SILKWORM BREEDS & HYBRIDS AT GALORE

Central Sericultural Research and Training Institute
(Central Silk Board, Ministry of Textiles, Govt. of India)
Srirampura, Mysore-570 008, Karnataka, India

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FOREWORD

In a tropical country like India, there is need to see that suitable silkworm breeds/hybrids which can sustain themselves in the tropical conditions are developed constantly and pushed to the field to meet the demand of hybrids with high survival and good quality silk to enable the farmers to have continued interest, besides enabling the reelers to pay remunerative price based on silk recovery. In this direction the efforts made by the silkworm breeders of Central Sericultural Research and Training Institute, Mysore for the last five decades in general and for the last one decade in particular to develop suitable silkworm breeds/hybrids is praise worthy.

It is also a privilege for the Japan International Co-operation Agency for lending an helping hand towards the development of productive bivoltine breeds/hybrids in terms of technical expertise and financial assistance. The Japanese experts who were part of this project in recent years are indeed very happy to be associated with this great endeavour by the silkworm breeders of this Institute.

Personally, it is a matter of great pleasure and satisfaction for me to note that the silkworm breeders of Central Sericultural Research and Training Institute, Mysore have come out with this valuable document of silkworm breeds and hybrids developed by the institute since its inception.

I congratulate the editors for their efforts of compiling all the available information in to an informative publication and their efforts are praise worthy. I am confident that this comprehensive document will be an extremely useful reference and an asset for all the scientists involved in sericulture research in general and silkworm breeding activity in particular all over the world.

AkioYAMAGUCHI
Expert, JICA
CSR&TI, Mysore

15-03-2005

PREFACE

The impact of sericulture research on the development of silk industry in the southern states has been very spectacular as evident from the quantum jump in productivity and income to the farmers. The new innovations of mulberry varieties and cultivation, improved silkworm hybrids and silkworm rearing have brought an unparalleled revolution in the silk industry of the southern states in India. Unambiguously, it is also evident that the production of good quality raw silk is based primarily on quality cocoons which in turn depends mainly on the superior silkworm breeds. In fact, the improvement of silkworm breeds for higher cocoon yield is the most direct and efficient way to achieve good quality raw silk. Accordingly, over the last fifty years, improvement of silkworm breeds has played a pivotal role in boosting the silk production in India in general and southern states in particular. In this direction, the contribution of silkworm breeders of Central Sericultural Research and Training Institute, Mysore towards the development of superior silkworm hybrids is the milestone. This document showcases the achievements made so far on the development of superior silkworm breeds/hybrids by this premier institute since five decades of its relentless service.

This document comprises of information on all the silkworm breeds and hybrids developed and authorized during the past five decades by this Institute with salient features and economic traits. List of all the scientists responsible for this task is also appended. The editors thankfully acknowledge the significant and meritorious contributions made by all the silkworm breeders both past and present and also the team of scientists actively involved at present in the Institute for the development of superior breeds/hybrids which are invaluable treasures of immense value to Indian sericulture industry.

The contribution of Japan International Co-operation Agency towards the accomplishment of the production of quality oriented quantitative silk output by giving an helping hand in the development of productive bivoltine breeds/hybrids is quite laudable. The editors thankfully acknowledge Dr.Yoshiki Ohtsuki, Dr.Kiyoshi Kawakami and Dr. Hiroaki Yanagawa, JICA team leaders for their keen interest and encouragement.

The editors wish to place on record their indebtedness to Mr.Akio Yamaguchi, JICA expert, silkworm breeding for the constant support and also for writing the foreword for this publication.

The editors also place on record the immense interest, encouragement and guidance rendered by the Japanese experts, Mr.Yasuhisa Mano, Dr.Kunio Takamiya, Ms.Hiroko Matuso, Dr.Toshio Yamamoto, Dr.Osamu Ninagi, Mr.Yukio Tanaka and Dr.Toshiki Tamura while serving as silkworm breeding experts under the JICA programme.

The editors thankfully acknowledge all those have lent their helping hand directly or indirectly towards the accomplishment of this task as a consolidated information resource of silkworm breeds and hybrids. Editors also acknowledge greatfully the support and encouragement given by Central Silk Board authorities. Finally, it is earnestly hoped that this publication finds its way as an hand tool to those who are in silk industry.

S.B.Dandin
H.K.Basavaraja
N.Suresh Kumar

15-03-2005

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Sericulture in India - Past and present

Indian silk industry has registered a phenomenal growth over the years and presently is accounting for more than 18% of the global silk production. India has emerged today as the second largest producer of mulberry raw silk, besides being producing all the five varieties of commercially exploited silks of the world. Such an achievement was made possible as a result of significant breakthrough made in Research and Development in tropical sericulture. However, the bulk of silk production comes from polyvoltine and polyvoltine x bivoltine hybrids, which is largely suited for handloom sector. There is an urgent need for production of superior warp quality silk to meet powerloom requirement and which has to come necessarily from bivoltine cocoons. Besides, Indian silk industry is suffering from two major constraints i.e., low productivity and high production cost.

Bottlenecks in the field of cocoon production have been identified and addressed to a great extent. The new breeds and hybrids, which have been released in the field, are high yielding and hold promise for producing international grade silk. Bivoltine production targets can be increased by providing suitable packages and technical support to more number of farmers. Infact, the " new era" in production of bivoltine has begun with a promise of higher gain for both the primary producers and reelers alike. Needless to mention that, still more is to be done in achieving the target of enlarging the production base of bivoltine in the larger interest of sericulture industry in the country and also to compete in the international market.

Sericulture an instrument for employment generation and alleviation of poverty

The new innovations of mulberry cultivation, silkworm rearing and improved hybrid silkworm seeds have brought an unparalleled revolution in the silk industry of the southern states in India. They do not call for any special heavy investment as the same are developed to suit the existing socio-economic conditions of the farm house-holds. The simplicity in adoption of these technologies and attractive income thereof have great appeal to the farmers with the result that sericulture is spreading fast in new areas covering practically almost all the districts of the southern states. It is also helping in rapid transformation of the poor sericulture villages into reasonably prosperous rural areas. The new sericulture technologies are very much farmer oriented and have in fact, transformed sericulture which used to be a subsidiary rural occupation in the past, into a full time highly remunerative agricultural activity better than any other cash crops. In view of the high employment potential and remunerative income generation, sericulture has come to be regarded as one of the important means of alleviating rural poverty and ushering in rural prosperity and is therefore, receiving due attention in rural development programmes both at the State and National levels. In physical terms, the impact of sericulture research on the development of silk industry in the southern states has been very spectacular as evident from the quantum jump in productivity and expansion of the industry.

Importance of silkworm breeds

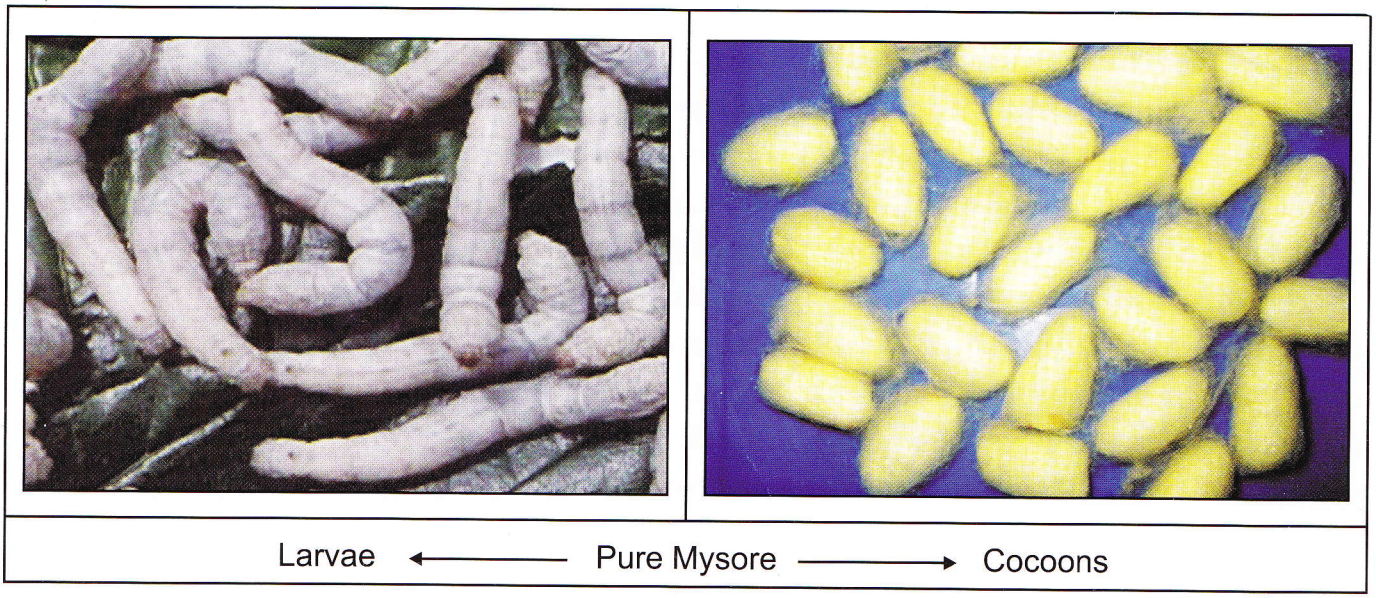
Silkworm breeds and hybrids play a prominent role in deciding silk output and quality. However, the problems with silkworm breeds have been many and varies in different sericultural regions of the

country. In the northern temperate regions, only one major crop during spring season is harvested which makes sericulture only as a subsidiary occupation. The farmers by and large in southern tropical regions have reservations about the bivoltine rearings and therefore, the acceptance of bivoltine hybrids on large scale as choice of seed has remained restricted. Besides, the yield potential of earlier bivoltine silkworm breeds and hybrids was low with poor cocoon characteristics (high renditta and low neatness). These aspects made bivoltine rearing less attractive in the major silk producing areas of Karnataka, Andhra Pradesh and Tamil Nadu.

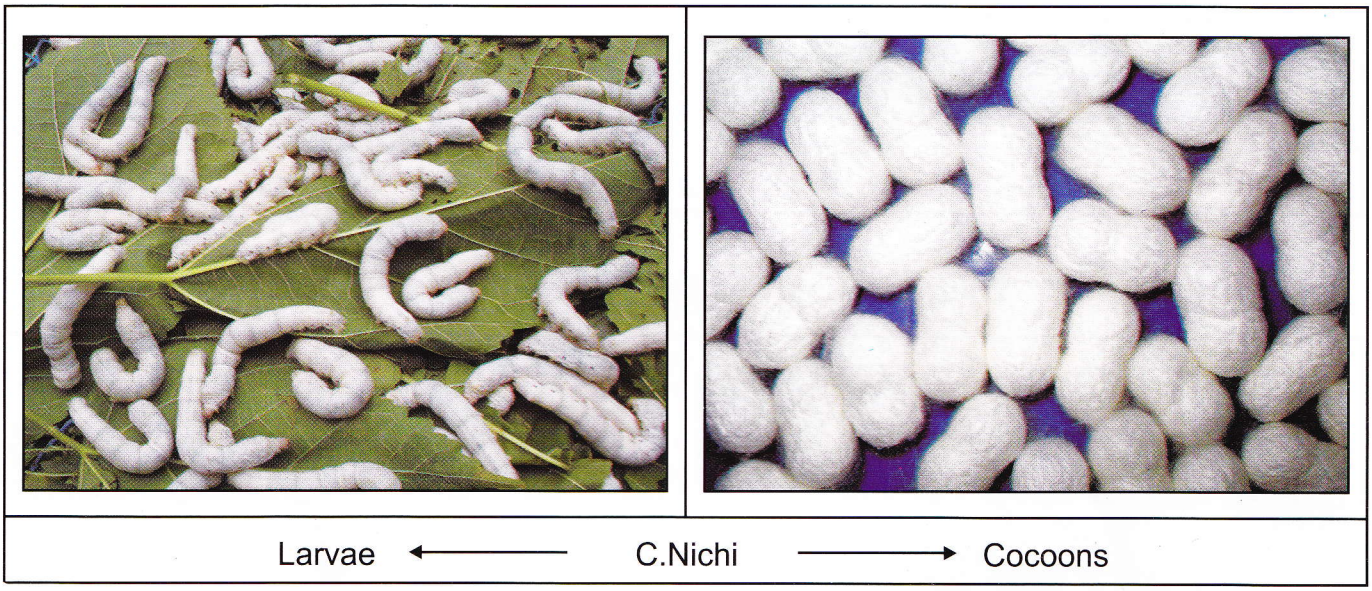
Added to this, the bivoltine hybrid cocoons have always beset with problems of marketing at remunerative price and thereby till recently it is felt that besides the risk involved, the rearing of bivoltine is not economically viable. On the other hand, the reelers are hesitant to offer a higher price for cocoons because of low price experienced by the reelers which has direct bearing on the economics of the reeling units. In fact, the private reeling sector has not developed to a stage to consume bivoltine cocoons in a rational way because of the cottage structure.

Early history of Indian silkworm breeds

The goal of silkworm breeding is to attain maximum productivity in yield and quality. This goal is achieved by bringing genetic improvement through combination of desired genes by crossing two selected pure stocks of the silkworm followed by selection. Though, sericulture is introduced as commercial venture way back in late 17th century, silkworm breeding was initiated only in 1920s. Basically polyvoltine culture prevailed up to the 50s and indigenous polyvoltine breeds like Pure Mysore and C.Nichi in South India, Nistari in West Bengal, Sarupat and Moria in the North East were reared. Though, these breeds were very well adapted and popular in respective regions, their productivity and quality of silk was strikingly low with very high renditta.



- Indigenous race quite popular with the farmers of South India
- Low productive race
- Characterized by greenish yellow spindle shaped cocoons
- Suitable for subsistence farming condition, fluctuating temperature and poor hygienic conditions
- More floss percentage (18-22%)
- Very poor post cocoon quality parameters
- High renditta (11-12)



- Exotic race quite popular in rainfed areas
- Low productive race
- Characterized by typical dumb-bell shaped white cocoons with coarse grains
- Suitable for subsistence farming condition, fluctuating temperature and poor hygienic conditions
- Very poor post cocoon quality parameters
- High renditta (14-15)

Traditional polyvoltine hybrid

Larvae ← Pure Mysore x C.Nichi → Cocoons

4-1

Traditional polyvoltine x bivoltine hybrid

Larvae ← Pure Mysore x NB4D2 → Cocoons

- These polyvoltine silkworm hybrids are low in productivity, but better suited for subsistence farming condition, fluctuating temperature and poor hygienic conditions , hence popular among resource poor farmer.

Polyvoltine breeds and hybrids of the past

Attempts made during the 60s to improve the indigenous polyvoltine breeds by introducing the exotic bivoltine genes has resulted in the evolution of a number of improved polyvoltine breeds namely, Kolar Gold, Kollegal Jawan, Mysore Princess, Hosa Mysore, Tamil Nadu White, A4E, MBDIV, D14b etc.

Early polyvoltine pure races

Larvae ← Kolar Gold → Cocoons

- Developed by CSRTI, Mysore during 60s
- Parentage : (PM x NN6D) x (Shungetsu x Hosho)
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated oval shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.nichi
- High renditta (10-11)

Larvae ← Kollegal Jawan → Cocoons

- Developed by CSRTI, Mysore during 60s
- Parentage : (PM x NN6D) x (Shungetsu x Hosho)
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated oval shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (10-11)

Larvae ← Mysore Princess → Cocoons

- Developed by CSRTI, Mysore during 60s
- Parentage : (PM x NN6D) x (Shungetsu x Hosho)
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated oval shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (11-12)

Larvae ← Hosa Mysore → Cocoons

- Developed by CSRTI, Mysore during 70s
- Parentage : PM x A4E
- Low productive breed, but better than PM and C.Nichi
- Characterized by greenish yellow elongated oval shaped cocoons with coarse grains
- Sometimes hibernating eggs appear
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (11-12)

Early polyvoltine pure races

Larvae ← Kolar Gold → Cocoons

- Developed by CSRTI, Mysore during 60s
- Parentage : (PM x NN6D) x (Shungetsu x Hosho)
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated oval shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.nichi
- High renditta (10-11)

Larvae ← Kollegal Jawan → Cocoons

- Developed by CSRTI, Mysore during 60s
- Parentage : (PM x NN6D) x (Shungetsu x Hosho)
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated oval shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (10-11)

Larvae ← Mysore Princess → Cocoons

- Developed by CSRTI, Mysore during 60s
- Parentage : (PM x NN6D) x (Shungetsu x Hosho)
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated oval shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (11-12)

Larvae ← Hosa Mysore → Cocoons

- Developed by CSRTI, Mysore during 70s
- Parentage : PM x A4E
- Low productive breed, but better than PM and C.Nichi
- Characterized by greenish yellow elongated oval shaped cocoons with coarse grains
- Sometimes hibernating eggs appear
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (11-12)

Larvae ← Tamil Nadu White → Cocoons

- Developed by DOS Tamil Nadu
- Parentage : PM x J122
- Low productive breed, but better than PM and C.Nichi
- Characterized by white elongated spindle shaped cocoons with coarse grains
- Very poor post cocoon quality parameters, but better than PM and C.Nichi
- High renditta (12-13)

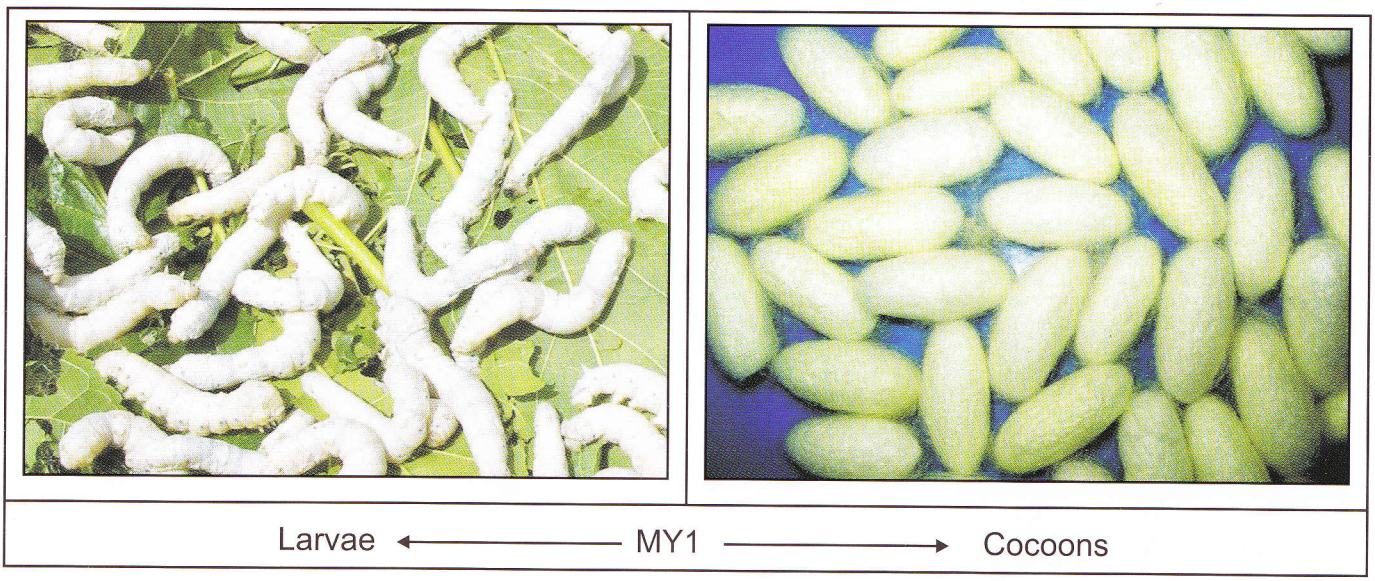
Larvae ← Hosa Mysore x NB18 → Cocoons

- Characterized by its robust larvae, high shell weight, high silk content, long filament length and better neatness and reelability
- Larvae are plain and bluish white in colour
- Cocoons are light greenishyellow and intermediate in shape
- Total larval duration is 22-23 days
- Renditta is about 9
- Gives 10-15% higher yield than existing hybrid, PM xNB4D2

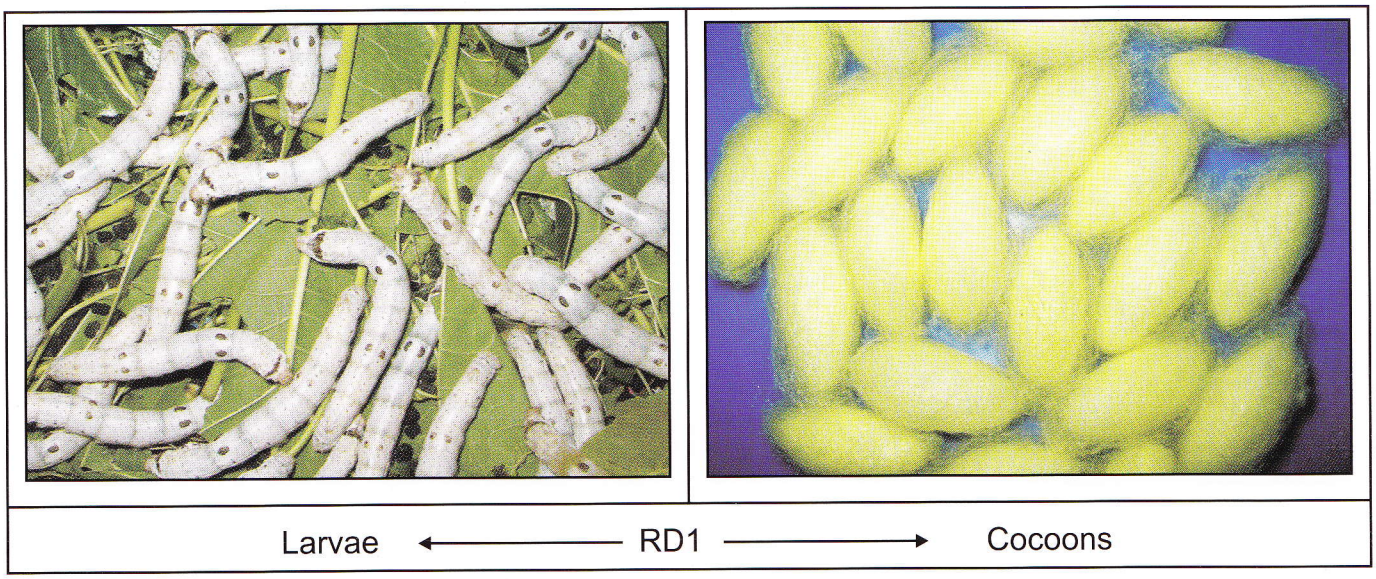
Though, the exploitation of the cross breeds was realized as early as 1920, it is only during 70s, development of improved rearing technology paved the way for introduction of polyvoltine x bivoltine hybrids using the bivoltine breeds evolved during 70s. This has resulted in the linear improvement of cocoon yield and silk content, as a result renditta was brought down considerably.

During 80s, new breeding approaches were initiated to evolve polyvoltines with shorter larval duration, high silk content and better quality silk. Breeds like, MY1, RD1, P2D1 were developed. By crossing these races with bivoltines namely, NB18 and NB4D2 as male components, three hybrids were developed and authorized in 1995.

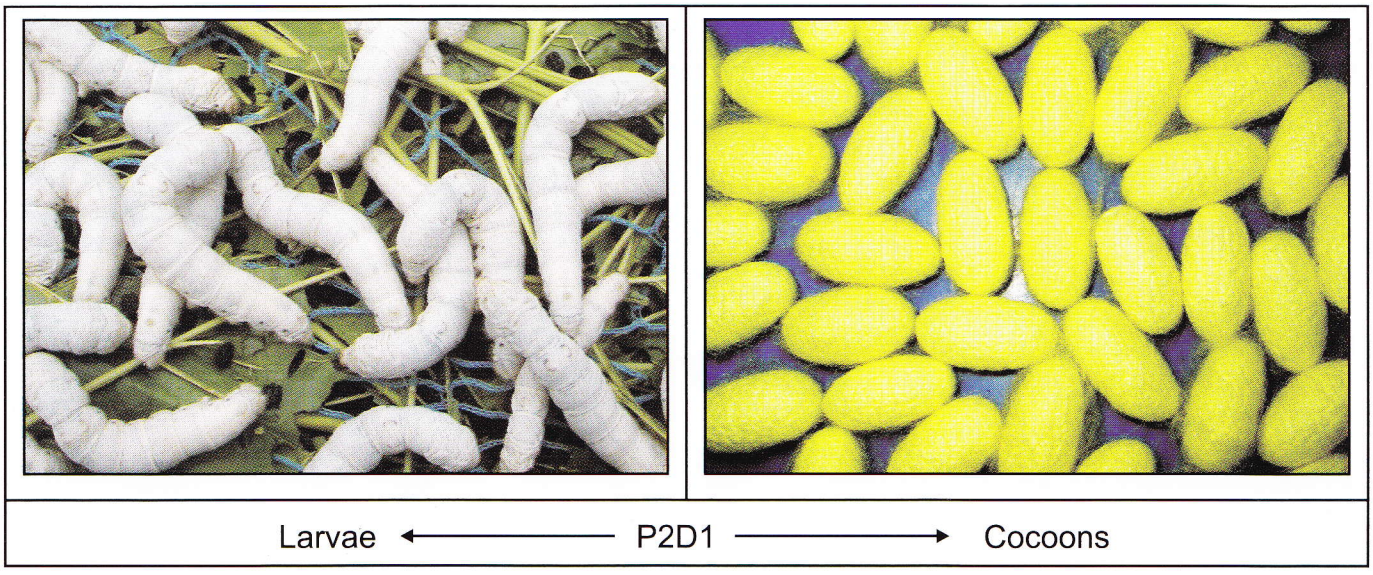
Improved polyvoltine races



- Developed by CSRTI, Mysore during 80s
- Parentage : Pure Mysore x Nistari
- Higher cocoon yield than PM
- Plain larvae with shorter larval duration than Pure Mysore
- Characterized by light greenish yellow elongated oval shaped cocoons with coarse grains
- Better post cocoon quality parameters than Pure Mysore
- High renditta (11-12)



- Developed by CSRTI, Mysore during 80s
- Parentage : Rong Dazao
- Higher cocoon yield than Pure Mysore
- Marked larvae
- Characterized by greenish yellow elongated oval shaped cocoons
- Post cocoon quality parameters better than Pure Mysore
- High renditta (13-14)



- Developed by CSRTI, Mysore during 80s
- Parentage : (PM x Daizo) x NB2C1
- Higher cocoon yield than Pure Mysore
- Plain larvae
- Characterized by greenish yellow elongated oval shaped cocoons with coarse grains
- Post cocoon quality parameters better than Pure Mysore
- High renditta (10-11)

Larvae ← MY1 X NB18 → Cocoons

- Parentage of MY1 : Pure Mysore x Nistari
- Higher cocoon yield
- Shorter larval duration when compared to PM x NB4D2.
- Recommended for rearing in West Bengal, Bihar and Assam

Larvae ← RD1 X NB18 → Cocoons

- Parentage of RD1 : Rong Dazao
- Robust, shorter larval duration.
- Require acid treatment
- Recommended for rain-fed areas during summer and early autumn of UP

Larvae ← P2D1 X NB18 → Cocoons

- Parentage of P2D1 : (PM x Daizo) x NB2C1
- High yielding with longer filament length
- Recommended for irrigated areas of AP, West Bengal, Orissa , MP and UP.

Productive polyvoltine x bivoltine hybrids

During the 90s, new polyvoltine breeds like **BL23** and **BL24** were evolved using the indigenous and exotic genetic resources through hybridization and selection. The hybrids **BL23 x NB4D2** for rainfed areas and **BL24 x NB4D2** for irrigated areas were tested with the farmers on large scale. These hybrids were authorized at the national level in 1997.

Larvae ← BL23 → Cocoons

- Developed by CSRTI, Mysore during 90s
- Parentage : (Oval x A2) x (Oval x Daizo)
- Higher cocoon yield than Pure Mysore
- Plain larvae
- Characterized by greenish yellow elongated oval shaped cocoons with coarse grains
- Floss percentage less than Pure Mysore
- Post cocoon quality parameters better than Pure Mysore
- Recommended for rain-fed areas of South India
- High renditta (10-11)

Larvae ← BL24 → Cocoons

- Developed by CSRTI, Mysore during 90s
- Parentage : Hosa Mysore, Nistari, Pure Mysore and NB7
- Higher cocoon yield than Pure Mysore
- Plain larvae
- Characterized by greenish yellow elongated oval shaped cocoons with coarse grains
- Floss percentage less than Pure Mysore
- Post cocoon quality parameters better than Pure Mysore
- Recommended for irrigated areas of South India
- High renditta (10-11)

Larvae ← BL23 X NB4D2 → Cocoons

- Parentage of BL23 : (Oval x A2) x (Oval x Daizo)
  Characterized by its robust larvae, high shell weight, high silk content, long filament length and better neatness with higher reelability as compared to PM x C.Nichi
- Larvae are plain and bluish white in colour
- Cocoons are light greenish yellow and intermediate in shape
- Total larval duration is 22-23 days

- Gives higher yield than existing hybrid, PM x C.Nichi
- Floss with reference to shell is less (4.8%)
- Recommended for rain-fed areas.

Larvae ← BL24 X NB4D2 → Cocoons

- Parentage of BL24 : Hosa Mysore, Nistari, Pure Mysore and NB7
- Characterized by its robust larvae, high shell weight, high silk content, long filament length and better neatness and reelability
- Larvae are plain and bluish white in colour
- Cocoons are light greenish yellow and intermediate in shape
- Total larval duration is 22-23 days
- Renditta is about 8
- Gives 10-15% higher yield than existing hybrid, PM xNB4D2
- Recommended for irrigated areas.

Further, attempts to improve the qualitative and quantitative traits of polyvoltines resulted in the development of another productive polyvoltine breed, **BL43**.

Larvae ← BL43 → Cocoons

- Developed by CSRTI, Mysore during 90s
- Parentage : Pure Mysore, Hosa Mysore and Nistari
- Higher cocoon yield than Pure Mysore
- Plain larvae
- Characterized by greenish yellow elongated oval shaped cocoons with coarse grains
- Floss percentage less than Pure Mysore
- Post cocoon quality parameters better than Pure Mysore
- Recommended for irrigated areas of South India
- Renditta (9-11)

The new productive polyvoltine breed was crossed with bivoltine and a new hybrid combination, **BL43 x NB4D2 (Kapila)** with better productivity and quantitative traits than PM x NB4D2 was identified. The hybrid was authorized by Central Silk Board for commercial exploitation in 2002.

Larvae ← BL43 X NB4D2 → Cocoons

- Parentage of BL43 : Pure Mysore, Hosa Mysore and Nistari
- Characterized by its robust larvae, high shell weight, high silk content, long filament length and better neatness and reelability
- Larvae are plain and bluish white in colour
- Cocoons are light greenish yellow and intermediate in shape
- Total larval duration is 22-23 days
- Renditta is about 8
- Gives 10-15% higher yield than existing hybrid, PM xNB4D2
- Recommended for irrigated areas.

Productive Cross Breed (Polyvoltine hybrid) for irrigated zone

Recently, for the irrigated area, one more highly productive polyvoltine breed, BL67 with better productivity and quality traits than Pure Mysore was developed.

Larvae ← BL67 → Cocoons

- Developed by CSRTI, Mysore during 90s
- Parentage : BL24 x BL27
- Higher cocoon yield than Pure Mysore
- Plain larvae
- Characterized by light greenish yellow elongated oval shaped cocoons with medium to coarse grains
- Floss percentage less than Pure Mysore
- Post cocoon quality parameters better than Pure Mysore
- Recommended for irrigated areas of South India
- Renditta (8-9)

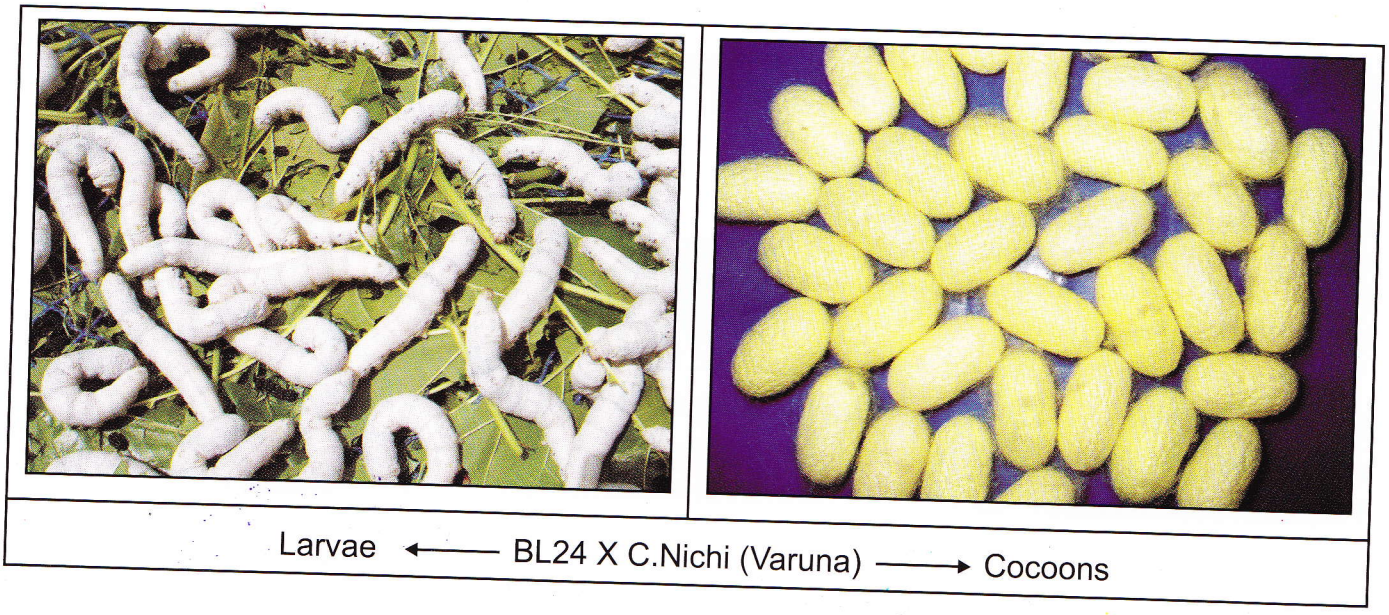
The new breed was crossed with bivoltine and the new polyvoltine x bivoltine hybrid, **Cauvery (BL67 x CSR101)** has been identified with better productivity traits, high silk recovery with 6.5~7.0 renditta and "A" grade silk. The hybrid is being tested on large scale with the farmers of Karnataka, Tamil Nadu and Andhra Pradesh. The hybrid recorded an average cocoon yield of 54 kg/100 dfls. The cocoons fetched higher rate of Rs. 15~20 per kg with A grade silk when compared to PM x NB4D2.

Larvae ← Cauvery (BL67 X CSR101) → Cocoons

- Parentage of BL67 : BL24 x BL27
- Highly productive with survival >90%, cocoon shell ratio around 20% and renditta around 6.5
- Overall silk grade A
- Recommended for irrigated areas of South India
- Tolerant to high temperature and BmNPV.

Polyvoltine hybrid for rain-fed zone

To replace the existing PM x C.Nichi in rain-fed areas, a new polyvoltine x polyvoltine hybrid, **Varuna (BL 24 x C.Nichi)** with high survival and better productivity traits has been developed. The average cocoon yield is 31kg/100 dfls and renditta of 10-11 as compared to 23 kg/100 dfls and 12-13 renditta realised for the popular hybrid, PM x C.Nichi. Cocoons of the hybrid is fetching Rs.8-10/- more per kg as compared to the control hybrid, PM x C.Nichi.



- Characterized by its robust larvae, high shell weight, high silk content, long filament length and better neatness with higher reelability as compared to PM x C.Nichi
- Larvae are plain and bluish white in colour
- Cocoons are light greenish yellow and intermediate in shape
- Gives higher yield than existing hybrid, PM x C.Nichi
- Recommended for rain-fed areas.

Of late, realizing the productivity potential of CSR breeds, CSR2 was crossed with Pure Mysore and released to the farmers in the name of **Kolar Gold** and gained wide acceptance by the sericulturists of South India.

Larvae ← PM X CSR2 (Kolar Gold) → Cocoons

- Characterized by its robustness
- Higher reelability as compared to PM x NB4D2
- Larvae are plain and bluish white in colour
- Cocoons are light greenish yellow
- Hybrid cocoons with oblong shape
- Gives higher yield than existing hybrid, PM x NB4D2

Characteristics of polyvoltine pure races

Characteristics	Pure Mysore	C.Nichi	Kolar Gold	Mysore Princess	Kollegal Jawan	Tamil Nadu White	Hosa Mysore
Larval markings	Plain	Plain	Plain	Plain	Plain	Plain	Plain
Cocoon colour	LGY	White	White	White	White	White	LGY
Cocoon grains	No grains	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse
Pup.Rate(%)	88.7-90.0	89.2-96.0	85.1-90.0	87.1-90.0	84.6-89.8	82.8-89.8	83.4-89.5
Shell ratio(%)	14.2-15.0	11.1-12.0	15.0-15.5	15.0-15.6	15.6-15.8	14.2-14.5	15.6-15.8
Floss percentage	18.2-22.4	4.1-4.6	4.5-4.76	4.75-5.22	5.00-5.48	8.75-9.84	5.0-5.48
Fil. Length(m)	352-375	350-375	501-521	469-500	480-500	400-438	480-495
Raw silk (%)	8.0-8.6	6.50-6.89	9.0-9.32	9.00-9.11	9.25-9.72	7.50-7.97	9.0-9.25
Neatness (points)	76-80	74-76	80-82	79-81	76-80	78-80	79-81
Reelability (%)	74-75	76-77	79-80	80-81	87-88	86-87	80-81
Renditta	11-12	14-15	10-11	11-12	10-11	12-13	11-12
Season	All Seasons	All Seasons	All Seasons	All Seasons	All Seasons	All Seasons	All Seasons

Charactersitcs	MY1	RD1	P2D1	BL23	BL24	BL43	BL67
Larval markings	Plain	Marked	Plain	Plain	Plain	Plain	Plain
Cocoon colour	LGY	GY	GY	GY	GY	GY	LGY
Cocoon grains	Coarse	No Grains	Coarse	Coarse	Coarse	Coarse	Medium to coarse
Pup.Rate(%)	87.3-90.6	90.0-95.0	85.5-90.1	80.5-90.4	88.7-94.0	86.9-91.0	91.8-94.0
Shell ratio(%)	15.2-15.5	14.3-14.8	15.6-16.2	15.0-15.8	15.1-15.9	14.8-15.8	17.0-17.8
Floss percentage	7.00-7.62	15.00-15.58	5.60-6.54	6.00-6.76	6.00-6.92	6.00-6.50	5.00-5.20
Fil. Length(m)	450-491	325-345	483-502	468-500	498-520	575-616	650-696
Raw silk (%)	8.25-8.64	7.00-7.20	9.50-9.85	9.00-9.38	9.50-9.70	10.00-10.38	11.00-11.36
Neatness (points)	78-81	71-74	79-80	84-86	84-86	86-87	87-88
Reelability (%)	76-77	83-84	81~82	85-86	87-88	87-88	90-93
Renditta	11-12	13-14	10-11	10-11	10-11	9-10	8-9
Season	All Seasons	All Seasons	All Seasons	All Seasons	All Seasons	All Seasons	All Seasons

Characteristics of polyvoltine x bivoltine hybrids

Characteristics	PMx C.Nichi	BL24x C.Nichi	PMx NB4D2	Hosa Mysore x NB18	MY1x NB18	RD1x NB18	P2D1x NB18
Larval markings	Plain	Plain	Plain	Plain	Plain	Plain	Plain
Cocoon colour	LGY	LGY	LGY	LGY, Colour variation	LGY	LGY, Colour variation	LGY, Colour variation
Cocoon grains	No prominent grains	Coarse	No prominent grains	Coarse	Coarse	Coarse	Coarse
Pup.Rate(%)	92.9-95.0	95.7-97.0	91.0-93.0	93.6-95.0	86.7-92.5	90.3-95.0	90.2-95.0
Shell ratio(%)	13.4-14.1	14.8-15.0	17.2-17.8	18.5-18.8	17.5-17.7	17.2-17.5	18.7-19.0
Fil. Length(m)	450-525	535-580	732-750	875-882	855-888	750-796	850-894
Raw silk (%)	9.0-9.82	10.6-11.0	11.1-12.0	11.3-12.5	12.0-12.5	10.5-11.0	11.5-12.5
Neatness (points)	86	87	83	86	84	82.5	84.4
Reelability (%)	82.1	85.0	91.3	90.8	88.0	86.6	84.0
Renditta	12.4-13.0	10.11	9.0-9.5	8.13-8.5	8.1-8.3	9.52-9.75	8.69-9.0
Silk quality	No grade	No grade	No grade	No grade	No grade	No grade	No grade

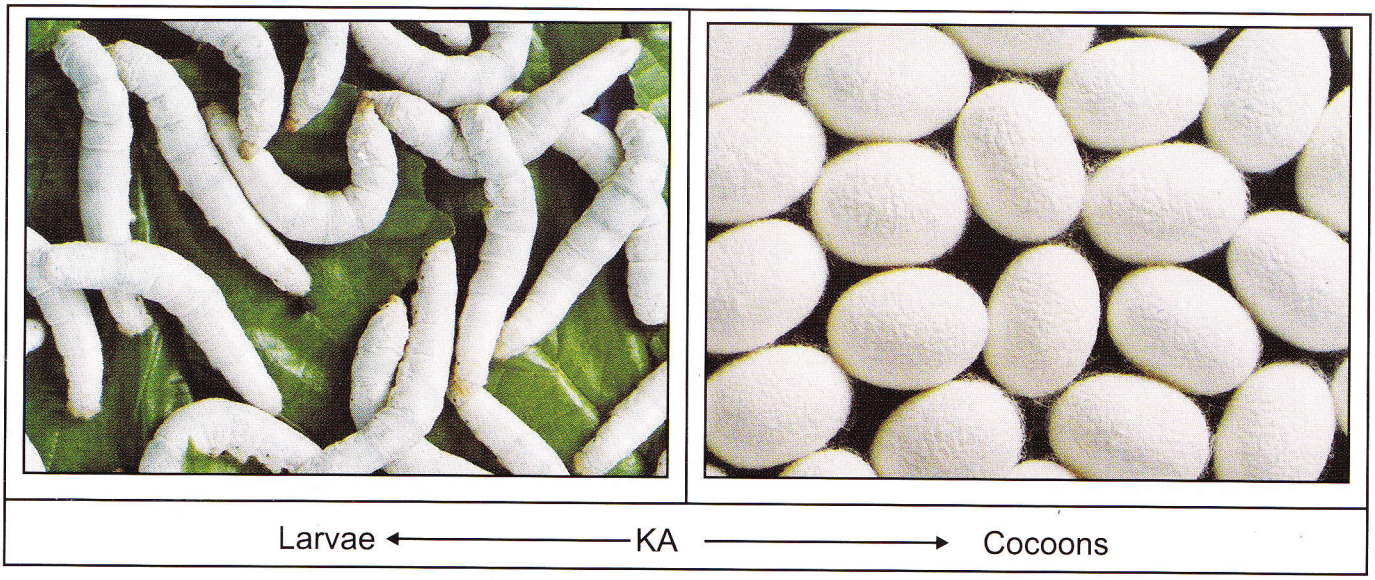
Characteristics	BL23x NB4D2	BL24x NB4D2	BL43x NB4D2	BL67x CSR101	PM x CSR2
Larval markings	Plain	Marked	Plain	Plain	Plain
Cocoon colour	LGY	LGY, Colour variation	LGY, Colour variation	LGY	LGY
Cocoon grains	Coarse	No Grains	Coarse	Coarse	Coarse
Pup.Rate(%)	92.0-94.5	92.0-95.0	93.6-95.0	95.0-96.7	95.7-97.0
Shell ratio(%)	18.0-18.8	18.3-18.5	18.5-18.8	19.3-20.1	17.2-17.8
Fil. Length(m)	824-850	844-875	875-882	900-920	768-760
Raw silk (%)	12.0-12.5	12.3-13.5	12.3-13.5	14.8-15.0	11.5-12.8
Neatness (points)	84.5	85.2	86	90	85
Reelability (%)	91.5	92.1	90.8	85.5	90.0
Renditta	8.31-8.5	8.24-8.5	8.13-8.5	6.5-7.0	9.0-9.2
Silk quality	No grade	No grade	No grade	A-2A	No grade

BIVOLTINE RACES

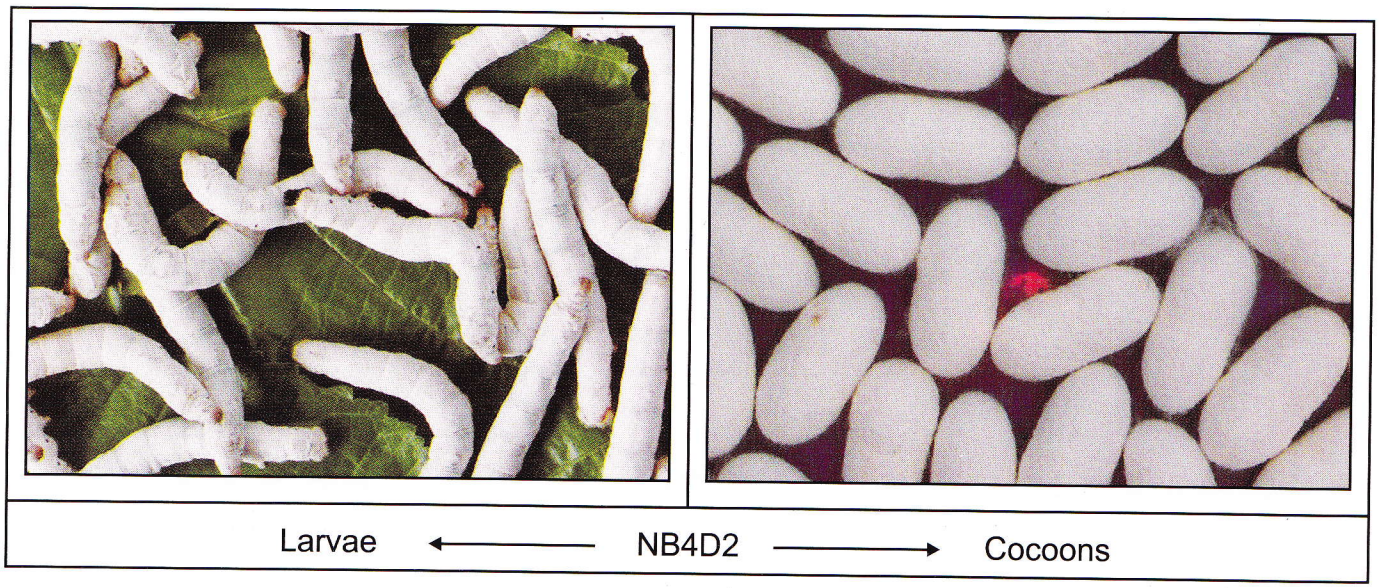
Bivoltine breeds and hybrids of the past

During 70s, efforts were made to develop bivoltine breeds by extraction of lines from the single and double hybrids of exotic origin. A number of productive bivoltine breeds like NB7, NB18, NB4D2 at Mysore, KA, KB at Kalimpong, SH6, YS3 at Dehradun, J112, J122, C110, C108 at Kashmir (exotic collection) were evolved.

Bivoltine pure races



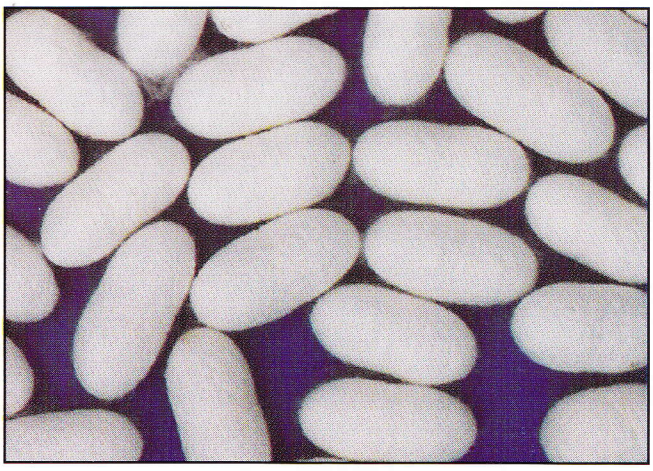
- Developed at RSRS Kalimpong during 70s
- Parentage : (N122x C110) x (N124 x C124)
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with medium grains
- Cocoon shell ratio : 18-19%
- Raw silk percentage : 15-16 %
- Fibre quality : 2A grade



- Developed at CSRTI, Mysore during 70s
- Parentage : (Koko x Seihaku) x (N124 x C124)
- Plain larvae with bluish white body colour
- Bright white dumb-bell shaped cocoons with medium grains
- Cocoon shell ratio : 18-19%
- Raw silk percentage : 15-16 %
- Fibre quality : 2A grade

Larvae ← NB7 → Cocoons

- Developed at CSRTI, Mysore during 70s
- Parentage : Kinshu x Showa
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with medium grains
- Cocoon shell ratio : 18-19%
- Raw silk percentage : 14-15 %
- Fibre quality : 2A grade



Larvae ← NB18 → Cocoons

- Developed at CSRTI, Mysore during 70s
- Parentage : (Koko x Seihaku) x (N124 x C124)

- Plain larvae with bluish white body colour
- Bright white dumb-bell shaped cocoons with medium grains
- Cocoon shell ratio : 18-19%
- Raw silk percentage : 15-16 %
- Fibre quality : 2A grade

Larvae ← CC1 → Cocoons

- Developed at CSRTI, Mysore during 80s
- Parentage : (NB7 x NB-1) x (KA x SPC1)
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 16-17 %
- Fibre quality : 2A ~3A grade

Larvae ← CA2 → Cocoons

- Developed at CSRTI, Mysore during 80s
- Parentage : NB7 x SPC2
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with medium grains

- Cocoon shell ratio : 22-23%
- Raw silk percentage : 16-17 %
- Fibre quality : 2A~3A grade

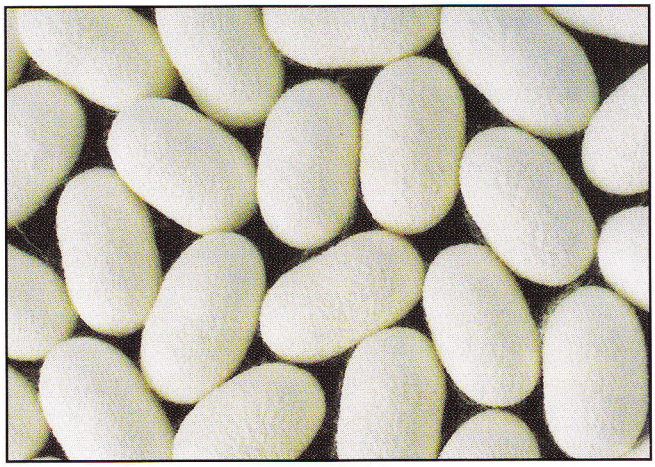
Bivoltine hybrids

Bivoltine x bivoltine hybrids like KA x NN6D, KA x NB4D2, NB7 x NB18, CC1 x NB4D2, CA2 x NB4D2 were found highly promising initially. However, this could not make a significant dent because polyvoltine x bivoltine hybrids gained stupendous popularity among the farmers. Accordingly, the bivoltines were used only as male components for cross breed preparation and PM x NB4D2 became very popular in South and Nistari x NB4D2 in West Bengal.

Characteristics of KA x NN6D

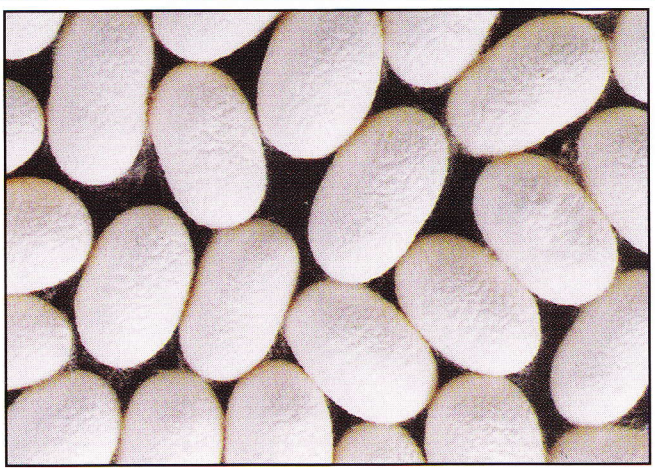
- Parentage of KA : (N122 xC110) x (N124 x C124)
- Parentage of NN6D : Chinese Race (Nan Nung 6D)
- Hybrid with cocoon shell ratio (18-19%) and raw silk recovery (14-15%)
- Fibre quality : 2 A grade
- Plain larvae with bluish white body colour
- Cocoons are bright white with oval shape and medium grains
- Renditta : 8~9

- Parentage of KA : (N122 xC110) x (N124 x C124)
- Parentage of NB4D2 : (Koko x Seihaku) x (N124 x C124)
- Hybrid with cocoon shell ratio (19-20%) and raw silk recovery (15-16%)
- Fibre quality : 2A grade
- Plain larvae with bluish white body colour
- Cocoons are bright white with intermediate shape and medium grains
- Renditta: 7~8



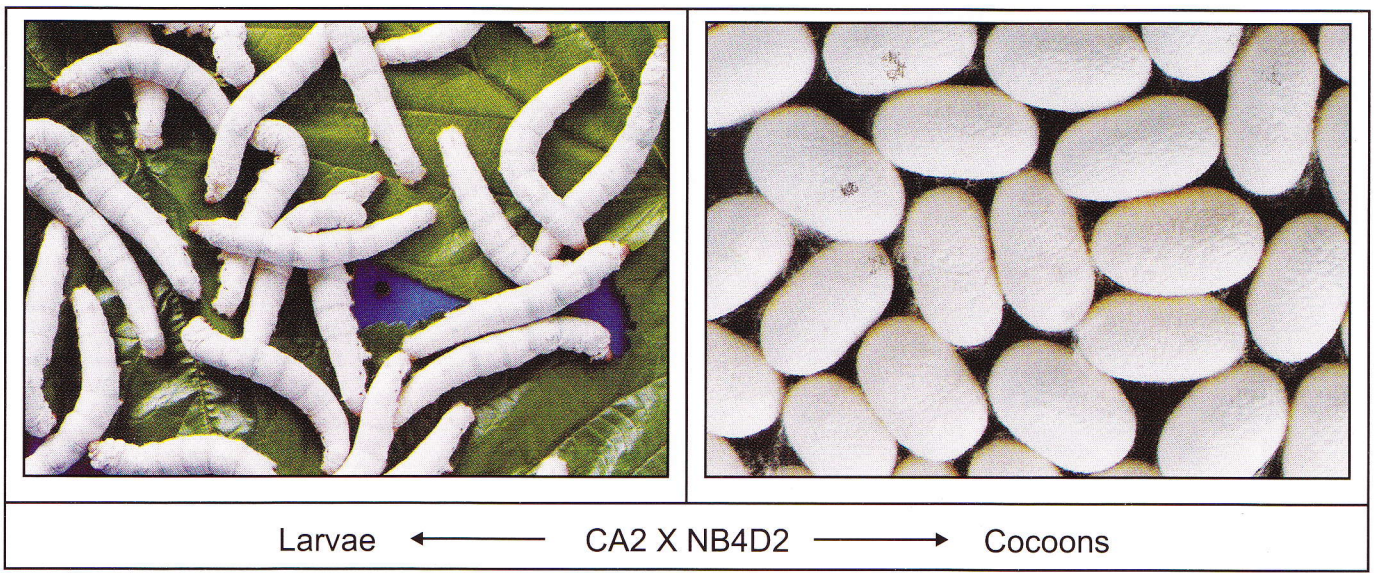
Larvae ← NB7 X NB18 → Cocoons

- Parentage of NB7 : Kinshu x Showa
- Parentage of NB18 : (Koko x Seihaku) x (N124 x C124)
- Hybrid with cocoon shell ratio (18-19%) and raw silk recovery (14-15%)
- Fibre quality : 2A grade
- Plain larvae with bluish white body colour
- Cocoons are bright white with intermediate shape and medium grains
- Renditta : 8~9



Larvae ← CC1 X NB4D2 → Cocoons

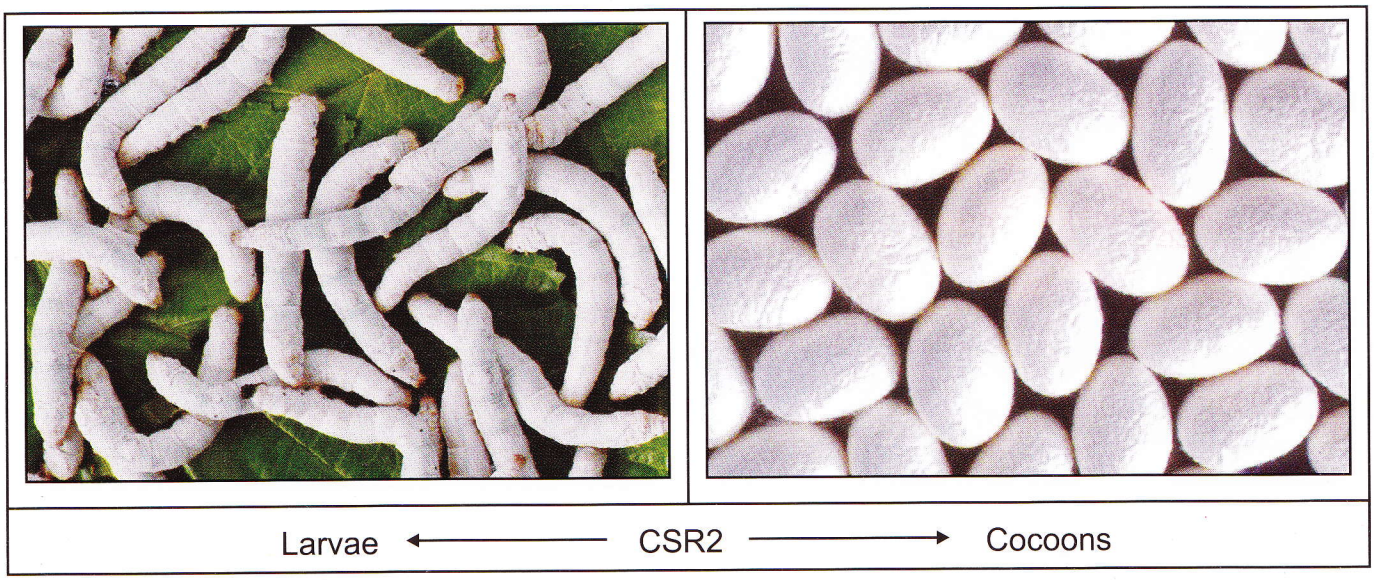
- Parentage of CC1: NB7 x SPC2
- Parentage of NB4D2 : (Koko x Seihaku) x (N124 x C124)
- Hybrid with cocoon shell ratio (20-22%) and raw silk recovery (17-19%)
- Fibre quality : 2A grade
- Plain larvae with bluish white body colour
- Cocoons are bright white with intermediate shape and medium grains
- Renditta: 7~8



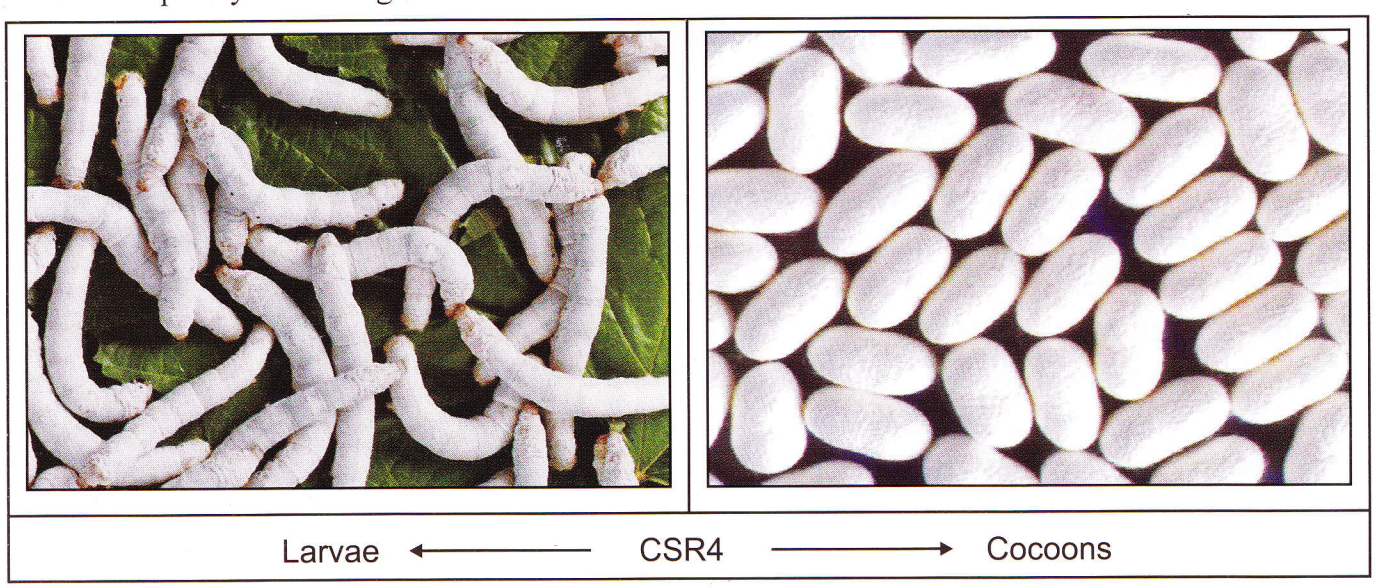
- Parentage of CA2 : (NB7 x NB-1) x (KA x SPC1)
- Parentage of NB4D2 : (Koko x Seihaku) x (N124 x C124)
- Hybrid with cocoon shell ratio (20-22%) and raw silk recovery (17-19%)
- Fibre quality : 2A grade
- Plain larvae with bluish white body colour
- Cocoons are bright white with intermediate shape and medium grains
- Renditta: 7~8

New productive bivoltine breeds and hybrids

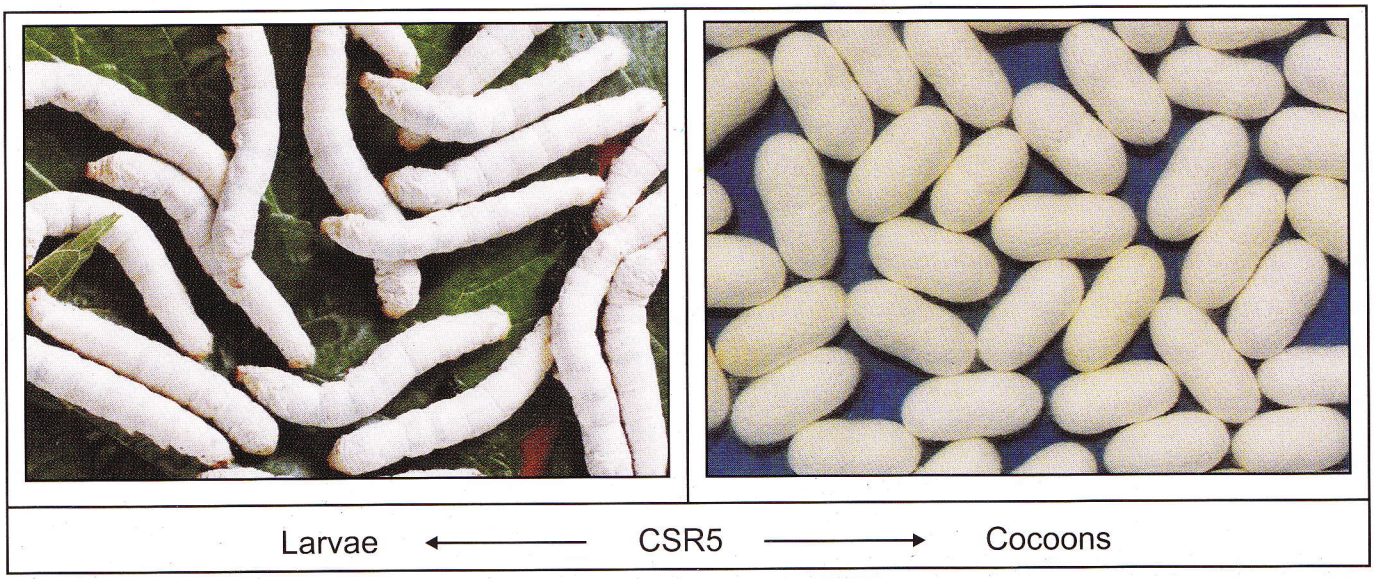
The bivoltine breeds developed earlier could not be popularized as the shell ratio realized at the commercial level was around 18-19% only which is slightly higher than cross breeds. Hence, efforts were made under JICA, an Indo-Japanese collaborative project, to evolve hybrids with high survival and cocoon shell ratio (above 23%) coupled with better reeling traits. As a result, five hybrids namely, CSR2 x CSR4, CSR2 x CSR5, CSR3 x CSR6, CSR12 x CSR6 and CSR16 x CSR17 were identified as highly productive hybrids and were authorized by CSB for commercial exploitation during the years 1997-1999.



- Developed at CSRTI, Mysore during 90s
- Parentage : Shunrei x Shogetsu
- Productive breed with better post cocoon parameters
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with fine to medium grains
- Cocoon shell ratio : 24-26%
- Raw silk percentage : 19-20 %
- Fibre quality :2A ~4A grade

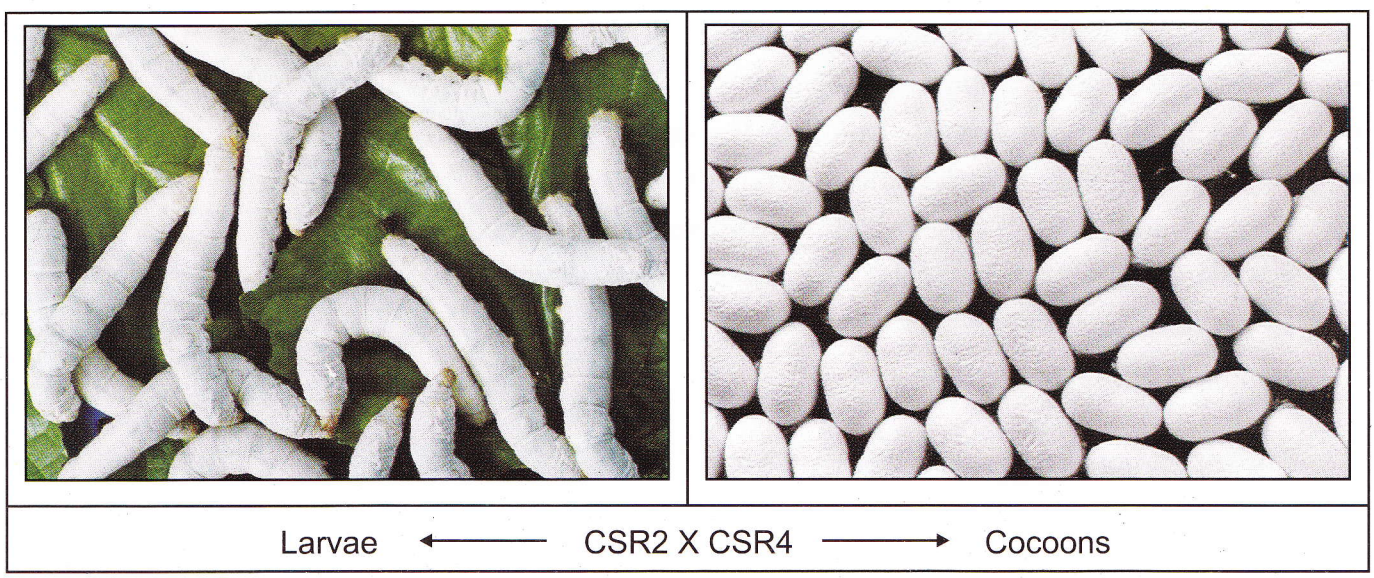


- Developed at CSRTI, Mysore during 90s
- Parentage : (BN18 X BCS25) X NB4D2
- Productive breed with better post cocoon parameters
- Plain larvae with bluish white body colour
- Bright white dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 17-18 %
- Fibre quality : 2A ~4A grade



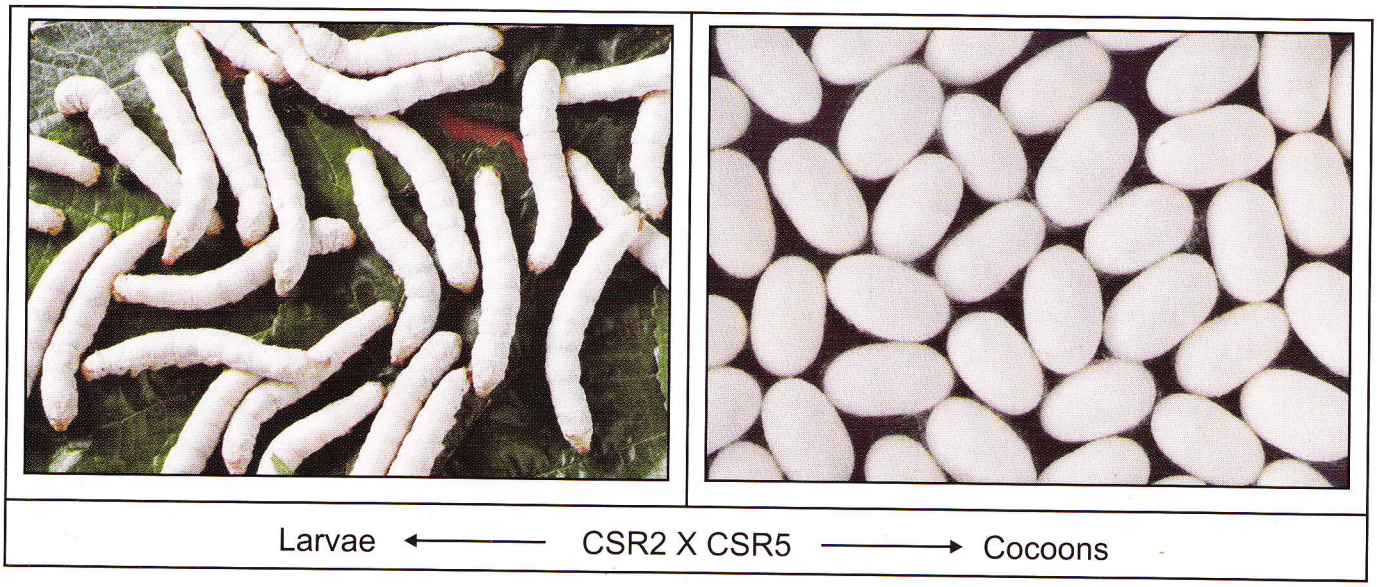
- Developed by CSRTI, Mysore during 90s
- Parentage : Shunrei x Shogetsu
- Productive breed with better post cocoon parameters
- Plain larvae with creamish white body colour
- Creamish white dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio 23-25%
- Raw silk percentage : 18-20 %
- Fibre quality : 2A ~3A grade

The hybrids viz, CSR2 x CSR4 and CSR2 X CSR5 (shell ratio>23.0% and raw silk% 19-20) were authorized (1997) and are being exploited commercially on a large scale at farmers level during favourable months (Sep.-Feb.). These hybrids recorded an average cocoon yield of 65kg/100dfls. Both the hybrids and their reciprocals recorded renditta on an average of 6.0 and produced quality silk of 2A to 4A grade.



- Parentage of CSR2 : Shunrei x Shogetsu
- Parentage of CSR4 : (BN18 x BCS25) x NB4D2

- Productive hybrid and easy to handle by farmers under hygienic conditions
- Hybrid with high cocoon shell ratio (22-24%) and raw silk recovery (19-20%)
- Better fibre quality (2A~4A)
- Rearing during favourable months in southern states and spring in Jammu and Kashmir province, Uttaranchal, HP, etc.,
- Plain larvae with bluish white body colour
- Cocoons are bright white with intermediate shape and medium grains
- Better return for cocoon producer and reeler
- Renditta : 5.6-6.1



- Parentage of CSR2 : Shunrei x Shogetsu
- Parentage of CSR5 : Shunrei x Shogetsu
- Productive hybrid and easy to handle by farmers under hygienic conditions
- Plain larvae with creamish white body colour
- Cocoons are creamish white with intermediate shape and medium grains
- Hybrid with high cocoons shell ratio (23-25%) and raw silk recovery (19-20%)
- Better fibre quality (2A~4A)
- Renditta : 5.6-6.1

Three productive hybrids, **CSR3 x CSR6**, **CSR12 x CSR6** and **CSR16 x CSR17** and their reciprocal crosses (raw silk percentage : 18-20 and 2 A to 3A grade silk) were authorized during 1999 for commercial exploitation during favourable months. The hybrids, CSR3 x CSR6 and CSR16 x CSR17 recorded an average cocoon yield of 65/kg 100 dfls under post authorization trial.

Larvae ← CSR3 → Cocoons

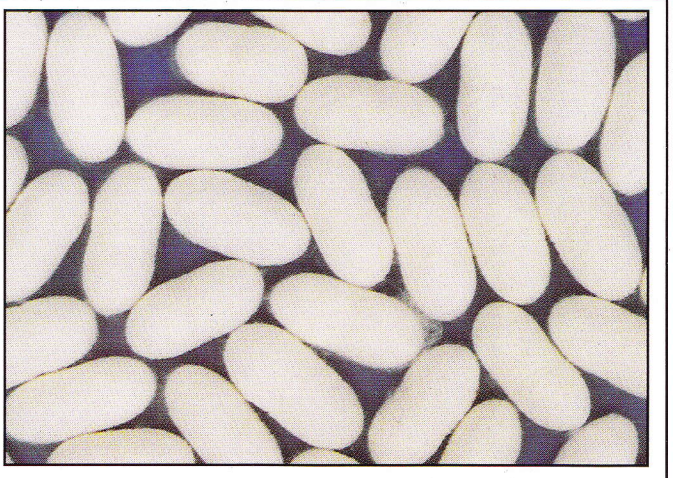
- Developed at CSRTI, Mysore during 90s
- Parentage : (BN18 x BC25) x CC1
- Productive breed with better post cocoon parameters
- Marked and plain larvae with reddish tinge colour (sex-limited)
- Dull white oval shaped cocoons with medium grains
- Cocoon shell ratio : 23-25%
- Raw silk percentage : 18-20 %
- Fibre quality : 3A ~4A grade

Larvae ← CSR6 → Cocoons

- Developed at CSRTI, Mysore during 90s
- Parentage :Shunrei x Shogetsu
- Productive breed with better post cocoon parameters
- Marked larvae with reddish tinge colour
- Dull white dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 18-20 %
- Fibre quality :2A ~3A grade

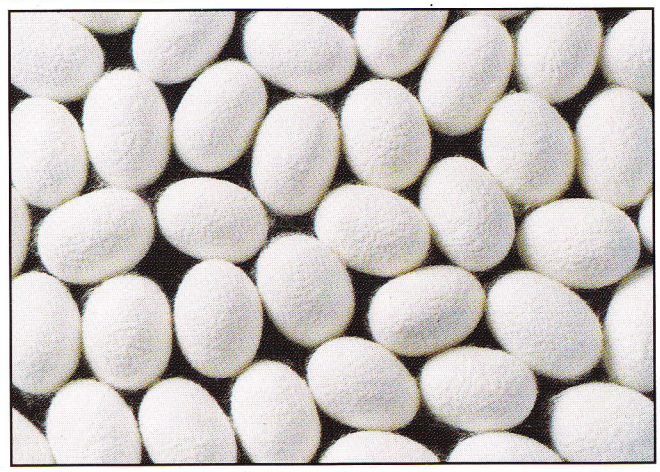
Larvae ← CSR12 → Cocoons

- Developed at CSRTI, Mysore during 90s
- Parentage : (BN18 x BCS25) x KA
- Productive breed with better post cocoon parameters
- Marked and plain larvae with reddish tinge colour (sex-limited)
- Dull white oval shaped cocoons with fine to medium grains
- Cocoon shell ratio : 23-25%
- Raw silk percentage : 18-20 %
- Fibre quality : 3A ~4A grade



Larvae ← CSR16 → Cocoons

- Developed at CSRTI, Mysore during 90s
- Parentage : (C135 x N134) x J14
- Productive breed with better post cocoon parameters
- Marked larvae with dull white body colour
- White dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 17-18 %
- Fibre quality : 3A ~4A grade

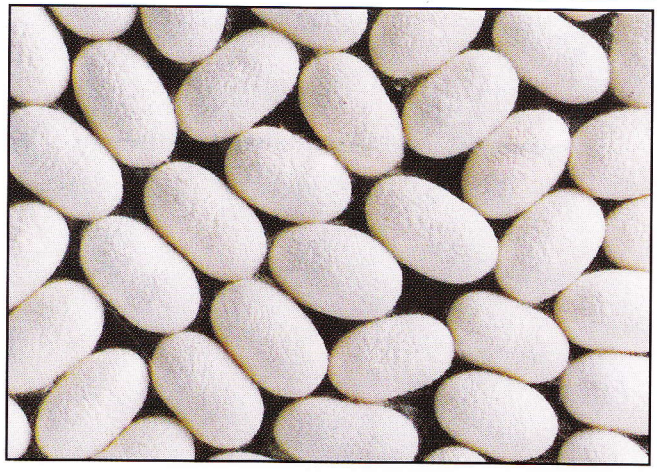


Larvae ← CSR17 → Cocoons

- Developed at CSRTI, Mysore during 90s
- Parentage : (N137 x C146) x A24
- Productive breed with better post cocoon parameters
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 18-20 %
- Fibre quality : 3A ~4A grade

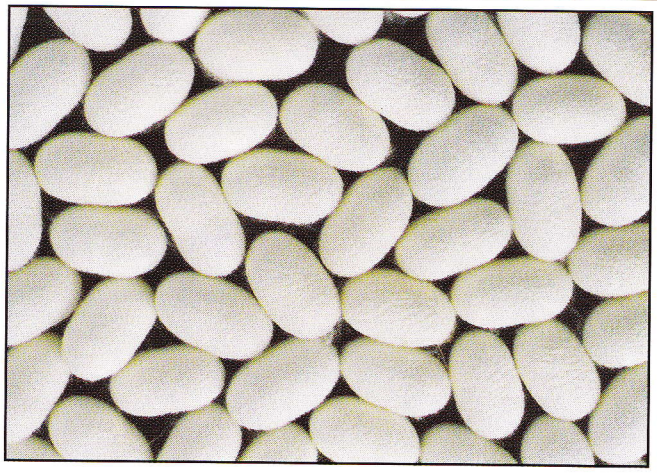
Larvae ← CSR3 X CSR6 → Cocoons

- Parentage of CSR3 : (BN18 x BCS25) x CC1
- Parentage of CSR6 : Shunrei x Shogetsu
- Productive hybrid with high silk recovery
- Marked larvae with dull white body colour
- The female parent of CSR3 is sex-limited in nature
- Cocoons are dull white with intermediate shape and medium grains
- Hybrid with high shell ratio (23-25%) and raw silk recovery (19-20%)
- Silk quality parameters are better than CSR2 x CSR4



Larvae ← CSR12 X CSR6 → Cocoons

- Parentage of CSR12 : (BN18 x BCS25) x KA
- Parentage of CSR6 : Shunrei x Shogetsu
- Marked larvae with dull white body colour
- The female parent of CSR12 is sex-limited in nature
- Cocoons are dull white with intermediate shape and medium grains
- Productive hybrid with high silk recovery
- Hybrid with high shell ratio (23-25%)and raw silk recovery (19-20%)
- Quality parameters better than CSR2 x CSR4



Larvae ← CSR16 X CSR17 → Cocoons

- Parentage of CSR16 : (C135 x N134) x J14
- Parentage of CSR17 : (N137 x C146) x A24
- Productive hybrid with high silk recovery
- More robust than CSR2 x CSR4
- Marked larvae with dull white body colour
- Cocoons are dull white with intermediate shape and medium grains
- Hybrid with high shell ratio (23-25%)and raw silk recovery (19-20%)
- Quality parameters are better than CSR2 x CSR4

Robust bivoltine breeds and hybrid

The hot climatic conditions of tropics prevailing particularly in summer are not conducive to rear high yielding bivoltine hybrids. Considering the importance of developing robust breeds for rearing especially during unfavourable season of the year, CSR18 and CSR19 were evolved..

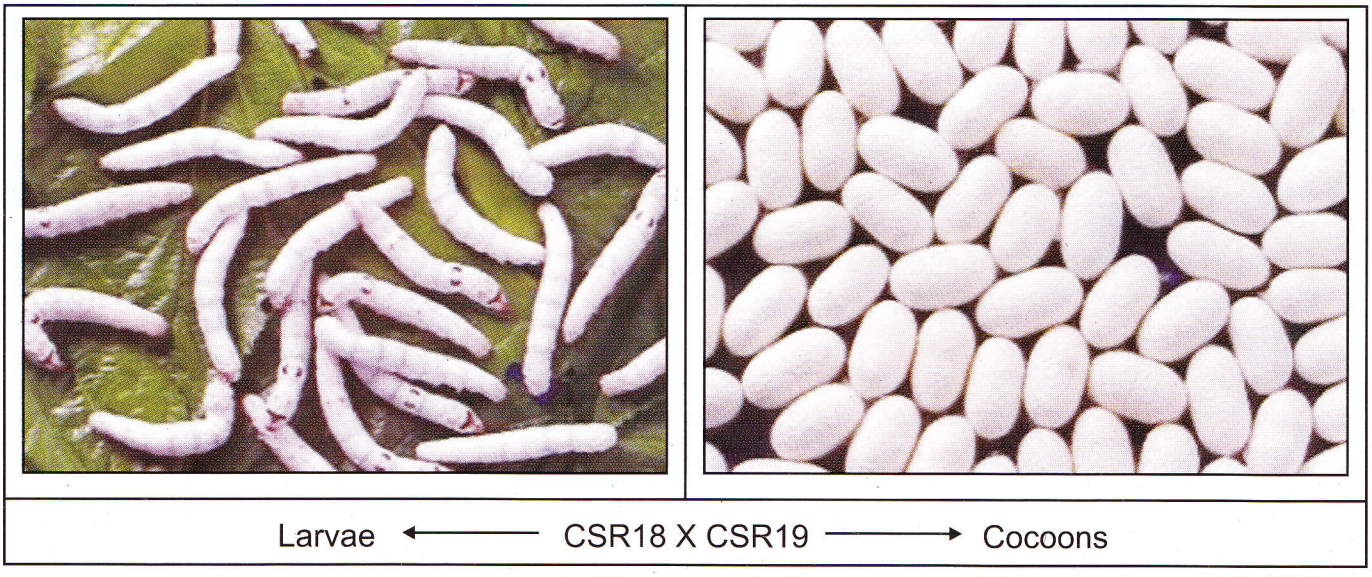
Larvae ← CSR18 → Cocoons

- Developed by CSRTI, Mysore during 90s
- Parentage : B201 x BCS12
- Robust breed with better post cocoon parameters
- Developed under high temperature (36±1°C) and high humidity (85±5% RH) conditions
- Characterized by high pupation (>60%) under high temperature (36±1°C) and high humidity (85±5% RH) conditions
- Marked and plain larvae with reddish tinge colour (sex-limited)
- Larval duration one day less than other bivoltine breeds
- Creamish white oval shaped cocoons with medium grains
- Cocoon shell ratio : 21-23%
- Raw silk percentage : 17-18 %
- Fibre quality : 2A~3A grade

Larvae ← CSR19 → Cocoons

- Developed by CSRTI, Mysore during 90s
- Parentage : B201 x BCS12
- Robust breed with better post cocoon parameters
- Developed under high temperature (36±1°C) and high humidity (85±5% RH) conditions
- Characterized by high pupation (>60%) under high temperature (36±1°C) and high humidity (85±5% RH) conditions
- Marked and plain larvae with reddish tinge colour (sex-limited)
- Larval duration one day less than other bivoltine breeds
- Creamish white dumb-bell shaped cocoons with medium grains
- Cocoon shell ratio : 21-22%
- Raw silk percentage : 17-18 %
- Fibre quality : 2A~3A grade

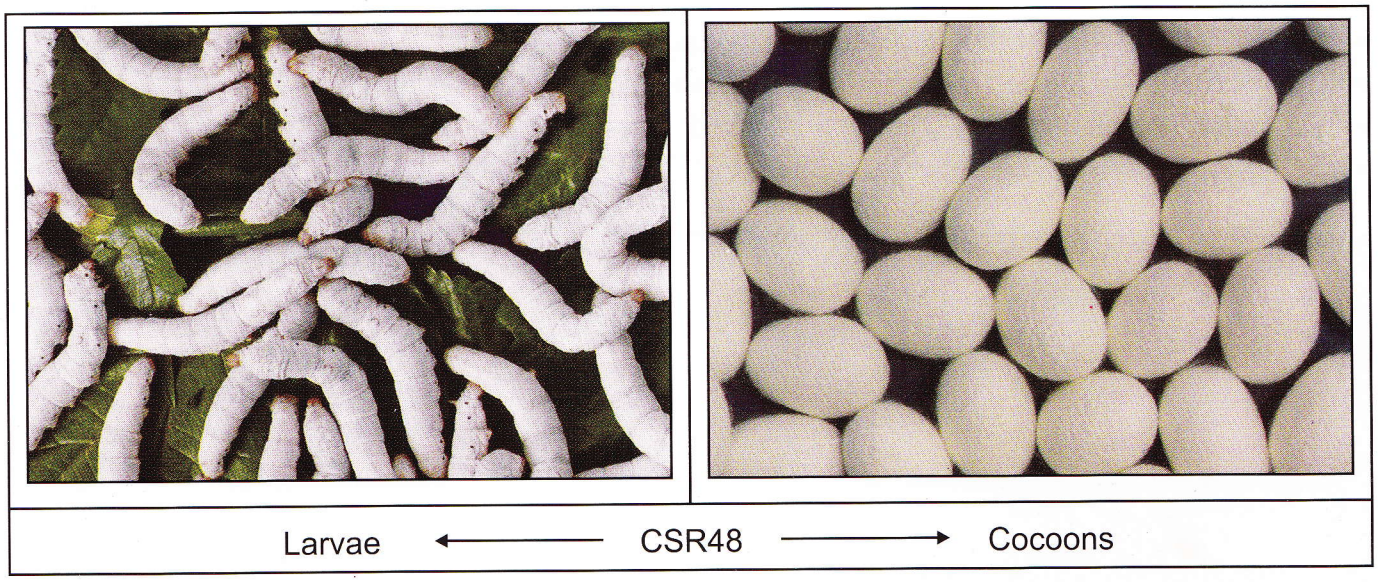
By utilising these robust breeds, the hybrid combination, **CSR18 x CSR19** was developed which was authorized by CSB in 1998 for commercial exploitation throughout the year. The hybrid recorded an average yield of 50 kg per 100 dfls during summer months



- Parentage of CSR18 :B201 x BCS12
- Parentage of CSR19: B201 x BCS12
- Robust hybrid developed under high temperature (36±1°C) and high humidity 85±5% RH) conditions.
- Marked and plain larvae with reddish tinge in colour (Sex-limited)
- Larval duration one day less than productive hybrids (CSR2 x CSR4)
- Consumes less leaf (100-150 kg/100 dfls) than productive hybrids (CSR2 x CSR4).
- Hybrid characterized by high pupation rate (>80%) under high temperature (36±1°C) conditions.
- Creamish white cocoons
- Cocoon yield :50-60 kg/100 dfls
- Better fibre quality (2A~3A)

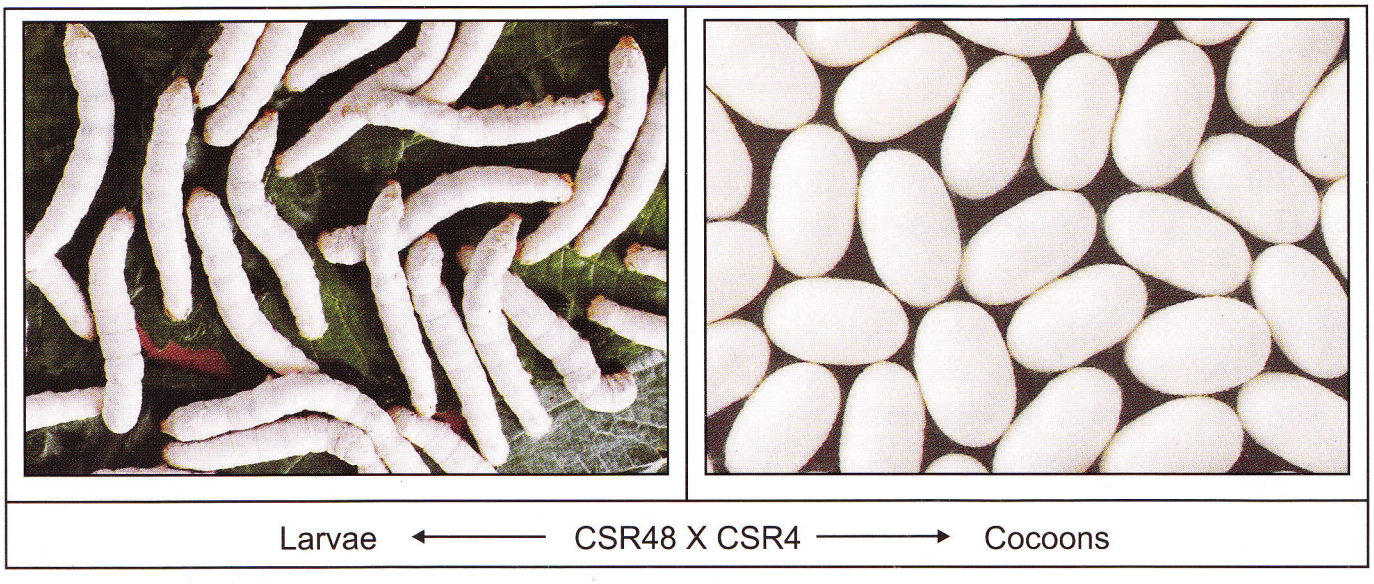
Productive bivoltine breed and hybrid for special denier

To cater to the need of thin denier for the production of finer fabric, directional breeding has been carried out and a new new productive bivoltine breed, CSR48 has been evolved with longer filament length (>1500 m) and thin denier (2 d).

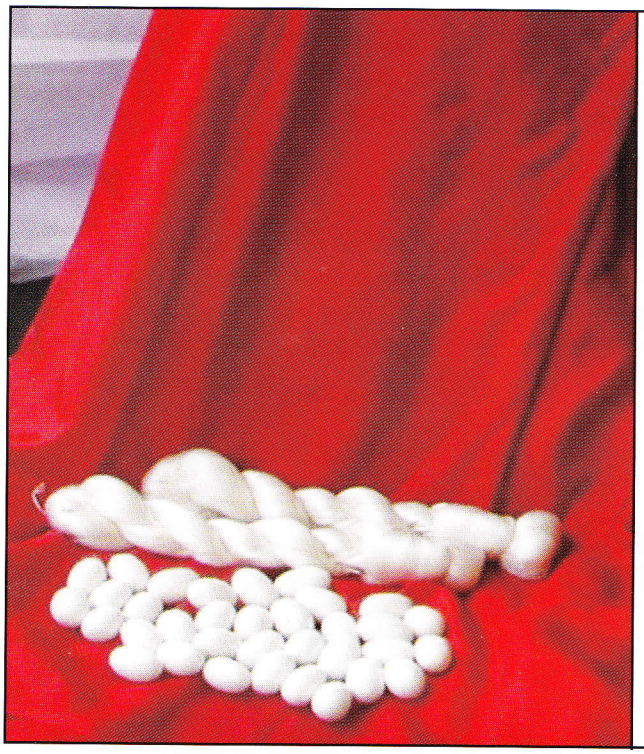


- Developed at CSRTI, Mysore during 2000
- Parentage : JPN8
- Productive breed with better post cocoon parameters
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with fine to medium grains
- Thin denier breed (2 d) with longer filament length (> 1500 m)
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 18-20 %
- Fibre quality : 3A ~4A grade

By utlising the thin denier breed, CSR48 a productive hybrid , CSR48 x CSR4 has been identified for longer filament length of more than 1400 m with thin denier of less than 2.4.



- Parentage of CSR48 :JPN8
- Parentage of CSR4 : (BN18 x BCS25) x NB4D2
- Productive hybrid with high silk recovery
- More robust than CSR2 x CSR4
- Plain larvae with bluish body colour
- Cocoons are white with intermediate shape and medium grains
- Hybrid with high shell ratio (23-25%)and raw silk recovery (19-20%)
- Longer filament length (> 1500 m) and thin denier (2.2 to 2.4 d)
- Quality parameters are better than CSR2 x CSR4



Thin denier hybrid, CSR48 x CSR4

Productive hybrid with longer filament, less denier and size deviation.

No difference in yield/100 dfls when compared with CSR2 x CSR4

Good raw material for the manufacture of Zari, Chiffon and georgette fabric

Sex-limited breeds-A boon for egg producers

Presently more than 90% of the total cocoons raised for production of raw silk are from the cross breeds of indigenous polyvoltine females and males of bivoltine breeds. As a result, the separation of males and females to prevent selfing is a very important task in the preparation of commercial hybrid eggs. Because of the practical difficulties in sex separation at larval or cocoon stage, the separation of sexes is generally carried out at pupal stage which is highly skilled, laborious and time consuming, besides being expensive.

To overcome these drawbacks, two new sex-limited breeds, **CSR8(SL)** and **Nandi (CSR2-SL)** have been developed which produces yellow coloured female and white coloured male cocoons. This is a boon to the grainuers as it is not only helping in easy sex separation process but also saves considerable time, labour and money.

CSR8 (SL)

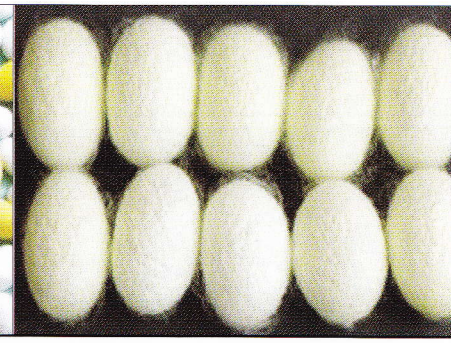
PM X CSR8(SL)

- Parentage of CSR8(SL): Japanese hybrid(SL) x NB4D2
- The cross breed silkworm seed producers can purchase only white cocoons as they need only male moths for the preparation of cross breed layings.
- P1 seed farmers can get more income from white cocoons and yellow cocoons can be marketed for reeling
- The egg number is slightly less in CSR8(450-475) when compared to NB4D2.
- There is no difference in the recovery of eggs between PM x NB4D2 and PM x CSR8. The cocoon yield is also on par with that of PM x NB4D2.

Similarly, in place of normal CSR2 as male component with PM, the new breed **"Nandi (CSR2 - SL)"** with sex-limited for cocoon colour was developed to facilitate easy sex separation based on cocoon colour at grainages (yellow cocoon : female and white cocoon : male) .

PM X CSR2 (NORMAL)

NANDI (CSR2-SL)



PM X CSR2(SL)

- Parentage of CSR2(SL) :CSR2 x CC1(SL)
- PM x CSR2(SL) is on par with that of other hybrid, PM x CSR2 and superior over PM x CSR8 and PM x NB4D2 (control) in yield with marginal improvement in reeling characters.
- The egg number is slightly less in CSR2 (SL) (450-475) when compared to CSR2 (Normal).

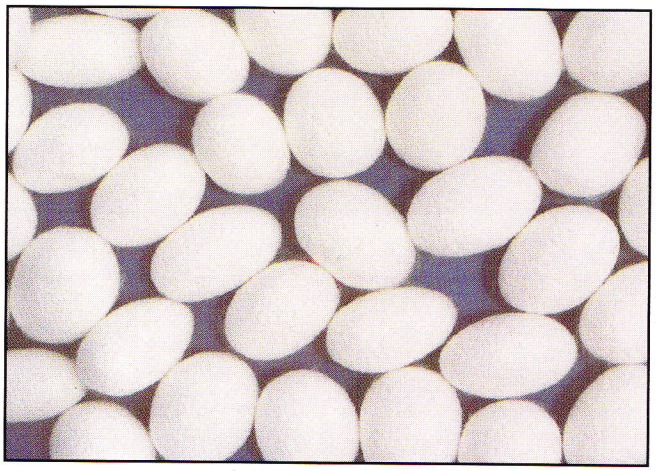
Double hybrid for high egg recovery and cocoon crop stability

Owing to the existence of negative correlation between high cocoon shell ratio and low pupation rate in pure races, the handling of these pure races needs more care and attention by seed cocoon farmers. Keeping this in mind, the double hybrid, (CSR6 x CSR26) x (CSR2 x CSR27) has been selected for commercialization.

Parents of double hybrid (Refer page 31 for CSR2 and page 34 for CSR6)

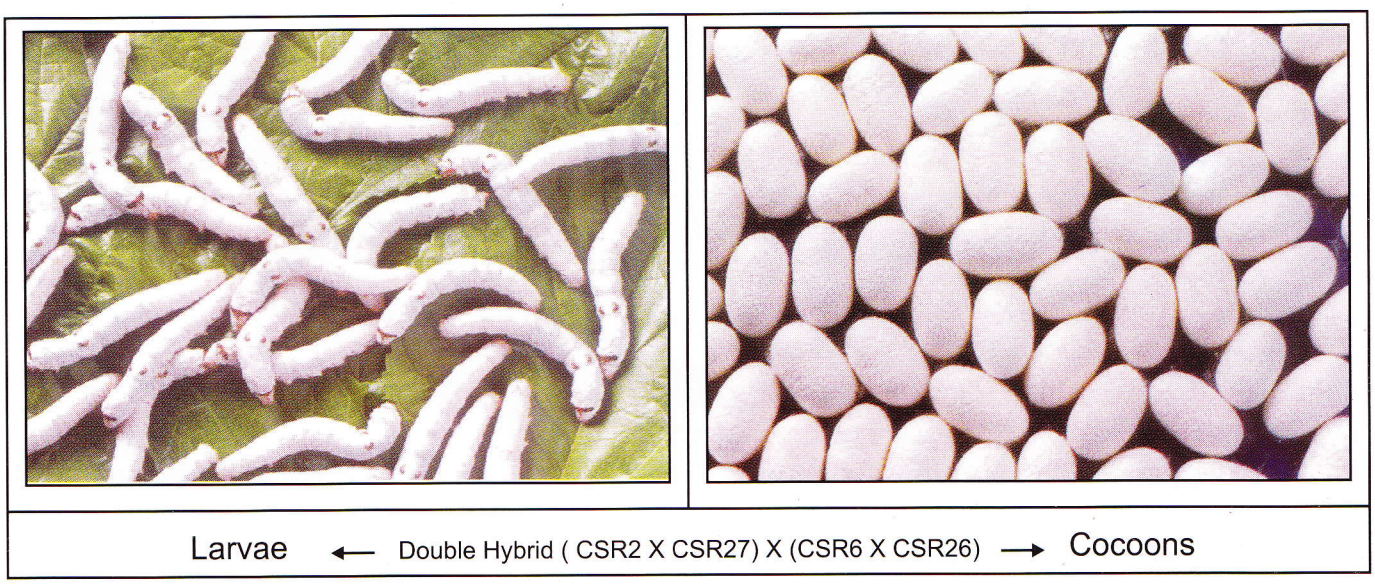
Larvae ← CSR26 → Cocoons

- Developed at CSRTI, Mysore during 2000
- Parentage : C135 x N134
- Productive breed with better post-cocoon parameters
- Marked larvae with dull white body colour
- White dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 17-18 %
- Fibre quality :2A ~3A grade



Larvae ← CSR27 → Cocoons

- Developed at CSRTI, Mysore during 2000
- Parentage : Thaihei x Choan
- Productive breed with better post cocoon parameters
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with fine to medium grains
- Cocoon shell ratio : 23-24%
- Raw silk percentage : 18-20 %
- Fibre quality : 2A ~3A grade



- Parentage of CSR2 : Shunrei x Shogetsu
- Parentage of CSR27: Thaihei x Choan
- Parentage of CSR6: Shunrei x Shogetsu
- Parentage of CSR26 : C135 x N134
- Cocoon yield/100 dfls : 60~70 kg.
- The foundation crosses are more robust than single parents.
- Easy rearing of foundation crosses (P1) i.e seed cocoons
- Quality seed cocoons with less defect can be ensured.
- 12 ~15 % improvement in egg number over single hybrid

Bivoltine breed and hybrid for sub-optimal conditions

By introgression the amylase genes from the popular polyvoltine breeds, Pure Mysore and Nistari into CSR2 and CSR5 two breeds namely, GEN3 and GEN2 were evolved.

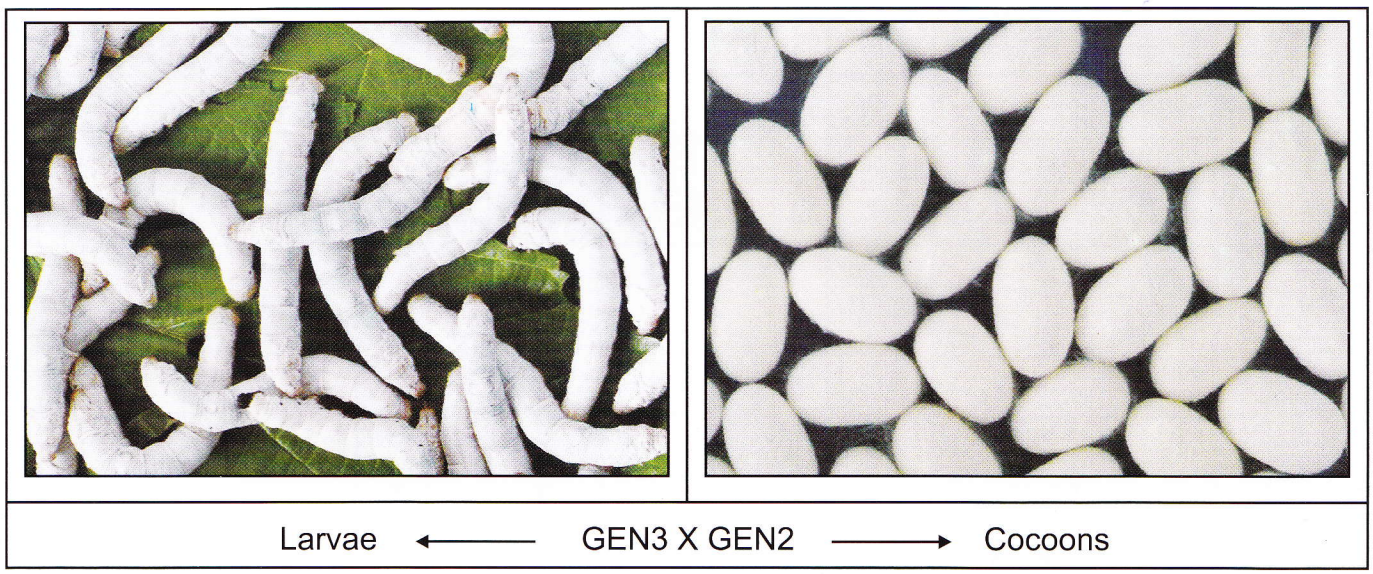
Larvae ← GEN3 → Cocoons

- Developed at CSRTI, Mysore during 2000
- Parentage : Pure Mysore and CSR2
- Developed by introgressing amylase genes from polyvoltine race, Pure Mysore
- Robust breed with better post cocoon parameters
- With high amylase activity, better digestibility and higher survival under sub-optimal conditions of nutrition (leaf quality) and rearing management
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 18-19%
- Fibre quality : 2A ~ 3A grade
- Recommended for rearing throughout the year

Larvae ← GEN2 → Cocoons

- Developed at CSRTI, Mysore during 2000
- Parentage : Nistari and CSR5
- Developed by introgressing amylase genes from polyvoltine race, Nistari
- Robust breed with better post cocoon parameters
- With high amylase activity, better digestibility and higher survival under sub-optimal conditions of nutrition (leaf quality) and rearing management
- Plain larvae with dull white body colour
- Creamish white dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 18-19%
- Fibre quality : 2A~3A grade
- Recommended for rearing throughout the year

By utilising these breeds, the hybrid, **GEN3 x GEN2** with higher amylase activity has been developed



- Parentage of GEN3 : Pure Mysore and CSR2
- Parentage of GEN2: Nistari and CSR5
- Developed by introgressing amylase genes from polyvoltine races-Pure Mysore and Nistari : into CSR2 and CSR5.
- Plain larvae, Creamish white cocoons with intermediate shape
- With high amylase activity, better digestibility and higher survival under sub-optimal conditions of nutrition (leaf quality) and rearing management
- Cocoon yield/100 dfls : 60~65 kg
- Easy rearing under sub-optimal conditions
- Recommended for rearing throughout the year

Characteristics of bivoltine pure races

Characteristics	KA	NB7	NB18	NB4D2	CC1	CA2	CSR2	CSR3	CSR4
Larval marking	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Sex-limited Dull white	Plain, Bluish white
Cocoon colour and shape	Bright white, Oval	Bright white, Oval	Bright white, Dumb-bell	Bright white, Dumb-bell	Bright white, Oval	Bright white, Oval	Bright white, Oval	Dull white, Oval	Bright white, Dumb-bell
Cocoon grains	Medium	Medium	Medium	Medium	Medium	Medium	Fine to medium	Fine to medium	Fine to medium
Pupation rate (%)	80-85	80-85	80-85	80-85	80-85	80-85	85-90	80-85	80-85
Cocoon shell ratio (%)	19-20	19-20	19-20	20-21	22-23	22-23	24-26	23-25	22-23
Filament length (m)	850-900	850-900	850-900	850-900	900-950	900-950	1000-1100	1100-1200	950-1000
Filament size (d)	2.9-3.0	2.9-3.0	2.9-3.0	2.9-3.0	2.9-3.0	2.9-3.0	3.0-3.1	2.9-3.0	3.0-3.2
Raw silk %	15-16	15-16	15-16	15-16	16-17	16-17	19-20	18-20	17-18
Neatness (points)	80-85	80-85	80-85	80-85	85-90	85-90	85-90	85-90	90-92
Reelability (%)	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85
Season	Aug-Feb.	Aug-Feb.	Aug-Feb.	Aug-Feb.	Aug-Feb.	Aug-Feb.	Aug-Feb.	Aug-Feb	Aug-Feb

Characteristics of bivoltine pure races

Characteristics	CSR5	CSR6	CSR12	CSR16	CSR17	CSR18	CSR19	CSR48	GEN3	GEN2	CSR26	CSR27
Larval marking	Plain Brownish white	Marked Dull white	Sex-limited Dull white	Marked Brownish white	Plain Bluish white	Sex-limited Brownish white	Sex-limited Brownish white	Plain Bluish white	Plain Bluish white	Plain Brownish white	Marked Brownish white	Plain Bluish white
Cocoon colour and shape	Dull white Dumb-bell	Dull white Dumb-bell	Dull white Oval	Bright white Dumb-bell	Bright white Oval	Creamish white Oval	Creamish white Dumb-bell	Bright white Oval	Bright white Oval	Dull white Dumb-bell	Dull white Dumb-bell	Bright white
Cocoon grains	Fine to medium	Fine to medium	Fine to medium	Fine to medium	Fine to Medium	Medium	Medium	Fine to medium	Medium	Medium	Fine to medium	Fine to medium
Pupation rate (%)	80-85	80-85	80-85	85-90	85-90	85-90	85-90	80-85	80-85	80-85	80-85	80-85
Cocoon shell ratio (%)	23-25	22-23	23-25	22-23	22-23	21-22	21-22	22-23	22-23	22-23	22-23	23-24
Filament length (m)	900-1000	900-1000	1100-1200	900-1000	900-1000	850-900	850-900	1400-1500	1000-1100	900-1000	900-1000	1000-1100
Filament size(d)	2.9-3.0	2.9-3.0	2.9-3.0	2.8-3.0	2.8-3.0	2.6-2.8	2.6-2.8	2.2-2.4	2.9-3.0	2.9-3.0	2.9-3.1	2.9-3.1
Raw silk %	18-20	18-20	18-20	17-18	18-20	17-18	17-18	18-19	18-19	18-19	17-18	18-20
Neatness (points)	90-92	90-92	90-92	90-92	90-92	90-92	90-92	90-92	90-92	90-92	90-92	90-92
Reelability(%)	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85
Season	Aug-Feb	Aug-Feb	Aug-Feb	Aug-Feb	Aug-Feb	All seasons	All seasons	Aug-Feb seasons	All seasons	All seasons	Aug-Feb	Aug-Feb

Characteristics of bivoltine hybrids

Characteristics	KA x NN6D	KA x NB4D2	NB7 x NB18	CC1 x NB4D2	CA2 x NB18
Larval marking	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white	Plain, Bluish white
Cocoon colour	Bright white	Bright white	Bright white	Bright white	Bright white
Cocoon grains	Medium	Medium	Medium	Medium	Medium
Pupation rate (%)	90-93	90-93	90-93	93-95	93-95
Cocoon shell ratio (%)	19-20	19-20	19-20	21-23	21-23
Filament length (m)	900-1000	900-1000	900-1000	950-1000	950-1000
Filament size (d)	2.9-3.2	2.9-3.2	2.9-3.2	2.9-3.2	2.9-3.2
Raw silk %	15-16	15-16	15-16	16-17	16-17
Neatness (points)	85-90	85-90	85-90	85-90	85-90
Reelability (%)	80-85	80-85	80-85	80-85	80-85
Renditta	7.0-8.0	7.0-8.0	7.0-8.0	7.0-8.0	7.0-8.0
Silk quality	2A	2A	2A	2A-3A	2A-3A
Season	Aug.Feb	Aug.Feb	Aug.Feb	Aug.Feb	Aug.Feb

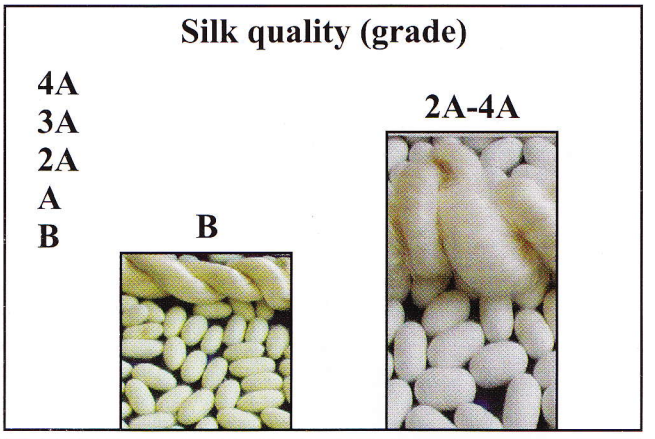
Characteristics of bivoltine hybrids

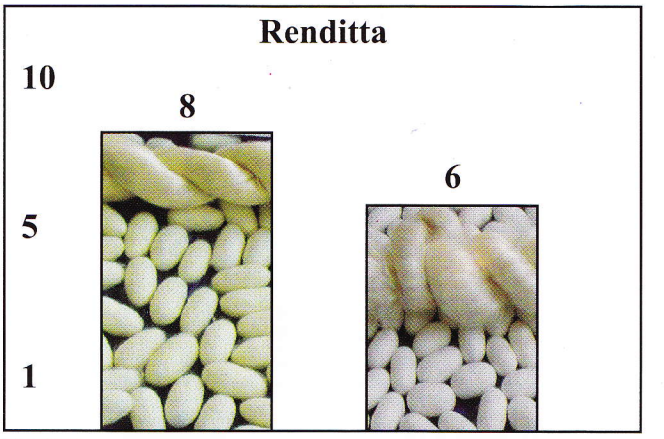
Characteristics	CSR2 X CSR4	CSR2 X CSR5	CSR3 X CSR6	CSR12 X CSR6	CSR16 X CSR17	CSR18 X CSR19	CSR48 X CSR4	GEN3 X GEN2	Double hybrid
Larval marking	Plain Bluish white	Plain Brownish white	Marked Dull white	Marked Dull white	Marked Brownish white	Sex-limited	Plain Bluish white	Plain Brownish white	Marked Brownish white
Cocoon colour	Bright white	Dull white	Crèamish white	Dull white	Bright white	Crèamish white	Bright white	Dull white	Bright white
Cocoon grains	Fine to Medium	Fine to Medium	Fine to Medium	Fine to Medium	Fine to Medium	Medium	Fine to Medium	Medium	Fine to Medium
Pupation rate (%)	95-97	95-97	95-97	95-97	95-97	95-98	95-97	95-97	95-97
Cocoon shell ratio (%)	23-24	24-25	24.-25	24.-15	23-24	21-22	23-24	23-24	23-24
Filament length (m)	1000-1150	1100-1200	1200-1300	1200-1300	1100-1200	950-1100	1300-1500	1100-1200	1100-1200
Filament size (d)	2.9-3.2	2.9-3.2	2.9-3.2	2.9-3.2	2.9-3.2	2.6-2.8	2.2-2.4	2.9-3.2	2.9-3.2
Raw silk %	19-20	19-20	19-20	19-20	19-20	17-18	19-20	18-19	19-20
Neatness (points)	93-95	93-95	93-95	93-95	93-95	93-95	93-95	93-95	93-95
Reelability (%)	80-85	80-85	80-85	80-85	80-85	85-90	80-85	80-85	80-85
Renditta	5.0-5.5	4.8-5.0	4.8-5.0	5.0-5.5	5.0-5.5	5.5-6.0	5.0-5.5	5.5-6.0	5.0-5.5
Silk quality	2A-4A	2A-4A	2A-4A	2A-4A	2A-4A	2A-3A	2A-4A	2A-3A	2A-4A
Season	Aug. -Feb	Aug.-Feb	Aug-.Feb	Aug-.Feb	Aug-Feb	All seasons	Aug.-Feb	All seasons	Aug.-Feb

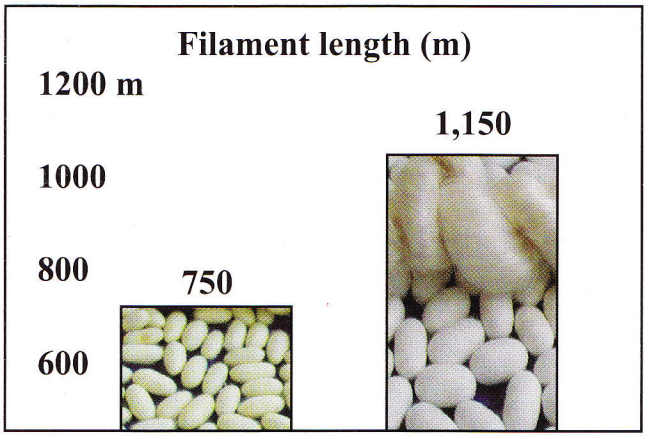
Comparison between Cross Breed and Bivoltine hybrid

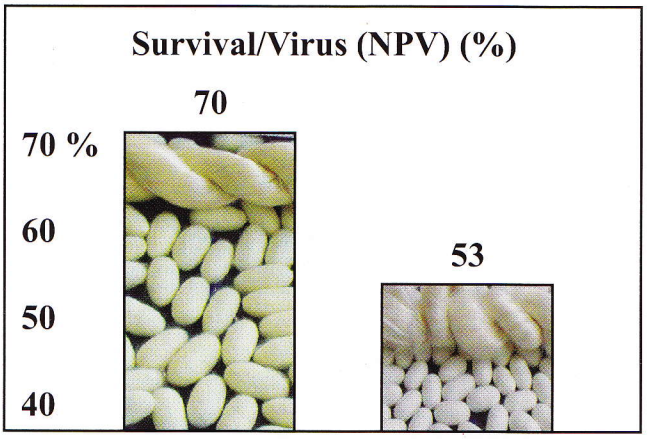
Cross Breed (Pure Mysore×NB4D2)

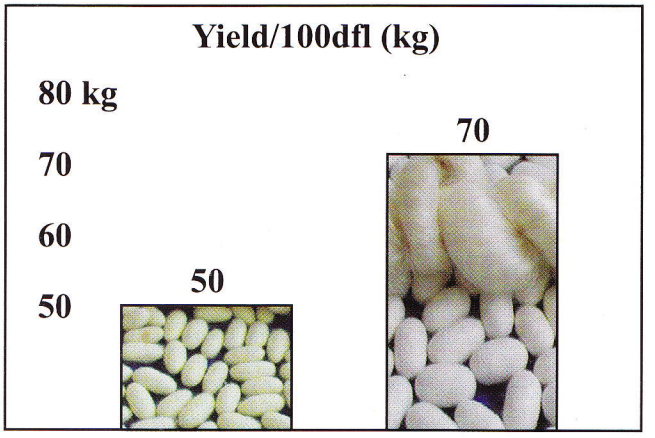
Bivoltine (CSR2×CSR4)

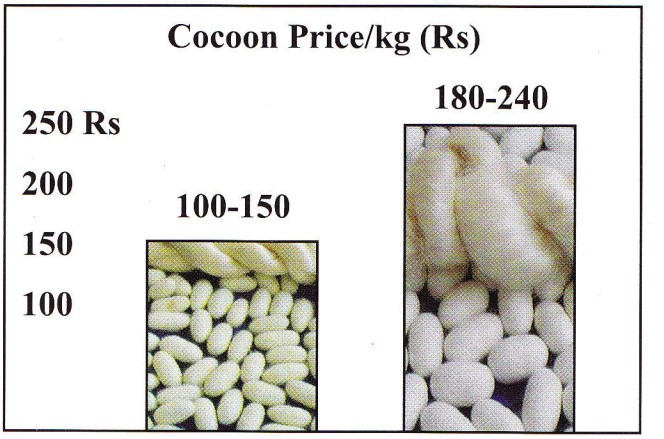












Thrust for the future

India is now on the threshold of further vitalizing the silk industry focusing attention on the quality and production cost rather than quantity alone. To realize the dream of producing large quantity of high quality international grade silk at a competitive price, a sustainable tropical bivoltine sericulture technology has to be refined and popularised. The general opinion is that the bivoltine hybrids do not display crop stability with the farmers as compared to polyvoltine x bivoltine cross breeds . The reasons attributed to such instability are that the bivoltines suffer badly in adverse conditions like high temperature and high/low humidity, low management, poor quality of mulberry and crop losses due to diseases etc. As a result, yield gap and instability are some of the constraints coming in the way of rapid progress of bivoltine sericulture programme. To address these constraints and to suit the varied agro-climatic and socio-economic conditions prevalent in India, development and popularization of location specific and trait specific suitable silkworm breeds is of utmost importance.

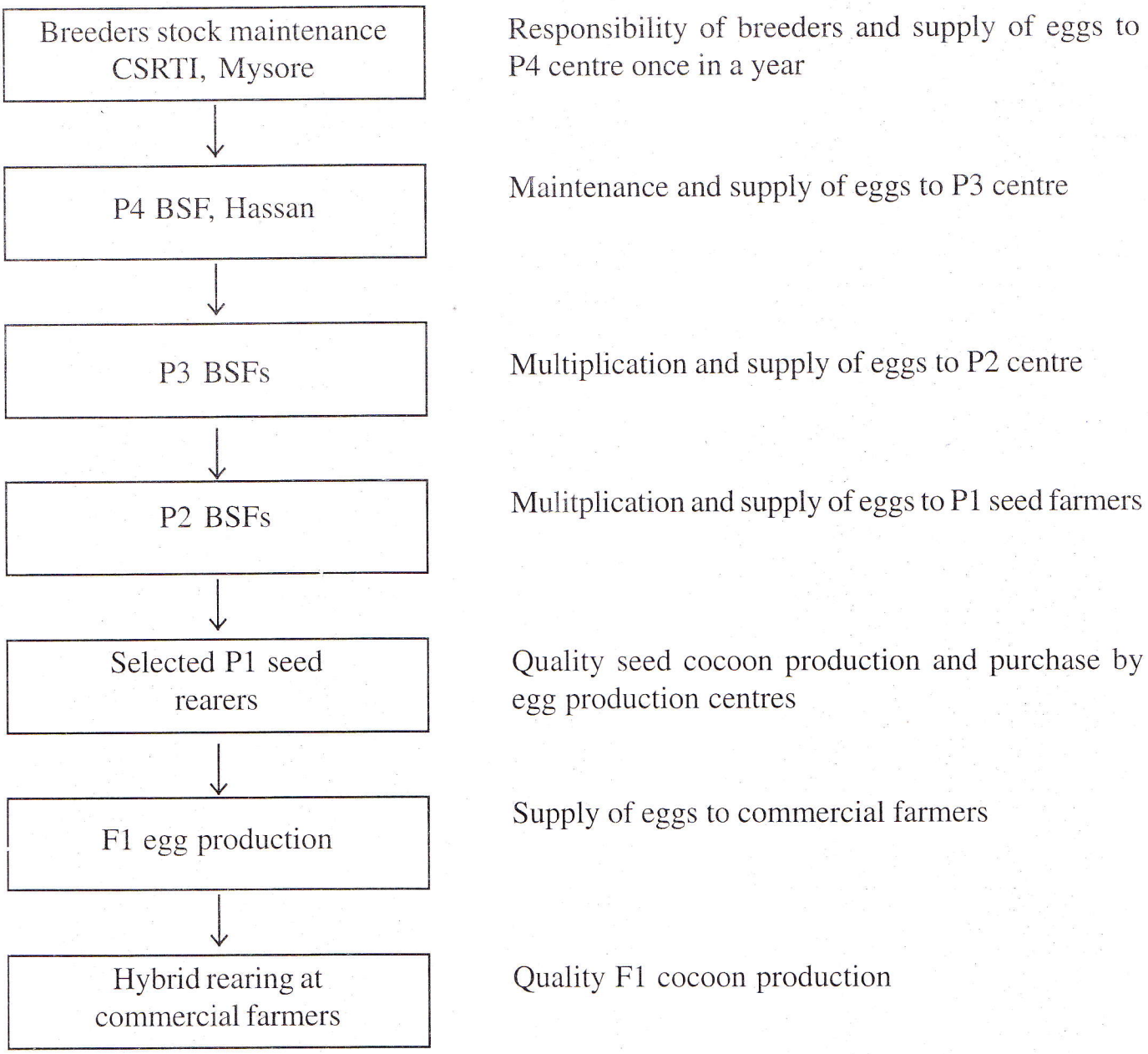
To meet these challenges, intensified and sharp focused silkworm breeding programme emphasizing on breeding for disease resistance, optimal and sub-optimal conditions, special characters to match the industrial requirement, development of economically viable sex-limited breeds, induction of female lethality and production of male silkworm for high silk content, directional breeding using the molecular biology tools to develop novel silkworm breeds to use as breeding resource material are the needs of the hour. This could be accomplished by mobilization of the genetic resources across the institutes and the combining ability studies of races evolved in different institutions could be taken up as a multi-institutional approach.

Silkworm race maintenance and multiplication system

Success of bivoltine cocoon production lies in the maintenance and multiplication of authorized parental silkworm races for commercial utilization. The production of hybrid eggs for commercial rearing involves a long chain of independent and specialized operations right from the systematic multiplication of races for production of quality cocoons in order to meet the demand of the industry. Race maintenance is defined as maintenance of silkworm breeds conforming to their original characteristics. It is the responsibility of the silkworm breeders to maintain the breeder's stock (Parental breeds) after authorization of the hybrids for commercial rearing.

Large number of polyvoltine and bivoltine breeds have been developed by different institutes. The productive bivoltine breeds are recommended for multiplication during favourable months (Sept.-Feb.) at selected Basic Seed Farms. In the three tier system being practiced in India for the past 3 decades indicated the deterioration in the quality of the cocoons produced and are not in conformity with the original character. This may be attributed to the following factors such as intensity of cocoon selection, unskilled/poor knowledge of staff in-charge of maintenance and multiplication and exposing the breeds to adverse conditions at different levels of maintenance and multiplication. To maintain the purity and vigour of the basic stocks and also to avoid repeated multiplication of same stock, one-way system of multiplication(P4~ P1) is of utmost importance. The breeder's stock maintenance should be the responsibility of the breeders of Research Institutes. It is the responsibility of the breeders and P4 station to maintain the original breed characteristics without any deterioration/deviation. Consequently, a new one-way system of race maintenance has been introduced for quality seed production and hybrid vigour. The details are shown in the flowchart.

One way system of race maintenance and multiplication



Silkworm hybrids developed and authorized by CSR&TI, Mysore

Sl.No.	Name of the hybrid	Year of development/authorization
Bivoltine hybrids		
1 2 3	KA x NN6D KA x NB4D2 NB7 x NB18	1970s
4 5	CC1 x NB4D2 CA2 x NB4D2	1980s
6 7	CSR2 x CSR4 CSR2 x CSR5	1997
8 9 10 11	CSR18 x CSR19 CSR3 x CSR6 CSR12 x CSR6 CSR16 x CSR17	1999
12	CSR48 x CSR4	2004
13	PM x CSR8(SL)	2004
14	PM XCSR2(SL)	2004
15	(CSR2 x CSR27) x (CSR6 x CSR26)	2004
16	GEN3 x GEN2	2004
Polyvoltine x Bivoltine hybrids		
1 2 3	MY1 x NB18 P2D1 x NB18 RD1 x NB18	1995
4	BL23 x NB4D2	
5	BL24 x NB4D2	1997
6	BL43 x NB4D2 (Kapila)	2002
7	BL67 x CSR201(Cauvery)	2004
8	BL24 x C.Nichi (Varuna)	2004

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