MATERIALS AND METHODS

The present study has been undertaken in Multivoltine Breeding Laboratory at Central Sericultural Research and Training Institute, Mysore with the main objective to select promising multivoltine × bivoltine hybrids for commercial exploitation. At the very outset, selection of promising parents was made. Different multivoltine and bivoltine silkworm breeds were drawn from the working germplasm maintained at CSR & TI, Mysore. Eighteen multivoltine silkworm breeds viz; BL23, BL24, BL27, BL33, BL43, BL44, BL61, BL62, BL65, BL67, BL68, BL69, 96A, 96C, 96E, 96H, RD1 along with Pure Mysore (PM) and twelve bivoltine silkworm breeds namely, CSR2, CSR3, CSR4, CSR5, CSR6, CSR12, CSR16, CSR17, CSR18, CSR19, NB4D2 and KA were utilized as initial materials in the present study.

Rearing of multivoltine and bivoltine silkworm breeds was carried out twice during November - December, 2003 and February - March, 2004 to assess the performance of the breeds. Each multivoltine and bivoltine silkworm breed was reared in replicates of three by feeding leaves of V1 mulberry variety. After 3rd moult, 300 larvae were retained in each replicate until spinning. Cocoons were harvested on 6th day of spinning. Good as well as defective cocoons were sorted out and cocoon assessment was made. Sixty cocoons were utilized for reeling test. Data were recorded for ten economic characters viz., fecundity, hatching percentage, pupation
rate, cocoon weight, cocoon shell weight, cocoon shell percentage, filament length, reelability, raw silk percentage and neatness, pooled together and subjected to relevant statistical analysis such as Multiple Traits Evaluation Index method of Mano et al. (1993). Evaluation index (E.I.) values for different characters in multivoltine and bivoltine breeds are given in Table 1 and 2 respectively. Based on E. I. values, relative rankings were assigned. Breeds that scored more average E.I. value greater than 50, were considered to possess greater economic value. Top ranked six multivoltine breeds namely, BL<sub>67</sub>, BL<sub>68</sub>, 96A, 96E, 96H and PM and six bivoltine breeds viz., CSR<sub>2</sub>, CSR<sub>3</sub>, CSR<sub>4</sub>, CSR<sub>12</sub>, CSR<sub>17</sub> and NB<sub>4D</sub><sub>2</sub> were short listed as potential parents for hybrid evaluation. Selected multivoltine breeds were utilized as lines whereas bivoltine breeds were utilized as testers. Characteristics of selected breeds are shown in Table 3. Each line was crossed with all the testers raising thirty six hybrids.

Rearing of hybrids along with parents was carried out with three replications following standard rearing technique during three major seasons of the year i.e., Summer (March – April), Rainy (July – August) and Winter (November – December) in order to assess their performance under varying environmental conditions. After 3<sup>rd</sup> moult, 250 larvae were retained in each replication and reared up to spinning in well maintained environmental conditions. Cocoons were harvested on 6<sup>th</sup> day of spinning. After harvesting, cocoons were deflossed and good as well as defective cocoons such as uzi infested, melted, undersized were sorted out. Cocoon assessment was made on the subsequent day. Twenty five male and
twenty five female cocoons were utilized for cocoon assessment. Sixty cocoons were taken for reeling test and one hundred cocoons were utilized for cocoon size measurement.

**Computation and Data analysis**

Data were generated on the expression of fourteen characters *viz.*, fecundity, hatching percentage, total larval duration, $V^{\text{th}}$ instar larval duration, yield / 10,000 larvae, pupation rate, cocoon weight, cocoon shell weight, cocoon shell percentage, filament length, reelability, raw silk percentage, denier and neatness, pooled together and subjected to relevant statistical analysis to adjudicate superior multivoltine × bivoltine hybrids.

**Statistical approaches followed**

Various statistical methods were employed to analyze the performance of parental silkworm breeds and their hybrids for fourteen characters of economic importance. A brief account of the statistical approaches followed is mentioned as –

**Combining ability analysis** : Line × tester method for combining ability analysis suggested by Kempthorne (1957) was employed to determine general combining ability (GCA) of lines and testers and specific combining ability (SCA) of hybrids and also to understand the magnitude of hybrid vigour in different hybrids. It is one of the most important methods to analyze the relative capacity of a number of female
and male parents to produce desirable hybrids. Formulae applied for analyzing GCA and SCA are as follows:

**General Combining ability**

\[ g_i = \frac{\sum_{j=1}^{t} x_{ij}}{l} \]

a) Lines \( g_i \)

\[ g_j = \frac{\sum_{i=1}^{l} x_{ij}}{t} \]

b) Testers \( g_j \)

**Specific Combining Ability:**

\[ s_{ij} = \frac{\sum_{j=1}^{t} x_{ij}}{r} \]

Hybrids \( s_{ij} \)

where, \( g_i \) = general combining ability of lines

\( g_j \) = general combining ability of testers

\( s_{ij} \) = specific combining ability of hybrids

\( l \) = number of lines

\( t \) = number of testers

\( r \) = number of replications

\( X_i \) = performance of \( l \)th line with \( t \) testers

\( X_j \) = performance of \( j \)th tester with \( l \) lines

\( X_{ij} \) = performance of \((i \times j)\) th hybrid and

\( X \) = grand total
**Hybrid vigour analysis**: Heterosis over mid parental value (MPV) and better parental value (BPV) were calculated using following formulae:

\[
\text{Heterosis over Mid Parent Value (MPV)} = \frac{(F_1 - \text{MPV})}{\text{MPV}} \times 100
\]

\[
\text{Heterosis over Better Parent Value (BPV)} = \frac{(F_1 - \text{BPV})}{\text{BPV}} \times 100
\]

**Multiple Traits Evaluation Index**: In order to judge the superiority of a breed/hybrid impartially, a common index called ‘Evaluation index is used. Formula of multiple trait evaluation index method as suggested by Mano *et al.* (1993) is given below:

\[
\text{Evaluation Index} = \frac{A - B}{C} \times 10 + 50
\]

where, 

A – Value obtained for particular hybrid combination.
B – Mean value of a particular trait for all hybrid combination.
C – Standard deviation
10 – Standard unit
50 – Fixed value.

The indices obtained for all the characters are combined to get a single value which is actually E. I. Average index value fixed for selection of combination is greater than 50. Characters that showed relatively higher value (>50) were considered to have greater economic value and those hybrids that showed E. I. value above 50 were considered promising.
Cocoon size uniformity: Uniformity in cocoon size in different crosses between multivoltine and a bivoltine breed has been observed. One hundred cocoons from each hybrid were randomly picked up, cocoon length and width were measured separately using Vernier calipers. Cocoon width was measured in the middle region of each cocoon. Length / width ratio was calculated using following formula:

\[
\frac{L}{W} \text{ ratio} = \frac{\text{Length}}{\text{Width}} \times 100
\]

Standard deviation and coefficient of variation were also calculated. Based on standard deviation (SD) and coefficient of variation (CV), cocoon size uniformity was determined. Hybrids that showed SD value around 8 or less than 8 as well as less CV were considered uniform in cocoon size.

Analysis based on genotype × environment interaction

Genotype × environment interaction is of major importance to the breeders in developing new breeds. The choice of a breed depends not only on genotype itself but also on its performance under variable environmental conditions. Hence, analysis of variance for genotype × environment interaction (G × E) for highly significant differences among the breeds / hybrids for specific characters in all rearing seasons has also been analyzed as per Kempthorne (1957).
Evaluation of multivoltine × bivoltine hybrids

Promising multivoltine × bivoltine hybrids were further evaluated in a limited scale with the farmers. Five hundred disease free layings (dfls) of each hybrid were supplied to a few farmers. Data were recorded for cocoon yield/100 dfls, cocoon weight, cocoon shell weight, cocoon shell percentage and cocoon rate in order to select promising hybrid for commercial exploitation.