PROFORMA – I

PROFORMA FOR SUBMISSION OF PROJECT PROPOSALS ON RESEARCH AND DEVELOPMENT, PROGRAMME SUPPORT

(To be filled by the applicant)

PART I: GENERAL INFORMATION

1.	Name of the Institute/University/ Organisation submitting the Project Proposal	: Central Sericultural Research and Training Institute, Central Silk Board, Ministry of Textiles, Govt. of India, Berhampore.
2.	State	: West Bengal
3.	Status of the Institute	: Research and Development
4.	Name and designation of the Executive Authority of the Institute /University forwarding the application	: Dr. S. Nirmal Kumar, Director, Central Sericultural Research and Training Institute, Berhampore 742 101, West Bengal.
5.	Project Title	:**Population interactions of pests and natural enemies in mulberry eco-system.**
6.	Category of the Project (Please tick)	: R&D
7.	Specific Area	:Crop Protection Entomology – Biological Control
8.	Duration	: 5 Years
9.	Total Cost	: Rs. **3208290**/-
10.	Is the project Single Institutional or Multiple-Institutional (S/M) ?	: M

11. If the project is multi-institutional, please furnish the following :

Name of Project Coordinator	: Dr. S.Nirmal Kumar, Director
Affiliation	: Central Sericultural Research and Training Institute, Central Silk Board, Ministry of Textiles, Govt. of India. This institute was recognized as Center of Excellence in Sericultural Research by University of Kalyani, Kalyani, West Bengal.
Address	: Central Sericultural Research and Training Institute, Central Silk Board, Ministry of Textiles, Govt. of India, Berhampore 742 101, West Bengal.

12. Project Summary (Not to exceed one page. Please use separate sheet).

In eastern and north-eastern parts of India, the major pests of mulberry are thrips, mealy bug, whitefly, root mealy bug and leaf webber. During varying seasons, these pests used to cause 10% - 25% leaf yield loss. Though several chemical pesticides were recommended for their control, due to deleterious effects on environment and residual problems associated with chemical pesticides, efforts were made by the present investigators to find out alternative management measures, which are eco-friendly on silkworm as well as on the environment. Further, in many parts of eastern and north-eastern India, surface water is the only source of drinking water and many states are gradually restraining the use of chemical pesticides.

Preliminary works undertaken in this institute, includes recording of 4 Coccinellid predators on thrips, 17 Coccinellid predators and 5 Hymenopteran parasitoids on mealy bug, and 4 Coccinellid predators on whitefly, 2 Hymenopteran parasitoids each on whitefly and leaf webber.

In the present study, it is proposed to study the population interactions of mulberry pests and their natural enemies by recording fortnightly incidence of pests and their natural enemies, their population will be correlated with each other and abiotic factors, the host range of major pests and their natural enemies will be studied, migration of the natural enemies during the non-availability of the host and host plant, migration of the pest when host plantation is not available due to pruning, life stages of the pests & predators that will be striving the unfavorable conditions like severe cold and severe hot, biology and feeding efficiency / parasitization ability of the natural enemies will be studied. The vision of this project proposal is to provide basic information on tritrophic interactions behavioral aspects of the major pests of mulberry along with their incidence pattern of their natural enemies. Life table studies will be undertaken for the selected natural enemies.

The eastern and north-eastern parts of India, especially the gangetic plains of West Bengal harbor rich fauna of coccinellid predators, which can be effectively utilized for the management of the major pests of mulberry. The thrust area in XII plan is development of bio-safety and bio-control related strategic technologies. New long-term research policy adopted by Central Silk Board (dtd 26-3-2010) also emphasizes the reduced use of pesticides and enhanced use of biological control agents. Hence the proposed study on tritrophic interactions, in the mulberry ecosystems of eastern and north-eastern India becomes the need of the hour to screen the promising predator/ parasitoid for future augmentation and success in biological control programs.

PART II: PARTICULARS OF INVESTIGATORS

(*One or more co-investigators are preferred in every project. Inclusion of co-investigator(s) is mandatory for investigators retiring before completion of the project*)

13	Name: Date of birth Sex Indicate whether Principal Investigator / Co-investigator Designation Department Institute / University: Address		Mrs. Lalitha.N 26.11.1976 Female Principal Investigator Scientist C, Entomology CSR&TI, Berhampore
	Name: Date of birth Sex Indicate whether Principal Investigator / Co-investigator Designation Department Institute / University: Address		Dr. Manne Venkata Santha Kumar 01-07-1964 Male Co-Investigator Scientist D, Entomology CSR&TI,Berhampore
	Name: Date of birth Sex Indicate whether Principal Investigator / Co-investigator Designation Department Institute / University: Address		Dr. Atul Kumar Saha 27.08.1957 Male Co-Investigator Scientist D, Head, Sericulture Division CSR&TI,Berhampore
	Name: Date of birth Sex Indicate whether Principal Investigator / Co-investigator Designation Department Institute / University: Address		Mr. Debojit Das 20.09.1963 Male Co-Investigator Scientist C, Extension CSR&TI,Berhampore
	Name: Date of birth Sex Indicate whether Principal Investigator / Co-investigator Designation Department Institute / University: Address		Dr. Yumnam Debraj 01-03-1964 Male Co-Investigator Scientist D, Entomology RSRS, Jorhat, Assam
	Name: Date of birth Sex Indicate whether Principal Investigator / Co-investigator Designation Department Institute / University: Address		Mr. Sudeb Chatterjee, 22.11.1956 Male Co-Investigator Scientist C, Entomology RSRS, Kalimpong, West Bengal

14.	No. of Projects being handled by each investigator at present: 1. Mrs. Lalitha.N 2. Dr. Manne Venkata Santha Kumar 3. Dr.A.K.Saha 4. Mr. Debojit Das 5. Dr. Yumnam Debraj 6. Mr. Sudeb Chatterjee		 3 3 12 2 2 2
15	Proposed Research fellows		1

PART III: TECHNICAL DETAILS OF PROJECT

16. Introduction (not to exceed 2 pages or 1000 words)

Mulberry eco - system of Eastern and North-eastern India is invaded by variety of polyphagus pests due to which crop losses are being recorded up to 25%. During outbreaks of these pests, due to non-availability of quality mulberry leaves farmers used to suffer total loss of silkworm crops. Chemical control measure is always not feasible, due to fixed silkworm crop schedule, which limits the time to spray and comply the safe periods for leaf harvest.

16.1 Origin of the proposal

A wide range of biological control agents comprising of parasitoids and predators are also associated with mulberry eco-system. The thrust area in XII plan is development of bio-safety and bio-control related strategic technologies for the management of pests. Even the new long term research policy adopted by central silk board (26-3-2010) also emphasizes the reduced use of pesticides and enhanced use of biological control agents. For effective implementation of biological control practices, thorough information on the ecology of biological control agents and their main and alternative hosts and their host plants has to be generated along with basic information on biology, feeding efficiency / parasitizing ability and intrinsic rate of multiplication of natural enemies. Studies on interaction of natural enemy complex to influence herbivore (pest) populations are of vital importance for both population ecology and integrated pest management.

16.2 Rationale of the study

Indiscriminate use of pesticides has made the crop ecosystem free of natural enemies, in turn affecting the tritrophic interaction (Host, pest and parasitoid). Importance of biological control and conservation of natural enemies is emphasized to obtain natural balance in the ecosystem and reach sustainability. Predator / parasitoid species sharing the same resource may

also influence each other's survival and offspring production. Such interactions may affect the survival of the shared prey species to a greater extent. This kind of interaction has not been studied so far in mulberry eco-system and it has wide applicability in devising augmentative bio control programs for suppressing pest populations. The present study is aimed to determine:
1) The species composition of insect predators and parasitoids associated with the life stages of the major pests. 2) The impact of the predators and parasitoids on pest populations. 3) How the predators and parasitoids influence each other in terms of reproductive success and 4) The consequences on the pests due to possible interaction between the predators and parasitoids.

Further, basic information on determination of host range of pests and their natural enemies, migration of pests and their natural enemies during the non-availability of the host and host plant, migration of the pest when host plantation is not available due to pruning, life stages of the pests and natural enemies that will be striving the unfavourable conditions (severe cold / hot/ humid) and biology of natural enemies and their feeding efficacy / parasitizing ability shall be generated. All this information will be integrated in formulating augmentative biological control programmes

16.3 Relevance to the current issues and expected outcome:

Population interaction study to elucidate tritrophic relationships of pests and natural enemies in mulberry eco-system could go a long way in effectively integrating the biological control tactics sustainably in the IPM practices. Studies on biology, feeding efficiency/ parasitization ability can facilitate screening of promising predator/parasitoid for future mass multiplication and augmentation. Further life table studies can predict the key natural factors responsible for causing fluctuations in the populations of natural enemies and depict the general magnitude of its potential of multiplication when given a chance in the ideal mulberry ecosystem.

16.4 OBJECTIVES

- To study the population interactions of host plant, major mulberry pests and their natural enemies and correlation with abiotic factors.
- Studies on the biological attributes of the natural enemies
- Life table studies of the promising natural enemy complex (predator/parasitoid) of the major mulberry pests

16.5 Current status of research and development in the subject (both international and national status):

International Status:

- Popularization of other biological control agents through mass production in other agricultural crops has already been established and they are more responsible for practical biological control in several countries.
- It is reported that in China several species of *Trichogramma* are mass produced in the communes of various provinces and released extensively for control of European corn borer, pine caterpillars, rice leaf roller, sugarcane borers and other Lepidoptera infesting cotton. On cotton alone, the parasite has been released in some 680,000 hectares annually and obtained best control (Huffaker, 1976).
- Similar reports on augmentation of natural enemies are also available from other countries;170 million *Encarsia* are being released annually for control of whiteflies on cucumbers in glasshouses in Britain and Netherlands; 32 million *Opius* against Olive flies in Sicily and over 4 million *Lixophaga* against sugarcane borers in Cuba (Ridgway *et al*, 1977).
- A cooperative classical biological control project against the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green), infestation in the low-desert region of California was initiated in the fall of 1999 (Anonymous 1999, 2005). Subsequently, the parasitoids *Anagyrus kamali* Moursi (Encyrtidae), *Gyranusoidea indica* Shafee, Alam & Agarwal (Encyrtidae) and *Allotropa* sp. nr. *mecrida* (Walker) (Platygastridae) were reared and released for permanent establishment. Population densities of mealybug and percent parasitism were monitored at a number of mulberry and carob tree sites for five consecutive years. The population density of *M. hirsutus* within the first year was reduced by approximately 95%. Over the entire 5-year period of the project, the average regional population density of the mealy bug exhibited a continued decline.

National Status :

At Central Sericultural Research & Training Institute, Berhampore the following studies were conducted for the biological suppression of mulberry pests.

Mealy bug:
On Mealy bug, *Maconellicoccus hirsustus* (Green) (Hemiptera: Pseudococcidae) the following native predators (Coleoptera : Coccinellidae) were recorded :

- *Scymnus* (*Pullus*) *bourdilloni* Kapur (Santha Kumar *et al*., 1997), *Scymnus nubilus* Mulsant (Santha Kumar, 1995), *Scymnus coccivora* Aiyar (Santha Kumar and Chakrabarti, 1995), *Scymnus brunnescens* Mots., *Scymnus fuscatus* Bohem, *Scymnus apiciflavus*,Mots., *Scymnus pallidicolli* (Mulsant), *Scymnus pyrocheilus* Mulsant, *Scymnus ceylonicus* (Mots.), *Scymnus quadrillus* (Mots.), *Pharoscymnus* sp., *Brumoides suturalis* (Fabricius), *Nephus sp.* near roepkei, *Nephus* sp. (Chakraborty, 1999), *Nephus tagiapatus* (Kamiya), *Stethorus indira* Kapur, *Stethorus tetranychi* Kapur.

- Among these predators biology, feeding efficacy and field efficacy of *Scymnus* (*Pullus*) *bourdilloni* were studied (Santha Kumar *et al*., 1997& 2000), biology and feeding efficacy of *Scymnus nubilus (*Santha Kumar *et al., 1996), Nephus* sp.(Santha *Kumar et*

al., 1995), *Scymnus pallidicolli* and *Brumoides suturalis* (Santha Kumar *et al*., 2000) were studied. Further, field efficacy of an exotic predator *Cryptolaemus montrouzieri* Mulsant was studied (Chakraborty, 1996).

- In addition to the above, the following Hymenopteran parasitoids were also recorded on mealy bug: *Coccidoxenoides peregrinus* (Timberlake), *Leptomastix dactylopii, Anagyrus kamali, Prochiloneurus sp. Near nigriflagellum Girault (*Hymenoptera : Encyrtidae) and *Meteorus sp*.(Hymenoptera: Braconidae).

Thrips:

On thrips, *Pseudodendrothrips mori* (Niwa), the following predators were recorded : *Micraspis discolor* (Fabricius), *Micraspis crocea* (Fabricius) and *Brumoides suturalis* (Fabricius) (Coleoptera : Coccinellidae). The biology and feeding efficacy studies of *Micraspis discolor* on thrips were carried out by Prasad *et al*., (1995).

Whitefly:

- On two species of whitefly, *Dialeuropora decempuncta* (Quaintance & Baker) and *Aleuroclava pentatuberculata* (David & Sundar Raj) (Homoptera : Aleyrodidae), the following native predators were recorded. Viz., *Micraspis discolor* (Fabricius), *Micraspis crocea* (Fabricius), *Brumoides suturalis* (Fabricius). Among them the biology and feeding efficacy of *Micraspis discolor* (Santha Kumar *et al*., 2001) and biology, feeding efficacy and field efficacy of *Brumoides suturalis* (Bandyopadhyay, 2010) were worked out.
- Further two parasitoids viz., *Eretmocerus adustiscutum* Krishnan & David and *Encarsia levo* Hayat (Hymenoptera : Chalcidoidea) were found to parasitize both species of whitefly. Among these two, the later one was described for the first time from the collections of this Institute by Prof. Md. Hayat, Aligarh Muslim University, Aligarh and published in Oriental Insects, 2005.

At Regional Sericultural Research Station, Kalimpong, West Bengal the major pests are Root mealy bug, *Paraputo sp.*, Leaf webber, *Glyphodes pyloalis* Walker and Stem borer, *Apriona* sp and the minor pest that is gaining importance in recent times is scale insect, *Saissetia nigra.* On Scale insect, the following predators (Coleoptera : Coccinellidae) were recorded viz., *Oenopia kirbyi* Mulsant, *Chilocorus rubidus* Hope, *Chilocorus circumdatus* Sch., *Crypotogonus postmedialis* Kapur, *Crypotogonus bimaculatus* Kapur, and *Crypotogonus quadriguttatus* Weise. In addition to the above, on leaf webber, *Glyphodes pyloalis* four Hymenopteran parasitoids belonging to family Braconidae were recorded.

At Regional Sericultural Research Station, Jorhat, Assam, the major pests are Thrips, Mealy bug and Whitefly. On two species of whitefly viz., *Dialeuropora decempuncta* (Quaintance & Baker) and *Aleuroclava pentatuberculata* (David & Sundar Raj) (Homoptera : Aleyrodidae), the following native predators were recorded viz., *Micraspis discolor* Fabricius, *Coelophora unicolor, Scymnus posticaulis* (Coleoptera : Coccinellidae). Biology and feeding efficacy of *C.unicolor* and *S.posticaulis* were worked out.

At Central Sericultural Research and Training Institute, Mysore the following studies were conducted for the biological suppression of mulberry pests:

- Mass multiplication technique for production of *Cryptolaemus montrouzieri* Mulsant (Coleoptera : Coccinellidae) was developed with a cost production of Rs. 40 per 100 beetles, the field efficacy studies on biological control of mealy bug revealed that

release of *Cryptolaemus montrouzieri* @ 125 beetles/ acre in 36 holdings and *Scymnus Coccivora* @ 250 beetles/ acre in 21 days. As a result, mealy bug infestation was suppressed by 63.72% in the treated gardens (Ramkishore *et al*., 1993, 1997).

- *Anagyrus kamali* Moursi (Hymenoptera : Encyrtidae), a solitary parasitoid of mealy bug, when released @ 2000 adults/acre parasitized 69.1% population of mealy bug and *Scymnus coccivora* @ 550 adults / acre suppressed tukra infestation by 82.93% in the field (Manjunath *et al.*, 1996).
- The management of Bihar hairy caterpillar by release of pupal parasitoid, *Tetrastichus howardii* (@ 50, 000 adults/ha) and release of egg parasitoid, *Trichogramma chilonis* (@ one trichocard / week) is recommended (Manjunath *et al.*, 2005, Pradeep kumar *et al.*, 1995)
- Katiyar (1999) studied the role of *Trichogramma chilonis* (Hymenoptera : Trichogrammatidae) in the suppression of field population of Bihar hairy Caterpillar in mulberry. Katiyar (2000) studied the biology and field efficacy of *Meteorus dichomeridis* (Wilkinson) (Hymenoptera : Braconidae) - a larval endo-parasitoid of Bihar hairy caterpillar, *Spilosoma obliqua.*
- Chrysopids, *Chrysoperla carnea* and *Mallada boninensis* (Neuroptera : Chrysopidae) are generalist predators and effectively used in the management practices of mealy bug and leaf roller. The chrysopids feed on eggs, nymphs and young caterpillars (Narendra Kumar *et al*., 2011).
- Narendra Kumar *et al*., 2011 and Shylesha *et al*., 2012, have detailed a comprehensive method for mass production *Acerophagus papayae*, a parasitoid of exotic pest, papaya mealy bug, *Paracoccus marginatus* in mulberry.

In Jammu & Kashmir, Punjab & Dehradun the following species of Hymenopteran parasitoids were observed to parasitize larvae of leaf webber, *G. pyloalis* in mulberry eco-system. The parasitoids were *Apanteles oblique* Wilkinson (Family : Braconidae), *Bracon hebtor* (Famiy : Braconidae) (Khan *et al*., 1995), *Auleacocmtrum brues*, *Cedria paradoxa* (Punjab & Dehradun) (Mathur, 1980), *Chelonus tabonus* and *Ichneumonid* sp. (Ichneumonidae) (Anonymous, 2008).

- The Convention on Biological diversity recognizes the risk posed by alien species and requests contracting parties to "Prevent the introduction, control or eradicate those alien species which threaten ecosystems, habitats or species (Article 8.h)".

- The Project Directorate of Biological Control, ICAR, Bangalore, had anticipated such development much before this recommendation was made. Since inception, 82 exotic natural enemies (NEs) have been studied for utilization against alien pests. Fifty- Six NEs could be successfully multiplied in the laboratory. Fifty species have been recovered from the fields out of which eight have permanently established providing recurring economic benefits worth millions of rupees in addition to environment protection and enhancement of biodiversity. At least twelve of the exotic natural enemies are augmented the same way as indigenous NEs are used to get maximum benefits.

- The encyrtid nymphal parasitoid, *Laptomastix dactylopii* introduced from the West Indies in 1983 has successfully established on the common mealybug, *Planococcus citri* infesting citrus and many other crops in south India. Insecticidal sprays are not necessary.

- The exotic natural enemies which have proved effective through augmentation include egg parasitoid, *Telenomus remus* **(Origin**: New Guinea) against *Spodoptera litura*

infesting tobacco, 6 species of *Trichogramma* egg parasitoids, viz *T. brasiliense* (Origin: USA) and *T. pretiosum* (Origin: USA) against *Helicoverpa armigera* infesting tomatoes; *T. japoninicum* (Origin: Japan) against *Scirpophaga incertulas & Cnaphalocrocis medinalis* on rice; *Trychogrammatoidea eldanae* (Origin: West Indies) against sugarcane tissue borers; *T. embryophagum* (Origin: Russia) against *Cydia pomonella* infesting apple and *Trichogrammatoidea bactrae* (Origin: Taiwan) against *Plutella xylostella* infesting cruciferous crops; the egg larval parasitoids *Chelonus blackburni* (Origin: Hawaii) and *Codosoma koehlei* (Origin: Australia) against several species of mealy bugs and sac forming scale insects of citrus , guava, grapes, mango, custard apple, brinjal, crotons, etc.; predatory mite, *Phytoseiulus persimilis* (Origin : England) against spider mites on vegetables and strawberries and entomophilic nematode *Steinernema carpocapsae* (Origin : East Europe) against cutworms, tissue borers, sawfly, etc. in humid ecosystems.

- Three parasitoids – two bethylids (*Cephalonomia stephanoderis* and *Prorops nasuta*) and one eulophid (*Phymasitichus coffea*) – introduced against coffee berry borer, *Hypothenemus hampei*. Of these, only C. *stephanoderis* was established.
- Two aphelinid parasitoids of South American origin, *viz., Encarsia guadeloupae* and *E. sp. nr. meritoria* fortuitously got introduced against the spiraling whitefly, *Aleurodicus disperses. E. guadeloupae* has competitively displaced *E. sp. nr. meritoria* in several parts of peninsular India.

- *Trichogramma sp. nr.mwanzai* from Kenya for evaluation against *(Helicoverpa armigera)* and *Eriborus trochanteratus* (adapted to *Opisina arenosella* from Sri Lanka) were introduced.

- *Trichogramma mwanzai* introduced as a potential candidate against *Helicoverpa armigera.*

- The gall fly, *Cecidochares connexa,* introduced from Indonesia for trials against the Siam weed, *Chromolaena odorata,* did not attack 78 species of plants in host-specificity tests. Limited field releases of the stem gall fly at the UAS, Bangalore, resulted in significant decrease in several plant growth parameters.

Basic Research :-

- Survey for natural enemies of key crop pests has been conducted and the list of predators, parasitoids and pathogens compiled at Project Directorate of Biological Control (PDBC).

- Multiplication techniques for 46 host insects have been standardized including rearing on semi synthetic diet. The cost of production has also been worked out.

- Improved laboratory techniques have been worked out for the multiplication of twenty-six egg parasitoids, six egg larval parasitoids, Thirty- nine larval nymphal parasitoids thirty-three predators and seven species of weed insects.

- Mealy bug, aphid and scale insect predators *Cryptolaemus montrouzieri, Cheilomenes sexmaculata, Coccinella septempunctata* and *Chilocorus nigrita* were successfully mass produced on a semi-synthetic diet.

- Successfully developed semi-synthetic diets for chrysopids, *Orius tantillus*, *Cryptolaemus montrouzieri* and *Cheilomenes sexmaculata*, which supported their development.

- The optimum host and parasitoid ratio for the multiplication of different parasitoids has been worked out.

- The bioecology of the important parasitoids *Alltropa japonica, Blepyrus insularis, Coccidoxenoides peregrina, Hyposoter didymator, Cotesia Kazak, Copidosoma desantisi, C. koehleri,* and *predators chilocorusbijugus, mallada astur, Chrysoperla carna, Cheilomenes sexmaculata, Curinus coeruleus, Cryptolaemus montrouzieri, Metasyrphus confrater,* etc.has been studied. Feeding potential studies on these predators proved their promise.

- Suitable low temperatures for short term storage of trichogrammatids, *Sticholotis madagassa. Eucelatoria bryani, Carcelia illota, Allorhogas pyralophagus, Copidosoma koehleri, Hyposoter didymator, Cotesia marginiventris, Leptomastix dactylopii, Sturmiopsis inferens, Pareuchaetus pseudoinsulata,* etc. have been determined. Storage and shipment techniques for *Telenomus remus* were standardized.

- Superior geographical strains of *Campoletis chlorideae* and *Trichogramma chilonis* Bio C1, Bio C2, and Bio C6, (for cocoon bollworms), BioSc1 (for sugarcane borers) and BioH1 (for tomato fruit borer) have been determined.
- An endosulphan – tolerant strain of *Trichogramma chilonis* (Endogram) developed for the first time in the world. Technology transferred to private sector for large- scale production. So far, 24000 ha. Of cotton and vegetables have been protected by this technology in 6 states.
- Developed multiple insecticide tolerant strain of *T. chilonis* , high temperature tolerant strains of *T. chilonis* and *T. japonica, T. achaeae and Tr. Bactrae*. The genetical and biochemical mechanisms of resistance of various strains have been established.
- Studied the biochemical profile of host and artificial diet and studied electrophoretic pattern of diet reared predators and tolerant strains.
- Optimum host parasitoid ratios (dosages) standardized for utilization of *Telenomus remus* and *Trichogramma chilonis* against *S. litura* and *H. armigera*, respectively on soybean. *T. remus* was also evaluated against *S. litura* eggs on castor, rose, tobacco, *Bt* and non-*Bt cotton*.
- A website on the Coccinellidae of the Indian region featuring image galleries of common species and their natural enemies has been constructed and hosted. Identification guide to 125 species of coccinellids commonly found in the agro ecosystems of the Indian subcontinent has been prepared.
- Tritrophic relationships between natural enemies, their hosts and host plants have been determined. *Hyposoter didymator* and *Telenomus remus* preferred to parasitize *Spodoptera litura* larvae and eggs, respectively on castor and beet root. *Cotesia Kazak* preferred host plants like tomato, cotton and okra, while *Cotesia marginiventris* preferred knol khol, castor and cowpea. *Diadegama semiclausum* preferred to parasitize, *P.xylostella* on cabbage and cauliflower to that on rapeseed.
- Tritrophic interaction studies between egg parasitoid, *T.chilonis*, bollworm, *H.armigera* and cotton, chickpea, pigeonpea, sunflower and tomato genotypes helped in identifying biocontrol friendly genotypes.

Biological Suppression of Crop pests:-

- **Sugarcane:-**Tissue borers:- The inundative release of egg parasitoids, *Trichogramma chilonis*, *T. japonicum* and *Telenomus gignoides*, larval parasitoids, *Cotesia flavipes*, *Glyptomorpha nicevillei* and *Isotima javensis* has proved effective in suppressing the population of sugarcane tissue borers. Sugarcane wooly aphid:- Spectacular success has been achieved in the biological control of the sugarcane woolly aphid by the deployment and conservation of two predators viz., *Dipha aphidivora* and *Micromes igorotusin* the states of Maharashtra, Karnataka and Tamilnadu. The parasitoid *Encarsia flavoseutellus* is established well in Karnataka and parasitizing to an extent of about 30 percent.
- **Cotton:-** Biointensive Integrated Pest Management (BIPM) modules for cotton crop have been formulated in Ludhiana, Coimbatore, Anand comprising of releases of *Chrysoperla carnea* and need based insecticide sprays against sucking pests and *Spodoptera litura* in comparison with the farmers' package of practices(FPP) for Bt and non-Bt cotton was found better in Tamil Nadu. Bt cotton under BIPM and FPP performed better against bollworm, increased seed cotton yield and natural enemy population than non-Bt cotton. Pesticide-tolerant *Trichogramma* was more effective against bollworms in multilocation trials.
- **Rice:** Stem borer:- Bio-control based IPM modules involving trichogrammatid releases for the control of stem borer and leaf folder of rice were found better than insecticide schedules. The release of *Trichogramma japonicum* against stem borer, *Scripophaga incertuals* has given good results in Assam and Tamil Nadu. Indigenous natural enemies, *Telenomus dignoides*, *T. rowani*, *Tetrastichus schoenobii* and others were conserved. Inundative release of *Cyrtorhinus lividipennis* has proved effective. Rice leaf folder:- Release of *Trichogramma japonicum* is effective in suppressing *Cnaphalocrocis medinalis* also.
- **Groundnut:-** Release of *Cheilomenes sexmaculata* has been recommended for the control of *Aphis craccivora*.

Temperate fruits :-

- **San Jose Scale on Apple:-** *Encarsia perniciosi* is well established against San Jose scale on apple. Besides, *Aphytis proclia*, *Chilocorus bijugus*, *Pharscymnus flexibilis* and *Cybocephalus* sp. also play an important role in the population suppression of this pest in Jammu & Kashmir and Himachal Pradesh.
- **Apple wooly aphid:-** In Himachal Pradesh, heavy parasitization of woolly aphid was due to *Aphelinus mali*. Several Coccinellid predators viz., *Coccinella septempunctata* and *Hippodamia variegate* also played important role in regulating its population.

Tropical fruits :-

- **Mealy bugs in grapes, guava and mango :-** *Cryptolaemus montrouzieri* gave effective suppression of *Planococcus citri* on citrus and grapevine, *Chloropulvinaria psidii*, *Ferrisia virgata, Maconellicoccus hirsustus*, and *Rastococcus iceryoides* on guava, grapes and mango. *Leptomastix dactylopii* was also effective on *P.citri*. Effectiveness of *C.montrouzieri* against mealy bugs on grapevine and *Encarsia guadeloupae* against spiralling whitefly on guava was demonstrated in farmers' fields in Karnataka.
- **Spiralling whiteflies in guava :-** Maximum parasitism of spiraling whitefly on guava by *Encarsia spp.* Observed during February, 2005 (KAU). *Encarsia guadeloupae* was recovered in guava orchards in Maharashtra two months after release, indicating its establishment.

Pomegranate:-

- **Fruit borer:-** Eggs of pomegranate fruit borer, *Deudorix isocrates* were heavily parasitized by three species of egg parasitoids.
- **Sucking pests:-** On pomegranate, *Encarsia inaron* could check the whitefly population and indigenous natural enemies could check the population of *Aphis punicae*.

Vegetable crops:-

- **Diamond black moth of cabbage:-** In Karnataka, *Cotesia plutellae* and *Oomyza sokolowskii* were effective parasitoids of the diamond black moth on cabbage. Coccinellides and syrphid predators could suppress aphids. *Epilachna* beetle could be suppressed by *Pediobius foveolatus*. At Solan, *Pieris brassicae* was suppressed by *Hyposoter ebeninus* and *Cotesia glomerata*. *Trichogrammotoidea bactrae* and sporeless mutants of Bt were found effective against *Plutella xylostella* in protecting cabbage and cauliflower. The entomofungus, *Verticillium lecanii* could cause high mortality of *P. xylostella*.

Demonstrations in Biological Control:- Project Directorate of Biological Control conducted demonstration of the impact of generalist parasitoid, *Trichogramma* and generalist predator, *Chrysoperla carnea*. The impact of these biological control agents has been demonstrated in 1737 ha area under sugarcane, maize, sorghum, rice, tomato and cotton.

In India, the departments of Agriculture and Horticulture of certain state governments and others have operated parasitoid breeding laboratories where a few selected parasitoids of sugarcane borers, coconut black- headed caterpillar etc. were multiplied and distributed. However, the numbers produced in these laboratories are insignificant compared to the total requirement. Hence, efforts have to be made for exploring the region specific potential biological control agents so as to manage the wide range of polyphagus pests.

16.3 Importance of the proposed project in the context of current status

Mulberry eco - system of Eastern and North-eastern India is invaded by variety of polyphagus pests due to which crop losses are being recorded up to 25%. During outbreaks of these pests, due to non-availability of quality mulberry leaves farmers used to suffer total loss of silkworm crops. Pest management by chemical means, is always not feasible, due to fixed silkworm crop schedule, which leaves a very little time for spray and to overcome their safe periods. Under these circumstances, the focus is being made on the biological pest suppression**.** A wide range of biological control agents comprising of parasitoids and predators are also associated with them. The thrust area in XII plan is development of bio-safety and bio-control related strategic technologies for the management of pests. The long term research policy adopted by central silk board (26-3-2010) also emphasizes the reduced use of pesticides and enhanced use of biological control agents. For effective implementation of biological control practices, thorough information on the ecology of biological control agents and their main and alternative hosts and their host plants has to be generated along with basic information on biology, feeding efficiency, multiplication rate of natural enemies.

16.4. Anticipated products, processes/technology packages, information or other outcome from the project and their expected utility:

The present study is aimed at to generate information on the tritrophic interaction between host plant, pests and natural enemies and how the multiple natural enemies (biocontrol agents) does collectively impose mortality of the pests in mulberry ecosystem. The project envisaged generating vital information on the incidence pattern of natural enemies on major mulberry pests and their correlation with abiotic factors. Further, basic information on determination of host range of pests and their natural enemies, migration of pests and their natural enemies during the non-availability of the host and host plant, migration of the pest when host plantation is not available due to pruning, life stages of the pests and natural enemies that will be striving the unfavourable conditions (severe cold / hot/ humid) and biology of natural enemies and their feeding efficiency / parasitizing ability shall be generated. All this information will be integrated in formulating augmentative biological control programmes.

16.5. Expertise available with proposed investigation group/ institution on the subject of the project:

Adequate expertise is available with proposed investigation group for carrying out the proposed project.

Name of the Scientists	Designation	Experience
Mrs. N.Lalitha	Sc.C	Having competence in agricultural entomology and adequate knowledge and experience in the area of the proposed project
Dr. M.V. Santha Kumar	Sc-D	Has been working since 25 years for Integrated management of major pests of mulberry with special emphasis on biological and botanical means. He has carried out 9 research projects pertaining to various aspects of Integrated pest Management.
Mr. Debojit Das	Sc-C	Having competence in agricultural entomology and adequate knowledge and experience in the area of the proposed project
Dr. Yumnam Debraj	Sc-D	Having competence in agricultural entomology and adequate knowledge and experience in the area of the proposed project
Mr. Sudeb Chatterjee	Sc-C	Having adequate knowledge and experience in the area of the proposed project

Name and address of 5 experts in the field

Sl. No.	Name	Designation	Address
1.	Dr. K.C. Narayanaswamy	Professor	Department of Sericulture University of Agricultural Sciences, GKVK, Bangalore
2.	Dr.T.V.Sathe	Professor	Department of Zoology, Shivaji University, Kolhapur, MS.Pin.: 416 004.
3.	Dr. U. Sreedhar	Principal scientist	Head, Division of Entomology, Central

			Tobacco Research Institute, ICAR, Rajahmundry, Andhra Pradesh
4.	Dr. M. Mani	Principal Scientist	Head,Indian Institute of Horticultural Research, Hessaraghatta Lake post, Bangalore.
5.	Dr. S.K. Jalali,	Principal Scientist	NBAII (ICAR), Bellary Road, Bangalore - 560 024.
6.	Dr. CR. Ballal	Principal Scientist (Head – Entomology)	NBAII, (ICAR), Bellary Road, Bangalore - 560 024.

17. Work Plan:

17.1 Work plan (methodology/experimental design to accomplish the stated aim)
Methodology:

E01.Tritrophic interactions between host plant, pests and natural enemy complex.

1. This study will be conducted in the mulberry fields of Central Sericultural Research & Training Institute, Berhampore, Farmers' fields of Murshidabad dt., Nadia dt., Birbhum and Malda dt., Regional Sericultural Research Station, Kalimpong and Jorhat.

2. The seasonal incidence of major mulberry pests viz., thrips, mealy bug, whitefly, bihar hairy caterpillar, root mealy bug, leaf webber and stem borer will be studied along with their natural enemies at fortnightly intervals. The data will be correlated with meteorological factors. The life stages of the pests will be collected from the field and screened in the laboratory for the emergence of parasitoids & predators. (Sathe, 1986 a&b, Sathe, 1987a, Sathe *et al*., 1987)

3. The collected and emerged natural enemies will be duly identified either from our own collection or from the experts based at Zoological Survey of India, Kolkata, National Bureau of Agriculturally Important Insects, Bangalore, Prof. Md. Hayat, Aligarh etc.

4. As the above-mentioned pests are polyphagus and most of the natural enemies are generalist in nature their incidence will also be recorded from the alternate host plants / agricultural crops adjoining the mulberry eco-system. The alternate hosts of natural enemies on other agricultural crops will be recorded and duly identified.

5. Determination of host range of pests and their natural enemies, migration of pests and their natural enemies during the non-availability of the host plant due to pruning, life stages of the pests and predators that strive during the unfavourable conditions will be recorded.

6. During the study, host preference, host specificity, host range of the pests and their natural enemy complex, migration of the pest when host plantation is pruned, life stages of the pests & predators that will be striving the unfavorable conditions like severe cold and severe hot conditions (Lewis & Vinson, 1971, Hopper & King, 1984, Jackson *et al*., 1979, Salt, 1935, Sathe, T.V., 1985 1987 &1988, Sathe *et al*., 1987, Sathe & Santha Kumar, 1992).

EO2:- Studies on the biological attributes of the natural enemies

Methodology:-

1. Studying the biology of predators/ parasitioids including their life cycle, biometry, longevity, mating, oviposition, feeding efficiency/ parasitization ability & parasitization behaviour will be done by following established procedures (Cardona & Oatman, 1971, Nikam & Sathe, 1981, Oatman *et al*., 1969, Sathe, 1984, 1986 b 1987a, b, c ,d,1988 a,& b & 1990a & b, Sathe & Nikam, 1985 & 1986, Sathe & Santha Kumar, 1988, 1989 a, b & 1992 Sathe *et al*., 1987,1988, 1989).
2. Host cultures will be established in the laboratory.
3. After mating, the gravid females will be released on the host colonies to facilitate oviposition. The eggs will be separated from host colonies and will be kept individually in cavity blocks for hatching. During the egg stage biometry and incubation period will be recorded. During the grub stage longevity of each instar and their biometry will be recorded. The biometry of pupa and its duration will be recorded. All observations will be made on 10 replications individually kept in cavity blocks.
4. The adults biometry and longevity will be recorded by providing cotton swab dipped in 50% honey solution. Newly emerged males and females (10 replications) will be kept individually in plastic containers and their longevity will be studied.
5. Pre-mating, mating and post- mating periods of both males and females will be recorded.
6. For conducting fecundity studies, after completion of pre- mating, pairs of the predators will be released in a plastic vial containing egg masses of hosts. Daily observations will be made on the number of eggs laid and fresh egg masses will be provided till the completion of oviposition period. Further, pre-ovipositional, ovipositional and post-ovipositional periods will be determined.
7. These studies will be conducted by following the methodology suggested by Santha Kumar *et al*., (1994, 1995 1997a, 1997b), Mani, M. & Thontadarya, T.S. (1987 a &b and 1988).
8. Newly hatched grubs/larvae/ nymphs will be kept individually in cavity blocks.
9. Known number of mealy bug eggs will be provided to each immature stage. After 24 hours, observations have to be made on the number of life stages (host) consumed and accordingly fresh eggs have to be provided. The observations will continue till the grubs/larvae/ nymphs enter in to pupal/ adult stage. Observations will be made on 10 replications.
10. Similarly nymphal stages of mealy bug will be provided to record the consumption of mealy bug nymphs by individual grubs/larvae/ nymphs. Observations will be made on ten replications.
11. For recording the feeding efficacy of males and females, eggs and nymphs of mealybug have to be provided separately till the death of the predator by maintaining 10 replications.
12. The studies will be conducted as per the methodology laid by Mani & Thontadarya (1987, 2008) Santha Kumar *et al*., 1994 and Santha Kumar and Chakravorty 1997).

Key words: Mulberry pests, natural enemies, population interactions, abiotic factors, correlation, ecology, Host range, host preference, host specificity, biology, feeding efficiency, parasitizing ability

EO3:- Life table studies of natural enemies

1. Determining the key natural factors responsible for causing fluctuations in the populations of promising natural enemies in the mulberry ecosystem (Birch,1948; 1953, Southwood, 1968, Atwal and Bains, 1974, Yazdani and Agarwal, 1997). Life tables give the most comprehensive description of the age specific survival rates of the predator/ parasitoid populations and forms an important basis for quantitative and qualitative study of population growth.
2. Temperature dependent complete life tables for the promising natural enemies are built by partitioning its life cycle into distinct development stage (eggs, larvae, pupae and adults) (Messanger, 1964, Sathe,1987 b, Dhandapani *et al*., 1985 Rajadurai *et. al*.,2002, Yazdani and Samih, 2012)
3. According to available information and experience establishment of an effective insect predator/ parasitoid rearing facility to deliver sufficient off- springs (eggs) for the study.
4. The total duration of the immature stages (cohort) of the predator/ parasitoid from egg to adult eclosion stage will be recorded in different temperature conditions (10°C - 45°C) as manipulated in the growth chamber. The relative humidity is optimized to the requirements of the insect species and will be kept at a range between 60 to 80%. The temperatures inside the incubators were regularly monitored using a temperature data logger or other kind of standard min.-max. thermometer.
5. On the day of emergence, adults are identified by sex and grouped at a species-specific sex ratio for mating at the required temperature. Individualize a couple of parasitoid/ predator and provide them daily with an adequate number of host stages on a suitable growth media. Replace host stages daily until the death of the female. Provide optimal conditions for predation/ parasitism including the provision of adequate feed (e.g., 5% sugar solution). Record in daily intervals: the number and sex of progeny development and survival time of individual female and males
6. The lower and upper threshold of temperature for survival of predators/ parasitoids will be determined.
7. Survivorship curve and mortality curves will be drawn based on the key determining factors as studied.
8. Observations will be made under stereomicroscope with a good source of light.

17.2: Organization of work elements:

Name	Designation	Time	Work to be done
Dr. S. Nirmal Kumar, Executive Authority	Director		Over all coordination, guidance & periodical review of progress made.
Dr. A. K. Saha, Co-Investigator	Scientist- D	5%	Coordination and guidance
Mrs. N. Lalitha Principal Investigator	Scientist- C	25%	Data collection, Biology and Life table studies of predator and parasitoids directly associated with E 01, E 02 and E 03, compilation and interpretation of data, submission of report time to time and final report preparation.
Dr. M.V. Santha Kumar Co-Investigator	Scientist - D	15%	Data collection, tritrophic interaction studies of predator and parasitoids. Associated with E 01, E 02 and E 03
Mr. Debojit Das, Co-Investigator	Scientist - C	15%	Data collection, tritrophic interaction studies of predator and parasitoids. Associated with E 01, E 02 and E 03
Dr. Yumnam Debraj Co-Investigator	Scientist - D	20%	Implementation of the project in Jorhat, Assam
Mr. Sudeb Chatterjee Co-Investigator	Scientist - C	20%	Implementation of the project in Kalimpong, W.B.

17.3: Proprietary / patented items, if any, expected to be used for this project –
NA

17.4: Suggested plan of action for utilization of the expected outcome from the project:

The detailed ecological information that will be generated on tritrophic interactions between host plant, pests and natural enemy complex, their correlation with abiotic factors along with the biological attributes will be utilized for formulation of comprehensive biological control programmes to manage the mulberry pests, which is an efficient and eco-friendly tool for conserving the ecosystem. Life table data of natural enemies is vital to depict the general magnitude of its potential of multiplication when given a chance in the ideal ecosystem. Elucidation of life table studies for the screened natural enemies would effectively complement advocating biological control as a component in existing IPM.

17.5. Time schedule of activities giving milestones

Sl.no	Activity	Symbol	Preceding Activity	Estimated time
1	Seasonal incidence of all major pests and their biological control agents,	A	-	4yrs 6 m Continuous
2	Establishment and maintenance of laboratory cultures of the field collected natural enemies	B	-	4yrs 6 m Continuous
3	Host range, host preference of pests and their natural enemies, Host specificity studies	C	-	3yrs
4	Studies on the biological attributes of the natural enemies	D	B	3yrs 6m
6	Life table studies of the selected natural enemies	E	D	2yrs
7	Data analysis, Compilation of results and outcome of the project work and submission of report.	F	ABCDE	6 m

Timelines:

Time scale	Year 1				Year 2				Year 3				Year 4				Year 5			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Tritrophic interactions (Field)																				
Host preference/specificity(Lab)																				
Biology of natural enemies (Lab)																				
Life table studies of the selected NE																				
Data analysis,Compilation of results																				

Activity table providing quantifiable outputs

Period of study	Achievable targets
1st year	Initiation of the project at all Co-ordinating centers, Initiation of the seasonal incidence of all major pests and their biological control agents, recording of alternate host plants of major pests and alternate hosts of natural enemies, host range, host preference of pests and their natural enemies, establishment of laboratory cultures of pests.
2nd year	Continuation of the seasonal incidence of pests and their bio-control agents, identification of natural enemies, initiation of the studies on life cycle (biology) and biometry of natural enemies, recording of alternate host plants of major pests and alternate hosts of natural enemies, host range, host preference of pests and their natural enemies and migration behaviour of pests and their natural enemies. Establishment of laboratory cultures of pests and their natural enemies. Biology and feeding efficiency/ parasitisation ability of the natural enemies.
3rd year	Continuation of the seasonal incidence of pests and their bio-control agents, recording of alternate host plants of major pests and alternate hosts of natural enemies, studies on life cycle (biology) and feeding efficiency / parasitizing ability of natural enemies, recording of alternate host plants of major pests and alternate hosts of natural enemies, host range, host preference of pests and their natural enemies. Initiation of life table studies of the selected promising predators/ parasitoids.
4th year	Continuation of the seasonal incidence of pests and their bio-control agents, recording of alternate host plants of major pests and alternate hosts of natural enemies, host range, host preference of pests and their natural enemies, migration of major pests and their natural enemies, studies on life cycle (biology) and feeding efficacy / parasitizing ability of natural enemies, recording of alternate host plants of major pests and alternate hosts of natural enemies, host range, host preference of pests and their natural enemies. Life table studies of the selected promising predators/ parasitoids. The key natural factors responsible for causing fluctuations in the populations of promising natural enemies in the mulberry ecosystem will be determined.
5th year	Seasonal incidence of pests and their natural enemies in correlation with selected meteorological factors, studies on the feeding efficiency / parasitizing ability, mating and ovipositional behaviour of promising natural enemies, The life stages of the pests and their natural enemies which are overcoming the unfavourable conditions are studied. Identification of newly recorded natural enemies (parasitoids and predators), list of alternate hosts of pests and natural enemies, Migration pattern of pests and their natural enemies are elucidated. Completion of life table studies and interpretation of tritrophic interactions for effective execution of natural control and future augmentation of biocontrol agents. Data analysis, Compilation of results and outcome of the project work and submission of report.

17.6. Project Implementing Agency/ Agencies

Name of the Agency	Address of the Agency	Proposed Research Aspects	Proposed Amount	Cost Sharing %
Central Silk Board	BTM Layout, Madivala, Bangalore	Basic plus applied	Rs. 32.08 lakhs	100%

18. **PART IV: BUDGET PARTICULARS (in Lakhs) :** [In case of multi-institutional projects, the budget details should be provided separately for each of the Institute]

A) Non-Recurring (e.g.equipments, accessories, etc.)NA

Sl no.	Item	1st year	2nd year	3rd year	4th year	5th year	Total
A]	Land	-	-	-	-	-	-
B]	Building						
C]	Vehicle						
D]	Equipments Leica S8 APO Stereo zoom 10-80X magnification with Digital camera with PC display	1000000	-	-	-	-	1000000
	Trekker (Portable) microscope with digital camera	18290					18290
	BOD**	95000					95000
	Two Split AC machine	81000					81000
E]	Furniture						
F]	Fan & fixtures						
G]	Tools, plant & machineries						
Total							**1194290**

Sub-Total (A) =1192290

** EXCLUSIVELY PROCURED/BOOKED FOR THE PROJECT, IF ANY

B. Recurring

B.1 Manpower (See guidelines at Annexure-III)

S. No.	Position No.	Consolidated Emolument	Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	JRF(CSR&TI, Berhampore) (1)	16000/- pm for first 2 yrs and 18000/- pm afterwards	192000	192000	216000	216000	216000	1032000
								1032000

Sub-Total (B.1) =1032000

B.2 Consumables

S.No.	Item	1st Year	2nd Year	3rd year	4th year	5th year	Total
1.	Oviposition cages(1x1x1)	50,000	-----	----	-----	----	50000
2.	Pumpkin stands	2000	1000	1000	1000	1000	6000
3.	Crystalizing jars	50000	30000	30000	30000	30000	170000
4.	Speciman jars	10000	10000	10000	10000	10000	50000
5.	Specimen tubes	5000	2000	2000	2000	5000	16000
6	Plastic containers	10000	5000	5000	5000	5000	30000
7.	Test tubes	10000	10000	10000	10000	10000	50000
5	Forceps, Needles, Brushes and muslin cloth, Honey, Entomological pins, absolute alcohol, pumpkins, potatoes	10000	10000	10000	10000	10000	50000
	Sub-Total	1,47,000	68,000	68,000	68,000	71,000	422000

Sub-Total (B.2) =4,22,000

Other Items:

S.No.	Item	1st Year	2nd Year	3rd Year	4th year	5th year	Total
B3	Travel	72,000	72,000	72,000	72,000	72,000	360000
B4	Contingency	40,000	40,000	40,000	40,000	40,000	200000
	Total	112000	112000	112000	112000	112000	560000
Subtotal (B1+B2+B3+B4etc.)							**2014000**
Grand Total (A + B)							**3208290**

Note : Please give justification for each head and sub-head separately mentioned in the above table.

Financial Year : April - March

In case of multi-institutional project, the budget estimate to be given separately for each institution.

PART V: EXISTING FACILITIES

Resources and additional information

1. **Laboratory:**

a. Manpower

JRF: 1 No. At CSR&TI, Berhampore for conducting field works **in four traditional Sericultural districts (Murshidabad, Malda, Birbhum and Nadia districts) of West Bengal for collecting the extensive field data on incidence of pests and their natural enemies** in mulberry and adjoining agricultural crops, laboratory screening of the field collected material for natural enemies.

The project investigators are associated with laboratory cultures of pests and their natural enemies; host specificity and preference studies; mass culturing of natural enemies, identification of the new natural enemies collected from the field; studies on biological attributes of the promising natural enemies; feeding efficacy of predators and parasitization ability of parasitoids and life table studies.

Hence requirement of a skilled manpower assistance exclusively for the scheduled field visits and screening and handling of the large no. biological materials in the laboratory is justified.

b. Equipments

Digital microscope with PC display:

This facility is essential requirement of any entomological laboratory. The high grade microscope (Leica S8 APO) with 8:1 zoom range with higher resolution with colour digital camera delivering a high speed output, live image at a full 2.5 Megapixel resolution to the PC display is desirable to study the egg/ larval/ pupal predators/ parasitoids in detail. Further dissection studies for exploration of parasitism on host species deserve this facility. The digital microscope with 60X (integral std), 180X (std) integrated with PC will be a permanent asset to the Entomological Laboratory.

Trekker Field Microscope:

Trekker Field Microscope is a light weight, portable model, easy to use, 35x Pocket Sized, revolutionary design, built-In light microscope with camera is an useful aid to take photographs of pests and their natural enemies **in different field locations of farmers** in Nadia, Murshidabad and Malda districts of West Bengal. It will be permanent valuable record, if micro- photographs are taken while studying the tritrophic relationships of pest and their natural enemies in different alternate hosts adjoining mulberry fields.

BOD:

The facility is presently not available in entomology section and all other BODs of other section of the Institute are fully engaged in conducting their sectional project works. Hence a BOD facility is essential to conduct life table studies of the natural enemies as explained in the methodology of E03.

AC machine:

To enhance the facilities in entomology laboratory and the present project also demands a well-established bio-control laboratory facility conducive for biology studies of predator/ parasitoid, feeding efficacy experiments and Mass multiplication studies. **Two split AC machines are required for providing conducive temperature to the laboratory and the culture room.**

2. Other resources such as clinical material, animal house facility, glass house. Experimental garden, pilot plant facility etc. NA

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PART VI: DECLARATION/CERTIFICATION

It is certified that

a) The research work proposed in the scheme/project does not in any way duplicate the work already done or being carried out elsewhere on the subject.

b) The same project proposal has not been submitted to any other agency for financial support.

c) The emoluments for the manpower proposed are those admissible to persons of corresponding status employed in the institute/university or as per the Ministry of Science & Technology guidelines (Annexure-III)

d) Necessary provision for the scheme/project will be made in the Institute/University/State budget in anticipation of the sanction of the scheme/project.

e) If the project involves the utilisation of genetically engineered organisms, we agree to submit an application through our Institutional Biosafety Committee. We also declare that while conducting experiments, the Biosafety Guidelines of the Department of Biotechnology would be followed in toto.

f) If the project involves field trials/experiments/exchange of specimens, etc. we will ensure that ethical clearances would be taken from concerned ethical Committees/Competent authorities and the same would be conveyed to the Department of Biotechnology before implementing the project.

g) It is agreed that any research outcome or intellectual property right(s) on the invention(s) arising out of the project shall be taken in accordance with the instructions issued with the approval of the Ministry of Finance, Department of Expenditure, as contained in Annexure-V.

h) We agree to accept the terms and conditions as enclosed in Annexure-IV. The same is signed and enclosed.

i) The institute/university agrees that the equipment, other basic facilities and such other administrative facilities as per terms and conditions of the grant will be extended to investigator(s) throughout the duration of the project.

j) The Institute assumes to undertake the financial and other management responsibilities of the project.

Signature of Executive Authority
of Institute/University with seal

Signature of Principal Investigator :
Date :

Signature of Co-Investigator
Date :

Signature of Co-Investigator
Date :

Signature of Co-Investigator
Date :

Signature of Co-Investigator
Date :

Signature of Co-Investigator
Date :