Improving rural livelihoods through participative research on the domestication and breeding of the palm weevil larvae (*Rhynchophorus phoenicis Fabr.)*-

The African palm weevil project

FINAL PROJECT REPORT

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ABSTRACT

As part of efforts to fight against food insecurity, poverty and biodiversity erosion, this project was elaborated to initiate the breeding and domestication of the palm weevil grubs (edible larvae of the African palm weevil: *Rhynchophorus phoenicis Fabricius, 1801*). The project was aimed at determining an appropriate technique and feed formula for the domestication of the larvae, as well as training local people on acquired multiplication and breeding techniques. In order to meet this objective, an experimental system was established in the village of Ntoung, Abong-Mbang Division, East Cameroon. The experimental system was made up of a hut and seven boxes in which the domestication attempts were made. Four feed formulas were introduced in the boxes as substrates to which adult palm weevils were added after being coupled. The feed formulas included: i) only fresh stems of raffia; ii) A mixture of fresh and decayed raffia tissues; iii) Only decayed raffia tissues; and iv) A mixture of decayed raffia tissues and chicken feed. Water was sprinkled on the substrate on a daily basis to maintain the humidity of the milieu. In total, 13 grown individuals of palm weevil grubs were harvested in the domestication attempt, with only two of the feed formulas being efficient for the production of the grubs. However, young maggots were noticed in all the three food formulas within the first two weeks of the experiment, most of which died within the third week. Introduced adult weevils remained alive throughout the experimental period in some of the food formulas, while the survival of these weevils in some feed formulas only lasted for two weeks. Local people were involved at all the stages of the establishment of the experimental dispositive, making the research very participative. Such participatory approach allows for the integration of local knowledge into the planned methodology, while transmitting directly the experimented farming techniques to local communities. Though the results of this experiment indicate that the domestication of these edible larvae is possible, it is important to determine suitable conditions that favor the development of young maggots after the hatching of eggs. Considering the nutrient content of this insect larva, it is important to develop the gotten breeding, so that these larvae may effectively constitute a cheaper source of essential nutrients in Cameroon and in Sub-Saharan Africa at large.

INTRODUCTION

Background

The republic of Cameroon is known as one of the biodiversity hotspots in Africa (Davis et *al*., 1994; Myers et *al*., 2000; Oates et *al.*, 2004). However, this region is characterized by low levels of development, high levels of poverty and increasing rates of biodiversity erosion. More than half of the country's population lives in rural areas and depends almost entirely on agriculture, hunting and gathering for livelihoods. Like in other Congo Basin countries, human populations rely on bushmeat to meet dietary protein needs and as a primary and secondary source of income. Annual bushmeat consumption in the Congo Basin is estimated between 1 million tonnes (Wilkie and Carpenter, 1999) and 3.4 million tonnes per year, with 60% of species harvested at unsustainable rates, constituting great threats to biodiversity conservation (Fa et *al*., 2002).

The place of Non-Timber Forest Products (NTFPs) as an alternative to improve livelihoods while cutting down human pressure on biodiversity and the forest has largely been acknowledged, including NTFPs of plant origin (Arnold and Ruiz Pérez 2001; Belcher et *al*. 2005; Ndoye et *al*., 1997; Vantomme et *al*. 2004), bushmeat (Asibey, 1974, 1991; Wilkie & Carpenter, 1999) and forest insects (FAO, 1995; DeFoliart, 1997; Muafor et *al*., 2012, 2014; Stack et *al*., 2003; Vantomme et *al*., 2004). More recently, concerns are increasing at national, regional and international levels on the need to optimize the potentials of forest insects in human nutrition and as an alternative to food and income sources in participatory and community oriented forest management and conservation schemes. Emphasis is particularly laid on caterpillars, palm beetle grubs, termites, grasshoppers and locusts. These groups of insects have played a historical role in human nutrition across Cameroon and the entire Sub-Saharan African region (FAO, 1995; DeFoliart, 1997; Stack et *al*., 2003 and Vantomme et *al*., 2004).

The larvae of the African palm weevil, (*Rhynchophorus phoenicis Fabricius, 1801*), generally called the palm beetle grub, is particularly appreciated by a great majority of Congo Basin inhabitants. Together with caterpillars, they are the most widely consumed insect in the entire sub region. They equally constitute an important source of income for forest dependent people. Palm beetle grubs are frequently traded in both local and international markets. The demand for this insect is increasing not only in the Congo Basin area, but also in some western countries with high population of African immigrants (e.g. France, Belgium and Italy). However, palm beetle grubs are currently harvested only from the wild (from the stems of raffia and palms) and their availability is very much linked to seasonal variations. The irregular supplies of these larvae make it difficult to satisfy the rising demands, especially during the dry season when wild productions are generally low.

There have been a number of studies on the contribution of this insect to rural livelihoods in the Congo Basin (FAO, 1995; DeFoliart, 1997; Dounias, 1999; Stack et *al*., 2003; Vantomme et *al*., 2004). However, these studies address issues related to the harvesting, processing, consumption and trade of this insect species. Though some studies recommend the domestication and/or breeding of the species as a solution to seasonal irregularity and insufficiency, no attempt to farm the insects has ever been made in the Congo Basin area. The lack of interest in the domestication of this species is principally due to the lack of appropriate farming techniques.

Objectives

In order to make possible the domestication of the palm beetle grub, this research was aimed at developing a farming method that can locally be practiced for both subsistence and commercial production of the grubs at any period of the year. Specifically, the project aimed at:

- Determining an appropriate technique and food formula that can be used for the multiplication and breeding of the palm weevil larvae;
- Training local people on the acquired multiplication and breeding techniques.

Importance of the study

This study has raised the awareness of local people in the Ntung village area on the possibility of domesticating the palm beetle larvae. Many of the villagers plan to establish small farms for the production of the palm weevil larvae, once the farming technique has been improved upon. A successful farming of this insect will increase its availability for local subsistence, providing increased opportunity for alternative protein sources in the area of study, thereby assuring a year round availability of this resource. By providing the opportunity to villagers to increase their protein and income sources, the study contributes directly or indirectly to solving the major problems of food security, poaching and poverty in this humid forest region of Cameroon.

THE AFRICAN PALM WEEVIL IN CAMEROON

The African palm weevil is one of the ten species of the genus *Rhynchophorus* that exist across the world. They belong to the family *Curculionidae*, commonly called snout beetles and known to be one of the most diversified group of insects in the world. Members of this family are characterized by adults having a snout-like projection of their mandibles called rostrum (Photo 1). These modified mouthparts are used for feeding and to prepare holes in host plant material in which eggs are laid. The larvae (or grubs) have relatively large mandibles and are legless (Photo 2). In Cameroon, there are two species that belong to the genus *Rhynchophorus: Rhynchophorus phoenicis (Fabricius, 1801)* and *Rhynchophorus quadrangulus (Quedenfeldt,1888)*, both of which are consumed at their larvae stage. *Rhynchophorus quadrangulus is* adapted to highland areas and occurs only within the humid mountain ranges of the Cameroon Volcanic belt (Southwest, West and Northwest regions of Cameroon).

Photo 1: Adult African Palm Weevil

Photo 2: Larvae (grubs) of the African Palm Weevil

Rhynchophorus phoenicis is relatively more common and occurs in the entire humid lowland forest and savannah regions of the country. The distribution of this species has widely been recorded across tropical Africa (Tambe et *al.*, 2013), where they feed mainly on oil palm (*Elaeis guineensis Jacq*.), date palm (*Phoenix dactylifera L*.), raffia palm (*Raphia spp*.) and coconut palm (*Cocos nucifera L*.) (Gries et *al*., 1993). They are usually considered as important pests of these plants species; due to the boring action of the larvae into the plant stems, causing the yellowing of leaves (Mariau et *al*., 1981).

AREAS WHERE THE PALM BEETLE GRUBS ARE CONSUMED IN CAMEROON

The palm beetle grubs are consumed in seven of the ten regions of Cameroon (notably the East, South, Center, Littoral, Southwest, West and Northwest regions). These regions cove the entire humid part of the country, found south of Adamaoua (Figure 1). The larvae have different names according to the dialect of the different areas where they are consumed.

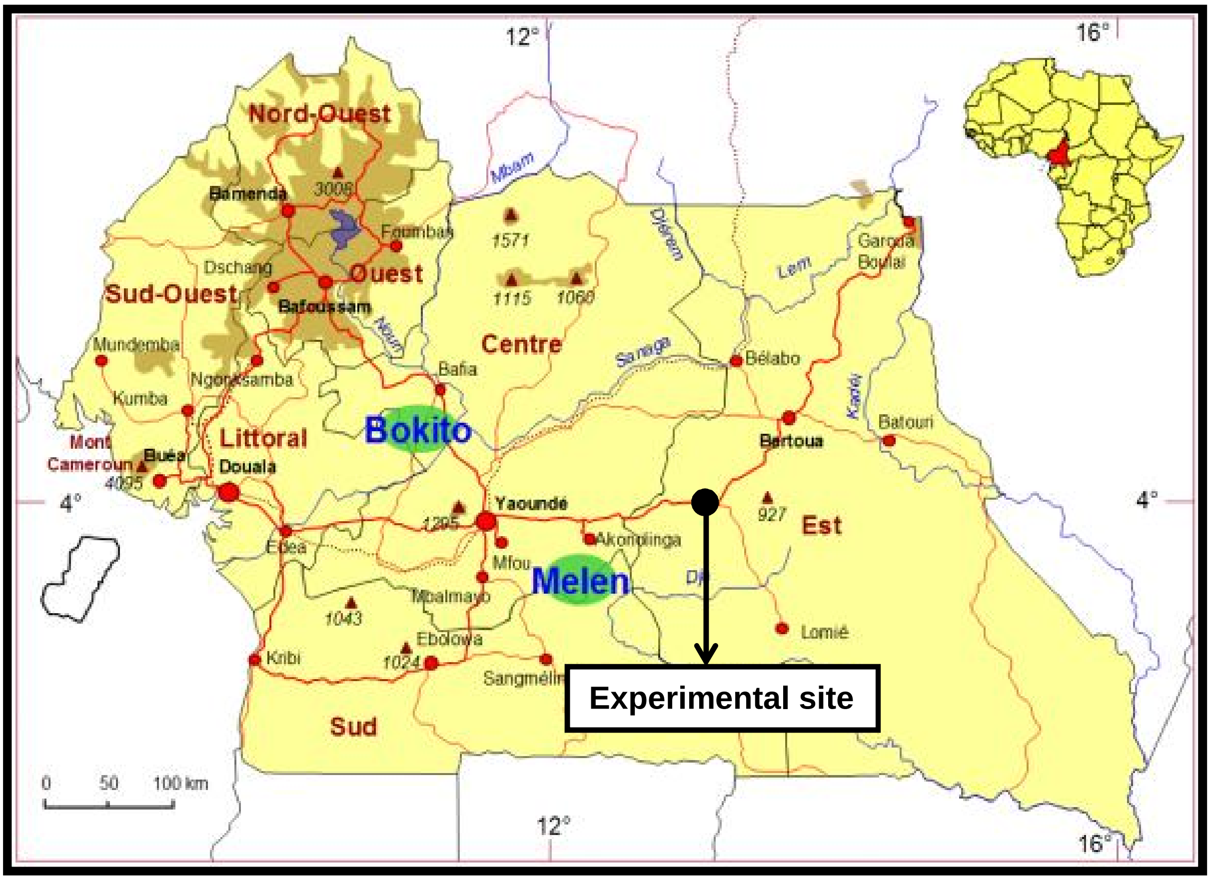

Figure 1: Area of consumption of the palm weevil larvae in Cameroon, showing the experimental site.

They are commonly called "fos" by the Ewondo people in the Center, ″mbé″ in the Yemba dialect (Dschang) in the West, “poseh” by the Baka and the Bagando communities in the East and ″tumbu″ or ″tumbu for palm tree″ in Pidgin English that is commonly used by the English speaking communities of the Southwest and Northwest regions of the country. These larvae are highly solicited for food in most parts of Cameroon today and are even offered as a special dish in important ceremonies and high standard restaurants in some urban cities in the South and Center regions of the country.

TRADITIONAL HARVESTING OF PALM BEETLE GRUBS

The larvae are harvested by systematically extracting them from trunks of oil palms when the palms have been cut down for palm wine production or from the trunks of Raphia palms growing densely in swampy lowlands. Adult females attracted to dying or damaged parts of palms lay eggs in the decaying parts of the trunks that are left after the extraction of sap. Mature larvae may then be harvested after some weeks. Quantity harvested from oil palms is generally lesser than those from raffia palms. In the case of raffia, harvesters spend hours in the dark muddy waters in order to obtain important quantities, ignoring risks of insect and snake bites. Dead raffia stems are split up with cutlass or axes and grubs are picked by hand. According to Dounias, only half a dozen villages in southern Cameroon specialize in the harvesting of larvae for trade. Such specialized collectors have developed some expertise, each with specific harvesting tools and techniques (Dounias, 1999). However, the identification of infested raffia stems is a prerequisite for local expertise. This is basically done by searching for raffia stems with slightly yellow juvenile leaves in the swampy raffia forest. Some skilled harvesters detect the odor, crawling, sound or vibrations produced by the larvae.

MARKET VALUE OF PALM WEEVIL GRUBS

Palm weevil grubs are a particularly important economic resource in Cameroon. They provide complementary income to many rural people who depend on growing palm weevil trade as their main or part-time activity. From the dense humid semi-deciduous forest zone in the East to the highland Savannah in the West, this insect is traded cooked or uncooked by small-scale roadside vendors or hawkers in some urban markets. Some markets in urban cities are particularly reputed for the sales of the palm weevil grubs, amongst which include the Mvog-Mbi and Nkondongo markets in Yaoundé, the Bertoua main market, the Abong-Mbang market, the Ayous market and the Mbalmayo market (Photo 3 and 4). In these markets, palm beetle grubs are traded at any period of the year, though at varied quantities.

Photo 3: Small scale traders of palm weevil grubs at the Abong-Mbang main market.

Photo 4: Measurement of palm weevil grubs in a market by the glass for sale

A single market glass of this insect costs 500 CFCA (US$1) in rural markets and 2500 FCFA (US$5) in urban markets. Brochettes of prepared palm weevil grubs are equally sold on roadsides, bus stops and drinking spots at 100 CFCA (US$0,2) per brochette containing 4 individuals of the palm weevil larvae.

The palm weevil business involves a network of collectors, intermediate traders (called bayam-sellam) and retailers. Each of these categories of traders derived important income from the sales of the palm beetle grubs. Though the actual amount of income that households generate from the sales of palm weevil grubs in cities has not been determined, Dounias (in a working paper edited by López C and Shanley, 2004), reported that the average monthly income for larvae harvesters in rural areas is about 35 500 FCFA (US$71), for live larvae sold to retailers supplying city markets and 25 000 FCFA (US$50) for roasted larvae sold in snacks bars and along roadsides. In the same paper, Dounias compared such income with other rural income sources and concluded that they were significantly higher than the monthly income obtained by unskilled workers in town, or by the rural producers of coffee (25 000FCFA or US$50) in good years. Compared with other NTFPs, the African palm weevil grub generate better monthly income than bushmeat (29 000 FCFA or US58), Gnetum leaves (15 500 FCFA or US$31) and rattan (13 000 FCFA or US$26).

THE NUTRIENT VALUE OF PALM WEEVIL GRUBS

Many studies on the biochemistry of palm weevil larvae have indicated that this insect is extremely rich in essential food nutrients. From studies conducted by Womeni et *al*. (2012), the chemical composition of these larvae is quite captivating (Table 1).

Table 1: Proximate nutrient content of palm weevil-grubs

Component	***% Fresh weight***	**g/100 g dry weight**
Moisture	61.85±0,2	-
Lipids	25.30±0,22	66.61±0.35
Proteins	8.21±0,35	21.06 ±0,22
Carbohydrates	2.97 ±0,01	7.63 ±0,12
Energy (Kcal)	684.81	714.25

Source: Womeni et *al*. (2012).

The moisture content per wet weight of the larva is quite high, comparable to that of fish, meat and egg. Such high moisture content imply that most of the essential nutrients in the larva will be in solution and in forms that are easily available to the body when the larva is consumed as food (Ekpo and Onigbinde, 2005). According to Elemo et al. (2013), the lipid value ranges between 25.30% and 66.61%. This oil extract is unique and different from other animal oils/fat, as it is liquid at room temperature, probably due to the presence of unsaturated fatty acids like oleic acid (C18:1) and linoleic acid (C18:2). An iodine value of 192.3 Wijs was observed, while the saponification value was observed to be 427.7 mg KOH/g of oil. These values are relatively high when compared to that of lard and other plant oils (Pearson, 1976).

In terms of protein, this larva contains at least 18 known amino acids with almost all the essential amino acids (EAA) except tryptophan and cysteine that were not evaluated. Most of the essential amino acids; including: lysine, valine, leucine, isoleucine, phenylalanine, threonine, methionine are contained in the larvae. Essential amino acids like lysine and threonine which are normally deficient in grains and cereals are present at high concentrations in these larvae. Tyrosine and methionine are present in low concentrations. Womeni et *al*. (2012) in table 2 compared the amino acids profile of these larvae with conventional food (egg).

Table 2: Comparison of the amino acid profile of palm weevil grubs and egg (mg/g protein).

Amino acid	***Palm weevil grubs***	**Egg**
Aspartic Acid	104.41	82.20
Glutamic Acid	155.05	121.30
Serine	41.23	67.20
Glycine	39.68	30.20
Histidine	24.00	20.90
Arginine	34.44	57.00
Threonine	23.91	44.70
Alanine	54.96	50.30
Proline	64.00	33.80
Tyrosine	25.15	38.10
Valine	27.64	54.20
Methionine	22.97	28.10
Tryptophane and cysteine	Non Evaluated	17.2 et 19.00
Isoleucine	67.33	48.80
Leucine	96.02	81.10
Phenylalanine	31.59	48.20
Lysine	54.84	65.90

Source: Womeni et *al*. (2012)

Looking at the amino acid table, it can be concluded that the supply of some of the essential amino acids is superior to those found in the conventional foods (egg). Ogbuagu et *al*. (2011) compared the essential amino acids of these larvae with references values given by FAO/WHO (1990) and concluded that some of the essential amino acids in the larvae were higher than the reference values (Table 3).

Table 3: Comparison of essential amino acid in palm weevil larva with reference values

Amino Acid	**Composition**	**FAO/WHO/UNU (1991)**
Lysine	8.3	5.8
Methionine + Cysteine	2.3	2.5
Threonine	3.4	3.4
Tryptophan	N	1.0
Valine	4.5	3.5
Leucine	8.0	6.6
Isoleucine	3.7	2.8
Phenylalanine +Tyrosine	8.6	6.3
Arginine	6.4	-
Histidine	3.5	-

Source: Ogbuagu et *al*. (2011)

The larvae of *Rhynchophorus phoenicis* (palm weevil) are also very rich in mineral composition. They have high values of sodium, magnesium, manganese, calcium, potassium and iron (Table 4).

Table 4: Mineral composition of palm weevil grubs (mg/100g)

Mineral	**Recorded value**
Fe	65.23 ± 0.15
Zn	10.57 ± 0.89
Mn	1.16 ± 0.09
Pb	0.21 ± 0.08
Cd	0.039 ± 0.022
Mg	127.16 ± 5.13
Ca	60.81 ± 0.32
Cu	1.26 ± 0.04
Na	773.49 ± 1.02
K	26.65 ± 0.24

NB: Results represent the mean ± SEM of three estimations

Source: Ekpo and Onigbinde (2005).

EXPERIMENTAL METHODS

Identification of the study site

The study site was identified during a preliminary field visit of neighborhoods stretching from Abong-Mbang to Dimako in November 2013. A visit was made to the Abong-Mbang main market where many small scale traders dealing with palm weevil grubs were identified and interviewed through direct oral discussion (Photo 5).

In total, ten (10) small scale traders were questioned on the main areas where they buy the weevil grubs for retailing in the Abong-Mbang market. A number of villages where listed, all of which are found in a quadrangle stretching from Abong-Mbang to Ayous, Abong-Mbang to Dimako and Abong-Mbang to Lomié.

Photo 5: Small scale traders interviewed at the Abong-Mbang main market

Amongst the different areas cited, the village of Ntoung was retained for the experimental breeding, because of its accessibility.

Description of the experimental site

The study was conducted in Ntoung village, 26 km from Abong-Mbang, capital of the Upper Nyong Division, East Region of Cameroon (See figure 1 above). This village harbors a population of about 1200 inhabitants, of which over 40% (mostly the youths) are involved in the extraction and trade of the palm weevil grubs. The fractions of the population who harvest the palm beetle grubs are equally fishermen or hunters in most cases. They usually practice fishing, hunting when they go out into the forest for grub collection. They go into the forest twice a month, during which they stay for 5 or 6 days per trip. During their stay in the forest, a single collector can harvest between 2 to 4kg of palm weevil grubs, depending on the season. Being part of the Abong-Mbang area, this village is one of the zones where the palm weevil grub is most largely collected and traded in Cameroon.

The climate of this area is of wet equatorial type (Guinea climate type). Temperatures are high (24˚C on average), with four seasons; a long dry season from December to May, a light wet season from May to June, a short dry season from July to October, and a heavy wet season from October to November. Humidity and cloud cover are relatively high, and precipitation averages 1500–2000 mm per year. Situated in the River Nyong basin, a greater part of the area is covered by swampy ecosystems, most of which are dominated by raffia species. However, the vegetation of the area is predominantly that of a rain forest type. The forests are dominated by hardwood species, some of which grow to heights above 70 meters, such as Ayous (*Triplochyton scleroxylon*), Sapelli (*Entandrophagma cylindricum*), Fraké (*Terminalia superba*), Tali (*Erytrophleum ivorense*), Kotibé (*Nesogordia papaverifera*), Kossipo (*Entandrophragma candolei*), Dibetou (*Lovoa trichilioides*), Padouk rouge (*Pterocarpus soyauxii*), Eyong (*Eribloma oblogum*) and Diana (*Celtis zenkeri*).

Preparation of the experimental site

After identifying the study site, a contact visit was made in the Ntoung village. During this visit a meeting was held with the village chief and the population to discuss the project (Photo 6). After accepting our idea to experiment the project in the village, the chief located and offered us a site for the construction of the experimental hut. Six men were delegated to assist us in the implementation of the project. The site was visited, cleared and measurements taken for the construction of the experimental hut (Photo 7). The cleaning of the construction site was done free of charge by the delegated men on the behalf of the village population, showing this way their interest and willingness to participate in the implementation of the project.

Photo 6: Preparatory meeting with the population *Photo 7: Preparation of construction site*

Construction of the experimental hut

An experimental hut of 4m long and 3m wide was constructed using materials like wood, metallic grid and aluminum sheets (Photo 8a and b).

a **b**

Photo 8a and b: Construction of an experimental hut.

The walls of the experimental hut were covered by metallic grids. The final structure of the experimental hut is given in Photo 9 below.

Photo 9: Experimental hut

Construction and placement of experimental boxes

Seven (7) experimental wood boxes of sizes 0.8m long, 0.4m wide and 0.4m high were constructed for placement in the hut (Photo 10). The boxes were placed in the hut by suspension to avoid or limit invasion by ants and crawling invertebrates that could prey on the future grubs (Photo 11).

Photo 10: Experimental boxes outside the hot Photo 7: Experimental boxes suspended in the hut

Collection of biological material (adult palm weevils)

Biological material, notably adult individuals of the palm weevil (*Rhynchophorus phoenicis*) and raffia stem tissues were collected to establish the experimental system. The adult palm beetles were harvested from decayed raffia tissues (Photo 8 and 9). In total, seventy (70) adult weevils were extracted from the dead (decayed) raffia tissues. Most of the collected adult weevils were male. However, female individuals were identified and coupled for the breeding.

Photo 12: Extraction of adult weevils.

Photo 13: Extracted adult palm weevils

Identification and coupling of female adult weevils

African palm weevil adults show sexual dimorphism: abdomen and head size are significantly greater in females, while pronotum (thorax) length is significantly greater in males. The females are larger than the males for abdomen length and width, total head size, and the length from tip of rostrum to antennal insertion. The females were coupled with males for a period of 24 hours for fecundation (Photo 14a and b).

a

b

Photo 14 a and b: Fecundation of adult palm weevils

Preparation of feed formula (substrate)

Six of the suspended boxes in the hut were filled with fresh and/or decayed raffia tissues. Four kinds of feed formula were introduced in the suspended boxes: i) only fresh stems of raffia were introduced as feed in 2 boxes (Photo 15); ii) A mixture of fresh and decayed raffia tissues was introduced in 2 boxes (Photo 16); iii) Only decayed raffia tissues were introduced in 2 boxes (Picture 17); iv) A mixture of decayed raffia and chicken feed was introduced in 2 boxes (Photo 18).

Photo 15: Boxes filled with fresh raffia

Photo 16: Boxes filled with mixture of fresh and decayed raffia tissues

Photo 17: Boxes filled with decayed raffia

Photo 18: Enriching a box with chicken food

Boxes containing feed formula comprising of fresh raffia tissues were labeled FRT (FRT= fresh raffia tissue), those containing a mixture of fresh and decayed raffia were labeled FDRT1 and FDRT2 (FDRT= fresh and decayed raffia tissue). Those containing only decayed raffia tissues were labeled DRT1 and DRT2 (DRT= decayed raffia tissue), while that containing a mixture of decayed or fresh raffia and chicken feed were labeled DRTC and FRTC respectively (C= chicken feed).

Introduction of fecundated adult weevils

In each of the boxes, ten (10) adult weevils (5 males and 5 females) were destined for introduction. However, since the number of females was limited, only 2 couples, comprising of 2 males and 2 females were introduced per box, after having paired them for 24 hours (Photo 19a and b).

a

b

Photo 19: Introduction of adult palm weevils into the experimental boxes

After introducing the weevils, the boxes were monitored daily. Water was sprinkled on the substrate on a daily basis to maintain the humidity of the milieu. The follow-up of the experimental system on a daily basis was done by the six local assistants. The experimental unit was visited and boxes opened quarterly to verify the presence of eggs or young larvae, the survival of introduced adults and to appreciate the development/evolution of the system. Produced grubs were counted and the sizes measured.

PROJECT RESULTS

A) Domestication technique and feed formula for palm weevil larvae production

Thirteen (13) weeks was the time duration for the first individuals of bred palm beetle grubs to be obtained from the experimental dispositive. In total, 13 grown individuals of palm weevil grubs were harvested in the domestication attempt. The larvae obtained were of the same color, texture and morphology as those obtained from the wild (Photo 20a and b).

a

b

Photos 20a and b: Domesticated samples of palm weevil grubs

Only two of the feed formulas were efficient for the domestication of the grubs. However, though the size of some of the bred individuals was quite interesting, most of the grubs obtained were relatively smaller than those from the wild. However, young maggots were noticed in all the three food formulas within the first two weeks of the experiment, most of which died within the third week. Also, introduced adult weevils remained alive throughout the experimental period in some of the feed formulas (Table 5).

Table 5: Production and characteristics of grubs in the different food formulas

Food formula	**FRT1**	**FRT2**	**FDRT1**	**FDRT2**	**DRT1**	**DRT2**	**DRTC**
Number of grubs	0	0	2	7	3	1	0
Maximum size of grubs (cm)	0	0	3,6	4,3	3,4	3,1	0
Color of grubs	NA	NA	Reddish white	Reddish white	Reddish white	Reddish white	NA
Young maggots Observed within 2 weeks	Yes	Yes	Yes	Yes	Yes	Yes	No
Survival of adult weevils	2weeks	2weeks	13weeks	13weeks	13weeks	13weeks	13week

NB: FRT= fresh raffia tissue, FDRT= fresh and decayed raffia tissue, DRT= decayed raffia tissue, DRTC = decayed raffia tissue mixed with chicken food, and NA= not applicable.

From the results on the table, it is observed that some of the feed formulas were able to sustain both the adult and larva stages of the palm weevil. Apart from the box containing a mixture of dead raffia tissue and chicken feed, all the other boxes were favorable for the production of young maggots within the first two weeks. The breeding technique simply consisted of daily watering the substrates made of raffia tissues in the boxes. The death of these maggots at their early age implies breeding conditions were not favorable. This is probably due to the non-respect of the level of humidity required for the growth and development of the maggots, as well as degradation in feed quality due to the decomposition of the substrates over time. The absence of young maggots in DRTC is probably due to the fact that the females introduced in the box containing DRTC were not fecundated.

B) Training local people on multiplication and breeding techniques

The training of local people on the acquired techniques was done directly as the project was being implemented (Photo 21, 22, 23 and 24).

Photo 21: Local people observing boxes in the hut

Photo 22: Participative extraction of adult weevils

Photo 23: Joint installation of experimental dispositive

Photo 24: Harvesting of grubs by local people

Apart from the six men who were delegated to assist in the project implementation, many other villagers were equally trained on different issues related to the domestication and breeding of these larvae. The research was purely participative and some good ideas came from local people. Discussions with local people were centered on the different species of the genus *Rhynchophorus* in Cameroon, their range of distribution, the nutrient value of these insects, identification of males and female individuals, characteristics of the production milieu, preparation of feed formulas and follow-up of the breeding system. Apart from learning, local people were equally very instrumental in the implementation of the project. They contributed ideas that permitted the amelioration of some aspects of the project. They equally provided all raffia materials and adult palm weevils used during the project implementation, as well as followed-up the project system on a daily basis until harvest. Such participatory approach allows for the integration of local knowledge into the planned methodology, while transmitting directly the experimented farming techniques to local communities.

Conclusion and Recommendation

This first attempt of domesticating the palm weevil grubs has proven that it is possible to produce this edible insect in an artificial environment. However, the results of this experiment are not very satisfactory, considering the fact that the number of successfully bred individuals was very low. In order to improve the domestication technique, the following recommendations can be made from this study:

- Additional research should be done to further test the different feed formulas;
- The appropriate humidity needed for the development of young maggots should be determined;
- Crossing of adult weevils should be done for 48 hours in order to increase the chances for female fecundation;
- Young maggots should be transferred to new substrates at the start of the third week of their existence to limit the effect of decomposing tissues on the development of the maggots;
- Other feed formula should be tested.

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