Template/Pro forma for Submission

NMHS-Himalayan Institutional Project Grant

**NMHS-FINAL TECHNICAL REPORT (FTR)**

Demand-Driven Action Research and Demonstrations

| | |
|---|---|
| **NMHS Reference No.:** | GBPNI/NMHS/2017-18/MG33/17 |

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| **Date of Submission:** | 0 | 8 | 1 | 2 | 2 | 0 | 2 | 2 |
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**PROJECT TITLE (IN CAPITAL)**

**SYSTEMATIC INVENTORIZATION, USE PROFILES AND MOLECULAR CATALOGUING FOR THE SUSTAINABLE MANAGEMENT OF EDIBLE INSECT RESOURCES FOR ENHANCING THE LIVELIHOOD OPPORTUNITIES OF LOCAL PEOPLE OF HIMALAYAN RANGE OF MANIPUR, NORTH EAST INDIA**

**Project Duration:** *from* (23.02.2018) to (30.11.2021)

***Submitted to*:**
Er. Kireet Kumar
Scientist 'G' and Nodal Officer, NMHS-PMU
National Mission on Himalayan Studies, GBP NIHE HQs
Ministry of Environment, Forest & Climate Change (MoEF&CC), New Delhi
E-mail: nmhspmu2016@gmail.com; kireet@gbpihed.nic.in; kodali.rk@gov.in

***Submitted by*:**
Dr. T. Shantibala (*Principal Investigator)*
*Associate Professor*
*College of Horticulture and Forestry, Pasighat*
*Central Agricultural University (Imphal)*
*Phone: 9856083444*
*Email: shantibro@yahoo.co.in*

*DSL: Date of Sanction Letter*

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*DPC: Date of Project Completion*

| 3 | 0 | 1 | 1 | **2** | **0** | **2** | **1** |
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## Part A: Project Summary Report

### 1. Project Description

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| i. | Project Reference No. | GBPNI/NMHS/2017-18/MG33/17 | | | | | | | | |
| ii. | Type of Project | Small Grant | | Medium Grant | ✓ | Large Grant | | | | |
| iii. | Project Title | **Systematic inventorization, use profiles and molecular cataloguing for the sustainable management of edible insect resources for enhancing the livelihood opportunities of local people of Himalayan range of Manipur, North East India** | | | | | | | | |
| iv. | State under which Project is Sanctioned | **Manipur** | | | | | | | | |
| v. | Project Sites (IHR States covered)<br>(Maps to be attached) | Manipur, Nagaland and Arunachal Pradesh<br>(Map at Appendix 1-(Figure 1) | | | | | | | | |
| vi. | Scale of Project Operation | Local | | Regional | ✓ | Pan-Himalayan | | | | |
| vii. | Total Budget/ Outlay of the Project | Approved Rs. 2.499/-Cores & Total Sanction Rs.1.8279720/- Cores | | | | | | | | |
| viii. | Lead Agency | National Mission on Himalayan Studies, GBP NIHE HQs<br>Ministry of Environment, Forest & Climate Change (MoEF&CC), New Delhi | | | | | | | | |
| | Principal Investigator (PI) | Dr. T. Shantibala, CHF, CAU. | | | | | | | | |
| | Co-Principal Investigator (Co-PI) | Prof. K. Mamocha Singh, CAU, IMPHAL MANIPUR and Dr. Priyadarsanan Dharma Rajan, ATREE, BANGALORE | | | | | | | | |

| | | |
|---|---|---|
| ix. | Project Implementing Partners | Central Agricultural University, Imphal, Manipur & Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Srirampura, Jakkur, Bangalore- 560064 |
| | Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail | Dr. T. Shantibala, CHF, CAU; shantibro@yahoo.co.in;9856083444 |

## 2. Project Outcomes

**2.1. Abstract** (not more than 500 words) [it should include background of the study, aim, objectives, methodology, approach, results, conclusion and recommendations).

Accepting insects and other invertebrate as food is a part of integral traditional culture of several ethnic people of the north-eastern states. Furthermore, the usage of insects in traditional medicine was recorded since time immemorial in this region. Over 2000 species of edible insects recorded over 300 ethnic groups around the world, among which over 200 species of insects and other invertebrate animals are consumed in North East India. A total of 263 insect specimens were documented and collected from five states of Northeast India viz., Arunachal Pradesh (85), Nagaland (59), Manipur (82), Mizoram (32) and Assam (5). Through purposive sampling information were collected from targeted informants such as village head, educated youths, home makers & traditional knowledge holders whose ages attained 20 years and above from each ethnic group. Out of these 192 insect species identified, 17 specimens are in larval form. All the identified specimens were photographed and curated in the museum (ATREE & CAU). Megaloptera and Trichoptera larvae are recorded as edible group for the first time from the Oriental region. More than 50 species are newly reported as edible. The hymenopteran, family Scoliidae (*Phalerimeris phalerata*) and Lepidopteran, family, Erebidae (*Perimcyma cruegeri*) are reporting for the first time as edible fauna of the world. Identification of insect specimens yielded more than 20 new distribution records from the Indian subcontinent. New distribution record of *Batocera lineolata* (Cerambycidae: Lamiinae: *Batocerini*) from India is also reported. To understand the socio-economic importance and sustainability of their entomophagic practices, documented weekly market survey from different markets of seven edible insects. From different markets more than twelve different insect species were found contributing in socio economic enhancement. Seven species of edible Mollusca having socio-economic importance were documented and characterized. Among the edible insects we have identified some insects like *Odoiporus longicollis* which has major pest status in South India which have been consumed by Northeast tribe. By considering this we can suggest a cultural control of these pests. Most importantly we are continuing rearing of Crickets (*Teleogryllus mitratus*) in ATREE, Bengaluru which will stand a good option to develop a protocol on rearing crickets with minimum trade-off between the cost and effort that goes in towards rearing and the final product.

For molecular cataloguing and genetic characterization to resolve the ambiguity, some economic importance species such as two new species of *Coridius*, Cerambycidae borer, Stingless bees, and aquatic larvae were analysed through barcoding**.** Mitochondrial sequencing of 3 unidentified species were undergoing.

Non-conventional food involving insect resources remains largely underexplored though a huge potential lies for exploiting such resources as nutritional food. Estimation of macro and micro nutrient profile of 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1) were completed. Completed Fatty acid profiling of one species (Lepidoptera) and Amino acid profile of two species of molluscs and anti-oxidant properties for 12 species edible insects.

Mass culturing of three edible insect species were initiated. Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and also to use in food and feed of animals. Technology was transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL for feed and food. Rearing of Crickets (*Teleogryllus mitratus*) is workout in ATREE, Bengaluru. Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect. This project developed a complete database of edible insects with associated information, including molecular data. Nutritive value, dietary uses, and food safety of selected widely used species also conducted. Few potential edible insects were also identified that can be sustainable for food production and to adapt sustainable farming and commercially viable. This project created awareness among the local communities about sustainable harvesting and insect rearing practices. Awareness about entomophagy among insects as food and the subsequent development of profitable markets is a very good way to enhance the conservation value of natural areas from which insects can either be harvested sustainably or artificially mass reared by manipulating the habitat in a benign manner. So, this project shared scientific information to enhance local livelihood, sustainable harvest & conservation of insects used in local culinary. This will help the local community in attaining better nutritional security and alleviation of malnutrition Popularization of the concept of "Insect Farming" or "Mini-livestock" among the local community is expected to bring in livelihood security to rural people.

## 2.2. Objective-wise Major Achievements

| S. No. | Objectives | Major achievements (in bullets points) |
|---|---|---|
| 1 | **Systematic inventorization and cataloguing of edible insects** | 1. A total of 263 edible insect specimens were documented and collected from five states of Northeast India (Appex-1, Figure 1a)<br>2. All the identified specimens were photographed and curated in the institutes (ATREE & CAU) (Appex-1Figure 2 to 8).<br>3. From the orders, Megaloptera and Trichoptera edible insects were reported for the first time from the Oriental region.<br>4. More than 50 species are newly reported as edible. The hymenopteran, family Scoliidae (*Phalerimeris phalerata*) and Lepidopteran, family, Erebidae (*Perimcyma cruegeri*) are reporting for the first time as edible fauna of the world (Appex-1, Figure 9).<br>5. Identification of insect specimens yielded more than 20 new distribution records from the Indian subcontinent. New distribution record of *Batocera lineolata* (Cerambycidae: Lamiinae: *Batocerini*) from India is also reported.<br>6. The socio-economic importance and sustainability of their entomophagic practices, documented weekly market survey from different markets of seven edible insects. From different markets more than twelve different insect species were found contributing in socio economic enhancement. Seven species of edible Mollusca having socio-economic importance were documented and characterized (Figure 10-13).<br>7. Around 65 percent of species were favoured in the larval stage.<br>8. 19 percent of species were preferred in both the adult and larval stages.<br>9. 16 percent were liked in the adult stage. |
| 2 | **Molecular cataloguing and genetic characterization of the potential edible insect and molluscs** | 1. For identification of ambiguity and economic importance species, based on COI gene sequence analysis using DNA barcode techniques five edible insect species, *Vespa magnifica* and *Lepidoptera sp.* two new species of *Coridius* have been collected and described through barcoding **(**Figure.14**).**<br>2. Mitochondrial DNA barcode sequencing of unidentified 3 species such as lepidoptera larva, stingless bees, and aquatic larvae were done the NCBI Accession no. are Lepidotrigona arcifera: ON521146; *Vespa magnifica* (Asian giant hornet): ON514039; *Autosticha* sp. ON533749 |

| | | |
|---|---|---|
| 3 | **Estimation of the nutritional and anti-nutritional factors of insects and molluscs** | 1. Macro and micro nutrient profile were estimated for 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1) Appex-1, Table 1-4.<br>2. Fatty acid profiling of *Omphisa fuscidentalis* revealed the present of Bicyclo[4.1.0] heptane 7 pentyl which was reported to have good anti-cancer metastatic effect against the pancreatic cancer cel (Appex-1, Figure-15).<br>3. Anti-oxidant properties for 12 species edible insects showed that eri silkworm and lesser banded hornet showed $IC_{50}$ value have good anti-oxidant property indicating below 100µg/ml (Appex-1, Figure-16).<br>4. Amino acid profile of two species of molluscs, *Pila thiobaldi* and *Lamellidens marginalis* analyses revealed that both content good amount of essential amino acids Histidine, Leucine and Lysine (Appex-1, Figure-17). |

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| 4 | **Exploration of the potentials for culturing edible insects producing value-added products for enhancing the livelihood opportunities of local people and promote sustainable harvesting practices** | 1. Mass culturing of three edible insect species were initiated.<br>2. Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and to use in food and feed of animals (Appex-4, Plate 1 & Figure-18).<br>3. Rearing of Crickets (*Teleogryllus mitratus*) is workout in ATREE, Bengaluru (Appex-4, Plate 2).<br>4. Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect (Appex-4, Plate 3).<br>5. This project developed a complete database of edible insects with associated information, including molecular data (Appex-1, Excel File 1).<br>6. This project created awareness among the local communities about sustainable harvesting and insect rearing practices.<br>7. To develop and promote the tourism sector through ethnic food a two days online workshop on "**Agro-tourism through underutilised ethnic foods"** was conducted in CHF, Pasighat, September, 2020.<br>8. Three days Web Workshop cum Training "**Edible insect and non-conventional foods as a nutrient pack and livelihood security**" was conducted in CHF, Pasighat during 27th to 29th, January, 2021.<br>9. Popularization of the concept of "Insect Farming" or "Mini-livestock" among the local community is expected to bring in livelihood security to rural people. |

## 2.3. Outputs in terms of Quantifiable Deliverables*

| S. No. | Quantifiable Deliverables* | Monitoring Indicators* | Quantified Output/ Outcome achieved | Deviations made, if any, & Reason thereof: |
|---|---|---|---|---|
| | **Molecular catalogue and maps of edible insects with demographic distribution and harvest** | Monitoring in comparison to the baseline information to be provided by the proponent in the 1st Quarter: | Molecular cataloguing of Vespa *magnifica*, stingless bees, unidentified *aquatic* insect larvae, unidentified *Lepidoptera sp.* and two new species of *Coridius* have been described through barcoding.<br>The barcode submitted to the NCBI Accession no. were *Lepidotrigona arcifera*: | |

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|---|---|---|---|---|
| | **practices for all NE states** | Region-specific harvest practices/Models (Nos.) | ON521146; *Vespa magnifica* (Asian giant hornet): ON514039; *Autosticha* sp. ON533749 | |
| | **Documentation on the Indigenous knowledge system that sustains the diverse livelihood option using edible insects** | . Molecular Catalogues and supporting maps (Nos);<br>Income generation (Rs. /Person);<br>No. of New Database/ Datasets generated on the identified dynamics (No.);<br>No. of Stakeholder benefited (No. of youth, no. of women, and total no. of beneficiaries):<br><br>. Other publications and knowledge products (Nos.) | A total of 263 insect specimens were documented and collected from five states of Northeast India viz., Arunachal Pradesh (85), Nagaland (59), Manipur (82), Mizoram (32) and Assam (5). Megaloptera and Trichoptera are recorded as edible group for the first time from the Oriental region. More than 50 species are newly reported as edible. | |
| | **Development of 5 conservation and sustainable models for economically important species for income generation.** | | We have developed a low cost set up for rearing crickets (*Teleogryllus mitratus*) in the lab (ATREE). In addition to this we are also documenting the rearing process for bees and wasps practiced by the tribes in Nagaland. We have completed Video documentation "Rearing giants" on rearing of giant hornet.<br><br>Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly).<br><br>Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect. | |
| | **Qualitative and quantitative baselines data base on resource use profiles, environmental conditions, institutional and policy regimes** | | Macro and micro nutrient profile were estimated for 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1).<br>Fatty acid profiling of *Omphisa fuscidentalis* revealed the present of Bicyclo[4.1.0] heptane 7 pentyl which was reported to have good anti-cancer metastatic effect against the pancreatic cancer cell.<br>Amino acid profile of two species of molluscs, *Pila thiobaldi* and *Lamellidens marginalis* analyses revealed that both content good amount of essential amino acids Histidine, Leucine and Lysine.<br>Anti-oxidant properties for 12 species edible insects showed that eri silkworm and lesser | |

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|---|---|---|---|---|
| | | | banded hornet showed $IC_{50}$ value have good anti-oxidant property indicating below 100µg/ml. | |
| | **An information portal (E-DIS) entomophagy in India.** | | A database integrating the species information containing updated name string of the species, HD Infocus Image, Diagnostic description, and distribution, uses, and associated traditional knowledge, and a bibliography. (ATREE_EI_NE_India_Secondary_data.xlsx) | |

(*) As stated in the Sanction Letter issued by the NMHS-PMU.

## 2.4. Strategic Steps with respect to Outcomes (in bullets)

| S. No. | Particulars | Number/ Brief Details | Remarks/ Attachment |
|---|---|---|---|
| 1. | New Methodology developed | Rearing of three edible insects were developed; such as crickets (*Teleogryllus mitratus*);<br><br>Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed for rearing of *Hermetia illucens* (Black soldier Fly).<br><br>Giant water bug, *Lethocerus indicus*, for captive breeding for development of Mass production technology. | Rearing continued |

| S. No. | Particulars | Number/ Brief Details | Remarks/ Attachment |
|---|---|---|---|
| 2. | New Models/ Process/ Strategy developed | Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed for rearing of *Hermetia illucens* (Black soldier Fly) | ✓ Technology transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL<br>✓ Trained the volunteers to breed BSF in love-cages to produce eggs<br>✓ To use the larvae for animal feed and food. |
| 3. | New Species identified | Two new species of *Coridius. sp* | |
| 4. | New Database established | A database integrating the species information containing updated name string of the species, HD Infocus Image, Diagnostic description, and distribution, uses, and associated traditional knowledge, and a bibliography. (ATREE_EI_NE_India_Secondary_data.xlsx) | |
| 5. | New Patent, if any | Nil | |
| | I. Filed (Indian/ International) | Nil | |
| | II. Granted (Indian/ International) | Nil | |
| | III. Technology Transfer (if any) | Technology transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL | |

| S. No. | Particulars | Number/ Brief Details | Remarks/ Attachment |
|---|---|---|---|
| 6. | Others (if any) | Megaloptera and Trichoptera are recorded as edible group for the first time from the Oriental region. More than 50 species are newly reported as edible. | |

## 3. Technological Intervention

| S. No. | Type of Intervention | Brief Narration on the interventions | Unit Details (No. of villagers benefited / Area Developed) |
|---|---|---|---|
| 1. | Development and deployment of indigenous technology | For exploring the potential for culturing edible insects collaborated with Greenhub (youth and community-based video documentation centre for recording the environment, wildlife and people's biodiversity in the North East region (NER) of India) for video documentation of rearing of honeybees and wasps in Nagaland India.<br>Traditional rearing of **stingless bee** for edible and medicinal purpose as well as income generation in Ukhrul district of Manipur | Nagaland in one village.<br>Ukhrul district of Manipur |
| 2. | Diffusion of High-end Technology in the region | Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed for rearing of *Hermetia illucens* (Black soldier Fly) | Developed by ATREE |
| 3. | Induction of New Technology in the region | Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed for rearing of *Hermetia illucens* (Black soldier Fly) | Nagaland |

| | | | |
|---|---|---|---|
| 4. | Publication of Technological / Process Manuals (Appendix-2) | **1.** Dr. T. Shantibala, R. K. Lokeshwari, N. Surmina Devi and B.N. Hazarika (2021). EDIBLE AND MEDICINAL INSECTS OF NORTH-EAST INDIA, SPECIAL REFERENCE TO MANIPUR By, ISBN:78-93-9106-388-7; NARENDRA PUBLISHING HOUSE.<br>**2.** R. K. Lokeshwari, **T. Shantibala**, K. Mamocha Singh & B.N. Hazarika (2019). The nutritional goldmine waste: the spent pupae of mulberry, eri and oak tasar silkworms for combating malnutrition. *International Journal of Environment, Ecology,Family and Urban Studies (IJEEFUS)*, 9 ( 2 ); 129-138, Paper Id.: IJEEFUSAPR201913.<br>**3.** R.K. Lokeshwari and T. Shantibala (2019). Edible insect consumed by different ethnic people in Manipur and its potential use in food and feed. **FOOD BIORESOURCES AND ETHNIC FOODS OF MANIPUR, NORTHEAST, INDIA. ISBN: 978-81-944069-0-7;** First Impression: 2019**:38-46; Empyreal Publishing House.**<br>**4.** **Tourangbam Shantibala**, Gusheinzed Waikhom, K. Mamocha Singh and B. N. Hazarika. 2020. Low-cost fish feed formulation with nutritional goldmine, seri-pupae waste and conventional agricultural byproducts for betterment of fish farmer of Manipur. *Innovative Farming*, 5(3): 131-134.<br>**5.** **T. Shantibala** (2021) Career opportunities in Entomological Sciences through Insect as food Resources. *National e conference on Carrier Opportunity in Entomological Science, 28th -29th June, 2021*, Veer Kunwar Singh College of Agriculture, Dumraon, Buxur, Bihar Agricultural University, Sabour, Bhagalpur, India, pp-75-80.<br>**6.** **T. Shantibala**, Tantulung Tatan, Mohd Talha Ansari, N. Surmina Devi and Gusheinzed Waikhom (2021) Multiple Facets of Edible Insect Utility as Nutrient Power Pack and Economic Empower Bank. Biological Forum – An International Journal 13(3): 643-647.<br>**7.** Thounaojam Sheileja, **Tourangbam Shantibala** and K Mamocha Singh (2022). Nutritive value of bamboo worm *Omphisa fuscidentalis* (Lepidoptera: Crambidae): An edible insect as protein rich food. The Pharma Innovation Journal 2022; 11(7): 2229-2233.<br>**8.** T Sheileja, KM Singh, **T Shantibala**, SM Haldar and KI Singh (2022). Nutritional aspects of an edible insect, *Coridius* sp. (Hemiptera: Dinidoridae) of Manipur. Volume: 14 "Journal of Agriculture and Ecology (JAE) (Accepted). | |
| | Others (if any) | | |

**4. New Data Generated over the Baseline Data**

| S. No. | New Data Details | Status of Existing Baseline | Additionality and Utilisation New data |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **1** | A total of 263 edible insect specimens were documented and collected from five states of Northeast India | A database developed integrating the species information containing updated name string of the species, HD Infocus Image, Diagnostic description, and distribution, uses, and associated traditional knowledge, and a bibliography. (ATREE_EI_NE_India_Secondary_data.xlsx) | Database development |
| **2** | Macro and micro nutrient profile were estimated for 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1). | Few data published and working for further publication. | Revealing of nutritional value of edible insects for further utilization. |
| **3** | Molecular cataloguing of Vespa *magnifica*, stingless bees, unidentified *aquatic* insect larvae, unidentified *Lepidoptera sp.* and two new species of *Coridius* have been described through barcoding. sp. ON533749 | The barcode submitted to the NCBI Accession no. were Lepidotrigona arcifera: ON521146; *Vespa magnifica* (Asian giant hornet): ON514039; *Autosticha* | Used for identification of species ambiguity. |

## 5. Demonstrative Skill Development and Capacity Building/ Manpower Trained

| S. No. | Type of Activities | Details with number | Activity Intended for | Participants/Trained | | | |
|---|---|---|---|---|---|---|---|
| | | | | **SC** | **ST** | **Woman** | **Total** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | Workshops | To create awareness about the importance of Ethnic food and promote the tourism sector through ethnic food, two days online workshop was conducted on "**Agro-tourism through underutilised ethnic foods"** in CHF, Pasighat, with 765 nos participation during 17th to 18th, September, 2020. | Two days online workshop on "Agro-tourism through underutilised ethnic foods" was conducted during 17th to 18th, September, 2020 (Appendix-3) | | | | 765 |
| | | To create awareness about the nutrition and it's important for health supplement, three days Web Workshop cum Training on "**Edible insect and non-conventional foods as a nutrient pack and livelihood security**" was conducted in CHF, Pasighat with 254 nos participated in 3 days during 27th to 29th, January, 2021. | | | | | 254 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2. | On Field Trainings | 25 nos of trainees belonging to silkworm rearers, local youths, elder peoples, school dropped out, sericulture departmental staffs were participated to learn the technique of POST COCOON TECHNOLOGY to create the aware of edible silk worm for self empowerment. | Hands on training on Venture of Edible Silkworm to Post Cocoon Technology, w.e.f, 24-28th April, 2019, under NMHS-Project. (Appendix-3) | - | - | **25** | **25** |
| 3. | Skill Development | Trained for silkyarn production skill both manual and using spun, mud pot, on own legs and reeling machines to get benefit of edible as well as usable products for earning extra income. | Training on Venture of Edible Silkworm to Post Cocoon Technology, w.e.f, 24-28th April, 2019. (Appendix-3) | - | - | **25** | **25** |
| 4. | Academic Supports | **NA** | | | | | |
| | Others (if any) | | | | | | |

## 6. Linkages with Regional & National Priorities (SDGs, INDC, etc)/ Collaborations

| S. No. | Linkages /collaborations | Details | No. of Publications/ Events Held | Beneficiaries |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1. | Sustainable Development Goal (SDG) | Biopod RSH v.1 developed technology for rearing BSF for organic waste management was transferred to volunteers (edible insect entrepreneurs) of Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL . | Biopod RSH v.1 technology trained and transfer to farmer. | To the local community |
| 2. | Climate Change/INDC targets | Collaborated with Greenhub (youth and community-based video documentation center for recording the environment, wildlife and people's biodiversity in the North East region (NER) of India) for video documentation of rearing of honeybees and wasps in Nagaland India. | Video documentation of rearing of honeybees and wasps | Academician and Local community for understanding rearing technique. |
| 3. | International Commitments | Interaction with international organizations, Academics by organizing two workshops conducted through online platform | Participation in online workshop through presentation of work activities by international renown figures. | Academic, students, young entrepreneurs and community as whole. |
| 4. | Bilateral engagements | NA | | |
| 5. | National Policies | NA | | |
| 6. | Others collaborations | Collaborated in IBSD | Scientific work | Academic and community |

## 7. Project Stakeholders/ Beneficiaries and Impacts

| S. No. | Stakeholders | Support Activities | Impacts |
|---|---|---|---|
| 1. | Gram Panchayats | Documentation, collection and understanding utilization technique and purposes of ethnic base practices from Village Head, local communities, student, Villagers etc. | Helpful in documentation of different mode of insect utilization in their cultural civilization of different ethnic communities. |
| 2. | Govt Departments | State Forest Department, Central | In healthy collection. Physical |

| | | | |
|---|---|---|---|
| | (Agriculture/ Forest ) | Agricultural University, Other institutes in academic related support like identification, analysis etc. | support, and other related academic analysis. |
| 3. | Villagers | Supported as village guides, stay as care taker and local knowledge sharing. | Helpful both in site and information gathering whenever needed |
| 4. | SC Community | Not specify as separate community but received support as whole | Helpful in documentation of different mode of insect utilization in their cultural civilization of different ethnic communities. |
| 5. | ST Community | Not specify as separate community but received support as whole | -do- |
| 6. | Women Group | Not specify as separate community but received support as whole | -do- |
| | Others (if any) | | |

## 8. Financial Summary (Cumulative)

| S. No. | Financial Position/Budget Head | Funds Received | Expenditure/ Utilized | % of Total cost |
|---|---|---|---|---|
| I. | Salaries/Manpower cost | | | |
| II. | Travel | | | |
| III. | Expendables &Consumables | | | |
| IV. | Contingencies | | | |
| V. | Activities & Other Project cost | | | |
| VI. | Institutional Charges | | | |
| VII. | Equipments | | | |
| | Total | | | |
| | Interest earned | | | |
| | Grand Total | | | |

* Please attach the consolidated and audited Utilization Certificate (UC) and Year wise Statement of Expenditure (SE) separately, *ref.* **Annexure I.**

## 9. Major Equipment/ Peripherals Procured under the Project** (if any)

| S. No. | Name of Equipments | Cost (INR) | Utilisation of the Equipment after project |
|---|---|---|---|
| 1. | Ultra low temperature deep freezer (NBS)(1) | 7,51,857/- | For storage of the long-term sample materials of other continuity research activities of the university. |

| | | | |
|---|---|---|---|
| 2. | Bio Spectrometer (1) | 6,74,762/- | For analysis works of other continuity research activities of the university. |
| 3. | Stereo Microscope (1) | 789,524/- | For microscopic study of the students and other continuity research activities of the university. |
| 4. | Digital Handycam (1) | 1,01,067 | For image capturing of the continuity research activities of the university. |
| 5. | Field gears and storage units | 57,820/- | For field trip of the students and other continuity research activities of the university |
| 6 | Data Loggers (2) | 147600/- | For data records, official activities and storing information of the other continuity research activities of the university |
| 7 | Printer (1), EPSONPRINTER L380 | 24,200/- | For printing of data records, official activities and stored information of the other continuity research activities of the university |
| 8 | Image analyzer, Macbook Pro | 1,77,104/- | For data records, official activities and storing information of the other continuity research activities of the ATREE. |

**Details should be provided in details **(***ref* **Annexure III &IV).**

**10. Quantification of Overall Project Progress**

| S. No. | Parameters | Total (Numeric) | Remarks/ Attachments/ Soft copies of documents |
|---|---|---|---|
| 1. | IHR States Covered | 3 | Arunachal Pradesh, Nagaland & Manipur (Raw data collection) |
| 2. | Project Site/ Field Stations Developed | 3 | *Manipur, Arunachal Pradesh and Banglore* |
| 3. | New Methods/ Modeling Developed | 2 | *Low cost fish feed formation with silkworm pupae &* Biopod RSH v.1 developed technology for rearing BSF for organic waste management |
| 4. | No. of Trainings arranged | 4 | *Training brochure and newspaper report attached* |
| 5. | No of beneficiaries attended trainings | 1044 | *Both online and offline participated numbers* |
| 6. | Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA): | 6 | *Staffs engased in CAU and ATREE with one Ph. D student in CAU* |
| 7. | SC stakeholders benefited | Whole | *Not specified as SC* |
| 8. | ST stakeholders benefited | Whole | *Not specified as ST* |
| 9. | Women Empowered | 25 | *Trained through individual training.* |
| 10. | No of Workshops Arranged along with level of participation | 6 | *Arranged both online and offline* |
| 11. | On field Demonstration Models initiated | *Photograph of training participation* (attach maps about location & photos) | *Attached* |
| 12. | Livelihood Options promoted | Fish feed formulation with silkworm pupae, Rearing of Cricket & Biopod RSH v.1 developed technology for rearing BSF for organic waste management | *Enclosed as paper and photograph* |
| 13. | Technical/ Training Manuals prepared | *One book published, 6 papers* | *Attached documents* |
| 14. | Processing Units established | Biopod RSH v.1 developed technology for rearing BSF for organic waste management (attached photos) | *Procedure mentioned in report* |
| 15. | No of Species Collected | 263 insect specimens | *Photo attached* |
| 16. | New Species identified | Two *Coridius* sp. | *Phylogenetic tree provided* |

| | | | |
|---|---|---|---|
| 17. | New Database generated (Types): | A database developed integrating the species information containing updated name string of the species, HD Infocus Image, Diagnostic description, and distribution, uses, and associated traditional knowledge, and a bibliography. (ATREE_EI_NE_India_Secondary_data.xlsx) | *With ATREE* |
| | Others (if any) | - | - |

**11. Knowledge Products and Publications:**

| S. No. | Publication/ Knowledge Products | *Number* | | *Total Impact Factor* | *Remarks/* Enclosures |
|---|---|---|---|---|---|
| | | National | International | | |
| 1. | Journal Research Articles/ Special Issue: | 6 | | NASS rated total 10+ | References provided |
| 2. | Book Chapter(s)/ Books: | 1 | | | References provided |
| 3. | Technical Reports | 3 | | | Annual report submitted to NMHS |
| 4. | Training Manual (Skill Development/ Capacity Building) | - | | | - |
| 5. | Papers presented in Conferences/Seminars | 3 | | | Leaflet enclosed |
| 6. | Policy Drafts/Papers | 2 | | | Enclosed as attachment |
| 7. | Others: | | | | |

* Please append the list of KPs/ publications (with impact factor and further details) with due Acknowledgement to NMHS.

**12. Recommendation on Utility of Project Findings, Replicability and Exit Strategy**

| Particulars | Recommendations |
|---|---|

| | |
|---|---|
| Utility of the Project Findings | Documentation of the ethnic knowledge and the information of above 200 different kinds of the edible insect species of the country, particularly in the North east India. Nutritional profiling of the edible insects to provide the nutritional utility for mass utilization to its goodness to the wider communities. |
| Replicability of Project | Mass rearing of the potential edible insect for income generation, product developments, value addition of the edible insect products for wider awareness and promotion of its utilization to obtain its benefit to wider communities. |
| Exit Strategy | Documentation, record and preservation and conservation of the ethnic knowledge and the information of different kinds of the edible insect species utilization of the country, Northeast India, Manipur.<br>Nutritional profiling of the edible insects to provide the nutritional utility for mass utilization to its goodness to the wider communities.<br>Development of Captive Mass rearing of the potential edible insect for income generation. |

Dr. T. SHANTIBALA
Associate Professor
College of Horticulture & Forestry
Central Agricultural University
Pasighat - 791102, Arunachal Pradesh

(**PROJECT PROPONENT/ COORDINATOR**)

**(Signed and Stamped)**

(**HEAD OF THE INSTITUTION**)

**(Signed and Stamped)**

**Place:** ……..
**Date:** …../……/……

## PART B: PROJECT DETAILED REPORT

The Detailed report should include an Executive Summary and it should have separate chapters on (i) Introduction (ii) Methodologies, Strategy and Approach (iii) Key Findings and Results (iv) Overall Achievements (v) Project's Impacts in IHR (vi) Exit Strategy and Sustainability (vii) References and (viii) Acknowledgement (It should have a mention of financial grant from the NMHS, MoEF&CC)

Further, description of Technical Activities, List of Trainings/ Workshops/ Seminars with details of trained resources, list of New Products developed under the project, Manual of Standard Operating Procedures (SOPs) developed, Technology developed/Transferred etc should be enclosed as Appendix.

## 1 EXECUTIVE SUMMARY

Accepting insects and other invertebrate as food is a part of integral traditional culture of several ethnic people of the north-eastern states. Furthermore, the usage of insects in traditional medicine was recorded since time immemorial in this region. Over 2000 species of edible insects recorded over 300 ethnic groups around the world, among which over 200 species of insects and other invertebrate animals are consumed in North East India. A total of 263 insect specimens were documented and collected from five states of Northeast India viz., Arunachal Pradesh (85), Nagaland (59), Manipur (82), Mizoram (32) and Assam (5). Through purposive sampling information were collected from targeted informants such as village head, educated youths, home makers & traditional knowledge holders whose ages attained 20 years and above from each ethnic group. Out of these 192 insect species identified, 17 specimens are in larval form. All the identified specimens were photographed and curated in the museum (ATREE & CAU). Megaloptera and Trichoptera larvae are recorded as edible group for the first time from the Oriental region. More than 50 species are newly reported as edible. The hymenopteran, family Scoliidae (*Phalerimeris phalerata*) and Lepidopteran, family, Erebidae (*Perimcyma cruegeri*) are reporting for the first time as edible fauna of the world. Identification of insect specimens yielded more than 20 new distribution records from the Indian subcontinent. New distribution record of *Batocera lineolata* (Cerambycidae: Lamiinae: *Batocerini*) from India is also reported. To understand the socio-economic importance and sustainability of their entomophagic practices, documented weekly market survey from different markets of seven edible insects. From different markets more than twelve different insect species were found contributing in socio economic enhancement. Seven species of edible Mollusca having socio-economic importance were documented and characterized. Among the edible insects we have identified some insects like *Odoiporus longicollis* which has major pest status in South India which have been consumed by Northeast tribe. By considering this we can suggest a cultural control of these pests. Most importantly we are continuing rearing of Crickets (*Teleogryllus mitratus*) in ATREE, Bengaluru which will stand a good option to develop a protocol on rearing crickets with minimum trade-off between the cost and effort that goes in towards rearing and the final product.

For molecular cataloguing and genetic characterization to resolve the ambiguity, some economic importance species such as two new species of *Coridius*, Cerambycidae borer, Stingless bees, and aquatic larvae were analysed through barcoding**.** Mitochondrial sequencing of 3 unidentified species were undergoing.

Non-conventional food involving insect resources remains largely underexplored though a huge potential lies for exploiting such resources as nutritional food. Estimation of macro and micro nutrient profile of 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5),

Hymenoptera (7), Orthoptera (2) and Isoptera (1) were completed. Completed Fatty acid profiling of one species (Lepidoptera) and Amino acid profile of two species of molluscs and anti-oxidant properties for 12 species edible insects.

Mass culturing of three edible insect species were initiated. Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and also to use in food and feed of animals. Technology was transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL for feed and food. Rearing of Crickets (*Teleogryllus mitratus*) is workout in ATREE, Bengaluru. Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect. This project developed a complete database of edible insects with associated information, including molecular data. Nutritive value, dietary uses, and food safety of selected widely used species also conducted. Few potential edible insects were also identified that can be sustainable for food production and to adapt sustainable farming and commercially viable. This project created awareness among the local communities about sustainable harvesting and insect rearing practices. Awareness about entomophagy among insects as food and the subsequent development of profitable markets is a very good way to enhance the conservation value of natural areas from which insects can either be harvested sustainably or artificially mass reared by manipulating the habitat in a benign manner. So, this project shared scientific information to enhance local livelihood, sustainable harvest & conservation of insects used in local culinary. This will help the local community in attaining better nutritional security and alleviation of malnutrition Popularization of the concept of “Insect Farming” or “Mini-livestock” among the local community is expected to bring in livelihood security to rural people.

## 2 INTRODUCTION

### 2.1 Background of the Project (max. 500 words)

Insect and other invertebrates are attractive and important natural source of food for many kinds of vertebrate animals, including human. Insects are an excellent source of protein and a major ingredient of the diets of several communities around the world., Insects are considered as an inexpensive substitute for meat in many developing countries. According to United Nation Food and Agriculture organization (FAO), over 2000 insect species are eaten worldwide over 85 different countries. People do not just eat insect, they relish them as delicacies. Generally, insects often contain more protein, fat, carbohydrates and other essential micronutrients than equal amount of conventional meat. There are also various reasons to explore insects as a food sources like their impressive nutritive value, easy breeding in captivity and high biomass. For people who have traditionally relies on insects for food, sustainable utilization of insect resources could lower nutritional deficiencies.

The North-East India having a total geographical area of 2,62,179 $km^2$ (about 8 % of the total area of India) form a genetic treasure house of plant, animal and microbial resources. The region forms a distinctive part of the Indo-Burmese Hotspot and is a prime one among the two identified for the Indian sub-continent. The region also falls in the bio-geographic tri-junction of the Indian, the Himalayan and the oriental landmass. It lies in the north of the Himalayas where immense variety of the climatic, edaphic, and altitudinal variations have resulted in a great range of ecological habitats. The lushness of its landscape, favourable climatic condition, the range of communities and geographical and ecological diversity makes the North-Eastern part of India quite different from other parts of the subcontinent. Many ethnic people are also inhabitants in this part of India and they also possess a vast traditional knowledge on effective utilization of edible insects and other edible invertebrates were acquired through the experience and usually passed on by oral traditions as a guarded secret of certain families.

Accepting insects and other invertebrate as food is a part of integral traditional culture of several ethnic people of the north-eastern states. Furthermore, the usage of insects in traditional medicine was recorded since time immemorial in this region. Over 2000 species of edible insects recorded over 300 ethnic groups around the world, it is estimated that over 200 species of insects and other invertebrate animals are consumed in North East India. Many species have served as traditional foods among indigenous peoples and played an important role in their food culture and nutrition. Insects have higher food conversion efficiency than other higher animals. This makes invertebrate meat more ecological than vertebrate meat. However, wider acceptance of edible insect and other invertebrates as standard food in the other part of the country is a big question. Reducing the bias against insects as food will be promising by promoting nutritional value to stable diets and maximizing ecological benefits with edible insects. The traditional use of insects as food and other invertebrates is widespread in N. E. India and provides significant nutritional, economic and ecological benefits for rural communities

2.2 Overview of the Major Issues to be Addressed (max. 1000 words)

Since, the Northeast remained geographically isolated from the rest of the country, several ethnic groups of the region have their own culture and traditions in preserving many of their ancient practices without much influence by the modern trend in civilization. Thus, these have made a special attraction for the scientific researchers as well as ethnobiologists to study the folklore culture on the use invertebrate animals. Coming to the context of edible insect and other invertebrate remain on documentation studies, utilization for wider acceptance and value addition remain scientifically neglected area of the study in today's research arena. On the other hand, there has been a general trend of the people to give up their age-old cultures, traditions, believes by present generation due to the influence by the modern way of civilization. Many of the insect are used in folk medicine, nutritive purpose, industrial aspect, and other valuable activities have been neglected. The information on the utilization of edible insect and other invertebrates could be used to develop scientific basis for sustainable resource management as well as to work out the welfare programs to improve the quality of the life of the communities. Hence, it is of utmost important to explore, document and monitor ecologically and economically important edible insect across the Himalayan range of Northeast India and develop mass rearing methods and develop value-added products.

2.3 Baseline Data and Project Scope (max. 1000 words)

- The project envisioned here would have a long-term impact rather than short term. The impact can

be from various aspects of projects such as

- Complete documentation of edible insect resources of the state which will lead to conservation, sustainable management, and enhanced livelihood of local people
- Document on the Indigenous knowledge system that sustains the diverse livelihood options and rich biodiversity will be useful to be adapted in other regions as part of upscaling the project findings.
- Unique edible insect accessions or land races, semi-domesticated edible insect and snail resources could result from the project efforts and they could be used in other appropriate regions of Himalayas.
- Indigenous wild invertebrate animal resource knowledge could be used to sustainably use the insect bioresources elsewhere in the country.
- The outcome will also help in devising species-specific conservation and recovery plans and in the light of resource use intensity and global change.
- Research findings will be useful to resolve the conflicts in biological resource use and knowledge based on national level policies and local level community rights.
- Identification of women's contribution towards the indigenous practices and knowledge regarding edible insects will help empowering women in the biological resource management in future.
- Diversity and associated knowledge can be used for various decision-making purpose for managers, research purpose for teachers and students, and for educational purpose for conservation educators and for popularizing the concept of insect eating
- Overall changes expected through the project efforts could be safeguarding the centuries old knowledge system of this mountainous state that sustained millions of humans, their customs, and culture those are intertwined with rich biological diversity and ecosystem services.

2.4 Project Objectives and Target Deliverables (as per the NMHS Sanction Order)

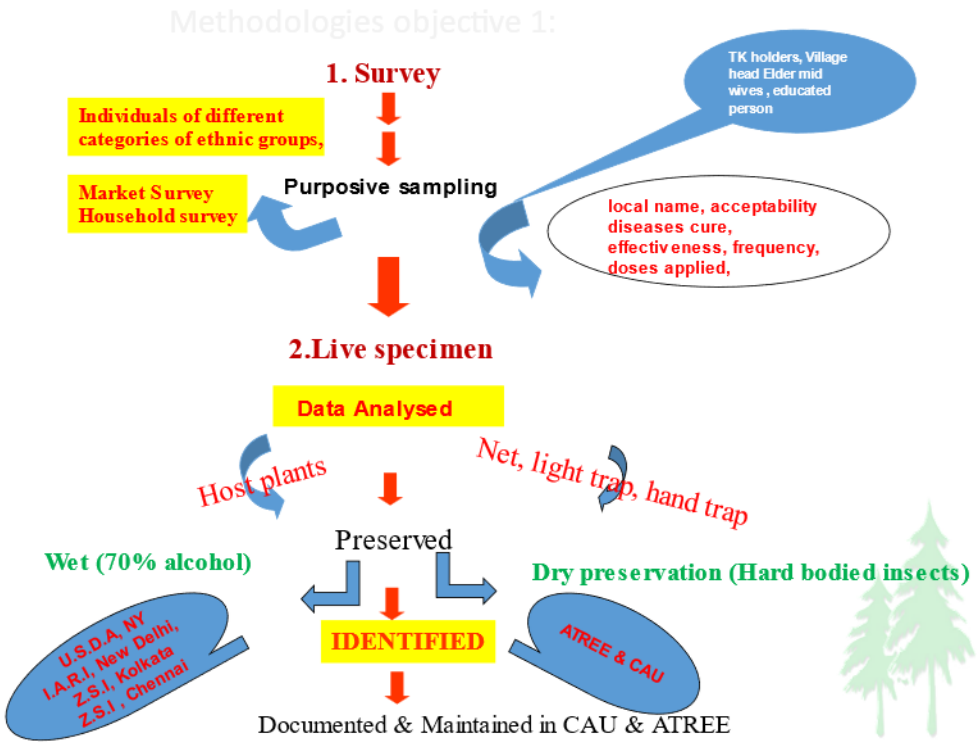
| **Project Objectives** | **Target Deliverables** |
|---|---|
| **Systematic inventorization and cataloguing of edible insects and molluscs** | **Documentation on the Indigenous knowledge system that sustains the diverse livelihood option using edible insects** |
| **Molecular cataloguing and genetic characterization of the potential edible insect and molluscs** | **Molecular catalogue and maps of edible insects with demographic distribution and harvest practices for all NE states** |
| **Estimation of the nutritional and anti-nutritional factors of edible insects and molluscs** | **Qualitative and quantitative baselines data base on resource use profiles, environmental conditions, institutional and policy regimes** |

| | |
|---|---|
| **Exploration of the potentials for culturing edible insects producing value-added products for enhancing the livelihood opportunities of local people and promote sustainable harvesting practices.** | **Development of 5 conservation and sustainable models for economically important species for income generation.**<br><br>**An information portal (E-DIS) entomophagy in India.** |

## 3 METHODOLOGIES, STARTEGY AND APPROACH

3.1 Methodologies used for the study (max. 1000 words)

**Objective 1: Systematic inventorization and cataloguing of edible insects and molluscs**



| Objectives | Objective-wise Brief Methodology followed |
|---|---|
| • Molecular cataloguing and genetic characterization of the potential edible insect and Mollusca for conservation and sustainable utilization. | mtDNA was extracted following the protocol of Clark and Nicklas (1970) and outsource for sequencing. PCGs of the mitogenome were identified by ORF finder. tRNA genes were identified in tRNAscan-SE Search (http://lowelab.ucsc.edu/ tRNAscan-SE/). Phylogenetic trees based on maximum likelihood analysis were constructed on MEGA 5.1 (Tamura et al. 2011). |
| • Estimate the nutritional and antinutritional factors of insects and Mollusca that widely consumed by people | **Proximate compositions** (moisture content, crude protein, crude fat, crude fiber, ash) were determined according to the Association of Official Analytical Chemists methods (AOAC, 1990). **Assay for Minerals:** The mineral content was determined after wet digestion of sample with a mixture of sulfuric, nitric, and perchloric acids at the ratio of 1:10:4 using an atomic absorption spectrophotometer. **HPLC Analysis of amino acids:** Acid hydrolyzed samples of molluscs were subjected to HPLC analysis against amino acid standards for quantification. |
| • Explore the potentials for culturing edible insects producing value added products for enhancing the livelihood opportunities of local people and promote sustainable harvesting practices. | Rearing methods interviews: The rearing methods are recorded by visiting the rearing sites using a questionnaire. Photographs and descriptive recording of the rearing methods are collected. The specimens are collected as mentioned above.<br>Prototypes for rearing cages was developed based on secondary literature |

## 3.2 Preparatory Actions and Agencies Involved (max. 1000 words)

Collection, preservation, inventorization and documentation of edible insects have been started through collection of primary data using questionnaires for field and market survey. Information acquired on different aspect on economic, social values, cultural and therapeutic information from several ethnic communities relating to traditional ecological knowledge in the region. Field surveys, documentation and collections of edible insects was collected covering different villages of Manipur, Nagaland and Arunachal Pradesh. Data on different type of insect species consumed by each ethnic group were obtained by performing personal interview from various ethnic communities comprising of village heads, traditional knowledge holder, educated youth and homemakers. Information was collected from targeted informants in each ethnic group. The age of these informants were above 20 years and included both man and woman. In each village, each tribal ethnic community has their own village head, locally known as the village king (Khun Ningthou, vernacular dialect) of that community. Village heads and traditional knowledge holders (TK holders) are aware about their age-old practices of entomophagy. Homemakers were included because they are responsible for collection, selling and preparation of the edible insects. Educated youths were taken to record their views about the habit of insect eating. As such specified Agencies were not defined but took the help of State Forest Departments, different institutes, and local clubs.

3.3 Details of Scientific data collected and Equipments Used (max 500 words)

| S. No. | Name of Equipments | Utilisation of the Equipment after project |
|---|---|---|
| 1. | Ultra low temperature deep freezer (NBS)(1) | For storage of the long-term sample materials of other continuity research activities of the university. |
| 2. | Bio Spectrometer (1) | For analysis works of other continuity research activities of the university. |

| | | |
|---|---|---|
| 3. | Stereo Microscope (1) | For microscopic study of the students and other continuity research activities of the university. |
| 4. | Digital Handycam (1) | For image capturing of the continuity research activities of the university. |
| 5. | Field gears and storage units | For field trip of the students and other continuity research activities of the university |
| 6 | Data Loggers (2) | For data records, official activities and storing information of the other continuity research activities of the university |
| 7 | Printer (1), EPSONPRINTER L380 | For printing of data records, official activities, and stored information of the other continuity research activities of the university |
| 8 | Image analyzer, Macbook Pro | For data records, official activities and storing information of the other continuity research activities of the ATREE. |

3.4 Primary Data Collected (max 500 words)

3.5 Details of Field Survey arranged (max 500 words)

For conducting field survey, first we identified the location and places and listed out were to be visited. After identifying the places, contacted local persons from each village and fixed the days and date to be stayed. We narrated the purpose of visit and stared gathering information through collection of primary data using questionnaires. Data on different type of insect species consumed by each ethnic group were obtained by performing personal interview from various ethnic communities comprising of village heads, traditional knowledge holder, educated youth and homemakers. Information was collected from targeted informants in each ethnic group. During study, edible insect species were also collected from different habitats such as ponds, lakes, streams, trees, shrubs, grassland, soils, paddy fields, dwellings, sericulture farms and forests (Figure 6). They were preserved following the standard methods of Ghosh and Sengupta, 1982 and

identified up to family level by following the standard taxonomic keys of Castner, 2008. For the identification of the species, samples were sent out to institutes like United States Department of Agriculture (USDA) for Hemipterans, Zoological Survey of India (ZSI), Chennai for Odonata, Indian Agricultural Research Institute for terrestrial Coleopterans and ZSI, Pune for aquatic Coleopterans etc. Voucher specimens and photographs were deposited in the Insect Bioresources Laboratory, Institute of Bioresources and Sustainable Development, Imphal, Manipur, India and Department of Plant Protection, College of Horticulture and Forestry, Pasighat, Central Agricultural University, Imphal.

3.6 Strategic Planning for each Activities (max. 1000 words)

Initially the activity begins with the literature survey to understand the scenario of utilization of edible insects in different part of the globe. Regional survey, documentation and collection of information was done through recording of photographic pictures, videography and specimens were proceeded. Purposive sampling method was used, questionnaire was fill up from targeted informant s such as village heads, traditional knowledge holder, educated youth and homemakers for each ethnic community. Analysis of ethno-entomophagy practices were characterized and evaluated to know mode of utilization in their cultural heritage. Specimens were preserved, maintained, and identified authentically through literatures, intuitionally & molecular analysis etc. To provide nutritional information to public and wider communities, use profile and nutritional values were found out and allow to accessible through different platforms like scientific journal, workshop, seminar, training etc. For sustainable utilization of potential edible insect captive mass rearing also developed and made available to the community. Various capacity building workshops, training was also conducted for community to make aware and dissipate its utility benefit to the mass public.

3.7 Activity wise Time frame followed [using Gantt/ PERT Chart (max. 1000 words)]

| **Activities** | 1st year | | 2nd year | | 3rd year | |
|---|---|---|---|---|---|---|
| | 6 | 12 | 18 | 24 | 30 | 36 |
| Literature survey | | | | | | |
| Field Surveys, Data collection & cleaning, | | | | | | |
| Identification and documentation of insect bioresources | | | | | | |
| Edible insects Demographics | | | | | | |
| Ethno-entomophagy knowledge | | | | | | |
| Edible Insect Database | | | | | | |
| Developing edible insect portal | | | | | | |
| Populating and popularising edible insect portal | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| DNA barcoding | | | | | | |
| Genetic diversity analysis | | | | | | |
| Data analysis | | | | | | |
| Dietary assessment | | | | | | |
| Capacity building workshops for community | | | | | | |
| Identifying candidate species for mass rearing | | | | | | |
| Developing techniques for mass rearing insects | | | | | | |
| Experimental Participatory rearing | | | | | | |
| National level symposium on Edible insects | | | | | | |
| Reports | | | | | | |

## 4 KEY FINDINGS AND RESULTS

4.1 Major Research Findings (max. 1000 words)

The exploitation and utilization of insect resources presented in this book are grouped into three different categories based on their mode of application. First one is the insect utilized for edible purpose, secondly, insects of medicinal application and thirdly, insects having industrial utility. A total of 263 insect specimens were documented and collected from five states of Northeast India viz., Arunachal Pradesh (85), Nagaland (59), Manipur (82), Mizoram (32) and Assam (5) (Figure 1 & 2). Out of these 192 insect species identified, 17 specimens are in larval form. All the identified specimens were photographed and curated in the museum (ATREE & CAU). Edible insect species distributed in nine orders, Viz., Blatoidea, Coleoptera, Dermaptera, Diptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Odoneta, Orthoptera, and Trichoptera. More than 50 species are newly reported as edible. The hymenopteran, family Scoliidae (*Phalerimeris phalerata*) and Lepidopteran, family, Erebidae (*Perimcyma cruegeri*) are reporting for the first time as edible fauna of the world. Around 65 percent of species were favoured in the larval stage. 19 percent of species were preferred in both the adult and larval stages. 16 percent were liked in the adult stage. Identification of insect specimens yielded more than 20 new distribution records from the Indian subcontinent. New distribution record of *Batocera lineolata* (Cerambycidae: Lamiinae: *Batocerini*) from India is also reported. From different markets more than twelve different insect species were found for the socio-economic importance and sustainability of their entomophagic practices.

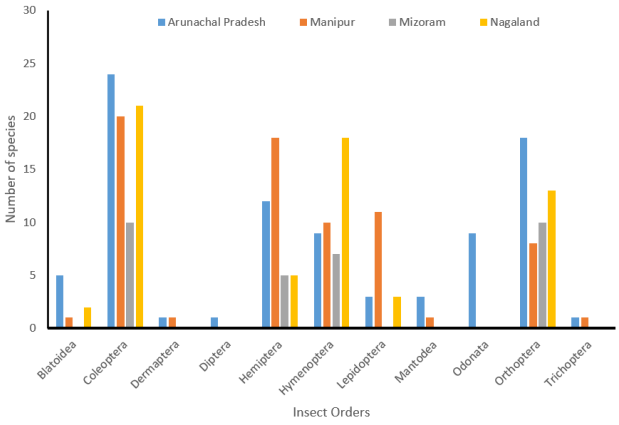



Figure 1. Identified species of edible insects collected from four states.

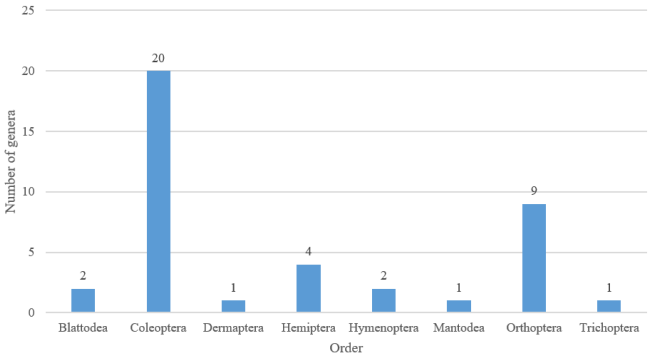



Figure 2. New generic report as edible group.

Depending upon the type of insects and stages, these are consumed as raw, roasted, fried and curry forms. The method of preparation is mostly traditional and is handed down from generation to generation.

Completed Nutritional profiling of 32 edible insect species belonging to Odoneta (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1). Completed Fatty acid profiling of one species (Lepidoptera) and Amino acid profile of two species of molluscs and anti-oxidant properties for 12 species edible insects (Table 1-3; Figure 15 & 17). Mass culturing of three edible insect species were initiated. Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and also to use in food and feed of animals (Figure 18 & Plate 1). Technology was transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL for feed and food. Rearing of Crickets (*Teleogryllus mitratus*) in ATREE, Bengaluru is initiated and undergoing (Plate 2). Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur is started for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect (Plate 3).

4.2 Key Results (max 1000 words in bullets covering all activities)

1. A total of 263 edible insect specimens were documented and collected from five states of Northeast India.
2. Edible insect species distributed in nine orders, Viz., Blatoidea, Coleoptera, Dermaptera, Diptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Odoneta, Orthoptera, and Trichoptera.
3. All the identified specimens were photographed and curated in the institutes (ATREE & CAU).
4. From the orders, Megaloptera and Trichoptera edible insects were reported for the first time from the Oriental region.
5. More than 50 species are newly reported as edible. The hymenopteran, family Scoliidae (*Phalerimeris phalerata*) and Lepidopteran, family, Erebidae (*Perimcyma cruegeri*) are reporting for the first time as edible fauna of the world .
6. Identification of insect specimens yielded more than 20 new distribution records from the Indian subcontinent. New distribution record of *Batocera lineolata* (Cerambycidae: Lamiinae: *Batocerini*) from India is also reported.
7. The socio-economic importance and sustainability of their entomophagic practices, documented weekly market survey from different markets of seven edible insects. From different markets more than twelve different insect species were found contributing in socio economic enhancement. Seven species of edible Mollusca having socio-economic importance were documented and characterized.
8. Around 65 percent of species were favoured in the larval stage.
9. 19 percent of species were preferred in both the adult and larval stages.
10. 16 percent were preferred to eat in the adult stage.
11. Mitochondrial DNA barcode sequencing of unidentified 3 species such as lepidoptera larva, stingless bees, and aquatic larvae were analysed and the NCBI Accession no. are *Lepidotrigona arcifer*a: ON521146; *Vespa magnifica* (Asian giant hornet): ON514039; *Autosticha* sp. ON533749
12. Macro and micro nutrient profile were estimated for 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1).
13. Fatty acid profiling of *Omphisa fuscidentalis* revealed the present of Bicyclo[4.1.0] heptane 7 pentyl which was reported to have good anti-cancer metastatic effect against the pancreatic cancer cell.
14. Amino acid profile of two species of molluscs, *Pila thiobaldi* and *Lamellidens marginalis* analyses revealed that both content good amount of essential amino acids Histidine, Leucine and Lysine.
15. Anti-oxidant properties for 12 species edible insects showed that eri silkworm and lesser banded hornet showed $IC_{50}$ value have good anti-oxidant property indicating below 100µg/ml.
16. Mass culturing of three edible insect species were initiated.
17. Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and to use in food and feed of animals.
18. Rearing of Crickets (*Teleogryllus mitratus*) is workout in ATREE, Bengaluru.
19. Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect.
20. This project developed a complete database of edible insects with associated information, including molecular data (ATREE_EI_NE_India_Secondary_data.xlsx).
21. This project created awareness among the local communities about sustainable harvesting and insect rearing practices.

4.3 Conclusion of the study (maximum 500 words in bullets)

Edible insect species are widely accepted by different ethnic communities of Northeast India. Observation indicated the significance acceptance of the insects as an important dietary food items, ethno-entomotheraphy role, industrial utility prospects and noticeable supporting contribution in livelihood income sources. This useful biomass would be significant and comparable in terms of nutritional implement with other conventional food products, which was proven by integrating scientific validation through nutritional profiling in support to the traditional wisdom as an important bio-prospect.

The existence of the culture of eating insects in Northeast India ensures nutritional needs of the indigenous people are being met. Although, the use of edible insects has been trivialized, they can play a major role in food security, health, and environment management. Edible insects are rich in protein, fat, carbohydrates, minerals and other activated elements that promote human health. Insects are characterized by rich species diversity and large populations, therefore as nutritive resources, they can be widely exploited and have great development potential. It is also necessary to promote captive and mass breeding of potential edible insect species to sustain its utilization.

Considering the popularity of the edible insects, it is also not surprised that scores of species have been a prominent item of commerce in the town and village markets of different regions of the world. The capturing, processing, transporting, and marketing of edible forest insects provides important income and livelihood opportunities for an undetermined number of people. Traditionally, these activities were all locally based and largely under-recognized. Recently, more sophisticated, and wide-reaching marketing or commercialization of edible insects has been advanced, including attractive packaging and advertising. It is also believed that creating a wider market for food insects could provide an economic incentive for conserving insect habitats.

In India, entomophagy is more prevalent in North-East India where insects are readily available. North-east India can be treated as epicenter of entomophagy. Eventually, more research is needed to understand the prevailing entomophagy in the North East region where indigenous communities enjoy nutritious insect foods as sustainable ingredient in their main diet or as supplement. More down the line, studies on production of value-added products are needed at this hour. In this juncture, researchers are required to go in collaborative work with food industries and entrepreneurs. Once the hope of incorporating the benefits of edible insects into the food resources is successful, it will combat malnutrition and undernourishment.

The use of insect resources for various therapies has been documented in many different parts of the world but largely in remote regions, where traditional medicines provide a *de facto* alternative to “modern” health care systems. However, little is known about entomotheraphy in the academic world, as it is practiced by the lesser-known community groups.

From across the world, some of the scientifically validated insect species are already described for their existence of the biologically active compounds having immunological, analgesic, antibacterial, diuretic, anesthetic and antirheumatic properties. For example, bioactive compound, Inhibine, pH 3.9, a strong antibacterial chemical from honey, which had been identified as hydrogen peroxide that used in ‘wound dressing’ by the traditional healer is scientifically proven. There is no doubt that insect resources significantly contribute to the health care system of the past and present in many corners of the world. However, the wide and depth of this study is not properly systematized, in the context of the scientific arena in concerned to world’s scenario. However, the time has come to record the use of insects in traditional

medicine and devise the strategies to exploit these natural resources more sustainably with proper authentic scientific validation.

To throw the light of initiation of utilizing of nutritious resourceful edible insects, the author team begins it uses with the silkworm pupa, a major by-product in sericulture industry. Silkworm pupa occupied one of the major preference foods among 100 species of edible insect consumed by the indigenous peoples of northeast India. This by-product which is presently felt as wastes can be put into better use by converting value-based products, thereby making the industry more profitable and economically viable spot. Therefore, low cost fish feed formulation with locally available materials was made to permit profit maximization in aquaculture ventures, just to begin.

## 5 OVERALL ACHIEVEMENTS

5.1 Achievement on Project Objectives [Defining contribution of deliverables in overall Mission (max. 1000 words)]

| Quantifiable Deliverables* | Monitoring Indicators* | Quantified Output/ Outcome achieved |
|---|---|---|
| **Molecular catalogue and maps of edible insects with demographic distribution and harvest practices for all NE states** | Monitoring in comparison to the baseline information to be provided by the proponent in the 1st Quarter:<br>Region-specific harvest practices/Models (Nos.)<br>. Molecular Catalogues and supporting maps (Nos);<br>Income generation (Rs. /Person);<br>No. of New Database/ Datasets generated on the identified dynamics (No.);<br>No. of Stakeholder benefited (No. of youth, no. of women, and total no. of beneficiaries):<br><br>. Other publications and knowledge products (Nos.) | Molecular cataloguing of Vespa *magnifica*, stingless bees, unidentified *aquatic* insect larvae, unidentified *Lepidoptera sp.* and two new species of *Coridius* have been described through barcoding.<br>The barcode submitted to the NCBI Accession no. were *Lepidotrigona arcifera*: ON521146; *Vespa magnifica* (Asian giant hornet): ON514039; *Autosticha* sp. ON533749 |
| **Documentation on the Indigenous knowledge system that sustains the diverse livelihood option using edible insects** | | A total of 263 insect specimens were documented and collected from five states of Northeast India viz., Arunachal Pradesh (85), Nagaland (59), Manipur (82), Mizoram (32) and Assam (5). Megaloptera and Trichoptera are recorded as edible group for the first time from the Oriental region. More than 50 species are newly reported as edible.<br>(Enclosed in Figure 1-13) |
| **Development of 5 conservation and sustainable models for economically important species for income generation.** | | We have developed a low cost set up for rearing crickets (*Teleogryllus mitratus*) in the lab (ATREE). In addition to this we are also documenting the rearing process for bees and wasps practiced by the tribes in Nagaland. We have completed Video documentation "Rearing giants" on rearing of giant hornet.<br><br>Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed by ATREE for rearing of *Hermetia illucens* (Black soldier Fly). |

| | | |
|---|---|---|
| | | Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect. |
| **Qualitative and quantitative baselines data base on resource use profiles, environmental conditions, institutional and policy regimes** | | Macro and micro nutrient profile were estimated for 32 edible insects belonging to Odonata (1), Coleoptera (10), Lepidoptera (6), Hemiptera (5), Hymenoptera (7), Orthoptera (2) and Isoptera (1).<br>Fatty acid profiling of *Omphisa fuscidentalis* revealed the present of Bicyclo[4.1.0] heptane 7 pentyl which was reported to have good anti-cancer metastatic effect against the pancreatic cancer cell.<br>Amino acid profile of two species of molluscs, *Pila thiobaldi* and *Lamellidens marginalis* analyses revealed that both content good amount of essential amino acids Histidine, Leucine and Lysine.<br>Anti-oxidant properties for 12 species edible insects showed that eri silkworm and lesser banded hornet showed $IC_{50}$ value have good anti-oxidant property indicating below 100µg/ml. |
| **An information portal (E-DIS) entomophagy in India.** | | A database integrating the species information containing updated name string of the species, HD Infocus Image, Diagnostic description, and distribution, uses, and associated traditional knowledge, and a bibliography.<br>(ATREE_EI_NE_India_Secondary_data.xlsx) |

5.2 Establishing New Database/Appending new data over the Baseline Data (max. 1500 words, in bullet points)

- Documenting community knowledge associated with insect bio-resources of Northeast India, together with their dynamics and sustainability challenges and management were conducted.
- A list of edible insects found in Manipur with other adjoining states were recorded and collected with its mode of preparation, practicing community and their habitats.
- Documentation and cataloguing from Manipur, Arunachal Pradesh and Nagaland were undergone through primary and secondary data collection by direct personal interaction and presence using questionnaires. (Enclosed the Questionnaires models)
- A list of edible insects compiles for preparation of database were provided as example.

- A database integrating the species information containing updated name string of the species, HD Infocus Image, Diagnostic description, and distribution, uses, and associated traditional knowledge, and a bibliography were developed (ATREE_EI_NE_India_Secondary_data.xlsx)

5.3 Generating Model Predictions for different variables (if any) (max 1000 words in bullets)

Low-cost fish feed formulation developed with nutritional goldmine, edible silkworm pupae as animal protein supplements and conventional locally available agricultural byproducts such as mustard oil cake and rice bran are cheaper than the conventional protein feed sources such as groundnut cake, fish meal and soybean meal and effective too. This fish feed developed can be an alternative low-cost protein supplement for effective fish feed formulation in the state to permit profit maximization in aquaculture ventures. Different good protein sources animals feed can be developed with the replacement of other proteinaceous edible insect such as Black shoulder larva, cricket and any other nutritious edible insects depending on the availability of the biomass.

5.4 Technological Intervention (max 1000 words)

Mass culturing of three edible insect species were initiated. Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and to use in food and feed of animals. Technology was transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL for feed and food.

Rearing of Crickets (*Teleogryllus mitratus*) is workout in ATREE, Bengaluru.

Giant water bug, *Lethocerus indicus*, one of the high Price and favorable Edible and medicinal insect in Manipur was initiated for captive breeding experimentation for development of Mass production technology for future entrepreneurship prospect.

5.5 On field Demonstration and Value-addition of Products (max. 1000 words, in bullet points)

Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and also to use in food and feed of animals. Technology was transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and rear BSFL for feed and food.

5.6 Promoting Entrepreneurship in IHR

Promotion of Low-cost fish feed formulation with nutritional goldmine, edible silkworm pupae as animal protein supplements and conventional locally available agricultural byproducts such as mustard oil cake and rice bran for local fish feed development as an an alternative low-cost protein supplement for effective fish feed formulation in the state to permit profit maximization in aquaculture ventures.

Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management.

5.7 Developing Green Skills in IHR

Biopod RSH (Rearing & Self Harvesting), Biopod RSH v.1 self-rearing case and self-harvesting unit was designed and developed for rearing of *Hermetia illucens* (Black soldier Fly) for promotion for sustainable organic waste management and to use in food and feed of animals. Technology was transferred to volunteers (edible insect entrepreneurs) from Dimapur, Nagaland to make Biopod RSH v.1. and to rear BSFL for feed and food.

5.8 Addressing Cross-cutting Issues (max. 500 words, in bullet points)

1. Consumption of ethno-entomophagy practices was highlighted and linked with its high value nutritional impact by depicting the nutritional profiling of edible insect.
2. Edible insects are rich in protein, fat, carbohydrates, minerals, and other activated elements that promote human health.
3. Edible insects are prominent as marketed items among the food commodities.
4. In entomophagy-practicing regions, edible insects are mostly marketed in the local market either as street foods or dietary food items.
5. Edible insect species that are readily available and easy to capture from natural habited are collected and sold in the local market for an additional economic supplement.
6. It provides inexpensive foods that are ready to eat daily. The economic supports contributed from the marketing of edible insects is noticeable even though generally underestimated and uncountable.
7. The local community are also attaining better nutritional security and economic supports by practicing traditional "Insect Farming" or "Mini-livestock" of certain high price species like *Vaspa mandarina* in Nagaland, stingless bee in Ukhrul district of Manipur, giant lepidopteran tree borer species which supported in bringing livelihood security to the local community.

## 6 PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic Development (max. 500 words, in bullet points)

The edible insects, it is not surprised that scores of species have been a prominent item of commerce in the town and village markets of different regions. The capturing, processing, transporting and marketing of edible forest insects provides important income and livelihood opportunities for an undetermined number of people. Traditionally, these activities were all locally based and largely under-recognized. Recently, more sophisticated and wide-reaching marketing or commercialization of edible insects has been advanced, including attractive packaging and advertising. Creation of a wider market for food insects could provide an economic incentive for conserving insect habitats.

6.2 Scientific Management of Natural Resources In IHR (max. 500 words, in bullet points)

1. Documentation and characterization of the Indigenous knowledge system that sustains the diverse livelihood options using edible insects
2. Impartment of Nutritional potentiality of the edible insect to general public for wider acceptance.
3. Development of conservation and sustainable harvest strategies for economically important species for income generation.
4. Impartment of Nutritional potentiality of the edible insect to general public for wider acceptance

5. Development of conservation and sustainable harvest strategies for economically important species for income generation.

6.3 Conservation of Biodiversity in IHR (max. 500 words, in bullet points)

Creating awareness among the local communities about sustainable harvesting and insect rearing practices, nutritive value, dietary use and food safety of edible insect highlighted the need of sustainable availability. This will also identify edible insects that will be more suitable for food and how to sustainably farm them and which species would be best suited for this and would be commercially viable. Awareness about entomophagy among insects as food and the subsequent development of profitable markets maybe a very good way to enhance the conservation value of natural areas from which insects can either be harvested sustainably or artificially mass reared by manipulating the habitat in a benign manner. So, this project highlighted the importance of edible insect in enhancing local livelihood, sustainable harvest & conservation of insects used in local culineary. This also assure the local community in attaining better nutritional security and alleviation of malnutrition. Popularization of the concept of "Insect Farming" or "Mini-livestock" among the local community will bring the need of conservation of edible insect in livelihood security to rural the people.

6.4 Protection of Environment (max. 500 words, in bullet points)

Documentation, characterization, and exploration of edible insect utilization provides the status of the current prevailing scenario in respect to environment and ecosystem. For sustainable service continuity of the edible insect, protection and conservation through mass rearing and captive breeding ensure environmental protection. Entomophagy offers dietary foods with less environmental effort, support livelihood and plays an important ecological role in nature. The emerging health benefits and documentation of indigenous foods as described in the above paragraphs are the need of the hour for strategic community-based interventions so that it would help to improve food security, nutrition, and health of populations. The more effective use of such diversity can also serve to be a more sustainable and environmentally friendly solution to the problems of food production. Further, documentation of the nutritional values of insects to promote insects more efficiently as a healthy food source is needful.

6.5 Strengthening Networking in IHR (max. 700 words, in bullet points)

The acceptance of benefits of edible insects will firm in strengthening successful networking in the field of non-conventional food resources utilization through combating malnutrition and undernourishment. Utilization of value-added products of edible insects in the form of Protein concentrate powder as a nutrient

supplement will be a good scope for network promotion. The development of a clear and comprehensive legal framework at the international or national level could pave the way for more investment, leading towards the full development from the household scale to the industrial scale of production as well as trade-in insect products for food and feed internationally. Strengthen the researcher's works in collaboration with food industries and the expansion of entrepreneurship are required for its promotion. Proper utilization of insect food resources can be chosen as a Carrier Opportunity for the young mind through innovation, value addition and promotion by educating its various beneficial aspects for humankind.

## 7 EXIT STRATEGY AND SUSTAINABILITY

7.1 How effectively the project findings could be utilized for the sustainable development of IHR (max. 1000 words)

- Complete documentation of edible insect resources of the state which will lead to conservation, sustainable management and enhanced livelihood of local people
- Document on the Indigenous knowledge system that sustains the diverse livelihood options and rich biodiversity will be useful to be adapted in other regions as part of upscaling the project findings.
- Unique edible insect accessions or land races, semi-domesticated edible insect resulted from the project efforts and they could be used in other appropriate regions of Himalayas.
- Indigenous wild invertebrate animal resource knowledge could be used to sustainably use the insect bioresources elsewhere in the country.
- The outcome will helpful in devising species-specific conservation and recovery plans and in the light of resource use intensity and global change.
- The documentation will help the community and the state biodiversity board to safe guard the traditional knowledge under the NBA regulations.
- Research findings will be useful to resolve the conflicts in biological resource use and knowledge based on national level policies and local level community rights.
- Overall changes expected through the project efforts could be safeguarding the centuries old knowledge system of this mountainous state that sustained millions of humans, their customs and culture those are intertwined with rich biological diversity and ecosystem services.

7.2 Efficient ways to replicate the outcomes of the project in other parts of IHR (Max 1000 words)

- Document on the Indigenous knowledge system that sustains the diverse livelihood options and rich biodiversity will be useful to be adapted in other regions as part of upscaling the project findings.
- Unique edible insect accessions or land races, semi-domesticated edible insect resulted from the project efforts and they could be used in other appropriate regions of Himalayas.
- Indigenous wild invertebrate animal resource knowledge could be used to sustainably use the insect bioresources elsewhere in the country.
- Value added Protein production from insects for human consumption would be more effective for consumption, as fewer resources were needed than vertebrate protein. This activity can be replicated elaborately to maximize edible insect utilization as insect meat are more ecological than vertebrate

meat.

- Popularization of the concept of "Insect Farming" or "Mini-livestock" among the local community will bring the need of conservation of edible insect for livelihood and environmental security.

7.3 Identify other important areas not covered under this study needs further attention (max 1000 words)

Value added insect Protein production for human consumption would be more effective and attentive for sustainable resource utilization. Popularization of the concept of "Insect Farming" or "Mini-livestock" among the local community need further attention for conservation and utilization of edible insect in livelihood security to rural the people. It was estimated that 10% increase in the world supply of animal protein through mass production of insects would largely eliminate the malnutrition problem and also decreases the pressure on other protein sources. Entomological Science through Insect as Food Resources can be focused in two broad categories such as *nutrient power pack* and *economic empower bank*. In terms of nutritional package, these insects hold the promise of exploitation of non-conventional food resources and represent a genuine food category. The edible insect, by-product or felt as wastes can be put into better use by converting value-based products, thereby making more profitable and economically viable spot. Proper utilization of insect food resources can be chosen as a Carrier Opportunity for the young mind through innovation, value addition and promotion by educating its various beneficial aspects for humankind.

7.4 Major recommendations for sustaining the outcome of the projects in future (500 words in bullets)

Insect and other invertebrates are major ingredient of the diets of several communities. It acts as an excellent source of protein. Entomophagy, the practice of eating insect has started to gain the momentum of 'Economic empower bank' as income sources and 'Nutrient power pack' as complete nutritional package in terms of nutritional value. Development and exploration of insect food utilization can be opted as a successful carrier opportunity through innovation, value addition and promotion of its various beneficial aspects for humankind. Trade on insect food products and feed for animals will surely empowered the ethnic food tourism and support sustainable livelihood. Advance enterprises in these fields and their values do not get due recognition, as compare to insect resources utilization in different corners of the world. Insects give higher food conversion efficiency than other higher animals. This makes invertebrate meat more ecological than vertebrate meat. Reducing the bias against insects as food will be promising by promoting nutritional value to stable diets and maximizing ecological benefits with edible insects. The traditional use of insects as food and other invertebrates is widespread in different part of the country will provide significant nutritional, economic and ecological benefits for the community as whole. Development of a clear and comprehensive legal framework at the international or

national level could pave the way for more investment, leading towards the full development from the household scale to the industrial level. Production as well as trade of insect products for food and feed will certainly empowered the ethnic food tourism and promote sustainable livelihood support.

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## APPENDICES

Appendix 1 – Details of Technical Activities
Appendix 2 – Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS
Appendix 3 – List of Trainings/ Workshops/ Seminars with details of trained resources and dissemination material and Proceedings
Appendix 4 – List of New Products (utilizing the local produce like NTFPs, wild edibles, bamboo, etc.)
Appendix 5 – Copies of the Manual of Standard Operating Procedures (SOPs) developed
Appendix 6 – Details of Technology Developed/ Patents filled
Appendix 7 – Any other (specify)

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