Chapter

Econometrics of Domestication of the African Palm Weevil (*Rhynchophorus phoenicis* F.) Production as Small-Scale Business in Ghana

Thomas Commander N., Jacob P. Anankware, Onwugbuta O. Royal and Daniel Obeng-Ofori

Abstract

A reconnaissance survey of the domestication of the African palm weevil (APW) (*Rhynchophorus phoenicis*), which produces the edible larvae that are cherished as a delicacy among many tribes in Ghana, was conducted. Out of a total number of 560 semi-trained farmers, 271 (48.39%) were actively engaged in *R. phoenicis* farming near their homes or gardens, while 289 (51.61%) were non-active. Economic viability analyses showed that the active farmers would break even and repay their loans of GH¢1000 when they produce 3020 larvae at unit selling price of GH¢0.33, within a period of 4 months and 7 days (17 weeks). In a year, a farmer would have three production cycles and generate a total revenue of GH¢3018.79, at average monthly production of 755 edible larvae, net cash availability of GH¢1448.79, and projected net profit of GH¢448.79 in the first year of production. The farmer would make more profit and become wealthy in business in subsequent years. The pilot scheme of palm weevil farming was viable and ameliorated poverty and malnutrition of rural farmers in Ghana.

Keywords: African palm weevil (*Rhynchophorus phoenicis*), larvae, domestication, farming, revenue

1. Introduction

The practice of eating insects as food by humans is human entomophagy [1]. Although this is traced to the biblical literature, nevertheless, eating of insects by humans had been a taboo in many western nations [2]. Insect farming and entomophagy has developed fast to emerge as a strong economic contributor in recent times. It is estimated that insect eating is practiced regularly by over 2 billion people worldwide [3]. In most tropical countries like Nigeria, Ghana, Cameroon, Congo, Angola, and South Africa, the utilization of insect species as food has been reported [4]. The world population is expected to be above 9.2 billion people, adding more than 2 billion to an already crowded planet earth in 2050 [5].

The Food and Agriculture Organization (FAO) estimates about 1.2 billion are suffering from chronic hunger globally. Therefore, the major challenge is achieving global food security including the hungry populace by 2050 [5]. Meeting this massive additional demand for food will require concerted actions on a number of fronts including focusing on increasing the production and consumption of underutilized and underappreciated natural food resources such as insects [3]. Edible insects constitute about 80% of the animal kingdom [6–8]. This has high potentials of contributing to food and nutrition security globally. Another aspect is to increase the promotion and consumption of other foods which have been constrained by production; processing and trade laws and challenges are to be considered. Although human entomophagy is widely reviled in European and North American societies, more than 1900 species of insects have been reported as edible by humans in over 112 countries of the world, particularly in Asia, the pacific, Africa, Latin America, and Europe [9]. However, the consumption of different species of the edible larvae of palm weevils (***Rhynchophorus*** spp.) has been confirmed as highly nutritious globally. According to the World Health Organization (WHO), every 100 g of palm weevil larvae contains 182 kcal of energy, 6.1% of protein, 3.1% of fat, 9.0% of carbohydrates, 4.3 mg of iron, 461 mg of calcium, and other important vitamins and minerals [10]. A reconnaissance survey of the semi-cultivation (domestication) of African palm weevil (*Rhynchophorus phoenicis*) assessed the profitability of domesticating the production of edible larvae near homes and gardens in Ghana and was undertaken in September to October, 2016. Semi-cultivation refers to the domestication of the breeding of African palm weevil (APW) near living homes and gardens for proper management and continuous production of the edible larvae all year round. This step has been taken to avert the risk of sourcing for the edible larvae from the host plants, raffia palm (*Raphia hookeri*) and oil palm (*Elaeis guineensis* Jacq.), from the wild, since it has been difficult to successfully mass-rear the edible larvae under laboratory conditions, for sustainable production for consumption and commercialization of the edible larvae throughout the year [11] instead of its sensational availability in Ghana and other parts of the world [1].

2. Materials and method

2.1 Study area

The study was conducted in two regions (Ashanti Region and Brong-Ahafo Region) in Ghana. Four communities, Bomfa, Asotwe, Doyina, and Amoafo-Bekwai, were visited in Ashanti Region, while one community, Jema, was visited in the Brong-Ahafo Region. The selection of these communities was based on accessibility and availability of the host plants, oil palms (*Elaeis guineensis*) and raffia palms (*Raphia hookeri*), in Ghana.

2.2 Data collection and training of farmers

Out of a total of 560 trainees, 406 from Ashanti Region and 154 farmers from Brong-Ahafo were engaged and trained in a palm weevil larvae production. The farmers were interviewed orally and salient data were taken. Questionnaires were sent to farmers in some localities which could not be directly accessed. On the process of domestication, the rural farmers were taught how to collect adult palm weevils from the infested host plants (oil and raffia palms).

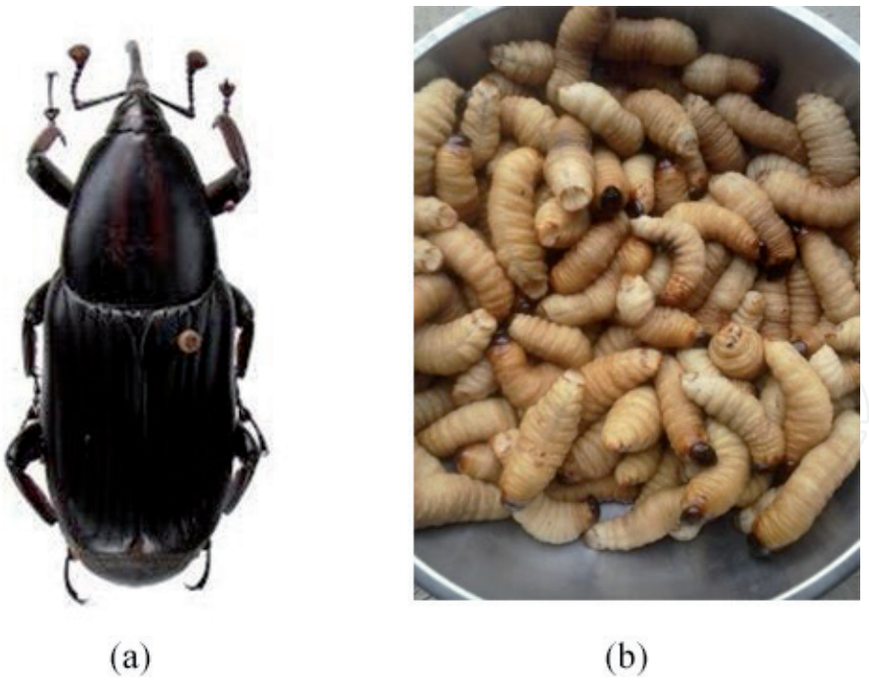

Figure 1.
(a) Adult (female) of R. phoenicis and (b) edible larvae of R. phoenicis.

2.3 Breeding activities

The breeding of the palm weevils was carried out in laboratory following known methods [12, 13]. The breeding took place in plastic containers where sex identification, mating, and oviposition activities were carried out under suitable ambient environmental conditions. The captured adult palm weevils were fed with portions of the natural host plants (raffia or oil palm stems) which were renewed on weekly basis to enable the young larvae develop to food size within 3–4 weeks and harvested for sale to consumers. Some final instar larvae were allowed to develop to pupal stages and emerged as adults to ensure continuity of adult generations. Upon completion of the training, each farmer was given a seed capital of GH¢1000 (which was equivalent to US$250) to procure the needed infrastructure and commence production by the Aspire Food Group (AFG), an international nongovernmental organization (NGO) that initiated the pilot scheme in Ghana. Profitability of the business was calculated using break-even point analysis, while cash flow statement was obtained by direct method [14]. **Figure 1a** and **b** shows the adult palm weevil and the larvae, respectively.

3. Results

A total of 560 farmers were trained on palm weevil production across 5 communities in 2 regions of Ghana. Out of which, 271 (48.39%) were active farmers, while 289 (51.61%) were non-active farmers (**Table 1**). **Table 2a** and **b** showed the various items that constituted the fixed and variable costs estimated at GH¢285 and GH¢715, respectively. The total number of 500 larvae produced within a cycle of production at the unit selling price of GH¢0.3332 (**Table 3**) yielded total sales of GH¢166.6. **Table 4** showed the first break-even point of an active farmer who produced 3020 edible larvae and sold them to consumers to raise funds to repay the loan of GH¢1000. The number of three production cycles which an active palm

S/No.	Regions	Communities	Number trained	Active farmers	Non-active farmers
1	Southern Ghana Ashanti Region	Bomfa	120	20	100
		Asotwe	70	65	5
		Doyina	200	87	113
		Amoafo-Bekwai	70	45	25
2	Brong-Ahafo Region	Jema	100	54	46
		Total trained farmers	**560**	**271**	**289**
		Percent	**100**	**48.39**	**51.61**

Table 1.
Number of trained farmers in palm weevil larvae production in Ghana.

Expenses (items)	Units	Amount per unit	Sub total GH¢	Total
(a) Fixed cost				
Nursery/shield	1	450	450	
Plastic containers	10	10	100	
Machete	1	35	35	
Watering can	3	10	30	
Labor/construction of shield nursery	—	—	100	
Total fixed cost (TFC)			715	715
(b) Variable cost				
Palm trunk (sup/feed)			100	
Local transport per day (21 days)			126	
Miscellaneous/sundry			59	
Total variable cost (TVC)			285	285
Grand total cost (TFC + TVC)				1000

Table 2.
Cost of palm weevil production.

No. of larvae per cycle harvest (21 days) (GH¢)	Unit selling price (GH¢)	Total sales (GH¢)
1	0.3332	0.3332
(370–500 yield) 500	0.3322	166.6

Table 3.
Income estimate for a cycle of production.

weevil farmer would carry out successfully within a year was estimated to generate a revenue of GH¢**3018.79** (**Table 5**). The net cash available for the total investment within the farming year after repayment of the loan value of GH¢1000 was estimated to be GH¢1448.79 (**Table 6**), while the summary of the annual financial report showed a net profit of GH¢44.879 with first farming year (**Table 7**).

Items	Variables	Outcomes
Selling price (SP)	166.6	—
Variable cost (VC)	285	
Contribution (SP-VC)	—	−118.4
Contribution (C)	118.4	—
Number of larvae (NOL)	500	—
Contribution/larvae (^{c}/NOL)	—	0.2368
Fixed cost (FC)	715	
Contribution/larvae (C/L)	0.2368	
Break-even point nos larvae (FC/CL)	—	3020 larvae
Break-even point nos of larvae (BEP)	3020	
Unit selling price (USP)	0.3332	
Break-even point sales (BEP larvae × USP)	—	GH¢ 1006.26

Table 4.
Break-even point in palm weevil farming.

Items	Variables	Outcomes
Break-even point larvae (BEP larvae)	3020	—
Number of larvae (Nos)	500	
Number of cycles to break even (BEP/Nos)	—	3.0
Number of cycles to break even	3.0	—
Number of days in a cycle	21	—
Number of days to break even	—	126.84
Number of months to break even	—	4 months 2 days
Number of months in a year	12	
Larvae per month (3020/4)	—	755
Annual larvae production (12 × 755)	—	9060
Annual revenue (9060 × 0.3332)	—	GH¢ 3018.79

Table 5.
Production cycles/annual revenue.

	Unit cost (GH¢)	Total cost (GH¢)
Operating activities		
Cash from customers	3018.79	
Operating cost to be paid (285 × 3)	(855)	
Net cash flow from operating activities	—	2163.79
Investing activities		
Purchase/construction of fixed assets	(715)	
Net cash flow from investing activities		(715)
Financing activities		
Loan received	1000	

	Unit cost (GH¢)	Total cost (GH¢)
Loan repayment	(1000)	
Net cash flow from financing activities	—	
Net increase in cash/cash equivalent		**1448.79**
Net projected profit		**448.79**

Table 6.
Cash flow statement for the first year.

Items	Expenses (GH¢)	Revenue (GH¢)
Total revenue		3018.79
Less cost		
Operating cost	855.00	
Fixed cost	715.00	
Loan repayment	1000.00	
Total cost	2570.00	
Net profit		**448.79**

Table 7.
Summary of annual financial report of palm weevil farming.

4. Discussion

The study has shown that palm weevil farming is profitable and a thriving small-scale business in four communities (Bomfa, Asotwe, Doyina and Amoafo-Bekwai) in the Ashanti Region and Jema community in the Brong-Ahafo Region of southern Ghana, where the indigenes were vested with traditional cultivation and harvesting of the larvae from host plants in the wild [15]. The survey showed that over 48.39% (271) farmers who benefited from the palm weevil larvae breeding training were able to establish, manage, and harvest their larvae at least once within 3–4 weeks, while 51.61% (289) farmers were inactive and could not manage their palm weevil farms successfully. This is an indication that acquiring training for weevil larvae production requires low level of formal education of the trainee. This also agrees with earlier reports which stated that income earning from rearing and processing of edible insects is generally at subsistent level in Cameroon and other African countries [16]. All the actively trained farmers who secured a loan of GH¢1000 were able to successfully establish a palm weevil farm and achieved a break-even point within 4 months and 7 days (17 weeks). In a cycle of production, each farmer could raise a total number of about 3020 larvae at unit selling price of GH¢0.332 translating to a total revenue of GH¢1006.26. In all, a farmer will have three production cycles and generate a total annual revenue of GH¢3018.79 and make a net profit of over GH¢448.79 in the first year of operation and make greater profit in subsequent years. Palm weevil larvae are a good source of protein [17] and contain polyunsaturated fatty acids such as omega-3 and omega-6 which are recommended for diabetic and hypertensive patients with heart disorders [18, 19]. Therefore, the harvested larvae formed reliable alternative source of high-quality animal protein food for the local communities for healthy living [20]. The breeding of palm weevil larvae also provides employment opportunities for youths, women, and aged pensioners who have retired from the civil service [15]. Considering the high socioeconomic benefits accruing to the farmers, it is recommendable that the

palm weevil larvae farming be adopted as veritable scheme for economic empowerment of rural farmers in tropical African countries. However, the scheme needs to be upgraded and supported with more funds by donors to make greater impact by training more people and increasing the seed capital for those successfully trained to commence the business. Consequently, there is a need to provide funds to support critical aspects of researches that will lead to mass production of the edible larvae of the African palm weevil which have been found to be a "super food" that provides acceptable amounts of "macro and micro" nutrients required for enhancing the longevity of life. Palm weevil production has been a small-scale family-based business which can translate to a Cooperative Association of Insect Producers to attract funding from financial institutions and influence policy-making toward their trade and development in rural communities in Africa as advocated by the Food and Agriculture Organization (FAO).

5. Conclusion

The domestication of palm weevil currently practiced at small-holder level in Ghana is profitable. It is a source of additional income stream of the families, thus enhancing the financial capacity of the farmers and improving their socioeconomic status. Therefore, international and national agencies of government and nongovernmental organizations (NGOs) associated with poverty alleviation, malnutrition, and food security should fund research and development activities, especially that funding of the commercial rearing of this important natural food resource is inevitable in Africa and, indeed, all over the world.

Author details

Thomas Commander N.[1], Jacob P. Anankware[2*], Onwugbuta O. Royal[3] and Daniel Obeng-Ofori[4]

1 Department of Biological Sciences, Niger Delta University, Bayelsa State, Nigeria

2 Department of Horticulture and Crop Production, School of Agriculture and Technology, Sunyani, Ghana

3 George and George Chartered Accountants, Port Harcourt, Nigeria

4 Office of the Vice Chancellor, Catholic University College of Ghana, Sunyani, Ghana

*Address all correspondence to: anankware@yahoo.com

References

[1] Anankware JP, Osekre AE, Obeng-Ofori D, Canute KM. Identification and classification of common edible insects in Ghana. International Journal of Entomology Research. 2016;**1**(5):33-39

[2] Thomas CN, Okwakpam BA, Ogbalu OK, Empere CE. Utilisation of the larvae of *Rhynchophorus phoenicis* F. (Coleoptera: Curculionidae) as human food in Niger Delta, Nigeria, Niger Delta. Biologia. 2006;**6**(2):18-22

[3] Van Huis A, Van Iterbeeck J, Klunder H, Mertens E, Halloran A, Muir G, et al. Edible Insects: Future Prospects for Food and Feed Security. Rome: Food and Agriculture Organization of the United Nations (FAO); 2013

[4] Ntukuyoh AI, Udiong DS, Ikpe E, Akpakpan AE. Evaluation of nutritional values of termites (*Macrotermes bellicosus*): Soldiers, workers and queen in Niger Delta Region of Nigeria. International Journal of Food Nutrition and Safety. 2012, 2012;**1**(2):60-65

[5] FAO. The State of Food and Agriculture. Rome: Food and Agriculture Organization of the United Nations; 2009

[6] Victor YL. Basic Invertebrate Zoology. P.M.B.1515 Ilorin, Nigeria: Ilorin University Press; 1988

[7] Premalatha M, Abbasi T, Abbasi SA. Energy efficient food production to reduce global warming and ecodegradation: The use of edible insects. Renewable and Sustainable Energy Review. 2011;**15**:4357-4360

[8] Alamu OT, Amao AO, Nwokedi CI, Oke OA, Lawal IO. Diversity and nutritional status of edible insects in Nigeria: A review. International Journal of Biodiversity and Conservation. 2013;**5**(4):215-222

[9] Durst PB, Shono K. Edible forest insects: Exploring new horizons and traditional practices. In: Proceedings of a Workshop on Asia- Pacific Resources and Their Potential for Development. 19-20 February 2008. Chiang Mai, Thailand, Bangkok: Food & Agricultural Organization of United Nations; 2010. pp. 1-4

[10] Mercer CWL. Sustainable production of insects for food and income by New Guinea villagers. Ecology of Food and Nutrition. 1997;**36**(2-4):151-157

[11] Ebenebe CI, Okpoko VO. Preliminary studies on alternative substrates for multiplication of African palm weevil under captive management. Journal of Insects for Food and Feed. 2016;**2**(3):171-177

[12] Thomas CN. Biology utilisation and roaring of African palm weevil (*Rhynchophorus phoenicis* F) in palms of the Niger Delta, Nigeria [PhD Thesis]. Nkpolu, Port Harcourt, Nigeria: Department of Biological Sciences, Rivers State University; 2003

[13] Hoddle SM. Entomophagy: Faming Palm Weevil. Riverside, CA, USA: Food University of California; 2013

[14] Adeniji AA. An Insight: Management Accounting. 4th ed. Lagos, Nigeria: El-Toda Ventures Ltd; 2008. p. 93

[15] Offenberg J, Wiwatwitaya D. Weaver ants (*Oecophylla smaragdina*) convert pest insects into food: Prospects for the rural poor. In: Paper presented at the International Conference on Research, Food Security, Natural Resource Management and Rural Development,

University of Hamburg, Germany, 6-8 October 2009. 2009

[16] Muafor FJ, Gnetegha AA, Le Gall P, Levang P. Exploitation, trade and farming of palm weevil grubs in Cameroun. In: Working Paper 178. Bogor, Indonesia: (CIFOR) Centre for International Forestry Research; 2015

[17] Ayieko MA, Oriaro V. Consumption, indigenous knowledge and cultural values of the Lakefly species within the Lake Victoria region. African Journal of Environmental Science and Technology. 2008;**2**(10):282-286

[18] Finke MD. Complete nutrient composition of commercially raised invertebrates used as food for insectivores. Zoo Biology. 2002;**21**:269-285

[19] USDA. National Nutrient Database for Standard References. 2012. Available at: www.ars.usda.gov/ba/bhnre/ndi. [Accessed: 12-12-12]

[20] Okaraonye CC, Ikewuchi JC. *Rhynchophorus phoenicis* (F) larvae meal: Nutritional value and health implications. Journal of Biological Sciences. 2008;**8**:1221-1225