EXTRAMURAL PROJECTS CARRIED OUT BY R&D INSTITUTES OF CENTRAL SILK BOARD DURING THE PERIOD OF 2014-2019

S.No	Particulars	No. of Projects
A	**Projects funded by International agencies**	
1	Swedish Research Council	1
2	University of Tokyo, University of Ryukuys and NIAS, Japan	1
3	Deakin University Australia	3
4	Sericulture Experiment Station, Vratza, Bulgaria	1
B	**Projects funded by National agencies**	
1	DBT sponsored research projects	10
2	DST sponsored research projects	6
3	Other agencies	3
	Total	**25**

S.No	Title of the project	Period and Budget (Rs. Lakh)	Objective	Status
CSR&TI, MYSORE				
1	Development of Distinctiveness, Uniformity and Stability (DUS) Descriptors for Mulberry (*Morus spp*.) and their validation- Phase III - **PIE 3611**	2016-2019 (Rs.14.00)	Establishment and maintenance of example and reference varieties. Development of database for the descriptors of mulberry and add on to INDUS. Establishment of Co-nodal DUS test centre at CSR&TI, Berhampore. DUS testing of new / extant varieties and their registration under PPV & FR Act, 2001.	The example and reference varieties are being maintained. DUS testing application for V1 and G4 mulberry varieties has been prepared and finalized for submission to PPV & FRA.
2	Assessment of SNP variation in silkworm (*Bombyx mori L*.) by genotyping by sequencing and genome-wide association mapping of important	2017-2020 (Rs.67.42)	Identification of SNP variation in silkworm genotypes through genotyping by sequencing of diverse silkworm genotypes. Analysis of SNP data for use in different	Phenotyping of 100 silkworm genotypes from CSRTI-Mysore, Berhampore, Pampore, CSGRC-Hosur, KSSRDI-Thalaghattapura and APSSRDI-Hindupur for five qualitative traits and

	commercial traits - **AIT 3628 DBT funded- collaboration with RVCE, Bengaluru**		aspects of molecular breeding of silkworm. Development of web accessible database hosting the developed genomics resources for use by different silkworm researchers in India.	nine economically important quantitative traits was completed. The 2nd cycle of Phenotyping is under progress.
3	Genetic enhancement of mulberry by genomic approaches: A Multi-Component (10) Network Project - **PIC 01003 CN (DBT funded)** **NW1**: Development of Genomic Resources of Mulberry by WGS of Indian Mulberry germplasm **NW2a**: Validation of a high-density SNP genotyping array for QTL discovery by association mapping and bi-parental analysis in mulberry **NW2b**: Discovery of QTL to drought adaptive traits by association mapping in Mulberry **NW 2C**: Identification of QTLs for yield associated traits in mulberry (Mul.Physiology) **NW2d** : Identification of QTLs for nutrient use efficiency (Soil Science)- **NW2e**: Sustaining Mulberry Yield: Identification of QTLs Conferring	2018-2021 (CSB: Rs.422.38 & DBT: 442.33 **Total Rs.864.71)**	Establishment of KASP SNP genotyping facility, Genome estimation and genotyping the panel of germplasm using SSR markers, SNP genotyping of panel of diverse germplasm and mapping population, Construction of genetic linkage map using SNP, QTL discovery by marker trait association and linkage mapping using phenotypic data for different traits.	Genome estimation was done using flow cytometry for 10 mulberry, Isolation of DNA from 311 mulberry genotypes was completed, Forty eight mulberry genotypes were screened against existing 16 SSR markers, Standardization of new set of thirty SSR markers obtained from UAS, Bangalore. New set of SSR markers are using against 96 mulberry germplasm for assessment of genetic diversity.

	Resistance to Root Rot Disease by Linkage Mapping and Trait Introgression (Molecular Biology-I) **NW3b:** Development of new generation transgenic mulberry for drought stress tolerance and characterization of existing transgenic mulberry for confined field trials (MBG) **NW4a**: Comparative quantitative and qualitative analysis of secondary metabolites for identification of biomarkers responsible for feed quality in mulberry (MBG)			
4	Indo-Bulgarian Collaborative research project for improvement of silkworm breeding in India and Bulgaria **Sericulture Experiment Station, Vratza, Bulgaria & CSR&TI, CSB, Mysore AIB-3537**	2015 -2020 (Rs.12.25)	To develop high productive silkworm breeds.	25 Oval foundation crosses and 15 Dumbbell FC were developed utilizing silkworm genetic resources from Bulgaria and a new bivoltine double hybrid BFC1 x BFC 10 was developed with 24.3 SR%, 1120 M filament length and 5.5 renditta, which is under field trial now.
SBRL, KODATHI				
5	Validation of the DNA markers in silkworm breed developed by introgression of DNA markers associated with NPV resistance using Marker	2017-2020 (Rs.71.17)	Validation of DNA markers for NPV resistance and stress tolerance in selected lines. Continuous maintenance of MAS-N lines, Co-ordination	Validation of different batches of selected Marker assisted selection lines for NPV resistance (MASN) is under progress. Establishment of MASN

	Assisted Selection Breeding and large scale field trial of the breed - **ARP 3605 (DBT funded)**		and statistical analyses of observations from lines reared at different stations To evaluate evolved lines in various agro-climatic conditions and select lines for their suitability in that particular environment at RSRS/ REC at Bangalore, Salem, Chamarajnagar, Ananthapur, Berhampore, Jammu & Kashmir and Dehradun (through respective CSRTIs To Prepare DFLs of PM (or other promising multivoltine race of the area) x MASN and MASN x CSR4 through NSSO (CSB) - Bangalore and distribute to Sericulture farmers for field evaluation and to evaluate crossbreed and bivoltine hybrids utilizing MASN lines.	lines at Dehradoon, Jammu, Berhampore (West Bengal) and at Mysore is in progress. MASN lines are silkworm breeds developed with NPV resistance through molecular marker assisted selection breeding.
6	Development of diagnostic tool for early detection of baculovirus causing tiger band disease in *Antheraea proylei"* - **ARP 3606 (DBT funded)**	2017-2020 (Rs.47.98)	To characterize the baculovirus pathogen causing tiger band disease in Oak tasar silkworm, *Antheraea proylei*, To study the pathogenesis, source and mode of infection of viral pathogen, To develop DNA based diagnostic tools for early detection of baculovirus causing	It is found that the genome of viral pathogen has a homology with alpha-baculovirus (Anpr*NPV*) infecting saturnid silkworms. The information is used for developing a diagnostic kit for early detection of the virus.

			tiger-band disease, Validation of developed diagnostic tools in Oak tasar grainage and egg production centre.	
7	Studies on the genetic characterization, transmission and tissue distribution of Iflavirus infecting the Indian tropical tasar silkworm, *Antheraea mylitta*" – **ARP 08001 CI (Swedish RC funded)**	2018-2021 (Rs. 81.00)	To characterize the Iflavirus infecting two silkworm species, *Antheraea mylitta* & *Antheraea proylei*, To analyze the source of infection, tissue tropism, cross-infectivity, biogeography surveys and life histories, To study the effect of iflavirus infection on susceptibility status of host silkworms & its impact on infection of other potential pathogens i.e., microsporidian & baculovirus, To develop simple & easy diagnostic method early detection of viral pathogen.	Characterization of the Ifla virus infecting the *Antheraea mylitta* was done. While deciphering the source of infection it was observed that the virus transmits vertically.
8	Molecular characterization of Indian isolate(s) of Densovirus (DNV) and viral resistance gene in the host, silkworm *Bombyx mori L* **University of Tokyo, University of Ryukuys and NIAS, Japan & SBRL Kodathi, CSB Bengaluru - ARP-3513**	2014-2016 (Rs.6.40)	To clone and characterize the full length viral genome as well as its open reading frames (ORFs) of Indian Densovirus Isolate. To study the Denso virus (DNV) pathogenesis in silkworm *B. mori* To elucidate the level of Denso virus resistance genes (*nsd-1, nsd-2 a*nd *nid-1*) expression in	Characterized DNV genome and identified *nsd*2 gene responsible for infection and multiplication in the host. This gene is being used for screening the germplasm towards developing disease resistant silkworm breeds.

			various silkworm germplasm races in relation to viral pathogenesis.	
9	Gene Expression Profiling for the Identification of Resistant/Tolerant Genes to Microsporidian Infection in Lamerin Breed of Silkworm, *Bombyx mori L.*	2019 -2021 (SBRL-51.22 & IISc 21.93)	To identify and evaluate the resistance/tolerant genes with potential function against microsporidian infection.	Project approval received and it will be initiated from September, 2019
CTR&TI, RANCHI				
10	Studies on utilization of solar energy in Tasar post cocoon technology operations – **CED 4723** (**funded by MNRE)**	2016-2019 (Rs. (38.73 MNRE & 12.0 CTRTI Ranchi)	Economizing the energy consumption in Tasar post cocoon technology operations by utilizing the solar energy.	Solar power derived reeling and spinning machines were developed in post cocoon technology section of CTR&TI, Ranchi and are running with solar power now.
11	Integrated biotechnological approach towards improvement of quality and productivity of tropical and temperate tasar silk. (Mega Project comprising of two full projects) - **AIT 4727** **Project 1:** Genetic characterization of tropical tasar silkworm, *Antheraea mylitta* through single nucleotide polymorphism based molecular barcode. **Project 2:** Sequencing of whole-genome of tasar silkworm, *Antheraea mylitta.* **(DBT funded)**	2018-2021 **Sub Project-1:** (Rs. 90.60 CSB &: 120.46 NIAB) **Sub Project:2:** (Rs. 62.42 CSB &: 93.41NIAB)	Whole genome sequencing of Daba ecorace of *Antheraea mylitta* and elucidation of the molecular basis of different qualitative and quantitative traits of *Antheraea mylitta*.	Bioinformatics analysis of the Shallow sequence data was performed. Minor variant calling data showed that total variants and SNP values are more in *Antheraea yamamai* as compared to *Bombyx mori* when their genome were aligned with *Antheraea mylitta.* Major variant calling data showed that ICT, INV, DEL and INS values are more in *Antheraea yamamai* as compared to *Bombyx mori* when their genome were aligned with *Antheraea mylitta.* Mapping of non-sericiginous insect genome against *A. mylitta* genome is being performed.
12	Identification most-active cocoonase of	2018-2021 (Rs. 24.43	To identify the most active cocoonase of	Cocoonase variants papain and trypsin

	sericigenous insects and its variant through molecular characterization - **AIT 4728 (DBT funded)**	CSB; 23.87 IISER & 71.23 BIT)	sericigenous insect through molecular characterization. To evaluate the most suitable cocoonase /variants for its future application in silk processing.	enzymes were used for softening of tasar cocoons of *A. mylitta*. Impact of pH, temperature, enzyme concentration and buffer strength for cocoonase variant activity in cocoon softening has been evaluated. Reeling of the softened cocoons were done and reeling parameters of the silk threads were studied. From 200 emerging pupae approx 30 ml cocoonase sample was collected.
CMERTI, LAHDOIGARH				
13	Development of microbial biocatalyst by heterologous expression of hpaC & soxABC gene cluster in biosurfactant producing bacterium for effective desulfurization of dibenzothiophene - **AIT 5885 (DST Fast track project)**	2016-2019 (Rs.23.71)	Cloning, expression and purification of hpaC and soxABC gene cluster in a biosurfactant producing bacterium Bacillus subtilis LBBMA 155 Characterization of the DBT desulfurization activity by recombinant strain LBBMA 155 Industrial applications of recombinant strain in biorefining the hydrotreated fuels.	Viability of *E.coli* extracted DNA checked by PCR amplification of 16S rRNA of size 1500 bp. HpaC gene of size 500bp confirmed in *E.coli* by PCR amplification from the new set of primers from xcelris. The libraries were prepared from the sample *Gordonia* by *Truseq Nano DNA Library preparation kit*. The average size of library is 512bp. The library will be sequenced on Illumina platform (2 x 150 bp chemistry) to generate ~3 GB data / Sample. Sub culturing of Bio surfactant producing and BDS isolates is under progress.
14	Biodiversity assessment of wild silk moths and rearing potentialities of muga (*Antheraea*	2017-2020 (Rs.54.41)	Biodiversity assessment of wild silk moths and rearing potentialities of muga *(Antheraea*	Ungma, Kobulong, and Aosenden areas of Nagaland were surveyed for collection of wild sericigenous insects.

	assamensis Helfer) and eri silkworm (*Samia ricini Donovan)* for sustainable development in Nagaland – **APR 5890 (DBT funded)**		*assamensis Helfer*) and eri silkworm (*Samia ricini Donovan)* for sustainable development in Nagaland.	Cocoons of Muga were collected and characterization is under progress.
15	Isolation and characterization of lytic bacteriophages infecting bacterial pathogens of Muga silkworm *Antheraea assamensis Helfer* - **ARP 5887 (DST funded)**	2017-2019 (Rs.67.56)	Isolation and characterization of bacteriophages against Muga silkworm bacterial pathogens and study of the phage biology and genome organization Evaluation of the potential phages cocktail against Muga silkworm pathogens.	Four bacterial cultures viz. *Serratia marcescens*, *Bacillus* and two species of *Pseudomonas* which were available in the laboratory along with *Lysinibacillus sphaericus* were used for phage isolation from environmental samples. The environmental samples were collected from cow dung; drain water and water retained after washing som and soalu leaves. Flacherie infected Muga larvae were collected from which 5 different types of bacteria were isolated and pure cultures are maintained for further use. Bacterial pathogens of Muga silkworms were isolated as pure colonies. Standard cultures from MTCC were procured. And bacteria isolated from Muga silkworm were also used in spot test for phage with same environmental samples mentioned above. MTCC numbers for the standard bacterial cultures were identified as MCC 2231- *Lysinibacillus fusiformis;*

				MCC 2045- *Lysinibacillus sphaericus*; MCC 2689- *Serratia marcescens* & *Pseudomonas aeruginosa*. Fresh soil, water and leaf samples were collected for isolation of bacteriophages.
16	*In-situ* conservation of muga and other wild silk moths in Natural Habitat – **AIB 5894 (NERTPS, Funded)** (In collaboration with R.O., CSB, Guwahati and Directorates of Sericulture, Concerned State - Assam, BTC, Meghalaya, Arunachal Pradesh).	2016-2019 (Rs.400.00)	Development of in-situ conservation site for muga silkworm and other wild silk moths species. Utilization of muga silkworm germplasm for breeding and seed production.	**Assam:** MoU has been signed between Assam Forest Department and CMERTI, Lahdoigarh for Upper Doigrung Wild Life area, Golaghat up to 2047 (30 years). Two weather stations were installed, one at the peripheral village (Bankathar Village) and another one at the *ex situ* site at Bogidhola farm of State Sericulture Department, Golaghat for recording meteorological data. **BTC, Assam** MoU was signed between Assam Forest Department and CMERTI, Lahdoigarh for Kuklung forest area, Kokrajhar upto 2047 (30 years). Weather station was installed for recording meteorological data. During December, 2018, Muga silkworms were released through egg and seed cocoons. **Meghalaya** "Tura Peak" was found to be most suitable area in terms of host plant availability, monitoring, accessibility besides

				pertaining to reserve forest area of Meghalaya. **Arunachal Pradesh:** Mebo forest Pasighat was selected for *in situ* conservation whereas Borguli state farm was selected for *ex situ* conservation.
17	Development of LED traps for controlling major insect pests and predators in muga ecosystem – Needs for organic muga silk production - **ARE-5891** **DST, New Delhi funded**	2017-2019 (Rs.14.73)	To develop light traps through LED (Light Emitting Diode) for controlling major insect pests and predators in muga ecosystem. Field trials for validation of developed LED traps for controlling major insect pests and predators in muga ecosystem.	Solar trap has been developed and is being utilized to control insect pests. Field trial was conducted and validated the device and popularization is being done under various extension programmes.
18	Establishment of Institutional Biotech Hub– **AIT 5876 (DBT funded project).**	2010 -2019 (Rs.125.02)	The institutional biotech hubs will be providing basic biotechnology infrastructure facility for the students, faculties and researchers of individual institutions as well as nearby institutions.	13 No. Laboratory equipments viz. Phase contrast Microscope, deep freezer, Gel documentation centre, computer with peripherals etc., costing Rs.14.26 Lakhs were procured. 6 JRF/SRF/RA were engaged during the project period. More than 10 PhD students, 100 plus BSc, M.Sc students utilized the facilities of the Biotech Hub and perused their higher studies. Three training programme on 1) Techniques and Technologies of Seri-biotechnology, 2) Soil Health

				Management and 3) Mushroom cultivation using bio-waste materials at the institute were organized. The Biotech Hub was able to disseminate knowledge (training) and popularize basic science. A scientific magazine namely **"BioQuest"** (half yearly) has been published under the Hub. Many foreign and national delegates visited the Biotech Hub. National Science Day was observed. Awareness progranmmes were organized at the different schools of Jorhat – on Integrated technologies of Muga and Eri cultures and Basic Science and its future scopes.
19	Development of technology for enhancing egg laying in Vanya silk moths by application of host plant volatiles - **APS05001EF (DBT funded)**	2018-2021 (Rs.71.34)	Development of technology for enhancing egg laying in Vanya Silk moth by application of plant host volatiles.	Collection of leaves and **kharikas** (A bundle of thatch grass of about 30cm in length and 1 cm in diameter across, bent to resemble a hook in shape, and used to transfer larvae from hatching site to host plant) from primary and secondary host plants were done. Gravid moths were tied with Kharikas made out of different host plants and fecundity was recorded.
20	Popularization and utilization of foldscope for detection of pebrine disease *(nosema assame*) in muga silkworm seed	2018-2019 (Rs.5.00)	Utilization of Foldscope for detection of pebrine disease in muga silkworm seed production areas.	Training programmes on sensitization on pebrine disease, in muga silkworms and usage of foldscope were organized for the farmers of Assam. Muga mother

	production areas - **APS05002EF (DBT funded)**			moth examination was demonstrated during the programmes.
21	Socio economic upliftment of farmers through adoption of improved technologies and skill development on eri culture at RSRS Boko - **MOE05003EF (DST funded)**	2018-2020 (Rs.23.85)	To adopt improved technologies (both pre and post cocoon sectors) at farmers' level. To improve the economies of scale through group approach Diversification of Eri-culture towards income and employment generation.	Improved castor seeds viz. RB-2, Eri DFLs of C-2 and Kesseru saplings were supplied to the beneficiaries. 20 groups (each group comprising of 10 beneficiaries from each village) were formulated and the project activities are being taken up. Ginger seeds and Colocasia cormal are being supplied to beneficiaries for intercropping in kesseru garden for income generation.
CSTRI, BANGALORE				
22	Development of Sericin Based Nano Finish for Textile Materials **- CFC 7072 Deakin University, Australia and CSTRI, CSB, Bangalore**	2015 – 2018 (Rs.12.62)	To develop ways to prepare stable dispersion of TiO2, Silver and ZrO2 nano particles in sericin solution nd apply on various fabrics. Various pre and post treatments (cross linking agents) will also be investigated. To study the influence of relative amounts of sericin and nano particles on functional properties, handle and colour of fabric. Understand the binding mechanism of sericin and nano particles with different textile substances. Understand the fastness against wash, light and abrasion cycles.	A process was developed for sericin application on polyester, cotton, PC blend, wool and silk fabric with improved durability and with eco-friendly chemicals, which can be utilized by fabric processors. The treated fabric offers better wicking, moisture regain, smoothness and dye ability.

23	Studies on Photo Degradation of Silk Fabrics - **CFC 7073 Deakin University, Australia and CSTRI, CSB, Bangalore**	2015- 2018 (Rs.32.62)	To study the photo degradation behavior of mulberry, tasar, muga and eri silk fabrics. To understand and analyze the chemical and physical changes occurring in silk fabrics due to photo degradation. To develop a suitable finishing treatment for silk fabrics to improve photo degradation resistance of silk fabrics To evaluate the effect of developed finishing treatment on the other properties of the silk fabrics.	Optimized yarn and fabric structural parameters and finishing treatment to improve the photo degradation property of silk fabric. Optimized fabric structure using spun silk yarn has been produced and cross checked for UPF factor. Usage sol gel (sericin) property along $Ti0_2$ has been examined and recipe optimized. Pigments with and without $Ti0_2$ are also recommended to enhance UPF especially at humid and hot conditions. Digital printed colorants are cross checked for their performance during UV exposure found better than normal inks used in printing industry. Natual mud source available at few parts of Belgam, Kotpad (Odisha) were used as pigment shown appreciable response against UV degrading of silk. The outcome of the project is being presented in the International symposium to be held during November, 2019 in Japan.
24	Studies on electrospun silk fibroin nanocomposite fibres for biomaterial applications – **CYF-7074 Deakin University,**	2015- 2018 (Rs.27.62)	To develop silk nano-composite fibres using electrospinning technique. To understand the influence of sericin for nano-composite applications in terms	Established Electro-spinning facility at CSTRI, Central Silk Board, Bangalore. Optimized the process parameters and developed drug induced fibroin/sericin matrix

	Australia and CSTRI, CSB, Bangalore		of encapsulation stability and biodegradation. To study the influence of fibroin matrix and sericin reservoir system of encapsulation technique on the release kinetics. To evaluate the cytotoxicological properties of the developed silk nano-composite fibers.	based silk nano-composites through Electrospinning process. Studied the influence of fibroin and sericin matrix for drug stability of Curcuminoids, L-Dopa, Euganol & Gallic Acid towards nano-composite applications. Curcuminoids and L-Dopa herbal drugs are found to be stable with Silk Fibroin and Sericin matrix systems. FTIR Spectra confirms the presence of silk fibroin, sericin & drugs in both types of the samples prepared. Further, SEM images and FTIR analyses of silk fabric samples coated and electrospun nanocomposite fibres point to uniform dispersion on the silk fabric and stable interaction between fibroin, sericin and drug molecules. The developed silk coated and nano-composite samples have been subjected to Cytotoxicological studies which point to safe for biomaterial use results for Curcuminoids coated and nanocomposite samples along with nanocomposite samples of L-Dopa. Influence of fibroin and sericin matrix system of drug encapsulation on the release kinetics has

				been evaluated Both Silk fabric coated & electrospun nano-composite fibre with Fibroin + Sericin + Curcuminoid Drug show drug release upto 24 hrs time duration. The L-Dopa coated samples exhibited moderate toxicity which could be due to instantaneous release of drugs from the sample observed through drug release studies.
25	Adaption of improved sustainable technologies of muga culture for elevation of cocoon production in the tribal belt of Assam. **MOE 05004 EF (Funded by DST Seed Division)**	2019-2022 (Rs.27.90)	To empower tribal muga rearer through adoption of improved technologies for increasing cocoon production and income generation. To improve the socio economic condition of tribal population through muga culture.	Project work initiated.