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# Genetic variability in ultrasound records of breast muscle in a broiler breeding program

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## ABSTRACT

**Breast weight is one of the most economically important traits in the poultry industry, but direct selection for weight is expensive. The use of ultrasonography enables *in vivo* measurements of the broiler's breast muscle size, which may be much more feasible for broiler selection. Previous studies of broilers concluded that ultrasound of the breast muscle is feasible and favorable for meat production. According to previously obtained genetic parameters, breast weight could be efficiently improved by ultrasound of the breast muscle. The use of ultrasonography for the indirect selection of breast weight does not affect the body composition or meat quality of broilers, despite the meat's paleness and shear force; therefore, the use of ultrasound as a selection criterion might be a useful monitoring tool. Studies on the utilization of ultrasound in broiler breeding programs allow a better understanding of the relationship between traits of economic interest and the establishment of the selection schemes.**

**Keywords:** Genetic Parameters; Meat; Poultry; Selection

## 1. INTRODUCTION

In the last few decades, the Brazilian broiler production industry has made great progress, which is mainly due to the selection of specific traits of commercial interest. These gains resulted primarily from the intense selection process employed since the first usage of breed crosses in broilers and, more recently, from the use of advanced technologies to collect the data used for this selection process.

Ultrasonography is an important technology used by the poultry breeding industry to obtain depth and width data for broiler breasts. Breast weight is one of the most economically important traits in the poultry industry, but its selection requires a sib test and slaughter of the broilers, which is expensive [1]. The use of ultrasonography enables *in vivo* measurements of the broiler's breast muscle size, which may be a much more feasible approach for broiler selection.

In broilers, individual selection is usually performed in juveniles [2] and is called pre-selection. This selection can be used for traits that have been previously identified as being favorably associated with breast weight (e.g., ultrasound records of breast muscle) and may facilitate the early removal of poor quality broilers. These associations may be evaluated by phenotypic and genetic correlations [3,4].

Estimating the genetic parameters (heritability and genetic correlation coefficients) of traits of economic interest is the first step in the development of the strategies used in animal breeding programs because investigating these parameters allows for evaluation of the response to trait selection and understanding of the genetic associations between different traits of interest.

Previous studies estimated the genetic parameters of performance traits in a male broiler line to specify the impact of ultrasound usage in the broiler breeding program [5-8]. Current approaches enable us to better appreciate the efficiency of the breast muscle ultrasound as a selection criterion in addition to genetic relationships with body composition and meat quality traits.

## 2. ULTRASOUND RECORD AND ADDITIONAL DATA ORIGIN

Sibs from an elite flock that underwent selection for the development of a broiler male line were investigated using different approaches [5-8] and selected to emphasize performance and carcass traits. Pedigree chicks were wing-banded at hatching and housed and raised as rec-

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ommended by the company guidelines for nutritional planning, management conditions and vaccination. On the breeder unit, the broilers' breast muscle was assessed using ultrasound from the longitudinal and transverse directions (US1 and US2, respectively) in millimeters. US1 was gauged along the keel, and US2 was gauged over the coracoid bone. Data collection was performed at 35 d of age from Nov. 1999 to Jan. 2001 [5], at 38 d of age from Nov. 2002 to Jun. 2003 [6], and at 30 d of age from May. 2005 to Mar. 2006 [7,8]. Previous studies considered the average of the breast muscle depth in the longitudinal and transverse directions (US) in the ultrasound record [7,8]. The other considered traits were: breast weight, boneless and without skin; abdominal fat content, corresponding to abdominal fat pad weight plus gizzard fat weight; initial meat pH, corresponding to the internal meat pH measured inserting the electrode into the pectoral muscle, at 15 min after slaughtering; lightness, measured at 24 h after slaughtering using a portable colorimeter; drip loss, corresponding to the meat sample weight loss during chill storage; thawing loss, corresponding to the meat sample weight loss after thawing; and shear force, corresponding to the force needed to shear the cooked meat sample obtained by a Warner Bratzler blade.

The (co)variance component estimates and genetic parameters were obtained by restricted maximum likelihood using the animal model. The following mathematic model was used: $\mathbf{y} = \mathbf{Xb} + \mathbf{Zu} + \mathbf{e}$, where **y** is the dependent variables vector; **X** is the fixed effects incidence matrix, associating elements from **b** to **y**; **b** is the fixed effects vector; **Z** is the random effects incidence matrix, associating elements from **u** to **y**; **u** is the random effect vector, and **e** is the residual effects vector.

Statistical and collection methods for the data pertaining to performance, body composition, and meat quality traits in this broiler line shortly described above were previously reported and detailed [5-7].

## 3. WITHIN-LINE VARIABILITY OF THE BREAST MUSCLE ULTRASOUNDS

Additive genetic variability in ultrasounds of breast muscle has been previously reported in broilers. The heritability estimates for US1 and US2 were similar to each other ($h^2$ 0.29 ± 0.02 and 0.28 ± 0.02, respectively) [6], and the heritability estimate for US1 was moderate and slightly lower than previously described ($h^2$ 0.46 and 0.51, for US1 and US2, respectively) [5]. This result indicates that these traits are of the same genetic and/or environmental origin [9] and may result in a similar intensity of response if used individually as selection criteria. If environmental conditions are maintained [10], we could use direct selection of US1 and/or US2 for preselection, which can be useful for the breeding of this broiler line and other broilers. These results emphasize the feasibility of using ultrasound technology in a broiler breeding program. The heritability estimates for breast muscle ultrasound are reported in **Table 1**.

## 4. THE EFFICIENCY OF BREAST MUSCLE ULTRASOUND AS A SELECTION CRITERION FOR BREAST WEIGHT

The US1 and US2 measures could be efficient if used as a selection criterion for obtaining heavier breast weights in broilers. The genetic correlation estimate between US1 and breast weight was 0.68 and 0.64 and between US2 and breast weight was 0.67 and 0.69, respectively [5,6]. It is possible to choose between US1 and US2 as a selection criterion for producing indirect genetic gains for breast weight because both traits appear to have a high genetic association with breast weight and present a similar ability to respond to selection.

Individual pre-selection from ultrasound records of broilers is recommended because they can be evaluated early (30 to 38 d of age) and *in vivo* to check breast measurements as an alternative to slaughter [8]. This is possible because US displays moderate to high heritability [10] and has an important phenotypic cause-effect relationship with breast weight. Individual pre-selection using US could favor an increased breast weight in future candidate reproducers of this line because the depth of the breast muscle measured by ultrasonography was directly related to the breast weight. The genetic correlations reported for the breast muscle ultrasound records and breast weight are shown in **Table 2**.

## 5. SELECTION FOR BREAST MUSCLE ULTRASOUND RECORDS: IMPACT ON BODY COMPOSITION AND MEAT QUALITY TRAITS

It has been reported that selection for higher breast weight has modified the glycolytic potential of the muscle cells in broilers, which tends to increase protein denaturation and the incidence of the PSE (pale, soft exudative) condition in broiler meat. Consequently, these events reduce the initial meat pH and water holding capacity and increase the paleness and the shear force of the meat [11,12]. The selection of economically important traits could also affect fat deposition in broilers. Increased fat deposition in broilers due to genetic selection for body weight was verified [13] and is usually associated with some increase in breast weight [5,6]. Therefore, as ultrasound records are used in breeding programs to increase breast weight, investigating the associations among US, fat deposition, and meat quality traits becomes essential.

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**Table 1.** Heritability estimates ($h^2$) for ultrasound records from previous studies in a male broiler line (standard errors in parenthesis).

| Trait | $h^2$ (SE) | N | Age of broilers (d) | Author |
|---|---|---|---|---|
| US1 | 0.46 | 12,259 | 35 | Argentão *et al*. (2002) |
| US2 | 0.51 | 12,259 | 35 | Argentão *et al*. (2002) |
| US1 | 0.29 (0.02) | 12,284 | 38 | Gaya *et al*. (2006) |
| US2 | 0.29 (0.02) | 12,048 | 38 | Gaya *et al*. (2006) |

N = number of observations; US1 = ultrasound record of breast muscle assessed from the longitudinal direction; and US2 = ultrasound record of breast muscle assessed from the transverse direction.

**Table 2.** Genetic correlation estimates (rg) for ultrasound records from previous studies in a male broiler line (standard-errors in parenthesis).

| Traits | rg (SE) | N | Age of broilers (d) | Author |
|---|---|---|---|---|
| BRE and US1 | 0.68 | 9463 | 35 | Argentão *et al*. (2002) |
| BRE and US2 | 0.67 | 9463 | 35 | Argentão *et al*. (2002) |
| BRE and US1 | 0.64 | 6123 | 38 | Gaya *et al*. (2006) |
| BRE and US2 | 0.69 | 6123 | 38 | Gaya *et al*. (2006) |
| FAT and US1 | −0.16 | 6089 | 38 | Gaya *et al*. (2006) |
| FAT and US2 | −0.13 | 6089 | 38 | Gaya *et al*. (2006) |
| pHi and US | 0.38 ± 0.324 | 938 | 30 | Gaya *et al*. (2011) |
| $L^*$ and US | 0.33 ± 0.164 | 2130 | 30 | Gaya *et al*. (2011) |
| DL and US | 0.11 ± 0.196 | 2030 | 30 | Gaya *et al*. (2011) |
| TL and US | 0.31 ± 0.168 | 2125 | 30 | Gaya *et al*. (2011) |
| SF and US | 0.38 ± 0.168 | 2113 | 30 | Gaya *et al*. (2011) |

N = number of observations; BRE = breast weight; US1 = ultrasound record of breast muscle assessed from the longitudinal direction; US2 = ultrasound record of breast muscle assessed from the transverse direction; FAT = abdominal fat content; pHi = initial meat pH; US = average of ultrasound records of breast muscle assessed from the longitudinal and transverse directions; $L^*$ = meat paleness; DL = meat drip loss; TL = meat thawing loss; and SF = meat shear force.

Low genetic associations between US1 and US2 and the abdominal fat content (rg −0.16 and −0.13) have been previously reported [6]. This finding suggests that selection by ultrasound does not affect broiler fat deposition in this line.

The genetic association between US and initial meat pH (rg 0.38 ± 0.324) was moderate, although here was a high standard error [7]. Therefore, the glycolytic potential of the muscle cells was not disfavored by the increased breast meat in this broiler line, as expected [14]. These estimates disagree with a previous report [12] that suggested selection for a higher breast weight tends to reduce the initial meat pH and consequently yields a higher frequency of PSE meat. US was moderately correlated with the paleness of the meat (rg 0.33 ± 0.164). Therefore, industrial use of these selection criteria would affect the color of the meat, which is an essential parameter to consumers. US selection could not strongly affect drip and thawing losses because these traits are not correlated and the genetic correlations among these traits were weak (rg 0.11 ± 0.196 and 0.31 ± 0.168). There was a moderate genetic correlation between US and the shear force of the meat (rg 0.38 ± 0.168). Thus, selection for larger US values could potentially increase the shear force, although the meat shear force is strictly related to the water holding capacity [15].

Therefore, evaluation of genetic variation in breast muscle ultrasound records in this broiler breeding program has been useful to alert breeders to the unfavorable responses that may occur (*i.e*., meat paleness and increased shear force) due to the unplanned use of US as a selection criterion. Moreover, although an important progress was obtained in poultry industry regarding the ultrasound measurements, further studies concerning the genetic parameters, genetic trends and genetic gains about the ultrasonography utilization in broiler breeding programs are also necessary. These future findings might contribute to a better knowledge about the genetic behavior of the ultrasound measurements in poultry.

The genetic correlations reported for breast muscle ultrasound records and fat deposition and meat quality traits are shown in **Table 2**.

## 6. CONCLUSION

It is possible to use the depth and width of the breast muscle as measured by ultrasonography for individual pre-selection to favor larger breast weights. The use of ultrasound technologies in broiler breeding programs has

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been imperative to ensure rapid and effective indirect selection for breast weight that does not prejudice against body composition or meat quality. However, some attention should be given to the indirect effects of this selection on meat paleness and shear force. Ultrasonography is a feasible and consolidated method for collecting data in broilers and has contributed to the optimization of poultry industry meat production. Further studies in this field may contribute to the entire understanding of the genetic behavior of ultrasound records in poultry.

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