Entomophagy: Success story of Majuli Beetle-Pest into Cuisine

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The white grub, *Lepidiota mansueta* was first detected in October 2005 in the farmers' field of Majuli river island of Assam. Field surveys conducted during 2005-2009 revealed that *L. mansueta* had appeared as an extremely severe key pest in Majuli river island and the most severely affected crops were potato, sugarcane, *Colocasia* and green gram, and the extent of damage varied from 42-48, 15-20, 35-40 and 30-35 per cent, respectively (Bhattacharyya *et al*., 2013). Majuli is the largest fresh water mid-river deltaic island (26° 45 N to 27°12 N latitude and 93° 39 E to 94° 35 E longitudes) and is situated in the upper reaches of the Brahmaputra, 630 km upstream of the Indo-Bangladesh border and 100 km from its mouth and the elevation from the mean sea level is 84.50 meters. Majuli falls under the tropical climate zone; however, the numerous wetlands, streams, etc. endow Majuli with a sub-tropical climate. The average annual temperature is 22.5° C. The average annual rainfall ranges from 200-250 cm with 80 per cent relative humidity. The island is a "Bio-diversity hotspot" and has rich ecology with rare breeds of flora and fauna and is a part of a major path for many species of migratory birds. The government of Assam has also proposed that the island be included in the UNESCO's "World Heritage Site" list because of its unique historic importance, rich biodiversity and co-existence of various cultures.

Realizing the seriousness of the problem, the seasonal life cycle and biology of the white grub beetle, *L. mansueta* were studied in crop fields of Majuli and in the laboratory of All India Network Project on Soil Arthropod Pests, Assam Agricultural University, Jorhat Centre during 2005-2009. *L. mansueta* has a

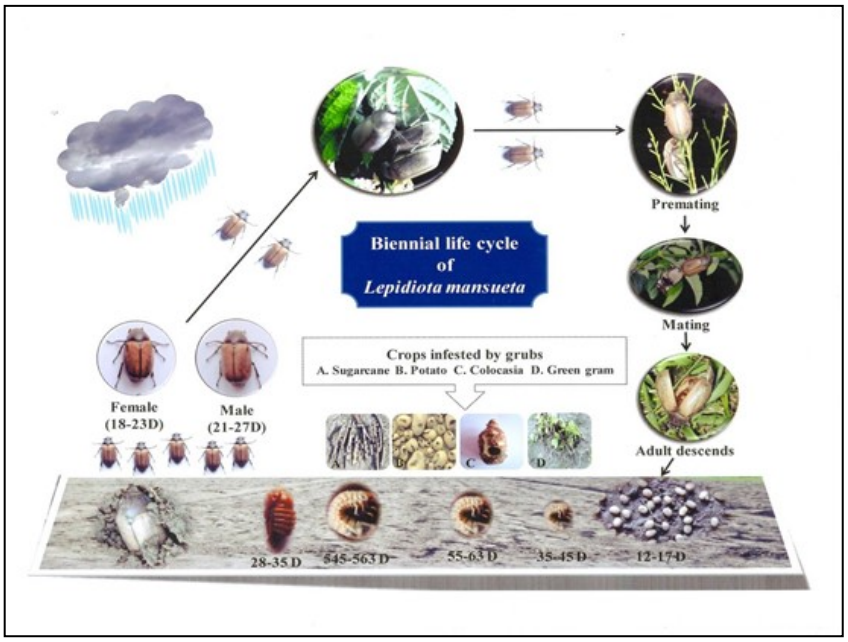

Fig. 1. Biennial life cycle of *L. mansueta*

biennial life cycle (Fig.1), which is the first of its kind from North East India. It is a unique biennial species, spending its entire life cycle under the ground except for a very short period during which adults come out of the ground for mating and oviposition. Grubs are voracious feeders. However, there is no evidence showing that the adults fed on any plants either in the field or laboratory and hence this species has the unique distinction as the first Indian phytophagous white grub species with nonfeeding adults (Bhattacharyya *et al*., 2015). The probable reasons of endemism/outbreak are due to the high organic carbon content of the soil (0.75-1.00%) and presence of abundant thatch zone (dead grass, stems and other organic debris) in the endemic pockets. Other reasons may be nonarrival for last several years, of the migratory bird Siberian crane (*Grus leucogeranus*), a seasonal predator of the grubs in Majuli probably because of the changing climate with erratic rainfall and early onset of summer in the riverine island. Moreover, conversion of virgin low grass lands (sand bars) by the flood and erosion affected people into agricultural farm lands-a potential problem inviting future outbreaks of the species in massive proportions in Majuli. Of late, this species has crossed the geographical barrier of the mighty Brahmaputra and spread to other adjacent riverine areas.

Worrying factors

There were lots of "worrying factors" as far as management of this atypical species of white grub as mentioned below:

a) *L. mansueta* has biennial life cycle which is first of its kind from North East India. Third instar grubs were found to be voracious feeders of roots/tubers/corms of crops and they remained active in the field up to 18 months. As it spends its entire life cycle under the ground except for a short period during which adults come out of the ground for mating, the species was thought to be irregular in occurrence or even migratory; whereas it was very much resident species of Majuli.

b) Application of soil insecticide was effective only against the short-lived 1st and 2nd instar grubs but not against the 3rd instar grubs. Third instar grubs showed typical downward vertical migration into the deeper layer of soil and remained inaccessible to the insecticidal treatments and hence unaffected.

c) It was very difficult to detect the presence of white grubs in both cultivated and noncultivated fields though the grubs were abundantly available in endemic areas (10-15 grubs/sq. m) without showing any detectable above ground symptoms of infestation on the plants.

d) One of the major tactics for managing the adult scarab beetle population that congregated on some preferred host plants during pre-monsoon or monsoon by spraying recommended insecticides during daytime was found to be absolutely ineffective in case of *L. mansueta*. Because, the adults of both sexes were observed not to feed on any plants in the field and hence this species has got the unique distinction of being the "First record of Indian phytophagous scarab beetle with non-feeding adult**s"**. Moreover, the adult beetles became over ground during evening hours only for 2-3 weeks in April and hence, managing the huge population of adults within a very short period in the evening over a large area was utterly difficult.

e) Majuli river island is an aspirant for getting the tag of "World Heritage site" from UNESCO. Therefore, there was also an urgent need to ponder about nonchemical approaches of managing this insect pest since the application of chemical pesticides is not allowed in such sites.

Vital tipoffs

After unravelling the seasonal cycle and biology, the investigators learned few vital tipoffs worthy of managing the beetles as mentioned below:

- Rush of adult emergence took place for a short period of time in the evening during April-May. Except for this short aerial life for nuptial activity, the species lives a subterranean life.
- Both sexes of the beetle were positively phototactic.
- Beetles emerged from soil for mating during evening hours and spend almost one hour (6.15pm-7.15pm) for premating flight. Beetles could be collected in huge numbers by operating light traps in endemic pockets during 6.30pm-7pm.
- Scouting for hand collection is also effective since the mated pairs are found abundantly on selected sheltering plants in field during 7pm-8.30 pm.
- Beetles can also be used as animal feed for poultry, pigs, dogs, cats etc.
- Some indigenous tribes also consume the beetles as their food.
- Concept of Social Engineering/Farmers participatory approach could be encouraged for the mass collection and destruction of beetles during the period after premonsoon showers in the endemic areas of Majuli river island. In white grub endemic areas adult collection campaigns are being resuscitated, as farmers do not appear to realise their potential impact on reducing damage; this is because they are not conversant with the life cycle of the white grub. In this regard, the community action programmes aimed at collecting adult beetles as they emerge offer a practical and cost-effective method of management, and should be pursued.

How the Social engineering concept was embraced for the management of Majuli beetle?

Social engineering is a discipline in social science that refers to efforts to influence particular attitudes and social behaviors on a large scale, whether by governments, media or private groups in order to produce desired characteristics in a target population. Adaptive research and development methods, participatory technology development and community involvement are important elements for the desired outcomes. Social engineering means a balance between the competing interests in society, in which applied science are used for resolving individual and social problems. Social engineering is a data-based scientific system used to develop a sustainable design so as to achieve the intelligent management of resources and capital with the highest levels of freedom, prosperity and happiness within a population. A participatory approach, tends to focus initially on small numbers of clients participatory and is location specific in nature. Rather than "passive participation," it is aimed to inspire "self-mobilization", where

communities organize and take initiative independently to solve their problems/issues. Community mobilization is the process of engaging communities to identify community priorities, resources, needs and solutions in such a way as to promote representative participation, good governance, accountability, peaceful change and achieving the objectives. Participatory technology development programme with farmers can be done in collaboration with NGOs and extension staff, albeit with training and adjustments to present methods of operation. In case of group approach the main challenge is sustainability of the groups. This concept heavily relies on all the members coming together to achieve a common goal, finding technical solutions and building capacities in the extension system and bridge the gaps in knowledge and technology dissemination.

The underlying principles of social engineering/participatory approaches/community mobilization can effectively and intelligently be explored in solving some crucial constraints related to agriculture and allied sciences. Such type of approaches not only improves crop productivity and livelihood but also tremendously improves overall knowledge contents and capacity building of the farming community. Most of such approaches are ecofriendly, economical and sustainable. The visibility of extension programmes as well as accountability also become more vibrant.

Salient features of the beetle management approach

Field and laboratory studies on seasonal cycle and bio-ecology of *L. mansueta* conducted during 2005-2009 in Majuli and adjacent endemic villages located in different sandbars revealed that the mass collection and destruction of adult beetles by mass campaigning during the period after pre-monsoon showers became inevitable in the endemic areas. During that period, farmers of Majuli did not realised the potential impact of this pest since they were not at all conversant with the biennial life cycle of *L. mansueta* with nonfeeding adults but voracious grubs. Majority of the farmers believed that the grubs were not pests but helpful in increasing the fertility of soil, just like earthworms. Considering farmers wrong perceptions about this notorious pest, a parallel planning was done to carry out both basic research as well as community action programmes/ social engineering/farmers participatory approaches aimed at collecting adult beetles during evening hours (6pm-9pm during April-May) as a practical and cost-effective method of management. These extension activities were initiated from 2010 onwards in collaboration with different stakeholders under the theme "Mass campaigning against *L. mansueta* in Majuli river island and adjacent sandbars through social engineering".

How the "*Lepidiota* Management Groups" were formed?

From the very beginning of mass campaigning against *Lepidiota* beetles, group-based approach for the mass collection and destruction of beetles was given the top most priority. Each village was selected based on the population and extent of damages caused by the grubs, presence of functional farm management committee/self-help groups/gram panchayats and a "*Lepidiota* Management Groups" was formed in each beetle endemic village consisting of 10 active farmers. The year wise numbers of *Lepidiota* Management

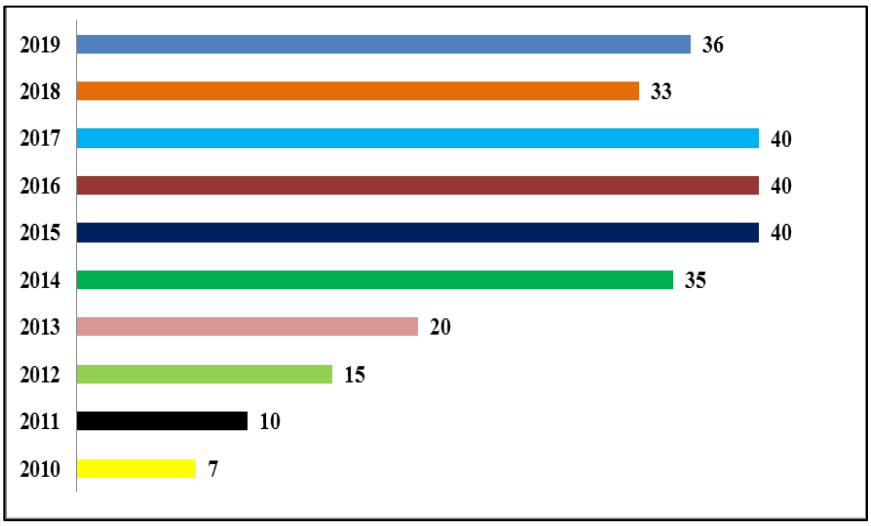

Fig. 2. Year wise (2010-2019) *Lepidiota* Management Groups (LMGs) who received technical knowledge and skill, technical input and other necessary supports from AINP-SAP, AAU- Jorhat Centre

Groups (LMGs) is presented in Fig. 2. These active LMGs since 2010 onwards, who received technical knowledge and skills, technical inputs and other necessary supports from AINP on Soil Arthropod Pests, AAU, Jorhat Centre.

Towards participatory approaches for beetle management

Parallel planning was done to carry out both basic research as well as community action programmes/social engineering/farmers participatory approaches aimed at collecting and destructing the adult beetles during April-May with the help of tribal and other farmers in Majuli from 2010 to 2019. Besides involving farmers, collaboration in this regard was sought from farm management committee, self-help groups, KVK Jorhat, state extension staff, *gram panchayat,* NGOs and district administration, Majuli. To sensitize farmers the following tools of social engineering were extensively used.

a) Smart SMSing to farmers through www.way2sms.com

b) Video-conferencing

c) Use of social networking site

d) Use of print and electronic media

e) Extension trainings

f) Farmer-scientist interaction

g) Field day

h) Exhibition

i) Awareness meeting

j) Documentary shows

k) Posters and banners

l) Distribution of photographs/leaflets

m) Exposure visit

n) Conducting field experiments in endemic areas

o) Visit of Entomologists from other institutes/university

p) *Rongoli* making to depict the life cycle of *L. mansueta*

Fig. 4 (A-H). Collection and destruction of *Lepidiota* beetles through mass campaigning programme conducted at Majuli during 2010-21

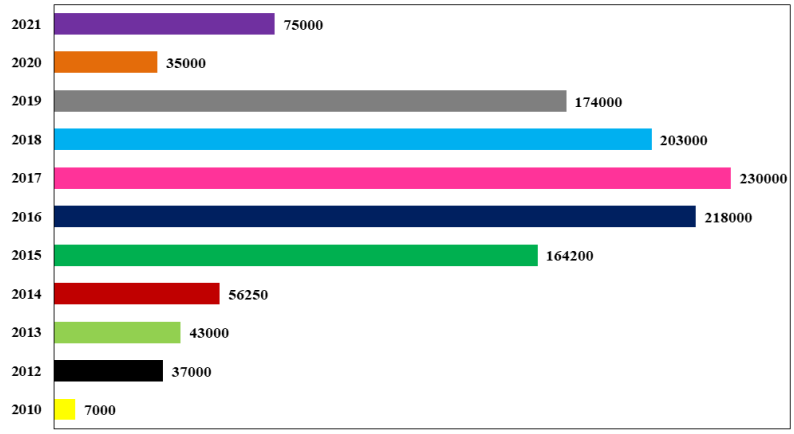

Fig. 3. *Lepidiota* beetles collected and destroyed during 2010-21

(Unsuccessful collection in 2011 due to heavy rain and low emergence of beetles)

q) Demonstration on collection of beetles using Solar LED light traps

r) Demonstration on using *Lepidiota* beetles as human food/animal feed

s) Use of public address system

t) Distribution of extension bulletins

u) Technology showcasing

v) Telephonic discussion

w) Developing interactive mobile app

x) Organizing insect photography competition

y) Distribution of awareness calendar, awareness cup, awareness plate and awareness rain head umbrella

z) Use of drone technology as a means of artificial intelligence for monitoring beetle holes

Mass collection and destruction of beetles

This mass campaigning programme received overwhelming response and was exceedingly successful leading to massive collection and killing of about 12.43 lakhs of *L. mansueta* beetles in Majuli river island during 2010-2021 (Fig. 3 and 4). The major advantages of such approach are -(i) the gravid females are killed before egg laying, (ii) capacity building amongst the farmers in white grub endemic areas and the management approach is ecofriendly and cost effective. It is worth mentioning that some of the local tribal people relished the cooked/fried adults of *L. mansueta* as protein rich food which opens up an avenue of further research on its nutritive/nutraceutical value.

Nutritional profiling of Majuli beetle

Efforts were also made to analyse the nutritional profiling of the beetles for their further exploration as human food/animal feed (Bhattacharyya *et al*., 2018). The proximate analysis of the beetles revealed a higher amount of crude protein content (76.42%) along with other proximate parameters like crude fat (4.10%), crude fibre (5.16%), total mineral (2.98%), carbohydrate (9.18%) and moisture (2.16%). The energy content was 379.29 kcal/100 g of sample. Elemental analysis revealed the presence of 7 minerals *viz*., Na (27.76), K (14.20), Ca (33.33), Fe (1.64), Cu (6.52), Zn (15.55) and Mn (1.30) mg/100 g of sample. As

antioxidant properties, the phenol and flavonoid content was found to be 4.00 mg catechol equivalent/g and 1.59 mg quercetin equivalent/g, respectively. The DPPH was registered 22.60 per cent whereas tannin (3.24 mg/g) as antinutritional compound was recorded at acceptable level. Fatty acid profiling showed maximum amount of saturated fatty acid (2.24%) followed by mono unsaturated fatty acid (0.57%) and polyunsaturated fatty acid (0.49%). Altogether 10 fatty acids were estimated, of which palmitic acid content was recorded in maximum amount (0.28%). Amino acid profiling registered 17 amino acids, of which 8 were found essential. Considering the immense nutritional value of the beetles, beetle fry dish (https://www.youtube.com/watch?v=ZaTKT_ftT5M) was developed and popularized through community feast. Of late, concerted efforts have also been initiated to explore *L. mansueta* powder for making biscuits and other confectioneries (Fig. 5).

Initially, the tribal populace relished the cooked/fried adults of *L. mansueta* as protein rich food as part of their traditional belief and wisdom. However, of late, nontribal people are also equally showing their interest to explore the beetles as human food/animal feed after knowing the nutritional advantages of the beetles. This effort had tremendous impact in reducing beetle load in Majuli island in terms of protecting the crops, enhancing crop productivity as well as improving both livelihood and nutritional security.

What makes *L. mansueta* beetles as an ideal edible insect?

a) The nutritionals advantages of *L. mansueta* in terms of proximate and elemental composition, antioxidants as well as profiling of fatty acids and essential amino acids have attracted the people to accept the beetles as human food. Demonstration on exploration of the beetles through community feast organized across the island has helped not only to promote entomophagy but also found to build-up confidence on the people as far as safety factor is concerned.

b) As regards to antinutritional compound, the mean tannin content (3.24 mg/g) was recorded at an acceptable level and hence there is no chance of any detrimental effect on health.

c) *L. mansueta* beetles do not feed on any plants and consequently there is no chance of accumulation of toxic chemicals through feeding by the beetles.

d) Both the sexes of the beetles exhibited ever-empty thread like gut that further confirmed the nonfeeding nature of the adults.

e) No toxic glands in the grubs were detected even though the third instar grubs are voracious root feeders.

f) The processing and preparation of beetle fry dish doesn't take much time. Fried beetles are crispy and good in taste. Fried female beetles having eggs were more preferred than the male beetles.

India Book of Records for massive beetle collection

The AINP on Soil Arthropod Pests, AAU, Jorhat Centre has made "National Record" of "Most Beetles collected in 3 hours" by collecting 73700 numbers of white grub beetle, in collaboration with 100 farmers

Fig. 5. Exploration of *Lepidiota mansueta* beetles as "human food/animal feed" A. Fried dish prepared from adult *L. mansueta*; B. Roasted *L. mansueta* beetle dish; C, D. Feast to popularize the "beetle fry" dish; E. Value added products like biscuits, cake and bhujia prepared from *L. mansueta* powders; F, G. Lepidiota beetles using as "animal feed"

of Majuli at Maharichuk Village on 9th April, 2018. This record attempt was made under the ongoing mass campaign against white grub beetles with the following objectives:

a) To destroy the huge breeding ground/ reservoir of white grub beetle in a single strike

b) To create awareness about the beetle menace among the farmers and other stakeholders

c) To show the power of "Social Engineering/Large Community Mobilization" in pest management

It is worthy to mention that a major portion of the beetles so collected were explored as both human food/animal feed to build up confidence amongst the clients. The success story of setting national record was highlighted by most of the print and electronic media of North East India and hence, the zeal for the mass collection of beetles as well their consumption was tremendously increased by many folds.

Impact assessment study on group approach on extension management of white grub

A total of 200 beneficiary farmers belonging to 36 numbers of "Lepidiota Management Group" were randomly selected for the study and interviewed personally through semi-structured pre-tested questionnaire to know the real impact of the group approach on extension management of white grub in Majuli. It revealed that the main logic of the mass campaigning conducted during 2010-2019 for managing the white grub with the help of farmers group was fulfilled to a great extent. The group members perceived that due to formation of the groups, there was reduction in white grub infestation, reduction in occurrence of adult beetles from soil leading to decline in population of grubs in soil. Most of the members also perceived that productivity of different crops such as potato, sugarcane, Colocasia, green gram had increased due to reduction in white grub infestation after the introduction of group approach of extension management. Wide varieties of assistances/material incentives were received by the Lepidiota Management through "Tribal Sub Plan Grant" provided by the Indian Council of Agricultural Research, New Delhi. Social engineering and free inputs to the groups were the major interventions and the immediate output was the formation of groups and this output led to different outcomes such as decrease in population of white grub, decrease in pest infestation/damage, increase in crop production and productivity, increase in farm income, adoption of recommended practices for management of white grub, and above all, the extent of people participation and zeal to work in group also increased. Moreover, impact was also observed in non-project areas due to spreading effect of group approach in a passive way. Majority of the respondents of both group and non- group members had favorable attitude towards group approach of management of white grub. Farmers also readopted the crops that were discontinued earlier due to severe white grub infestation and successfully expanded crop area under crop cultivation after reduction of grub population. Constant efforts of project team to convert this pest as both human food and animal feed also gained popularity among the Majuli populace.

Success stories documented

Success story of the whole mass campaigning programme and the exploration of *Lepidiota* beetles as human food has been highlighted

by almost all vernacular daily newspapers and electronic media of Assam and also cited by many national e-journals/Magazines/ conservation and environment sites etc. The lead scientist of this endeavour also received "Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems, 2014" (bestowed ICAR, New Delhi) and "Dr. H. K. Jain CAU Award 2015-16" for "Excellence in Agricultural Research in the North-Eastern States of India" besides other recognition.

Conclusion

The mass campaigning programme explored the group approach of extension mostly targeting the flood and erosion affected farmers in Majuli and had tremendous impact in terms of protecting the crops, disseminating ecofriendly technologies, enhancing crop productivity as well as improving both livelihood and nutritional security. White grub is a dangerous destructive insect which can cause major havoc in almost all cropping systems generally followed in the North Eastern region. Hence ecofriendly management of scarab beetles by embracing "Social Engineering" is extremely important during the peak emergence of beetles, immediately after the first shower of pre monsoon rains. Awareness creation is one of the main requisites to manage this insect, not only in Majuli, but also in other parts of the country.

Edible insects can be considered as a biological treasure in North Eastern region and needs proper exploration to provide both nutritional and livelihood security. To harness the enormous economic value from the edible insects a more holistic approach with multi-disciplinary linkages involving policy makers and other stakeholders needs to be embraced. Due to the high resource efficiency and good nutritional value of insects, insect rearing for entomophagy seems to fit perfectly with a modern food production system. The edible insects could therefore be potential source for human food and animal feed since they exhibited a well-balanced nutrient profile. Extensive study is also needed to explore the edible insect fauna of this region and develop noble bioprospecting models so that they could be explored as mini livestock. Proper roadmaps for promoting insects as human food/animal feed as well as development of supportive and comprehensive legal frame work could pave the way for more investments for making it as a profitable business venture. Recent initiative of the Central Government to implement "Act East Policy" may facilitate international trade with South East Asia Countries, where "Edible Insect Industry" has already flourished.

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