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Stochastic production function and costs-returns analyses of apiarists in Adamawa State, Nigeria

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Abstract. *This study assessed apiculture enterprise to determine the output elasticity of production, returns to scale, technical efficiency and profitability in Adamawa State, Nigeria. A total of four agricultural zones out of six, and 108 apiarists were selected through purposive and simple random methods, respectively. Descriptive statistics, stochastic frontier production function and budgetary technique were used in the analyses of data. Findings revealed that all (100%) the respondents were males within the age range of 21-30 years (44.44%). The majority of apiarists (87.0%) were married with household size of 1-10 persons (77.78%) and 50.0% of them had secondary school education. A larger proportion (37.0%) had between 6 and 10 years of beekeeping experience with 41.67% earning monthly income of N11000 (USD30.8) - N20000 (USD56.0) from other sources. Further, the findings revealed that labor and number of hives had reassuring influence on the industry, while age, education and experience could be used to reduce inefficiency in the industry to improve efficiency status. The apiarists also had mean technical efficiency of 89.9%, while the inefficiency estimate was only 10.1%. In terms of profitability, beekeeping in the study area was found to have had a high gross margin of N16800.00 (USD47.0) and net farm income of N15225.97 (USD42.6) for every beehive in a cropping season. The major constraints to beekeeping reported in the area included beehive crops theft, high propensity of bees' stings, inadequacy of finance, rampant bush burning and deforestation, among others. It was concluded that beekeeping in the study area was found to be profitable and technically efficient. Improving beekeeping business in the area, among other things, would require its modernization and involvement of female participants, provision of soft credit facilities and enactment of stringent forestry laws to check unwholesome forestry practices.*

Keywords*:* beekeeping, respondents, apiarists, profitability, efficiency

Introduction

Apiculture, otherwise referred to as beekeeping, is the act of taming honeybees in a box-like structure called beehive for proper management for the sake of producing copious honey for human and livestock consumption, and industrial uses. Anonymous (2018a) noted that although there are varied opinions as to when apiculture commenced in the world, fossilized remains of honey suggest that beekeeping probably started as far back as 150 million years ago. While pre-historic drawings discovered in caves showed that eating of honey and beeswax date back to 10000 years ago, other paintings and drawing found in Spain gave indications of some forms of beekeeping around 7000 years old. In any instance reported, there are clear evidences that beekeeping has been an aged long agriculture enterprise.

The essence of bees and beekeeping industry in the development of both developing and developed nations has grossly been reported in literature (RMALR, 2009; TFS, 2010; Belavadi and Ganeshajah, 2013; Lee, 2014). Apart from the beehive crops (honey, beeswax, propolis, bee venom, pollen grain and royal jelly) serving as major raw materials in industries like confectionaries, tobacco, pharmaceuticals, and breweries, etc. HAGRC (2008) reported that an estimated economic value of €153 billion was accounted for crops pollinated mainly by bees worldwide. And that the world would stand to lose an estimated sum between €190 and €310 billion of consumer surplus if bee pollinators were to disappear. Similarly, in 2013 alone, Anonymous (2018b) documented that the United States realized a total sum of over US$300million from honey. However, these impressive values are largely complied from systems or nations that encourage modernized or improved apiculture.

In spite of the fact that improved methods of beekeeping were introduced in Zaria, Nigeria, in 1914, some authors (Ojeleye, 1999; Ja'afar-Furo, 2005, 2007, 2016 and Ja'afar-Furo and Madu, 2017) reported that the methods of keeping bees in the country and particularly the study area have been largely traditional and evaluation of the enterprise to determine the various facets of the farming system has been conducted with remarkable success. For instance, Ja'afar-Furo et al. (2006), Olatubosun et al. (2016), Akinmulewo et al. (2017) and Dia et al. (2018) among many

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others assessed the beekeeping industry in the country and confirmed its high profitability. Similarly, the apiculture industry was evaluated in some developed parts of the world like the US and Europe (Abrol, 2011; Anonymous, 2015), and Asia (Ghafary, 2015), which findings also showed huge returns on investment, implying that beekeeping is profitable. However, although most, if not all, of these studies are mainly centered on bee pollination services and marketing of the beehive crops, the major factor of production in the farming system, which is labor, has largely been neglected. Absolutely very minimal researches have tilted toward this particular aspect of the enterprise (Akinmulewo et al., 2017).

Despite the availability of numerous techniques of evaluation of various production units or components of beekeeping efficiency, paucity of information still exists in literature. This study therefore, attempted to bridge this gap by focusing, among other things, on firm level technical efficiency measurement of apiarists in Adamawa State, Nigeria, which may lay basis for further inquiries in this direction for improvement of the beekeeping enterprise.

Material and methods

Study area

The study was conducted in Adamawa State, Nigeria; located at the North Eastern part of the country. It lies between latitude 7° and 11° N and between longitude 11° and 14° E. It shares boundary with Taraba State in the south and west, Gombe State in its North-west and Borno State to the North. The State has an international boundary with the Cameroon Republic along its eastern side (Figure 1). It has a land area of about 38741km^2, with 21 Local Government Areas (LGAs). Adamawa State has a defined tropically wet and dry climate. The latter commences in November and ends in March, which is about five months, while the wet season starts in April and lasts till October. It has mean annual rainfall from 700mm in the North-west to 1600mm in the extreme Southern part of the State (Adebayo, 1999).

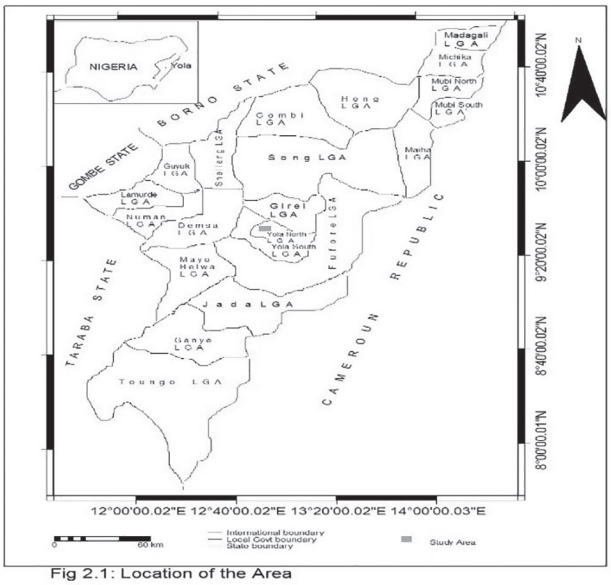

Figure 1. Map of Adamawa State showing the study area

The State has two ecological zones naturally divided into Guinea and Sudan Savannah. In general, the distribution of vegetation reflects the combined control of rainfall, topography and to a lesser extent, that of soils. The major economic activity of the inhabitants is agriculture, accounted by about 80.0% of the population (Adebayo, 1997). Based on the ecological condition of the State, cultivation of cereals, root crops and raising of livestock have been the main practices of the people. However, other pronounced sideline economic activities such as apiculture, fishing, pottery and petty trading abound in the area.

Sampling procedure and data collection

The LGAs and respondents were selected for the study through purposive and simple random methods, respectively. Adamawa State was divided into four agricultural zones based on soil, climate and vegetation. These zones are Northeast (I), Northwest (II), Central (III) and Southwest (IV) (Table 1). In spite of the fact that the whole State has great potentials for beekeeping, the study was concentrated specifically on the main producing areas. In this regard, two LGAs were selected from each zone thereby making a total of eight LGAs studied in the State. Fifteen (15) apiarists were drawn from each LGA using simple random sampling, thereby making a total of 30 apiarists from each agricultural zone and 120 in the entire study area. Of the 120 respondents given a questionnaire, a total of 108 were retrieved in the whole study area. Data for the study were collected from the field survey conducted during 2017/2018 production season through a well-structured questionnaire that was supplemented by oral interviews and group discussion.

Table 1. Distribution of LGAs based on agricultural zones in Adamawa State, Nigeria

Agricultural zone	LGAs selected
Zone I	Maiha and Mubi-South
Zone II	Hong and Song
Zone III	Yola-South and Fufore
Zone IV	Ganye and Toungo

Source: Field survey, 2017/2018

The data for this study were mainly derived from primary sources. The primary data were collected with the aid of a well-structured questionnaire supplemented with personal interviews. The data were collected on socio-economic attributes of the apiarists as well as production activities during the 2017/2018 production season.

Methods of data analysis

The data were analyzed by the use of both descriptive and inferential statistics. The descriptive statistics involved the use of mean, frequency distribution, percentages and tables for presentation. It was used to analyze the socio-economic characteristics of the respondents and constraints faced by apiarists in the study area. The inferential statistics involved the application of budgetary technique and Stochastic Frontier Production Function (SFPF). The specific budgetary technique used was the Gross Margin (GM) analysis. The GM was used

to estimate the cost and returns associated with apiculture in the study area. This is expressed as:

$GM = \Sigma P_i Y_i - K_i X_i$, (1)

Where:

GM = Gross Margin (₦);

P_i = Unit price of output (₦/L);

Y_i = Quantity of output (L);

K_i = Unit cost of variable input (₦);

X_i = Quantity of variable input (number);

Σ = Summation sign.

The cost components of honey production include buckets, honey extractor, catcher box, protective clothing, bee brush, empty container, hives, baiting material, labor and storage equipment, while the returns associated with honey production in the study area and sales of apiary products were honey and beeswax.

The SFPF was employed to measure the production function and technical efficiency of the apiarists. The use of this SFPF has some important advantages in that it allows the decomposition of the error term into random error and inefficiency effects rather than attributing all errors to random effects (Yao and Liu, 1998). The model specified output (Y) as a function of inputs (X) and a disturbance term (μ):

$Yi = f(X_i : \beta) + (V_i - U_i)$, (2)

Where:

Y_i = production of the i^{th} firm;

X_j = vector of input quantities of the i^{th} firm; $X_{j=} X_1, X_2, X_3$ and X_4;

X_1 = Labor (mandays);

X_2 = Number of hives;

X_3 = Farm distance (km);

X_4 = Other costs (₦);

β = vectors of unknown parameters;

V_i and U_i are assumed to be independent of each other.

V_i is the asymmetric random error which is assumed to be normally distributed N (0, c^2_v) and accounts for measurement errors and other factors beyond the control of the beekeeper. U_i is the negative random error which is assumed to account for errors in technical efficiency in production and assumed to be half normally distributed N (0, a^2_u) (Aigner et al., 1977).

There are a number of functional forms used in frontier analysis; but for simplicity of analysis the Cobb-Douglass function was adopted in this study.

The inefficiency model is defined as:

$\mu_i = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5$, (3)

Where;

μ_i = Technical inefficiency;

Z_1 = Age (in years);

Z_2 = Education (in years);

Z_3 = Farming experience (in years);

Z_4 = Access to formal credit (1 access to credit and 0 no access to credit);

Z_5 = Family size (number);

δi, δ^2 and *γ* - Unknown parameters to be estimated.

The study used FRONTIER 4.1 program software for its data analysis.

Results and discussion

Description of demographic parameters of apiarists in the study area

For any agricultural development policy content to be meaningful, the socio-economic variables of farming communities, be it on local, regional or national plane, have to be properly and adequately captured and inclusive. Development economists posit that these parameters assist policymakers significantly in determining what types of improvement packages would suit specific progressive farming intentions, and on the part of the farmers, these qualities help immensely in enhancing adoption processes. In line with this, Table 2 shows the descriptive statistics of apiarists in the area studied according to age, gender, marital status and family size. It could be observed from the table that a larger proportion of apiarists (44.44%) were within their youthful age. This is followed by beekeepers that were in their middle aged group in the area of survey. The elderly persons that engaged in keeping bees in the State were in the minority (12.97%). This implies that the larger chunk of those that practiced the culture of bees for honey production were young persons in the area. This could largely be linked with the rigors involved (climbing trees, night outings, bees sting, etc.) with the bee farming exercise which is mainly indigenous in nature. Ja'afar-Furo (2017) earlier reported that the majority of beehives used in beekeeping in the State were of indigenous types (logs, earthen pots, gourds, woven straw, among others).

Gender wise, all apiarists were males in the area surveyed; indicating clearly that the farming system was absolutely women exclusive. This is taking into account the activities involved in keeping bees which are absolutely tasking. The culture of the larger communities in the State which mainly excludes females from out-door economic activities, and majorly confines them to a state of purdah might be another contributory factor. However, earlier findings such as Udofia and Edet (2016) in Akwa Ibom State in the eastern part of the country indicated that 83.0% of the apiarists were males, with only 17.0% females. But the same authors' survey outcome on age of apiarists showed that 92.0% were above 50 years of age, which is at variance with the result of this study. Similarly, the data in Table 2 give a reflection of the marital status and family size of the apiarists. It shows that the majority of apiarists were married (87.0%) with most of them (77.78%) having between 1 and 10 members of family in a household. The reason for this might be connected with the fact that married persons with high number of members of household tend to find various avenues for complementing their major sources of income which is crop production with beekeeping, considered as a strong money spinner.

In terms of experience in beekeeping production, 37.04% of the respondents had the largest beekeeping experience of 6-10 years within the rural farming community. This was followed

Table 2. Socioeconomic attributes of apiarists in Adamawa State, Nigeria

Variable	Frequency	%	Variable	Frequency	%
Age (years)			Level of education		
20-30	48	44.44	Non-formal	17	15.74
31-50	46	42.59	Primary	25	23.15
51 and above	14	12.97	Secondary	54	50.00
Total	108	100.00	ND/HND	07	06.48
			Degree	05	04.63
Gender			Total	108	100.00
Male	108	100.00			
Female	-	00.00			
Total	108	100.00			
Marital status			Beekeeping experience (Years)		
Married	94	87.00	1-5	29	26.85
Single	10	09.30	6-10	40	37.04
Widower	04	03.70	11-15	17	15.74
Total	108	100.00	16-20	10	9.26
			Above 20	12	11.11
			Total	108	100.00
Family size (Number)			Monthly income from other sources, (₦)		
1-10	84	77.78	5000-10000	34	31.48
11- 20	23	21.29	10001-20000	45	41.67
Above 20	01	00.93	Above 20000	29	26.85
Total	108	100.00	Total		100.00
Membership of association					
Member	33	30.56			
Non-member	75	69.44			
Total	108	100.00			

Source: Field survey, 2017/2018; 1₦=USD0.0028

by a group of apiarists with 1-5 years accounting for 26.85%. While groups of apiarists with 11-15 years and those above 20 years of experience in keeping bees trailed in descending order, and lastly a group with 16-20 years constituted the least (9.26%). What these findings show is that apiarists in the study area are fairly experienced. The level of education of an individual certainly correlates with his/her ability to comprehend rapidly and enable them to acquire the capacity of utilizing their immediate or remote environment positively for the upliftment of their livelihoods of which agriculture forms a larger chunk in most developing economies.

The finding in Table 2 further shows that collectively about 83.00% of the total apiarists have had some form of western education from primary to tertiary, indicating that the apiculture enterprise in the area was dominated by enlightened persons. It is only 15.74% of the population that had informal education. However, this minority of the apiarists were not totally illiterate, as they might be within the category of those who study and write the holy Qur'an traditionally or books of other faiths. The result agreed with Adgaba et al. (2014) who studied socio-economic factors influencing beekeeping in five regions in Saudi Arabia and discovered that the level of literacy among apiarists ranges from 83.9-100% in the area surveyed.

With regards to membership of associations by apiarists as also shown in Table 2, the majority (69.44%) of them had no affiliation with any registered organization; implying that they lacked access to cooperative soft loans and subsidized apicultural inputs in the area. This could thwart adoption of improved methods and expansion of apiaries. In terms of monthly income generated from other sources by the apiarists, a pooled figure of 73.15% indicated that beekeepers earned between ₦5000 (USD14.0) and ₦20000 (USD56.0) outside the beekeeping enterprise business. This was just barely adequate to assist in the housekeep of families of 1-5 persons, and also use in expansion of apiaries.

Maximum likelihood estimate of parameters of the Cob-Douglas production function of beekeeping

Table 3 indicates the Maximum Likelihood Estimate (MLE) of the parameter of the Cobb Douglas Production Function (CDPF) of honey production in Adamawa State. Going by specific parameters determining honey production in the state, labor and number of hives are positively related with honey production and labor significant at $p<0.10$. In this study, both inputs and outputs were normalized by respective sample means. Thus, the output elasticities were evaluated at mean with respect to their various inputs. The output elasticities of labor and number of hives are 0.8119 and 0.5698, respectively. The positive relationship on both elasticities indicates that 1% increase in labor, increases honey production by 0.81% and similarly, 1% increase in number

of hives, increases honey production by 0.57%. This therefore, means labor and number of hives exert reassuring increase on honey production in the state.

On the other hand, distance and other costs both have negative output elasticity of production and significant at p<0.10. Distance with elasticity (-0.2184) shows that additional distance by 1% decreases honey production by 0.22%, while other costs with elasticity (-0.1727) also indicate that additional other costs by 1% lead to decrease in honey production by 0.17%. The negative elasticity of other costs could be explained by the small scale nature of apiarists in the study area whose operations are capital constrained, thus, additional costs are hardly incurred and inability to incur affects the production processes of the industry. However, the total other costs would be kept low by positioning apiaries at good locations devoid of pests, predators and harsh environmental conditions. Ja'afar-Furo et al. (2009) earlier reported lizards (31.67%), ants/mites (17.50%) and hot weather (12.50%) as the foremost in the category of predators, pests and environmental factors, respectively, that hampered beekeeping in the area of study. Among other factors were termites, bush baby, hot weather and owls in descending order. Therefore, avoiding these factors by appropriate selection of apiary sites would minimize other costs incurred.

Table 3. Maximum likelihood estimate of parameters of the Cobb-Douglas production function of honey production in Adamawa State, Nigeria

Production	Parameters	Coefficient	Stand. Error	P- value
Constant	X_o	-0.1727	0.2476	0.1297
Labor	X_1	0.8119	0.4520	0.0753*
Number of hives	X_2	0.5698	0.3620	0.1185
Distance	X_3	-0.2184	0.1167	0.0641*
Other costs	X_4	-0.1727	0.1000	0.0870*
Inefficiency Model				
Constant	δ_o	-0.3422	0.1055	0.0016***
Age	δ_1	-0.2242	0.8819	0.0125***
Educational Level	δ_2	-0.2706	0.8073	0.0011***
Farming Experience	δ_3	-0.2305	0.5356	0.0001***
Credit Facilities	δ_4	0.8833	0.5395	0.0001***
Family Size	δ_5	0.4975	0.2214	0.0471**
Sigma squared	δ^2	0.1442	0.8592	0.0961*
Gamma	γ	0.9869	0.6138	0.0118**
Log likelihood		0.9364		

Source: Field survey, 2017/2018; *p<0.10, **p<0.05 and ***p<0.01

Distance from the home of apiarists to their apiaries as a determinant of honey production is also related to other costs since the longer the distance to apiary sites, the higher additional costs are incurred. The shorter the distance, the more prone apiaries become to bush burning, honey theft and predators. However, the further the locations of apiaries to human habitation, the more apiary products and equipment are preserved. The returns to scale in honey production were measured by the sum of individual output elasticity to be 0.9906. This indicates that if all factor inputs are jointly increased by 1%, honey production will attract honey production by 0.991%. Note also, 0.9906<1; an indication that apiarists produce honey under decreasing returns to scale scenario. In terms of determinants of inefficiency, 3 out of the 5 socioeconomic variables included in the inefficiency model show the *a priori* expected negative coefficients. The variables that satisfied the *a priori* expected signs are age, education and experience in honey production and all are significant at p<0.05, p<0.01 and p<0.01, respectively.

The overall implication for this is that additional units of these variables (age, education and production experience) reduces inefficiency in honey production. About age, the implication is that the older the apiarist, the less inefficient he becomes. This is linked to the fact that the older farmers are more experienced than the younger ones and even in terms of capital base, the older are more equipped. Fumuyide et al. (2014) earlier documented a similar finding. As for the extent of educational attainment, the more educated the apiarist becomes, the more his ability to adopt, reject or interpret innovations.

Apiarist's experience which is related to honey production at p<0.001, and signed negative, implied that the variable improved the beekeeper's technical efficiency. In other words, as the experience of the beekeeper increases, the technical efficiency tends to improve. However, education and business status revealed a positive relationship with efficiency. Credit facility is a facet of agricultural production that is absolutely crucial in improvement of farm productivity or gross output. Rahman et al. (2014) outlined this positive relationship in an empirical study in Pakistan where they found out that credit enabled farmers to purchase superior quality or high yielding seeds, fertilizers and pesticides, and the timely supply of these inputs increased yield of farmers tremendously. Also, in this survey, credit facility has a relationship with honey production at p<0.01 and signed positive. This implied that increase in credit facilities decreases inefficiency of honey production in the area. This finding of positive coefficient between credit and inefficiency is contrary to

a priori expectations. In spite of the significance of credit in small scale agricultural production in the developing economies, the positive sign is rather surprising. From the findings of this study, family size has a positive association with the yield of beehive crops production at $p<0.05$ in the area surveyed, implying that as the size of the household increases, more labor was made available for apiary activities which invariably decreased yield. This positive sign of farm size could be attributed to the over utilization of labor in the study area.

Table 4 shows the summary of technical efficiency scores of honey production in Adamawa State. The predicted technical efficiencies of the apiarists ranged from 0.41-0.98, while the mean technical efficiency was 0.89. In other words, it implied that on the average, an apiarist produced about 89.0% of maximum attainable output for a given input level. Although apiarists were relatively efficient, there was still room for increase of efficiency in their apicultural activities. This means that if the average apiarist were to achieve the technical efficiency level of his most efficient counterpart in Adamawa State, he would realize 10.1% to be more productive. This finding was similar to Obayelu et al. (2016) who reported values of technical efficiency of 89.0% and 78.0% for apiarists in Iwo, Osun State, Nigeria, respectively. However, it was contrary to Makri et al. (2015) who revealed an overall value of 57.0% for apiarists in Greece, which means that beekeepers on average could reduce their inputs by 43.0% while retaining the same level of output.

Table 4. Summary of technical efficiency scores of honey production in Adamawa State, Nigeria

Efficiency Level	Frequency	%
0.0000 – 0.2500	-	-
0.2510 – 0.5000	-	-
0.5100 – 0.7500	9	8.3
0.7510 – 0.9999	99	91.6
Total	108	100.0
Minimum	0.41	
Maximum	0.98	
Mean	0.89	

Source: Field Survey, 2017/2018

The costs and returns associated with beekeeping in the area studied are documented in Table 5. These include variable cost, fixed cost, gross receipts and net apiary income associated with the beekeeping in the area. A larger proportion of farming activities in developing economies is handled by subsistence farmers who undertake cultivation of land using indigenous implements which lessen efficiency and productivity. Therefore, beekeeping like any other agricultural enterprise requires appropriate utilization of resources to ascertain its profitability or otherwise, in order to make way for its awareness and possible adoption by the majority of the rural population. In line with this, the results in Table 5 show cost and returns associated with honey production in the study area. Of the total cost of production per beehive in the area surveyed, the TVC accounted for the larger chunk (65.59%), with only a minor (34.41%) portion recorded for the TFC. Both the GM and the NFI were highly on the positive side, implying that the beekeeping enterprise is a very profitable business in the area. Prior findings by Ja'afar-Furo (2006), Ja'afar-Furo et al. (2006, 2007) revealed that apiculture practices in Adamawa State, Nigeria, were a highly rewarding enterprise in terms of return on investments.

Table 5. Average costs and returns in honey production per beehive in Adamawa State, Nigeria

Items	Values (₦)	%
Variable Costs (VC)		
Baiting material	600.00	13.12
Transportation	300.00	6.56
Packaging materials	1300.00	28.42
Storage	300.00	6.56
Labor	500.00	10.93
Total VC	3000.00	65.59
Fixed Cost (FC)		
Beehives	729.03	15.94
Buckets	400.00	8.74
Rope	280.00	6.12
Gloves	165.00	3.61
Total FC	1574.03	34.41
Total Cost (TC)	4574.03	100.00
Gross Receipts (GR)		
Honey sales	17300.00	87.37
Bee wax sales	2500.00	12.63
Total Gross Receipts (TGR)	19800.00	100.00
Gross Margin (GM)	16800.00	
Net Farm Income (NFI)	15225.97	

Source**:** Field survey, 2017/2018; 1₦=USD0.0028

Challenges encountered in beekeeping in Adamawa State, Nigeria based on the opinions of apiarists, problems associated with beekeeping enterprise are documented in Table 6.

Table 6. Constraints associated with beekeeping in paddy processing areas of Adamawa State, Nigeria

Constraint	Frequency	%
Beehive crops theft	107	99.07
Bees' abscondment	86	79.63
Bush burning	89	82.41
Fear of bees' stings	104	96.30
Inadequacy of finance	105	97.22
Lack of credit facility	98	90.74
Lack of government support	97	89.81
Deforestation	92	85.19
Pests and diseases	84	77.78
Lack of beekeepers' association	82	75.93
Lack of extension visits	63	58.33

Source: Field survey, 2017/2018; *Multiple responses were recorded

Apiculture, like any other agricultural enterprise in a tropical underdeveloped country is faced with several challenges ranging from application of indigenous methods, inadequacy

of resources to pests and diseases. The most prominent of all was the theft of beehive crops which represents 99.07% of the apiarists. This was immediately followed by inadequacy of finance, fear of bees' stings, lack of credit facilities and lack of government support in descending order. Others that trailed accordingly were deforestation which limited bees foraging activities, bush burning which destroyed beehives and vegetation cover, bees' abscondment from beehives that reduced population of colonies, and pests and diseases which depopulated colonies leading to low yield of beehive crops (honey, beeswax, propolis, etc.). The lowest challenges experienced in the area were lack of beekeepers' associations which thwarted the efforts of apiarists in accessing government supports, and lack of extension services that seriously undermined the aspect of capacity building on modernization of apiculture among apiarists. These are results that aligned with previous studies of Akinwande et al. (2013) who documented challenges associated with honeybee colonies establishment in Nigeria, Munuo (2015) who reported challenges and prospects facing beekeepers commercializing bees' products in Tanzania, and Areda (2016) who stated the constraints and opportunities of honeybee production and marketing system in Tanzania.

Conclusion

The study concluded that beekeeping in Adamawa State, Nigeria was found to be profitable and highly technically efficient (89%), but with scope for improvement. Labor and number of beehives were important factors of honey production predicted, while age, education and experience were found to be significant in reducing the effects of inefficiency in beekeeping. Among the major challenges experienced by apiarists in the study area were beehive crops theft, inadequacy of finance, fear of bees' stings and lack of credit facilities. Based on the aforesaid, apiarists should maximize their man-days to improve efficiency, there should be provision of soft credit facilities to apiarists to assist them in acquisition of quality inputs, new forestry laws should be enacted by policymakers to take care of the weaknesses explored by honey hunters, and afforestation campaigns should be made to create awareness on the dangers faced by deforestation.

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