WITHIN AND BETWEEN LINE VARIATION IN ASCITES RELATED TRAITS IN BROILERS

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[1]*The contribution of members of the project group 'vitale vleeskuikens' is appreciated.*

SUMMARY

A dataset quantifying ascites related traits in 10 broiler lines was analyzed to study systematic effects within and between lines. Degree of (subclinical) ascites could be described well from a combination of ascites-indicating measurements using Principal Component Analysis. Analysis between and within line revealed the same major traits predicting ascites (especially venous blood gas traits). Lines were fairly similar in their relations between ascites and body & blood traits. Line-contrasts in ascites sensitivity were predicted well by a simple 3-trait model, but not to their full extent. The dataset & study failed in explaining the superiority of crossbreds over purebreds. The major conclusion is that the between line variation is congruent with within line variation and therefore produces valid traits for within line selection.
Keywords Ascites; broilers; line comparison; cold challenge; metabolic disorders

INTRODUCTION

Ascites in broilers is a complex syndrome. It is related to insufficient O_2 supply, resulting in changes in blood and heart characteristics, eventually resulting in increased mortality (Maxwell *et al.* 1990; Scheele 1996). A dataset describing various ascites related traits was available to study prospects for breeding against ascites sensitivity, albeit based only on between line variation and within line on a phenotypical level. Present study focuses at revealing whether contrasts between lines in resistance to ascites are valid as candidate traits for selection indices within lines. First, an underlying continuous trait for ascites is developed (section a). Next, this ascites-trait is related to animal characteristics in order to elucidate animal-related risk factors using simple and multiple (stepwise) regression (section b-c). Prediction errors are used to study systematic differences between lines (section d).

MATERIAL AND METHODS

Ten lines of broilers (7 purebred, 3 commercial crosses) were housed in cages of each 32 male chicks equally allocated over a thermoneutral and a challenging (cold) environment (n=691). Weekly, aselect individuals were taken from each cage for determination of the following traits: Weight of body (BODY) and components: BREAST, HEART, LIVER, LUNGS, GITRACT; Venous blood gas traits VPH, VPO_2, $VPCO_2$, $VHCO_3$, VP_SAT (%saturation) and the corresponding arterial values: APH, APO_2, $APCO_2$, $AHCO_3$, AP_SAT; packed cell volume: PCV; the hormone values T3 and T4; pericardial moisture score (MOIST), Arterial Pressure Index: API, dilatation score of the right heart wall (DILATATION) and the liver abnormality scores:

COLOUR, CIRRHOSIS and FIBRINOGEN. Daily gain (ADG), feed intake per day (FID) and feed conversion ratio (FCR) were measured weekly on cage basis.
Mortality until week 6 of the experiment was regarded as the reference trait to rank lines in their susceptibility for ascites. The lines were coded in an alphabetical order on basis of the overall gain in the thermoneutral environment during the first 6 weeks of the experiment (A: fastest growth, K: slowest growing line). Line C,D and E were commercial crossbreds.
general structure of the analysis

a. development of an aggregate trait describing ascites using principal component analysis on observations describing the ascites syndrome
b. single trait association of traits with ascites ('simple correlations')
c. multi trait analysis: prediction of ascites by stepwise multiple regression ('stepwise')
d. study of prediction residuals. The deviation between observed (section a) and predicted (section c) ascites was studied to elucidate systematic between line contrasts.

RESULTS AND DISCUSSION

Average weight at 6 weeks of age ranged between lines from 1928g to 2696g in the thermoneutral environment. Exposure to the cold environment decreased weight at 6 weeks of age by 4% on average, ranging considerably between lines (-8.8% to +3.4%). In the cold, mortality increased considerably in most lines (upto 26%).

a. description of ascites using indicative traits

Before analysis, the traits MOIST, DILATATION, API, PCV, COLOUR, CIRRHOSIS and FIBRINOGEN were classified as being indicators of metabolic distortions (indicative traits for ascites: merely describing an aspect of the syndrome than causing it). A set of principal components was fitted on these indicative traits (observations of week 2-6). The first two vectors (INDIC1 and INDIC2, respectively) fitted well to the data. INDIC1 explained 35% of total variance in the traits, INDIC2 accounted for 18% of the variance. There are two distinct groups of traits discernable (figure 1): those highly correlated to the first component INDIC1, mainly heart-related traits, whereas the second component is mainly correlated to liver traits. Ranking of the line averages of INDIC1 was similar to the ranking of line averages of mortality until 6 weeks of age (Spearmans rankcorrelation (r_S) = 0.81, $p<0.0001$). INDIC1 ranked lines well in the cold environment (r_S = 0.96, $p<0.0001$) but not in the warm environment (r_S = -0.09, ns).
Conclusion a. **The principal component INDIC1 is an underlying continuous variable which is closely correlated to ascites related mortality. In the following sections, INDIC1 will therefore be regarded as an underlying continuous trait describing ascites.**

b. univariate associations with ascites.

Between lines: Line*temperature averages (n=20) of CIRRHOSIS, API and DILATATION showed the highest correlations with line mortality ($r>0.8$). This confirms the earlier mentioned view that these traits are indicators of metabolic problems. When excluding the indicative traits, $vHCO_3$, $aHCO_3$ and T4 figures correlated best with mortality ($r>0.6$).
Between & within lines: Simple correlations between the ascites indicators INDIC1 and INDIC2 and other traits were calculated on both the raw data and on data corrected for the systematic

effects of temperature and line (n=691). Both approaches reveal that most traits, especially blood gas data, are more closely related to INDIC1 than to INDIC2. Correcting the data (before analysis) for the systematic effects of Temperature and Line hardly affected the correlations.
Conclusion b. **There are clear correlations between ascites and some weight, hormone and blood gas traits. Between line and combined between- and within line analysis reveal the same major traits: blood CO_2. Removing the systematic effects (Line and Temperature treatment) reveals that lines are similar in their relations ascites - body&blood traits.**

c. multitrait analysis: prediction of ascites by stepwise regression
Between lines: A stepwise regression in the line averages (n=20) predicting mortality from body and blood traits revealed 3 significant traits: $vHCO_3$, VP_SAT and VPH (R^2=0.78).
Between & within lines: Stepwise regression models were fitted to predict INDIC1 and INDIC2 from body and blood traits, both overall (n=691) and for each line separately. Lines were fairly consistent in the major predictors: HEART and BODY. More between line variation existed in the next traits to enter the model. Generally, the first 3 traits explained about 50% of total variation and 90% of the total explainable variation using all significant (about 10) traits. After the 2 weight related traits, $vHCO_3$ (venous HCO_3 concentration) explained most additional variation, confirming that ascites is related to the oxygen metabolism in the animal. Reduction to a 3 trait prediction (HEART, BODY and $vHCO_3$) still showed a good ranking of the line mortality (r_S: 0.75, $p<0.0001$). INDIC2 was only marginally related to other parameters, and will not be analyzed further.
Conclusion c. **Within line, weight of the body and heart are positively related to ascites. Above that, between line comparison and combined between&within line comparison revealed the same major trait: CO_2 in the venous blood. Prediction of ascites with only weight of body and heart and the venous HCO_3 concentration produced accurate estimations of ascites for a wide range of lines (from highly to not ascites-sensitive).**

d. analysis of the prediction residuals
The residuals of the multiple regression are plotted against the observed INDIC1 value for each line*temperature combination (Figure 2). Generally, exposure to the cold increased the

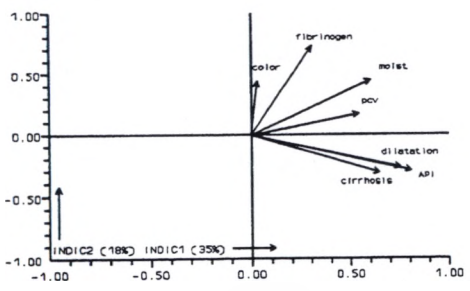

Figure 1. Composition of the principal components INDIC1 and INDIC2.

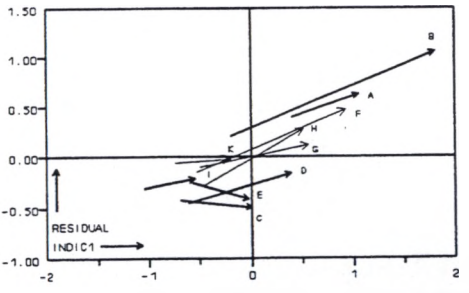

Figure 2. Prediction residuals (section d) versus observed ascites (INDIC1, section a).

residual, implying that the prediction does not account for the cold-induced ascites-increase to its full extent. Line C and E had less additional ascites then expected from their characteristics. Thus, the effect of temperature (cold induced increase in ascites) was predicted better. Analysis of variance on the prediction residuals confirmed the between line effects on the relation between body & blood measurements and ascites. A stepwise regression (within and over lines) in the residuals of the prediction of ascites (section d) indicates that feed conversion ratio is an important predictor in fast growing lines, whereas blood gas traits are more important in other lines. The lines C and E were not consistently different in their optimal models.
Conclusion d. **The effect of cold exposure on ascites is predicted only partly. Prediction residuals reveal systematic between line effects. Two crossbred lines (C and E) appear to be different but further analysis failed to reveal causes for this.**

FINAL DISCUSSION & CONCLUSIONS

Based of mortality in a cold environment, it was shown that there are clear line differences in susceptibility to ascites. Death is a 0-1 trait and therefore difficult to approach in a phenotypic analysis. The successful development of an underlying trait (INDIC1) provided the basis for the presented analysis of the dataset. Also for breeding purposes, a continuous underlying trait measurable on individuals has clear advantages.

The lines (from fully resistant: I,K to highly ascites sensitive: A,B,F) showed unexpectedly high similarity in their relations between ascites and body&blood traits. The consistency of between line variation with within line variation was demonstrated from two angles: 1. regression through line averages revealed the same risk factors as regression on all observations; 2. taking away systematic effects (line and temperature) did not substantially change correlations.
The crossbred lines appear to combine a high level of performance with moderate ascites sensitivity, superior to predictions from the line characteristics. An explanation of these crossbreeding effects is not revealed in the present study. Except for their relatively high feed conversion ratio, the crossbreds appear to be quite similar to the best producing pure lines.

Besides the weight related measurements, blood gas traits were good predictors for ascites. Regarding the aetiology of ascites, this supports the causal basis of the associations. Dependent on their relation to performance characteristics, these traits provide promising candidate traits for breeding against ascites susceptibility. The data, however, clearly show that ranking will only be informative in a challenging (cold or low O_2) environment. The relevance of blood CO_2 related traits emerged both from between line comparison and from combined between&within line analysis. The major conclusion from this work therefore is that between line contrasts provide reliable traits for within line selection. Beneficial crossbreeding effects could not be rationalised using present traits and methods.

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