BREEDING FOR IMMUNE RESPONSIVENESS AND DISEASE RESISTANCE IN POULTRY

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Introduction

The efficiency of poultry production can be greatly improved by reducing disease losses. Biggs (1982) indicated that the total economic loss from disease in the USA is about 20% of the value of poultry production and is about three times the loss from mortality. In his review, he also pointed out that the relative importance of diseases may differ between countries but few are unique to particular parts of the world. Gavora and Spencer (1983) also quoted 12-15% economic losses caused by disease.

Disease may be controlled by eradication, vaccination, medication and genetic improvement. These control measures are geared to improvement of the animal's resistance or to eliminate the pathogens from its environment. Other measures for decreasing infection chances are improved hygiene (including all in/all out systems), SPF stock and FAPP (filtered air positive pressure) housing. Often a combination of measures will lead to the best end result. For Marek's disease, vaccination in combination with genetically resistant stock reduced mortality considerably (Gavora and Spencer, 1983).

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Genetic improvement of disease resistance has various advantages. Its effects are long term and it is applicable in situations where vaccination is not possible. Genetic resistance may even reduce the need for vaccination, thereby eliminating stress caused by vaccination. Problems of genetic resistance to disease are the high costs of these breeding programs. Selection for specific resistance to all diseases of poultry is impossible. Breeders, therefore, are interested in indirect selection, which avoids direct exposure of breeding stock (or their sibs) to pathogens. The use of the B21 antigen, part of the major histocompatibility complex (MHC) of the chicken, to increase the resistance to Marek's disease is an example of successful application of a marker (Briles et al., 1977).

Selection against total mortality is probably most commonly practiced. However, this is a poorly defined trait with low heritability. Potential losses caused by disease are also prevented by vaccination, hygiene, preventive medication and FAPP housing. These measures mask the genetic capacity of the animals to resist disease. If the genetic correlations between production traits and disease resistance are negative, then adverse effects can be expected for disease resistance.

Gavora and Spencer (1978) defined general disease resistance as the ability to resist any alteration of the state of the body by external causes (microorganisms and/or stress) which interrupts or disturbs proper performance. General disease resistance circumvents the problems associated with selection for specific resistance to all diseases and against total mortality. It can be expected that general disease resistance will be a composite trait, consisting of immunoresponsiveness characters and genetic markers related to disease resistance, including the MHC.
Our own research for general disease resistance has been geared to the use of sheep red blood cells (SRBC) as a multideterminant antigen. We are selecting for low and high antibody response and have planned to test the immunological differences and the response to pathogens of these lines. More recently, we have started a cooperative project with Euribrid B.V. to research the value of haemagglutination-inhibition (HI) titers to Newcastle disease (ND) vaccine as a selection criterion. The latter is an example of specific disease resistance.

Selection for Haemagglutination Titers to SRBC

Our research in this area has been inspired by the work of Biozzi et al. (1979) in mice. The Biozzi group has carried out five selective breedings; in two experiments SRBC were used as an antigen. Selection was always for high or low antibody production. About 10 loci are responsible for the expression of this quantitative character. One locus is identified as the immunoglobulin allotype locus; another is part of the MHC. A major result of their research is the inverse relationship between antibody synthesis and bactericidal capacity. No differences in cell-mediated immunity between high and low lines have been detected.

Heritability estimates of haemagglutinin titers to SRBC in the chicken are presented in Table 1.
Table 1. Heritability estimates of haemagglutinin titers to SRBC

<table>
<thead>
<tr>
<th>Stock</th>
<th>Primary-secondary Response</th>
<th>Day Post-immunization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>WL</td>
<td>primary</td>
<td>nd</td>
</tr>
<tr>
<td>WPR</td>
<td>primary</td>
<td>.39</td>
</tr>
<tr>
<td>WPR</td>
<td>secondary</td>
<td>.28</td>
</tr>
<tr>
<td>ISA Warren</td>
<td>primary</td>
<td>.57</td>
</tr>
<tr>
<td>ISA Warren</td>
<td>secondary</td>
<td>.14</td>
</tr>
</tbody>
</table>

nd = not done

Considering the size of the heritabilities, we planned a selection experiment for high and low antibody titers, including a random control. The last stock, ISA Warren, formed the base population. The total number of animals per generation varies from 700-800. The random control consists of 40 males and 80 females; the selection lines comprise of 25 males and 50 females. In Table 2, the average antibody titers on day 5 post-immunization (selection criterion) are presented for pullets.

Table 2. Haemagglutinin titers to SRBC in four selection generations of female ISA Warren stock

<table>
<thead>
<tr>
<th>Generation</th>
<th>High</th>
<th>Line control</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0</td>
<td>5.05</td>
<td>5.97</td>
<td>5.37</td>
</tr>
<tr>
<td>S1</td>
<td>6.23</td>
<td>6.35</td>
<td>5.43</td>
</tr>
<tr>
<td>S2</td>
<td>5.72</td>
<td>5.95</td>
<td>4.01</td>
</tr>
</tbody>
</table>

Differences between high and low lines were significant (P<.005) for titers on day 5 p.i. in generation S1 and further. We also measure the secondary
response to SRBC. Differences on day 5 p.i. were significant (P<.005) for the S2 generation. The ND-HI titers were higher for the high line in comparison with control and low line.

In the S2 generation, bodyweight at 57 days of age was significantly (P<.05) lower in the high line. In our previous studies, we had consistently found negative genetic correlations between body weight and antibody titer to SRBC, varying from -.07 to -.83. Phenotypic correlations varied from -.01 to -.13. Siegel et al. (1982) found the same negative association with body weight measured at 28 and 168 days of age. Although these negative correlations could have serious implications for the health status of broilers, the results should be interpreted with caution. The negative correlation may be specific for SRBC, especially because we found with ND vaccine that rg was .07.

Our future research is aimed at the immunological comparison of the lines. Preliminary results indicate that there is no dose by line interaction. Further, the differences in antibody production between lines are large at 4 to 9 weeks of age but decline before and after this age period. A small survey indicated that the B21 antigen is most frequent in the high line. In the long term, the lines will be compared for production traits and resistance to pathogens. For further information, please refer to the research by Siegel and Gross, as reported in Poultry Science (1980) and Animal Blood Groups and Biochemical Genetics (1982).

Heritability of the Immune Response to ND Virus Vaccine

Inactivated ND vaccines exclude virus multiplication and, therefore, the effects of tissue susceptibility on the immune response of the chicken. Haemagglutination-inhibition (HI) titers are positively correlated with
protection against challenge-exposure with virulent ND virus. Housing in FAPP accommodation offers the possibility to vaccinate at an age when interference with maternal antibodies is minimized and the immune system has matured.

Heritability estimates for HI titers to inactivated and attenuated ND vaccine are presented in Table 3.

Table 3. Heritabilities for HI titer post ND vaccination

<table>
<thead>
<tr>
<th>Stock</th>
<th>Inactivated</th>
<th>Attenuated</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Rock</td>
<td>.60</td>
<td>.31</td>
<td>Peleg et al., 1976</td>
</tr>
<tr>
<td>White Rock</td>
<td>.41</td>
<td>nd</td>
<td>Soller et al., 1981</td>
</tr>
<tr>
<td>WPR</td>
<td>nd</td>
<td>(1)</td>
<td>Van der Zijpp et al., 1983</td>
</tr>
<tr>
<td>ISA Warren</td>
<td>.14</td>
<td>nd</td>
<td></td>
</tr>
</tbody>
</table>

1) Negative variance component
nd = not done

In our present study, data were available from 868 pullets and 293 cockerels of an experimental White Leghorn strain. At 62 days of age, the chicks were intramuscularly vaccinated with 1 ml of an inactivated ND vaccine. Two weeks later, blood samples were taken for HI titer determination. The heritability for HI titer was \(0.42 \pm 0.13\) from paternal halfsibs and \(0.16 \pm 0.09\) for maternal halfsibs. The genetic correlations with production traits are shown in Table 4.
Table 4. Genetic correlations between HI titers to inactivated ND vaccine and production traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Age (weeks)</th>
<th>( r_g )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg production</td>
<td>18-26</td>
<td>-0.16</td>
</tr>
<tr>
<td>Egg production</td>
<td>18-34</td>
<td>-0.15</td>
</tr>
<tr>
<td>Body weight</td>
<td>18</td>
<td>0.07</td>
</tr>
<tr>
<td>Egg weight</td>
<td>26</td>
<td>-0.21</td>
</tr>
</tbody>
</table>

The genetic correlations were relatively low and, therefore, selection for HI titer should not lead to major correlated responses in these production traits.

It will be of great interest to know whether selection for increased HI titers to inactivated ND vaccine also will affect ND virus replication when live ND viruses are used.

Conclusion

Based on the inverse relationship between antibody production and bactericidal capacity, Biozzi et al. (1979) concluded that extreme values for either trait would not be desirable for survival. However, for a population, there will always be some survivors, depending on the value of the trait in a severe infection situation. Siegel et al. (1982) expanded this view with regard to production traits. An intermediate immune response may be optimum under most husbandry situations. Their low antibody producers showed a greater initial growth and hen-day egg production, but lower overall resistance to infectious challenges in comparison with the high line.

We need more information on the mechanisms of disease resistance and on heritabilities and genetic correlations of production, immune response and
disease traits. This knowledge should enable us to understand what happened to disease resistance when selecting for production traits and provide us with insight in the consequences of breeding for disease resistance. Only with this information, simultaneous improvement of production traits and disease resistance can be carried out; maybe even by removing restrictions on production caused by disease.

References


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RESISTANCE IN POULTRY
Questions and Answers

1. Bill Rishell

You have shown rather consistent negative genetic correlations between productive traits and immune response. Does this mean that applied breeders are tending to produce birds that lack immune competence when they select for improved growth or production?

Dr. van der Zijpp

In our research, using the antigens sheep red blood cells and inactivated Newcastle disease vaccine, we have found negative genetic correlations with production traits. Some caution is necessary, however, before concluding that these negative relationships are a general phenomenon. For example, we found that genetic correlations between body weight and antibody titer to SRBC varied from -.07 to -.83, but for titers to ND vaccine, the genetic correlation was .07. An extensive study about the relationship between production traits and resistance to Marek’s disease has been carried out by Gavora et al. (1974), also, showing the variable nature of the genetic correlations. The type of antigen or pathogen and the production trait involved both determine the genetic correlation. Evidence about these genetic correlations is still scarce and, thus, more information is needed to design a breeding strategy for production and resistance traits.

2. Terry Wing

Was there any evidence of immunosuppression from gumboro disease in your birds?

Dr. van der Zijpp

We have no evidence of Gumboro disease in our flock. We vaccinate our chicks at 16 days of age by applying a mild vaccine. Because we vaccinate for many diseases, interactions do occur; as we have shown in our paper in Avian Diseases (Vol. 26, 1982). The agglutinin titer to SRBC is, therefore, also defined by the vaccination environment.

3. B.B. Bohren

Standard errors were presented on the h² estimates. They were not shown for the phenotypic and genetic correlations. Were they calculated?

Dr. van der Zijpp

The heritabilities and genetic correlations for antibody titers to SRBC were calculated by using Harvey's LSML76 program, and standard errors for these parameters were derived too. For the HI titers to inactivated Newcastle disease vaccine, Harvey's program was also used. For the relationship of HI titers with production traits, we have to rely on a statistical program according to Becker, produced and utilized by Euribrid B.V. Unfortunately,
the "Becker" program does not yet provide standard errors for genetic correlations and heritabilities.

4. **Bob Smyth**

Have you monitored autoantibodies in your selected lines? Do you believe that selection for increased immune response could lead to autoimmune diseases?

**Dr. van der Zijpp**

We have not monitored autoantibodies in our selected lines, but are aware that autoimmune diseases may possibly occur in our high line in the future. Dr. Buschmann from Munich did observe autoimmune disease in swine, selected for a high immune response to DNP-hapten.

5. **Jerry Smith**

Do you antibody titer to SRBC in non-challenged birds at 38 days of age?

**Dr. van der Zijpp**

We always determine the antibody titer to SRBC just before we start to immunize. Generally, these titers are 0 for young birds, but there is an increase with age. It is doubtful whether these positive titers indicate antibodies, because the chicks produce a typical primary immune response. When these antibodies, presumably produced against food antigens and microbial agents with similar determinants as SRBC, are present, they are always of the IgM type. For levels of agglutinin titers to SRBC, see also our 1980 and 1983 papers in Poultry Science.

6. **Loyd Patterson**

Have you tested lines for ability to resist challenge with NDV?

**Dr. van der Zijpp**

We have not yet tested our lines for their ability to resist challenge to NDV. We do, however, monitor HI titers to NDV as a correlated response. In the third selection generation, the HI titers of the high line were significantly higher than those of the low line, after two vaccinations with inactivated NDV. For further information, see the paper by Gross et al. (1980) in Poultry Science.