~~Analyzing the~~ Phenotypic ~~Relationship~~ Correlation between Growth and Reproductive Traits in Crossbred Layer Chickens ~~Populations~~

ABSTRACT

Aims: To study the phenotypic correlation between growth and reproductive traits in layer chicken.

Place and Duration of Study: This study was carried out in Poultry Research Farm, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India, between 2019-2021.

Methodology: In this study, 450 crossbred layer chickens were selected from three distinct genetic groups: Desi Cross 1, Desi Cross 2, and Punjab Red. Data collection occurred between 2020 and 2021, focusing on several economically important traits. These included body weight at sexual maturity (BWSM; g), age at sexual maturity (ASM; days), weight of the first egg (FEW; g), egg production at the 40^{th} weeks and 52^{nd} weeks (EP; number) and egg weight at the 40^{th} weeks and 52^{nd} weeks (EW; g). Additionally, weekly body weights were recorded from day 0^{th} to the 20^{th} and 40^{th} weeks (BW; g).

Results: The highest coefficient of variation (CV; %) for body weight was observed at the 4th week, while the lowest CV was recorded at the 0th week. Among reproductive traits, the average age at sexual maturity (ASM) was 165.61 ± 0.81 days, with a CV of 14.05%. The egg production at the 40th and 52nd weeks displayed the greatest variability, whereas egg weight at these weeks showed relatively low variation. The first egg weight exhibited moderate variability, with a CV of 13.29%. Meanwhile, the body weight at sexual maturity had a CV of 19.97%, reflecting a moderate level of variation for this trait. The phenotypic correlations among these traits were estimated using the WOMBAT software. The analysis revealed highly significant phenotypic correlations between body weight at 1^{st} week and egg production at 40^{th} week, as well as first egg weight. Similarly, significant correlations were observed between body weight at 2^{nd} weeks and egg weight at 40^{th} weeks, body weight at 3^{rd} weeks and first egg weight, body weight at 10^{th} weeks and egg production at 52^{nd} weeks, and body weight at 14^{th} weeks and ~~body weight~~ egg weight at 40^{th} weeks.

.**Conclusion:** ~~Therefore~~, Overall, the present study suggests that while body weight traits demonstrate relative consistency in growth patterns, reproductive traits, particularly egg production, show greater variability and thus offer more opportunities for genetic improvement. Selective breeding efforts should be focused on reducing variability in key traits such as EP40 and EP52 to enhance overall productivity in layer chickens. Moreover, this study highlights the significant phenotypic relationships between growth and reproductive traits in layer chicken populations.

Keywords: *Crossbred layer chickens, Body weight, Egg production, Phenotypic correlation, WOMBAT software*

1. INTRODUCTION

The poultry industry in India has become the most dynamic and fastest-growing sector of the livestock economy. Over the past five decades in India, poultry farming has transformed from a subsistence activity into a highly integrated and commercially driven enterprise. This growth has been marked not only by an increase in scale but also by advancements in productivity, technology, and quality [7]. India ranks as the third-largest producer of eggs and the sixth-largest producer of poultry meat globally, with an annual production of 138.38 billion eggs and 9.77 million tons of meat [1]. The primary driving force behind the current revolution in poultry development has been the effective application of quantitative genetics in poultry breeding techniques [3]. Accurate estimates of phenotypic correlations between various traits are essential for evaluating genetic progress in economically important traits and for designing future breeding strategies to enhance them. Therefore, ~~the aim of this study was~~ this study aimed to assess the ~~genetic parameters, specifically~~ phenotypic correlations, associated with growth and reproductive traits in three genetic groups of crossbred layer chickens in Punjab. These correlations hold significant importance for breeders.

2. MATERIAL AND METHODS

2.1 Experimental Animals and Management

Parents from three distinct genetic varieties of chickens viz., Punjab Red, Desi Cross 1, and Desi Cross 2 were selected for this study. A total of 600-day-old female chicks were hatched from these genetic groups' parents. Mating was performed through artificial insemination using the semen from selected males. All birds were raised under the same management practices and according to established standards. Ultimately, 150 birds from each genetic group were chosen for analysis, and data collection continued up to 52^{nd} weeks of age. The pedigree chicks were hatched at the university's hatchery unit starting in the winter of 2020 for this investigation. The sexing of the chicks was performed using the vent method, and day-old chicks were banded on their wings for identification. All birds in the study were provided with similar feeding, environmental, and management conditions. Various traits were measured using an electronic weighing scale. The Punjab Red variety was previously established and maintained at the poultry research farm, while Desi Cross 1 and Desi Cross 2 were created by crossing Rhode Island Red with local desi birds and Punjab Red with local desi birds from Punjab, respectively.

2.2 Data Description

The present study was conducted from 2020 to 2021 at the Poultry Research Farm of the Directorate of Livestock Farms at Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. Data were collected from 450 egg-laying birds across three genetic groups: Punjab Red, Desi Cross 1, and Desi Cross 2, with each group comprising 150 birds. To evaluate the reproductive and growth traits of the birds, the following characteristics were selected and recorded: weekly body weight from day 0^{th} to the 20^{th} weeks and at the 40^{th} weeks (BW; g), body weight at sexual maturity (BWSM; g), age at sexual maturity (ASM; days), weight of the first egg (FEW; g), egg production up to 40^{th} weeks of age (EN; no.), egg weight at 40^{th} weeks (EW; g), egg production up to 52^{nd} weeks of age (EN; no.), and egg weight at 52^{nd} weeks (EW; g).

2.3 Statistical Analysis

Descriptive statistics for the growth and reproductive traits were performed using all available records in the SPSS software, version 24 [9]. For the genetic evaluation of economic traits, only data from hens that survived up to 52nd weeks of age were included. The phenotypic correlations among the various economic traits were estimated by using WOMBAT software and it is calculated as follows:

$$r_{g_{xy}} = \frac{\mathrm{Cov}_{s_{xy}} + \mathrm{Cov}_{e_{xy}}}{\sqrt{[\sigma^2_{s_x} \times \sigma^2_{e_x}] + [\sigma^2_{s_y} \times \sigma^2_{e_y}]}}$$

where, $\mathbf{Cov_{s(x,y)}}$ represents the sire component of phenotypic covariance between traits x and y; $\mathbf{Cov_{e(x,y)}}$ denotes the error component of phenotypic covariance between traits x and y; $\boldsymbol{\sigma^2 e_x}$ is the error component of variance for trait; $\boldsymbol{\sigma^2 e_y}$ is the error component of variance for trait y; $\boldsymbol{\sigma^2 s_x}$ is the sire component of variance for trait x; $\boldsymbol{\sigma^2 s_y}$ is the sire component of variance for trait y; The formula proposed by [6] was utilized to calculate the standard error of the phenotypic correlation.

$$\text{S.E.} = \frac{1 - r^2 \text{p(x,y)}}{\sqrt{N-2}}$$

where, $\mathbf{r^2_{p(x,y)}}$ denotes the phenotypic correlation between traits x and y, while **(N-2)** represents the degrees of freedom. To assess the level of significance, the tabulated value was compared with the phenotypic correlation at **(N-2)** degrees of freedom, as provided by [8].

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The descriptive statistics for various growth and reproductive traits in layer chickens, including the means, standard errors (S.E.), standard deviations and coefficients of variation (CV; %), are presented in Table 1. BW 0th week to 40th weeks demonstrated a general trend of increasing mean values with age. The BW0 averaged 37.11 ± 0.14 g, progressively increasing to 1653.76 ± 13.32 g by 40th weeks of age. The highest CV for body weight was observed at 4th weeks (30.38%), while the lowest was recorded at BW 0th week (11.26%).

For reproductive traits, ASM had a mean of 165.61 ± 0.81 days, with a CV of 14.05%. The EP 40th weeks and 52nd weeks exhibited the highest variability, with CV of 39.55% and 42.94%, respectively. Conversely, EW 40th weeks and 52nd weeks showed relatively low variability, with CV of 8.17% and 10.68%, respectively.

The variability in FEW was moderate, with a CV of 13.29%. The BWSM had a CV of 19.97%, indicating some degree of variation in this trait.

The results from Table 1 reveal several important trends in growth and reproductive traits in layer chickens. The body weight data exhibited a consistent growth pattern from hatch to 40 weeks, with the CV for body weight traits stabilizing as the birds matured. The relatively low CV at hatch suggests uniformity in early-stage development, which can be attributed to the controlled environmental and genetic factors affecting the flock. However, the increasing variability in body weight up to 4th week could be linked to variations in the birds' ability to utilize feed and adapt to the environment during this critical growth phase. After this period, the CVs gradually declined, indicating more uniform growth as the birds approached sexual maturity.

Egg production traits, particularly at 40 and 52 weeks, exhibited the highest variability, with CV of 39.55% and 42.94%, respectively. This significant variation highlights the potential for improvement through selective breeding. Since egg production is a key economic trait, the high variability underscores the importance of EP40 and EP52 as selection parameters for enhancing productivity. The relatively high standard deviations further support the conclusion that there is considerable scope for optimizing egg production traits through genetic and environmental management. In contrast, EW exhibited much lower variability, especially at 40 weeks (CV of 8.17%). This consistency in egg weight suggests that the trait is more stable and less influenced by environmental factors, making it a reliable trait for selection. A low CV in egg weight indicates that breeders have achieved a good level of uniformity in this trait, likely due to the strong genetic control of egg size in the population. The ASM had a moderate CV (14.05%), indicating some degree of variability in the onset of reproductive maturity. This trait is important for optimizing the reproductive efficiency of layer chickens, as earlier maturation can lead to a longer productive lifespan. The variability observed here suggests that there is scope for further improvement through breeding programs aimed at reducing the ASM.

3.2 Phenotypic Correlation

Tables 2a, 2b and 2c display the phenotypic correlations among various growth and reproductive traits in layer chickens. The phenotypic correlation of body weight at 0th week was found to be positive and significant with BW at 3rd weeks, ASM, 52nd weeks egg production and egg weight, while it showed a negative correlation with 40th weeks and 52nd weeks egg production. According to [2], body weight at 0th week exhibited a positive association with body weights at 2nd and 6th weeks but had only a weak positive phenotypic correlation with body weights at 8th, 12th and 16th weeks, as well as egg production. Additionally, body weight at 1st week demonstrated a positive correlation with most economic traits, except for ASM, and showed a highly significant correlation with 40th week and 52nd weeks egg production, along with FEW. The study by [12] found a very weak association between body weight and measurements taken at 8th weeks, 12th weeks, and the age at the first egg. However, body weight at 2nd weeks showed a positive phenotypic correlation with most traits, while having a negative association with egg weight at 40th weeks and age at sexual maturity. Despite this, body weight at 2nd week displayed a highly significant correlation with 40th week egg weight and a significant correlation with both FEW and 52nd week egg weight. Similarly, [2] reported a positive association between body weight at 2nd week and body weight at 6th, 8th, 12th, and 16th weeks, though only a weak phenotypic correlation with egg production. In the present study, a positive phenotypic correlation was observed between body weight at 3rd weeks and body weight from 4th weeks to 20th and 40th weeks, as well as a positive association with BWSM, EP40, EP52, EW52, and FEW, with a highly significant correlation found with FEW. However, a negative relationship was observed ~~with~~ between age at sexual maturity and 40th weeks of body weight. Body weight at 4th and 5th weeks showed similar patterns, with 4th weeks body weight positively correlated with BW5 to BW20, BW40, BWSM, EP40, EP52, EW40, EW52, and FEW. Additionally, 5th weeks body weight had positive associations with BW6 to BW20, BW40, BWSM, EP40, EP52, EW40, EW52, and FEW. Both 4th and 5th weeks body weights showed a negative correlation with ASM and were highly significant with FEW. Furthermore, body weight at 6th week showed a positive phenotypic correlation with all other economic traits except ASM. It also showed significant associations with 40th week egg weight and FEW. According to [2], body weight at 6th weeks was positively correlated with body weights at 8th, 12th, and 16th weeks, though it exhibited a weak correlation with egg production. Body weight at 7th weeks exhibited positive phenotypic correlations with BW8 to BW20, BW40, BWSM, EP40, EP52, EW40, EW52 and FEW, while showing a negative correlation with age at sexual maturity. Similarly, body weight at 8th weeks was positively associated with BW9 to BW20, BW40, BWSM, EP40, EP52, EW40, EW52, and FEW, but negatively related to age at sexual maturity. Body weight at 9th weeks demonstrated positive phenotypic correlations with all traits, except for age at sexual maturity, and all were significantly correlated with FEW. The body weight at 8th weeks was positively correlated with body weights at 12th and 16th weeks, though it showed a weak association with egg production [2]. The body weight at 8th weeks was positively correlated with body weight at 12th weeks but exhibited low correlations with FEW and ASM [12]. In the present study, body weights between 10th and 20th weeks showed negative phenotypic correlations with age at sexual maturity. Furthermore, body weight at 10th and 14th weeks showed highly significant correlations with EP52 and EW40, respectively. Body weights at 11th, 12th, 13th, 16th, and 18th weeks were significantly correlated with egg weight at 40th weeks, while body weights at 5th, 12th and 15th weeks showed significant correlations with first egg weight. A strong phenotypic association between body weights at 12th and 16th weeks [2]. Body weight at 40th weeks was positively correlated with ASM, BWSM, EW40, and EW52, but negatively associated with first egg weight, egg production at 40th weeks, and egg weight at 52nd weeks. The correlation between body weight at 40th weeks and FEW, EP52, ASM, and EP40 was significant. Additionally, EP40 and EP52, as well as EW40, EW52, and BWSM, were negatively correlated with ASM, while showing a positive correlation with FEW. Significant associations were found with EW52, FEW and BWSM. However, contrary findings were reported by [5], who found that ASM was positively associated with both EP52 and EP40. The phenotypic relationship between 40th weeks egg production and both EP52 and EW52 was positive, while the correlation between 40th weeks egg weight and first egg weight were negative; however, the results indicated a significant association with 40th weeks egg weight. Both [10] and [5] reported similar findings, showing a substantial positive correlation with 52nd weeks egg production. Egg weights at 40^{th} and 52^{nd} weeks were positively correlated with EP52, but FEW was negatively correlated. The phenotypic correlation between EW40 and EW52 was significant and positive, while negatively associated with FEW. Additionally, the correlation between EW52 and FEW was both significant and positive. The EW40 had a low positive correlation with FEW, while [11] demonstrated that EW52 was positively associated with first egg weight [4]. EW40 was significantly correlated with BWSM, which was positively associated with EW40, EW52, FEW and EP40.

4. CONCLUSION

Overall, the present study suggests that while body weight traits demonstrate relative consistency in growth patterns, reproductive traits, particularly egg production, show greater variability and thus offer more opportunities for genetic improvement. Selective breeding efforts should be focused on reducing variability in key traits such as EP40 and EP52 to enhance overall productivity in layer chickens. Moreover, this study highlights the significant phenotypic relationships between growth and reproductive traits in layer chicken populations. By analyzing various traits, including body weight, age at sexual maturity, egg production, and egg weight, we identified key correlations that can inform breeding strategies aimed at improving productivity and efficiency within poultry farming. The BW at the 1^{st} week demonstrated a significant correlation with other economic traits. Notably, the correlation between BW from the 1^{st} to the 20^{th} week and ASM was negative, while positive correlations were observed with all other traits. There was a positive correlation between BW at the 40^{th} week and ASM, although egg production at both the 40^{th} and 52^{nd} weeks was relatively low. Highly significant phenotypic correlations were found between BW at the 1^{st} week and egg production at the 40^{th} week and FEW; BW at the 2nd week and EW at the 40th week; BW at the 3rd week and FEW; BW at the 10th week and egg production at the 52nd week; and BW at the 14th week and EW at the 40th week. ~~Therefore,~~ Understanding these relationships not only contributes to the advancement of poultry genetics but also supports sustainable practices in the poultry industry, ultimately benefiting both producers and consumers.

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Table 1. Descriptive statistics of growth and reproductive traits in layer chicken

Traits	Mean±S.E.	Standard Deviation	CV (%)
BW0	37.11±0.14	4.18	11.26
BW1	61.18±0.38	11.08	18.11
BW2	101.94±0.81	23.25	22.08

BW3	145.60±1.40	39.90	27.40
BW4	187.36±1.99	56.92	30.38
BW5	245.68±2.50	71.48	29.09
BW6	316.37±3.20	91.24	28.83
BW7	413.74±4.19	119.39	28.85
BW8	507.83±4.92	140.46	27.65
BW9	615.34±5.58	159.12	25.85
BW10	746.28±6.47	184.48	24.71
BW11	817.69±7.32	208.66	25.51
BW12	905.07±7.71	219.87	24.29
BW13	933.84±7.68	219.02	23.45
BW14	1049.60±8.56	244.04	23.25

BW15	1150.94±9.18	261.59	22.72
BW16	1210.62±10.13	288.74	23.85
BW17	1290.00±10.38	295.97	22.94
BW18	1369.60±10.83	308.75	22.54
BW19	1447.97±11.37	324.03	22.37
BW20	1546.97±12.51	356.63	23.05
BW40	1653.76±13.32	353.00	21.34
FEW	42.79±0.19	5.69	13.29
BWSM	1604.38±11.27	320.52	19.97
EW40	53.11±0.16	4.34	8.17
EP40	53.72±0.74	21.25	39.55
EP52	85.45±1.28	36.70	42.94

EW52	56.73±0.26	6.06	10.68
ASM	165.61±0.81	23.28	14.05

Table 2(a): Phenotypic correlation with standard error between growth and reproductive traits in Layer Chicken

	BW0	**BW1**	**BW2**	**BW3**	**BW4**	**BW5**	**BW6**	**BW7**	**BW8**	**BW9**	**BW10**	**BW11**	**BW12**	**BW13**
BW0	**1**	0.127±0.04	0.086±0.04	0.018±0.04	0.117±0.04	0.132±0.04	0.108±0.04	0.138±0.04	0.083±0.04	0.101±0.04	0.085±0.04	0.123±0.04	0.09±0.04	0.106±0.04
BW1		**1**	0.665±0.02	0.494±0.03	0.583±0.02	0.5±0.03	0.497±0.03	0.474±0.03	0.432±0.03	0.46±0.03	0.44±0.03	0.431±0.03	0.442±0.03	0.422±0.03
BW2			**1**	0.637±0.02	0.751±0.01	0.682±0.02	0.631±0.02	0.591±0.02	0.56±0.02	0.547±0.02	0.529±0.03	0.557±0.02	0.548±0.02	0.523±0.03
BW3				**1**	0.713±0.02	0.638±0.02	0.585±0.02	0.557±0.02	0.521±0.03	0.508±0.03	0.492±0.03	0.491±0.03	0.5±0.03	0.484±0.03
BW4					**1**	0.834±0.01	0.77±0.01	0.717±0.02	0.693±0.02	0.664±0.02	0.665±0.02	0.656±0.02	0.665±0.02	0.62±0.02
BW5						**1**	0.836±0.01	0.775±0.01	0.75±0.01	0.735±0.01	0.725±0.02	0.703±0.02	0.704±0.02	0.673±0.02
BW6							**1**	0.87±0.01	0.837±0.01	0.789±0.01	0.79±0.01	0.777±0.01	0.769±0.01	0.737±0.01
BW7								**1**	0.837±0.01	0.811±0.01	0.806±0.01	0.803±0.01	0.806±0.01	0.781±0.01
BW8									**1**	0.82±0.01	0.83±0.01	0.805±0.01	0.8±0.01	0.754±0.01
BW9										**1**	0.826±0.01	0.792±0.01	0.81±0.01	0.802±0.01
BW10											**1**	0.853±0.01	0.851±0.01	0.844±0.01
BW11												**1**	0.894±0.008	0.878±0.009
BW12													**1**	0.909±0.007
BW13														**1**

* P≤0.05; ** P≤0.01

Table 2(b): Phenotypic correlation with standard error between growth and reproductive traits in layer chicken

	BW14	BW15	BW16	BW17	BW18	BW19	BW20	BW40	ASM	BWSM	EP40	EP52	EW40	EW52	FEW
BW0	0.086±0.04	0.094±0.04	0.077±0.04	0.071±0.04	0.085±0.04	0.078±0.04	0.077±0.04	0.099±0.04	0.031±0.04	0.149±0.04	-0.051±0.04	-0.023±0.04	0.09±0.04	0.017±0.04	0.03±0.04
BW1	0.388±0.03	0.423±0.03	0.394±0.03	0.389±0.03	0.365±0.03	0.355±0.03	0.357±0.03	0.105±0.04	-0.08±0.04	0.353±0.04	0.008±0.04	0.004±0.04	0.017±0.04	0.068±0.04	0.008±0.04
BW2	0.511±0.03	0.516±0.03	0.508±0.03	0.494±0.03	0.474±0.03	0.469±0.03	0.469±0.03	0.078±0.04	-0.167±0.04	0.41±0.03	0.086±0.04	0.079±0.04	-0.003±0.04	0.039±0.04	-0.041±0.04
BW3	0.461±0.03	0.431±0.03	0.444±0.03	0.443±0.03	0.41±0.03	0.421±0.03	0.422±0.03	0.067±0.04	-0.137±0.04	0.401±0.03	0.072±0.04	0.065±0.04	-0.051±0.04	0.061±0.04	0.001±0.04
BW4	0.595±0.02	0.617±0.02	0.571±0.02	0.559±0.02	0.532±0.03	0.533±0.03	0.536±0.03	0.099±0.04	-0.183±0.04	0.488±0.04	0.088±0.04	0.092±0.04	0.036±0.04	0.079±0.04	0.013±0.04
BW5	0.653±0.02	0.653±0.02	0.69±0.02	0.605±0.02	0.575±0.02	0.554±0.02	0.556±0.02	0.103±0.02	-0.221±0.04	0.476±0.04	0.101±0.03	0.095±0.04	0.033±0.04	0.064±0.04	0.03±0.04
BW6	0.708±0.02	0.713±0.02	0.68±0.02	0.669±0.02	0.636±0.02	0.59±0.02	0.592±0.02	0.102±0.04	-0.267±0.03	0.493±0.03	0.158±0.04	0.145±0.04	0.026±0.04	0.078±0.04	0.025±0.04
BW7	0.733±0.019	0.725±0.02	0.708±0.02	0.694±0.02	0.65±0.02	0.608±0.02	0.61±0.02	0.115±0.04	-0.268±0.03	0.514±0.03	0.153±0.04	0.134±0.04	0.019±0.04	0.066±0.04	0.034±0.04
BW8	0.755±0.01	0.745±0.01	0.724±0.02	0.704±0.02	0.66±0.02	0.617±0.02	0.619±0.02	0.12±0.02	-0.271±0.04	0.52±0.03	0.163±0.03	0.153±0.04	0.057±0.04	0.078±0.04	0.046±0.04
BW9	0.757±0.01	0.757±0.01	0.719±0.02	0.707±0.02	0.666±0.02	0.615±0.02	0.617±0.02	0.137±0.04	-0.245±0.03	0.171±0.04	0.146±0.04	0.101±0.04	-0.002±0.04	0.08±0.04	0.024±0.04
BW10	0.801±0.01	0.818±0.01	0.762±0.01	0.747±0.01	0.713±0.02	0.688±0.02	0.691±0.02	0.116±0.04	-0.251±0.03	0.6±0.02	0.154±0.04	0.001±0.04	0.027±0.04	0.085±0.04	0.077±0.04
BW11	0.858±0.01	0.805±0.01	0.807±0.01	0.792±0.01	0.756±0.01	0.705±0.02	0.708±0.02	0.131±0.04	-0.258±0.03	0.608±0.02	0.156±0.04	0.142±0.04	0.021±0.04	0.077±0.04	0.041±0.04
BW12	0.851±0.01	0.849±0.01	0.812±0.01	0.81±0.01	0.764±0.01	0.717±0.02	0.72±0.02	0.131±0.02	-0.268±0.03	0.625±0.02	0.159±0.04	0.134±0.04	0.018±0.04	0.084±0.04	0.039±0.04
BW13	0.901±0.007	0.881±0.009	0.849±0.01	0.853±0.01	0.871±0.01	0.757±0.01	0.76±0.01	0.137±0.04	-0.272±0.03	0.663±0.02	0.19±0.04	0.156±0.04	0.025±0.04	0.078±0.04	0.057±0.04

* P≤0.05; ** P≤0.01

Table 2(c): Phenotypic correlation with standard error between growth and reproductive traits in layer chicken

	BW14	BW15	BW16	BW17	BW18	BW19	BW20	BW40	ASM	BWSM	EP40	EP52	EW40	EW52	FEW
BW14	**1**	0.882±0.009	0.886±0.009	0.883±0.009	0.844±0.01	0.778±0.01	0.78±0.01	0.13±0.04	-0.267±0.03	0.669±0.02	0.197±0.04	0.171±0.04	0.002±0.04	0.125±0.04	0.063±0.04

BW15		**1**	0.882±0.009	0.882±0.009	0.864±0.01	0.793±0.01	0.796±0.01	0.119±0.04	-0.273±0.03	0.681±0.02	0.182±0.04	0.144±0.04	0.053±0.04	0.106±0.04	0.026±0.04
BW16			**1**	0.939±0.005	0.883±0.009	0.797±0.01	0.799±0.01	0.114±0.04	-0.29±0.03	0.676±0.02	0.205±0.04	0.179±0.04	0.032±0.04	0.105±0.04	0.06±0.04
BW17				**1**	0.916±0.006	0.808±0.01	0.811±0.01	0.118±0.04	-0.292±0.03	0.693±0.02	0.189±0.04	0.165±0.04	0.812±0.01	0.1±0.04	0.065±0.04
BW18					**1**	0.869±0.01	0.871±0.01	0.105±0.04	-0.311±0.03	0.734±0.01	0.217±0.04	0.189±0.04	0.032±0.04	0.095±0.04	0.041±0.04
BW19						**1**	0.085±0	0.086±0.04	-0.341±0.03	0.817±0.01	0.222±0.04	0.2±0.04	0.052±0.04	0.111±0.04	0.068±0.04
BW20							**1**	0.085±0.04	-0.338±0.03	0.82±0.01	0.221±0.04	0.199±0.04	0.053±0.04	0.114±0.04	0.07±0.04
BW40								**1**	0.046±0.04	0.146±0.04	-0.024±0.04	-0.021±0.04	0.064±0.04	0.074±0.04	-0.045±0.04
ASM									**1**	-0.013±0.04	-0.479±0.03	-0.431±0.03	-0.058±0.04	-0.012±0.04	0.044±0.04
BWSM										**1**	0.104±0.04	0.087±0.04	0.01±0.04	0.112±0.04	0.14±0.04
EP40											**1**	0.933±0.005	-0.016±0.04	0.007±0.04	-0.046±0.04
EP52												**1**	0.012±0.04	0.007±0.04	-0.051±0.04
EW40													**1**	0.047±0.04	-0.05±0.04
EW52														**1**	0.004±0.04
FEW															**1**

* P≤0.05; ** P≤0.01