Application of Stability Analysis for Silkworm Breeding

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Abstract

Levels of genetic diversity in the silkworm populations affect with yield of economic traits and its stability. The quantitative genetic and biometry scientists have been largely interested to truly investigate on gene expression, with less emphasis on the environment and the genetic × environment interaction. In this investigation, stability of evaluation index (as a multi traits selection index) was evaluated in thirteen silkworm genotypes across three season in Mysore, India, during 2004 to 2007. The data was evaluated by means of Huehn through nonparametric stability indices by analyzing of $S_i^{(3)}$, $S_i^{(6)}$ and Lin and Binns method using $P_i$ index. The three different non parametric methods demonstrated that (MU406, MG414, MU405, MU1, Tamil Nadu white and Hosa Mysore), (MU406, MG414, MU405, MU1 and Tamil Nadu white) and (MU406, MU405, MU1, Tamil Nadu White and Hosa Mysore) have shown good stability for evaluation index
during the experiment period through analyzing of $S_i^{(3)}$, $S_i^{(6)}$ and $P_i$, respectively. Most of stability statistics have not been extensively used and their benefit has not been investigated thoroughly. Because the computational algorithms are not included in the commercial software packages, but nonparametric methods yet are reliable and easy to application for breeders.

**Keywords:** Bombyx mori, diversity, nonparametric analysis, stability

**Introduction**

For many years, the rearing of silkworms as the most economically important insects throughout the world for silk production was one of the most important industries in more than thirty countries, especially in China, Japan, Korea, Thailand, India, France, Italy, Russia, Rumania, Bulgaria and in the twentieth century, Brazil. India the homeland of all varieties of natural silk is the cultural heritage of Indians. The sericulture is an agro-based industry; the wide range of ecological situation existing in India and varied need of domestic purposes have made it imperative to look back to diversity and its conservation. The climate alteration with effecting on production level and genotypes stability is a threat to diversity of domestic silkworm. The diversity is to adapt to the change climate brings loss of wild and domestic diversity including loss of crop species, animal breeds, fish stocks, and silkworm races etc., ultimately leading to loss of valuable germplasm. The germplasm banks play a crucial role in the conservation. Thus estimating of stability is very important statistical tool for maintain of created silkworm genotype. The diversity in animal husbandry and silkworm depend on its production, resistance to disease and stability to environmental effects. As per the demand of present sericulture industry, silkworm genotypes suited for different agro-climatic zones are need. The study of diversity in Bombyx mori is important for selection of useful races, use of the heterosis advantages and generate of new race. During the recent years, diversity conservation programmes have drawn the attention of many countries including developing nations. The commission on genetic resources for food and agriculture (CGRFA) was originally established in 1983 as the commission on plant genetic resources (PGR), by the FAO, to deal with issues related to plant genetic resources. The silkworm germplasm resources have a very importance not only for useing in sericulture and silkworm breeding researches but also for making experiments in the field of genetics and molecular biology (Petkov et al., 2006).

India is belongs to sub continental climatic region, where most of the breeds developed are suitable for rearing in favorable seasons and they require optimum inputs of mulberry leaf and ideal rearing conditions, to exhibit their full potentiality. If these breed when reared in sub optimal conditions suffer a heavy loss due to different diseases and feed deficiency. Breeders are not given due attention for undesirable weather conditions and Genotype × Environmental interaction. Therefore, the sciences of quantitative genetics and biometry have
been largely devoted to the study of gene action, with less emphasis on the environment and the G × E interaction. The G × E interaction seems to have gained more attention in the last few decades. Though not comparable to the sophisticated biometrical models, various methodologies have been proposed to extract more information from these components than analysis of variance (ANOVA). The univariate parametric and nonparametric stability statistics have been proposed to determine the response of genotypes to changing environment. Multivariate analytical tools originally designed in other fields have been applied to extract more patterns from the G × E interaction. The influence of environment on silkworm rearing performance was experienced by silkworm scientists (Mohapatra, 2009 and Singh et al., 2009). The selection of high yielding genotypes with wider adaptation and stable performance in targeted agro-ecology remains an important goal in breeding programs. Many researches applied different nonparametric statistic methods to evaluate stability. Several nonparametric procedures proposed by Nassar and Huehn (1987), Kang (1988), Fox et al. (1990), Huehn (1990) and Thennarasu (1995) are based on the ranks of genotypes in each environment and genotypes with similar ranking across environments are classified as stable. This is an effective tool to judge the stability and superiorit of silkworm races from which the breeders make ultimately new genotypes through utilizing standard procedure of breeding technique. According to Huehn, nonparametric stability analysis procedures have the following advantages. They reduce the bias caused by outliers, no assumptions are needed about the distribution of observed values, they are easy to use and interpret and additions or deletions of one or a few genotypes do not cause much. Stability performance of silkworm across contrasting environments is necessary for the selection of suitable and high yield genotypes. The main objective of this experiment was to estimate stability in thirteen silkworm races.

**Materials and methods**

Thirteen silkworm genotypes namely, C.nichi, Nistari, G111, Pure Mysore, G112, Kolar gold, GNP, MU1, Tamil Nadu white, Hosa Mysore, MU405, MG414 and MU406, reared in the germplasm of University of Mysore, Mysore were studied for four years (2004-2007) and each year is characterized by three seasons viz. pre-monsoon, monsoon and post-monsoon. The rearing was conducted following the method suggested by Krishnaswami (1978). Observations were conducted on thirteen genotypes, in three seasons of a year (three seasons × four years). The data pertaining to ten metric traits viz., fecundity (FEC), larvae brushed percentage, hatching percentage (Hatch %), weight of 10 matured larvae (LWT), larval duration (LD), single cocoon weight (SCW), single shell weight (SSW), shell ratio (SR) and cocoon yield/10,000 larvae (by no. & wt.) (YLN & YLW) were recorded.
Evaluation index as an important index \((e_i \text{ and } e'_i)\) was computed for all the traits except larval duration by the following formula suggested by Mano \textit{et al.} (1993):
\[
e_i = \frac{(A-B) \times 10}{C} + 50
\]
Where, as for the larval duration trait the modified formula by Talebi and Subramanya (2009) was used:
\[
e'_i = \frac{(B-A) \times 10}{C} + 50
\]
Where:
- \(A\)=Value of particular genotype for a trait,
- \(B\)=Mean value, \(C\)=Standard deviation, \(10\)=Standard unit and \(50\)=Fixed value

The two nonparametric stability statistics \((S_i^{(3)} \text{ and } S_i^{(6)})\) that combine mean yield and stability have been described in detail by Huehn (1990) and nonparametric stability measures \((P_i)\) that described in detail by Lin and Binns (1988) were measured.

\[
S_i^{(3)} = \frac{\sum_{j=1}^{n} (r_{ij} - \bar{r}_i)^2}{\bar{r}_i}
\]
\[
S_i^{(6)} = \frac{\sum_{j=1}^{n} |r_{ij} - \bar{r}_i|}{\bar{r}_i}
\]
Where, \(r_{ij}\)= rank of \(i^{th}\) genotype in \(j^{th}\) environment
\(\bar{r}_i\)= mean of ranks over all environment for \(i^{th}\) genotype

\[
P_i = \frac{\sum_{j=1}^{n} (X_{ij} - M_j)^2}{n}
\]
Where:
- \(P_i\)= mean square between evaluation index and overall for each location
- \(X_{ij}\)=evaluation index of \(i^{th}\) genotype in \(j^{th}\) environment
- \(M_j\)=maximum evaluation index among all environment
- \(n\)= number of environment

### Results and discussion

The stability is sometimes used to define a genotype that shows relatively constant yield, regardless of changes in environmental conditions. Hence it is very necessary to evaluate the silkworm races which have high stability with regards to genotype \(\times\) environment interaction. Ever before in the history of sericulture industry with regards to silkworm races, there were very rare information available about stability analysis especially through utilizing non-parametric methods so far and with this emphasis, the evaluating the 13 different genotype of
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silkworms viz, C.nichi, Nistari, G111, Pure Mysore, G112, Kolar Gold, GNP, MU1, Tamil Nadu White, Hosa Mysore, MU414, MG405 and MG406 to determine the stability and its effect on silkworm diversity.

The results of non-parametric stability measures and genotypes mean evaluation index are summarized in Table-1. The $S_i^{(3)}$ and $S_i^{(6)}$ statistics are based on rank of the genotypes across environments and they give equal weight to each environment. Genotypes with fewer changes in rank are considered to be more stable (Becker and Leon, 1988). The $S_i^{(3)}$ and $S_i^{(6)}$ estimates are based on all possible pair-wise rank differences across environments for each genotypes (Huehn, 1987 and Sabaghnia et al., 2006). With this regards, recently Kaya and Taner (2002), Sabaghnia et al. (2006), Abdulahi (2007), Adugna (2007), Ardeelean et al. (2007), Aremu et al. (2007), Mitre et al. (2007), Mohammadi et al. (2007) and Solomon et al. (2007) and were emphasized towards yield parameters through nonparametric analysis both in plants and animals being have got significantly useful result in the field of genetic science. These stability parameters fail to select genotypes on the basis of high yield and stable performance. The limitations resulting from these parameters therefore led to the development of techniques combining high yield with stable performance (Kroonenberg, 1995). Lin and Binns (1988) cultivate superiority measure ($P_i$) based genotype yield in each environment on ranks with the lowest rank assigned to most desirable genotype.

Table 1. Estimation and nonparametric test of stability of evaluation index with Huehn, Lin and Binn methods

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Rank mean</th>
<th>Standard deviation of rank</th>
<th>Evaluation index</th>
<th>$P_i$</th>
<th>$S_i^{(3)}$</th>
<th>$S_i^{(6)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU406</td>
<td>1.67</td>
<td>0.78</td>
<td>61.87</td>
<td>8.40</td>
<td>19.27</td>
<td>4.73</td>
</tr>
<tr>
<td>MG414</td>
<td>2.08</td>
<td>0.90</td>
<td>61.58</td>
<td>19.88</td>
<td>20.95</td>
<td>5.26</td>
</tr>
<tr>
<td>MU405</td>
<td>2.25</td>
<td>0.75</td>
<td>61.17</td>
<td>7.96</td>
<td>18.37</td>
<td>4.98</td>
</tr>
<tr>
<td>Hosa Mysore</td>
<td>5.17</td>
<td>0.72</td>
<td>52.57</td>
<td>13.74</td>
<td>23.12</td>
<td>5.58</td>
</tr>
<tr>
<td>Tamil Nadu White</td>
<td>5.83</td>
<td>1.62</td>
<td>52.54</td>
<td>9.44</td>
<td>21.10</td>
<td>5.40</td>
</tr>
<tr>
<td>MU1</td>
<td>6.67</td>
<td>1.44</td>
<td>51.17</td>
<td>4.25</td>
<td>11.55</td>
<td>3.45</td>
</tr>
<tr>
<td>GNP</td>
<td>7.25</td>
<td>2.60</td>
<td>51.15</td>
<td>43.40</td>
<td>41.64</td>
<td>8.24</td>
</tr>
<tr>
<td>Kolar gold</td>
<td>7.33</td>
<td>1.87</td>
<td>50.74</td>
<td>25.64</td>
<td>26.00</td>
<td>5.73</td>
</tr>
<tr>
<td>Pure Mysore</td>
<td>9.67</td>
<td>1.78</td>
<td>48.17</td>
<td>9.52</td>
<td>26.50</td>
<td>6.30</td>
</tr>
<tr>
<td>G112</td>
<td>9.50</td>
<td>2.28</td>
<td>48.47</td>
<td>27.70</td>
<td>33.91</td>
<td>6.55</td>
</tr>
<tr>
<td>G111</td>
<td>9.75</td>
<td>1.54</td>
<td>47.87</td>
<td>20.73</td>
<td>18.68</td>
<td>4.39</td>
</tr>
<tr>
<td>Nistari</td>
<td>10.90</td>
<td>1.45</td>
<td>46.52</td>
<td>9.80</td>
<td>19.85</td>
<td>4.39</td>
</tr>
<tr>
<td>C.nichi</td>
<td>12.83</td>
<td>0.39</td>
<td>40.23</td>
<td>11.22</td>
<td>22.49</td>
<td>5.56</td>
</tr>
</tbody>
</table>
From Table-1, it was revealed that estimation of stability non-parametric test of evaluation index with Huehn, Lin and Binns methods have shown that MU406 race recorded highest $e_i$ (61.87) while least $e_i$ (40.23) was recorded in C.nichi race. GNP race was showed as highest $P_i$ (43.40) and MU1 race was least $P_i$ (4.25). Using $S_i^{(3)}$ statistic method MU1 race recorded least $S_i^{(3)}$ (11.55), while highest $S_i^{(3)}$ (41.64) were exhibited in GNP. Further, using $S_i^{(6)}$ statistic method, the MU1, recorded least $S_i^{(6)}$ (3.45) and highest $S_i^{(6)}$ (8.24) were observed in GNP race. It was interesting to Table -1 that, the MU1 race observed least $P_i$, $S_i^{(3)}$ and $S_i^{(6)}$. Whereas GNP race showed highest $P_i$, $S_i^{(3)}$ and $S_i^{(6)}$. This runs confirm to the work of Aremu et al. (2007) who rated $P_i$ statistics as a better technique in selecting high yielding genotypes. The discussed results suggested that the evaluation index of MU1 do not react identically to the genotype × environment influences. Finally, GNP race was showed very poor stability with respect to evaluation index.

By this technique, only genotypes with wide adaptation are selected. According to Acciaresi et al. (1997), the success in identifying high yielding genotype is dependent on effectiveness of stability and selection parameters used. However, high precision has been achieved in selecting for high yield with stable performance (Acciaresi et al., 1997; Singh, 2000 and Yan and Hunt, 2001). This investigation determined the effect of environment on different genotypes and evaluated the relationship between the stability and selection techniques.

With these overall Fig.1 to 3 transmittance diagram of evaluation index and nonparametric stability analysed were concluded that, the Hosa Mysore, Tamil Nadu white, MU405, MU406, MG414 and MU1 races in section 1 were under the mean stability index as well as $e_i$ was above 50 and were considered as good stability and good $e_i$ but GNP and Kolar gold were environment insensitive and could be rear in the favourable season. From Fig.1, it has revealed that GNP, Kolar gold and MG414 fall in section 2 where environment effects and could be rear in the favourable season. But Nistari, C.nichi and Pure Mysore in section 4 have under the mean $P_i$ considered as good stability with low evaluation index because of the voltinism, where as Hosa Mysore, Tamil Nadu white, MU1, MU405 and MU406 have not only good stability but also have good $e_i$ because they falls under $P_i$ mean and above 50 $e_i$. 
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Fig 1. Transmittance diagram of evaluation index and Pi

Fig 2. Transmittance diagram of evaluation index and Si

Fig 3. Transmittance diagram of evaluation index and Si
Moreover, the Fig.2 and 3 nearly showed same results in Fig.1. Genotypes with fewer changes in rank are considered to be more stable. This idea of stability is often considered as a biological or static concept of stability. However, most breeders and agronomists prefer genotypes with high mean yields and the potential to respond to improved management practices or environmental conditions. Data as those analyzed above are of real value since they could offer the opportunity to choose genitors with levels of stability both for yield and other quantitative characters of interest in silkworm breeding programmes. It is assumed that such genitors might transmit to off springs the genetic basis of this stability and diversity of silkworm races. Conservation of commercial genotypes in germplasm depends to production and stability. Thus, nonparametric methods for estimation of stability for evaluation index will help in judging selection of suitable genotypes and appropriate crossing programs in silkworm.

References


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