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Original Article

Comparative Analysis of Colony Performance and Profit from Different Beehive Types in Southwest Ethiopia

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ABSTRACT

The sole purpose of a hive is to encourage the bees to build their nests in such a way that it is easy to manage and maintain them. This study examined four beehive types: namely improved frame hive (Zander model), Kenya Top Bar Hive (KTB), Ethio-ribrab hive and traditional log hives based on honey yield performance, honeybee colony strength and profitability under environmental condition of Bonga, southwest Ethiopia. The overall average annual honey yield performance clearly revealed both improved frame hive (30.09 ± 2.69 kg/hive) and Ethio-ribrab hive (29.22 ± 2.69 kg/hive) were significantly higher ($p < 0.0001$) than KTB hive (15.71 ± 2.22 kg/hive) and traditional log hive (15.36 ± 0.86 kg/hive). In addition, the strength of honeybee colonies in the present study found to be higher in improved frame hive and Ethio-ribrab hive but medium in KTB hive and Traditional log hive. The total cost of production and gross return of improved frame hive was higher than Ethio-ribrab, KTB hive and traditional log hives. However, Ethio-ribrab hive stands first in profitability followed by improved frame hive compared to KTB and traditional log hive types. The study result could be useful in humid and sub-humid areas of the country, therefore, introduction of both improved frame hive and Ethio-ribrab hives is recommended along with all packages important to beekeepers.

Keywords: Comparative analysis, beehive, honey yield, colony strength, production cost, profit.

INTRODUCTION

Beekeeping and related trades can be sources of valuable economic/financial strength and an important occupation to enormous numbers of rural people's livelihoods worldwide (FAO, 2009). In Ethiopia beekeeping is one of the oldest agricultural activities having been passed from generation to generation up to present times (Fichtl and Admasu, 1994). Large number

of honeybee colonies, estimated about 10 million, are managed with the same old traditional beekeeping methods in almost all parts of the country (Ayalew, 1978). Ethiopia has the potential to produce about 500,000 tones of honey and 50,000 tones of beeswax per year, however, currently production is limited to 43,000 tones of honey and 3,000 tones of beeswax due to traditional way of beekeeping (MOARD, 2008).

South-west of Ethiopia is known as the major source of natural forest from which rural people produce honey, bees wax, coffee, spices, and other non-timber products. Beekeeping in this areais still based on traditional practices which accounts for more than 99% while intermediate and modern hives are less used (Awraris *et al*., 2012). Traditional hives usually kept on trees to attract new swarms and after two-three months the beekeepers check the hive for honey harvesting. During honey harvesting most beekeepers in Kaffa and Sheka zones bring the log hives with the bees down to the ground and open the splits of the logs to let the bees leave away. Then, beekeepers harvest all the content of the hive (honey combs, brood and larvae), discarding the colony on the ground and keep hives in shelter until next season (Awraris *et al*., 2012). In this regard, one colony in traditional beekeeping practice mostly serves for a single honey harvest only and most colonies are abandoned after each harvesting season. The amount of honey beekeepers can harvest highly depends on the level of management and appropriate volume of the hive the beekeeper can provide to his/her bee colonies.

The sole purpose of a hive is to encourage the bees to build their nests in such a way that it is easy to manage and maintain them (FAO, 2012). Different beehive types are used for honeybees nest in the world. In recent years, Kenya Top Bar Hive (KTB) and improved frame hives are in the state of introduction to beekeepers in the study area though the rate of adoption is very low. High yield of honey, ease of inspection to know the status of colony and ease of product harvesting are the major advantage of modern and KTB hives over traditional ones (FAO, 1990; Beyene *et al*., 2015). Improved frame hives enhance honey production because they save bees' effort in creating beeswax comb: for that reason, improved frame hives enable harvests of honey rather than beeswax (FAO, 2012). However, the colony strength and hive preference of honeybees varied in different environmental conditions and different honeybee races (Abou-Shaara *et al*., 2013). So far, there is no study undertaken to assess the performances of colonies in different beehives and their profitability under the environmental conditions of the study areas. In order to improve beekeeping sector, selection and adoption of hive types has to be based on productivity, affordability, availability and profitability. Thus, the purposes of this study were to identify suitable beehive to honeybees, to evaluate yield performance and profitability of beehive types at Bonga condition.

MATERIALS AND METHODS

Study Area

The study was conducted at Bonga Agricultural Research Center (BARC), Kaffa Zone, Southwest Ethiopia, during 2009 and 2012. BARC is located at 7˚16'48.82"N, 36˚14'25.7"E, at an altitude of 1860 m. The area comprises of mixed arable farming and woodland, including much relict primary tropical forest, and receive a relatively high (2000 mm) annual rainfall (Chernet, 2008).

Experimental Treatments

Four beehive types namely: improved frame hive (Zander model), Kenya Top Bar hive (KTB), Ethio-ribrab and Traditional log bee hives were used as treatments (Fig. 1). Each beehive type was replicated three times. Improved frame hive and KTB hives were purchased from Mizan Teferi Rural Technology while Ethio-ribrab and Traditional log hives were constructed from locally available materials. Ethio-ribrab hive is similar to KTB hive but both the body and top bars are made from locally available material (Fig. 1b).Three strong and

well established honeybee colonies from each hive type were selected and kept under uniform environmental condition. Equal honeybee management practice was undertaken to each beehive type.

Fig. 1: Types of beehives used for comparison: a) Improved frame hive, b) Ethio-ribrab hive, c) Traditional log hive, d) KTB hive

Data Collection

During the study period the data was collected on honeybee colony strength, honey yield and production cost of each beehive types. Honeybee colony strength was simply assessed as strong, medium and weak based on honeybee population estimation during the study period due to the limitation of traditional hive to manipulate detailed internal observations like measurement of brood area and pollen stored. In the present study, colonies were considered as strong when honeybee population occupied full of the hive, medium if more than half and weak when they covered less than half of the hive volume including the combs during honey harvesting season. Moreover, data on honey and beeswax productivity (yield performance) of each of four beehive types were recorded and compared both in major (April-June) and minor (November and December) honey flow seasons.

Data Analysis

The data was analyzed using JMP-5 statistical software (SAS, 2003). Every comparison was made assuming variation between the beehive types in honey and beeswax productivity. One way ANOVA were computed to compare honey and beeswax productivity means per annum as well as in major and minor harvesting seasons between beehive types.

Cost Benefit Analysis

The most important issue of the present study was to determine the type of beehive with better profit for better life of small scale beekeepers. In order to perform cost benefit analysis, major production cost of each beehive type was considered. Hence, production cost of beehive, inputs for honey production, honeybee colony purchase, apiary establishment expenses, protective clothes, labour and etc were considered to be the major total production costs. Accordingly, the price of beehives (improved frame hive, KTB hive, Ethio-ribrab hive and traditional hive) were obtained and honeybee colonies purchasing cost were assessed based on the average price of the study area. In the study areas, improved frame hive and KTB hives are estimated to serve for 10 years, while Ethio-ribrab and traditional log hive types are estimated to serve for five years. Further, two honey flow seasons are expected in the study areas (Awraris *et al*., 2012). Hence, total cost of production was calculated for a year or two honey flow seasons. Finally, selling price for a kg of honey in local market was assessed in the study areas. Assuming that an average beekeeper will have 10 bee hives in his apiary, cost benefit analysis of each beehive types was determined using the following formula (Onwumere *et al*., 2012; Folayan and Bifarin, 2013).

NI = GR – TC

Where: NI = Net Income, GR = Gross Return, TC = Total production Cost

The gross return represents the income from honey and beeswax sales while the total production costs represent direct expenses and purchases for the beekeeping activities.

RESULTS AND DISCUSSIONS

Honeybee Colony Strength

The strength of honeybee colonies (*Apis mellifera scutellata)* in the current study was higher in improved frame hive and Ethio-ribrab hive types but medium in Traditional and KTB hive types. Abou-Shaara *et al*., (2013) reported honeybee colony performance differences between two races (Carniolan and Yemeni honeybees) in different beehive types under hot and arid environmental conditions. In the present study, the reason that Ethio-ribrab hive to be preferred by honeybee colonies could be due to its insulating nature of the hive to maintain optimum hive temperature during hot and cold season than other hive types. Similarly, improved frame hive is convenient to manage its volume or chambers according to the strength of honeybee colonies and environmental condition. Whereas reasons for relatively lower performance of KTB and traditional log hive types could be due to fixed volume and susceptible to absorb both high temperature and cold weather conditions which affect honeybee colony establishment or performance. This result contradicted with Ande *et al*., (2008) who reported that the best hive for honeybee colony establishment and highest colonization rate was KTB hive in Nigeria condition (Fig. 2).

Honey Yield Performance of Beehive Types

The overall average annual honey productivity analysis clearly revealed both improved frame hive and Ethio-ribrab hive types were significantly (*p <0.0001*) higher than KTBH and traditional log hive types (Table 1).

Table 1: Presentation of honey and beeswax productivity of beehive types (Mean ± SD)

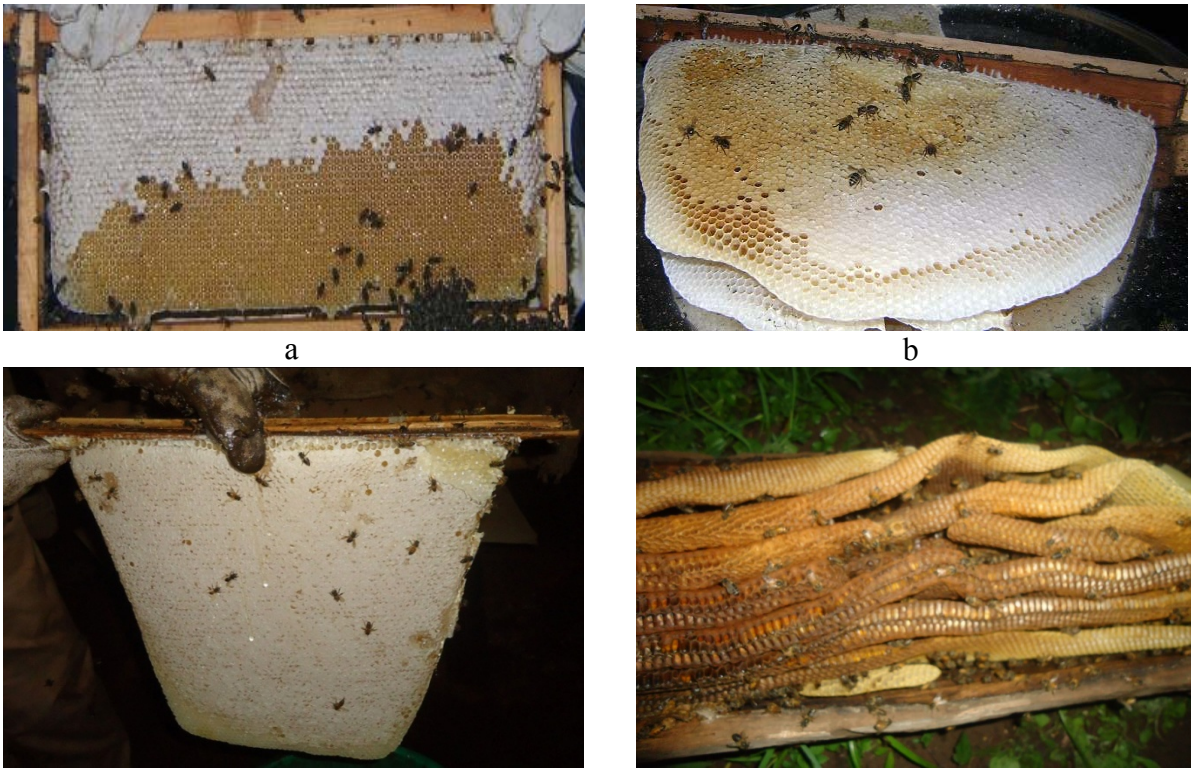
Beehive types	Honey yield (kg/hive/annum)	Honey productivity (kg/hive/season)		Bees wax (kg/hive/annum)
		Major season	Minor season	
Improved frame hive	$30.09^{a***} \pm 2.69$	$18.5^{a***} \pm 0.62$	$11.59^{a*} \pm 2.98$	$0.3^{a} \pm 0.03$
KTB hive	$15.71^{b***} \pm 2.22$	$9.33^{b} \pm 0.74$	$6.38^{ab} \pm 1.92$	$1.57^{b**} \pm 0.22$
Ethio-ribrab	$29.22^{a} \pm 2.69$	$20.0^{a***} \pm 1.32$	$9.22^{ab} \pm 2.36$	$2.92^{c***} \pm 0.27$
Traditional	$15.36^{b} \pm 0.86$	$9.83^{b} \pm 0.44$	$5.52^{b} \pm 0.44$	$1.54^{b**} \pm 0.09$

Different letters in each column indicate significant differences between treatment means.

** p < 0.05, ** p < 0.001, *** p<0.0001*

Similarly, honey productivity analysis in major harvesting season showed both improved frame hive and Ethio-ribrab hive types were significantly ($p < 0.0001$) higher than KTB and traditional log hive types (Table 1). In the case of minor harvesting season, however, only improved frame hive was significantly ($p < 0.05$) higher in honey productivity than traditional log hive type (Table 1).

In general, the present study clearly revealed that improved frame hive and Ethio-ribrab hive types were the most productive while KTB and Traditional log hive types were the least productive among hive types evaluated (Table 1). The average annual honey yield of traditional, transitional and improved frame hives at national level was reported 5-8 kg (crude honey/hive) , 10 - 15 kg (crude honey/hive) and 20-25 kg/hive, respectively (Nuru, 2007; Workneh *et al*., 2008). In the present study, higher honey yield (30.09 kg/hive/annum) was obtained from improved frame hive than the national average. Furthermore, higher than the annual honey yield of improved frame hive (22.8 kg/hive, 21.02 kg/hive) reported by Haftom and Awet (2013) in Tigray region and Beyene *et al*., (2015) in mid Rift Valley of Ethiopia, respectively.



a b c d

Fig. 2: Honey combs from each beehive types: a) Improved frame hive, b) KTB hive, c) Ethio-ribrab hive, d)Traditional log hive

Similarly, the average annual honey yield (15.36 kg pure honey/hive) of traditional log hive in the present study was higher than the national average of traditional hive. Annual honey yield obtained from Ethio-ribrab hive (29.22 kg/hive) in the present study was higher than the honey yield (12.51 kg/hive) reported by Beyene *et al*., (2015). The average honey yield per year (15.71 kg pure honey/hive) of KTB hive obtained in Bonga condition was almost similar to the national average. The variation in the volume of honey production from previous research reports at different locations could be associated with variations in the potentiality of the study areas, in that Bonga area is densely covered with very good nectar source natural forest trees. Similarly, study in Serbia stated that the level of honey production is influenced by specific apicultural conditions, climate and pasture conditions as well as by the applied apicultural technique (Marinković and Nedić, 2010). Moreover in the area there

are different species of bee forage plants that serve as dearth period forage sources. Further, the present study shows that beeswax productivity from improved frame hive was significantly lower ($p < 0.001$) than beeswax productivity of other beehive types compared (Table 1).

Table 2: Presentation of production costs of each beehive types

Major items	Unit price (ETB)	Service year of items	Items per beekeeper	Production cost/annum/beehive type			
				Improved frame hive	KTB hive	Ethio-ribrab hive	Traditional log hive
Casting mould	3600	10	1	360			
Honey extractor	3500	10	1	350			
Beeswax (kg)	100	2	20	1000			
Overall	600	5	2	400	400	400	400
Improved frame hive	1300	10	10	1300			
KTB hive	900	10	10		900		
Gloves	150	3	2	100	100	100	100
Traditionallog hive	90	5	10				90
Ethio-ribrab hive	250	5	10			500	
Shelter	2000	5	1	400	400	400	400
Smoker	200	5	1	67	67	67	67
Battery	50	1	1	200	200	200	200
Feeding	400		1	400	400	400	400
Hive stand	50	10	10	50			
honeybee colony	200		10	2000	2000	2000	2000
Honey container	50		10	500	500	500	500
Total production cost				7127	4967	4567	4157

Note: An average beekeepers' annual production costs who owned 10 colonies in his/her backyard apiary were calculated for each beehive types as follows : Unit item price multiplied bynumber of items needed per beekeeper and then divided by estimated service year of each items.

About eight percent beeswax per kilogram of honey could be extracted from the KTB hive, Ethio-ribrab and traditional hives (Tessega, 2009), but a very small amount of beeswax can be obtained from the modern hive (0.5-2%) of the honey yield (Melaku *et al*., 2008). Therefore, Ethio-ribrab, KTBH and traditional hive types can be good source of beeswax production in order to fulfill beekeepers beeswax demand in national and world market.

Cost and return analysis of beehive types

Total cost of production and Gross return of improved frame hive was higher than other beehive types (Table 2 & 3). However, Ethio-ribrab hive stands first in profitability followed by improved frame hive, which is supported by Beyene *et al*., (2015) who reported 18,794.8 ETB and 10,313.5 ETB profit from 15 hives for Ethio-ribrab and improved frame hives, respectively. This is because total cost of production for Ethio-ribrab hive was much cheaper than improved frame hive (See table 3). In addition, significant amount of money can be earned from selling of pure beeswax produced per Ethio-ribrab hive than from improved frame hive. The study clearly showed KTB hive and traditional log hives were the least profitable from sell of honey and bees wax produce (Table 3).

Table 3: Presentation of yearly cost and return of each beehive types per beekeeper owned 10 bee hives in backyard beekeeping practice. Price of pure honey per kg was 80 ETB

Beehive types	Total production cost (ETB)	Gross return (ETB)	Net income per beekeeper (ETB)	Net income per hive (ETB)
Improved frame hive	7127	24072	16945	1695
KTBH	4967	12497	7530	753
Ethio-ribrab	4567	23354	18787	1879
Traditional hive	4157	12245	8088	809

CONCLUSION AND RECOMMENDATIONS

This study clearly revealed that annual honey yield performance and honeybee colony strength in the case of improved frame hive and Ethio-ribrab hive types were higher than KTB hive and Traditional log hives at Bonga condition. Furthermore, a significant amount of pure beeswax can be produced per Ethio-ribrab hive than from improved frame hive. Hence, profitability of Ethio-ribrab hive ranks first and followed by improved frame hive compared with other hive types. The study result could be useful to humid and sub-humid areas of the country and will help to justify and assist the introduction of selected hives or packages. In addition, Ethio-ribrab and improved frame hives' maximum productivity potential should be tested for several honey flow seasons by providing plenty amount of bee flora in the apiary site and timely scheduled improved honeybee management practice. Therefore, introduction of both improved frame hive and Ethio-ribrab hives in the study areas is strongly recommended along with all packages important. Since both types of hives are new to the community adequate training should be provided for beekeepers.

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