GRAHAM SUSTAINABILITY INSTITUTE
UNIVERSITY OF MICHIGAN

Catalyst Grant Final Project Reporting

Final Project Report

Date: May 24, 2021

Final Report Template

Part 1:

Project title: Sustainable Palm Weevil Farming to Address Food Insecurity and Income Generation at Maternity Waiting Homes in Liberia

Project team

Principal Investigator: Jody R. Lori PhD, Professor & Associate Dean for Global Affairs, School of Nursing, 400 N. Ingalls Building, Ann Arbor, MI 48109, Phone: (734) 763-0097, Email: jrlori@umich.edu

Additional Co-Investigators: Cheryl A. Moyer PhD, Associate Professor, Learning Health Sciences, School of Medicine, 1111 Catherine St. Ann Arbor, MI 48109, Phone: (734) 615-2838, Email: camoyer@umich.edu

Additional Team Members:
Jacob Anakware PhD, is CEO and Founder of AnePaare Farms. Phone: +233246776156, Email: anankware@yahoo.com His role is to provide expert consultation and supervision of training in the processes of palm weevil farming.

Alphonso Kofa MPH, Director, Bong County Health Team, Liberia. Phone: +23177565756 Email: alphonsokofa@yahool.com Mr. Kofa role as project manager is for coordination of the training, purchasing supplies for set up of the palm weevil farms and on-going process evaluation.

Barsee Zogbaye, RN, BSc, Reproductive Health Supervisor and Aloysius Nyanplu, BA, Monitoring & Evaluation Specialist, Bong County Health Team, Liberia. Phone: +231886421062/+231880918639, Email: barseezogbaye@gmail.com and bnyanplu@gmail.com Together they will be responsible to training (with oversight from Dr. Anakware) for the midwives and traditional birth attendants and provide follow-up and data collection at the community level for the duration of the project.

UM Nursing, Public Health & Medical Students will also be incorporated into the project.

Summary

Food insecurity is widespread in Liberia, with every fifth household considered food insecure, mainly affecting poor rural households. Nearly two-thirds of pregnant women in Liberia are anemic. In 2010, the UM and the Bong County Health Team established the first six maternity waiting homes (MWHs) in post-

conflict Liberia. MWHs are residential dwellings located near health facilities where women in the late stages of pregnancy stay to await childbirth and receive immediate postpartum services. In 2019, a country-wide assessment of MWHs throughout Liberia, was conducted, identifying scale-up to 114 MWHs. Data identified access to food at MWHs as a major barrier to women using MWHs. Interviews revealed indigenous insects are an acceptable food source consumed by pregnant women in rural areas.

This intervention was a unique public/private partnership between the University of Michigan (UM), Ghana-based AnePaare Farms, and the Bong County Health Team. The goals of the intervention were to: 1) develop local knowledge for the start-up, maintenance, and processing of edible insects through a training program; 2) document successful larvae production from project evaluation participants' rearing kits after two complete cycles; 3) evaluate whether income generation through insect farming will generate a sustainable source of revenue at rural MWHs.

Table 1*:* Comparison of sources of protein and iron

Meat	Protein Content (g/100 g)	Iron Content (mg/100 g)
Palm weevil Rhychophorus phoenicis larva	**66.3**	**30.8**
Goat (Chevon)	**27.1**	**3.8**
Cow (Beef)	**27.4**	**3.4**
Fowl (Chicken)	**24.0**	**1.7**
Sheep/lamb (Mutton)	**25.6**	**1.6**
Fish	**23.3**	**0.9**
Duck	**11.5**	**2.7**

Training was successfully conducted for about 60 participants in four MWHs namely; Naama, Fenutoli, Janyea and Phebe). Participants were also provided palm larvae rearing kits, starter culure of adults, larvae and cocoons as well as a wooden structure for their insect colonies. Naama and Phebe MWHs were able to produce enough larvae for sale and consumption. Fenutoli mainly produced for consumption. We had challenges at Janyea where all their larvae got drowned after the second cycle. The intervention was able to reduce food insecurity for pregnant women awaiting delivery and also served as an income generating activity. Generally, sourcing palm yolk or cassava as feed for the larvae was the major setback to the intervention. Rearing palm larvae has the potential to provide a sustainable source of revenue at rural MWHs in Liberia to purchase additional staple foods. Future projects should make funds available for participants to source feed for at least the first two cycles and plan for future scale-up to all 114 MWHs across Liberia

Project background and approach

- Provide a brief overview of the issue, including the sustainability challenge the work sought to address
- Identify the external partner(s) and their interest in the work
- Describe the activities/process

Background

Food insecurity is a significant problem in low-resource countries, where poverty and lack of resources results in much of the population becoming malnourished.[1] Women and children are especially at risk; it is estimated that undernutrition is the underlying cause of over one-third of child deaths and 10% of the total worldwide burden of disease. [2] In Liberia, food insecurity is widespread, with every fifth household considered food insecure, mainly affecting poor rural households. Nearly one-third of children under age five in Liberia suffer from stunting, and micronutrient deficiencies are highly prevalent. [3] In addition, nearly two-thirds of pregnant women in Liberia are anemic. Providing adequate nutrition, including

balanced protein and iron intake, to pregnant women has been shown to reduce the incidence of small-for-gestational age births, stillbirths, and low birthweight newborns. [1,4]

While strategies such as crop modification and various income-generating activities (IGAs) have been proposed as potential solutions to food insecurity, very little literature is specific to sub-Saharan Africa, and none explicitly addresses the impact of such interventions on the planet or considers long-term sustainability.

One approach gaining recognition is the consumption of nutritious indigenous insects as a safe dietary supplement, which can also serve as an IGA for economic stability, if insects are commercially harvested. [5,6,7] Studies have found that insects provide four times the amount of iron and ten times the amount of protein as beef and are far more environmentally sustainable [8,9] (See Table 1.) In addition, our previous project evaluation has demonstrated that insect consumption is acceptable among pregnant women in Liberia. [10]

External partners

Our main partner, the Bong County Health Team, is a branch of the central Ministry of Health (MOH). The role of the members of the Bong County Health Team was to coordinate and conduct the training at the rural MWHs, purchase supplies for the set-up of the palm weevil farms, provide on-going process evaluation, collect data for the duration of the project, contribute to data analysis, and dissemination of findings.

Our Ghanaian partner, Dr. Jacob Anakware, CEO and Founder of AnePaare Farms provided the critical, expert consultation and supervision of training in the processes of palm weevil farming.

AnePaare Farms developed an innovative approach to rearing edible insects using simple tools, including a bucket and mesh screen, packaged as a rearing kit. The ‘insect farmer’ needs three minutes every two days to attend to the rearing kit until insect maturity in 21 to 28 days, at which time matured larvae were ready for harvesting.

Activities/Process

The cultivation of edible insects has minimal impact environmentally, unlike raising animals or large agricultural crops for consumption. Adult palm weevils are harvested from dead palm trees usually felled to pave way for new plantings. Only 10% of a dead palm tree is used in palm larvae production. The ‘yolk’ (Inner core of dead palm trees) from the apical merismatic tissues was harvested as feed for palm larvae farming; the remainder is allowed to rot and fertilize the land. Palm weevil farming is economically sustainable because it uses alternative feed substrates such as sugar cane, pawpaw, brewery waste, local beer brewing and coconut husk waste that is typically discarded. The utilization of organic waste contributes to the environmentally sustainable nature of insect cultivation and reduces environmental pollutants. Project outputs and outcomes from this evaluation provided data for decision-making to support future country-wide scale-up.

Data collection was done in Bong County within four (4) MWHs in four communities (Naama, Janyea, Phebe and Fenutoli). The Bong County Health Team members collected process evaluation data through discussions with participants and direct observation and documented system barriers and facilitators to program implementation.

Aim #1: Develop local knowledge for the start-up, maintenance, and processing of edible insects through a training program.

To achieve aim #1, AnePaare Farms hosted and trained two Bong County Health Team members (Barsee Zogbaye and Aloysius Nyanplu) in January 2020 in Ghana for 11 days on basic introduction to palm weevil farming. They served as the lead trainers for participants at the MWHs in Liberia under AnePaare Farms supervision.

These lead trainers returned to Liberia and trained three midwives and three trained traditional midwives (TTMs) at 1 of the original 5 MWHs established in rural Bong County on the process of how to start and maintain the rearing kits.

Dr. Anankware from AnePaare Farms traveled to Liberia in September 2020 to evaluate the start up and train an additional 16 participants in total at four MWH sites: Naama, Phebe, Fenutoli, and Janyea. These participants were pre-and post-tested on knowledge of palm weevil farming (see tables 2 and 3 below). Data collection included a pre-to-post knowledge test of participants on the startup, maintenance, and processing of edible insects. The training included how to process the palm weevil larvae into food powder, cubes, protein bars, pies, cakes and as a weaning feed for infants. Rearing the palm weevil from an adult to the consumable larval stage takes only 21 to 28 days depending on the environmental conditions, the quality of the feed, and the presence or absence of parasitoids. A complete lifecycle for continuous rearing takes 60 days.

Table 2. Pre- and Post- training knowledge test descriptive statistics

	Pre-test (N=16) n (%)	**Post-test (N=16) n (%)**	**p-value**
Overall score, mean (SE)	**2.31 (0.45)**	**7.75 (0.39)**	
There is more protein in palm weevils than in chicken.	6 (37.50)	16 (100.00)	<.01
There is more protein in palm weevils than in beef.	8 (50.00)	16 (100.00)	<.01
There is more protein in palm weevils than in fish.	5 (31.25)	16 (100.00)	<.001
Insect farming is more sustainable than livestock farming.	5 (31.25)	15 (93.75)	<.01
Palm weevil larvae matures in which stage?	0 (0)	7 (43.75)	<.01
Palm weevils have males and females.	5 (31.25)	16 (100.00)	<.001

How many eggs does a palm weevil lay after mating?	0 (0)	5 (31.25)	.02
How long does it take for palm weevil eggs to hatch?	0 (0)	7 (43.75)	<.001
You must feed palm weevil larvae every day.	7(43.75)	13 (81.25)	.05
Which metamorphic (developmental) stage is consumed?	0 (0)	13 (81.25)	<.001

Table 3. Pre-and post-training knowledge test paired samples statistics

	Mean	N	Std. Deviation	Std. Error Mean	Significance
Pre-test	2.31	16	1.81	0.45	<.001
Post-test	7.75	16	1.57	0.39	

Aim #2: Document successful larvae production from project evaluation participants' rearing kits after two complete cycles.

Participants were trained to complete daily data collection on larvae production worksheets. All four sites successfully produced larvae from their rearing kits for two or more cycles (four months).

Aim #3: Evaluate whether income generation through insect farming will provide a sustainable source of revenue at rural MWHs.

Participants recorded income generated through insect farming. Only one of the four MWHs was able to produce enough palm weevil for consumption as well as to provide a source of income for the MWH. Approximately 50% of the production was consumed by pregnant women staying at the MWH and 50% were sold for a profit at the Phebe Maternity Waiting Home. At the remaining MWHs (Janyea, Fenutoli, and Naama) all palm weevils raised were consumed by pregnant women staying at the maternity waiting homes. Table 4 shows the average number of deliveries and women staying at each of the MWHs during the time of palm weevil production (July-December 2020).

Table 4. Average number of deliveries and number of women staying at MWH (July-December 2020)

Facility	Average Number of Deliveries	Average number of women staying at MWH
Phebe	49.33	5.83
Naama	29.17	11.50
Janyea	16.67	5.67
Fenutoli	30.00	13.17

Findings

We found a statistically significant difference in the pre- and post-test knowledge acquisition on the start-up, maintenance, and processing of edible insects through a training program. Participants were able to understand the content of the training and start-up a palm weevil insectary at four maternity waiting homes in rural Liberia (see photos 1 & 2).

Photo 1. Insectary in rural Bong County

Photo 2. Harvesting Palm Yolk for Larvae Feed

When participants were asked about the best way to eat the harvested palm weevil larvae, 50% indicated the larvae were best eaten when grilled while 25% preferred to eat fried and 25% favored boiled larvae (Photos 3 & 4).

Photo 4. Palm weevil harvest at Fenutoli

Photo 3. Child with Harvested Palm Weevil Larvae

The larval production from the various rearing centers was relatively low, ranging from 120 to 721 within the two production cycles (Table 5). This was attributable to the lack of feed for the larvae. Although the colony started with artificial selection through the control and manipulation of feed (palm yoke and sugar) without environmental manipulation, natural selection selected offspring with unique and heritable fitness within the population to increase the fitness of the individuals in the subsequent generations. In nature, complex community interactions drive natural selection, and these interactions were underpinned by the variations in environmental condition across rearing centers leading to relatively low larval output from some breeding centers (Janyea, Fenutoli, and Phebe). Furthermore, rainwater drowning (Janyea) and lack of feed for continuous palm weevil larval production were some other factors that might have led to a reduction in output. Cocooning and adult eclosion was averagely low across all rearing center (Table 6). This may be attributed to the activities of parasitoids and predation at Fenutoli and Phebe.

Table 5: Average number of larvae produced at the various rearing centers

Respondents	Number of Bins Inoculated	Number of larvae at harvest	Number of larvae diverted	Larval mortality	Adult mortality	Larval duration
Naama	2	721	300	80	5	28
Janyea	2	187	102	21	3	28
Fenutoli	2	120	84	17	3	28
Phebe	2	200	107	48	4	27

Table 6: Average number of cocoons and adults from the production centers

Respondents	Number of Bins Inoculated	Number of larvae inoculated per bin	Number of cocoons sorted	Adults sorted at harvest	Duration
Naama	2	20	10	10	21
Janyea	2	20	10	6	21
Fenutoli	2	20	12	8	21
Phebe	2	20	2	0	21

Outputs

A manuscript of our project is currently underway. Outputs achieved include: 1) develop local knowledge for the start-up, maintenance, and processing of edible insects through a training program; 2) document successful larvae production from study participants' rearing kits after two complete cycles; 3) evaluate whether income generation through insect farming will provide a sustainable source of revenue at rural MWHs. We are currently developing a manuscript from our data for publication in a peer-reviewed journal. Using data from this pilot project, we have submitted a proposal to the Grand Challenges – Small Farming Innovations for Small-Scale Producers funded by the Bill & Melinda Gates Foundation.

Outcomes

Our identified project outcomes include a small-scale evaluation/proof of concept for sustainable palm weevil farming at maternity waiting homes in rural Liberia. Our long-term outcome is to develop a sustainable solution to food insecurity for pregnant women awaiting delivery in rural Liberia. The intervention was able to address food insecurity for pregnant women awaiting delivery and served as a successful income generating activity at one maternity waiting home (Phebe).

Generally, sourcing palm yolk or cassava as feed for the larvae was the major setback to the intervention. Rearing palm larvae has the potential to provide a sustainable source of revenue at rural MWHs in Liberia to purchase additional staple foods.

Other information (optional)
A main challenge was the difficulty with support and supervision from higher level trainers at the MWHs. COVID-19 disrupted the ability to support early learners in a more hands with a more hands-on approach. The most successful MWH site, Phebe, was in close proximity to the Bong County Health Team office. Therefore, the lead trainers were more consistently available for consultation and support.

References

1. Black RE et al. (2008). Maternal and child undernutrition: Global and regional exposures and health consequences. The Lancet, 371(9608):243-260.
2. Muller O, Kawinkel M. (2005). Malnutrition and health in developing countries. Canadian Medical Association Journal, 173(3):279-286.
3. United States Agency for International Development (USAID). Liberia: Nutrition Profile. June 2014.
4. United States Agency for International Development (USAID). Role of Nutrition in Preventing Child and Maternal Deaths: Technical Guidance Brief. August 2017.
5. Anankware J, Osekre E, Obeng-Ofori D, Khamala C. (2016). Identification and classification of common edible insects in Ghana. International Journal of Entomology Project evaluation, 1:2455-4758.
6. Dzerefos CM, Witkowski ET, Toms R. (2013). Comparative ethnoentomology of edible stinkbugs in southern Africa and sustainable management considerations. Journal of Enthobiology and Ethnomedicine, 9(20).
7. Bauserman M, Lokangaka A, Kodondi KK, et al. Caterpillar cereal as a potential complementary feeding product for infants and young children: nutritional content and acceptability. Matern Child Nutr. 2015; 11 (Suppl 4): 214-20.
8. United States Department of Agriculture (USDA) Agricultural Project evaluation Service. Food Composition Database. Accessed March 10, 2018.
9. Elemo BO, Elemo GN, Makinde MA, Erukainure OL. (2011). Chemical evaluation of African palm weevil, Rhychophorus phoenicis, larvae as a food source. Journal of Insect Science, 11(146):1-6.
10. Coley K, Perosky JE, Nyanplu A, Kofa A, Anankware J, Moyer CA & Lori, JR. (2020).Examining the Acceptability and Feasibility of Insect Consumption Among Pregnant Women in Liberia: A Qualitative Project evaluation, Maternal & Child Nutrition, e12990. https://doi.org/10.1111/mcn.129908.