GENETIC PARAMETERS OF LAYING HENS IN SINGLE AND GROUP CAGES

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INTRODUCTION
Genetic parameters of laying hens were usually estimated based on individual observations from hens, housed in single cages. But in commercial egg production farms, hens are commonly kept in group cages. To avoid genotype and environment interactions between these different housing types, breeding hens can also be tested in group cages. Especially important is the magnitude of genetic correlation between single and group observation. Several studies have been conducted to estimate genetic parameter on monthly egg production in single cages (Saadeh et al., 1967, Engstroem et al., 1986, Savas, 1998, Anang et al., 2001), but those based on data available in single as well as in group cages are rare. This study was conducted to estimate the heritability and genetic correlation between monthly egg production and egg weight of White Leghorn in single and group cages.

MATERIAL AND METHODS
Data structure. Egg production and egg weight data from two commercial lines of White Leghorn hens (line A and line D) tested in single cages as well as in group cages were used. The period of data collections was from 20 to 48 weeks of age. The egg production was recorded in seven monthly periods, in which each period consisted of 28 days. In the group cage data, the observation unit was the average performance of hens per cage. Only cages, where all hens survived to 7 month were included in the analyses. A total of 2289 records (line A) and 2596 records (line D) in single cages and 518 and 541 records (for line A and line D, respectively) in group cage were analysed. The traits studied were monthly egg production of 1st to 7th period (EN1 to EN7), total egg production of 1st to 7th period (EN1-7), egg weight at 28 (EW1) and 33 (EW2) weeks of age.

Statistical analyses. (Co) variance for monthly egg production and egg weight in single cages were analysed using VCE4 programme (Groeneveld, 1998) based on the restricted maximum likelihood (REML) method and a multiple trait animal model. The following model was used: 
\[ y_{ijk} = \mu + HHT_i + a_j + e_{ijk} \] where: \( y_{ijk} \) is the kth monthly records of jth hen within the ith house-hatch-tier block, HHT is the fixed effect of block i and \( a_j \) is random effect of jth animal. In group cages, a situation is considered, that each cage may contain a different numbers of hens (2, 3, or 4), in which hens within cages could be full sibs or half sibs. For cage data, the following sire model was used: 
\[ \bar{y}_{ijk} = \mu + HHT_i + s_j + r_{ijk} \] where: \( \bar{y}_{ijk} \) is the average of all animals from kth cage within jth sire in ith house-hatch-tier block. Because offspring of jth dam could be found in different cages, the residual effects of \( r_{ijk} \) could be correlated. A programme based on EM-algorithm with considering inhomogeneity of error variance and correlated residual effects (Mielenz, 2001) was used to calculate (co) variance components of group cage data. Genetic correlations between monthly egg production in single
and group cages were analysed using sire model with assuming that monthly egg production in single and group cages as different traits. VCE4 Programme (Groeneveld, 1998) was used to estimate (co) variance components of single and group cage data.

**RESULT AND DISCUSSION**

The means of egg production in period 1, period 3 and cumulative production could be seen in table 1. Estimates of heritability in single and group cages are presented in table 2. The trend of heritability estimates is in essential agreement with previous studies from Savas (1998) and Anang et al. (2001). Heritability estimates of monthly egg production in group cages have not been reported. Monthly egg production of 1st period showed high estimates for heritability. These results agree with those of Preisinger and Savas (1997) and Fairfull and Gowe (1990) who suggested the high heritability value of 1st period of laying in single cages was influenced by variation in sexual maturity. Heritability values for total egg productions in single cages were smaller than those reported by Anang et al. (2000), but higher than results obtained by Savas (1998). In group cages, heritability estimates for cumulative productions are in the same range as values reported by Kuehne (1978).

**Table 1. Means of egg production of line A and line D in single and group cages**

<table>
<thead>
<tr>
<th>Traits</th>
<th>Single cages</th>
<th>Group cages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EN1</td>
<td>EN3</td>
</tr>
<tr>
<td>Line A</td>
<td>8.8±7.6</td>
<td>26.3±2.3</td>
</tr>
<tr>
<td>Line D</td>
<td>13.8±9.0</td>
<td>26.9±1.8</td>
</tr>
</tbody>
</table>

**Table 2. Heritability of monthly egg production and egg weight in line A and line D**

<table>
<thead>
<tr>
<th>Line A</th>
<th>EN1</th>
<th>EN2</th>
<th>EN3</th>
<th>EN4</th>
<th>EN5</th>
<th>EN6</th>
<th>EN7</th>
<th>EN1-7</th>
<th>EW1</th>
<th>EW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>0.44</td>
<td>0.12</td>
<td>0.14</td>
<td>0.09</td>
<td>0.08</td>
<td>0.10</td>
<td>0.10</td>
<td>0.32</td>
<td>0.54</td>
<td>0.44</td>
</tr>
<tr>
<td>Group</td>
<td>0.42</td>
<td>0.23</td>
<td>0.05</td>
<td>0.07</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.18</td>
<td>0.36</td>
<td>0.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Line D</th>
<th>EN1</th>
<th>EN2</th>
<th>EN3</th>
<th>EN4</th>
<th>EN5</th>
<th>EN6</th>
<th>EN7</th>
<th>EN1-7</th>
<th>EW1</th>
<th>EW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>0.43</td>
<td>0.15</td>
<td>0.14</td>
<td>0.04</td>
<td>0.05</td>
<td>0.08</td>
<td>0.05</td>
<td>0.29</td>
<td>0.40</td>
<td>0.39</td>
</tr>
<tr>
<td>Group</td>
<td>0.18</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.07</td>
<td>0.11</td>
<td>0.05</td>
<td>0.25</td>
<td>0.27</td>
</tr>
</tbody>
</table>

As expected, the heritability estimates for egg weight were high in single as well as group cages. These results are in accordance with the findings of Poggenpoel et al. (1996) and Francesch, et al. (1997) for single cages and Kuehne (1978) for group cages. The estimates of heritability for egg weight seem to be different for the two lines, the estimates were higher in line A compared to line D. Preisinger and Savas (1997) reported similar results for brown layer and suggested that it may reflect the high variation in egg weight of male lines. Compared to group cage data, the single cage data results showed higher heritability estimates for monthly egg production and egg weight in both lines. Kuehne (1978) suggested that the difference between those estimates was probably due to reduced variability in group cage.
Table 3. Genetic correlations of Line A in single cages (above the diagonal) and group cages (below the diagonal)

<table>
<thead>
<tr>
<th>Traits</th>
<th>EN1</th>
<th>EN2</th>
<th>EN3</th>
<th>EN4</th>
<th>EN5</th>
<th>EN6</th>
<th>EN7</th>
<th>EN1-7</th>
<th>EW1</th>
<th>EW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN1</td>
<td>0.81</td>
<td>-0.04</td>
<td>-0.10</td>
<td>-0.17</td>
<td>-0.12</td>
<td>-0.15</td>
<td>0.83</td>
<td>-0.19</td>
<td>-0.32</td>
<td></td>
</tr>
<tr>
<td>EN2</td>
<td>0.45</td>
<td>0.55</td>
<td>0.48</td>
<td>0.36</td>
<td>0.30</td>
<td>0.01</td>
<td>0.95</td>
<td>-0.41</td>
<td>-0.53</td>
<td></td>
</tr>
<tr>
<td>EN3</td>
<td>0.37</td>
<td>0.95</td>
<td>0.99</td>
<td>0.87</td>
<td>0.69</td>
<td>0.27</td>
<td>0.48</td>
<td>-0.11</td>
<td>-0.23</td>
<td></td>
</tr>
<tr>
<td>EN4</td>
<td>-0.06</td>
<td>0.93</td>
<td>0.94</td>
<td>0.86</td>
<td>0.69</td>
<td>0.32</td>
<td>0.45</td>
<td>-0.31</td>
<td>-0.47</td>
<td></td>
</tr>
<tr>
<td>EN5</td>
<td>-0.06</td>
<td>0.66</td>
<td>0.50</td>
<td>0.87</td>
<td>0.95</td>
<td>0.65</td>
<td>0.41</td>
<td>-0.12</td>
<td>-0.22</td>
<td></td>
</tr>
<tr>
<td>EN6</td>
<td>-0.08</td>
<td>-0.21</td>
<td>0.17</td>
<td>0.68</td>
<td>0.69</td>
<td>0.83</td>
<td>0.43</td>
<td>-0.19</td>
<td>-0.30</td>
<td></td>
</tr>
<tr>
<td>EN7</td>
<td>-0.15</td>
<td>0.02</td>
<td>-0.09</td>
<td>0.63</td>
<td>0.86</td>
<td>0.95</td>
<td>0.25</td>
<td>-0.10</td>
<td>-0.22</td>
<td></td>
</tr>
<tr>
<td>EN1-7</td>
<td>0.82</td>
<td>0.84</td>
<td>0.78</td>
<td>0.64</td>
<td>0.46</td>
<td>0.25</td>
<td>0.46</td>
<td>-0.28</td>
<td>-0.47</td>
<td></td>
</tr>
<tr>
<td>EW1</td>
<td>-0.53</td>
<td>-0.29</td>
<td>-0.40</td>
<td>0.03</td>
<td>0.09</td>
<td>-0.27</td>
<td>-0.05</td>
<td>-0.50</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>EW2</td>
<td>-0.48</td>
<td>-0.49</td>
<td>-0.69</td>
<td>-0.31</td>
<td>-0.14</td>
<td>-0.67</td>
<td>-0.22</td>
<td>-0.68</td>
<td>0.95</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Genetic correlations of Line D in single cages (above the diagonal) and group cages (below the diagonal)

<table>
<thead>
<tr>
<th>Traits</th>
<th>EN1</th>
<th>EN2</th>
<th>EN3</th>
<th>EN4</th>
<th>EN5</th>
<th>EN6</th>
<th>EN7</th>
<th>EN1-7</th>
<th>EW1</th>
<th>EW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN1</td>
<td>0.08</td>
<td>-0.21</td>
<td>-0.19</td>
<td>-0.11</td>
<td>0.02</td>
<td>-0.28</td>
<td>0.86</td>
<td>-0.24</td>
<td>-0.23</td>
<td></td>
</tr>
<tr>
<td>EN2</td>
<td>-0.05</td>
<td>0.86</td>
<td>0.86</td>
<td>0.72</td>
<td>0.52</td>
<td>0.39</td>
<td>0.50</td>
<td>0.03</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>EN3</td>
<td>-0.29</td>
<td>0.90</td>
<td>0.86</td>
<td>0.70</td>
<td>0.42</td>
<td>0.31</td>
<td>0.26</td>
<td>-0.05</td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>EN4</td>
<td>-0.82</td>
<td>0.41</td>
<td>-0.24</td>
<td>0.82</td>
<td>0.78</td>
<td>0.73</td>
<td>0.45</td>
<td>0.01</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>EN5</td>
<td>-0.25</td>
<td>0.71</td>
<td>0.94</td>
<td>0.95</td>
<td>0.84</td>
<td>0.72</td>
<td>0.47</td>
<td>-0.16</td>
<td>-0.18</td>
<td></td>
</tr>
<tr>
<td>EN6</td>
<td>-0.53</td>
<td>0.35</td>
<td>0.71</td>
<td>0.90</td>
<td>0.94</td>
<td>0.92</td>
<td>0.48</td>
<td>-0.16</td>
<td>-0.13</td>
<td></td>
</tr>
<tr>
<td>EN7</td>
<td>-0.32</td>
<td>0.45</td>
<td>0.77</td>
<td>0.62</td>
<td>0.94</td>
<td>0.79</td>
<td>0.21</td>
<td>-0.01</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td>EN1-7</td>
<td>0.26</td>
<td>0.62</td>
<td>0.91</td>
<td>0.48</td>
<td>0.96</td>
<td>0.63</td>
<td>0.76</td>
<td>-0.29</td>
<td>-0.25</td>
<td></td>
</tr>
<tr>
<td>EW1</td>
<td>-0.37</td>
<td>-0.18</td>
<td>-0.13</td>
<td>-0.15</td>
<td>-0.25</td>
<td>-0.03</td>
<td>-0.01</td>
<td>-0.32</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>EW2</td>
<td>-0.45</td>
<td>-0.12</td>
<td>-0.26</td>
<td>-0.23</td>
<td>-0.00</td>
<td>-0.11</td>
<td>-0.02</td>
<td>-0.33</td>
<td>0.90</td>
<td></td>
</tr>
</tbody>
</table>

Genetic correlations of monthly egg production were high in contiguous periods then these values decreased as the interval between months increased. Egg production of 1st period in single and group cages showed a negative genetic correlation with other periods. Savas (1998) reported similar results. In the contrary, Anang et al (2000) reported positive correlations between first and later periods, that is probably due to the exclusion of hens that laid no eggs in the 1st period, from the analyses. Moderate to high genetic correlations were found between monthly production and total production in single as well as group cages. The results for single cages were in agreement with the results of Savas (1998), but no reports were found for group cages. Surprising values were found for genetic correlations between monthly egg production in single and group cages. Kuehne (1978) reported higher genetic correlation between cumulative production of 1st-6th period in single and group cages (0.94). The standard errors of genetic correlations ranged from 0.05 to 0.89. The large standard error indicates that the estimates were extremely variable, possibly due to the low heritability values of the traits and the limited number of records used in the estimations.
Table 5. Genetic correlations between monthly egg production of single and group cages

<table>
<thead>
<tr>
<th>Traits</th>
<th>Line A</th>
<th>Line D</th>
<th>Traits</th>
<th>Line A</th>
<th>Line D</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN1</td>
<td>0.85</td>
<td>0.85</td>
<td>EN5</td>
<td>-0.09</td>
<td>0.89</td>
</tr>
<tr>
<td>EN2</td>
<td>0.78</td>
<td>0.95</td>
<td>EN6</td>
<td>0.19</td>
<td>0.45</td>
</tr>
<tr>
<td>EN3</td>
<td>0.66</td>
<td>0.65</td>
<td>EN7</td>
<td>0.43</td>
<td>0.48</td>
</tr>
<tr>
<td>EN4</td>
<td>0.56</td>
<td>0.63</td>
<td>EN1-7</td>
<td>0.89</td>
<td>0.63</td>
</tr>
</tbody>
</table>

CONCLUSION
It can be concluded that the attitude of genetic parameters of monthly egg productions estimated in group cages is almost the same as those in single cages. Based on the results of high genetic correlations between single and group cages, it seems to be a good chance to estimate genetic parameter of laying hens in group cages. Advances in the methods and programme package should be very useful in order to obtain more precise and better estimates of genetic parameter of group means.

REFERENCES
Mielenz, N. (2001) EM Algorithm with correlated residual effects (Personal communication).