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SHORT COMMUNICATION

Determination of bee spacing and comb cell dimension for *Apis mellifera scutellata* races across different agroecology in western Ethiopia

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ABSTRACT

This investigation was done at Wombera and Pawe study areas of Metekel zone of Benishangul-gumuz regional state, western Ethiopia, with the aim of determine the bee spacing and cell dimensions and recommended an appropriate bee spacing and cell dimension for *Apis mellifera scutellata*. Wombera and Pawe study areas were selected to represent highland and lowland agro-ecologies respectively. The measurement of bee space, cell diameter, cell depth, comb thickness and hive dimension were taken from 20 traditional hives at each agro-ecology by using caliper to 0.1mm accuracy. Collected data were analyzed in descriptive statistics, correlation and General Linear Model (GLM) procedures using statistical package for social sciences (SPSS) software. The current study overall mean results of bee space, cell depth, cell diameter and comb thickness were 16.5 ±0.5 mm, 10.4 ±0.06 mm, 4.68 ±0.03 mm, and 19.9 ±0.14 mm respectively. The hive width and length were 27.1 ±0.5 cm and 76.5 ±0.9 cm respectively. The results of bee space and comb thickness showed significance difference among districts ($P < 0.05$), whereas cell depth, cell diameter, hive length and hive width were not difference among districts ($P > 0.05$). Therefore, there were difference in bee space and comb thickness in similar honeybee race among two different agroecology but preparing of new casting molds and box hives consistent to the agroecology.

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***Keywords*:** bee space, cell depth, cell diameter, comb thickness, hive dimension, *Apis mellifera scutellata*

1. INTRODUCTION

Ethiopia has a diversified agroecology, climate and vegetation cover, which are responsible for the presence of higher amount of honeybee colonies and a diversity of honeybee races. Five honeybee races are found in different agroecological zones of Ethiopia. These are *Apis mellifera bandasii, Apis mellifera jementica, Apis mellifera monticola, Apis mellifera scutellata* and *Apis mellifera woyi-gambella* (Amsalu *et al*., 2004).

Bee space is a path bee want to move between the combs and around the nest in the wild. It is important to allow bees walk freely on the comb (Jones, 1999). In frame hives, bee space is needed between the outside end of each frame and inner hive wall opposite it, between opposite surface of completed and sealed worker brood combs and between the top of frames in the lower box and the bottom of the frames in the upper box (Crane, 1990). This bee space varies from 6 to 10 mm for *Apis mellefera* races depending on their body sizes. Wild bees start comb construction from one point and develop other combs on each side at equal distance leaving equal gap between each comb (Jones, 1999).

Comb spacing and cell structure are determined by the size of the worker bees of the particular races. This should be the same as the center-to-center distance between adjacent combs and depth and diameter of comb cells built by similar bee races in the wild nest. If too small spacing is used, bees cannot rear brood on both sides of the combs, if the spacing is too large, they are forced to build "burr or bracing" comb in over large gaps between combs (Jones, 1999). European bees comb spacing is about 35mm (ranging from 32 to 38mm), while for most African honeybee races is about 32 mm (30 to 34). However, honeybees tolerate certain bee space and comb cell dimensions in honey chamber (Crane 1990)

Thus, worker bees cell dimension is very important factor to determine the bee space and comb spacing of bee races are to make efficient hive operation. But for local honeybee races in Ethiopia, the appropriate bee space and comb cell structure in the wild nest (traditional hives) and the tolerable frame space in modern hives are not yet studied. Moreover, no standardized hive and casting mold design have been made in the country so far. The construction of hives in Ethiopia is simply by adoption of European dimensions that is not comparable with the size of local bees, as a result so many problems have been observed during hive management.

Therefore, the objective of this study was to investigate bee space and comb cell dimension of the local honeybee races and determine the tolerable frame or bar spacing in modern frame hives and top bar hives respectively.

2. MATERIALS AND METHODS

2. 1. Description of the study area

This investigation was done in two districts of Metekel zone Benishangul-gumuz regional state, Wombera and Pawe. Metekel zone is the largest zone of the region which is covering an area of 3,387,817 hectares consisting of seven districts. The topography of the zone presents

undulating hills slightly sloping down to low land Plateaus having varying altitudes from 600-2800 m and mean annual rainfall of 900-1450mm. About 80% of the area is characterized by sub-humid and humid tropical climate with annual minimum and maximum temperature of 20 ºC and 35 ºC respectively (Metekel Zone Department of Agriculture). Wombera and Pawe represents highland and lowland agro-ecologies of the region respectively. Pawe town is located 572 km west of Addis Ababa. Wombera is located about 192 km south of Pawe town. Major crops grown in the areas are sorghum, maize, finger millet, soybean and groundnut. Livestock species commonly kept are goats, sheep, cattle, chicken and donkeys in order of importance (Metekel Zone Department of Agriculture).

2. 2. Sampling method

Two districts (Wombera and Pawe) were selected purposively based on their agroecology (highland and lowland). One representative Village was selected randomly from each district and 20 traditional bee hives were established from each agroecology. Bee colonies were transferred to traditional hives at right time for data collection.

2. 3. Data collection

2. 3. 1. Bee space and cell depth

The natural bee space of *Apis mellifera scutellata* was measured as the distance between two adjacent combs of naturally built combs in traditional hives. Honey combs were considered for measurement. Accordingly, 20 traditional hives were used per agroecology. A total of 200 measurements of bee space five random points in each traditional hives were measured. The measurements of bee space were done in millimeters using caliper to 0.1mm accuracy. All treatments were done on the same races of *Apis mellifera scutellate* and two different agro ecologies. Cell depth measurements were taken in the center of hexagon downward between parallel walls using digital caliper. The cell depth will be measured for all the 20 colonies of each agroecology. A total of 600 measurements of cell depth were taken, 15 from each hive on both sides of the comb. The measurements were made in millimeters using caliper to 0.1 mm accuracy.

Fig. 1. Measuring of bee space

Fig. 2. Measuring of cell depth

2. 3. 2. Cell diameter and comb thickness

Measurements of the cell diameters were taken across the diagonal using a digital caliper. The cell diameters were measured for all the 20 colonies in each agro-ecology and 15 cell diameters per colony. A total of 600 measurements were taken for cell diameter, 15 from each hive on both sides of the comb. The measurements were made in millimeters using caliper to 0.1mm accuracy. Measurements of comb thickness were carried out on the combs cut vertically or horizontally. Then the distance from the edge of the cell at one side to the opposite side of the cut comb at right angle was measured. A total of 200 measurements were taken for comb thickness, 5 in each colony. The measurements were made in millimeters using digital caliper to 0.1 mm accuracy.

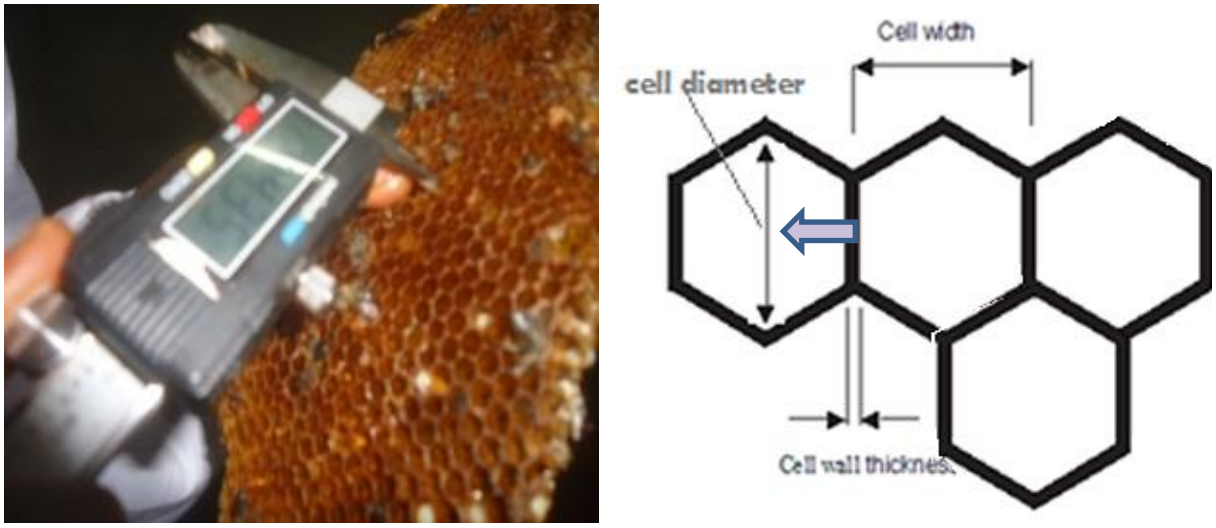

Fig. 3. Measuring of cell diameter

Fig. 4. Measuring of comb thickness

2. 3. 3. Hive length and hive width

The hive length and width were measured for all the 20 colonies of each agro-ecology. The measurements were conducted in meter.

Fig. 5. Measuring of hive length

Fig. 6. Measuring of hive width

2. 4. Data collection, management and statistical analysis

All collected data were entered, organized and managed using Microsoft Excel. Data was analysed using statistical packages for social sciences (SPSS) version 20.GLM and descriptive statistics were employed to test significant differences and means were compared with Fisher's LSD test for each of the parameters between agro-ecologies and using 5% significance level. Correlation analysis was done to determine the degree of relationship of variables. The model was $Yij = \mu + Ai + Eij$, where Yij is measured parameter, μ is over all mean, Ai is effect of agro-ecology and Ɛij is random error.

3. RESULT AND DISCUSSION

3. 1. Bee space

A significance difference ($P<0.05$) at bee space was observed between agro-ecologies on the determined bee space in traditional hives of 16.5 mm and 15.2 and 17.9 mm in highland and lowland agroecology respectively (Table 1). This result is higher with highland 13.5 mm but consistent with mid-land 14.9 mm and low land 14.5 mm of Jimma zone south west Ethiopia (Abera and Kassa, 2016) but higher than 6.5 to 10 mm Curtis (1982) and the determined bee space in traditional hives in which the overall mean is 8.98 mm and it ranges from 6.46-10.98 mm in south western part of Ethiopia Endale *et al.* (2015). Mulisa *et al* (2018) who reported *Apis mellifera scutellata* bee space at mid altitude and highland in western Ethiopia was 10.66 and 20.03 mm, respectively. The result of highland and midland agroecology was higher than and lower than in the current study respectively. The current study showed that lowland agroecology had higher bee spacing than lowland agroecology. This may be due to the presence of cold environment in highland and hot environment in lowland.

3. 2. Cell diameter

Cell diameter in highland and Lowland areas were 4.7 mm and 4.7 mm (Table 1). No significance difference (P>0.05) was observed among agroecologies. The current result showed that preparing of new wax mold instead of currently used which has a diameter of 5.4-5.5 mm (David, 2007) are available. The difference between natural cell diameter and wax molds in case of current study could be a reason for higher absconding rate of *Apis mellifera scutellata* race in Benishangul-gumuz region of Ethiopia (Alemayehu *et al.*, 2015). In addition, Nuru et *al.* (2016) indicated that the low success rate of box beekeeping in Africa and Asia is associated with direct use of technology designed for temperate bees without considering the biology of the target races. The current result lined with Mulisa *et al* (2018) that reported 2.46-4.2 mm in mid-altitude and highland in western Ethiopia, Abera and Kassa 2016 reported 3.68, 3.59 and 3.56mm in highland, midland and lowland respectively Jimma zone south west Ethiopia but lower than Endale *et al*. (2015) reported 5.48 in south west Ethiopia.

3. 3. Cell depth

The average cell depth in highland and lowland were recorded 10.5 and 10.3 mm in the mean of 10.4 respectively (Table 1). There was no significance difference (P>0.05) among agroecologies. The current result agreed with Mulisa *et al* (2018) who reported *Apis mellifera* scutellate the cell depth of mid-altitude and highland were 11.05 and 9.53 mm respectively, Abera and Kassa (2016) reported the cell depth of highland, midland and lowland were 10.45, 10.48 and 11.6 mm respectively and Endale *et al*. (2015) reported lowland, midland and highland were 12.69 mm, 11.28 mm and 12 mm respectively.

3. 4. Comb thickness

The average comb thickness in highland and mid altitude areas were 20.2 and 19.6 in the mean 19.9 mm respectively (Table 1). There was significance difference (*P*<0.05) among agroecologies. Comb thickness in highland areas was larger than that of lowland agroecology. Mulisa et al (2018), Abera and Kassa (2016) and Endale *et al*. (2015) also reported that agroecology had effect on thickness of naturally built combs. The difference in comb thickness between the ago-ecologies could be associated with availability of honey due to strong nectar flow season, honey cells are lengthened resulting in thicker combs (David, 2007). This result lined with Mulisa *et al* (2018) the average comb thicknesses in midland and highland areas were 22.10 and 19.01 mm, respectively but lower than Endale *et al*. (2015) reported lowland, midland and highland were 24.88, 24.59 and 24.99 mm respectively. Abera and Kassa 2016 reported lowland, midland and highland were 23.01, 23.33 and 22.94 mm respectively.

Table 1. Bee space, cell diameter, cell depth and comb thickness honey combs in (mm) of *Apis mellifera scutellate* in two agroecology (N= 40)

Variables	Highland (Mean±SE)	Lowland (Mean±SE)	Overall (Mean±SE)	CV	P-Value
Bee Space (BS)	15.2±0.8	17.9±0.27	16.5±0.5	18.2	0.003**
Cell Diameter (CD)	4.7±0.04	4.7±0.04	4.7±0.03	4.4	0.495

Cell Depth (CDP)	10.5±0.09	10.3±0.09	10.4±0.06	4.1	0. 243
Comb Thickness (CT)	20.2±0.2	19.6±0.16	19.9±0.14	4.5	0.020*

Double asterisk (**) are highly significance (p<0.01) whereas single asterisk (*) are significance difference (P<0.05).

3. 5. Hive Dimensions

The overall mean hive length and width in the study area were 76.5 and 27.1 cm respectively. Traditional hives were not significantly different in length and width (P>0.05) between highland and lowland agroecology of the study area (Table 2).

Table 2. Dimensions of traditional hives (cm) in two agroecology of the study area (N = 40).

Variables	Highland (Mean±SE)	Lowland (Mean±SE)	Overall (Mean±SE)	CV	P-Value
Hive Length (HL)	77.3±1.2	75.6±1.4	76.5±0.9	7.7	0.370
Hive Width (HW)	26.6±0.8	27.5±0.5	27.1±0.5	11.6	0.345

3. 6. Correlations among five parameters

The BS was negatively correlated with CT but positively correlated with CD, CDP, and AR. BS was significance difference (P<0.05) in AR but not in CD, CDP and CT. CD was negatively correlated with AR, but positively correlated with BS, CDP and CT. CD was no significance difference (p>0.05) among other parameters. CDP was positively correlated with BS, CD, CT and AR. CDP was highly significance difference (p<0.01) with CT but not in BS, CD, CT and AR. CT was negatively correlated with BS and AR, but positively correlated with CD and CDP. CT was highly significance difference (P<0.01) with CDP but not with BS, CD, CT and AR. AR was negatively correlated with CD and CT, but positively correlated with BS and CDP. AR was significance difference (P<0.05) with BS but not with CD, CDP and CT (Table 3).

Table 3. Pearson correlation among five parameters (N = 40).

		BS	CD	CDP	CT	AR
BS	PCC		.159	.131	-.156	.346*
	Sig		.328	.421	.335	.029
CD	PCC	.159		.251	.277	-.069
	Sig	.328		.118	.084	.672

CDP	PCC	.131	.251		.519**	.137
	Sig	.421	.118		.001	.400
CT	PCC	-.156	.277	.519**		-.120
	Sig	.335	.084	.001		.462
AR	PCC	.346*	-.069	.137	-.120	
	Sig	.029	.672	.400	.462	

*. Correlation is significant at the 0.05 level (2-tailed). PCC = Pearson correlation coefficient, sig = significance, BS = bee space, CD = comb diameter, CDP = cell depth, CT = comb thickness and AR = area of hive

4. CONCLUSIONS

This study result revealed the presence of variation in natural bee space and comb thickness with in the same honey bee race (*Apis mellifera scutellate*) at two different agroecology in Metekel zone. The variation of bee space among two agroecology might be due to environmental effect. In the highland agroecology bees are exposed for cold weather condition, due to this honeybee are constructed comb closing each other whereas, in lowland the honeybees are exposed to high temperature, this might have honeybees forced to constructed adjacent combs distantly. Comb thickness in lowland is thinner than in highland, because in the lowland agroecology honey comb are exposed to higher temperature due to this the comb try to melt and it becomes thinner than highland agroecology. HL, HW, CD and CDP were no significant differences among the two agroecology. Therefore, considering the natural bee space is very important issue while constructing box hive and to use casting molds with a suitable cell size that matches honeybees with natural cell size. Further investigation is also needed to relate the behaviour, nature and size of local bees with the natural dimensions

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