GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

www.scienceandnature.org

# PERFORMANCE OF *APIS MELLIFERA* SPP. ON HONEY AND BEESWAX PRODUCTION IN DIFFERENT TYPE OF BEEHIVES IN ENDA MEKONI WOREDA, TIGRAY REGION, ETHIOPIA

Gebreagziabher Aregawi[1], Mohammed Tilahun[2], S.K. Gangwar[2] & Girmay Gebresamuel[3], Girmay Tesfay[4]
[1]Bureau of Agriculture and Rural Development, Enda Mekoni Woreda, Tigray, Ethiopia.
[2]Mekelle University, Department of Animal, Rangeland and Wildlife Sciences, Ethiopia.
[3]Mekelle University, Department of Land Resource Management and Environmental Protection, Ethiopia.
[4]Mekelle University, Department of Natural Resource Economics Management, Ethiopia.

**ABSTRACT**
The objectives of the study was to compare honey and wax production performance of four types of beehives; clay frame hive, Kenyan top bar hive, traditional hive and modern frame hives using locally adapted *Apis mellifera* spp. In this experimental study a total of 36 beehives (9 from each type) were prepared. These beehives were kept into three farmers apiary sites with three replications from each beehive. All colonies used (*Apis mellifera*) were bought from farmers of the study area and had similar strengths. Evaluations were made for parameters of flight intensity, colony strength, development of combs (frames) (DCF), area of comb/frame covered by brood (BC), pollen and nectar (PNC). Data were also recorded for the total production of honey per hive, average production of honey per frame, total weight of beeswax per hive and average production of beeswax per frames. General linear model was used to analyze the effect of hive on each parameter measured using SAS software version 9.2. The study revealed that there was no significant difference in honey production per hive between clay frame (16.081kg), KTB (19.359kg) and modern (12.501kg) hives ($p>0.05$). However, traditional hive (3.599kg) showed significantly lower average production of honey per hive from all other hives ($p<0.05$). Average honey production per frame was significantly higher ($p<0.05$) in KTB (1.506kg) and clay (1.325kg) hives when compared with both modern (0.817kg) and traditional (0.432kg) hives. Traditional hive (4.124kg) showed significantly higher beeswax production per hive than modern (0.248kg) and clay frame (0.329kg) hives but no significant difference with KTB hive (3.205kg). DCF, FB and PNC parameters showed significantly higher for KTB than all the other three hive types. As a result flight intensity at the entrance and colony strength was higher in KTB than all the other hives. The study result implied that KTB hive can be used as an alternative technology in the study area, however longer period of evaluation is necessary to study disease and pest prevalence as well as quality of the produce from such hive.

**KEY WORDS:** Clay hive, modern hive, Kenyan top bar, traditional hive.

## INTRODUCTION

Beekeeping in Ethiopia has long tradition with most of the colonies nested under traditional hives. The presence of diverse agro-climatic zones resulted from the diverse topographic variations make the country suitable for many bee floras. This situation plays role for the large number of honeybee colonies present in Ethiopia. In Tigray regional state there were about 229,626 bee colonies and 3,271,658 kilograms of honey production in 2012 (CSA, 2013). The region has long years of practice and potential in beekeeping (Haftom and Awet, 2013). Beekeeping can be an important profitable agro-business enterprise with little investment made in it and requires the most suitable management practice (considering other environmental factor) to maximize its output. One of the management considerations in beekeeping is selecting a suitable hive and fulfilling seasonal management requirements. Research findings indicated that the temperature and humidity created inside the hive have effect on survival and honey yield of the colonies (Human *et al*., 2006). Honey production surveys and experimental researches indicated that in Tigray regional state honey yield varies within the range of 6-25kg/hive in traditional hive (Teferi *et al*., 2011, Gidey *et al*., 2012, CSA, 2013, Melaku *et al*., 2013) and 16-50kg/hive from modern hive (Teferi *et al*., 2011, Gidey *et al*., 2012, CSA, 2013, Haftom and Awet 2013, Melaku *et al*., 2013). Acquaintance of farmers with KTB to use as alternative technology was close to nil according the national report. However, Haftom and Awot (2013) tested the performance KTB on honey production in the lowland area of Tigray and the honey yield obtained was in the range of 15.74-19.91kg/hive. KTB hive was also acknowledged to increase the profitability of the beekeeping sector for many sub Saharan African countries due to the low cost of making the hive (Wilson 2006). The European box hive (modern hive or movable frame box hive) has been introduced and recognized for its increased production under good management conditions. However, its temperature regulation potential, attack from pests and lack of foundation sheet /wax/, and its requirement of other tools such as extractors are making it difficult for the local farmers to maximize their benefit out of its merits (Gangwar *et al*., 2010, Chala *et al*., 2012, Gizachew *et al*., 2013). It is also clear that such problems could arise from lack of management skill, quality of the material used in temperature regulation, and variations in the bee space requirement of local honeybee races (Kerealem *et al*., 2009). As a result farmers are building traditional and

prototype of modern beehives from different locally available materials like clay, cow dung, ash, a hollowed-out log, and bamboo stem. Thus, the purpose of this experiment was to evaluate the performance of locally adapted honeybee species (*Apis mellifera*) on honey and wax yield managed in different types of hives in one of the beekeeping potential highland area of Tigray regional state, Enda Mekoni woreda.

## MATERIALS & METHODS

### Description of the study area

The study was carried out in the northern part of Ethiopia, Tigray regional state, southern zone, Enda Mekoni woreda (Figure 1) at Mekan kebele. The experiment site is categorized in the highland agro-ecological zone (> 2470 masl**)**. The woreda is divided into 19 rural Peasant Associations (PAs) and 2 urban Kebeles. Topography of the woreda can be classified as very steep 65%, steep 12%, gentle 15% and valley 8%. The total land area of the woreda is 62,184 hectare and average land holding is about 0.5ha with a minimum and maximum of 0.25 and 0.75 hectares respectively. The total human population of the woreda is 98416. The number of agricultural households is 21,394 and out of this 40% are female. The woreda is endowed with diverse natural resource and can grow diverse annual and perennial crops. Mean annual rainfall is 650-950 mm received in bimodal pattern Belg (short rain season) and Kiremt (long rainy season). Farmers depend on Kiremt season for crop production. The woreda is endowed with surface and ground water resources that play great role in the agricultural productivity. These rivers are mainly used for irrigating horticultural crops, mainly vegetables and fruits, during the dry season and the mean annual temperature ranges between $12^0$C and 18 $^0$C (EMWARD 2013).

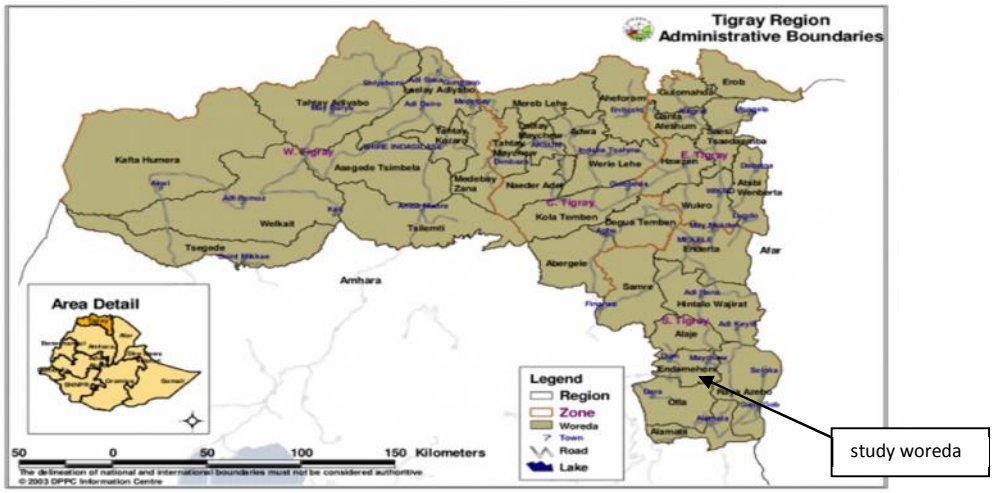


**FIGURE 1**: Map of study area

### Experimental design

Three farmers at the same ecological zone (Highland) were selected from the woreda Enda Mekoni, Mekan kebele. Nine from each of the four types of beehives (traditional, Kenyan top bar, clay frame and modern hives) were prepared. These hives were installed at three different farmer's apiary sites and randomly placed using a Completely Randomized Design (CRD). Similarly, 36 honeybee colonies (*Apis mellifera* spp.) were purchased from the local farmers of Mekan Kebelle. Colonies were randomly allocated to each hive to avoid bias in colony strength. Finally, each of the three farmers received the four types of beehives and honeybee colonies with three replications. During colony transferring all materials pollen, nectar, brood, honey and worker bees were transferred to each hive to help establish transferred colonies. In addition all colonies were fed sugar syrup for one week equally using outside feeding system.

### Data collection parameters

Performance evaluation of honeybee colonies under each type of beehive was done by measuring parameters of colony strength, brood area, pollen area, nectar area coverages of combs/frames. The record was taken for 10 consecutive weeks. In addition, extracted honey and crude wax yield per hive and frame was measured twice during the main harvesting season, November to December 2013. Colony strength was rated as excellent, very good, good and poor based on the number of worker bees covering three randomly inspected frames/combs/ from each hive. If all the frames/combs/ were covered by bees during inspection it was rated as 'excellent'. Otherwise if about 50-75%, 25-50% and less than 25% of the frames/combs were covered by bees it was rated as very good, good and poor respectively. The weight of honey and crude wax was measured using a digital balance with 0.01g recording error. The number of frames developed and covered with brood, nectar and pollen were also counted to identify the suitability of each hive for the bees.

### Data analysis methods

General linear model procedure of the SAS version 9.2 was employed for dependent variables to detect statistical differences among different types of beehives (SAS, 2008). Types of hives were fitted as fixed independent variables. Mean comparisons were made using Tukey`s studentized range test method at $p<0.05$.

Model used for the least - squares analysis of dependent variables was:

$Yij = \mu + Hi + eij$

Where: Yijk = Observed dependent variables
μ = Overall mean
Hi = Fixed effect of hive type (i=4; clay framed, modern framed, KTB and traditional hives)
eij = Residual error

## RESULTS & DISCUSSION

### Honey production performance of different types of beehives

The present study revealed that there was no significant difference in honey production per hive between clay frame, KTB and modern hives ($p>0.05$). However, traditional hive showed significantly lower average production of honey from all other hives ($p<0.05$) (Table 3). The highest average honey yield per hive was recorded from Kenyan top bar (19.359kg) than clay (16.081kg) and modern (12.501kg) hives. Average honey yield per frame was significantly higher ($p<0.05$) in KTB (1.506kg) and clay (1.325kg) hives when compared with both modern (0.817kg) and traditional (0.432kg) hives (Table 1). This variation might be due to the larger comb size and thickness of KTB combs than the other hives. This result also indicates that if all frames in modern and KTB hives are filled with ripened honey at good times, the production potential of KTB will exceed much higher than modern hives under such ideal conditions. On farm evaluation of the productivity of KTB and modern hives in Begasheka and Debrekidan districts of Tigray regional state indicated that KTB provided average honey yield of 17.82kg/hive while modern hive provided 22.80kg/hive of average honey yield (Haftom and Awet 2013). In this study modern hive showed relatively lower average honey yield which might be ascribed to the variations in the climatic zone of the experimental sites. The present study was conducted in highland area with cold climate while the study by Haftom and Awot (2012) was done on the lowland and warm climate part of the region. according to the central statistical record the regional average honey yield from modern and traditional hives was about 16.2kg/hive/year and 6kg/hive/year respectively (CSA 2013). On the other hand community response from Enderta woreda of Tigray region indicated that 33kg/hive and 16kg/hive honey yield was found from modern and traditional hives respectively (Teferi et al. 2011). As survey result from Atsgede Tsembla district of Tigray region reported that the maximum honey production potential of modern hive was within the range of 45-50kg/hive while 20-25kg/hive from traditional hives (Gidey *et al*., 2012). Even in Kafa zone in the Southern part of the country where bee forage is not a limitation traditional hives produced within the range of 10.53-16.06kg/hive(Awraris *et al.*, 2012). Such variations indicate that local environmental factors particularly of climate and bee flora availability have impact on honey yield of the different hives (Chagwiza *et al*., 2011, Teferi *et al*., 2011, Haftom and Awet, 2013).

### Beeswax production performance of different types of beehives

The present study indicated that types of hives had significant effect in total weight of crude wax per hive and average weight of crude wax per frame produced ($p<0.05$). As shown in Table 1, there was significantly higher ($p<0.05$) total weight of crude wax production per hive in traditional (4.124kg) hive than both modern (0.248kg) and clay frame (0.329kg) hives. However, there was no significant difference ($p>0.05$) among clay frame hive, modern and KTB hives. Similarly KTB (3.205kg) and traditional hives didn't show significant difference in crude wax production per hive. On the other hand, the average weight of crude wax produced per frame from traditional hive was significantly higher than both the modern and clay hives ($p<0.05$). From modern and clay hives very small amount of beeswax were collected compared to traditional (4.124kg/hive) and KTB (3.205 kg/hive) hives. This might be due to the reason that the two frame hives (modern and clay) have small comb thickness and after extraction the wax is replaced again to save time for the bees. The bees in KTB and traditional hives construct the comb (frame) by themselves that have greater thickness, depth and cannot be returned again after extraction of honey.

**(a)** **(b)**

**FIGURE 2:** Beeswax produced from modern (a) and traditional (b) hives

According to the previous findings the average beeswax yield from traditional hives amounted for 8 to 10% of the honey yield (Hartmann 2004). Similarly (HBRC 2004) finding indicated that from the total honey production 29.2% was beeswax in traditional hives. However the result of the present study indicated that the amount of honey production from traditional hive was (3.599 kg/hive) which is less than the wax yield (4.12 kg/hive) due to the exceptional seasonal conditions experienced in the study area. The bees in traditional hive developed the

combs for honey and brood however the honey could not ripened due to the cloudy weather condition during the harvesting season. The bees consume majority of the unripe honey.

**TABLE 1:** Total honey yield per hive (THPH), average honey yield per frame (AHYF), total weight of beeswax per hive (TWWH) and Average of weight beeswax per frame (AWWF) from different bee hives.

| | Parameters (mean ± SE) | | | |
|---|---|---|---|---|
| Type of hive | THPH (g) | AHYF (g) | TWWH (g) | AWWF (g) |
| Clay | 16081 ± 4146[a] | 1325.4 ± 198[a] | 329 ± 93.2[b] | 25.9 ± 4.7[c] |
| Modern | 12501 ± 5088[a] | 816.5 ± 279[b] | 248 ± 107[b] | 16.0 ± 5.8[c] |
| KTB | 19359 ± 4258[a] | 1505.8 ± 124[a] | 3205 ± 587[a] | 262.2 ± 9.5[b] |
| Traditional | 3599 ± 1109[b] | 432.0 ± 92.8[b] | 4124.4 ± 889[a] | 581.0 ± 124[a] |
| Grand mean | 12885 ± 2136 | 1020 ± 115 | 1977 ± 388 | 221.3 ± 49.0 |

[abc] Means in a column with different superscript letters denote significant differences at $p < 0.05$

**Development of combs/frames at different types of beehives**

The total numbers of combs developed for brood and honey as well as combs covered with pollen were counted over the entire inspection period (10 consecutive weeks) for each of the four types of hives. The result showed that (Table 2) there was significantly larger number of combs developed by bees from KTB hive (10.6±0.56 frames/ hive) when compared with modern (7.80 ± 0.41), clay (7.23 ±0.38) and traditional (7.23 ± 0.38) hives. However, there was no significant difference between modern, clay and traditional hives ($p>0.05$). Larger number of developed combs/frames, frames with brood, pollen and nectar coverage was recorded from KTB hives whereas the fewer numbers recorded from traditional hives. This result implies that a hive that encourage population growth will produce more honey and reduce honey consumption per bee during the dearth period (Szabo and Lefkovitch, 1989). Nevertheless care is needed to minimize the high tendency of the colonies in KTB to brood rearing during the peak nectar flow season. High brooding during the peak nectar flow season can potentially reduce honey yield (Adgaba *et al*., 2013). The results in Table 1 and Table 2 seem contradicting with regard to crude wax production. The highest crude wax production was recorded from traditional hive (Table 1) however the smallest number of developed frames was recorded for traditional hive. The reason was that most of the developed combs in traditional hive were empty and harvested as wax yield while most frames in KTB hive were covered by brood and pollen (Table 2).

**TABLE 2:** The development of combs/frames (DCF), frames with brood (FB), and frames with pollen and nectar coverage (PNC) in different beehives

| | Parameters (Mean ± SE) | | |
|---|---|---|---|
| Type of hives | DCF | FB | PNC |
| Clay | 7.23 ± 0.38[b] | 5.62 ± 0.32[b] | 1.61 ± 0.09[b] |
| Modern | 7.80 ± 0.41[b] | 6.24 ± 0.35[b] | 1.57 ± 0.12[b] |
| KTB | 10.60 ± 0.56[a] | 8.56 ± 0.49[a] | 2.01 ± 0.13[a] |
| Traditional | 7.23 ± 0.38[b] | 3.91 ± 0.19[c] | 0.48 ± 0.06[c] |
| Grand mean | 7.49 ± 0.24 | 6.08 ± 0.20 | 1.42 ± 0.06 |

[abc] Means in a column with different superscript letters denote significant differences at $p < 0.05$.

**(a)** **(b)**

**(c)** **(d)**

**FIGURE 2:** Coverage of pollen (a), nectar (d), and brood (c) on combs/frames and comb development (b)

**Flight intensity and colony strength at different hives**

Within 10 weeks of inspection period colonies under KTB hive were scored as excellent 53 times (Table 3) from all hives indicating better intensity of flying bees from the entrance for foraging and defense. Similarly the highest proportions of 'excellent' ratings were recorded for KTB followed by clay frame hive in colony strength. The study conducted in Nigeria showed similar result with the present study that KTB hive and clay-pot hives showed significantly higher performances in colony establishment than Langstroth hive (Ande *et al*., 2008).

**TABLE 3:** Flight intensity and colony strength, in the different types of beehives.

| Parameters (%) | Type of beehives* | | | | |
|---|---|---|---|---|---|
| | Clay | Modern | KTB | Traditional | Overall |
| Flight intensity | | | | | |
| Excellent | 38 (42.22) | 38 (42.22) | 53 (58.89) | - | 129 (35.83) |
| Very good | 33 (36.67) | 23 (25.56) | 31 (34.44) | 36 (40) | 123 (34.17) |
| Good | 15 (16.67) | 22 (24.44) | 4 (4.44) | 53 (58.59) | 94 (26.17) |
| Weak | 4 (4.44) | 7 (7.78) | 2 (2.22) | 1 (1.11) | 14 (3.89) |
| Colony strength | | | | | |
| Excellent | 40 (44.44) | 38 (42.22) | 53 (58.89) | - | 131 (36.39) |
| Very good | 31 (33.44) | 24 (26.67) | 32 (35.56) | 36 (40) | 123 (34.17) |
| Good | 13 (14.44) | 21 (23.33) | 5 (5.56) | 53 (58.89) | 92 (25.56) |
| Weak | 6 (6.67) | 7 (7.78) | - | 1 (1.11) | 14 (3.89) |

* Values in parenthesis are percentages

## CONCLUSION

This study conducted in the highland part of Enda Mekoni Woreda indicated that KTB hive had superiority in average honey production per hive, flight intensity and colony strengths when compared with modern, clay and traditional hives. Wax production per hive was also comparable with traditional hive. The implication of the finding is that KTB can be used as an alternative technology in the study area to increase wax and honey production. However, further study should be carried out for longer period of time to identify its disease and pest infestation rate and to verify the quality of honey produced from such hive.

## ACKNOWLEDGEMENT

The authors would like to thank Ato Mache Adhana, Ato Abraha Kalayu, Ato Reda Gaebo who allowed their apiary sites; Ato Yemane Gebremeskel and Ato Temesgen Tesfaye for the technical advice during the research work; and the Netherland Government fund under CASCAPE project of Mekelle University for funding the entire research work.

## REFERENCES

Adgaba, N., Al-ghamdi, A. A., Hailu, M., Shenkute, A. G., Ansari, M. J., Hepburn, H. R. and Radloff, S. E. (2013) Queen excluders enhance honey production in African honey bees, Apis mellifera, by limiting brood rearing during peak nectar flow. Journal of Apicultural Research **52**:184-189.

Ande, A., Oyerinde, A. and Jibril, M. (2008) Comparative study of the influence of hive types on bee colony establishment. International Journal of Agricultural Biololgy **10**:517-520.

Awraris, G. S., Yemisrach, G., Dejen, A., Nuru, A., Gebeyehu, G. and Workneh, A. (2012) Honey production systems (Apis mellifera L.) in Kaffa, Sheka and Bench-Maji zones of Ethiopia. Journal of Agricultural Extension and Rural Development **4**:528-541.

Chagwiza, C., Muradian, R., Ruben, R. and Tessema, W. (2011) Collective Entrepreneurship: A Comparison between two Producer Organizations in the Ethiopian Honey Sector. Cyprus **23**:2012.

Chala, K., Taye, T., Kebede, D. and Tadele, T. (2012) Opportunities and challenges of honey production in Gomma district of Jimma zone, South-west Ethiopia. Journal of Agricultural Extension and Rural Development **4**:81-91.

CSA (2013) Central statistical agency agricultural sample survey 2012/13 [ 2005 e.c.]: Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Federal Democratic Republic of Ethiopia Central Statistical Agency. Addis Ababa, Ethiopia.

EMWARD (2013) 9th month Annual Report. Enda Mekoni Woreda Agricultural and Rural Development Office (EMWARD).Tigray, Ethiopia.

Gangwar, S. K., Ebrahim, A., Gebremariam, H. and Tajebe, S. (2010) Characteristics of honey produced by different plant species in Ethiopia. Advance in Bioresearch **1**:100-104.

Gidey, Y., Bethelhem, K., Dawit, K. and Alem, M. (2012) Assessment of beekeeping practices in Asgede Tsimbla district, Northern Ethiopia: Absconding, bee forage and bee pests. African Journal of Agricultural Research **7**:1-5.

Gizachew, G., Sefinew, A., Amssalu, B. and Malede, B. (2013) Prevalence and Associated Risk Factors of Bee Lice in Holeta and its Suroundings, Ethiopia. J Veterinar Sci Technol **4**.

Haftom, G. and Awet, E. (2013) On farm evaluation of Kenyan Top bar hive (KTBH) for honey production in Tigray Region, Northern Ethiopia. Livestock Research for Rural Development **25**.

Hartmann, I. (2004) The management of resources and marginalization in beekeeping societies of South West Ethiopia. Page 1 *in* Paper submitted to the conference: Bridge Scales and Epistemologies, Alexandria.

HBRC (2004) Beekeeping training manual.Holeta Bee Research Center (HBRC). Holeta, Ethiopia.

Human, H., Nicolson, S. W. and Dietemann, V. (2006) Do honeybees, Apis mellifera scutellata, regulate humidity in their nest? Naturwissenschaften **93**:397-401.

Kerealem, E., Tilahun, G. and Preston, T. R. (2009) Constraints and prospects for apiculture research and development in Amhara region, Ethiopia. Livestock Research for Rural Development **21**.

Melaku, B., Girmay, M. and Bereket, G. (2013) Identifying beekeepers' adaptation strategies in response to climate change in Tigray, Ethiopia. Wudpecker Journal of Agricultural Research **2**:155 - 159.

SAS (2008) SAS Users guide version 9.2. SAS institute.NC, USA.

Szabo, T. and Lefkovitch, L. (1989) Effect of brood production and population size on honey production of honeybee colonies in Alberta, Canada. Apidologie **20**:157-163.

Teferi, M., Yirga, G., Hailemichael, T. and Amare, S. (2011) Prospects of beekeeping in the Northern Ethiopian highlands. Scientific Research and Essays **6**:6039-6043.

Wilson, R. (2006) Current status and possibilities for improvement of traditional apiculture in sub-Saharan Africa. Livestock Research for Rural Development **18**:77.