Factors affecting growth and body dimensions of pigs reared in alternative production

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ABSTRACT
The objective of the present study was to investigate the effect of farrowing month (FM) and sex on growth performance (GP), measured in terms of body weight (BW) and dimensions such as the girth, length and the leg heights, of purebred Berkshire pigs reared in a hoop structure. Body weights were recorded at birth and every four weeks until 20th week for all traits. Backfat thickness (BF) was measured at the shoulder, in the middle and at the back with an ultrasound prior to slaughter. Least square means of GP traits were estimated with Proc Mixed in SAS 9.3 for fixed effects such as sex, parity, FM and FM by day of age interaction. Sex did not have a significant effect on GP. Farrowing month made a difference in GP, however. Pigs farrowed in June were born the heaviest and the largest and finished the heaviest and the largest at 20th week, closely followed by pigs farrowed in October. The smallest pigs were found in those farrowed in September. Prominent trend in correlation between BW and body measurement ratios could not be found. However, pigs with taller legs and shorter length at 8th week have smaller BF, indicating leaner meat.

Introduction

With the consolidation of swine farms that resulted from the industrialization of swine production, swine farms decreased in number but increased in size (Gentry and McGlone 2003). In more recent years, such large production systems has raised concerns regarding the environment and animal welfare. Along with the development of pork niche markets for pigs raised in non-confinement production systems, concerns for environmental protection and animal welfare have caused an increased interest in alternative production systems, including the deep-bedded hoop barns. The deep-bedded indoor hoop barn system, which is a more recent development introduced to the United States in the mid-1990s, was rapidly adopted due to their low cost and versatility (Honeyman 2005). Furthermore, studies have shown that when pigs are allowed more space, their meat had superior quality and taste (Sather et al. 1997; Muriel et al. 2002). Consumer perception of pork from pigs raised in non-confinement production systems also coincides with the results of the studies. Higher preference in meat quality was found among consumers for organic animal products (Whitley et al. 2012). With the decline in concerns regarding low productivity of sows and pigs raised outdoors (Kleinbeck and McGlone 1999), the niche market developed for pork from pigs raised outdoors can provide the farmers more than double the price of pork from pigs raised in confinement systems. According to Honeyman (2005), many consumers show interest in paying more for pork with positive attributes to the environmental protection, pig welfare and structural characteristics of the pork they buy.

In general, conflicting reports are found in regard to the comparisons of indoor and outdoor pig growth performances (GPs). Gentry et al. (2004) reported that at most growth intervals postweaning, pigs reared outdoors were heavier and had a greater average daily gain (ADG). Same findings were reported by Olsson et al. (2003) and Lebret et al. (2006). Some have reported that indoor pigs had a greater ADG (Sather et al. 1997), while still others reported no significant difference in the GPs of pigs reared outdoor and indoor (Van der Wal et al. 1993). According to Whitley et al. (2012), anecdotical evidence is found that suggests some breeds of pigs perform better outdoors than others, but research in the breeds of pigs that actually excel in outdoor production facilities is limited. Limited research has been reported that involve performance tests of purebred Berkshires has already been established in Japan (Suzuki et al. 2003). The high price formation for animal products of an outdoor production system with verified superior performance is not only appropriate, but is necessary to account for its small scale.

Due to the difficulty in handling animals outdoors, few studies have been conducted that involve performance tests of purebred Berkshire pigs, especially those that involve body measurements, such as girth, length and leg heights. The amount of research on the reproductive and GP of purebred Berkshires is limited, with majority of the limited research focused on East Asia. Recent studies on farrowing performances...
of Berkshire sows have been reported in Japan by Tomiyama et al. (2008), Sasaki et al. (2014) and Usui and Koketsu (2015). A study was conducted in Iowa that reported the feed intake and growth rate of purebred Berkshire pigs housed in hoop buildings in terms of initial weight, final weight, ADG and feed-to-gain ratio (Swantek et al. 2013). However, body measurement records and factors affecting their relative growth have not been reported specifically on purebred Berkshire pigs in the United States. The objective of the present study was to investigate the effect of FM and sex on GP, measured in terms of body weight (BW) and dimensions such as the girth, length and the leg heights, of purebred Berkshire pigs reared in a hoop structure.

Materials and methods

Animals and housing

The experiments were conducted at the North Carolina Agricultural & Technical State University (NC A&T SU) farm, which is located in Greensboro, North Carolina (latitude 36° 4’ 16.63” longitude –79° 43’ 33.02”). Greensboro features a humid subtropical climate (Köppen climate classification), which has subtropical summer temperatures and mild winters, and the average annual precipitation is about 107 cm. More detailed descriptions can be found in the paper published by Whitley et al. (2012).

A total of 274 Berkshire purebred pigs from 27 sows were used for the study. After artificial insemination, the sows were kept in a deep-bedded hoop barn until the last month of pregnancy, during which the sows were moved to a pasture-based feeding system. The sows were relocated in 14 × 24 m² lots, individually, with a unit of 2 acres. A week before the expected farrowing dates, the sows were moved to a pasture-based feeding system. They were weaned at four weeks of age and were reared from nursery to finish in a separate hoop structure from the sows. Boars were not castrated. Deep beddings used in the hoop structures were generally straw, corn stalks or hay, and were spread approximately 35–45 cm thick every five to six weeks.

Data collection and adjustment

BW and other measurements, such as girth, length, and front and rear leg heights, were measured at birth and every 4 weeks until 20 weeks of age. Over a 2-year period from 2012 to 2014, 1573 BW records and 1159 of each body measurement records were generated. Due to the limited conditions of the outdoor rearing system, however, measurements were not always recorded exactly on schedule. Sow aggressiveness, severe weather conditions and so on caused advancements and postponements of scheduled measurement dates. Adjustment was necessary to conform the measurement dates between individuals.

Polynomial functions were used to estimate the measurements on days 0, 28, 56, 84, 112 and 140. Existing records for an individual were plotted by trait, and growth curves were fitted to the points using polynomial functions whose powers were determined by the number of existing observations for the respective trait. Then, the fitted growth curves were used to estimate the body measurements for those whose measurement schedules were advanced or postponed to conform the measurement age among individuals.

Backfat was measured at the 1st rib, 10th rib and the last rib of the body the same day the last body measurements were taken, using the Renco Lean-Meater ultrasound. Due to the same advancements and postponements of scheduled measurement dates issue, the average of the three BF thickness measurements was recalculated using the following formula:

$$\text{Adjusted BF} = \text{actual BF} + (\text{desired BW} - \text{actual BW}) \times (\text{actual BF} + (\text{actual BW} - 25))$$

(Almond et al. 1998)

Backfat thickness was adjusted at the desired BW of 113 kg.

Statistical analysis

Least square means of BW, girth, length, and front and rear leg heights were estimated with Proc Mixed in SAS 9.3 for fixed effects such as sex, parity, FM and FM by day of age (DOA) interaction. Other interactions were excluded from the statistical model because they were not significant. The GP records of the piglets did not exist for the months of February, March and August. For the months of January and December, the number of GP records did not exceed 100, and therefore were excluded from the analysis. The differences within fixed effects were compared using least significant differences with PDIF option in SAS 9.3.

Results and discussion

The mean parity (±SD) of the sows used in the present study was 3.48 ± 2.13 and a total of 45 farrowing occurred from year 2012 to 2014. The mean number of total born (TB), number born alive (NBA), number born dead (NBD), number of mummies (NM) and number weaned (NW) were 9.33 ± 2.47, 7.93 ± 2.52, 1.20 ± 1.31, 0.04 ± 0.21 and 6.07 ± 2.61, respectively. The average weights (±SD) at birth and at weaning were 1.95 ± 0.85 kg and 8.40 ± 2.04 kg, respectively. Sex did not have a significant effect on the GP of the piglets. Arithmetic means and standard deviations of sow reproductive performance by farrowing month are provided in Table 1. Sows farrowed in September and October had the highest numbers of piglets weaned with 7.33 ± 2.08 and 7.33 ± 2.07 piglets, respectively. Even though the sows farrowed in July had the highest total born with 10.50 ± 3.51, their number of piglets weaned was among the lowest with an average of 5.25 ± 2.05 piglets.

Table 1. Arithmetic means and standard deviations of sow reproductive performance by farrowing month.

| FM (n) | Total born | Number born alive | Number weaned |
|--------|------------|-------------------|---------------|
| April  (7) | 9.29 ± 2.63 | 8.57 ± 2.70 | 7.29 ± 2.81 |
| May    (6) | 9.00 ± 1.79 | 6.33 ± 2.07 | 5.00 ± 2.10 |
| June   (4) | 6.25 ± 2.22 | 5.50 ± 1.91 | 5.25 ± 1.71 |
| July   (8) | 10.50 ± 3.51 | 7.88 ± 2.85 | 5.25 ± 2.05 |
| September (3) | 9.67 ± 4.16 | 9.67 ± 4.16 | 7.33 ± 2.08 |
| October (6) | 10.33 ± 1.51 | 8.50 ± 2.07 | 7.33 ± 2.07 |
| November (6) | 9.33 ± 1.97 | 8.33 ± 2.25 | 5.17 ± 3.49 |

Notes: FM = Farrowing Month; n = number of observations.
For the following traits, majority of the GP records at birth were missing: girth, length, and front and rear leg height. The sows become extremely aggressive during birth and lactation, and recording the GP measurements accurately with the aggressive sow around is difficult. Therefore, GP measurements were not recorded at birth in order to protect the piglets and the people collecting the data, and any GP measurements recorded at birth were discarded due to inaccuracy.

According to the correlation coefficients between body measurement ratios and BW and their significant differences presented in Table 2, the girth to length ratio (G:L) and the BW have the highest negative correlation (−0.20) at weaning. When girth is larger than length at weaning, BW is smaller compared to when length is larger than girth. The negative correlation between G:L and BW is significant at 16th week as well. However, the correlation becomes positive and no longer significant by week 20. No noticeable trend was observed in the correlation coefficients between body measurement ratios and BW by weight class.

For the correlation coefficients and their significant differences between body measurement ratios and BF thickness, a more prominent pattern was observed (Table 3). The correlation between BF and body measurement ratios was the strongest for length to leg height ratios. At weaning and 8th week, both the length to FLH (L:F) and the length to RLH (L:R) ratios have positive correlation with BF thickness. At 8th week, the positive correlations are marked significant, with the correlation coefficient of 0.21 and 0.24 for L:F and L:R, respectively. Beginning at 12th week, the correlations become negative and continue to be negative until the 20th week, at which the negative correlations become significant. At 20th week, the correlation between L:R and BF are the strongest, with the correlation coefficient of −0.28. The coefficient of correlation between L:F and BF is −0.21 at 20th week.

The least square means and standard errors for GP traits by FM and DOA are presented in Tables 4–8. For all traits except for the leg heights, month of June had the highest records at weaning, which continued to be the case throughout the months. For leg heights, pigs farrowed in June had one of the higher records, but the tallest leg heights were found among pigs farrowed in October. By week 20, however, pigs farrowed in June had the tallest leg heights, making them the heaviest and the largest pigs.

The smallest pigs were found among pigs farrowed in September with the average BW (±SD) of 3.98 ± 1.84 kg, and girth and length measurements of 42.23 ± 1.56 cm and 45.06 ± 1.82 cm. Even though the average leg heights of pigs farrowed in September are not among the shortest at weaning, pigs farrowed in September become the smallest pigs with the shortest legs by week 20, with average FLH of 47.05 ± 1.51 cm and RLH of 50.42 ± 1.54 cm. The average leg heights for pigs farrowed in the spring months were generally shorter at weaning. However, the GP traits disclosed a general pattern by the 20th week. Pigs farrowed in June were the largest and the heaviest, closely followed by pigs farrowed in October, while pigs farrowed in September were the smallest and lightest.

Berkshires are known for their superior meat quality but inferior reproductive performance. The amount of research on

Table 2. Correlation coefficients and their significant differences between body measurement ratios and BW by weight class.

|       | G:L | G:F | GR | LF  | LR  | FR  |
|-------|-----|-----|----|-----|-----|-----|
| BW    |     |     |    |     |     |     |
| Wean  | −0.20** | −0.068 | −0.012 | 0.0290 | 0.094 | 0.127 |
| 8th   | 0.056 | −0.084 | −0.115 | −0.178* | −0.174* | −0.045 |
| 12th  | −0.029 | 0.002 | −0.011 | 0.001 | −0.010 | −0.045 |
| 16th  | −0.195* | −0.102 | −0.127 | 0.048 | 0.034 | −0.053 |
| 20th  | 0.014 | 0.135 | 0.190* | 0.127 | 0.190* | 0.098 |

Notes: aGirth; bLength; cFront leg height; dRear leg height. *p < .05; **p < .01.

Table 3. Correlation coefficients and their significant differences between body measurement ratios and backfat by weight class.

|       | G:L | G:F | GR | LF  | LR  | FR  |
|-------|-----|-----|----|-----|-----|-----|
| Backfat |     |     |    |     |     |     |
| Wean  | 0.139 | 0.190** | 0.201* | 0.081 | 0.092 | 0.020 |
| 8th   | −0.083 | 0.177 | 0.219* | 0.211* | 0.241** | 0.109 |
| 12th  | 0.170 | −0.073 | −0.075 | −0.165 | −0.179* | 0.019 |
| 16th  | 0.166 | 0.137 | 0.140 | −0.028 | −0.028 | 0.013 |
| 20th  | 0.090 | −0.155 | −0.217* | −0.205* | −0.280** | −0.118 |

Notes: aGirth; bLength; cFront leg height; dRear leg height. *p < .05; **p < .01.

Table 4. Least square means and standard errors for BW by farrowing month (FM) and days of age.

| Days of age | FM 4 | FM 5 | FM 6 | FM 9 | FM 10 | FM 11 |
|-------------|------|------|------|------|-------|-------|
| Wean        | 7.07 ± 1.19b | 8.31 ± 1.58bc | 11.48 ± 2.16ab | 4.66 ± 1.27bc | 7.46 ± 1.29bc | 9.36 ± 1.46c |
| 8th         | 13.17 ± 1.26abcd | 11.11 ± 1.57bcd | 17.86 ± 2.07ab | 11.21 ± 1.28abcd | 8.59 ± 1.84abcd | 16.77 ± 2.02abcd |
| 12th        | 22.34 ± 4.1c | 18.11 ± 1.58cd | 35.71 ± 2.03abcd | 21.85 ± 1.35c | 18.67 ± 2.04abcd | 16.67 ± 2.02abcd |
| 16th        | 34.39 ± 1.21c | 20.08 ± 1.59cd | 51.72 ± 2.01abcd | 37.18 ± 1.41bcd | 26.15 ± 2.29abcd | 40.60 ± 1.69abcd |
| 20th        | 53.07 ± 1.23c | 42.64 ± 1.59c | 74.65 ± 2.14c | 56.05 ± 1.58c | 51.71 ± 2.02c | 52.01 ± 2.61c |

Notes: a,b,c,d Least square means in the same column with different superscripts differ (p < .05).
the reproductive and GP of purebred Berkshire is limited, with majority of the limited research focused on East Asia. Tomiyama et al. (2008) reviewed the reproductive performance of the purebred Berkshire breed in the temperate climate of Japan. They reported an average TB and birth litter weight of 9.60 ± 0.26 and 11.72 ± 0.29 kg, respectively. The average birth and weaning weights were smaller than those of the present study, 1.4 ± 0.16 kg and 6.90 ± 0.18 kg, respectively. A similar study was conducted by Sasaki et al. (2014) with Berkshire gilts and sows in Japan. The mean parity (±SD) of the sows was 3.0 ± 2.14, and the mean numbers of TB, NBA and NW were 8.9 ± 2.77, 8.4 ± 2.70 and 8.0 ± 1.83, respectively. The lower mean number of piglets weaned for the present study (5.94 ± 2.74), despite the similar TB and NBA, could be the result of different rearing systems. The lactating sows were housed indoors with crates for the study conducted in Japan, whereas the present study housed the lactating sows outdoors in pasture-based units with English huts. Piglets reared indoors in a farrowing crate have a higher survivability due to the decreased crushing occurrences by the sows.

Walstra (1980) distinguished two main groups of equations that can be used to fit the actual growth data: empirical

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Table 5. Least square means and standard errors for girth by farrowing month (FM) and days of age.

| FM | Wean | 8th | 12th | 16th | 20th |
|----|------|-----|------|------|------|
| 4  | 45.91 ± 1.03b | 52.46 ± 1.07b | 63.29 ± 1.19bc | 71.62 ± 1.04bc | 81.78 ± 1.06b |
| 5  | 42.90 ± 1.36bc | 47.68 ± 1.35b | 56.38 ± 1.36b | 66.21 ± 1.37d | 79.70 ± 1.37bc |
| 6  | 48.96 ± 1.82a | 58.26 ± 1.75b | 73.18 ± 1.71b | 82.56 ± 1.70e | 94.96 ± 1.79a |
| 7  | 43.48 ± 1.08bc | 51.91 ± 1.08b | 61.94 ± 1.13cd | 73.54 ± 1.18b | 81.78 ± 1.30b |
| 9  | 42.23 ± 1.56c | 47.06 ± 1.56a | 58.49 ± 1.70bc | 67.71 ± 1.87a | 76.02 ± 1.77c |
| 10 | 47.83 ± 1.75a | 54.30 ± 1.75b | 66.14 ± 1.75b | 75.43 ± 1.75a | 79.83 ± 1.75bc |
| 11 | 47.49 ± 1.25a | 56.20 ± 1.25a | 65.57 ± 1.41bc | 74.16 ± 1.41b | 80.57 ± 2.08bc |

Notes: a, b, c, d Least square means in the same column with different superscripts differ (p < .05).

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Table 6. Least square means and standard errors for length by farrowing month (FM) and days of age.

| FM | Wean | 8th | 12th | 16th | 20th |
|----|------|-----|------|------|------|
| 4  | 45.98 ± 1.21b | 58.55 ± 1.26b | 68.94 ± 1.40bc | 77.14 ± 1.23c | 88.02 ± 1.24bc |
| 5  | 44.41 ± 1.59a | 54.42 ± 1.58cd | 62.24 ± 1.59d | 70.63 ± 1.60d | 83.51 ± 1.60ad |
| 6  | 54.08 ± 2.14a | 65.18 ± 2.06a | 79.13 ± 2.01a | 90.46 ± 1.99a | 100.19 ± 2.11a |
| 7  | 45.89 ± 1.26bc | 57.35 ± 1.26a | 65.79 ± 1.33cd | 80.76 ± 1.39b | 88.98 ± 1.53b |
| 9  | 45.06 ± 2.05b | 57.64 ± 2.05b | 71.76 ± 2.05b | 82.37 ± 2.05ab | 87.24 ± 2.05bc |
| 11 | 48.40 ± 1.47bc | 55.89 ± 1.47bc | 66.04 ± 1.66d | 79.57 ± 1.66bc | 87.89 ± 2.48bc |

Notes: a, b, c, d Least square means in the same column with different superscripts differ (p < .05).

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Table 7. Least square means and standard errors for front leg height by farrowing month (FM) and days of age.

| FM | Wean | 8th | 12th | 16th | 20th |
|----|------|-----|------|------|------|
| 4  | 28.11 ± 0.85cd | 31.10 ± 0.89b | 41.61 ± 1.00cd | 48.14 ± 0.86b | 55.64 ± 0.87a |
| 5  | 24.41 ± 1.12b | 31.24 ± 1.11b | 35.50 ± 1.12* | 41.21 ± 1.13a | 53.12 ± 1.13ab |
| 7  | 31.70 ± 0.13ab | 40.20 ± 0.14* | 48.34 ± 0.14* | 52.79 ± 0.14* | 56.44 ± 0.14* |
| 9  | 31.26 ± 1.31ab | 36.95 ± 0.91* | 42.03 ± 0.95* | 46.42 ± 0.99ab | 50.62 ± 0.93bc |
| 11 | 35.14 ± 1.44a | 36.61 ± 1.44* | 45.01 ± 1.44ab | 49.28 ± 1.44ab | 53.14 ± 1.44ab |
| 11 | 29.62 ± 1.04bc | 38.45 ± 1.04* | 38.74 ± 1.19* | 51.87 ± 1.19a | 54.25 ± 1.82ab |

Notes: a, b, c, d Least square means in the same column with different superscripts differ (p < .05).

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Table 8. Least square means and standard errors for rear leg height by farrowing month (FM) and days of age.

| FM | Wean | 8th | 12th | 16th | 20th |
|----|------|-----|------|------|------|
| 4  | 29.91 ± 0.86c | 32.84 ± 0.91bc | 43.31 ± 1.01id | 49.79 ± 0.88b | 59.07 ± 0.89a |
| 5  | 26.40 ± 1.15d | 32.00 ± 1.14* | 38.18 ± 1.15* | 44.59 ± 1.16c | 56.73 ± 1.16ab |
| 6  | 32.02 ± 1.56bc | 40.64 ± 1.50* | 50.85 ± 1.47* | 56.68 ± 1.46a | 59.70 ± 1.54a |
| 7  | 30.66 ± 0.92c | 39.80 ± 0.93* | 45.15 ± 0.97bc | 49.48 ± 1.02b | 54.82 ± 1.13bc |
| 9  | 33.76 ± 1.33b | 35.16 ± 1.33* | 43.92 ± 1.48bc | 45.26 ± 1.65bc | 50.42 ± 1.54d |
| 10 | 38.06 ± 1.47a | 41.39 ± 1.47* | 47.84 ± 1.47ab | 53.59 ± 1.47a | 57.26 ± 1.47ab |
| 11 | 31.98 ± 1.06b | 41.48 ± 1.06* | 42.27 ± 1.21id | 54.64 ± 1.21a | 54.61 ± 1.85bc |

Notes: a, b, c, d Least square means in the same column with different superscripts differ (p < .05).
equations and polynomials. The empirical equations, Logistic, von Bertalanffy, Gompertz and Richards functions, are often applied to BW data from different animals such as cattle (Brown et al. 1976), poultry (Knizetova et al. 1991) and swine (Krieter and Kalm 1989). According to Coyne et al. (2015), suitable parametric growth functions for describing and forward-predicting growth throughout an animal’s life are von Bertalanffy, Gompertz and Richards. In this study, however, polynomial functions were used to estimate BW on days that correspond to the desired weight class, such as wean, 8th, 12th, 16th and 20th (0, 28, 56, 84, 112 and 140 DOA), considering the short lifespan of the animals used. In general, animals raised in farms are harvested before they reach full maturity, and therefore, growth curve functions that illustrate the full lifespan of the animals are inappropriate. Shull (2013) reported simple polynomial or logarithmic equations to provide more accurate estimates between live weight and periodic measures of GP in pigs. Furthermore, polynomials fit very well when the appropriate number of terms is chosen (Walstra 1980). Kohn et al. (2007) also reported linear polynomials of third and fourth order of fit as the best fit for BW data in the minipig.

In the present study, body measurements were estimated on days that correspond to the desired weight class using polynomial functions the same way BW records were estimated. An issue was observed, however, when polynomial functions were used to estimate measurements of individuals whose number of observations were even. With even number of data points, the highest degree of the polynomial becomes odd, and due to the nature of the polynomial function with an odd number as the highest degree, as x approaches negative infinite, y also approaches negative infinite. In such cases, extreme dive that drops below the x-axis was observed between the first and the second data points, causing the measurement at birth to be a negative number. Therefore, birth measurements were discarded after the adjustment to minimize inaccuracy in data.

Growth as defined in zootechnical studies has two aspects: increase in body size per unit time and development (Walstra 1980). Developmental changes cannot be accurately studied without anatomical dissections, and therefore, studies on the developmental changes of the live pig’s body are scarce. Pugliese et al. (2003) reported a study on similar body measurements as those reported in the present study. Their report on live weight, chest girth, body length and height at withers (same as the FLH in the present study) displayed similar trends as the trends of the present study. The live BW displayed a growth curve that mimics a quadratic function from the initial weight to approximately 20th week of age. Pugliese et al. (2003) took it further and measured the live weight until 590 days of age, which showed that the live weight begins to level off after about 500 days, drawing an S-curve instead. Girth, length and FLH were not directly comparable due to the difference in days of age on which the measurements were taken. However, from day 110 to day 150, the body measurements in both studies seem to grow in a linear trend.

According to the correlation coefficients between body measurement ratios and BF provided in Table 3, pigs with shorter length and taller legs at 8th week have leaner backfat. If leanness of the meat can be determined earlier in the growth stage based on body measurements, the selection process for the farmers can be quickened. However, leanness of the meat earlier in growth may not be an indicator of leanness of the meat at slaughter. Further study is necessary in order to link body measurements with certain meat quality characteristics, such as the leanness.

Conclusion
The Berkshire breed, which is known to have good meat quality when raised in a confinement system, can be a good candidate for rearing outdoors, as the superior meat quality can create an added value to being raised outdoors. Study did not show a prominent trend in correlation between BW and body measurement ratios of Berkshire purebreds raised outdoors. However, pigs with shorter length and taller legs at 8th week had leaner backfat. Also, farrowing month had a significant effect on the GP of Berkshire purebreds. Further study is necessary in order to link body measurements with BW and certain meat quality characteristics, such as the leanness.

Implications
Knowing when to breed the sows for maximum productivity has always been a major concern for the farmers. The objective of the present study was to investigate environmental factors (such as the farrowing month, affecting GP, measured in terms of BW and dimensions such as the girth, length and the leg heights) of purebred Berkshire pigs reared outdoors. Through the results of the present research, the GP of piglets reared in alternative production systems, which practices animal welfare through outdoor rearing, can be improved, allowing increased profit for farmers worldwide practising an alternative production system.

Disclosure statement
No potential conflict of interest was reported by the authors.

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