012) reported a significant effect of the age (and consequently the body weight) on the heart percentage in the body of ducks. The proportion of the heart in the body was 1% in 1-week-old ducks of both sexes and only 0.65% in birds aged 8 weeks. Bartyzel *et al.* (2005) reported on the heart percentage being lower in domestic than wild birds.

Conclusions

During the seven-week rearing period, males had greater body weight, body measurements, and the daily weight gains, compared with females. The sex of birds had a significant effect on the body length (35

and 49 days) and the length of shanks (35 days old). Male carcasses demonstrated a better muscling (a higher content of breast and leg muscles) and lower fatness (content of skin with subcutaneous fat and abdominal fat), compared with females. In the body of 49-days-old males, the proportion of gizzard was significantly higher, and that of heart – lower than in females. The relative length of the intestine and its parts (per 100 g of BW) was similar in males and females.

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Authors' Contributions

KS wrote the manuscript. DK, the doctoral student's tutor, checked the manuscript and made the corrections. DK, ZB and RW developed the methodology and performed the tests on a farm. RW and MS measured the digestive system. DK made the calculations. Finally, all the authors commented on the early and final responses of the manuscript.

Conflict of Interest Declaration

None of the authors of this work has a financial or other relationship with people or organizations that could influence inappropriately or bias the contents of this paper.

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