Evidence of Heterosis on Sexual Maturity and Egg Production in Reciprocal Crosses of Japane e Nagoyas and White Leghorns

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In order to utilize the maximum heterosis the principles of corn breeding were first applied to the poultry industry by BELL, MOORE and WARREN (1950).

There is a general agreement that the highest heterosis will be expressed in the best heterozygous combination of genes, but there still remain many problems as to which method produces greater heterosis, inter-breed crossing or intra-breed strain crossing.

Great promise of first-generation crossbreds in poultry was suggested by CUSHMAN (1892). Afterwards, WARREN (1927, 1930) reported that the crossbreds between White Leghorn and Jersey Black Giants were superior in laying performance to the parental breeds.

The progenies from the crossing between inbred lines were found by DUNN (1923), HAYS (1929) and JULL (1933) to have better rate of laying than the parental inbreds. Thus, the crossing between inbred lines was undertaken by many investigators. Of these works, the results of MAW (1942, 1949), GLAZENER and BLOW (1954) were not so favorable compared with those of the purebreds.

Also the results of crossbreeding by KNOX and OLSEN (1938), KNOX et al. (1943), DUDLEY (1944), BRUNSON and GODFREY (1951), GLAZENER et al. (1952) and MORLEY and SMITH (1954) were similar to or slightly superior to the control.

On the other hand, DICKERSON et al. (1950) compared intra-flock matings with inter-flock matings of the same breed. The latter had better viability and laying performance. HUTT and COLE (1952), using two strains of low amounts of coefficients of inbreeding, recognized that the hybrids were superior in age of sexual maturation and egg production.

KNOX et al. (1949), KING and BRUCKNER (1952), MUELLER (1952), JAAP et al. (1954), NORDSKOG and GHOSTLEY (1955) and SKALLER (1954) described that the crossbreds between different breeds had better characteristics of early maturation and laying performance.

In general, it is conceivable that heterozygosis per se increases vigor and that the vigor declines under inbreeding. However, practically as yet there is no agreement on the issue of heterosis in poultry breeding as reviewed above.

From 1951 to 1954, reciprocal crossing between Nagoya and White Leghorns was repeated three times at the National Institute of Agricultural Sciences, Livestock Section. In the present paper, the manifestation of heterosis in sexual maturity and egg production, and especially the analysis of laying performance in the reciprocal crosses will be given.

Materials and Methods

The Nagoyas used in this study were of the closed flock which, since 1935, had been bred for the homogeneity of the plumage at the National Institute of Agricultural Sciences. At the beginning of the experiment the average coefficient of inbreeding of them was twenty three per cent, and all of them went broody.

The White Leghorns used in this work were donated by Dr. K. MASUI, Professor Emeritus of University of Tokyo. They had been inbred for three generations, the coefficient of inbreeding being about thirty-one per cent. For their following three years no broody sign was observed.

In 1951, one unrelated White Leghorn sire which is produced at the Omiya Poultry Breeding Farm was served as a comparison.

The mating scheme was generally similar in every experiment. In each pen one sire was mated to ten to fifteen pullets. The birds were trapnest ed every day and their performances were tested during the periods from the first egg to the 365-day.

Since 1951, these two breeds were reciprocally mated and the results were compared with those of pure parental breeds.

Results and Discussion

Age at first egg

Average age at first egg or age of sexual maturation is presented in Table 1.

In 1951 and 1952, crossbred groups matured 30 days earlier in average than Nagoya and White Leghorn purebreds.
In general, the more intensely inbred bird requires longer days to attain sexual maturity compared to the original non-inbred foundation stock.

Table 1. Age at first egg

<table>
<thead>
<tr>
<th>Year</th>
<th>Breed and mating system</th>
<th>No. of birds</th>
<th>M±(95%Conf. lim.) Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>Nagoya</td>
<td>17</td>
<td>206.18±20.79</td>
</tr>
<tr>
<td></td>
<td>W. Leghorn</td>
<td>33</td>
<td>210.45±12.66</td>
</tr>
<tr>
<td></td>
<td>NG(♀♀)×WL(♂♂)</td>
<td>194</td>
<td>193.66±3.65</td>
</tr>
<tr>
<td>1952</td>
<td>Nagoya</td>
<td>28</td>
<td>222.16±15.27</td>
</tr>
<tr>
<td></td>
<td>NG(♀♀)×WL(♂♂)</td>
<td>52</td>
<td>193.86±7.59</td>
</tr>
<tr>
<td></td>
<td>WL(♀♀)×NG(♂♂)</td>
<td>176</td>
<td>193.52±4.66</td>
</tr>
<tr>
<td>1954</td>
<td>Nagoya</td>
<td>21</td>
<td>281.90±12.86</td>
</tr>
<tr>
<td></td>
<td>W. Leghorn</td>
<td>15</td>
<td>234.66±20.34</td>
</tr>
<tr>
<td></td>
<td>NG(♀♀)×WL(♂♂)</td>
<td>42</td>
<td>189.52±6.63</td>
</tr>
<tr>
<td></td>
<td>WL(♀♀)×NG(♂♂)</td>
<td>56</td>
<td>231.42±7.62</td>
</tr>
</tbody>
</table>

**...Significant at 1% level.

Age at first egg in these two parental breeds inclined to delay from year to year due to inbreeding. Mean age of sexual maturation of the daughters of Nagoya females × White Leghorn males was earlier than that of either parent, however, that of the reciprocal mating delayed to the level of the White Leghorns in 1954.

Throughout the experiments, although with the exceptional figure in the group of White Leghorn females × Nagoya males in 1954, the differences between crossbreds and purebreds were, no doubt, fairly significant.

It is considered that there appears heterosis in the sexual maturation as observed by many investigators.

There were no sire differences in age at first egg in all combinations. Birds which hatched in early spring (middle March) matured earlier than those hatched in late spring (middle May).

Annual egg production

The three years' experimental results are adjusted in Table 2.

One of the most striking feature observed in our experiments was the fact that egg production of the crossbred was superior to that of the original purebred, the difference between them being highly significant, although with the exceptional relation between White Leghorns and daughters of White Leghorn females × Nagoya males in 1954.

The maximum laying performances in the crossbreds in 1951, 1952 and 1954 were 324, 312 and 352, respectively. Moreover, we must notice the decrease of variance in F1 groups.

There were observed the effects of mating system on egg production; that is, the average number of egg production by the group of Nagoya females × White Leghorn males in 1952 and 1954 were 233.5 and 271.3, respectively. Whereas by the group of White Leghorn females × Nagoya males in 1952 and 1954, 217.5 and 224.5, respectively.

From these results, it is considered that sex-linkage may be a factor in the inheritance of egg production in the breed we used. Furthermore, we tried computation of intensity and persistency to analyze the laying performance in every mating system as shown in Table 3.

Intensity (the rate of laying from first egg to

Table 2. Annual egg production

<table>
<thead>
<tr>
<th>Year</th>
<th>Breed and mating system</th>
<th>No. of birds</th>
<th>M±(95%Conf. lim.) Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>Nagoya</td>
<td>17</td>
<td>162.95±18.15</td>
</tr>
<tr>
<td></td>
<td>W. Leghorn</td>
<td>31</td>
<td>193.38±16.67</td>
</tr>
<tr>
<td></td>
<td>NG(♀♀)×WL(♂♂)</td>
<td>184</td>
<td>242.65±5.98</td>
</tr>
<tr>
<td>1952</td>
<td>Nagoya</td>
<td>21</td>
<td>125.50±18.30</td>
</tr>
<tr>
<td></td>
<td>NG(♀♀)×WL(♂♂)</td>
<td>46</td>
<td>233.50±10.50</td>
</tr>
<tr>
<td></td>
<td>WL(♀♀)×NG(♂♂)</td>
<td>161</td>
<td>217.46±5.90</td>
</tr>
<tr>
<td>1954</td>
<td>Nagoya</td>
<td>12</td>
<td>121.66±29.92</td>
</tr>
<tr>
<td></td>
<td>W. Leghorn</td>
<td>10</td>
<td>218.00±51.87</td>
</tr>
<tr>
<td></td>
<td>NG(♀♀)×WL(♂♂)</td>
<td>31</td>
<td>271.30±11.35</td>
</tr>
<tr>
<td></td>
<td>WL(♀♀)×NG(♂♂)</td>
<td>22</td>
<td>224.54±16.47</td>
</tr>
</tbody>
</table>

**...significant at 1% level.

*...significant at 5% level.
Table 3. Intensity (the rate of laying from first egg to March 1st) and persistency.

<table>
<thead>
<tr>
<th>Year</th>
<th>Breed and mating system</th>
<th>Intensity</th>
<th>Persistency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of birds</td>
<td>%</td>
</tr>
<tr>
<td>1951</td>
<td>Nagoya</td>
<td>16</td>
<td>43.43 %**</td>
</tr>
<tr>
<td></td>
<td>W. Leghorn</td>
<td>29</td>
<td>66.30 %**</td>
</tr>
<tr>
<td></td>
<td>NG(♀♂)×WL(♀♀)</td>
<td>60</td>
<td>74.56 %**</td>
</tr>
<tr>
<td>1952</td>
<td>Nagoya</td>
<td>20</td>
<td>39.14 %**</td>
</tr>
<tr>
<td></td>
<td>NG(♀♂)×WL(♀♀)</td>
<td>46</td>
<td>61.56 %**</td>
</tr>
<tr>
<td></td>
<td>WL(♀♀)×NG(♂♂)</td>
<td>161</td>
<td>60.75 %</td>
</tr>
<tr>
<td>1954</td>
<td>Nagoya</td>
<td>10</td>
<td>48.95 %</td>
</tr>
<tr>
<td></td>
<td>W. Leghorn</td>
<td>10</td>
<td>66.56 %**</td>
</tr>
<tr>
<td></td>
<td>NG(♀♂)×WL(♀♀)</td>
<td>32</td>
<td>74.91 %</td>
</tr>
<tr>
<td></td>
<td>WL(♀♀)×NG(♂♂)</td>
<td>21</td>
<td>68.18 %</td>
</tr>
</tbody>
</table>

**...significant at 1 % level.

for crossbreds was generally longer than that of purebreds.

It should be noted that there exists a significant difference between reciprocal crosses on egg production as mentioned above.

Broodiness

In 1952, 28 per cent of the daughters of Nagoya females × White Leghorn males went broody whereas 73 per cent of the daughters of White Leghorn females × Nagoya males went broody.

And also in 1954, 38 per cent of the daughters produced by the former matings went broody whereas 85 per cent of the daughters produced by the latter matings went broody.

The results led us to conclude that the Nagoya used by us apparently had at least one sex-linked broody gene.

Furthermore, the existence of highly negative correlation (-0.5) between egg production and broody times in the crossbreds was observed (SAEKI, 1955). And no significant difference in intensity between reciprocal crosses was observed in this experiment.

Considering these results, it was attributed to the sex-linked broody gene possessed by Nagoyas that the laying performance of the daughters of White Leghorn females × Nagoya males was lower than that of the daughters of Nagoya females × White Leghorn males.

Japanese Nagoyas and White Leghorns mildly inbred were crossed reciprocally three times. Tripenning was continued throughout the experiments, and the results of every combination were compared to each other.

1. Mean age at first egg in the crossbred group was earlier about 30 days than that of the original purebred one.

2. Annual egg production in the crossbred averaged 238, and that of the purebred was 164, the heterosis manifested being statistically highly significant.

3. The percentage of broody birds in the pullets from Nagoya sires was remarkably higher than that in the pullets from White Leghorn sires. This result indicates that at least a sex-linked gene is involved in the inheritance of broodiness.

4. Highly significant difference in performance between the reciprocal crosses was largely attributed to the sex-linked factor of broodiness carried by the Nagoyas.

Acknowledgement

We wish to acknowledge the very valuable aid from Dr. K. MASUI who donated us the original foundation stock of White Leghorns.

References

1. BELL, A.E., C. H. MOORE and D.C. WARREN (1950) : Systems of breeding designed to give maximum hetero-


