INTRODUCTION

Breeding is defined as the overall improvement of a domesticated animal or plant for maximum exploitation of its genetic resources with reference to or in relation to the climatic zone and geographic area where it is reared. Silkworm is one of the most genetically exploited animal, since its domestication during ‘Han Dynasty’ in China about 5000 years ago. Silkworm is one of the few organisms wherein the principles of genetics and breeding were applied to harvest maximum output. It is next only to maize in exploiting the principles of heterosis and hybrid vigour.

Breeding as an important tool has been exploited by many breeders in the improvement of livestock for their economic gains. Apart from livestock, among insects, the silkworm *Bombyx mori* L. has been subjected to different kinds of breeding techniques to attain maximum silk productivity. Silkworm breeding is essentially conducted to bring together all desirable genes in appropriate combinations to improve the genetic potentiality for maximizing the cocoons yield and productivity per unit area and population. The genetic variability expresses in different genetic material paves the way to amalgamate many desirable genes into a single breed through conventional breeding methods.

Today, Silkworm races are available to the mankind in quite good number possessing considerable variation in different characters. Cause of such variations are mainly, because of the geographical differences wherein the natural selection and the genotype x environment interactions have played a significant role, by drifting them from their original stocks. Mankind is more interested in looking into these drifts / changes happened which are advantageous to his well being. However, the introduction of different stocks in different geographical / agroclimates and simply leaving to the nature to select, is time consuming and hence, he took up the Silkworm breeding techniques as a tool to bring in these “drifts” or changes in the original population / stocks. Large number of such improvement studies had resulted in quite a good number of silkworm genetic resources.

Silkworm breeders in tropical countries like India have the task of exploiting the potential of different stocks having superior qualities (of bivoltines) which are mainly not acquired in our conditions. Hence, it makes that more difficult to derive
few appropriate population or lines or breeds from these stocks which possess meaningful characters for our agro-climates.

Selection of appropriate breeding resource materials for any improvement programme is very essential but not a simple one. The desirable level of success depends on the selection of initial breeding resource materials, their effective utilization in different combinations to the genetic expression of the character under consideration (Mano, 1992). All animal improvement programmes aims at a derivation of better constellation of gene complex which suits to express good phenotypic values on a wide range of traits by amalgamating distinct and different gene pools. It is a well known fact that no breeder can expect a readymade supply of information on distinctness or the magnitude of difference existing amongst one another in a group of breeding resource materials available to him. Therefore, it is imperative to a breeder to identify distinct and different gene pools existing in a group of resource materials.

The success of breeding depends on the initial selection of parents, their judicious utilization in appropriate and desirable combinations and choice of mating systems to generate ample genetic variability for facilitating enough scope for selection. The genetic worth of the initial parents to be utilized in the breeding programme allows the breeder to critically analyze the most suitable and effective genoptype before choosing as a breeding resource material. Therefore, it is of paramount importance that utmost care has to be taken by the breeder in verifying and analyzing the genetic worth of the initial parents to be utilized as potential resource material by employing various selection methods (Suresh Kumar et al., 2006; Lakshmi and Chandrashekariah, 2007 and Harjeet Singh and Suresh Kumar, 2008).

The understanding of the genetic endowment of the parents to be utilized in the breeding programme permits the breeder to critically analyse the most effective genotypes before choosing as a resource material. It is well known that most of the characters of economic importance in silkworm are quantitative in nature, phenotypic expression of which is greatly influenced by the environmental factors such as temperature, relative humidity, light and nutrition. It is essential to measure the degree of phenotypic manifestation for the characters of economic importance under both similar and variable environmental conditions in order to understand the
genetic endowment pertaining to adaptability and productivity of the breeding material. Generally, such information is often not available to the breeder who is handicapped in selecting the initial parents from the local races without evaluation. As a result, they were able to fix certain gene blocks rapidly with correlated response in the adverse direction in many cases. Therefore, the problem of balancing and fixing the desirable traits for local environments is a challenge for the breeder (Nirmal Kumar and Yamamoto, 1994). Further, the breeder has to understand the range of reaction of the selected genotypes under variable environmental conditions in order to utilize them appropriately in the breeding programme (Nirmal Kumar and Sreerama Reddy, 1998).

Breeding programmes aimed at breed improvement have generally relied on the use of established breeds or elite lines. The goal of breeding is to bring together the desirable constellations of genes in appropriate combinations in order to improve the genetic performance for maximising the yield and productivity per unit of population. Many silkworm breeders (Nirmal Kumar and Sreerama Reddy, 1988; Kogure, 1933) emphasized the need for better understanding the genetic diversity of parental strains to be utilized in the breeding programme by systematic evaluation. Critical assessment of quantitative nature that is influenced by environmental factors paves the way for breeder for their effective utilization. The significant variations observed in the phenotypic manifestation for the traits analyzed among the breeds can be attributed to the genetic constitution of strains and their degree of expression to which they are exposed. Since, the genetic improvement of multiple traits being the objective of evolving the productive bivoltine hybrids suitable for tropical climate, many breeders (Naseema Begum et al. 2001; Ramesh Babu et al. 2001; Sudhakar Rao et al. 2001; Lakshmi and Chandrashekariah, 2008) followed specific methods to identify the suitable breeding resource materials. Therefore, it is imperative to a breeder to identify distinct and different gene pools existing in a group of resource materials.

The silkworm races in recognition of their economic importance have been extensively studied for the desirable traits through inbreeding by the breeders. However, continuous and prolonged inbreeding results in the deterioration of some of the economic traits. Nevertheless, the overall combinations of beneficial traits could be achieved in a reasonable way by several breeding techniques followed by selection procedures, as the silkworm breeder has at his disposal a diversified array
of gene combinations to manipulate and isolate new silkworm breeds having desirable qualities for commercial exploitation. According to Kovolov (1970), the improvement of indigenous races could be achieved through hybridization utilizing exotic races. Further, Harada (1956) opined that new silkworm breeds could only be evolved through hybridization followed by selection. Though, India has a number of indigenous races, it suffers for want of new silkworm races in competing with other sericulturally advanced countries such as China and Japan where significant progress has been achieved in synthesizing highly productive and resistant silkworm races suitable to their native climatic conditions through hybridization (Yokoyama, 1956).

Various silkworm improvement studies have been undertaken at different Sericultural Research Institutions, across the globe. Satellite Silkworm Breeding Station, Coonoor is one amongst such designated Institution in India, undertaking silkworm improvement studies orienting the objectives to meet out the regional requirements. Sub-tropical climate prevailing in the Nilgiris hill area brings boon, together with bane. Though the semi-temperate / sub-tropical conditions prevailing in the western ghats of Nilgiris been an ideal, to realize the full potential of bivoltine silkworm breeds and hybrids, the prolonged larval duration observed with sericulturists of the area acts as a deter to this avocation. The prolonged larval duration exposes more duration to the vagaries of hill climate and often leads to poor yield from crops succumbing to pathogens. It became imperative to take up silkworm improvement studies with an objective of developing breeds with relatively shorter larval duration with out compromising on productivity traits.

Silkworm breeding aims to achieve superior performances in respect of egg yield, cocoon raw silk yield, cocoon stability and production followed by expansion to new areas besides others. Silkworm breeders continue to strive for an inherent gain in resistance by incorporating resistant genes into the genetic backgrounds of high yielding temperate bivoltines. Besides this, the cocoon crop stability also relies more on improving other production technologies which have to be explored. It is interesting to note that in breeding experiments, besides choice of parents, selection and inbreeding the hybrids is very important which has to be carefully executed since both inbreeding and hybridization are forms of non-random mating or selective mating, but operate in opposite ways. Inbreeding is a kind of genetic assortative mating as compared with phenotypic assortative mating in hybridization. The major
effect of inbreeding which is most apparent in the reduction of mean performance of the population in question. While gene frequencies do not change on the whole, genotypic frequencies do change towards the production of more homozygotes and fewer heterozygotes. Thus, any change in the population mean as a result of inbreeding must be related to difference in genotype value between homozygote and heterozygote (Suresh Kumar, 2005).

The genetic effect of inbreeding is that it makes more pairs of genes in the population homozygous regardless of the kind of gene action involved. The fact that in breeding, the number of pairs of genes that become homozygous regardless of the phenotypic expression of these genes and how many genes are involved allows us to make certain conclusions regarding the important genetic effect. Inbreeding does not increase the number of recessive alleles in a population, but merely brings them to light through increasing homozygosity. Inbreeding fixes characters in an inbred population through increased homozygosity whether or not the effects are favourable or unfavourable. Since inbreeding makes more pairs of genes homozygous the offspring of inbred parents are more likely to receive the same genes of their parents than the offspring of non-inbred parents. Inbreeding, if accompanied by selection, increases the phenotypic uniformity within an inbred line. Many of the adverse effects of inbreeding in animals are known to be due to the action of recessive genes (Suresh Kumar, 2005).

Conventional breeding methods employed by the breeders have enabled to achieve the desired objective in several plant and animal species. The selection of superior parental combinations to a large extent determines the degree of success of the breeding programme. The success depends on the initial selection of parents, their effective utilization in desirable combinations, choice of mating systems to obtain genetic variability to step up selection. Proper evaluation of suitable parents is therefore crucial for breeders (Suresh Kumar and Mano, 2005).

It is well documented that F1 hybrids are superior to their parents in many qualitative and quantitative traits (Toyama, 1906). Chinese and Japanese breeders have made notable progress through the improvement of ecologically important quantitative traits in silkworm (Harada, 1961; Gamo, 1976; Mano, et al, 1991; Chen et al, 1994). Evaluation studies on various objectives of screening silkworm breeds / hybrids for tropical climate (Sudhakar Rao, et al, 2001 and 2002; Lakshmi and
Chandrashekharaiah, 2008), identification of silkworm breeds for thermo-tolerance (Lakshmi and Chandrashekariah, 2007; Harjeet Singh and Suresh Kumar, 2008) were taken up by many authors. Identification of different agro-climatic zones in India on the merits of climatic conditions, soil conditions and production constraints were also, attempted (Iyengar et al., 1993, Iyengar, 1995). Development of silkworm breeds / hybrids suitable to sub-tropical conditions of Northern India is primarily undertaken by Central Sericultural Research and Training Institute, Pampore and this institute had reported the development of new bivoltine hybrids, viz., YS3 x SF19, SH6 x KA, Pam 101 x SF19, SH6 x NB4D2 during 1980’s and CP1B x JP1B, CP1B x J-Plain, CS6 x PAM 101, Dun 6 x Dun 21, RSJ3 x RSJ1, RSJ14 x RSJ11 during 1990’s and also, Dun 6 x Dun 22 and Dun 16 x Dun 17 in recent times and further, CS6 x PAM 101, Dun 6 x Dun21 and RSJ3 x RSJ1 were authorized by provincial race authorization committee (Annual reports of CSRTI, Pampore). Similarly, Satellite Silkworm Breeding Station, Coonoor had undertaken silkworm improvement studies to address the specific needs of sub-tropical hill conditions.

Silkworm breeding is essentially conducted to bring together all desirable genes in appropriate combinations to improve the genetic potentiality for maximizing the cocoons yield and productivity per unit area and population. The genetic variability expresses in different genetic material paves the way to amalgamate many desirable genes into a single breed through conventional breeding methods. The desirable level of success depends on the selection of initial breeding resource materials, their effective utilization in different combinations to the genetic expression of the character under consideration (Mano, 1992a). The silkworm races in recognition of their economic importance have been extensively studied for the desirable traits through inbreeding by the breeders. However, continuous and prolonged inbreeding results in the deterioration of some of the economic traits. Nevertheless, the overall combinations of beneficial traits could be achieved in a reasonable way by several breeding techniques followed by selection procedures, as the silkworm breeder has at his disposal a diversified array of gene combinations to manipulate and isolate new silkworm breeds having desirable qualities for commercial exploitation.

It has been a long felt demand from DOS, Nilgiris that a bivoltine hybrid with shorter larval duration will be of better choice for hill area farmers, as the larval duration in the productive bivoltine hybrids, namely CSR hybrids, exceeds 27 days.
Prolonged larval duration also, exposes to the vagaries of hill climate for more period and subsequently often such crops succumbs to pathogens and resulting in poor yield. It is also a well established fact that shorter the larval duration, healthier the silkworms. Otherwise, increase the time lag, there is corresponding increase in multiplication of pathogen during the crop period. Therefore, not only in tropical highlands, in plains also, there was a need for silkworm breeds / hybrids with relatively shorter larval duration, which are comparatively in a better position to overcome poor yield levels.

Therefore, it becomes imperative to develop silkworm breeds / hybrids with relatively shorter larval duration without compromising the productivity traits. Earlier efforts made by many silkworm breeders had resulted with breeds of shorter larval duration successfully but often they were found to be with lower productivity merits. Bearing, these aspects in mind, a silkworm breeding study was formulated which is aimed to develop silkworm breeds with relatively shorter duration with out compromising much on the productivity merits.
The success of breeding or selection processes depends on how well the resulting populations are fit for a range of economic as well as climatic conditions. The main challenge for the breeder is to decide the order of priority for the required characters, to keep the short list of selected characters and stick to this decision. Most of the economic characters are influenced both by environment and genetic factors and the contributions of which may vary for different traits (Nagaraju, 1998). Adaptability of the breeds/hybrids and sustainability in cocoon yield are considered to be the prime characters. Since beginning, primary focus of most of the silkworm breeding programmes is centered on the exploitation of the quantitative traits through hybridization. However, for spring rearing, importance is given for heavy cocoon, high cocoon shell weight and high raw silk percentage, while for summer and autumn rearings, importance is given for high survival and shell percentage.

During the process of breeding and selection, the silkworm should be sturdy and easy to rear followed by the cocoon and silk quality. Further, ensuring good quality mulberry leaves is a pre-requisite for successful silkworm rearing. Optimal environmental conditions facilitate the full expression of the genotype under study. Therefore, during the course of breeding, creation and maintenance of more or less similar/uniform environmental conditions for which the genotypes are exposed is of paramount importance. Exposure of genotypes to fluctuating and unfavourable environment is to be avoided as evaluation may become erroneous (Suresh Kumar et al., 2004a).

In India, high yielding bivoltine silkworm strains are developed through inbreeding of hybrids obtained from Japan followed by selection for various yield attributes under laboratory (Basavaraja et al., 1995; Datta et al., 1997, 2000a, 2000b, 2001a). The silkworm strains thus developed are utilized to obtain hybrids of polyvoltines x bivoltine and bivoltine x bivoltine hybrids for farmers in different parts of the country, who often fail to provide optimum conditions that are required for full genetic manifestation of the silk attributes. As a result of this, it is estimated that only 40% of the genetic potential of these breeds is realized in India (Nagaraju, 2002). Therefore, it is of paramount importance to know in detail the effect of environment on the performance of silkworm races before contemplating on the idea of
formulating breeding programme for the development of silkworm breeds tolerant to adverse environmental conditions.

Though the nature of silkworm healthiness is unclear, healthy silkworm varieties are important for the stabilization of silkworm crops. There are two kinds of healthiness in the silkworm, one is on resistant against diseases and another is adaptability to adverse environment (high temperature, humidity, bad nutrition, etc). Shorter larval duration races are generally considered as healthy varieties. In India, several attempts have been made to isolate silkworm genotypes for different agro-climatic conditions (Datta, R.K., 1984; Kalpana and Sreerama reddy, 1988; Harjeet singh and Suresh Kumar, 2010; Lakshmi, et al, 2011). Various attempts have been made to isolate silkworm races with shorter larval duration (Raju and Krishnamurthy, 1987; Sreerama reddy and Subramanya, 1982; Subramanya and Sreerama reddy, 1982; Sudhakara Rao, et al., 2004; Shankar and Subramanya, 2010).

Lakshmanan, et al (2000a) had reported two new productive bivoltine hybrids, CNR 4 x CNR10 and CNR15 x CNR1, identified in a breeding study taken up at Regional Sericultural Research Station, Coonoor. Lakshmanan, et al (2000b) had also, reported on the mid way evaluation on synthesis of breeds with shorter larval duration and productive traits taken up at Regional Sericultural Research Station, Coonoor. Lakshmanan and Sen (2002) had reported on the measures of conservation, management and utilization of silkworm germplasm resources made at Regional Sericultural Research Station, Coonoor. Same authors (2003a) had given an over view and an account on pre-breeding strategies employed in silkworm breeding studies at Regional Sericultural Research Station, Coonoor. Lakshmanan, et al (2003b) had reported on the development of two new productive bivoltine hybrids, CSR13 x CNR3 and CNR4 x B120, derived from a hybrid study taken up at Regional Sericultural Research Station, Coonoor. Lakshmanan, et al (2008) had also, reported on the attempt made on shuttle breeding approach adopted in development of new bivoltine hybrids derived from two different environments, temperate conditions of Nilgiris and the plain conditions of Mysore.

Genotype- environment interactions are of major importance to the breeder in developing new breeds. It is well established that the phenotypic expression of genotypes for various quantitative traits are not consistent in all the environments. Further, the management practices, disease control measures, diverse
environmental factors prevailing in tropics play a significant role in the expression of quantitative traits. The association of genes and environment in the phenotypic manifestation of quantitative traits has been studied in silkworm also. With no exception to silkworm, a closer analysis of variability of the breeds, their respective environment and interaction between the two shows that environment can directly affect the phenotype through nutrition, disease incidence, management etc., However, it can directly affect the genotype by way of altering gene frequencies (Nirmal Kumar and Sreerama Reddy, 1998; Rajanna and Sreerama Reddy, 1998).

It is estimated that for one economic trait, in two genotypes reared at two environments, as many as 24 different G x E interactions are possible (Allard and Bradshaw, 1964). Accordingly, in silkworm breeding, when all the important economic number of possible G x E interactions become virtually infinite. Only a small portion of them are of interest to the breeder and the success of breeding programme depends on positive selection of these genotypes with desired interaction. But, our present understanding of G x E interactions is that, by rearing the breeds in laboratory environment, precise predictions cannot be made about their phenotypic expression in different environments but for measuring their phenotype and genetic mean as well as the environmental; component of variance. Nevertheless, the results of breed x location interaction studies have shown that in general, the performance of the breed itself will be the best indicator of the suitability of its genotype to the prevailing environment. In view of the above, it is opined that selection of the genotype based on their performance in the native environment would help to integrate various factors leading to isolation of region/season specific tropicalized breeds for commercial exploitation (Rajanna and Sreerama Reddy, 1998).

The environment can have direct effect on the phenotype, for example through nutrition, disease incidence and management, but can have no effect on the genotype. The genotype can only be indirectly affected by the environment by the alteration of gene frequency so that only certain animals are selected as parents for the next generation and others are ignored. It would appear that the character required is best selected for environmental conditions which favour its fullest expression and once developed it could also be used in other environments provided the other characters specially required for the new environment are also present in the animal. It is apparently assumed that genetic background for the
character is essentially the same in all the environments. Similarly, Mano (1992a, 1993) suggested that since the economically important characters of silkworms are affected by both genetic and environmental factors, during breeding, the effect of environmental factors should be minimized to the maximum extent possible and genetic variation should be measured and evaluated in order to select the desirable lines efficiently. Therefore, all the breeding lines should be reared at a time in good environment, so that it becomes easy for evaluation of different breeding lines and also to produce hybrids by utilizing the breeds evolved by different breeding methods (Basavaraja et al., 1998).

On the other hand, Falconer (1990) after reviewing the published work on various animal species concluded that performance is best improved by selection in the environment in which it is subsequently exploited. In light of the above, the yield gaps due to inconsistent and lower cocoon yields realized by the farmers may be visualized as the correlated response of the improved races, bred in the laboratory. Further, keeping in view of the complex interaction between the genotypes (specially at larval stage) and the tropical rearing environment, Rajanna and Sreerama Reddy, (1998) are of the opinion that, initiating breeding experiments in the native environment (in which they have to be commercially exploited later) would facilitate direct response of the suitable genotype to the prevailing environment and yield consistent cocoon crops.

It is well known that owing to severe socio-economic conditions, it is difficult to create the desired environment for the productive races in the farmers rearing house. As an alternative, suitable genotypes can be bred to meet the environmental challenges (Barker, 1982). Further, upward selection in bad environment reduces environmental sensitivity of the breed (Falconer, 1990). Accordingly, by rearing the segregating genotypes of silkworm in the native environment followed by selection and breeding over generations, the genotypes may get buffered against the prevailing environmental challenges (Rajanna and Sreerama Reddy, 1998).

The selection of suitable breeding resource material helps the breeder to successfully amalgamate desired traits. Appropriate experimental design, selection methods employed in fixing the major traits contributing to the improved cocoon yield leads to the success of any breeding programme. Besides, understanding the genetic diversity of parental strains to be utilized in the breeding programme by their
systematic evaluation, critical assessment of their quantitative nature which is greatly influenced by the environmental factors such as temperature, light, relative humidity, nutrition (Kogure, 1933; Legay, 1958; Ueda and Lizuka, 1962; Suzuki et al., 1962; Yokoyama, 1963; Arai and Ito, 1967; Horie et al., 1967; Naseema Begum et al., 2001; Sudhakar Rao et al., 2002 and Harjeet Singh and Suresh Kumar 2008). The selection of superior parental combinations to a large extent determines the degree of success of the breeding programme. The success depends on the initial selection of parents, their effective utilization in desirable combinations, choice of mating systems to obtain genetic variability to step up selection. Proper evaluation of suitable parents is therefore crucial for breeders (Suresh Kumar and Mano, 2005).

Synthesis of new gene combinations by conventional breeding techniques utilizing the appropriate breeding resource materials is one of the important tools for exploiting the phenomenon of hybrid vigour in the silkworm (Harada, 1961). Systematic hybridization coupled with appropriate selection procedures have contributed to amalgamate the major economic traits of choice from selected breeds and to synthesize genotypes of desirable genetic constitution. Hybridization of silkworm breeds with different genetic constitution can be made either by crossing two or four parents depending on the traits the breeder desires to introduce for improvement of productivity (Mano et al., 1998). Of the three methods of conventional breeding, the cross breeding is the most efficient and productive to improve the characters of commercial value (Sang, 1956; Bowman, 1959 and Kovalov, 1970).

The contribution of Japanese breeders in the field of silkworm breeding has resulted in an increase in quantitative traits. Further, they were able to establish correlation among the quantitative traits of economic importance (Tsuchiya and Kurashima, 1959; Suzuki and Naruyama, 1961; Kobari and Fujimoto, 1966 and Gamo and Ichiba, 1971). The Japanese breeders were able to analyse the characters that could be improved through selection and heterosis (Hirobe, 1956; Harada, 1961; Yokoyama, 1979 and Gamo, 1983).

The genetic consequences due to linkage, position effect, penetrance and expressivity decline the probability of fixation of desirable traits in a population (James, 1972; Harris, 1977 and Hill, 1974). Due to continuous inbreeding, the
chance of selection and rate of fixation of beneficial or deleterious alleles is very high in small populations (Charlesworth and Charlesworth, 1987 and Lynch, 1988). Inbreeding, if accompanied by selection, may increase the phenotypic uniformity within an inbred line. Many of the adverse effects of inbreeding in animals are known to be due to the action of recessive genes (Suresh Kumar, 2005). During the course of breeding, genetic response is taken as function of selection differential. Moreover, silkworm harbours genetic antagonism between the viability and productivity traits, the heritability of this trait is low and yield attributes with moderate to high heritability (Gamo, 1983 and Yan, 1983). This can be overcome by maintaining a large population size and utilization of mass sub groups and crossing them to obtain maximum selection gains. Population size (n) in the range of 60-240 is required in animal breeding to obtain the selection gain and to increase the fixation of desirable traits. According to Nirmal Kumar and Yamamoto (1994), high intensity of selection has to be avoided up to fourth/fifth generation.

According to Allard and Bradshaw (1964), performance of the strain itself in a given environment indicates its superiority. The significant variations observed in the phenotypic manifestation for the traits analyzed can be attributed to the genetic constitution of the strains and their degree of expression to which they are exposed during rearing. Variable gene frequencies at different loci make them to respond differently (Watanabbe, 1928; Hassanein and Sharawy, 1962; Krishnaswami and Narasimhanna, 1974; Ueda et al., 1975, Rajanna, 1989, Raju, 1990; Maribashetty, 1991; Kalpana, 1992; Nirmal Kumar, 1995, Basvaraja, 1996 and Sudhakar Rao et al., 2001).

The concept of genotype and environment interactions has been well documented (Sinnott et al., 1973); Knight, 1951; Yokoyama, 1956; Griffing and Zsiros, 1971; Orozco, 1976 and Strickberger, 1976). In silkworms, Harada (1961) has demonstrated a high degree of phenotypic variability with regard to various traits during different seasons.

Silkworm breeders have employed several statistical methods to evaluate the breeding resource material. Of late, sub-ordinate function method (Gower 1971 a, b) and joint scoring method is based on dependent characters (Arunachalam and Bandhyopadhyay, 1984) and Evaluation Index is accomplished for multiple traits.
Mano et al. (1993) are found to be more appropriate in evaluating the silkworm breeds.

Jayaswal, et al (2000) had studied genetic variation, correlation and path analysis for fecundity, larval period, larval weight, cocoon yield by number and weight, single cocoon weight, shell weight, shell ratio and filament length in thirty two bivoltine genotypes of tropical and temperate origin. The highest co-efficient of variation was observed for fecundity, filament length and cocoon yield by number. A high heritability value along with a high genetic advance was obtained for single shell weight, single cocoon weight and larval weight. Genotypic correlations of shell weight were significant in respect of larval weight, single cocoon weight, shell ratio and filament length. Path coefficient analysis revealed that the maximum direct positive effect to shell weight was contributed by the single cocoon weight followed by shell ratio, fecundity and larval period. The indirect effect of larval weight through single cocoon weight was higher than its direct effect. Combining ability in bivoltine genotypes under temperate conditions were studied by Chauhan, et al (2000), Rajalakshmi, et al, (1997) and these researchers had employed this method to estimate specific combining ability and general combining ability in new bivoltine genotypes developed in their breeding studies.

Animal breeding programmes aims to derive improvement in various quantitative traits simultaneously in a given point of time. Assessment of improvement achieved through various breeding approaches in all quantitative traits has been a difficult job, as the traits need to be measured are both negative as well as positive. Earlier attempts were made to design evaluation methods and indexing based on two to three traits (Saito, 1977; Iyengar, et al, 1983). However, in silkworm breeding studies, most commonly used method to evaluate quantitative traits was suggested by Mano, et. al (1992b and 1993) and being used widely since then by many silkworm breeders (Nirmal Kumar and Sreerama Reddy, 1998; Mano, et. al.,1998; Nassema Begum, et. al, 2001 and 2008; Ramesh Babu, et. al., 2002; Ramesha, et. al., 2009; Sudhakar Rao, et. al. 2001 and 2002). Some attempts were also made recently to assess genetic distance and heterosis through evaluation index method (Talebi and Subramanya, 2009). The joint scoring method suggested by Arunachalam and Bandyopadhyay (1984) also, was used by many authors (Lakshmi and Chandrashekharaiyah, 2008; Harjeet Singh and Suresh Kumar, 2008) to evaluate and screen out potential silkworm breeds.
Evaluation studies on various objectives of screening silkworm breeds / hybrids for tropical climate (Sudhakar Rao, et al, 2001, 2002, Lakshmi and Chandrashekharaiah, 2008), identification of silkworm breeds for thermo-tolerance (Lakshmi and Chandrashekariah ,2007, Harjeet Singh and Suresh Kumar, 2008) were taken up by many researchers. Identification of different agro-climatic zones in India on the merits of climatic conditions, soil conditions and production constraints were also, attempted (Iyengar et al, 1993; Iyengar, 1995; Hussain, et al, 2010; Gangwar, 2011). Development of silkworm breeds / hybrids suitable to sub-tropical conditions of Northern India is primarily undertaken by Central Sericultural Research and Training Institute, Pampore and this institute had reported the development of new bivoltine hybrids, viz., YS3 x SF19, SH6 x KA, Pam 101 x SF19, SH6 x NB4D2 during 1980’s and CP1B x JP1B, CP1B x J-Plain, CS6 x PAM 101, Dun 6 x Dun 21, RSJ3 x RSJ1, RSJ14 x RSJ11 during 1990’s and also, Dun 6 x Dun 22 and Dun 16 x Dun 17 in recent times and further, CS6 x PAM 101, Dun 6 x Dun21 and RSJ3 x RSJ1 were authorized by provincial race authorization committee (Annual reports of CSRTI, Pampore). Similarly, Satellite Silkworm Breeding Station, Coonoor has undertaken breeding studies to improve survival rate and shell ratio in bivoltine silkworm breeds for hill areas (Unpublished reports of SSBS, Coonoor) and has come up with two bivoltine hybrids, CNR4 x CNR3 and CNR14 x CNR3.

Heterosis, described in terms of the superiority of F1 hybrid performance over the parental performance, is a phenomenon widely observed in all improvement studies in plants as well as in animals. Heterosis breeding has been recognized as the most suitable breeding methodology for augmenting yield and quality parameters in silkworm and selection of suitable parents and assessment of degree of heterosis in resulting crosses forms an important step (Ridey et al., 2003). The term “heterosis” describes the superiority of heterozygous genotypes in one or more characteristics in comparison with the corresponding parental homozygotes (Shull, 1908). The increased productivity of the heterozygotes and the resistance of biotic and abiotic stress (Dobzhansky, 1950), is exploited through the development of hybrid varieties in several crop and animal species (Falconer, 1981; Stuber, 1994) and historically it represented one of the most revolutionary advancements in silkworm improvement (Ohkuma, 1971; Tayade, 1987; Nagaraju et al., 1996; Datta, et al, 2001). In India, the exploitation of heterosis through multivoltine x bivoltine crosses accounts for nearly 90% of silk production (Datta et al, 2001b).
Recent analysis of heterosis in selected quantitative traits in silkworm *Bombyx mori* L was taken up by Nirmal Kumar, *et al* (2010) wherein two different voltine groups were studied (Three multivoltine and five bivoltine breeds). They had found appreciable and variable amount of relative heterosis for pupation rate, cocoon weight, shell weight, shell ratio (%) and filament length which indicated genetic diversity among the parents used. Except for pupation rate, a negative heterobeltiosis was reported. The relative heterosis (%) varied from 8.95 to 37.14 in regular crosses and 8.97 to 36.6 in reciprocal crosses for different characters. In heterobeltiosis, it ranged from -10.57 to 4.17 in regular crosses and -11.06 to 5.68 in reciprocal crosses for different characters. Sudhakara rao *et al* (2006) has studied heterosis in five selected hybrids between resistant and susceptible bivoltine breeds of silkworm *Bombyx mori* to densonucleosis virus1 (BmDNV1) and reported that the selected hybrid CSR21DR x CSR28DR has exhibited significant positive heterosis and heterobeltiosis for maximum traits.

The magnitude of heterosis over mid parent and better parent were calculated in fifty bivoltine hybrids of five oval and five dumbbell type bivoltine genotypes of silkworm, *Bombyx mori* L for eight important traits under varying environmental conditions (Nirmal Kumar, *et al*, 2011). It was reported that the expression of both relative heterosis and heterobeltiosis was higher in summer (8.97 and 6.71%), followed by rainy (5.87 and 3.42%) and winter (2.13 and 0.03%). Among the characters, pupation exhibited higher heterosis (14.56%), followed by shell weight (11.74%), filament length (8.91%) and cocoon weight (6.49%) and further, it was found that all straight and reciprocal crosses exhibited significant positive heterosis and heterobeltiosis for pupation rate in all three environments. Suresh Kumar, *et al*, (2008) had taken up heterosis studies on hybrids of cocoon colour sex limited breed under different environments of thermal exposure and found that nine hybrids when compared with the parental values showed that all hybrids excelled their parents in many characters with significant positive heterosis over mid parent value and better parent value except few.

In India, concerted efforts of research and development contributed to the increased raw silk production, but the quality of raw silk is yet to match the international standard. But production of quality silk is a must to achieve a quantum jump in export of silk fabrics and also to save foreign exchange. Therefore, attempt
is made in this study to develop bivoltine breeds/hybrids with shorter larval duration without compromising on the productivity traits.
MATERIALS AND METHODS

Materials

Thirty one bivoltine silkworm breeds available at Satellite Silkworm Breeding Station, Coonoor, of which, eleven breeds, viz., C108, C120, CJ3P, SPC1, SH2, J2P, JC2P, JZH PO, NB1, A120 and A121, spin Chinese type or oval shaped cocoons and twenty breeds, viz., Dong 306, NN6D, N4, NJ1, SN1, SPJ1, SPJ2, 36PC, J1M, J2M, JA1, JB2, J122, JZH MC, M2, G146, G177, 14M, European and B120, spin Japanese type or peanut shaped cocoons were utilized for the new breeding study. The salient features of the germplasm screened for the selection of breeding resource materials is given in Table 1.

Table 1 Salient features of silkworm stock races available for selection of parents

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Race</th>
<th>Geographical origin</th>
<th>Larval Marking</th>
<th>Cocoons color / Cocoons shape / shell grains / floss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C108</td>
<td>China</td>
<td>Plain</td>
<td>white / oval / ordinary / less</td>
</tr>
<tr>
<td>2</td>
<td>C120</td>
<td>China</td>
<td>Plain</td>
<td>white / oval / medium / Less</td>
</tr>
<tr>
<td>3</td>
<td>Dong 306</td>
<td>China</td>
<td>Plain</td>
<td>white / short oval / medium / more</td>
</tr>
<tr>
<td>4</td>
<td>NN6D</td>
<td>China</td>
<td>Plain</td>
<td>white / oval / ordinary / less</td>
</tr>
<tr>
<td>5</td>
<td>J1(M)</td>
<td>Japan</td>
<td>Marked</td>
<td>white / elongate, constricted / ordinary / less</td>
</tr>
<tr>
<td>6</td>
<td>J2 (P)</td>
<td>Japan</td>
<td>Plain</td>
<td>white / elongate, oval / medium / less</td>
</tr>
<tr>
<td>7</td>
<td>J2(M)</td>
<td>Japan</td>
<td>Marked</td>
<td>white / deeply constricted / medium / less</td>
</tr>
<tr>
<td>8</td>
<td>JC2 (P)</td>
<td>Japan</td>
<td>Plain</td>
<td>white / oval / medium / less</td>
</tr>
<tr>
<td>9</td>
<td>CJ3(P)</td>
<td>Japan</td>
<td>Plain</td>
<td>white / oval / medium / less</td>
</tr>
<tr>
<td>10</td>
<td>M2</td>
<td>Japan</td>
<td>Plain</td>
<td>white / slight constriction / medium / less</td>
</tr>
<tr>
<td>11</td>
<td>SPC1</td>
<td>Japan</td>
<td>Plain</td>
<td>white / short oval / medium / less</td>
</tr>
<tr>
<td>12</td>
<td>SPJ1</td>
<td>Japan</td>
<td>Marked</td>
<td>white / slender constriction / medium / less</td>
</tr>
<tr>
<td>13</td>
<td>SPJ2</td>
<td>Japan</td>
<td>Marked</td>
<td>white / slender constriction / medium / less</td>
</tr>
<tr>
<td>14</td>
<td>N4</td>
<td>Japan</td>
<td>Marked</td>
<td>white / constricted / medium / less</td>
</tr>
<tr>
<td>15</td>
<td>J122</td>
<td>Japan</td>
<td>Plain</td>
<td>white / mild constriction / medium / less</td>
</tr>
<tr>
<td>16</td>
<td>14M</td>
<td>Japan</td>
<td>Marked</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>17</td>
<td>36 (PC)</td>
<td>Japan</td>
<td>Plain</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>18</td>
<td>SN1</td>
<td>Japan</td>
<td>Plain/Marked</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>19</td>
<td>NJ1</td>
<td>Japan</td>
<td>Marked</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>20</td>
<td>JA1</td>
<td>India</td>
<td>Plain/Marked</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>21</td>
<td>JB2</td>
<td>India</td>
<td>Marked</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>22</td>
<td>SH2</td>
<td>India</td>
<td>Marked</td>
<td>white / oval / fine / less</td>
</tr>
<tr>
<td>23</td>
<td>NB1</td>
<td>India</td>
<td>Plain</td>
<td>white / oval / medium / less</td>
</tr>
<tr>
<td>24</td>
<td>EUROPEAN</td>
<td>France</td>
<td>Plain</td>
<td>white / dumbbell / medium / less</td>
</tr>
<tr>
<td>25</td>
<td>JZH(P)</td>
<td>Brazil</td>
<td>Plain</td>
<td>white oval medium / less</td>
</tr>
<tr>
<td>26</td>
<td>JZH(MC)</td>
<td>Brazil</td>
<td>Plain</td>
<td>white / constricted / medium / less</td>
</tr>
<tr>
<td>27</td>
<td>G177</td>
<td>Vietnam</td>
<td>Marked</td>
<td>white / oval / medium / less</td>
</tr>
<tr>
<td>28</td>
<td>G146</td>
<td>Vietnam</td>
<td>Plain</td>
<td>white / constricted / medium / less</td>
</tr>
<tr>
<td>29</td>
<td>A120</td>
<td>India</td>
<td>Plain</td>
<td>White / oval / fine / less</td>
</tr>
</tbody>
</table>
Methods

1. Choice of parents

To select parental breeding resource materials, above thirty one bivoltine breeds were screened. Standard method of rearing practices were followed (Datta, 1992). The data pertaining to nine economically important traits viz., total larval duration, pupation rate, cocoon yield by weight for 10,000 larvae, cocoon weight, cocoon shell weight, cocoon shell percentage, average filament length, denier, and raw silk were recorded.

Multiple trait (Evaluation) Index

Multiple trait (Evaluation) Index was calculated as per the procedure suggested by Mano, et al (1992 and 1993).

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

Where, 

- A = Value obtained for a trait in a breed / hybrid,
- B = Mean value of a trait of all the breeds / hybrids,
- C = Standard deviation of a trait of all the breeds / hybrids
- 10 = Standard Unit
- 50 = Fixed value

In the above method, the objective as a whole is to select out those breeds which are scoring values above mean for any given trait. However, evaluation of negative traits cannot be made using the above formula and it warrants certain modification in the methodology.
Measurement of Negative traits

Measurement of negative traits such as larval duration and denier of thirty one silkworm genetic stocks were taken for the analysis.

Adopting the same principle followed in the above method outlined by Mano, *et al*, (1992b and 1993) and rather keeping it intact, the investigator group has modified the evaluation index for negative traits, as below:

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

Where, \(B\) = Mean value of a trait of all the breed /hybrid combinations,
\(A\) = Value obtained for a trait in a breed / hybrid combination,
\(C\) = Standard deviation of a trait of all the breeds / hybrids,
10 = Standard Unit
50 = Fixed value

By above modification, one can make out the measurement of negative traits which is desired to be lesser than the mean value for a given trait and the traits such as total larval duration, denier, etc., can be measured successfully.

As prescribed for positive traits, the breeds/ hybrids with average index value > 50, on negative traits are considered to be better performers which were the resultant of index measurement made on number of important traits covering various economic parameters.

Index Scoring Method

Index Score= Using suitable intervals, the range of variability with regard to a character is classified into maximum and minimum index values. The sum of index values with regard to all the characters of an individual represents the individuals’ score. The maximum and minimum score that an individual can get is nx3 and nx1 respectively, where n is the total number of traits studied
Table 2: Scoring of traits considered for the study

<table>
<thead>
<tr>
<th>Range of means</th>
<th>Larval Duration</th>
<th>Yield/10000 larvae</th>
<th>SCW</th>
<th>SSW</th>
<th>Shell (%)</th>
<th>Fila ment length</th>
<th>Fila ment size</th>
<th>Raw silk (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>652</td>
<td>7217</td>
<td>11.25</td>
<td>1.414</td>
<td>0.304</td>
<td>19.58</td>
<td>856</td>
<td>2.00</td>
</tr>
<tr>
<td>Max</td>
<td>749</td>
<td>9222</td>
<td>16.33</td>
<td>1.852</td>
<td>0.447</td>
<td>24.19</td>
<td>1191</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Index Score

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>652 – 684</td>
<td>8554 – 9222</td>
<td>14.64 – 16.33</td>
<td>1.706 – 1.852</td>
<td>0.399 – 0.447</td>
<td>22.65 – 24.19</td>
<td>1079 – 1191</td>
<td>2.00 – 2.25</td>
<td>17.74 – 19.21</td>
</tr>
</tbody>
</table>

2. Evolution of productive breeds through hybridization and selection

**Amalgamation**

Selected breeding resource materials, twelve breeds, were subjected for hybridization to amalgamate good economic traits on fitness, productivity, fibre quality and shorter larval duration. Oval breeds were crossed with ovals and dumbbells were crossed with dumbbells as also the breeds with plain larvae with plain larvae and marked larvae with marked larvae.

Priority was given to top performers in the evaluation and selective crossing was made keeping the objective and giving representation to different groups. Thus, seventeen F1 combinations were prepared considering the above parameters.

Table 1: List of new F1 Combinations prepared for the study.

<table>
<thead>
<tr>
<th>SI No</th>
<th>New F1 Combinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CJ3P x A120</td>
</tr>
<tr>
<td>2</td>
<td>CJ3P x A121</td>
</tr>
<tr>
<td>3</td>
<td>A121 x CJ3P</td>
</tr>
<tr>
<td>4</td>
<td>CJ3P x J2P</td>
</tr>
<tr>
<td>5</td>
<td>J2P x CJ3P</td>
</tr>
<tr>
<td>6</td>
<td>SPC1 x A120</td>
</tr>
<tr>
<td>7</td>
<td>SPC1 x A121</td>
</tr>
<tr>
<td>8</td>
<td>G146 x European</td>
</tr>
<tr>
<td>9</td>
<td>European x 36 PC</td>
</tr>
<tr>
<td>10</td>
<td>G146 x M2</td>
</tr>
<tr>
<td>11</td>
<td>M2 x 36 PC</td>
</tr>
<tr>
<td>12</td>
<td>G146 x 36 PC</td>
</tr>
<tr>
<td>13</td>
<td>SPJ2 x B120</td>
</tr>
<tr>
<td>14</td>
<td>SPJ2 x M2</td>
</tr>
</tbody>
</table>
From seventeen new F1 combinations, ten combinations were short-listed based upon the evaluation index and giving emphasis on consideration of fitness, productivity, as well as larval duration merits. Random recombination of genes, were allowed in these populations, up to F3 generations by rearing mass culture.

Observations on fifteen parameters covering pre-cocoon, cocoon and post-cocoon spheres such as fecundity, fifth age larval duration, pupation rate, cocoon yield per 10000 larvae, cocoon weight, cocoon shell weight, shell percentage, average filament length, filament size, raw silk content, renditta, reelability, neatness and silk productivity per day were recorded in all generations.

**Breeding for shorter larval duration**

To breed for shorter larval duration, the following productivity index was adopted as suggested by Gamo (1976):

Productivity index = Cocoon shell weight/Fifth age larval duration.

Further, the separation and selection of early spinners was adopted as a breeding strategy to apply selection pressure in order to reduce larval duration. Selection of early spinners and adoption of productivity indexing were carried out hand in hand so as to optimize larval duration vis-à-vis shorter larval duration, for three consecutive generations (F4 to F7). Batches with minimum of 30% females only were considered for further selection.

Fixation of breeds was achieved by adopting inbreeding from F8 to F10 generation.

**3. Evaluation of hybrids for commercial exploitation**

Ten newly evolved breeds, four ovals namely, SLD1, SLD2, SLD3, SLD4 and six dumbbells, namely, SLD5, SLD6, SLD7, SLD8, SLD9 and SLD10 were subjected for hybridization and forty-eight new all possible hybrid combinations were obtained.
Two hybrid rearing trials were carried out in three replicates each with above forty-eight new combinations along with CSR 2 x CSR 4, the ruling hybrid, as control. Observations on fifteen parameters covering pre-cocoon, cocoon and post-cocoon spheres such as fecundity, fifth age larval duration, pupation rate, cocoon yield per 10000 larvae, cocoon weight, cocoon shell weight, shell percentage, average filament length, filament size, raw silk content, renditta, reelability, neatness and silk productivity per day were recorded.

Hybrid trial data were subjected for evaluation by using multiple trait index suggested by Mano, et al (1998) to short-list superior hybrid combinations. Heterosis studies were carried out to obtain heterotic values over mid parent and better parent values by adopting the prescribed methodology as below:

\[
\text{Heterosis (H\%) = } \frac{\text{F1 value of a trait} - \text{Mid parent value (MPV) of a trait}}{\text{Mid parent value (MPV) of a trait}} \times 100
\]

\[
\text{Hetero-beltiosis (HB\%) = } \frac{\text{F1 value of a trait} - \text{Better parent value (BPV) of a trait}}{\text{Better parent value (BPV) of a trait}} \times 100
\]

Further, multiple trait index method (Mano, et al, 1998) was adopted to derive added inference on the above heterotic values of various traits obtained.

Besides this, cocoon uniformity was assessed in new hybrid combinations by measuring cocoon length and width in cm and the following index was computed:

\[
\text{Cocoon size index = Cocoon length (L) x Cocoon Width (W) x 100.}
\]

Standard deviation on the above index and the Co-efficient of Variation (CV) in % were also, calculated.

Silk productivity estimates as suggested by Gamo, 1976 was calculated for all new hybrids.

Further, the reproductive potential of the newly evolved breeds were studied by carrying out various observations on following parameters:
i) Egg yield per kg of cocoons

ii) Egg number per gram

iii) Egg yield per 100 females

iv) Number of females per kg of cocoons

v) Fecundity conversion.

Finally to assess the status and compare the superiority of the newly evolved breeds and the single and double hybrids obtained from them, Percentage improvement technique was adopted as follows:

\[
\begin{align*}
\text{Improvement (\%) in new breeds} &= \frac{\text{New breed value} - \text{Control breed value}}{\text{Control breed value}} \times 100 \\
\text{Improvement (\%) in new hybrids} &= \frac{\text{New hybrid value} - \text{Control hybrid value}}{\text{Control hybrid value}} \times 100
\end{align*}
\]
RESULTS

Selection of breeding resource materials

The main objective of the study was to select breeds to be used as breeding resource materials for the development of silkworm breeds to suit the hilly areas. The mean performance of the 31 breeds considered for the study are given in Table 3. The larval duration ranged from 652 to 749 hours with the shortest larval duration of 652 hours recorded for B120 and the longest larval duration of 749 hours recorded for 14M. The yield/10,000 larvae by number ranged from 7217 to 9238 with the lowest of 7217 recorded for NJ1 and the highest of 9238 recorded for JA1. The yield/10,000 larvae by eight ranged from 11.25 to 16.33 kg with the lowest of 11.25 kg recorded for G177 and the highest of 16.33 kg recorded for A120. The cocoon weight ranged from 1.414 to 1.852 g with the lowest recorded for G177 and the highest of 1.852 g recorded for A120. The cocoon shell weight ranged from 0.304 to 0.447 g with the lowest of 0.314 g recorded for G177 and the highest of 0.447 g recorded for A120. The cocoon shell percentage ranged from 19.58 to 24.19 % with the lowest of 19.58 % recorded for C108 and NN6D and the highest of 24.19 % recorded for A121. The average cocoon filament length ranged from 856 to 1128 m with the shortest of 856 m recorded for G177 and the longest of 1191 m recorded for A120. The cocoon filament size ranged from 2.00 to 2.75 d with the thinnest of 2.00 d recorded for European and the thickest of 2.75 d recorded for JA1. The raw silk percentage ranged from 14.79 to 19.21 % with the lowest of 14.79 % recorded for NN6D and the highest of 19.21 % recorded for A120.

The multiple trait evaluation index was computed for short listing the breeding resource materials (Table 4). The evaluation index for the trait of larval duration ranged from 35.69 to 72.12 with the lowest index value of 35.69 for SPC1 and the highest index of 72.12 in A121 and B120. The evaluation index for the trait yield/10,000 larvae by number ranged from 25.79 to 60.26 with the lowest of 25.79 recorded for NJ1 and the highest of 60.26 recorded for JA1. The evaluation index for the trait yield/10,000 larvae by weight ranged from 24.90 to 63.97 with the lowest of 24.90 recorded for G177 and the highest of 63.97 recorded for A120. The evaluation index for the trait cocoon weight ranged from 10.32 to 65.07 with the lowest of 10.32 recorded for G177 and the highest of 65.07 recorded for A120. The evaluation
index for the trait cocoon shell weight ranged from 26.90 to 74.57 with the lowest of 26.90 recorded for G177 and the highest of 74.57 recorded for A120. The evaluation index for the trait cocoon shell percentage ranged from 32.41 to 72.50 with the lowest of 32.41 recorded for C108 and NN6D and the highest of 72.50 recorded for A121. The evaluation index for the trait filament length ranged from 23.92 to 77.52 with the lowest of 23.92 recorded for G177 and the highest of 77.52 recorded for A120. The evaluation index for the trait filament size ranged from 32.88 to 72.77 with the lowest of 32.88 recorded for JA1 and the highest of 72.77 recorded for European. The evaluation index for the trait of raw silk ranged from 28.58 to 69.13 with the lowest of 28.58 recorded for NN6D and the highest of 69.13 recorded for A120.

The data were subjected for index scoring and the details of scoring allotted for different traits are presented in table 5. The total score for different breeds ranged from 13 to 25 with the lowest of 13 recorded for NN6D and the highest score of 25 recorded for A120 and A121.

Based on the evaluation index values and index score, the breeds viz., A120, A121, B120, European, G146, CJ3P, SPJ2, SPC1, M2, J2P, JA1 and 36PC were selected as breeding resource materials.

Breeding process

By utilizing the selected breeding resource materials 17 hybrid combinations were made to initiate the breeding programme. The fecundity of F1 generation ranged from 462 to 588 with the lowest of 462 recorded for SPJ2 x M2 and the highest of 588 recorded for CJ3P x A120. The fifth age larval duration of F1 generation ranged from 7.07 to 8.19 (Days:Hours) with the shortest duration of 7.07 (Days:Hours) recorded for G146 x 36PC and longest duration of 8.19 (Days:Hours) recorded for European x 36PC. The total larval duration of F1 generation ranged from 24.07 to 26.19 (Days:Hours) with the shortest duration of 24.07 (Days:Hours) recorded for G146 x 36PC and longest duration of 26.19 (Days:Hours) recorded for European x 36PC. The pupation rate of F1 generation ranged from 86.40 to 98.93 % with the lowest of 86.40 % recorded for G146 x European and the highest of 98.93% recorded for SPC1 x A121. The yield/10,000 larvae by weight of F1 generation ranged from 18.347 to 21.893 kg with the lowest of 18.347 kg recorded for G146 x European and the highest of 21.893 kg recorded for JA1 x SPJ2. The cocoon weight
of F1 generation ranged from 1.924 to 2.247 g with the lowest of 1.924 g recorded for European x 36PC and the highest of 2.247 g recorded for CJ3P x J2P. The cocoon shell weight of F1 generation ranged from 0.410 to 0.497 g with the lowest of 0.410 g recorded for European x 36PC and the highest of 0.497 g recorded for CJ3P x J2P. The cocoon shell percentage of F1 generation ranged from 21.31 to 23.65 % with the lowest of 21.31 % recorded for European x 36PC and the highest of 23.65 % recorded for SPC1 x A121. The filament length of F1 generation ranged from 963 to 1254 m with the shortest of 963 m recorded for M2 x 36PC and the longest of 1254 m recorded for SPC1 x A121. The filament size of F1 generation ranged from 2.31 to 2.56 d with the thinnest of 2.31 d recorded for CJ3P x A120 and the thickest of 2.56 d recorded for J2P x CJ3P. The raw silk percentage of F1 generation ranged from 16.35 to 19.15 % with the lowest of 16.35 % recorded for M2 x 36PC and the highest of 19.15 % recorded for SPC1 x A121. The renditta of F1 generation ranged from 5.22 to 6.12 with the lowest of 5.22 recorded for SPC1 x A121 and the highest of 6.12 recorded for M2 x 36PC and JA1 x SPJ2. The reelability of F1 generation ranged from 79 to 83 % with the lowest of 79 % recorded for G146 x European and the highest of 83 % recorded for CJ3P x A121, SPC1 x A121, B120 x JA1, M2 x B120 and JA1 x SPJ2. The neatness of F1 generation ranged from 91 to 94 points with the lowest of 91 points recorded for CJ3P x J2P, J2P x CJ3P, G146 x European, European x 36PC, G146 x M2, M2 x 36PC, SPJ2 x M2 and JA1 x SPJ2 and the highest of 94 points recorded for SPC1 x A120. The silk productivity/day of F1 generation ranged from 4.66 to 6.44 cg with the lowest of 4.66 cg recorded for European x 36PC and the highest of 6.44 cg recorded for A121 x CJ3P (Table-6).

Based on the multiple trait index obtained on fecundity, fifth age, total larval duration, pupation rate, yield per 10000 larvae by number, cocoon weight, shell weight, shell percentage, silk productivity per day of seventeen filial generation 1, the breeding lines were short listed to 10 (Table-7). The fecundity of F2 generation ranged from 498 to 544 with the lowest of 498 recorded for M2 x B120 and the highest of 544 recorded for SPC1 x A121. The fifth age larval duration of F2 generation ranged from 6.23 to 7.20 (Days:Hours) with the shortest duration of 6.23 (Days:Hours) recorded for G146 x 36PC and longest duration of 7.20 (Days:Hours) recorded for G146 x M2. The total larval duration of F2 generation ranged from 24.00 to 24.20 (Days:Hours) with the shortest duration of 24.00 (Days:Hours)
recorded for G146 x 36PC and M2 x 36PC and the longest duration of 24.20 (Days:Hours) recorded for G146 x M2. The pupation rate of F2 generation ranged from 91.27 to 95.33 % with the lowest of 91.27 % recorded for M2 x 36PC and the highest of 95.33% recorded for B120 x JA1. The yield/10,000 larvae by weight of F2 generation ranged from 16.747 to 18.187 kg with the lowest of 16.747 kg recorded for G146 x M2 and the highest of 18.187 kg recorded for J2P x CJ3P. The cocoon weight of F2 generation ranged from 1.797 to 1.957 g with the lowest of 1.797 g recorded for CJ3P x A120 and the highest of 1.957 g recorded for J2P x CJ3P. The cocoon shell weight of F2 generation ranged from 0.377 to 0.427 g with the lowest of 0.377 g recorded for M2 x 36PC and the highest of 0.427 g recorded for A121 x CJ3P and M2 x B120 . The cocoon shell percentage of F2 generation ranged from 20.98 to 22.86 % with the lowest of 20.98 % recorded for M2 x 36PC and the highest of 22.86 % recorded for SPC1 x A121. The filament length of F2 generation ranged from 882 to 1095 m with the shortest of 882 m recorded for M2 x 36PC and the longest of 1095 m recorded for SPC1 x A121. The filament size of F2 generation ranged from 2.66 to 2.90 d with the thinnest of 2.66 d recorded for G146 x M2 and the thickest of 2.90 d recorded for B120 x JA1 and JA1 x SPJ2. The raw silk percentage of F2 generation ranged from 15.93 to 17.67 % with the lowest of 15.93 % recorded for G146 x 36PC and the highest of 17.67 % recorded for SPC1 x A121. The renditta of F2 generation ranged from 5.66 to 6.28 with the lowest of 5.66 recorded for SPC1 x A121 and the highest of 6.28 recorded for G146 x 36PC. The reelability of F2 generation ranged from 81 to 83 % with the lowest of 81 % recorded for G146 x M2, M2 x 35PC, G146 x 36PC and M2 x B120 the highest of 83 % recorded for CJ3P x A120, A121 x CJ3P, J2P x CJ3P, B120 x JA1 and JA1 x SPJ2. The neatness of F2 generation ranged from 91 to 93 points with the lowest of 91 points recorded for J2P x CJ3P, G146 x M2 and M2 x 36PC and the highest of 93 points recorded for CJ3P x A120, SPC1 x A121, B120 x JA1 and M2 x B120. The silk productivity/day of F2 generation ranged from 4.92 to 5.96 cg with the lowest of 4.92 cg recorded for G146 x M2 and the highest of 5.96 cg recorded for A121 x CJ3P (Table -8).

The fecundity of F3 generation ranged from 478 to 538 with the lowest of 478 recorded for JA1 x SPJ2 and the highest of 538 recorded for SPC1 x A121. The fifth age larval duration of F3 generation ranged from 7.00 to 7.22 (Days:Hours) with the shortest duration of 7.00 (Days:Hours) recorded for M2 x 36PC and longest duration
of 7.22 (Days:Hours) recorded for SPC1 x A121. The total larval duration of F3 generation ranged from 24.22 to 25.21 (Days:Hours) with the shortest duration of 24.22 (Days:Hours) recorded for SPC1 x A121 and the longest duration of 25.21 (Days:Hours) recorded for JA1 x SPJ2. The pupation rate of F3 generation ranged from 88.33 to 96.22 % with the lowest of 88.33 % recorded for J2P x CJ3P and the highest of 96.22 % recorded for A121 x CJ3P. The yield/10,000 larvae by weight of F3 generation ranged from 16.400 to 19.288 kg with the lowest of 16.400 kg recorded for J2P x CJ3P and the highest of 19.288 kg recorded for CJ3P x A120. The cocoon weight of F3 generation ranged from 1.710 to 1.981 g with the lowest of 1.710 g recorded for SPC1 x A121 and the highest of 1.981 g recorded for G146 x 36PC. The cocoon shell weight of F3 generation ranged from 0.372 to 0.403 g with the lowest of 0.372 g recorded for M2 x 36PC and the highest of 0.403 g recorded for M2 x B120. The cocoon shell percentage of F3 generation ranged from 19.63 to 22.01 % with the lowest of 19.63 % recorded for JA1 x SPJ2 and the highest of 22.01 % recorded for SPC1 x A121. The filament length of F3 generation ranged from 946 to 1236 m with the shortest of 946 m recorded for G146 x M2 and the longest of 1236 m recorded for B120 x JA1. The filament size of F3 generation ranged from 2.41 to 3.11 d with the thinnest of 2.41 d recorded for M2 x 36PC and the thickest of 3.11 d recorded for CJ3P x A120. The raw silk percentage of F3 generation ranged from 15.16 to 18.27 % with the lowest of 15.16 % recorded for G146 x M2 and the highest of 18.27 % recorded for SPC1 x A121. The renditta of F3 generation ranged from 5.47 to 6.60 with the lowest of 5.47 recorded for SPC1 x A121 and the highest of 6.60 recorded for G146 x M2. The reelability of F3 generation ranged from 77 to 86 % with the lowest of 77 % recorded for G146 x M2 and the highest of 86 % recorded for SPC1 x A121 and M2 x 36PC. The neatness of F3 generation ranged from 91 to 93 points with the lowest of 91 points recorded for M2 x 36PC, G146 x 36PC, M2 x B120 and JA1 x SPJ2 and the highest of 93 points recorded for CJ3P x A120, SPC1 x A121 and B120 x JA1. The silk productivity/day of F3 generation ranged from 4.74 to 5.56 cg with the lowest of 4.74 cg recorded for JA1 x SPJ2 and the highest of 5.56 cg recorded for G146 x 36PC (Table-9).

From F4 generation onwards the breeding lines were designated as SLD1 to SLD10. From F4 to F6 generations, the early spinners were separated out to select lines with shorter larval duration. The fecundity of F4 generation ranged from 462 to 582 with the lowest of 462 recorded for SLD10 and the highest of 582 recorded for
SLD4. The fifth age larval duration of F4 generation ranged from 6.00 to 7.03 (Days:Hours) with the shortest duration of 6.00 (Days:Hours) recorded for SLD4 and longest duration of 7.03 (Days:Hours) recorded for SLD1. The total larval duration for the early spinners of F4 generation ranged from 23.00 to 23.16 (Days:Hours) with the shortest duration of 23.00 (Days:Hours) recorded for SLD4 and the longest duration of 23.16 (Days:Hours) recorded for SLD2. The total larval duration for the late spinners of F4 generation ranged from 23.16 to 24.04 (Days:Hours) with the shortest duration of 23.16 (Days:Hours) recorded for SLD1 and SLD6 and the longest duration of 24.04 (Days:Hours) recorded for SLD2. The pupation rate of F4 generation ranged from 92.80 to 97.74 % with the lowest of 92.80 % recorded for SLD9 and the highest of 97.74 % recorded for SLD2. The yield/10,000 larvae by weight of F4 generation ranged from 16.527 to 18.399 kg with the lowest of 16.527 kg recorded for SLD6 and the highest of 18.399 kg recorded for SLD5. The cocoon weight of F4 generation ranged from 1.746 to 1.861 g with the lowest of 1.746 g recorded for SLD9 and the highest of 1.861 g recorded for SLD3. The cocoon shell weight of F4 generation ranged from 0.349 to 0.406 g with the lowest of 0.349 g recorded for SLD6 and the highest of 0.406 g recorded for SLD5. The cocoon shell percentage of F4 generation ranged from 20.60 to 22.51 % with the lowest of 20.60 % recorded for SLD10 and the highest of 22.51 % recorded for SLD8. The filament length of F4 generation ranged from 945 to 1190 m with the shortest of 945 m recorded for SLD10 and the longest of 1190 m recorded for SLD2. The filament size of F4 generation ranged from 2.42 to 3.18 d with the thinnest of 2.42 d recorded for SLD2 and the thickest of 3.18 d recorded for SLD3. The raw silk percentage of F4 generation ranged from 15.55 to 18.24 % with the lowest of 15.55 % recorded for SLD10 and the highest of 18.24 % recorded for SLD8. The renditta of F4 generation ranged from 5.48 to 6.43 with the lowest of 5.48 recorded for SLD8 and the highest of 6.43 recorded for SLD10. The reelability of F4 generation ranged from 80 to 87 % with the lowest of 80 % recorded for SLD3 and the highest of 87 % recorded for SLD2, SLD6, SLD8 and SLD9. The neatness of F4 generation ranged from 91 to 93 points with the lowest of 91 points recorded for SLD3 and SLD6 and the highest of 93 points recorded for SLD4 and SLD8. The silk productivity/day of F4 generation ranged from 5.37 to 6.67 cg with the lowest of 5.37 cg recorded for SLD1 and the highest of 6.67 cg recorded for SLD4 (Table -10).
The fecundity of F5 generation ranged from 471 to 576 with the lowest of 471 recorded for SLD6 and the highest of 576 recorded for SLD4. The fifth age larval duration of F5 generation ranged from 6.10 to 6.23 (Days:Hours) with the shortest duration of 6.10 (Days:Hours) recorded for SLD6 and SLD7 and longest duration of 6.23 (Days:Hours) recorded for SLD5. The total larval duration for the early spinners of F5 generation ranged from 22.10 to 22.22 (Days:Hours) with the shortest duration of 22.10 (Days:Hours) recorded for SLD6 and the longest duration of 22.22 (Days:Hours) recorded for SLD5 and SLD9. The total larval duration for the late moulters of F5 generation ranged from 22.20 to 23.16 (Days:Hours) with the shortest duration of 22.20 (Days:Hours) recorded for SLD6 and the longest duration of 23.16 (Days:Hours) recorded for SLD9. The pupation rate of F5 generation ranged from 93.74 to 97.45 % with the lowest of 93.74 % recorded for SLD9 and the highest of 97.45 % recorded for SLD7. The yield/10,000 larvae by weight of F5 generation ranged from 17.127 to 19.671 kg with the lowest of 17.127 kg recorded for SLD7 and the highest of 19.671 kg recorded for SLD3. The cocoon weight of F5 generation ranged from 1.783 to 2.055 g with the lowest of 1.783 g recorded for SLD7 and the highest of 2.055 g recorded for SLD10. The cocoon shell weight of F5 generation ranged from 0.375 to 0.440 g with the lowest of 0.375 g recorded for SLD6 and the highest of 0.440 g recorded for SLD4. The cocoon shell percentage of F5 generation ranged from 20.35 to 23.79 % with the lowest of 20.35 % recorded for SLD10 and the highest of 23.79 % recorded for SLD4. The filament length of F5 generation ranged from 925 to 1132 m with the shortest of 925 m recorded for SLD10 and the longest of 1132 m recorded for SLD1. The filament size of F5 generation ranged from 2.33 to 3.10 d with the thinnest of 2.33 d recorded for SLD7 and the thickest of 3.10 d recorded for SLD10. The raw silk percentage of F5 generation ranged from 15.74 to 18.50 % with the lowest of 15.74 % recorded for SLD7 and the highest of 18.50 % recorded for SLD4. The renditta of F5 generation ranged from 5.40 to 6.35 with the lowest of 5.40 recorded for SLD4 and the highest of 6.35 recorded for SLD7. The reelability of F5 generation ranged from 80 to 87 % with the lowest of 80 % recorded for SLD3 and the highest of 87 % recorded for SLD2. The neatness of F5 generation ranged from 91 to 93 points with the lowest of 91 points recorded for SLD6, SLD7 and SLD8 and the highest of 93 points recorded for SLD3. The silk productivity/day of F5 generation ranged from 5.85 to 6.63 cg with the lowest of 5.85 cg recorded for SLD6 and the highest of 6.63 cg recorded for SLD4 (Table-11).
The fecundity of F6 generation ranged from 462 to 590 with the lowest of 462 recorded for SLD6 and the highest of 590 recorded for SLD4. The fifth age larval duration of F6 generation ranged from 5.20 to 6.15 (Days:Hours) with the shortest duration of 5.20 (Days:Hours) recorded for SLD6 and longest duration of 6.15 (Days:Hours) recorded for SLD1. The total larval duration for the early spinners of F6 generation ranged from 21.20 to 22.06 (Days:Hours) with the shortest duration of 21.20 (Days:Hours) recorded for SLD6 and the longest duration of 22.06 (Days:Hours) recorded for SLD2 and SLD5. The total larval duration for the late spinners of F6 generation ranged from 22.10 to 22.22 (Days:Hours) with the shortest duration of 22.10 (Days:Hours) recorded for SLD6 and the longest duration of 22.22 (Days:Hours) recorded for SLD2. The pupation rate of F6 generation ranged from 92.82 to 96.51 % with the lowest of 92.82 % recorded for SLD10 and the highest of 96.51 % recorded for SLD1. The yield/10,000 larvae by weight of F6 generation ranged from 16.369 to 18.399 kg with the lowest of 16.369 kg recorded for SLD6 and the highest of 18.399 kg recorded for SLD7. The cocoon weight of F6 generation ranged from 1.657 to 1.880 g with the lowest of 1.657 g recorded for SLD9 and the highest of 1.880 g recorded for SLD10. The cocoon shell weight of F6 generation ranged from 0.341 to 0.389 g with the lowest of 0.341 g recorded for SLD6 and the highest of 0.389 g recorded for SLD1. The cocoon shell percentage of F6 generation ranged from 20.08 to 22.45 % with the lowest of 20.08 % recorded for SLD10 and the highest of 22.45 % recorded for SLD4. The filament length of F6 generation ranged from 961 to 1237 m with the shortest of 961 m recorded for SLD5 and SLD6 and the longest of 1237 m recorded for SLD1. The filament size of F6 generation ranged from 2.41 to 2.93 d with the thinnest of 2.41 d recorded for SLD7 and the thickest of 2.93 d recorded for SLD4. The raw silk percentage of F6 generation ranged from 16.07 to 17.59 % with the lowest of 16.07 % recorded for SLD10 and the highest of 17.59 % recorded for SLD9. The renditta of F6 generation ranged from 5.69 to 6.23 with the lowest of 5.69 recorded for SLD9 and the highest of 6.23 recorded for SLD10. The reelability of F6 generation ranged from 81 to 87 % with the lowest of 81 % recorded for SLD2, SLD6 and the highest of 87 % recorded for SLD3. The neatness of F6 generation ranged from 91 to 92 points with the lowest of 91 points recorded for SLD2, SLD3, SLD5, SLD7 and SLD10 and the highest of 92 points recorded for SLD1, SLD4, SLD8 and SLD9. The silk productivity/day of F6 generation ranged from 5.85 to 6.34 cg with the lowest of 5.85 cg recorded for SLD6 and the highest of 6.34 cg recorded for SLD4 (Table-12).
The fecundity of F7 generation ranged from 472 to 588 with the lowest of 472 recorded for SLD7 and the highest of 588 recorded for SLD4. The fifth age larval duration of F7 generation ranged from 5.20 to 6.14 (Days:Hours) with the shortest duration of 5.20 (Days:Hours) recorded for SLD3 and SLD6 and longest duration of 6.14 (Days:Hours) recorded for SLD1. The total larval duration of F7 generation ranged from 21.05 to 22.14 (Days:Hours) with the shortest duration of 21.05 (Days:Hours) recorded for SLD6 and the longest duration of 22.14 (Days:Hours) recorded for SLD5. The pupation rate of F7 generation ranged from 87.60 to 97.73 % with the lowest of 87.60 % recorded for SLD6 and the highest of 97.73 % recorded for SLD8. The yield/10,000 larvae by weight of F7 generation ranged from 15.227 to 18.140 kg with the lowest of 15.227 kg recorded for SLD6 and the highest of 18.140 kg recorded for SLD1. The cocoon weight of F7 generation ranged from 1.590 to 1.780 g with the lowest of 1.590 g recorded for SLD9 and the highest of 1.780 g recorded for SLD1. The cocoon shell weight of F7 generation ranged from 0.344 to 0.381 g with the lowest of 0.344 g recorded for SLD5 and SLD10 and the highest of 0.381 g recorded for SLD4. The cocoon shell percentage of F7 generation ranged from 20.57 to 23.21 % with the lowest of 20.57 % recorded for SLD6 and the highest of 23.21 % recorded for SLD4. The filament length of F7 generation ranged from 953 to 1164 m with the shortest of 953 m recorded for SLD5 and the longest of 1164 m recorded for SLD9. The filament size of F7 generation ranged from 2.43 to 2.90 d with the thinnest of 2.43 d recorded for SLD4 and the thickest of 2.90 d recorded for SLD7 and SLD10. The raw silk percentage of F7 generation ranged from 16.19 to 19.14 % with the lowest of 16.19 % recorded for SLD10 and the highest of 19.14 % recorded for SLD4. The renditta of F7 generation ranged from 5.23 to 6.18 with the lowest of 5.23 recorded for SLD4 and the highest of 6.18 recorded for SLD10. The reelability of F7 generation ranged from 81 to 85 % with the lowest of 81 % recorded for SLD1, SLD3, SLD5, SLD7, SLD8, SLD9 and SLD10 and the highest of 85 % recorded for SLD2. The neatness of F7 generation ranged from 92 to 94 points with the lowest of 92 points recorded for SLD10 and the highest of 94 points recorded for SLD4 and SLD9. The silk productivity/day of F7 generation ranged from 5.59 to 6.18 cg with the lowest of 5.59 cg recorded for SLD5 and the highest of 6.18 cg recorded for SLD4 (Table-13).

The fecundity of F8 generation ranged from 456 to 596 with the lowest of 456 recorded for SLD7 and the highest of 596 recorded for SLD4. The fifth age larval
duration of F8 generation ranged from 5.16 to 6.14 (Days:Hours) with the shortest duration of 5.16 (Days:Hours) recorded for SLD3 and longest duration of 6.14 (Days:Hours) recorded for SLD2 and SLD5. The total larval duration of F8 generation ranged from 21.04 to 22.14 (Days:Hours) with the shortest duration of 21.04 (Days:Hours) recorded for SLD6 and the longest duration of 22.14 (Days:Hours) recorded for SLD2 and SLD4. The pupation rate of F8 generation ranged from 88.80 to 97.87 % with the lowest of 88.80 % recorded for SLD5 and SLD6 and the highest of 97.87 % recorded for SLD7. The yield/10,000 larvae by weight of F8 generation ranged from 16.110 to 18.213 kg with the lowest of 16.110 kg recorded for SLD9 and the highest of 18.213 kg recorded for SLD1. The cocoon weight of F8 generation ranged from 1.630 to 1.947 g with the lowest of 1.630 g recorded for SLD9 and the highest of 1.947 g recorded for SLD5. The cocoon shell weight of F8 generation ranged from 0.350 to 0.422 g with the lowest of 0.350 g recorded for SLD6 and the highest of 0.422 g recorded for SLD5. The cocoon shell percentage of F8 generation ranged from 20.48 to 23.59 % with the lowest of 20.48 % recorded for SLD3 and the highest of 23.59 % recorded for SLD4. The filament length of F8 generation ranged from 960 to 1182 m with the shortest of 960 m recorded for SLD5 and the longest of 1182 m recorded for SLD9. The filament size of F8 generation ranged from 2.20 to 2.99 d with the thinnest of 2.20 d recorded for SLD2 and the thickest of 2.99 d recorded for SLD5. The raw silk percentage of F8 generation ranged from 16.28 to 18.60 % with the lowest of 16.28 % recorded for SLD7 and the highest of 18.60 % recorded for SLD4. The renditta of F8 generation ranged from 5.38 to 6.14 with the lowest of 5.38 recorded for SLD4 and the highest of 6.14 recorded for SLD7. The reelability of F8 generation ranged from 80 to 83 % with the lowest of 80 % recorded for SLD7 and the highest of 83 % recorded for SLD2, SLD3, SLD4, SLD8 and SLD10. The neatness of F8 generation ranged from 93 to 94 points with the lowest of 93 points recorded for SLD3, SLD5, SLD6, SLD7 and SLD10 and the highest of 94 points recorded for SLD1, SLD2, SLD4, SLD8 and SLD9. The silk productivity/day of F8 generation ranged from 5.79 to 6.62 cg with the lowest of 5.79 cg recorded for SLD9 and the highest of 6.62 cg recorded for SLD4 (Table-14).

The fecundity of F9 generation ranged from 462 to 570 with the lowest of 462 recorded for SLD7 and the highest of 570 recorded for SLD4. The fifth age larval duration of F9 generation ranged from 6.02 to 6.20 (Days:Hours) with the shortest
duration of 6.02 (Days:Hours) recorded for SLD3 and longest duration of 6.20 (Days:Hours) recorded for SLD5. The total larval duration of F9 generation ranged from 22.04 to 22.20 (Days:Hours) with the shortest duration of 22.04 (Days:Hours) recorded for SLD3 and the longest duration of 22.20 (Days:Hours) recorded for SLD4, SLD5 and SLD7. The pupation rate of F9 generation ranged from 90.18 to 97.45 % with the lowest of 90.18 % recorded for SLD6 and the highest of 97.45 % recorded for SLD10. The yield/10,000 larvae by weight of F9 generation ranged from 13.939 to 18.181 kg with the lowest of 13.939 kg recorded for SLD6 and the highest of 18.181 kg recorded for SLD5. The cocoon weight of F9 generation ranged from 1.547 to 1.814 g with the lowest of 1.547 g recorded for SLD6 and the highest of 1.814 g recorded for SLD5. The cocoon shell weight of F9 generation ranged from 0.326 to 0.413 g with the lowest of 0.326 g recorded for SLD6 and the highest of 0.413 g recorded for SLD5. The cocoon shell percentage of F9 generation ranged from 20.74 to 23.28 % with the lowest of 20.74 % recorded for SLD10 and the highest of 23.28 % recorded for SLD4. The filament length of F9 generation ranged from 943 to 1125 m with the shortest of 943 m recorded for SLD7 and the longest of 1125 m recorded for SLD4. The filament size of F9 generation ranged from 2.25 to 2.89 d with the thinnest of 2.25 d recorded for SLD9 and the thickest of 2.89 d recorded for SLD6. The raw silk percentage of F9 generation ranged from 16.04 to 19.71 % with the lowest of 16.04 % recorded for SLD3 and the highest of 19.71 % recorded for SLD4. The renditta of F9 generation ranged from 5.07 to 6.23 with the lowest of 5.07 recorded for SLD4 and the highest of 6.23 recorded for SLD3. The reelability of F9 generation ranged from 81 to 85 % with the lowest of 81 % recorded for SLD8 and the highest of 85 % recorded for SLD2 and SLD5. The neatness of F9 generation ranged from 93 to 94 points with the lowest of 93 points recorded for SLD2, SLD6, SLD8, SLD9 and SLD10 and the highest of 94 points recorded for SLD1, SLD3, SLD4, SLD5 and SLD7. The silk productivity/day of F9 generation ranged from 5.17 to 6.29 cg with the lowest of 5.17 cg recorded for SLD6 and the highest of 6.29 cg recorded for SLD4 (Table-15).

The fecundity of F10 generation ranged from 486 to 594 with the lowest of 486 recorded for SLD7 and the highest of 594 recorded for SLD4. The fifth age larval duration of F10 generation ranged from 5.20 to 6.22 (Days:Hours) with the shortest duration of 5.20 (Days:Hours) recorded for SLD3 and longest duration of 6.22 (Days:Hours) recorded for SLD5. The total larval duration of F10 generation
ranged from 21.11 to 22.22 (Days:Hours) with the shortest duration of 21.11 (Days:Hours) recorded for SLD3 and the longest duration of 22.22 (Days:Hours) recorded for SLD5. The pupation rate of F10 generation ranged from 89.33 to 96.53 % with the lowest of 89.33 % recorded for SLD5 and the highest of 96.53 % recorded for SLD9. The yield/10,000 larvae by weight of F10 generation ranged from 15.147 to 16.973 kg with the lowest of 15.147 kg recorded for SLD6 and the highest of 16.973 kg recorded for SLD5. The cocoon weight of F10 generation ranged from 1.573 to 1.834 g with the lowest of 1.573 g recorded for SLD6 and the highest of 1.834 g recorded for SLD5. The cocoon shell weight of F10 generation ranged from 0.345 to 0.401 g with the lowest of 0.345 g recorded for SLD3 and the highest of 0.401 g recorded for SLD4. The cocoon shell percentage of F10 generation ranged from 20.97 to 23.03 % with the lowest of 20.97 % recorded for SLD3 and SLD10 and the highest of 23.03 % recorded for SLD4. The filament length of F10 generation ranged from 947 to 1160 m with the shortest of 947 m recorded for SLD7 and the longest of 1160 m recorded for SLD8. The filament size of F10 generation ranged from 2.35 to 2.63 d with the thinnest of 2.35 d recorded for SLD6 and the thickest of 2.63 d recorded for SLD2. The raw silk percentage of F10 generation ranged from 16.07 to 18.81 % with the lowest of 16.07 % recorded for SLD3 and the highest of 18.81 % recorded for SLD8. The renditta of F10 generation ranged from 5.32 to 6.22 with the lowest of 5.32 recorded for SLD8 and the highest of 6.22 recorded for SLD3. The reelability of F10 generation ranged from 80 to 83 % with the lowest of 80 % recorded for SLD4 and SLD7 and the highest of 83 % recorded for SLD1, SLD5 and SLD6. The neatness of F10 generation ranged from 92 to 94 points with the lowest of 92 points recorded for SLD3 and SLD7 and the highest of 94 points recorded for SLD1, and SLD8. The silk productivity/day of F10 generation ranged from 5.34 to 6.27 cg with the lowest of 5.34 cg recorded for SLD1 and the highest of 6.27 cg recorded for SLD8 (Table-16).

To have an assessment of performance of ten new SLD breeds over filial generation 1 to filial generation 10, data compiled thereon were presented in the Tables 17 to 26. Breed, SLD1 recorded a fecundity of 588, fifth age duration of 7.12 (Days:Hours), total duration of 24.12 (Days:Hours), pupation rate of 96.67, yield per 10000 larvae of 20.987 kgs, cocoon weight of 1.969g, shell weight of 0.449 g, shell percentage of 22.80, filament length of 1055m, filament size of 2.31d, raw silk content of 18.03%, renditta of 5.55, reelability of 81%, neatness of 93 pts with a silk
productivity per day of 5.99 cg at filial generation 1 and a fecundity of 540, fifth age duration of 6.18 (Days:Hours), total duration of 22.08 (Days:Hours), pupation rate of 94.80, yield per 10000 larvae of 15.920 kgs, cocoon weight of 1.711g, shell weight of 0.361 g, shell percentage of 21.12, filament length of 1065m, filament size of 2.45d, raw silk content of 17.69%, renditta of 5.65, reelability of 83%, neatness of 94 pts with a silk productivity per day of 5.34 cg at filial generation 10 (Table-17).

Breed, SLD2 recorded a fecundity of 564, fifth age duration of 7.10 (Days:Hours), total duration of 24.10 (Days:Hours), pupation rate of 97.60, yield per 10000 larvae of 20.160 kgs, cocoon weight of 2.035g, shell weight of 0.457 g, shell percentage of 22.44, filament length of 1023m, filament size of 2.49d, raw silk content of 17.86%, renditta of 5.60, reelability of 80%, neatness of 92 pts with a silk productivity per day of 6.44 cg at filial generation 1 and a fecundity of 576, fifth age duration of 6.10 (Days:Hours), total duration of 22.13 (Days:Hours), pupation rate of 95.73, yield per 10000 larvae of 16.347 kgs, cocoon weight of 1.732g, shell weight of 0.368 g, shell percentage of 21.25, filament length of 1119m, filament size of 2.63d, raw silk content of 17.68%, renditta of 5.66, reelability of 81%, neatness of 93 pts with a silk productivity per day of 5.74 cg at filial generation 10 (Table-18).

Breed, SLD3 recorded a fecundity of 560, fifth age duration of 7.15 (Days:Hours), total duration of 24.15 (Days:Hours), pupation rate of 97.87, yield per 10000 larvae of 21.680 kgs, cocoon weight of 2.178g, shell weight of 0.465 g, shell percentage of 21.37, filament length of 1054m, filament size of 2.56d, raw silk content of 17.03%, renditta of 5.87, reelability of 81%, neatness of 91 pts with a silk productivity per day of 6.10 cg at filial generation 1 and a fecundity of 524, fifth age duration of 5.20 (Days:Hours), total duration of 21.11 (Days:Hours), pupation rate of 96.00, yield per 10000 larvae of 16.040 kgs, cocoon weight of 1.647g, shell weight of 0.345g, shell percentage of 20.97, filament length of 966m, filament size of 2.57d, raw silk content of 16.07%, renditta of 6.22, reelability of 81%, neatness of 92 pts with a silk productivity per day of 5.92 cg at filial generation 10 (Table-19).

Breed, SLD4 recorded a fecundity of 584, fifth age duration of 8.01 (Days:Hours), total duration of 25.01 (Days:Hours), pupation rate of 98.93, yield per 10000 larvae of 19.627 kgs, cocoon weight of 1.999g, shell weight of 0.473g, shell percentage of 23.65, filament length of 1254m, filament size of 2.32d, raw silk content of 19.15%, renditta of 5.22, reelability of 83%, neatness of 93 pts with a silk
productivity per day of 5.88 cg at filial generation 1 and a fecundity of 594, fifth age
duration of 6.10 (Days:Hours), total duration of 22.18 (Days:Hours), pupation rate of
95.73, yield per 10000 larvae of 16.600 kgs, cocoon weight of 1.742g, shell weight
of 0.401g, shell percentage of 23.03, filament length of 1153m, filament size of
2.58d, raw silk content of 18.61%, renditta of 5.38, reelability of 80%, neatness of 93
pts with a silk productivity per day of 6.26 cg at filial generation 10 (Table-20).

Breed, SLD5 recorded a fecundity of 511, fifth age duration of 7.21
(Days:Hours), total duration of 24.21 (Days:Hours), pupation rate of 95.73, yield per
10000 larvae of 19.893 kgs, cocoon weight of 1.945g, shell weight of 0.436g, shell
percentage of 22.42, filament length of 982m, filament size of 2.38d, raw silk content
of 16.74%, renditta of 5.97, reelability of 80%, neatness of 91 pts with a silk
productivity per day of 5.54 cg at filial generation 1 and a fecundity of 512, fifth age
duration of 6.22 (Days:Hours), total duration of 22.22 (Days:Hours), pupation rate of
89.33, yield per 10000 larvae of 16.973 kgs, cocoon weight of 1.834g, shell weight
of 0.395g, shell percentage of 21.56, filament length of 1022m, filament size of
2.38d, raw silk content of 17.20%, renditta of 5.82, reelability of 83%, neatness of 93
pts with a silk productivity per day of 5.72 cg at filial generation 10 (Table-21).

Breed, SLD6 recorded a fecundity of 522, fifth age duration of 7.20
(Days:Hours), total duration of 24.20 (Days:Hours), pupation rate of 93.62, yield per
10000 larvae of 19.200 kgs, cocoon weight of 1.965g, shell weight of 0.421g, shell
percentage of 21.44, filament length of 963m, filament size of 2.39d, raw silk content
of 16.35%, renditta of 6.12, reelability of 81%, neatness of 91 pts with a silk
productivity per day of 5.38 cg at filial generation 1 and a fecundity of 498, fifth age
duration of 6.00 (Days:Hours), total duration of 21.20 (Days:Hours), pupation rate of
94.27, yield per 10000 larvae of 15.147 kgs, cocoon weight of 1.573g, shell weight
of 0.331g, shell percentage of 21.06, filament length of 968m, filament size of 2.35d,
raw silk content of 16.65%, renditta of 6.01, reelability of 83%, neatness of 93 pts
with a silk productivity per day of 5.52 cg at filial generation 10 (Table-22).

Breed, SLD7 recorded a fecundity of 534, fifth age duration of 7.07
(Days:Hours), total duration of 24.07 (Days:Hours), pupation rate of 91.53, yield per
10000 larvae of 18.780 kgs, cocoon weight of 2.087g, shell weight of 0.447g, shell
percentage of 21.43, filament length of 1081m, filament size of 2.52d, raw silk
content of 16.39%, renditta of 6.10, reelability of 81%, neatness of 91 pts with a silk
productivity per day of 6.13 cg at filial generation 1 and a fecundity of 486, fifth age
duration of 6.13 (Days:Hours), total duration of 22.14 (Days:Hours), pupation rate of
92.67, yield per 10000 larvae of 16.113 kgs, cocoon weight of 1.760g, shell weight
of 0.372g, shell percentage of 21.14, filament length of 947m, filament size of 2.60d,
raw silk content of 16.13%, renditta of 6.20, reelability of 80%, neatness of 92 pts
with a silk productivity per day of 5.68 cg at filial generation 10 (Table-23).

Breed, SLD8 recorded a fecundity of 524, fifth age duration of 7.21
(Days:Hours), total duration of 24.21 (Days:Hours), pupation rate of 97.07, yield per
10000 larvae of 20.640 kgs, cocoon weight of 2.132g, shell weight of 0.482g, shell
percentage of 22.61, filament length of 1143m, filament size of 2.51d, raw silk
content of 17.49%, renditta of 5.72, reelability of 83%, neatness of 93 pts with a silk
productivity per day of 6.12 cg at filial generation 1 and a fecundity of 534, fifth age
duration of 6.10 (Days:Hours), total duration of 22.19 (Days:Hours), pupation rate of
95.20, yield per 10000 larvae of 16.327 kgs, cocoon weight of 1.756g, shell weight
of 0.402g, shell percentage of 22.89, filament length of 1160m, filament size of
2.38d, raw silk content of 18.81%, renditta of 5.32, reelability of 81%, neatness of 94
pts with a silk productivity per day of 6.27 cg at filial generation 10 (Table-24).

Breed, SLD9 recorded a fecundity of 508, fifth age duration of 7.21
(Days:Hours), total duration of 24.21 (Days:Hours), pupation rate of 89.87, yield per
10000 larvae of 19.413 kgs, cocoon weight of 2.072g, shell weight of 0.471g, shell
percentage of 22.75, filament length of 1086m, filament size of 2.42d, raw silk
content of 17.20%, renditta of 5.81, reelability of 83%, neatness of 93 pts with a silk
productivity per day of 5.98 cg at filial generation 1 and a fecundity of 512, fifth age
duration of 6.14 (Days:Hours), total duration of 22.20 (Days:Hours), pupation rate of
96.53, yield per 10000 larvae of 15.787 kgs, cocoon weight of 1.654g, shell weight
of 0.374g, shell percentage of 22.61, filament length of 1036m, filament size of
2.35d, raw silk content of 18.23%, renditta of 5.48, reelability of 81%, neatness of 93
pts with a silk productivity per day of 5.68 cg at filial generation 10 (Table-25).

Breed, SLD10 recorded a fecundity of 516, fifth age duration of 7.12
(Days:Hours), total duration of 24.12 (Days:Hours), pupation rate of 98.13, yield per
10000 larvae of 21.893 kgs, cocoon weight of 2.192g, shell weight of 0.473g, shell
percentage of 21.60, filament length of 1092m, filament size of 2.54d, raw silk
content of 16.35%, renditta of 6.12, reelability of 83%, neatness of 91 pts with a silk
productivity per day of 6.31 cg at filial generation 1 and a fecundity of 506, fifth age
duration of 6.14 (Days:Hours), total duration of 22.20 (Days:Hours), pupation rate of
95.20, yield per 10000 larvae of 16.113 kgs, cocoon weight of 1.720g, shell weight
of 0.361g, shell percentage of 20.97, filament length of 971m, filament size of 2.38d,
raw silk content of 16.45%, renditta of 6.08, reelability of 81%, neatness of 93 pts
with a silk productivity per day of 5.48 cg at filial generation 10 (Table-26).

Comparative performance of selected breeds

After fixation of breeds at F10 generation, one oval breed SLD4 and one
dumbbell breed SLD8 were selected and they were compared with the control
breeds, CSR2 and CSR4 and the comparative performance is given in Table-27.
Almost all the parameters considered for the study for the newly developed breeds showed increased values as compared to the control breeds. The larval duration, filament size and neatness of the newly developed breeds were less than the control breeds. The larval duration for the oval breed, SLD4 was 22.16 days while it was 23.12 days for the control breed, CSR2. On the other hand, the larval duration for the dumbbell breed, SLD8 was 22.23 days while it was 24.20 days for the control breed, CSR4. The pupation rate for the oval breed, SLD4 was 93.3 % while it was 89.33 % for the control breed, CSR2. On the other hand, the pupation rate for the dumbbell breed, SLD8 was 92.2 % while it was 88.46 % for the control breed, CSR4. The cocoon yield/10000 larvae for the oval breed, SLD4 was 17.254 kg while it was 16.270 kg for the control breed, CSR2. On the other hand, the cocoon yield/10000 larvae for the dumbbell breed, SLD8 was 16.226 kg while it was 15.742 kg for the control breed, CSR4. The cocoon weight for the oval breed, SLD4 was 1.846 g while it was 1.810 g for the control breed, CSR2. On the other hand, the cocoon weight for the dumbbell breed, SLD8 was 1.756 g while it was 1.810 g for the control breed, CSR4. The cocoon shell weight for the oval breed, SLD4 was 0.410 g while it was 0.406 g for the control breed, CSR2. On the other hand, the cocoon shell weight for the dumbbell breed, SLD8 was 0.402 g while it was 0.416 g for the control breed, CSR4. The cocoon shell percentage for the oval breed, SLD4 was 22.86 % while it was 22.43 % for the control breed, CSR2. On the other hand, the cocoon shell percentage for the dumbbell breed, SLD8 was 22.89 % while it was 22.98 % for the control breed, CSR4. The filament length for the oval breed, SLD4 was 1026 m while it was 1008m for the control breed, CSR2. On the other hand, the filament length for the dumbbell breed, SLD8 was 1042 m while it was 1028 m for the
control breed, CSR4. The filament size for the oval breed, SLD4 was 2.56 d while it was 2.72 d for the control breed, CSR2. On the other hand, the filament size for the dumbbell breed, SLD8 was 2.65 d while it was 2.97 d for the control breed, CSR4. The raw silk percentage for the oval breed, SLD4 was 18.56 % while it was 18.22 % for the control breed, CSR2. On the other hand, the raw silk percentage for the dumbbell breed, SLD8 was 19.06 % while it was 18.78 % for the control breed, CSR4. The reelability for the oval breed, SLD4 was 86 % while it was 82 % for the control breed, CSR2. On the other hand, the reelability for the dumbbell breed, SLD8 was 84 % while it was 79 % for the control breed, CSR4. The neatness for the oval breed, SLD4 was 92 p while it was 93 for the control breed, CSR2. On the other hand, the neatness for the dumbbell breed, SLD8 was 93 p while it was 92 p for the control breed, CSR4 (Table -27).

**Hybrid evaluation**

**Performance of single hybrids**

By utilizing the 10 selected breeding lines 48 hybrid combinations were made and subjected for evaluation. The fifth age larval duration in the single hybrids ranged from 6.00 to 7.00 (Days:Hours) with the shortest of 6.00 (Days:Hours) recorded for SLD1 x SLD6 and the longest of 7.00 (Days:Hours) recorded for SLD7 x SLD1. The total larval duration ranged from 21.02 to 22.21 (Days:Hours) with the shortest of 21.02 (Days:Hours) recorded for SLD1 x SLD6, SLD3 x SLD10 and SLD4 x SLD6 and the longest of 22.21 days recorded for SLD1 x SLD7. The pupation rate ranged from 93.07 to 96.98 % with the lowest of 93.07 % recorded for SLD1 x SLD7 and the highest of 96.98 % recorded for SLD1 x SLD8. The yield/10,000 larvae by weight ranged from 18.397 to 21.325 kg with the lowest of 18.397 kg recorded for SLD10 x SLD3 and the highest of 21.325 kg recorded for SLD1 x SLD5. The cocoon weight ranged from 1.906 to 2.122 g with the lowest of 1.906 g recorded for SLD3 x SLD9 and the highest of 2.122 g recorded for SLD1 x SLD5. The cocoon shell weight ranged from 0.412 to 0.472 g with the lowest of 0.412 g recorded for SLD9 x SLD3 and the highest of 0.472 g recorded for SLD4 x SLD8. The cocoon shell percentage ranged from 21.24 to 23.32 % with the lowest of 21.24 % recorded for SLD3 SLD5 and the highest of 23.22 % recorded for SLD4 x SLD8. The filament length ranged from 941 to 1256 m with the shortest of 941 m recorded for SLD10 x SLD2 and the longest of 1256 m recorded for SLD1 x SLD8.
The filament size ranged from 2.58 to 3.36 d with the thinnest of 2.58 d recorded for SLD8 x SLD1 and the thickest of 3.36 d recorded for SLD2 x SLD5. The raw silk percentage ranged from 15.52 to 19.46 % with the lowest of 15.52 % recorded for SLD10 x SLD1 and the highest of 19.46 % recorded for SLD4 x SLD8. The renditta ranged from 5.14 to 6.45 with the lowest of 5.14 recorded for SLD4 x SLD8 and the highest of 6.45 recorded for SLD10 x SLD1. The reelability ranged from 83.00 to 89.00 % with the lowest of 83.00 % recorded for SLD10 x SLD2 and the highest of 89.00 % recorded for SLD3 x SLD7. The neatness ranged from 92 to 94 points with the lowest of 92 points recorded for SLD1 x SLD7, SLD1 x SLD9, SLD1 x SLD10, SLD2 x SLD5, SLD2 x SLD7, SLD3 x SLD6, SLD4 x SLD5, SLD6 x SLD3, SLD7 x SLD1, SLD7 x SLD2, SLD7 x SLD3, SLD10 x SLD1, SLD10 x SLD3 and SLD10 x SLD4 (Table-28).

The multiple trait evaluation index for fifth age larval duration ranged from 31.90 to 68.85 with the lowest of 31.90 recorded for SLD7 x SLD1 and the highest of 68.85 recorded for SLD1 x SLD6. The multiple trait evaluation index for total larval duration ranged from 35.68 to 68.21 with the lowest of 35.68 recorded for SLD7 x SLD1 and the highest of 68.21 recorded for SLD1 x SLD6. The multiple trait evaluation index for pupation rate ranged from 31.25 to 70.98 with the lowest of 31.25 recorded for SLD1 x SLD7 and the highest of 70.98 recorded for SLD1 x SLD8. The multiple trait evaluation index for yield/10000 larvae by weight ranged from 30.11 to 77.16 with the lowest of 30.11 recorded for SLD10 x SLD3 and the highest of 77.16 recorded for SLD1 x SLD5. The multiple trait evaluation index for cocoon weight ranged from 30.50 to 79.53 with the lowest of 30.50 recorded for SLD3 x SLD9 and the highest of 79.53 recorded for SLD1 x SLD5. The multiple trait evaluation index for cocoon shell weight ranged from 33.75 to 71.09 with the lowest of 33.75 recorded for SLD9 x SLD3 and the highest of 71.09 recorded for SLD4 x SLD8. The multiple trait evaluation index for cocoon shell percentage ranged from 35.97 to 72.76 with the lowest of 35.97 recorded for SLD3 x SLD5 and SLD3 x SLD10 and the highest of 72.76 recorded for SLD4 x SLD8. The multiple trait evaluation index for filament length ranged from 34.75 to 77.34 with the lowest of 34.75 recorded for SLD10 x SLD2 and the highest of 77.34 recorded for SLD1 x SLD8. The multiple trait evaluation index for filament size ranged from 28.24 to 70.31 with the lowest of 28.24 recorded for SLD2 x SLD5 and the highest of 70.31 recorded for SLD8 x SLD1. The multiple trait evaluation index for raw silk
percentage ranged from 32.05 to 77.55 with the lowest of 32.05 recorded for SLD10 x SLD1 and the highest of 77.55 recorded for SLD4 x SLD8. The multiple trait evaluation index for renditta ranged from 30.45 to 75.17 with the lowest of 30.45 recorded for SLD10 x SLD1 and the highest of 75.17 recorded for SLD4 x SLD8. The multiple trait evaluation index for reelability ranged from 33.11 to 75.06 with the lowest of 33.11 recorded for SLD8 x SLD3 and SLD10 x SLD2 and the highest of 75.06 recorded for SLD3 x SLD7. The multiple trait evaluation index for neatness ranged from 36.93 to 63.61 with the lowest of 36.93 recorded for SLD1 x SLD7, SLD1 x SLD9, SLD1 x SLD10, SLD2 x SLD5, SLD2 x SLD7, SLD3 x SLD6, SLD4 x SLD5, SLD6 x SLD3, SLD7 x SLD1, SLD7 x SLD2, SLD7 x SLD3SLD10 x SLD1SDL10 x SLD3 and SLD10 x SLD4 and the highest of 63.61 recorded for SLD1 x SLD8, SLD2 x SLD8, SLD2 x SLD9, SLD4 x SLD6, SLD4 x SLD8, SLD4 x SLD9, SLD6 x SLD4 SLD8 x SLD1, SLD8 x SLD2, SLD8 x SLD4, SLD9 x SLD2 and SLD9 x SLD4. The average evaluation index for all the traits considered for the study ranged from 40.96 to 64.66 with the lowest of 41 recorded for SLD9 x SLD3 and the highest of 64.66 recorded for SLD4 x SLD8 (Table-29).

Comparative performance of selected single hybrid

The comparative performance of the hybrids is given in Table-30. Similar to the parents, the larval duration and filament size of the new hybrid, SLD4 x SLD8 were less than the control hybrid, CSR2 x CSR4. However, almost all the other parameters considered for the study for the new hybrid were higher in the new hybrid than the control hybrid, CSR2 x CSR4. The larval duration for the new hybrid, SLD4 x SLD8 was 22.06 (Days:Hours) while it was 23.00 (Days:Hours) for the control hybrid, CSR2 x CSR4. The pupation rate for the new hybrid, SLD4 x SLD4 was 95.68 % while it was 92.44 % for the control hybrid, CSR2 x CSR4. The cocoon yield/10000 larvae for the new hybrid, SLD4 x SLD8 was 20.220 kg while it was 19.704 kg for the control hybrid, CSR2 x CSR4. The cocoon weight for the new hybrid, SLD4 x SLD8 was 2.102 g while it was 2.110 g for the control hybrid, CSR2 x CSR4. The cocoon shell weight for the new hybrid, SLD4 x SLD8 was 0.482 g while it was 0.478 g for the control hybrid, CSR2 x CSR4. The cocoon shell percentage for new hybrid, SLD4 x SLD 8 was 22.93 % while it was 22.65 % for the control hybrid, CSR2 x CSR4. The filament length for new hybrid, SLD4 x SLD 8 was 1220 m while it was 1217 m for the control hybrid, CSR2 x CSR4. The filament size for the new hybrid, SLD4 x SLD 8 was 2.84 d while it was 3.15 d for the control
hybrid, CSR2 x CSR4. The raw silk percentage for the new hybrid, SLD4 x SLD 8 was 19.88 % while it was 18.75 % for the control hybrid, CSR2 x CSR4. The reelability for the new hybrid, SLD4 x SLD 8 was 86 % while it was 81 % for the control hybrid, CSR2 x CSR4. The neatness for the new hybrid, SLD4 x SLD8 and the control hybrid, CSR2 x CSR4 was 93 p. Besides, the evaluation of pre-cocoon and post-cocoon parameters, the cocoon uniformity of the hybrid was measured and the standard deviation for the new hybrid, SLD4 x SLD8 was 6.3 while it was 6.9 for the control hybrid, CSR2 x CSR4.

Performance of foundation crosses

By utilizing the 10 breeding lines, 21 foundation crosses were made. The fecundity of foundation crosses ranged from 442 to 566 with lowest of 442 for SLD6 x SLD10 and the highest of 566 in SLD2 x SLD4. The fifth age larval duration ranged from 6.00 to 6.14 days with the lowest of 6.00 days in SLD1 x SLD2, SLD2 x SLD4, SLD3 x SLD4, SLD5 x SLD9, SLD8 x SLD9 and SLD9 x SLD10 and the highest of 6.14 days for SLD5 x SLD10 and SLD6 x SLD10. The total larval duration of the foundation crosses ranged from 21.05 to 22.15 days with shortest larval duration recorded for SLD2 x SLD4 and SLD3 x SLD4 and longest duration of 22.15 days was recorded for SLD6 x SLD7 and SLD7 x SLD8. Yield/10000 larvae by number ranged from 9028 to 9724 with the lowest of 9028 recorded for SLD1 x SLD3 and the highest of 9724 recorded for SLD2 x SLD4. Yield/10000 larvae by weight ranged from 15.317 to 18.451 with the lowest of 15.317 kg recorded for SLD7 x SLD8 and the highest of 18.451 kg recorded for SLD9 x SLD10. The cocoon weight ranged from 1.523 to 1.825 g with the lowest of 1.523 g recorded for SLD5 x SLD8 and SLD8 x SLD9 and the highest of 1.825 g recorded for SLD2 x SLD4. The cocoon shell weight ranged from 0.323 to 0.428g with the lowest of 0.323 g recorded for SLD5 x SLD8 and the highest of 0.428 g recorded for SLD9 x SLD10. The cocoon shell percentage ranged from 20.4 to 23.7 % with the lowest of 20.4 % recorded for SLD1 x SLD3 and the highest of 23.7 % recorded for SLD9 x SLD10. The filament length ranged from 953 to 1160m with the shortest of 953 m recorded for SLD6 x SLD10 and the logest of 1160 m recorded for SLD7 x SLD9. The filament size ranged from 2.44 to 2.95 d with the thinnest of 2.44 d recorded for SLD1 x SLD2 and the thickest of 2.95 d recorded for SLD5 x SLD8 and SLD7 x SLD10. The raw silk percentage ranged from 16.5 to 18.7 % with the lowest of 16.5 % recorded for SLD8 x SLD10 and the highest of 18.7 % recorded for SLD3
x SLD4 and SLD8 x SLD9. The renditta ranged from 5.34 to 6.36 with the lowest of 5.34 recorded for SLD3 x SLD4 and SLD8 x SLD9 and the highest of 6.86 recorded for SLD5 x SLD8. The reelability ranged from 81 to 86 % with the lowest of 81 % recorded for SLD1 x SLD4, SLD5 x SLD6, SLD5 x SLD7, SLD5 x SLD8, SLD5 x SLD10, SLD6 x SLD10, SLD7 x SLD10, SLD8 x SLD9 and SLD8 x SLD10 and the highest of 86 % recorded for SLD2 x SLD4 and SLD5 x SLD9. The neatness ranged from 91 to 94 p with the lowest of 91 p recorded for SLD1 x SLD3, SLD1 x SLD4, SLD 5 x SLD6, SLD5 x SLD7, SLD6 x SLD10, SLD7 x SLD8 and SLD7 x SLD10 (Table-31).

The performance of the foundation crosses were subjected for multiple trait evaluation index for short listing the better foundation crosses for making the double hybrids. The index value for fecundity in foundation crosses ranged from 31.91 to 71.23, the lowest of 31.91 recorded for SLD6 x SLD10 and the highest of 71.23 for SLD2 x SLD4. Index value for fifth age duration ranged from 42.75 to 60, the lowest of 42.75 obtained for SLD6 x SLD7 and the highest of 60 obtained for SLD1 x SLD2, SLD2 x SLD4, SLD3 x SLD4, SLD5 x SLD9 and SLD9 x SLD10. The index value for total larval duration ranged from 41.02 to 66.75 the lowest of 41.02 recorded for SLD6 x SLD7 and highest of 66.75 obtained for SLD8 x SLD9. Index value for pupation rate ranged from 33.60 to 71.63 with the lowest of 33.60 recorded for SLD1 x SLD3 and the highest of 71.63 recorded for SLD2 x SLD4. Index value for yield/10000 larvae by weight ranged from 37.33 to 67.52 with the lowest of 37.33 recorded for SLD6 x SLD7 and SLD7 x SLD8 and the highest of 67.52 recorded for SLD3 x SLD4. Index value for cocoon weight ranged from 35.65 to 64.72 with the lowest of 35.65 recorded for SLD5 x SLD8 and SLD8 x SLD9 and the highest of 64.72 recorded for SLD2 x SLD4. Index value for cocoon shell weight ranged from 37.33 to 67.13 with the lowest of 37.33 recorded for SLD5 x SLD8 and the highest of 67.13 recorded for SLD9 x SLD10. Index value for cocoon shell percentage ranged from 33.49 to 69.19 with the lowest of 33.49 recorded for SLD1 x SLD3 and the highest of 69.19 recorded for SLD9 x SLD10. Index value for filament length ranged from 35.24 to 69.77 with the lowest of 35.24 recorded for SLD6 x SLD10 and the highest of 69.77 recorded for SLD8 x SLD9. Index value for filament size ranged from 37.09 to 68.90 with the lowest of 37.09 recorded for SLD5 x SLD8 and the highest of 68.90 recorded for SLD1 x SLD2. Index value for raw silk percentage ranged from 29.45 to 68.52 with the lowest of 29.45 recorded for SLD8 x SLD10.
and the highest of 68.52 recorded for SLD3 x SLD4. Index value for renditta ranged from 28.20 to 67.92 with the lowest of 28.20 recorded for SLD8 x SLD10 and the highest of 67.92 recorded for SLD3 x SLD4. Index value for reelability ranged from 41 to 68.97 with the lowest of 41 recorded for SLD1 x SLD4, SLD5 x SLD6, SLD5 x SLD7, SLD5 x SLD8, SLD5 x SLD10, SLD6 x SLD8, SLD6 x SLD10, SLD7 x SLD10, SLD8 x SLD9 and SLD8 x SLD10 and the highest of 68.97 recorded for SLD2 x SLD4 and SLD5 x SLD9. Index value for neatness ranged from 38.81 to 67.41 with the lowest of 39 recorded for SLD1 x SLD3, SLD1 x SLD4, SLD 5 x SLD6, SLD5 x SLD7, SLD6 x SLD10, SLD7 x SLD8 and SLD7 x SLD10 and the highest of 67.41 recorded for SLD1 x SLD2, SLD5 x SLD9, SLD8 x SLD9 and SLD9 x SLD10 (Table-32). The average evaluation index ranged from 40.85 to 63.89 with the lowest of 40.85 recorded for SLD8 x SLD10 and the highest of 63.89 recorded for SLD2 x SLD4. Based on highest average index, three oval foundation crosses viz., SLD1 x SLD2, SLD2 x SLD3 and SLD3 x SLD4 and three oval foundation crosses viz., SLD5 x SLD9, SLD8 x SLD9 and SLD x SLD10 were short listed for making double hybrids.

**Performance of double hybrids**

By utilizing the short listed six foundation crosses, 9 double hybrids were made and subjected for evaluation. The fecundity in double hybrids ranged from 538 to 588, the lowest of 538 for (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 588 for (SLD2 x SLD4) x (SLD8 x SLD9). The fifth age duration ranged from 6.02 to 6.14 days, the lowest of 6.02 for (SLD2 x SLD4) x (SLD8 x SLD9) and the highest of 6.14 days for (SLD2 x SLD4)x (SLD5 x SLD9). The total larval duration of the double hybrids ranged from 21.10 to 22.16 days with shortest larval duration recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and longest duration of 22.16 days was recorded for (SLD3 x SLD4) x (SLD5 x SLD9). Yield/10000 larvae by number ranged from 9254 to 9758 with the lowest of 9254 recorded for (SLD1 x SLD2) x (SLD5 x SLD9) and the highest of 9758 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Yield/10000 larvae by weight ranged from 17.114 to 20.158 with the lowest of 17.114 kg recorded for (SLD1 x SLD2) x (SLD8 x SLD9) and the highest of 20.158 kg recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The cocoon weight ranged from 1.808 to 2.002 g with the lowest of 1.808 g recorded for (SLD3 x SLD4) x (SLD5 x SLD9) and the highest of 2.002 g recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The cocoon shell weight ranged from 0.388 to 0.462g with the lowest of
0.388 g recorded for (SLD3 x SLD4) x (SLD5 x SLD9) and the highest of 0.462 g recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The cocoon shell percentage ranged from 21.30 to 23.08 % with the lowest of 21.30 % recorded for (SLD1 x SLD2) x (SLD5 x SLD9) and the highest of 23.08 % recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The filament length ranged from 989 to 1125 m with the shortest of 989 m recorded for (SLD3 x SLD4) x (SLD9 x SLD10) and the longest of 1125 m recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The filament size ranged from 2.58 to 2.91 d with the thinnest of 2.58 d recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and the thickest of 2.91 d recorded for (SLD3 x SLD4) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD9 x SLD10). The raw silk percentage ranged from 17.14 to 18.8 % with the lowest of 17.14 % recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and the highest of 18.80 % recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The renditta ranged from 5.32 to 5.83 with the lowest of 5.32 recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and the highest of 5.83 recorded for (SLD2 x SLD4) x (SLD5 x SLD9). The reelability ranged from 81 to 86 % with the lowest of 81 % recorded for (SLD1 x SLD2) x (SLD5 x SLD9), (SLD1 x SLD2) x (SLD9 x SLD10), (SLD3 x SLD4) x (SLD5 x SLD9), (SLD3 x SLD4) x (SLD8 x SLD9), (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 86 % recorded for (SLD2 x SLD4) x (SLD7 x SLD9). The neatness ranged from 91 to 94 p with the lowest of 91 p recorded for (SLD1 x SLD2) x (SLD8 x SLD9), (SLD1 x SLD2) x (SLD9 x SLD10), (SLD3 x SLD4) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of 94 p recorded for (SLD2 x SLD4) x (SLD8 x SLD9) (Table-33).

The index value for fecundity in double hybrids ranged from 36.47 to 69.63, the lowest of 36.47 obtained for (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 69.63 obtained for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for fifth age duration ranged from 39.40 to 66.38, the lowest of 39.40 obtained for (SLD3 x SLD4) x (SLD5 x SLD9) and the highest of 66.38 obtained for (SLD2 x SLD4) x (SLD8 x SLD9). The index value for total larval duration of the double hybrids ranged from 44.67 to 75.12 with the lowest value of 44.67 recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and the highest value of 75.12 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for Yield/10000 larvae by number ranged from 41.25 to 74.97 with the lowest of 41.25 recorded for (SLD1 x SLD2) x (SLD5 x SLD9) and the highest of 74.97 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for yield/10000 larvae by weight ranged from 41.02 to 74.27 with the lowest of 41.02 recorded for
(SLD1 x SLD2) x (SLD8 x SLD9) and the highest of 74.27 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for cocoon weight ranged from 40.44 to 72.76 with the lowest of 40.44 recorded for (SLD3 x SLD4) x (SLD5 x SLD9) and the highest of 72.76 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for cocoon shell weight ranged from 39.07 to 75.02 with the lowest of 39.07 recorded for (SLD3 x SLD4) x (SLD5 x SLD9) and the highest of 75.02 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for cocoon shell percentage ranged from 37.48 to 69.43 with the lowest of 37.48 recorded for (SLD3 x SLD4) x (SLD5 x SLD9) and the highest of 69.43 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for filament length ranged from 39.54 to 72.69 with the lowest of 39.54 recorded for (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 72.69 recorded for (SLD2 x SLD4) x (SLD7 x SLD9). Index value for filament size ranged from 43.12 to 74.65 with the lowest of 43.12 recorded for (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 74.65 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for raw silk percentage ranged from 38.57 to 74.31 with the lowest of 38.57 recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and the highest of 74.31 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for renditta ranged from 38.04 to 73.88 with the lowest of 38.04 recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and the highest of 73.88 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). Index value for reelability ranged from 42.38 to 65.59 with the lowest of 42 recorded for (SLD1 x SLD2) x (SLD5 x SLD9), (SLD1 x SLD2) x (SLD9 x SLD10), (SLD3 x SLD4) x (SLD5 x SLD9), (SLD3 x SLD4) x (SLD7 x SLD9), (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 65.59 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The neatness ranged from 41.29 to 73.94 with the lowest of 41 recorded for (SLD1 x SLD2) x (SLD8 x SLD9), (SLD1 x SLD2) x (SLD9 x SLD10), (SLD3 x SLD4) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of 73.94 recorded for (SLD2 x SLD4) x (SLD8 x SLD9). The average index value for tall the traits considered from the study ranged from 39.12 to 69.63 with the lowest of 39.12 recorded for (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of 69.63 recorded for (SLD2 x SLD4) x (SLD8 x SLD9) (Table-34).

**Hybrid vigour**

**Heterosis in single hybrids**

Among the 48 hybrids, with regard to total larval duration almost all the hybrids recorded negative heterosis. For the trait, total larval duration, the negative
heterosis ranged from -0.18% to -5.45% with the lowest of -0.18% recorded for SLD2 x SLD7 and the highest of -5.45% recorded for SLD2 x SLD6 while positive heterosis ranged from 0.18 to 2.26% with the lowest of 0.18% recorded for SLD2 x SLD9 and the highest of 2.26% recorded for SLD8 x SLD2. It was also observed that there was no heterosis for the hybrids SLD2 x SLD5 and SLD4 x SLD5. With regard to pupation rate, half of the hybrids recorded positive heterosis ranging from 0.05 to 4.14% with the lowest of 0.05% recorded for SLD4 x SLD6 and the highest of 4.14% recorded for SLD1 x SLD5 and the remaining half of hybrids recorded negative heterosis ranging from -0.01 to -2.93% with the lowest of -0.01% recorded for SLD2 x SLD8 and the highest of -2.93% recorded for SLD9 x SLD3. Heterosis for yield/10000 larvae recorded positive heterosis for all the 48 hybrids and it ranged from 11.96 to 32.67% with the lowest of 11.96% recorded for SLD5 x SLD3 and the highest of 32.67% recorded for SLD1 x SLD6. Heterosis for cocoon weight for all the 48 hybrids recorded positive heterosis and it ranged from 11.01 to 28.50% with the lowest of 11.01% recorded SLD5 x SLD4 and the highest of 28.50% recorded for SLD1 x SLD6. Heterosis for cocoon shell weight for all the 48 hybrids recorded positive heterosis and it ranged from 10.10 to 33.24% with the lowest of 10.10% recorded SLD7 x SLD4 and the highest of 33.24% recorded for SLD1 x SLD6. For the trait, cocoon shell percentage positive heterosis was recorded for 36 hybrids ranging from 0.14 to 5.45% with the lowest of 0.14% recorded for SLD9 x SLD2 and the highest of 5.45% recorded for SLD1 x SLD9 and negative heterosis was recorded for 12 hybrids ranging from -0.17 to -2.80% with the lowest of -0.17% recorded for SLD8 x SLD4 and the highest of -0.20% recorded for SLD9 x SLD4. For the trait, filament length positive heterosis was recorded for 26 hybrids ranging from 0.21 to 16.40% with the lowest of 0.21% recorded SLD3 x SLD10 and the highest of 16.40% recorded for SLD3 x SLD5 and negative heterosis was recorded for 22 hybrids ranging from -0.28 to -10.67% with the lowest of -0.28% recorded for SLD2 x SLD9 and the highest of -10.67% recorded for SLD5 x SLD4. It was also observed that there was no heterosis for the hybrid, SLD8 x SLD2. For the trait, filament size all the 48 hybrids recorded positive heterosis ranging from 5.65 to 37.50% with the lowest of 5.65% recorded for SLD8 x SLD1 and the highest of 37.50% recorded for SLD1 x SLD9 and SLD9 x SLD1. For the trait, raw silk percentage, positive heterosis was recorded for 17 hybrids ranging from 0.19 to 4.22% with the lowest of 0.19 recorded for SLD7 x SLD3 and the highest of 4.22% recorded for SLD3 x SLD7 and negative heterosis was recorded for 31 hybrids
ranging from -0.69 to -9.08 % with the lowest of 0.69% recorded for SLD8 x SLD4 and the highest of -0.9.08 % recorded for SLD10 x SLD1. For the trait, reelability no heterosis was recorded for the hybrid, SLD8 x SLD3 while positive heterosis was recorded for 45 hybrids ranging from 020 to 10.56 % with the lowest of 0.20 % recorded for SLD10 x SLD4 and the highest of 10.56 % recorded for SLD3 x SLD7 and negative heterosis was recorded for SLD5 x SLD4 (-0.20 %) and SLD8 x SLD4 (-0.97 %). For the trait, renditta positive heterosis was recorded for 30 hybrids ranging from 0.54 to 10.07 % with the lowest of 0.54 % recorded for SLD2 x SLD9 and the highest of 10.07 % recorded for SLD10 x SLD1 while negative heterosis was recorded for 28 hybrids ranging from -0.16 to -3.93 % with the lowest of -0.16 % recorded for SLD7 x SLD3 and the highest of -3.93 % recorded for SLD4 x SLD8. For the trait neatness, no heterosis was recorded for the hybrids, SLD1 x SLD8, SLD2 x SLD6, SLD2 x SLD10, SLD3 x SLD8, SLD4 x SLD7, SLD4 x SLD8, SLD5 x SLD2, SLD6 x SLD2, SLD7 x SLD3, SLD7 x SLD4, SLD8 x SLD1, SLD8 x SLD3, SLD8 x SLD4 and SLD10 x SLD2. Positive heterosis was recorded for 14 hybrids ranging from 0.53 to 1.08 % with the lowest of 0.53 % recorded for SLD2 x SLD8, SLD4 x SLD6, SLD4 x SLD9, SLD6 x SLD4, SLD8 x SLD2 and SLD9 x SLD4 and the highest of 1.08 % recorded for SLD3 x SLD7 and negative heterosis was recorded for 20 hybrids ranging from -0.53 to -1.08 % with the lowest of -0.53 % recorded for SLD1 x SLD5, SLD1 x SLD6, SLD4 x SLD10, SLD5 x SLD1, SLD5 x SLD4, SLD6 x SLD1 and SLD9 x SLD1 and the highest of -1.08 % recorded for SLD1 x SLD7 and SLD2 x SLD5 (Table-35).

**Heterobeltiosis in single hybrids**

For the trait, total larval duration, the positive heterobeltiosis was recorded for 22 hybrids ranging from 0.19% to 5.44 % with the lowest of 0.19 % recorded for SLD3 x SLD6 and SLD10 x SLD3 and the highest of 5.44 % recorded for SLD8 x SLD3 while negative heterobeltiosis was recorded for 26 hybrids ranging from -0.18 to -4.21% with the lowest of -0.18 % recorded for SLD2 x SLD7 and the highest of -4.21 % recorded for SLD10 x SLD4. With regard to pupation rate, positive heterobeltiosis was recorded for 10 hybrids ranging from 0.20 to 1.87 % with the lowest of 0.20 % recorded for SLD2 x SLD6 and the highest of 1.87 % recorded for SLD1 x SLD8 and the remaining 38 hybrids recorded negative heterobeltiosis ranging from -0.06 to -3.20 % with the lowest of -0.06 % recorded for SLD4 x SLD10 and the highest of -3.20 % recorded for SLD9 x SLD3. Heterobeltiosis for
yield/10000 larvae recorded positive heterobeltiosis for all the 48 hybrids and it ranged from 8.88 to 29.73 % with the lowest of 8.88 % recorded for SLD5 x SLD3 and the highest of 29.73 % recorded for SLD1 x SLD9. Heterobeltiosis for cocoon weight for all the 48 hybrids recorded positive heterobeltiosis and it ranged from 7.47 to 23.32 % with the lowest of 7.47 % recorded SLD5 x SLD2 and the highest of 23.32 % recorded for SLD1 x SLD6. Heterobeltiosis for cocoon shell weight for all the 48 hybrids recorded positive heterobeltiosis and it ranged from 4.99 to 27.70 % with the lowest of 4.99 % recorded SLD10 x SLD4 and the highest of 27.70 % recorded for SLD1 x SLD6. For the trait, cocoon shell percentage positive heterobeltiosis was recorded for 28 hybrids ranging from 0.17 to 5.20 % with the lowest of 0.17 % recorded for SLD1 x SLD8 and the highest of 5.20 % recorded for SLD1 x SLD7 and negative heterobeltiosis was recorded for 20 hybrids ranging from -0.83 to -6.47 % with the lowest of -0.83 % recorded for SLD4 x SLD9 and the highest of -6.47 % recorded for SLD9 x SLD4. For the trait, filament length positive heterobeltiosis was recorded for 13 hybrids ranging from 0.09 to 13.21 % with the lowest of 0.09 % recorded SLD4 x SLD8 and the highest of 13.21% recorded for SLD3 x SLD5 and negative heterobeltiosis was recorded for 35 hybrids ranging from -0.10 to -15.91 % with the lowest of -0.10 % recorded for SLD3 x SLD10 and the highest of -15.91 % recorded for SLD10 x SLD2. For the trait, filament size all the 48 hybrids recorded positive heterobeltiosis ranging from 7.69 to 41.18 % with the lowest of 7.69 % recorded for SLD7 x SLD2 and the highest of 41.18 % recorded for SLD2 x SLD5. For the trait, raw silk percentage, positive heterobeltiosis was recorded for the four hybrids viz., SLD3 x SLD7 (4.03 %), SLD3 x SLD10 (1.22%), SLD4 x SLD8(3.46%) and SLD4 x SLD9 (0.11 %) and negative heterobeltiosis was recorded for 33 hybrids ranging from -0.36 to -11.74 % with the lowest of 0.36% recorded for SLD10 x SLD3 and the highest of -11.74 % recorded for SLD3 x SLD9. It was also observed that, no heterosis was recorded for the hybrid, SLD7 x SLD3. For the trait, reelability no heterobeltiosis was recorded for the hybrids, SLD4 x SLD9 and SLD8 x SLD1. While positive heterobeltiosis was recorded for 36 hybrids ranging from 0.38 to 9.88 % with the lowest of 0.38 % recorded for SLD4 x SLD10 and the highest of 9.88 % recorded for SLD3 x SLD7 and negative heterobeltiosis was recorded for 10 hybrids ranging from -1.16 to -2.71 % with the lowest of -1.16 % SLD4 x SLD6 and SLD9 x SLD4 and the highest of -2.71 % for SLD10 x SLD4. For the trait, renditta positive heterobeltiosis was recorded for 33 hybrids ranging from 0.49 to 14.16 % with the lowest of 0.49 %
recorded for SLD10 x SLD3 and the highest of 14.16% recorded for SLD10 x SLD1 while negative heterobeltiosis was recorded for 4 hybrids ranging from -0.19 to -3.71% with the lowest of -0.19% recorded for SLD4 x SLD9 and the highest of -3.71% recorded for SLD3 x SLD7. It was also observed no heterobeltosis was recorded for SLD7 x SLD3. For the trait neatness, no heterobeltiosis was recorded for the 20 hybrids viz., SLD1 x SLD8, SLD2 x SLD6, SLD2 x SLD8, SLD2 x SLD10, SLD3 x SLD5, SLD3 x SLD9, SLD3 x SLD10, SLD4 x SLD6, SLD4 x SLD8, SLD4 x SLD9, SLD5 x SLD2, SLD5 x SLD3, SLD6 x SLD2, SLD6 x SLD4, SLD7 x SLD3, SLD8 x SLD1, SLD8 x SLD2, SLD8 x SLD4, SLD9 x SLD3, SLD9 x SLD4 and SLD10 x SLD2. Positive heterobeltiosis was recorded for the 3 hybrids viz, SLD2 x SLD9 (1.08%), SLD3 x SLD7 (1.09%) and SLD9 x SLD2 (1.09%) and negative heterobeltiosis was recorded for 25 hybrids ranging from -1.16 to -2.13% with the lowest of -1.16% recorded for SLD1 x SLD5, SLD1 x SLD6, SLD3 x SLD8, SLD4 x SLD7, SLD5 x SLD1, SLD5 x SLD4, SLD6 x SLD1, SLD7 x SLD4, SLD8 x SLD3 and SLD9 x SLD1 and the highest of -2.13% recorded for SLD1 x SLD7, SLD1 x SLD9, SLD1 x SLD10, SLD4 x SLD5, SLD7 x SLD1, SLD10 x SLD1 and SLD10 x SLD4 (Table 36).

**Heterosis in double hybrids**

For the trait, total larval duration positive heterosis was recorded for all the double hybrids except for (SLD2 x SLD4) x (SLD8 x SLD9) where negative heterosis of -0.49% was recorded. The positive heterosis ranged from 4.03 to 6.77% with the lowest of 4.03% recorded for (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of 6.77% recorded for (SLD3 x SLD4) x (SLD5 x SLD9). For the trait pupation rate, negative heterosis was recorded for all the double hybrids except for (SLD2 x SLD4) x (SLD8 x SLD9) where positive heterosis of 1.31% was recorded and the negative heterosis ranged from -1.18 to -3.42% with the lowest of 1.18% recorded for (SLD1 x SLD2) x (SLD9 x SLD10) and the highest of -3.42% recorded for (SLD3 x SLD4) x (SLD8 x SLD9). For the trait yield/10,000 larvae by weight positive heterosis was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) (12.44%) and (SLD2 x SLD4) x (SLD9 x SLD10) (2.40%) and negative heterosis ranged from -2.21 to -16.05% with the lowest of -2.21% recorded for (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of -16.05% recorded for (SLD1 x SLD2) x (SLD9 x SLD10). For the trait, cocoon weight positive heterosis ranged from 0.17 to 10.67, the lowest of 0.17 was recorded for (SLD2 x SLD4) x (SLD9 x SLD10) and the highest of 10.67 was
recorded for (SLD2 x SLD4) x (SLD8 x SLD9). For the trait cocoon shell weight, positive heterosis of 10.26% was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and 0.24% was recorded for (SLD1 x SLD2) x (SLD9 x SLD10) and the negative heterosis ranged from -1.92 to -7.33% with the lowest of -1.92% recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and the highest of -7.33% recorded for (SLD3 x SLD4) x (SLD9 x SLD10). For the trait, cocoon shell percentage positive heterosis of 0.13% was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterosis ranged from -3.43 to -7.54% with the lowest of -3.54% recorded for (SLD1 x SLD2) x (SLD8 x SLD9) and the highest of -7.54% recorded for (SLD3 x SLD4) x (SLD9 x SLD10). For the trait, filament length negative heterosis was recorded for all the double hybrids ranging from -1.49 to -12.18% with the lowest of -1.49% recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and the highest of 17.07% recorded for (SLD1 x SLD2) x (SLD5 x SLD9). For the trait, raw silk percentage, positive heterosis of 2.17% recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterosis ranged from -2.47 to -7.01% with the lowest of -2.47% recorded for (SLD2 x SLD4) x (SLD9 x SLD10) and the highest of -7.01% recorded for (SLD3 x SLD4) x (SLD8 x SLD9). For the trait, renditta, negative heterosis of -0.38% was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and positive heterosis ranged from 5.32 to 21.34% with the lowest of 5.32% recorded for (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of 21.34% recorded for (SLD1 x SLD2) x (SLD5 x SLD9). For the trait, Reelability positive heterosis of 0.58% recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterosis ranged from -0.58 to -5.26% with the lowest of -0.58% recorded for (SLD2 x SLD4) x (SLD9 x SLD10) and the highest of -5.26% recorded for (SLD1 x SLD2) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD5 x SLD9). For the trait, neatness positive heterosis of 0.53% recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterosis ranged from -1.60 to -3.19% with the lowest of -1.60% recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of -3.19% recorded for (SLD1 x SLD2) x (SLD8 x SLD9) and (SLD1 x SLD2) x (SLD9 x SLD10) (Table-37).
Heterobeltiosis for double hybrids

For the trait, fecundity, positive heterobeltiosis was recorded for most of the combinations, ranged from 0.71 to 3.89, the lowest of 0.71 was recorded for (SLD2 x SLD4) x (SLD9 x SLD10) and the highest of 3.89 was recorded for (SLD2 x SLD4) x (SLD8 x SLD9). For the trait, total larval duration positive heterobeltiosis was recorded for all the double hybrids except for (SLD2 x SLD4) x (SLD8 x SLD9) where negative heterosis of -0.39 % was recorded. The positive heterobeltiosis ranged from 4.13 to 6.88 % with the lowest of 4.13 % recorded for (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of 6.88 % recorded for (SLD3 x SLD4) x (SLD5 x SLD9). For the trait pupation rate, negative heterobeltiosis was recorded for all the double hybrids except for (SLD2 x SLD4) x (SLD8 x SLD9) where positive heterobeltiosis of 0.35 % was recorded and the negative heterobeltiosis ranged from -1.30 to -3.98% with the lowest of -1.30 % recorded for (SLD1 x SLD2) x (SLD9 x SLD10) and the highest of -3.98 % recorded for (SLD3 x SLD4) x (SLD8 x SLD9). For the trait yield/10,000 larvae by weight positive heterobeltiosis was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) (12.07 %) and (SLD2 x SLD4) x (SLD9 x SLD10) (1.10 %) and negative heterobeltiosis ranged from -4.27 to -7.69 % with the lowest of -4.27 % recorded for (SLD3 x SLD4) x (SLD8 x SLD9) and the highest of -7.69 % recorded for (SLD3 x SLD4) x (SLD9 x SLD10). For the trait, cocoon weight positive heterobeltiosis ranged from 0.93 to 9.70 %, the lowest of 0.93% was recorded for (SLD2 x SLD4) x (SLD5 x SLD9) and the highest of 9.70% was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterobeltiosis was recorded for (SLD3 x SLD4) x (SLD9 x SLD10) (-0.06), (SLD2 x SLD4) x (SLD9 x SLD10) (-0.44) and (SLD3 x SLD4) x (SLD5 x SLD9) (-0.50). For the trait cocoon shell weight, positive heterobeltiosis of 8.71 % was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterobeltiosis ranged from -1.40 to -8.41% with the lowest of -1.40% recorded for (SLD1 x SLD2) x (SLD9 x SLD10) and the highest of -8.41% recorded for (SLD3 x SLD4) x (SLD9 x SLD10). For the trait, cocoon shell percentage, negative heterobeltiosis was recorded for all the double hybrids ranging from -0.94 to -8.90 % with the lowest of -0.94 % recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and the highest of -8.90% recorded for (SLD3 x SLD4) x (SLD9 x SLD10). For the trait, filament length negative heterobeltiosis was recorded for all the double hybrids ranging from -3.02 to -13.62% with the lowest of -3.02 % recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and the highest of -13.62% recorded for (SLD3 x SLD4) x (SLD9 x SLD10). For the trait, filament size positive heterobeltiosis was recorded for
all the double hybrids ranging from 1.57 to 18.03 % with the lowest of 1.57 % recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and the highest of 18.03 % recorded for (SLD1 x SLD2) x (SLD5 x SLD9). For the trait, raw silk percentage, positive heterobeltiosis of 0.53 % recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterobeltiosis ranged from -3.26 to -7.01 % with the lowest of -3.26 % recorded for (SLD2 x SLD4) x (SLD9 x SLD10) and the highest of -7.01 % recorded for (SLD3 x SLD4) x (SLD8 x SLD9). For the trait, renditta, no heterobeltiosis was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and positive heterobeltiosis was recorded for all the remaining double hybrids ranging from 6.96 to 22.93 % with the lowest of 6.96 % recorded for (SLD1 x SLD2) x (SLD9 x SLD10) and the highest of 22.93 % recorded for (SLD1 x SLD2) x (SLD5 x SLD9). For the trait, reelability no heterobeltiosis was recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterobeltiosis ranged from -1.16 to -5.81 % with the lowest of -1.16 % recorded for (SLD2 x SLD4) x (SLD9 x SLD10) and the highest of -5.81 % recorded for (SLD1 x SLD2) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD5 x SLD9). For the trait, neatness no heterobeltiosis recorded for (SLD2 x SLD4) x (SLD8 x SLD9) and negative heterosis ranged from -2.13 to -3.19 % with the lowest of -2.13 % recorded for (SLD1 x SLD2) x (SLD5 x SLD9), (SLD2 x SLD4) x (SLD5 x SLD9), (SLD2 x SLD4) x (SLD9 x SLD10) and (SLD3 x SLD4) x (SLD9 x SLD10) and the highest of -3.19 % recorded for (SLD1 x SLD2) x (SLD8 x SLD9), (SLD1 x SLD2) x (SLD9 x SLD10) (SLD3 x SLD4) x (SLD5 x SLD9) and (SLD3 x SLD4) x (SLD8 x SLD9) ( Table-38).

**Percentage improvement over control**

The percentage improvement of the new breeds and single and double hybrids over the control breeds and hybrids was calculated. Among the oval breeds, SLD1 recorded improvement over the control, CSR2 for pupation rate (3.26 %), filament length ( 3.9%), reelability ( 1.21 %) and neatness ( 1.07 %) and recorded decrease for larval duration ( -5.96 %), yeild/10000 larvae by weight (-1.83%), cocoon weight (-2.5%), cocoon shell weight (-9.97 %), cocoon shell percentage ( -7.53 %), filament size (-9.59 %), renditta (-0.52 %), fifth age larval duration (-5.81 %) and silk productivity/day ( -4.64 %). SLD2 recorded improvement over the control, CSR2 for pupation rate ( 4.28 %), yield/10000 larvae by weight ( 0.8%), filament length ( 9.17 %), Raw silk percentage ( 0.51 %) and silk productivity/day ( 2.50 %) and recorded decrease for larval duration ( -5.08 %), cocoon weight ( -1.31 %).
cocoon shell weight (-8.22 %), Cocoon shell percentage (-6.96 %), Filament size (-2.95 %), renditta (0.35 %), reelability (-1.21 %) and fifth age larval duration (-10.46 %). SLD3 recorded improvement over the control, CSR2 for pupation rate (4.57 %), renditta (9.5 %) and silk productivity/day (5.71 %) and recorded decrease for larval duration (-9.4 %), yield/10,000 larvae by weight (-1.09 %), cocoon weight (-6.15 %), cocoon shell weight (-13.96 %), cocoon shell percentage (-8.18 %), filament length (-5.75 %), filament size (-5.16 %), raw silk percentage (-8.64 %), reelability (-1.21 %), neatness (-1.07 %) and fifth age larval duration (-18.6 %). SLD4 recorded improvement for total larval duration (4.21 %), pupation rate (4.28 %), yield/10000 larvae by weight (2.36 %), Cocoon shell percentage (0.83 %), filament length (12.48 %), raw silk percentage (5.79 %) and reelability (4.87 %), neatness (1.07 %) and silk productivity/day (11.78 %) (Table 39).

Among the dumbbell breeds, SLD5 recorded improvement over the control, CSR4 for yield/10000 larvae by weight (5.76 %), cocoon weight (5.76 %), cocoon shell weight (5.05 %), filament length (1.38 %) renditta (1.04 %), reelability (3.75 %) and silk productivity/day (15.32 %) and recorded decrease for larval duration (-7.44 %), pupation rate (-2.48 %), cocoon shell percentage (-0.64 %), filament size (-15.9 %), raw silk percentage (-0.86 %) and fifth age larval duration (-8.79 %). SLD6 recorded improvement over the control, CSR2 for pupation rate (2.9 %), renditta (4.34 %), reelability (3.75 %) and silk productivity/day (11.29 %) and recorded decrease for larval duration (-10.88 %), yield/10000 larvae by weight (-5.61 %), cocoon weight (-9.7 %), cocoon shell weight (-11.96 %), cocoon shell percentage (-2.94 %), filament length (-3.96 %), Filament size (-16.96 %), raw silk percentage (-4.03 %) and fifth age larval duration (-20.87 %). SLD7 recorded improvement over the control, CSR2 for pupation rate (1.15 %), yield/10,000 larvae by weight (0.4 %), cocoon weight (1.03 %), renditta (7.63 %) and silk productivity/day (14.51 %) and recorded decrease for larval duration (-7.82 %), cocoon shell weight (-1.06 %), cocoon shell percentage (-2.58 %), filament length (-6.05 %), filament size (-8.12 %), raw silk percentage (-7.03 %), neatness (-1.07 %) and fifth age larval duration (-13.73 %). SLD8 recorded improvement for pupation rate (3.91 %), yield/10000 larvae by weight (1.73 %), cocoon weight (0.80 %), cocoon shell weight (6.91 %), cocoon shell percentage (5.48 %), filament length (15.07 %), raw silk percentage (8.41 %), reelability (6.25 %), neatness (1.07 %) and silk productivity/day (26.41 %) and recorded decrease for total larval duration (-6.97 %), filament size (-15.9 %), renditta
SLD9 showed improvement for pupation rate (-5.37 %), cocoon shell percentage (-4.19 %), filament length (2.77 %), raw silk percentage (5.07 %), reelability (1.25 %) and silk productivity/day (14.51 %). SLD10 recorded improvement for pupation rate (3.91 %), yield/10000 larvae by weight (0.4 %), renditta (5.55 %), reelability (1.25 %) and silk productivity/day (10.48 %) and recorded decrease for total larval duration (-6.80 %), cocoon weight (-1.260 %), cocoon shell weight (-3.90 %), cocoon shell percentage (-3.36 %), filament length (-3.67 %), filament size (-15.90 %), raw silk percentage (-5.18 %) and fifth age larval duration (-13.18 %) (Table-40).

The selected single hybrid, SLD4 x SLD8 recorded improvement over the control hybrid, CSR2 x CSR4 for almost all the parameters except for fifth age larval duration (-10.71 %) and renditta (-7.71 %). The improvement was recorded for fecundity (4.41 %), total larval duration (4.47 %), pupation rate (1.26 %), yield/10,000 larvae by weight (5.60 %), cocoon weight (1.80 %), cocoon shell weight (5.35 %), cocoon shell percentage (3.29 %), filament length (3.29 %), filament size (1.06 %), raw silk percentage (8.29 %), reelability (6.44 %) and silk productivity/day (29.53 %) (Table-41).

The selected double hybrid, (SLD2 x SLD4) x (SLD7 x SLD9) recorded improvement over the control hybrid, (CSR2 x CSR27) x (CSR6 x CSR26) for pupation rate (5.54 %), yield/10000 larvae by weight (10.39 %), cocoon weight (7.8 %), cocoon shell weight (11.32 %), cocoon shell percentage (3.26 %), filament length (6.63 %), raw silk percentage (4.44 %), reelability (3.61 %) and neatness (2.17 %) and recorded decrease for total larval duration (-7.66 %), filament size (-12.54 %) and renditta (-4.03 %). (Table-42)

**Silk yield estimates**

The silk productivity/day for all the 48 single hybrids was calculated and is presented in the Table-43. The fifth age larval duration ranged from 6.00 to 7.00 with the lowest of 6.00 (Days:Hours) for SLD1 x SLD6 and the highest of 7.00 (Days:Hours) recorded for SLD7 x SLD1. The shell weight ranged from 0.412 g to 0.472 g with the lowest of 0.412 g recorded for SLD9 x SLD3 and the highest of 0.472 g recorded for SLD4 x SLD8. The silk productivity/day ranged from 6.03 cg to 7.55 cg with the lowest of 6.03 cg recorded for SLD9 x SLD3 and the highest of 7.55 cg recorded for SLD4 x SLD8.
The silk productivity/day for all the 9 double hybrids was calculated and is presented in the Table-44. The fifth age larval duration ranged from 6.02 to 6.14 (Days:Hours) with the lowest of 6.02 (Days:Hours) recorded for (SLD2 x SLD4) (SLD8 x SLD9) and the highest of 6.14 (Days:Hours) recorded for (SLD2 x SLD4) (SLD5 x SLD9). The shell weight ranged from 0.392 g to 0.462 g with the lowest of 0.392 g recorded for (SLD3 x SLD4)x (SLD9 x SLD10) and the highest of 0.462 g recorded for (SLD2 x SLD4) (SLD8 x SLD9). The silk productivity/day ranged from 6.03 cg to 7.59 cg with the lowest of 6.03 cg recorded for (SLD3 x SLD4)x (SLD9 x SLD10) and the highest of 7.59 cg recorded for (SLD2 x SLD4)x (SLD8 x SLD9).

**Cocoon uniformity**

For calculating cocoon uniformity 100 cocoons each of the cocoons were taken at random and measured length and breadth of each of the 100 cocoons and cocoon index was calculated using the following formula

\[
\text{Cocoon index} = \frac{\text{Cocoon length}}{\text{Cocoon width}} \times 100
\]

The standard deviation and coefficient of variation of each of the hybrids were calculated. The hybrids with less size deviation and less coefficient of variation were short listed further screening. Among the single hybrid, SLD4 x SLD8 with low standard deviation (6.28) and low CV % (3.39 %) was selected for commercialisation (Table-45). Similarly, the double hybrid, (SLD2 x SLD4) x (SLD8 x SLD9) with low standard deviation 7.76 and low CV5( 3.99 %) was selected for commercialisation (Table-46).

**Reproductive Potential Studies**

**Reproductive potential of selected breeds**

Grainage parameters such as egg yield per kg cocoons, egg number per gram, and fecundity conversion on six selected SLD breeds along with control breeds of CSR2 and CSR4 were studied. Egg yield per kg of cocoons of six new breeds ranged from 69.356 g to 80.230g, the lowest of 69.356 obtained for SLD6 and the highest of 80.230 g obtained for SLD4. Egg number per gram in new breeds
ranged from 1716 to 1824, the lowest of 1716 obtained for SLD2 and the highest of 1824 obtained for SLD4. Fecundity conversion ranged from 460 to 552, the lowest of 460 obtained for SLD6 and the highest of 552 obtained for SLD4 (Table-47).

**Reproductive potential of selected foundation crosses**

Grainage parameters such as egg yield per kg cocoons, egg number per gram and fecundity conversion on six selected foundation crosses along with control crosses of CSR2 x CSR27 and CSR6 x CSR26 were studied. Egg yield per kg of cocoons of six new foundation crosses ranged from 69.380 g to 82.218 g, the lowest of 69.380 obtained for SLD9 x SLD10 and the highest of 82.218 g obtained for SLD2 x SLD4. Egg number per gram in new foundation crosses ranged from 1722 to 1846, the lowest of 1722 obtained for SLD1 x SLD2 and the highest of 1846 obtained for SLD9 x SLD10. Fecundity conversion ranged from 481 to 596, the lowest of 481 obtained for SLD9 x SLD10 and the highest of 596 obtained for SLD2 x SLD4 (Table-48).