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On station performance evaluation of local honey bee colonies traits (*Apis mellifera scutellata*) in Gedeo zone, Ethiopia

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Abstract
In Ethiopia, despite the potential of apicultural resource, production and productivity are relatively low. This could be due to many factors like management, environmental factors and races of honeybees. The aim of this study was to evaluate productive potentiality trait of local honeybee colonies for further colonies multiplication purpose. We obtained 20 selected strong honeybee colonies from local beekeepers within traditional hives and transferred into movable frame hive at Dilla site. All the transferred colonies were managed properly to establish themselves and acquire uniform strength. These colonies were evaluated for different parameters such as hygienic behavior, brood, pollen and nectar area, swarming and absconding tendency at different season. The result indicated that the mean percent removal per colony varied from 86.57 (February) to 99.62 (August). The highest brood rearing activity was observed in September and March that covered up to 148.9±14.16 unit areas while the least was observed during November (1.19±0.43) unit area. Maximum pollen and nectar area was found in October (97.5±12.40) unit area and April (81.88±9.47) unit area. While minimum pollen area (5.25±7.13) unit area and nectar (1.10±0.1) area was occupied in November. In general, the study showed that A. m. scutellata honeybees are good in hygienic behavior and brood rearing performance under optimum management practices in the study area. On average 25% of absconding was observed at study site over the last two years of the study period at the time of pollen and nectar shortage mainly November and May Therefore, it is recommended to investigate its detail behavioral aspects whether it is due to environmental or genetically factor for future selection and improvement.

Keywords: Honeybee, brood rearing, hygienic behavior, absconding

1. Introduction
For a successful beekeeper, beekeeping production depends on the selection of better performing honey bee colonies. Thus, selection aims and criteria are important tools in bee breeding program for a beekeeper in an apiary. Colonies in an apiary could be selected on the basis of some of the of most important measurable characteristics *viz*. spring colony development, gentleness and a tendency to remain calm on the comb, over wintering ability, honey production and resistance against diseases (Gregorc A and Vzreja, 2005) [7]. In honeybees as social insect, the colony is the level of selection, but most of the functions are performed by individual workers in the colony (Fewell and Page Jr, 2000) [4]. The various production activities of colonies are greatly influenced by the population of adult bees that forms each bee colony. Colonies with larger populations usually perform better than those with smaller populations. Hence, strength of bees in a colony affects productivity because of high level of correlation between hive strength and honey production. There are some of the important factors which affect colony strength viz. egg laying rate, viability rate, brood care, brood development time and life span (Gregorc and Lokar, 2010) [8]. Although, the worker population of each honey bee colony also depends on food availability (nectar and pollen), oviposition capacity is very important for the generation of populous hives (Rakesh K and Pramod, 2018) [10]. The effective defiance mechanism against disease is one of the most

important functions of the worker bees in a colony. The individual bee's immune system functions in a similar way to that of vertebrate animals, although the most effective defense mechanism that can lead to self-healing of the bee colony is the social behavior of removing as many pathogen agents or parasites as possible from the bee colony. This behavioral defense (entrance reduction and/or stinging) prevents parasites from penetrating the bee colonies, or their killing or removal. Disease resistance is known to correlate with the "hygienic behavior" of worker bees. This is the ability of workers to recognize dead brood and then remove infected or damaged brood. This characteristic has been found to be regulated by two pairs of recessive genes. The queen honey bee is an important member to a colony's survival and functions. The longevity of a queen in a colony depends on its reproductive potential, and its permanence in the colony is related to its oviposition capacity, which affects colony viability and vitality. The queen is naturally replaced when the spermatozoa stored in its sperm theca are depleted (Hatjina F *et al.*, 2020) [14]. Egg-laying capability "is not the only measure of a queen's performance. Queens produce pheromones that greatly affect the activities, especially foraging activity of workers. Pheromone production diminishes in quality and quantity as queen age. In peak season, a queen laid about 2000 eggs (Gary, 2010) [15]. Brood solidness is also an important trait of a colony. Brooding pattern/solidness of a colony could be erratic or solid. Brood solidness of a comb is expressed by the percentage of empty worker cells in a brood patch of a given area. Whether, an acceptable level of empty cells in a comb should be usually less than 10% (Delaplane *et al*., 2013) [3]. In the light of above facts regarding the importance of selection of better performing colonies, those colonies having all these important traits will be selected in breeding yard for further breeding programmed for improvement of the stock. Therefore, the aim of this work was to evaluate productive potentiality trait of local honeybee colonies for further colonies multiplication purpose.

2. Materials and Methods

2.1 Description of the Study area and source of experimental colonies

This study was conducted at Dilla apiary of Hawassa agricultural research center, south nation, nationality, people regional state, Ethiopia from October 2019 to November 2021 for two and half consecutive years. Twenty Model beekeepers were purposively selected in Dilla zuriya woreda. One strong colony per beekeepers was selected by examined via internal and external observation for their efficiency and purchased and collected in to study site. Finally the collected colony transferred to improved hive in experimental apiary site. Twenty experimental colonies of honeybees used for this experiment to evaluate the performance. The necessary seasonal colony management activities were undertaken throughout the study period. Performance evaluations of the colonies were studied through the following different parameters.

2.2 Data Collection

2.2.1 Evaluation of Hygienic Behavior

Hygienic behavior was determined by a pin-killed brood assay in which the time was recorded for colonies to detect and remove dead brood from a comb section containing 100 cells (containing approximately 100 capped pupae) on one side of the comb. This section of the comb was marked by removing one entire row of cells surrounding the 100 cells. The number of empty cells within the section was counted and recorded. Then every capped pupa within the section was pin-killed and placed back in to the hive of the test colony. After 24hrs the frame with the section will be taken out and then, the numbers of remaining dead brood and removed was recorded. This test was repeat five times for all the colonies to be tested for the hygienic behavior. Finally, the percent of removal of dead brood will calculated as follows the formula used by Kebede, 2006 [17].

$$R = \frac{K - E - C}{T - E} \times 100$$

Where: R = Percent removal of dead brood within 24hrs
K = Number of dead brood removed within 24hrs
E = Number of empty cell within the section insert before test
C = Number of brood cell remained capped after 24hrs
T = Total number of brood within the section of an insert

2.2.2 Evaluation of Brood Area, Pollen and Nectar Storage

The total brood area was measured during the study periods to determine the brood population using 5cm x 5cm gridded wooden frame and placed over each side of the brood combs. The total brood unit area was calculated from the area occupied by the brood. In addition to this, the comb area occupied by pollen and nectar stores was also measure in the same way.

2.2.3 Number of queen cells produced (Swarming Behavior)

Swarming tendency of the colonies was evaluated by counting the number of queen cells constructed from all colonies under the study. These counted cells were remove immediately to avoid double counting.

2.2.4 Evaluation of Absconding Tendency

Absconding tendency was assessed by the ratio of colonies evacuating to the total number of colonies used for the experiment provided that all the colonies are kept under uniform environmental condition.

2.3 Data Management and Statistical Analysis

Data collected will be entered into Microsoft excel 2007 and analyzed using SPSS version 23. Normality of the data will check and they are transformed on Arcsine transformation when necessary. One-way analysis of variance (ANOVA) will run and Tukey's student test (HSD) at 5% level of significance will used to make mean separation, whenever significant results will encountered.

3. Results and Discussion

3.1 Evaluation of Hygienic Behavior

The result of the hygienic behavior of twenty colonies in terms of removing successive pin killed capped brood in 24hrs in different seasons is shown in (Table 1). In this test, the mean percent removal per colony varied from 86.57 (February) to 99.62 (August). This indicated that there was a significant effect of test time (month) on performance of A. m. scutellata honeybee colonies in hygienic behavior. This is in line with the finding of Tadele Alemu *et al.* (2014) [12] who reported that there was a significant effect of test time (month) on performance of A.m. scutellata honeybee colonies in hygienic behavior. The mean percent removal per colony varied from 86.57 (June) to 99.62 (December) in Guji zone.

Table 1: Percent removal of pin-killed capped brood within 24hrs

Months	Removal of pin-killed brood (Mean+ SD)
February	86.57±3.16
March	94.50±2.81
April	98.25±1.14
August	99.62±0.27
September	94.87±1.20
October	93.45±4.46

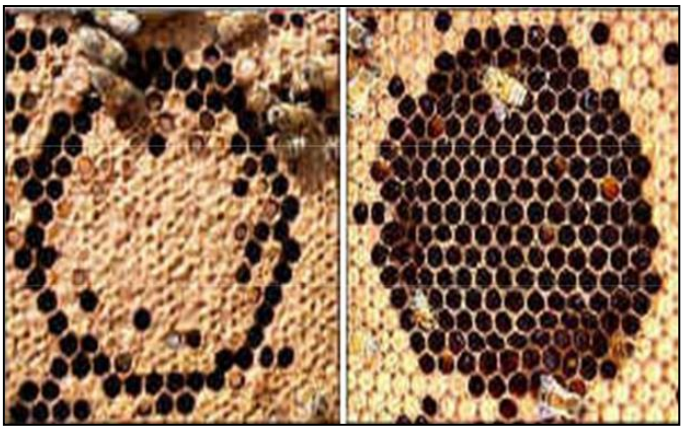

Fig 1: Field photo taken during data collection

3.2 Evaluation of Brood, Pollen and Nectar Area

Brood Area: The total brood area was measured during the study periods to determine the brood population using 5cm x 5cm gridded wooden frame and placed over each side of the brood combs. The results indicated that the highest brood rearing activity was observed in September and March that covered up to 148.9±14.16 unit areas while the least was observed during November (1.19±0.43) unit area. This results dis agrees with Tesfa Mossie and Kasabiratu (2019) [13] who had reported that the highest brood rearing activity was observed from May to June that covered with a mean of 231.63±161.8 and 252.19±143.43 unit areas of 5cm x5cm per colony in Jimma Zone. The brood rearing pattern of A. m. scutellata honeybee colonies showed fast buildup of population between December and February.

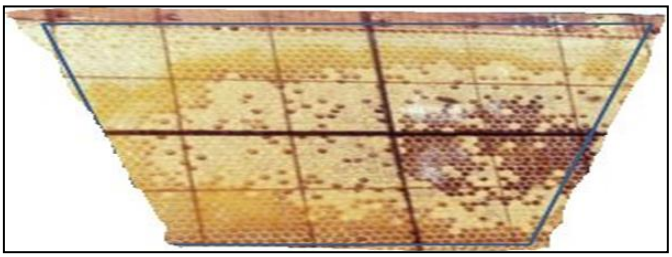

Fig 2: Field photo taken during data collection by grid frames placed over the brood comb

Nectar and pollen area

It was pretty clear from the data embodied in the table 2, maximum pollen and nectar area was found in October (97.5±12.40) unit area and April (81.88±9.47) unit area respectively. While minimum pollen area (5.25±7.13) unit area and nectar (1.10±0.1) area was occupied in November. The storage of nectar and pollen grains by A.m. scutellata honeybees showed a significant variation in different seasons (Table 2). The highest nectar and pollen grain storage was recorded in March and April while the least nectar was stored between Novembers. This is due to the availability of different bee forage species and seasonal variation. Similarly, different authors reported that the honey and pollen collection depends on gene pool of foragers bees significantly affected by environmental conditions (Rakesh K and Pramod M, 2018) [10].

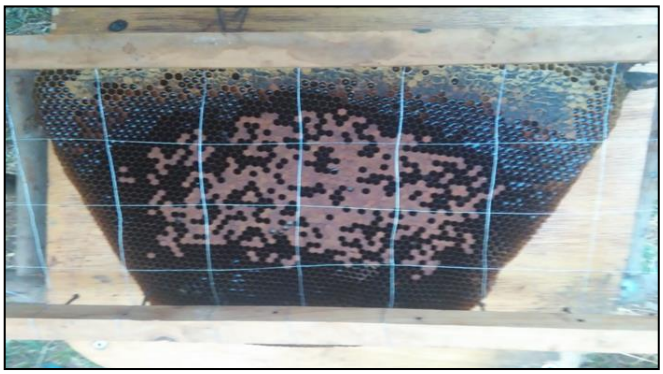

Fig 3: Field photo taken during data collection by grid frames placed over the nectar and pollen comb

Table 2: Mean± SE (number of 5cmx5 cm unit area) of brood, nectar, pollen cells observed in the colonies

Time	Brood area	Pollen area	Nectar area
February 2019	107.8±53.52	22.671±4.62	66.92±17.36
March 2019	138.8±20.23	81.69±14.64	14.43±1.93
April 2019	12.10±0.58	89.8±3.960	131.88±49.47
August 2019	133.38±17.70	6.88±0.55	12.46±0.68
September 2019	148.9±14.16	13.450±0.69	15.70±1.26
October 2019	14.29±1.97	97.5±12.401	13.86±0.9
November 2019	1.79±0.46	7.25±0.58	10.56±1.32
February 2020	111.82±20.62	41.25±0.16	56.50±26.69
March 2020	103.73±5.46	36.0±9.31	12.24±1.60
April 2020	13.20±1.54	19.43±1.72	6.04±0.79
August 2020	93.38±17.70	6.88±0.55	1.46±0.8
September 2020	97.31±9.66	34.69±0.46	5.69±0.73
October 2020	15.63±961	35.5±9.34	14.25±1.72
November 2020	1.19 ±0.43	5.25±7.13	1.10±0.1
February 2021	83.20±31.54	14.875±1.67	2.46±1.68
March 2021	88.8±20.23	51.69±14.64	14.43±1.93
April 2021	12.10±0.58	69.8±3.960	81.88±9.47
August 2021	83.38±7.70	16.88±1.55	12.46±0.68
September 2021	117.31±9.66	24.69±2.46	5.9±0.3
October 2021	13.29±0.97	17.5±2.401	13.86±1.91

3.3 Evaluation of swarming and absconding tendency

Swarming (Number of queen cells produced) tendency

Swarming tendency of the colonies were evaluated by counting the number of queen cells constructed from all colonies under the study and number of swarms produced during the normal honeybees' reproduction season. The average numbers of queen cells in colony per 21-day period were found to be 5.2 – 0 queen cells. As indicated in Fig. 4, bee colonies built a higher average number of queen cells for five months (September, October, March, April and August). Higher numbers of queen cells and peak reproductive swarming tendencies for local honey bees were recorded during September and March. These results are totally consistent with the previous reports of (Amssalu Bezabeh

2002 [16]; Ahmad *et al.*, 2017) [1] that declared tropical honeybees generally have a strong reproductive swarming impulse and tendency to increase population very quickly leading to rapid multiplication of colonies. Am. scutellata had higher tendency to reproductive swarming than A.m. Jemenitica and A.m. woyi-gambella as 36.6% of the populations of the former race swarm every year and issuing multiple swarms commonly 3 to 6 per colony per annum.

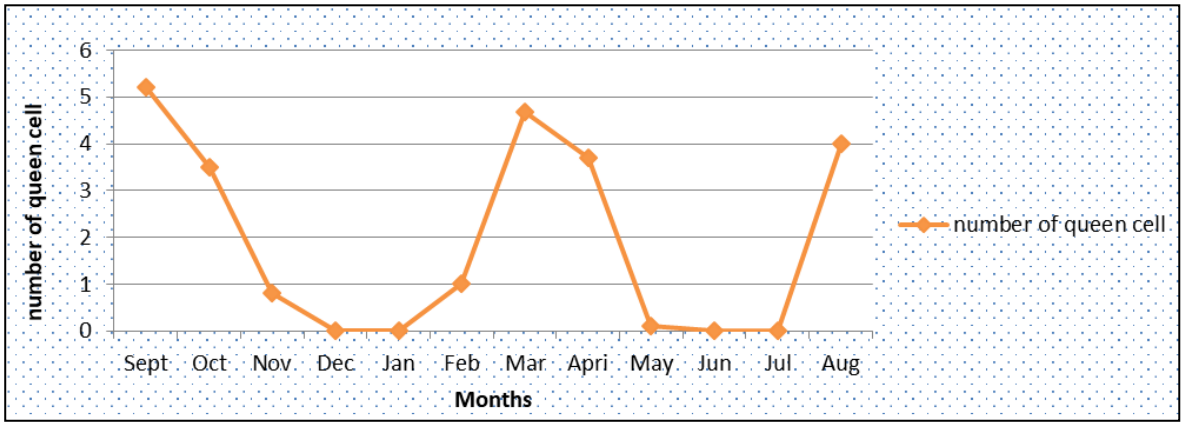

Fig 4: Seasonal distribution of the average number of queen cells produced

Absconding Tendency: Honeybee colonies abandoned their hives at any season of the year for different reasons. The result indicate that December (50.3%), January (54.4%), May (63.3%) and July (59%) as the first four main colony absconding months in Dilla site. As observed in research site, incidence of pests and predators, poor management, and excessive weather conditions (sun and rain) are the causes of colony absconding. The peak dearth periods of the year are dry season period (December and may) as there is no flowering plant as a source of pollen and nectar; and during rainy season (June to July), as the pollen of the flowering plants is diluted and the nectar is washed by the rain and is referred to as dearth period. This result correlates with Schneider S (1990) [11] results, who reported that absconding was very serious among the tested colonies due to frequent disturbances, pest attacks, shortage of bee forage in the rainy season which might be due to dearth or pesticide application used for crop production in the area.

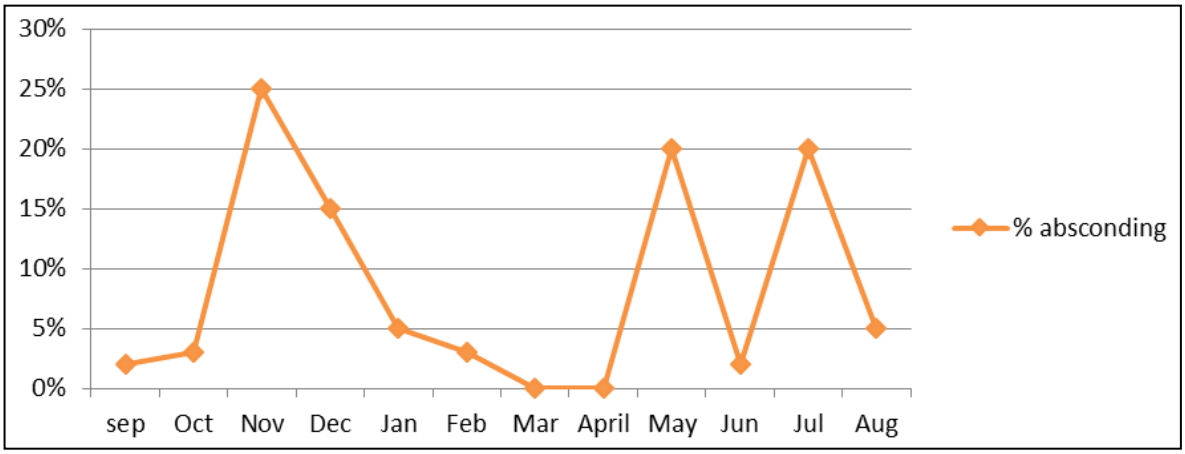

Fig 2: Colony absconding trend in different months of a year

Conclusion and Recommendations

It may be concluded from the present study that the different traits of colonies were tested. This study revealed that A. m. scutellata honeybee colonies in Gedeo had generally different behavioral and productive performances. The colonies had remarkable hygienic performance in removing pin-killed capped brood that reached up to 99.62% cleaning of dead broods within 24hrs in colonies. This high level of hygienic performance could be important in disease, varroa mite, pests, wax moth and bee beetle resistance. The colony strength associated with the performance of colonies and affect productivity of the high level of correlation between brood rearing time, nectar and pollen collection. The highest brood rearing activity was observed in September and March that covered up to 148.9±14.16 unit areas while the least was observed during November (1.19±0.43) unit area. On average 25% of absconding was observed at study site over the last two years of the study period at the time of pollen and nectar shortage mainly November and May. Therefore, it is recommended to investigate its detail behavioral aspects whether it is due to environmental or genetically factor for future selection and improvement.

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