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A Breeding Program for Balanced Improvement of Performance and Health in Broilers

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Abstract: To illustrate the consequences of including health related traits in a sustainable broiler breeding program, two scenarios were simulated using the SelAction program. In the first scenario (economic), selection was only for production traits and Gait Score (GS) and Heart Failure (HF) were ignored in the breeding goal. In the second scenario (sustainable), GS and HF as well as production traits were included in the breeding goal. Economic values of GS and HF were determined using desired-gain approach to obtain a zero response in GS and HF. The results indicate that, despite improved responses for production traits in the economic scenario, there was an unfavorable reduction in GS of about 0.13 points and an unfavorable increase in HF of about 0.025 points. In the sustainable scenario, the deterioration of GS and HF was stopped. In the economic scenario with zero economic values for GS and HF, the total monetary response was higher (0.104 €) than sustainable scenario (0.097 €). Due to negative correlations between health and production traits, increased emphasis on health traits in the sustainable scenario resulted in a reduction in the total monetary response. In conclusion to stop the increased incidence of diseases, health traits should be included in the breeding goal and assigned appropriate values.

Key words: Broiler, gait score, heart failure, sustainable production, breeding program

INTRODUCTION

Modern broiler chickens have been intensively selected for production traits, e.g., growth, breast meat yield and feed efficiency for more than 50 years. Havenstein *et al*. (2003 a, b) compared broiler performance of a 1957 random-bred control population with that of a 2001 broiler stain cross. They showed that the modern broiler grows more than three times faster, with greater meat yield and better feed conversion reaching market weight on less than half the feed required by the vintage broiler. The role of breeding in this success has been dominated and over 85% of these changes were due to improvements in the genetic potential of the birds (Mench, 2002). However, selection for growth and yield has been accompanied by negative consequences on different aspects of the birds' physiology (Havenstein *et al*., 1994; Julian, 1998; Bradshaw *et al*., 2002; Bessei, 2006; Hall and Sandilands, 2007). These negative consequences are mainly due to the tremendous increase in body weight mass without parallel improvements in internal organs, vascular system and skeleton to support such a rapidly growing and large mass (Dunnington and Siegel, 1996; Bessei, 2006; D'Silva, 2006). Selective breeding has resulted in the use of genotypes or phenotypes that may have a short productivity or high yield, but are unsustainable for the birds' own health and welfare. Commercial broilers today are showing higher mortality and higher susceptibility to suboptimal conditions than broilers that have been selected less extremely for growth, meat yield and efficiency (Arthur and Albers, 2003; Fanatico *et al*., 2005). There is concern about the undesired side effects of selection for high production (efficiency) on animal health and welfare (Harper and Henson, 2001). The poultry industry is the most highly intensified of the animal production industries. As a consequence, there has been a great deal of public concern about the welfare of poultry. Leg and cardiovascular problems are the main causes of mortality and consequently they are the major concerns for broiler welfare (European Commission Report, 2000).

Genetic selection has the potential for positive as well as negative effects on welfare. Selection for only production traits reduces the welfare, whereas selection for production together with welfare may lead to improve both. Selection of breeding stock for strong legs and low incidence of heart failure has started and should be more strongly encouraged. Accurate monitoring of leg and cardiovascular conditions will provide the information needed for genetic improvement in these traits. Several techniques, e.g., X-ray, computer tomography scan

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(CT scan) and electrocardiography, have been introduced in breeding programs to assist in improving leg strength and ascites in broiler stocks (McAdam, 2004). There is a growing awareness about the welfare of broilers by consumers, especially in the European Union (Blandford and Fulponi, 1999). Despite increased selection for welfare, reports show that improvements in broiler welfare are still desirable (Turner *et al.*, 2003). Breeding organizations are increasingly aware of this trend and are changing their breeding objectives by including traits related to animal welfare (Van Arendonk, 2003).

In commercial poultry production wide range of objectives need to be considered simultaneously in order to increase revenues and improving health and welfare. Consequently, breeding goals must include increased growth rate, increased breast muscle yield, improved skeletal system and overall fitness (Li *et al.*, 2005). However, more attention to health and welfare is needed to make a balanced broiler breeding program. The information on phenotypic and genetic parameters for production and health traits are required to develop a comprehensive broiler breeding program. Present research aims to study the consequences of using breeding program with balanced improvement of production and health traits in broilers.

MATERIALS AND METHODS

To show the consequences of including health related traits together with production traits in a balanced broiler breeding program, two scenarios were simulated by deterministic simulation using the SelAction program (Rutten *et al.*, 2002). The desired-gains approach was used in the simulation. A desired-gain index aims to maximize the absolute response for a predefined linear combination of relative genetic gains for breeding goal traits (Walsh and Lynch, 2000). This so-called balanced scenario is compared to a breeding program in which traits are weighted based on their economic importance without attention to health and welfare traits.

Population structure: In the present study, a population with discrete generations was simulated, in which 70 sires were randomly mated to 420 dams with a mating ratio of one male to 6 females. Each dams produced 30 offspring (15 males and 15 females) and each male had 90 progeny of each sex. The total number of progeny of each sex was 6300. Half of the males were randomly assigned to be slaughtered for the carcass test, to measure breast meat yield (BMY) and heart failure (HF) and were not available as selection candidates. The remaining males were assigned to the feed efficiency test, to measure Residual Feed Intake (RFI). Finally, 70 out of 3150 available males were selected as sires (selection proportion ≈ 0.02) and 420 out of 6300 available females were selected as dams (selection proportion ≈ 0.067) for next generation.

Breeding goal and index: In current study economic and balanced scenarios were considered. In economic scenario, the breeding goal was a combination of three traits: gain between 0 and 42 days (G), RFI and BMY.

$$H = V_G \times A_G + V_{RFI} \times A_{RFI} + V_{BMY} \times A_{BMY}$$

where, H is a weighted sum of the true breeding values, V_G, V_{RFI} and V_{BMY} are the economic values and A_G, A_{RFI} and A_{BMY} are the true breeding values for gain, RFI and BMY.

In practice an index I is used to predict value for the breeding goal H of each selection candidate. The index I is the estimated breeding value (EBV) of the breeding goal:

$$I = V_G \times EBV_G + V_{RFI} \times EBV_{RFI} + V_{BMY} \times EBV_{BMY}$$

The economic values for gain, RFI and BMY were taken from a study by Jiang *et al.* (1998). In economic scenario, selection candidates were selected only based on production traits and health related traits (GS and HF) were ignored in the breeding goal (zero weights for GS and HF in the breeding goal).

In balanced scenario, GS and HF were also included in the breeding goal. The index traits were the same as the breeding goal traits. The economic values of GS and HF were determined using the desired-gain approach in order to obtain a zero response in GS and HF (no deterioration of GS and HF).

To estimate the direct and correlated responses in each breeding program, heritability, genetic and phenotypic correlations of treats involved are required. The heritability, genetic and phenotypic correlations of production and health traits are presented in Table 1.

Table 1: Heritabilities on diagonal, genetic correlations above the diagonal and phenotypic correlations below the diagonal for breeding goal traits

Variable[1]	BW	RFI	BMY	GS	HF
BW	0.35	0.05	0.15	-0.17	0.18
RFI	0.04	0.41	0.03	0.02	-0.05
BMY	0.18	0.01	0.48	-0.10	0.05
GS	-0.10	0.00	-0.05	0.12	-0.10
HF	0.14	-0.03	0.02	-0.07	0.10
SD	0.25	0.41	0.97	1.98	0.37
Unit	kg	point	%	point	point
Economic value[2]	0.33	−0.30	0.06	-[3]	-

[1]RFI: Residual feed intake, BMY: Breast meat yield, GS: Gait score from 1 (bad) to 5 (good), HF: Heart failure scored from 0 (no abdominal fluid) to 2 (serious abdominal fluid), SD = phenotypic standard deviation. [2]Euros marketable/bird/unit. [3]The economic values for GS and HF were changed to obtain a zero response for these traits in the sustainable scenario

Most of the parameters were based on analysis of experiments done by Zerehdaran *et al*. (2004) and Pakdel *et al*. (2005).

RESULTS AND DISCUSSION

In the economic scenario, despite improved responses for production traits, there was an unfavorable reduction in GS of about 0.133 points (approximately -0.19 genetic standard deviation, σ_g) and an unfavorable increase in HF of about 0.025 points (approximately +0.21 σ_g). The results in Table 2 indicate that the economic scenario will result in reduced health and welfare. In the sustainable scenario, with weights of 0.045 for GS and -0.3 for HF, the deterioration of leg strength and ascites was stopped. In the economic scenario with zero economic values for GS and HF in the breeding goal, the total monetary response was higher (0.104 €) than sustainable scenario (0.097 €). Due to negative correlations between health and production traits, increased emphasis on health traits in the sustainable scenario, resulted in a reduction in the total monetary response (0.104-0.097 = 0.007 €). A reduction of 6% in monetary response in production traits was sufficient to offset the negative response in health traits.

In calculating the monetary responses in Table 2, the economic consequences of changes in health traits were ignored. The economic values for health traits are the result of decrease in production costs per slaughtered broiler in the case of improvement in health conditions as well as the impact on acceptability of the products. In order to stop the increased incidence of diseases, traits should be included in the breeding goal and assigned appropriate values. Kanis *et al*. (2005) reported that health traits have economic and non-economic values where non-economic values are the result of increasing societal pressure to improve animal welfare and the safety of animal production.

Table 2: The genetic response for production and health traits and the total responses (Euro per slaughter bird) in an economic and a sustainable scenario

	Economic scenario		Sustainable scenario	
Traits[1]	Economic value	Genetic response	Economic value	Genetic response
BW	0.33	0.089	0.33	0.073
RFI	-0.30	-0.196	-0.30	-0.193
BMY	0.06	0.269	0.06	0.252
GS	0	-0.133	0.045	0
HF	0	0.025	-0.30	0
Total monetary response (€)	0.104		0.097	

[1]RFI: Residual feed intake, BMY: Breast meat yield, GS: Gait Score, HF: Heart failure

Breeding organizations cannot neglect public concerns and must become convinced that a sustainable breeding goal should not only include the economic values of traits, but also non-economic values, such as emotional and societal values (Kanis *et al*., 2005). Growing awareness of animal welfare and food safety in society may increase the willingness of consumers to pay for non-economic values in the future and make the sustainable scenario more beneficial than the economic scenario for the industry.

The present simulation was just an example to illustrate the consequences of including health traits in a sustainable breeding program. It demonstrated that it is possible to avoid an unfavorable response in health traits with limited loss in response in production traits.

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