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Original article

Comparative analysis of profitability of honey production using traditional and box hives

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ABSTRACT

Information on the profitability and productivity of box hives is important to encourage beekeepers to adopt the technology. However, comparative analysis of profitability and productivity of box and traditional hives is not adequately available. The study was carried out on 182 beekeepers using cross sectional survey and employing a random sampling technique. The data were analyzed using descriptive statistics, analysis of variance (ANOVA), the Cobb-Douglas (CD) production function and partial budgeting. The CD production function revealed that supplementary bee feeds, labor and medication were statistically significant for both box and traditional hives. Generally, labor for bee management, supplementary feeding, and medication led to productivity differences of approximately 42.83%, 7.52%, and 5.34%, respectively, between box and traditional hives. The study indicated that productivity of box hives were 72% higher than traditional hives. The average net incomes of beekeepers using box and traditional hives were 33,699.7 SR/annum and 16,461.4 SR/annum respectively. The incremental net benefit of box hives over traditional hives was nearly double. Our study results clearly showed the importance of adoption of box hives for better productivity of the beekeeping subsector.

1. Introduction

Beekeeping has been practiced in Saudi Arabia for many centuries. At present, approximately 5000 household beekeepers engage in beekeeping practices in the country (Al-Ghamdi, 2010). Beekeeping is a viable business that significantly contributes in increasing and diversifying the incomes of many rural households in Saudi Arabia (Al-Ghamdi and Nuru, 2013a; Nuru et al., 2014). Beekeeping provides various benefits, such as income from the sale of bee products, self-employment opportunities, pollination and conservation of biodiversity. For instance, honeybee pollination service, have been reported to increase the yields and quality of many important cultivated crops, such as *Citrus sinensis* (by 30%), watermelon (by 100%) and tomatoes (by 25%) (Crane, 1990).

Although there has been a strong effort to promote improved beekeeping technologies through widespread demonstration of the technology, 70% of beekeepers in Saudi Arabia still practice traditional beekeeping methods (Al-Ghamdi, 2010). The low adoption of new technologies could be due to lack of tangible information on the profitability and productivity of beekeeping using different types of hives.

Productivity of beekeeping is a measure of honey yield per colony/beehive. Honey yield per beehive is a major factor affecting the profitability of beekeeping enterprises (Jones, 2004). There are variations in yield within the same locality among honeybee colonies. Queen quality, ecological conditions, floral composition, types of technology and resource management are among the major factors affecting the profitability of beekeeping enterprises (Tucak et al., 2004). Moreover, colony strength, types of hives used, age of the queen, swarming of colonies and honeybee management practices are also major factors influencing the profitability of beekeeping businesses.

Profit in beekeeping is defined as profit per colony, which is calculated by subtracting total apiary product sales from total costs and dividing by the number of colonies (Urbisci, 2011). In addition, profitability is defined as the difference between income earned from the sale of products and the cost incurred during production.

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In Uganda, regardless of profitability, a 50% higher honey yield was recorded for improved (top-bar) hives than traditional hives (Dathine, 2012), indicating the importance of improved beekeeping technologies in enhancing honey yield.

A study by Workneh (2011) concluded that beekeepers can increase their profit more than double by using box hives instead of traditional hives. Similarly, in his study using partial budgeting analysis, Melaku (2005) also reached a similar conclusion that both homemade and commercially made top-bar hives were beneficial and led to a higher net return per colony compared with traditional hives.

Beekeeping is practiced in the different regions of the Kingdom using different types of hives and honeybee races. However, to date, no adequate comparative study has been conducted on the profitability and productivity of traditional and box hives. Thus, the objective of this study was to analyze and compare the profitability and productivity of traditional and box hives considering annual operational costs and returns.

2. Materials and methods

2.1. Location of the study area and sampling techniques

The study was carried out in Saudi Arabia taking sample respondents from five regions. The regions were selected based on their potential for beekeeping and availability of information in line with the specific objective of the study. Accordingly, Madinah, Haiel, Taif, Jazan and Al-Baha regions were chosen and 30, 30, 31, 45 and 46 respondents respectively were selected from these regions, through random sampling techniques. Thus, the total sample size of the study was 182 beekeepers. According to Storck et al. (1991), the sample size should depend on the funds and time available as well as other factors but not necessarily on the total population. Both traditional and box hive owners were included in the sample respondents to analyze and compare the productivity and profitability of the two hive types.

2.2. Method of data collection

Mixed methods, such as surveys, key informant interviews and observations, were used for data collection to capture all of the relevant information. Besides beekeepers a support data were collected from extension workers and traders. The questionnaire was prepared in line with the specific objective of the study and was pre-tested on a small number of respondents. Using the feedback obtained during the pre-test, the questionnaire was customized in a way that was comprehensible to enumerators and respondents.

Information that was generated from the questionnaire includes: the demographic characteristics and socio-economic profiles of the beekeepers, education level, honeybee colonies holding size, and average honey yield per each type of hive per annum. Moreover, data on the major expenditures for producing honey, quantity of inputs (e.g., labor, feeds, medicine) and the average prices of honey and costs and returns from both hive types were used for analysis and comparison. Trained enumerators were employed to collect the data under close supervision of the researchers.

2.3. Data analysis

The data were analyzed using descriptive statistics and analysis of variance (ANOVA). Moreover, the Cobb-Douglas (CD) production function was used to measure the profitability and productivity of beekeeping. Partial budgeting was employed to analyze the profitability of box and traditional hives. Partial budgeting is a technique for assessing the benefits and costs of a practice relative to not using the practice. This method only accounts for those changes in costs and returns that directly result from using different production practices. According to Upton (1987), partial budgeting is useful for evaluating such changes as adopting a new technology, expanding an enterprise, alternative enterprises, different production practices, hiring a custom operation rather than purchasing equipment and making a capital improvement. Partial budgeting is based on the principle that a change in the organization of a farm or ranch business will have one or more of the following effects: eliminating or reducing some costs; eliminating or reducing some returns; causing additional costs to be incurred; and causing additional returns to be gained.

2.4. Model specification

The CD production function was used to analyze the difference in beekeeping productivity between using the traditional and box hives. Following Gujarati (1995), the generalized form of the CD production function can be specified as:

$$Y = AX_1^{B1}X_2^{B2}X_3^{B3}\cdots X_n^{Bn}e_1^u$$

where Y is the gross value of honeybee product outputs in Saudi Riyal (SR) per hive; Xi are explanatory variables, such as feeds, colony size, labor, medicine and capital; Bi are coefficients or elasticity of output and indicate how strongly each input affects the output; A is the efficiency parameter and represents the level/state of technology; Ui is the disturbance term.

The production function for box hives is represented as:

$$\ln Y_b = \ln A_b + B_b \ln X_b + B_b \ln X_b + B_b \ln X_b + \cdots + B_b \ln X_b + U_b$$

The production function for traditional hives is represented as:

$$\ln Y_b = \ln A_t + B_t \ln X_t + B_t \ln X_t + B_t \ln X_t + \cdots + B_t \ln X_t + U_t$$

The production function using pooled data is

$$\ln Y_p = \ln A_p + B_p \ln X_p + B_p \ln X_p + B_p \ln X_p + \cdots + B_p \ln X_p + U_p$$

where b = box hive; t = traditional hive; p = pooled data

3. Results and discussions

3.1. Demographic and socio-economic characteristics of the respondents

As shown in Table 1, the mean ages of the heads of households using traditional hives, box hives and both hive types were 46.6, 45.3 and 48.1 years, respectively. The overall mean age of the respondents was 46.6 years, with a range of 22–70 years. The data revealed that the majority of the respondents were in the age range of the working force of the population. Their years of experience in beekeeping ranged from 1 to 50 years, with a mean of 18 years. The mean family sizes of the households using traditional hives, box hives and both hive types were 8.9, 7.3 and 8.1 individuals, respectively. The overall mean of the family size of the respondents was 8.3 individuals, with a range of 2–27. Box hive owners have relatively small families. Moreover, box hive owners were more educated. The data in this study suggest that the education level not only influences the decision to use box hives but also contributes to having a better outlook on family planning and determining optimum family size.

As shown in Table 2, approximately 62.64% of our respondents were entirely engaged in traditional beekeeping practices. The remaining 37.36% of respondents were using box hives. The cur-

Table 1
Mean and standard deviation of the sample respondents by demographic variables (n = 182).

Variables	Traditional hive owners (n = 101)	Box hive owners (n = 44)	Traditional and box hive owners (n = 37)
Age	M = 46.6 SD = 11.7	M = 45.3 SD = 9.2	M = 48.1 SD = 7.9
Family size	M = 8.9 SD = 5.1	M = 7.3 SD = 3.8	M = 8.1 SD = 3.1
Work experience	M = 19 SD = 11.2	M = 14 SD = 9.7	M = 20.5 SD = 9

Table 2
The mean distribution of sample respondents by hive types used (n = 182).

Type of hive	Number	Minimum	Maximum	Mean
Box hives	68 (37.36)	5.00	1000.00	219
Traditional hives	114 (62.64)	16.00	3000.00	333
Total	182 (100)	5.00	3000.00	349

Values in the parentheses indicate percentage.

rent result more or less agrees with Al-Ghamdi (2010) study report that mentioned 70% of Saudi Arabia's beekeepers practice traditional beekeeping methods. The overall mean honeybee colony holding size of beekeepers was 349 with range of 5–3000. From an economics of scale perspective; the honeybee colony holding size recorded in the study is optimum and is suitable for earning attractive profits from the beekeeping industry. Similarly, Sandford (1992) stated that a positive return of profit is obtained when the numbers of hives are increased.

3.2. Source of beekeeping experiences

Beekeepers develop their beekeeping experience from various sources that vary between traditional to box hives owners. Approximately 48.4% and 35.2% of traditional hive owners obtained beekeeping experience from their parents and neighbors, respectively (Table 3). Over all training, parents and neighbors contributed a high share of beekeeping experiences (11.5%, 37.9% and 41.3%, respectively). However, the combinations of training and parents, training and neighbors, and parents and neighbors contributed less to sharing experiences. Across all hive owners, the contribution of neighbors in sharing beekeeping experience was high (41.3%), indicating that beekeeper-to-beekeeper knowledge exchange is important in the dissemination of improved beekeeping technologies. The result is in line with Workneh (2011) finding regarding the advantage of promoting farmer-to-farmer knowledge sharing and encouraging farmer groups in creating a learning environment for effectively disseminating beekeeping technologies. This result implies that in the process of disseminating improved technologies, more emphasis on beekeeper-to-beekeeper knowledge sharing may increase the dissemination of improved beekeeping practices by a large number of beekeeping communities. Observations on key informant interviews and field experience also showed that beekeepers trust their fellows more than external sources (extension interveners). Such an approach would not only accelerate the dissemination of improved beekeeping technologies but also fill the gaps of the extension workers in reaching large farming communities. Consequently, many beekeepers may have better opportunities to access improved farm technologies.

3.3. Honey marketing

Approximately 59.2% and 59.7% of traditional and box hive owners respectively supplied their honey to consumers, (Table 4). The number of hive owners (of both types) supplying honey to traders and processors was extremely low, which indicates the absence of a well-structured honey market. In the absence of a strong marketing structure, beekeepers may not have access to a sustainable market and attractive prices for their products. The availability of a suitable market is a driving force for the dissemination of improved farm technologies. Poor marketing structure also affects the development of beekeeping sub-sectors. The high proportions of beekeepers supplying their honey directly to consumers may reduce marketing costs and avoid intermediary actors. Although such marketing is advantageous to beekeepers for the purposes of obtaining a reasonable price for their products, they may not be able to sell their honey in bulk in a short period of time. Generally, having an adequate number of honey processors who receive honey from beekeepers in a sustainable manner is extremely important. Improved market structure may enhance the desire of other beekeepers to adopt improved beekeeping practices for producing more honey. Similarly, Workneh (2011) also obtained a similar finding regarding the role of the availability of markets for hive products in promoting the adoption of box hives.

3.4. Types of bee races used

Table 5 illustrates that the majority (89.9%) of the traditional hive owners own local bee race, whereas the majority (46%) of box hive owners own imported bee races. Across all types of hive owners, numbers of beekeepers own crossbreeds race are generally low. The traditional hive owners mainly preferred local honeybee race due to their better adaptability to the local hive types. The country imports 200,000 exotic package bees annually due to the shortage of local bees. However, the imported colonies are only surviving for one honey harvest or season (Al-Ghamdi and Nuru, 2013b).

Keeping other factors (e.g., availability of forage, supplementary feeds, conducive climate, and improved beekeeping management practices) constant, the type of bee race used has a direct effect on the amount of honey produced per colony. Beekeepers must own selected races that produce a high yield of honey. As the imported honey bee races perform better in box hives, the promotion of box hives and imported bee races must be synchronized. However, advocating for imported honeybee races to a large num-

Table 3
Sources of beekeeping experience by different hive owners (n = 182).

	Source of experience						
Type of hive	Training	Parent	Neighbors	Training and Parents	Training and Neighbors	Parents and Neighbors	Total
Traditional	10 (8.2)	59 (48.4)	43 (35.2)	4 (3.3)	4 (3.3)	2 (1.6)	122 (100)
Box hive	11 (18.4)	10 (16.7)	32 (53.3)	2 (3.3)	5 (8.3)	–	60 (100)
Total	21 (11.5)	69 (37.9)	75 (41.3)	6 (3.3)	9 (4.9)	2 (1.1)	182 (100)

Values in the parentheses indicate percentage.

Table 4
Categories of honey buyers by hive type owner (n = 182).

Type of hive	Categories of honey buyer						Total
	Consumers	Traders	Processors	Consumers and Traders	Consumers and Processors	All Receivers	
Traditional	71 (59.2)	3 (2.5)	–	44 (36.7)	2 (1.6)	–	120 (100)
Box hive	37 (59.7)	3 (4.8)	1 (1.6)	14 (22.6)	2 (3.2)	5 (8.1)	62 (100)
Total	108 (59.3)	6 (3.3)	1 (0.6)	58 (31.9)	4 (2.2)	5 (2.7)	182 (100)

Values in the parentheses indicate percentage.

Table 5
Types of bee races in different hive types (n = 182).

Type of hive	Type of bee races used by beekeepers				Total
	Imported	Local	Both	Crossbred	
Traditional	5 (4.2)	107 (89.9)	7 (5.9)	–	119(100)
Box hive	29 (46)	23 (36.5)	10 (15.9)	1 (1.6)	63 (100)
Total	34 (18.7)	130 (71.4)	17 (9.3)	1 (0.6)	182 (100)

Values in the parentheses indicate percentage.

ber of beekeepers may require prior performance evaluation trials compared with local race in different localities to increase confidence regarding the adaptability and productivity of the imported honeybee races.

3.5. Average honey yield of different hive types

The honey yield/colony/annum comparisons made between the different hive types, the mean honey yields for box and traditional hives were 6.6 and 3.7 kg, respectively, with an overall mean of 4.8 kg/colony (Table 6). The data indicated that the honey yields in all hive types are generally low compared with the potential of hives in other regions. However, the beekeepers were obtaining the optimum amount of honey production from the total number of hives. The low honey yield/colony could be due to shortage of forage as a result of long dry seasons and overcrowding of colonies. This finding is in agreement with previous reports (Al-Ghamdi and Nuru, 2013a,b; Al-Ghamdi et al., 2016) noting the presence of overcrowding (500 colonies/apiary) and severe resource competition of colonies from within and among adjacent apiaries. Planting of drought-resistant bee forages, provision of supplementary feeds, protection from bee enemies, and regular inspection and watering are among the improved management practices that beekeepers need to implement to optimize the honey yields of their bee colonies. To increase the honey yield per hive may require intensive extension intervention and integration of beekeeping with natural resource conservation programs.

Table 6
Annual mean honey yields of different hive types (n = 182).

Types of hives	Number (hives)	Minimum	Maximum	Mean
Box hive (pure honey)	17,967	1	37	6.6
Traditional hive (crude honey)	45,987	0.5	20	3.7
Total	63,954	0.5	37	4.8

3.6. Productivity of box and traditional hives

A comparison analysis was performed between both groups using the CD production function. The study results showed that the box hives used resources (e.g., bee feeds, labor and medicine) more effective than the traditional hives. The suitability of the box hives for favoring improved management practices could be one of the main contributors to the productivity of box hives. The CD production function revealed that the use of inputs such as bee feeds, labor and medicine were statistically significant for both box and traditional hives (Table 7). The comparison of the marginal value product with the factor cost indicated that using more bee feeds, medication and labor for management led to a 72% higher beekeeping productivity for box hives compared with traditional hives. The traditional hives could also increase the gross value of their output by 21.77% if similar inputs were used as for box hives. Generally, labor for bee management, supplementary feed and medication led to hive productivity differences between box and traditional hives of approximately by 42.83%, 8.91% and 5.34%, respectively (Table 8).

Table 7
Estimation of variables in the CD production function (n = 182).

Variables	Pooled (n = 182)		Box hive owners (n = 81)		Traditional hive owners (n = 101)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
Constant	5.645	25.534	4.079	18.453	3.191	14.436***
Watering	0.007	0.104	0.060	0.823	0.003	0.035
Medicine	0.295	4.034***	0.389	5.324***	0.223	3.051***
Bee feeding	0.237	3.523***	0.273	3.745***	0.176	2.054***
Labor	0.297	4.112***	0.301	4.132***	0.220	2.573**
Adjusted R^2		62.5%		61.3%		60.4%
F-Value		29.51***		14.23**		13.35**
Durbin Watson		3.02				

** and *** indicate statistical significance at the 5% and 1% probability levels, respectively.

Table 8
Difference in productivity between hive types.

Source of productivity difference	Percentage of contribution	
	Owing to output elasticity	Owing to input endowment
Total estimated difference (72%)	−21.77	93.77
Medicine use	1.35	5.34
Bee feeding	3.25	8.91
Labor for bee management	35.21	42.83

3.7. Productivity levels of different types of hives

Productivity is a measure of annual honey yield per type of hive which indicates the efficiency of beekeeping. An efficient beekeeper increases the probability of harvesting the maximum honey yield from each type of hive. As shown in Table 9, the mean productivity of traditional and box hives were 2.06 and 3.74 kg/harvest, respectively. Using post hoc multiple comparisons additional analysis was made to identify the significance of mean productivity differences between each hive type (traditional and box hives). Table 9 provides a summary showing that there is a significant mean productivity difference between traditional and box hives ($P < 0.01$). Although the amount of honey yield was not at the level of expectation and not comparable to the amount of honey yield in other regions, the productivity of box hives was significantly higher than traditional hives. This finding agrees with Al-Ghamdi (2005), Nuru et al. (2014) and Fadare et al. (2008) who showed the higher productivity of box hives compared with traditional hives. The low productivities of colonies may indicate the importance of strong beekeeping extension intervention to promote improved management practices and therefore enhance the amount of honey yield from both hive types.

3.8. Financial benefits of box and traditional hives

In general, in the process of promoting improved farm technology, farmers are sensitive to the yield obtained from the new practices introduced to them. As a result, the yield of the new practices needs to be significantly higher than the traditional practices. Honey yield is an important determining factor for deciding to use box hives and their accessories. The higher the yield obtained from using box hives, the easier it makes its adoption by the beekeepers. For the partial budgeting analysis, users of both traditional and box hives were considered to compare the profitability of the hives under similar circumstances. Accordingly, the returns and costs of 37 hives from each hive type were considered for the analysis.

The partial budgeting analysis indicated that the beekeepers were more profitable as a result of using box hives. The net incomes per hive were 910.80 SR and 444.90 SR for box and traditional hives respectively. The average gross net incomes of beekeepers with 37 box and traditional hives each were 33,699.7 SR/annum and 16,461.4 SR/annum respectively. The incremental net benefit of box hives was 17,238.3 SR (Table 10). This result indicates that box hives provide more than twice the income of traditional hives. This result agrees with the findings of Workneh (2011) who showed that the total incremental net benefit from box hives exceeds the benefit from traditional hives by more than two times. The author further underlined the importance of popularizing of box hives together with accessories and basic training. Similarly, Belet and Berhanu (2014) reported that the adoption of box hives makes smallholder beekeepers more profitable than with traditional hives, with a 20% increase in the variability of input cost and output prices. The finding is also in line with Melaku (2005), who reached a similar conclusion that box hives were more beneficial and remunerative. Our result also agrees with Behera and Mahapatra (1999), who reported that apiculture produced the highest return (7.94 RS per rupee, or 0.18 U.S. dollar invested). A relative profitability study by David and Michael (2009) also

Table 9
Productivity variances of different hive types.

Variable	Type of hive	Mean	Std. deviation	Std. error	Minimum	Maximum
Average productivity/hive	Traditional	2.06	1.53	0.15	0.33	9.44
	Box hive	3.74	3.00	0.45	0.19	13.20
LSD						
Variable	(I) types of hive	Mean Difference (I–J)		Std. error	Sig.	
Average productivity/hive	Traditional	−1.68		0.39	0.000	
	Box hive	1.68		0.39	0.000***	

*** = significant at 1% probability level.

Table 10
Partial budgeting for box and traditional hives.

Column 1			Column 2		
Added cost (SR)	Box hive	Traditional hive	Additional return (SR)	Box hive	Traditional hive
Transport	7.7	3.8	Honey yield	33,773	16,492
Feeding	10.8	1.3			
Medicine	3	2			
Labor cost	46.6	15.3			
Packaging	2.2	7.3			
Watering	3	0.9			
Total added cost	73.3	30.6	Total added return	33,773	16,492
Reduced return	–	–	Reduced cost	–	–
Total reduced	–	–	Total reduced cost	–	–
Total negative	73.3	30.6	Total positive	33,773	16,492

Net income from box hives (33,773−73.3 = 33,699.7).
Net income from traditional hives (16,492−30.6 = 16,461.4).
Incremental net benefit of box hives is (33,699.7−16,461.4 = 17,238.3).
(1 US dollar = 3.75 SR).

revealed that the use of improved hives increases gross margins from 2.75 to 7.70 US dollars per hive.

A similar study by Nuru et al. (2014) showed that the average annual household earnings from beekeeping is relatively high ($58,937.6) and constitutes an average of 29.67 ± 28.95% of their total annual incomes. Despite the low honey yield/colony, the high net income per hive and per beekeeper is due to the high price of locally produced honey in the country that fetches $58.87–$77.86/kg (Nuru et al., 2014).

3.9. Importance of bee product diversification

To be more successful in beekeeping, it needs to exploit all possible bee products. However, the beekeepers in Saudi Arabia only harvest honey. For instance, beeswax has more than 300 uses and fetches high price. It is possible to harvest beeswax at rates of 1% and 10% of the honey production from box and traditional hives, respectively. However, this valuable bee product is not utilized in the study area. The beekeepers usually discard the beeswax during the harvesting of the honey or after processing. The respondents collectively own 16,364 and 36,242 box and traditional hives, respectively. Considering the number of colonies and estimated proportion of beeswax to honey production, it would be possible to harvest an average of 831.5 and 12,322.3 kg of beeswax from box and traditional hives, respectively. Overall, it would be possible to harvest 13,153.8 kg of beeswax, which is valued at 460,383 SR using a unit price of 35 SR/kg. This figure indicates that the sampled beekeepers lose a significant amount of money annually as result of not utilizing beeswax. When this estimation is extrapolated to the 1 million colonies estimated to found throughout the country, beekeepers are wasting approximately 234,231 kg of beeswax, with a value of 8,198,114 SR annually. The improper utilization of bee products may also affect the contribution of beekeeping sub-sectors to household incomes and the national economy.

3.10. Conclusion and recommendations

Despite low colony productivity, beekeeping still remains a profitable and remunerative enterprise in the study area. It is less labor intensive compared to other agricultural activities and plays an important role as an additional source of income generation and diversification for beekeepers. The CD production function revealed that bee feeds, labor for bee management and medication were statistically significant for both box and traditional hives. The beekeeping productivity difference between box and traditional hives was approximately 72%. The partial budgeting result also indicated that box hives are more profitable than traditional hives. Hence, it is critical to promote the adoption of box hives with all accessories. Moreover, creating of sustainable markets, providing of training, extension services, and promoting beekeeper-to-beekeeper knowledge sharing practices, would be essential for the development of the sub-sector.

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References

Al-Ghamdi, A.A., 2005. Settlement and performance of evaluation of Apismellifera in relation to bees wax foundation use in modern hive. Pak. J. Biol. Sci. 8 (4), 631–635.

Al-Ghamdi, A.A., 2010. Comprehensive study for the current beekeeping industry of imported and native honeybee in the Kingdom of Saudi Arabia. Final report King Abdulaziz City for Science and Technology General Administration of Grant Program King Saud University.

Al-Ghamdi, A.A., Nuru, A., Awraris, G., Yilma, T., 2016. New approach for determination of an optimum honeybee colonies carrying capacity based on productivity and nectar secretion potential of bee forages species. Saudi J. Biol. Sci. 23 (1), 92–100.

Al-Ghamdi, A.A., Nuru, A., 2013a. Beekeeping in the kingdom of Saudi Arabia, past and present practices. Bee World 90 (2), 26–29.

Al-Ghamdi, A.A., Nuru, A., 2013b. Beekeeping in kingdoms of Saudi Arabia: opportunities and challenges. Bee World 90 (3), 54–57.

Behera, U.K., Mahapatra, I.C., 1999. Income and employment generation for small and marginal farmers through integrated farming systems. Indian J. Agron. 44 (3), 431–439.

Belet, G., Berhanu, G., 2014. Perceptions of smallholder farmers on improved box hive technology and its profitability in northern Ethiopia. J. Agric. Extension Rural Dev. 6 (12), 393–402. http://dx.doi.org/10.5897/JAERD14.0592.

Crane, E., 1990. Bees and Beekeeping: Science, Practice and World Resources. Comstock Publishing Associates (Cornell University Press), Ithaca, New York.

Dathine, 2012. Appropriate hive technology: towards resolving the appropriate hive technology debate. SNV Uganda.

David, K., Michael, K., 2009. Analysis of Relative Profitability of Key Ugandan Agricultural Enterprises by Agricultural Production Zone. Ohio State University Columbus, Ohio, USA.

Fadare, S.O., Ojo, S.O., Imoudu, P.B., 2008. Analysis of production performance of beekeeping in the niger delta area of Nigeria. Apiacta 43, 37–48.

Gujarati, D., 1995. Basic Econometrics. McGraw Hill Inc, New York.

Jones, R., 2004. European beekeeping in the 21st century: strengths, weaknesses, opportunities, threat. Bee World 85, 77–80.

Melaku, G., 2005. Adoption and profitability of Kenyan top bar hive beekeeping technology: a study in Ambassel woreda of Ethiopia Unpublished M.Sc thesis. Alemaya University, Alemaya.

Nuru, A., Al-Ghamdi, A.A., Shenkute, A.G., Ismaiel, S., Al-Kahtani, S., Tadess, Y., Ansari, M.J., Abebe, W., Abdulaziz, M.Q.A., 2014. Socio-economic analysis of beekeeping and determinants of box hive technology adoption in the kingdom of Saudi Arabia. J. Anim. Plant Sci. 24 (6), 876–1884. ISSN: 1018–7081.

Sandford, M.T., 1992. A Study in Profitability for a Mid-Sized Beekeeping Operation. Fact Sheet RF-AA089. University of Florida, Florida Cooperative service. pp. 22. http://ufdcimages.uflib.ufl.edu/UF/00/07/71/22/00001/AA08900.PDF. Accessed June, 2015.

Storck, H., Bezabih, E., Berhanu, A., Borowieck, A., Shimelis, W., 1991. Farming systems and farm management practices of small holders in the Hararge highlands. Farming systems and resource economics in the tropics, Wissenschaft surlangvauk, kiel, Germany, vol. 11.

Tucak, Z., Perispic, M., Beslo, D., Tucak, I., 2004. Influence of the beehive type on the quality of honey. Collegium Antropologicum 28, 463–467.

Upton, M., 1987. African Farm Management. Cambridge University Press, Cambridge.

Urbisci, L., 2011. The economic effects of size and enterprise diversity on apiary profits in Canada. (MSc Thesis) University of Gulf.PP 81. http://www.uoguelph.ca/canpolin/Publications/Thesis_Urbisci_Economic_Effects_of_Size Diversity Profits 2011.pdf, Accessed June, 2015.

Workneh, A., 2011. Financial benefits of box hive and the determinants of its adoption in selected district of Ethiopia. Am. J. Econ. 1 (1), 21–29. http://dx.doi.org/10.5923/j.economics.20110101.03.