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Effect of Queen Excluder Placing on Honey Yield and Honeybee Colony Performance in Selected Beekeeping Areas of East Shewa and West Arsi Zones of Oromia, Ethiopia

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Abstract
Honeybees in tropics are characterized by a strong propensity towards continuous brood rearing rather than storing honey. Such behavior lowers productivity and profitability of tropical bees. The possibility of maintaining a balance in resource allocation between brood rearing and honey storage is vital to assess.Study was conducted from July, 2020 through June, 2022 to examine the effect of insertingqueen excluder on honeybee population expansion and honey productivity in three adminstrative districts that are typefyied by different agroecologies.A total of 30 honeybee colonies (eight is fitted with honeybee queen excluder at each study district totaling to 24 and 6 (six) left without queen excluder) were randomly assigned to treatments. Before an expected honey harvest season, the treatment honeybee colonies were assigned to four different honeybee queen excluder fitting r time intervals viz. 1st week, 2nd week, third week and fourth week of the honey flow month. Data on number of honey comb area, brood comb area, pollen comb area and worker comb area were collected during flowering seasons over a two-year period. The total brood comb area was not differ significantly between the treatments. However, three weeks before honey harvest time,, there was a highly significant difference in the total brood population between the treatment and control groups. Honeybee colonies without queen excluders continued to rear brood, even during peak honey flow periods. The partial limiting of queen egg laying using queen excluders significantly reduced the total brood comb area compared to the control group at peak honey flow. The weekly total honey comb area was significantly different between the control and treatment groups. The honeybee colonies for which queen excluders were installed between the second and third weeks of the honey flow season had showed the highest number of honey comb areas.Installing queen excluders before the second or third weeks of the start of the honey flow is more practicable and economical.
Keywords: Honeybee colony , Queen, Queen-excluder , Beekeeping, Brood, Honey, Pollen
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Introduction

Beekeeping, also known as apiculture or meliponiculture, has been defined in various ways (Alfred and Roger, 2008; Cadwallader, 2011; Guyo *et al*., 2015; MNRT, 1998).But all definitions point to the art of managing honeybees sustainably for the purpose of tapping into the resource benefits. Beekeeping is more than collecting and retaining bees in a hive and apiary, or putting a hive in an apiary and waiting to benefit from the bee colony. Beekeeping involves effectively and sustainably managing the bee colony.Woyke(1984) reported that honey production is a complex characteristics of several factors and requires modern types of equipment and tools, applying appropriate beekeeping knowledge and skills, and accessing potential and profitable markets.

Among several things, beekeeping without understanding of local situation is nothing but wastage of time and other essential resources and will trivially contribute to economic and environmental sustainability. Therefore, utilization of improved beekeeping technologies has to be made sure under real circumstances of a given beekeeping region for successful and maximized profitability (Rodinov V. and Shabanshov.T, 2009).

Minimum ecological and temporal variations primarily affect beekeeping activities and matters further in the act to boost any agricultural products and honey production will not be exception.

Ethiopia, in East Africa, with more than 10 million honeybee colonies and nearly 1 million beekeepers, has long made a beekeeping part and parcel of rural livelihood making and income generation activities. However, the way of keeping bees has been of a little value and is very traditional. These way of beekeeping were deemed `not fit' by the government to meet current demands for honey in terms of quality and quantity (Desaleng P, 2012; Tsegay W.K, 2017). Hence, improved hives of different sorts have been introduced into the country. However, there are limited studies on the determination of the impact of improved hives and associated technologies on livelihoods and production (Gichora, 2003; Tsegay W.K, 2017). Among other major factors, honey production that is considered surplus is significantly influenced by seasonal and geographical variations that directly and indirectly affect reproductive and productive behavior of honeybee (Delgado *et al*., 2012, Mendizabal, 2005(Kugonza, 2009)) and flowering phenology of local honeybee plant species (Hegland et al.,2009).

Therefore, this situation does justify that any honeybee management activities must be geared towards the nature of particular honeybee race, the climate, the season, the vegetation and geography. Management skill that can be practically applied under local condition plays a key role in enabling beekeeping sector gainful.

Practice of beekeeping is not only depending on better strain of honeybees but also on abundance and occurrence of pollen and nectar sources within surrounding areas of an apiary (Free JB., 1970; Akrathanakal P, 1987). However plants of several families are blooming at different time and season of the year (Free JB., 1970) depending upon soil type, climatic factors and habitat of vegetation. Furthermore, blooming time may change for even the same nectariferous plant species (Kumar R, Rajput GS, Mishra RC, Agrawal OP., 2013). For a particular beekeeping technology to be of practical use, sound information and research based evidence is always of paramount importance to substantiate it at best (Rodinov VV, Shabanshov., 1986). Such information may enable beekeepers to utilize beekeeping at the maximum level so that they are able to harvest good yield of honey and other bee products.

Being one of the important components of modern hive, Queen Excluder-a device used to confine honeybee queen in the intended hive chamber-helps change honeybee workers tendency of rearing brood to honey storing tasks in a season.While the effectiveness of queen excluder insertion is strongly dependent on local conditions like vegetation, honeybee behavior and weather variables, research based utilization of the instrument appeared to have been loosely considered in the local beekeeping (Nuru Adgaba *et al* ,2007).

Tropical bees work all year round. There is no need to over winter them or keep them indoors and then to get them working again as in temperate regions. For this reason, unlike honey bees of temperate regions, those of tropical Africa exhibit a strong tendency towards continuous brood rearing rather than storing honey, a behavior that lowers both the productivity and commercial value of African bees.

In Ethiopia, honeybee queen excluder technology has been in use for decades but with minimum impact on honey production. In the country the rift system is characterized by highly variable climate and hence optimum time for use of queen excluder does always seem unreliable. Even though some studies have been conducted to identify optimum time of queen excluder insertion (Nuru Adgaba *et al.*,2007), taking into account the agro climatic and floral diversity of the country, further investigation is needed to make the finding obtained so far representative at best.

Therefore, this study is designed to identify a model time for utilization of honeybee queen excluder before main honey flow season in some beekeeping areas of East Shewa and West Arsi zones of Oromia. In this study, while maintaining a balance in resource allocation between brood rearing and honey storage,.queen excluder utilization practice under farmers condition and impact of queen excluder placing on honeybee colony performance were assessed.

Materials and Methods

The Locations

This study was conducted in East Shewa and West Arsi zones of Oromia, Ethiopia.Three beekeeping districts, each one from different type of agro ecologies viz. Lowland (Adami Tulu Jido Kombolcha), midland (Wondo) and highland (Kofale) were purposively selected based on beekeeping potential and, accessibility.

Kofele district is located in West Arsi zone of Oromia National Regional State, Ethiopia. The district is located at 305 km from Addis Ababa towards Southern direction. The major agro-ecologies of the district are high land (90%) and mid-land (10%) having clay loam soil type of 90% and the remaining 10% is red and black. The district was found within 2460 to 2790 masl. It receives an average rainfall of 1800 mm per annum with minimum 2000mm per annum and maximum 3050mm per annum. The district has bi-modal rainfall distribution with small rains starting from March/April to May and the main rainy season extending from June to September/October. The average temperatures were 19.5°C per year with minimum of 17°C and maximum of 22°C. The land use pattern of the district shows that 33,599 ha is cultivable, 21,631ha grazing land, 5,157 ha is covered by forest, bushes and shrubs, and 5,913 ha is being used for other purposes such as encampments, and infrastructure facilities. The types of crops widely grown in the district are barley, potato, maize, enset, normal cabbage (Ethiopian kale) and head Cabbage.

Adami Tulu Jido-Kombolcha (ATJK) district is located in East Shewa of Oromia, Ethiopia. The district is located in middle rift valley of Ethiopia, 160km from Addis Ababa the capital city of Ethiopia and it is , in south eastern part of Oromia. It lies at latitude of 7°44'59.99" N and 8°39'59.99" E and longitudes. The total land area of the district is 1403.3km2 (140,330 hectare) which is inhabited by 177,492 people, of which more than 79 percent are living in the rural area. The agro-ecological zone of the district is semiarid and sub-humid in which 90% of the area is lowland while the remaining 10% is midlandwith altitude ranges from 1500 –2000 meter above sea level. The mean annual rainfall is 875mm which ranges from 750-1000mm and the distribution is highly variable between and within years. The mean annual temperature ranges from 22-28^{0}C.

Wondo Genet is located in the southeastern escarpment of the Ethiopian Great Rift Valley (07-07- 06N and 38°and 42^{0}E), approximately 260 km south of Addis Ababa. The altitude ranges from 1,800 to 2,580 ma.s.l. The average yearly rainfall is 1,210 mm, with a rainy season during March to September, and a relatively dry period from December to February. The average annual temperature is 20°C.

Research Design and Methods

A quick assessment was done in the selected study districts to know the extent of use of modern hive before the actual experiment setting up .From available beekeepers list in the districts ,a total of thirty beekeepers were purposively interviewed from three districts to get supportive and feasiblity information for the study.

For the purpose of this experiment, a total of 30 honeybee colonies (eight is fitted with honeybee queen excluder at each study district totaling to 24 and 6 (six) left without being fitted with honeybee queen excluder) were randomly assigned to the treatment groups.

The colonies were randomly assigned to the treatments.Placing of Honeybee queen excluder in experimental honeybee colonies was done in a four weekly intervals i.e one week, two weeks, three weeks, and four weeks during the first experimental year (2020).

The brood rearing status of the colonies was continually inspected before determining when the queen excluders should be inserted in the treatment colonies. A queen excluder (5 mm mesh) was inserted into each of the treatment colonies at the beginning of each predetermined honey flow, before the expected honey harvest, while the control colonies were remain without queen excluder. All of the colonies were maintained in the same apiary with arbitrary access to the surrounding natural bee forage. Routine dearth and active period management activities, such as reducing and adding supers, maintenance feeding during dearth periods and controlling reproductive swarming through queen cell removal, were applied to all colonies.

Comb area occupied by adult bees, bee brood area, pollen area and honey areawere quantified during each honey flow season in both the treatment and control groups using frames with a wire grid to form equal unit areas (25 cm2).

Method of data analysis

Data coding and entry was done in excel MS-word and imported to Statistical package for social sciences (SPSS version 24).Frequency percentage was considered for analysis of nominal data. One way analysis of variance (ANOVA) was employed and LSD was used for mean separation by setting P-value at 0.05.

Result and Discussion

Effect of agroecology and queen excluder on hive parameters (Honeybee worker comb area , number of brood comb area, number of pollen comb area and number of honey comb area)

A colony cannot have any new members for at least 20 days after it is founded. As a result, the population shrinks. A colony can recover from losses more quickly and, in some situations, can increase its population from a low point due to the higher number of old brood.

The higher mean number of honey comb area in honeybee colonies with inserted queen excluders compared to those without queen excluders was observed regardless of agro-ecological differences (Figure 6), suggesting that insertion of queen excluder can rationally increase honey productivity in honeybee colonies. The use of honeybee queen excluders increases honey yield in African honeybee colonies, according to Nuru Adgaba et al. (2013).

Table 1. Mean number of workers, closed brood comb area, open brood comb area, pollen comb area and honey comb area in cm^2 in hives with queen excluder and hives without queen excluder

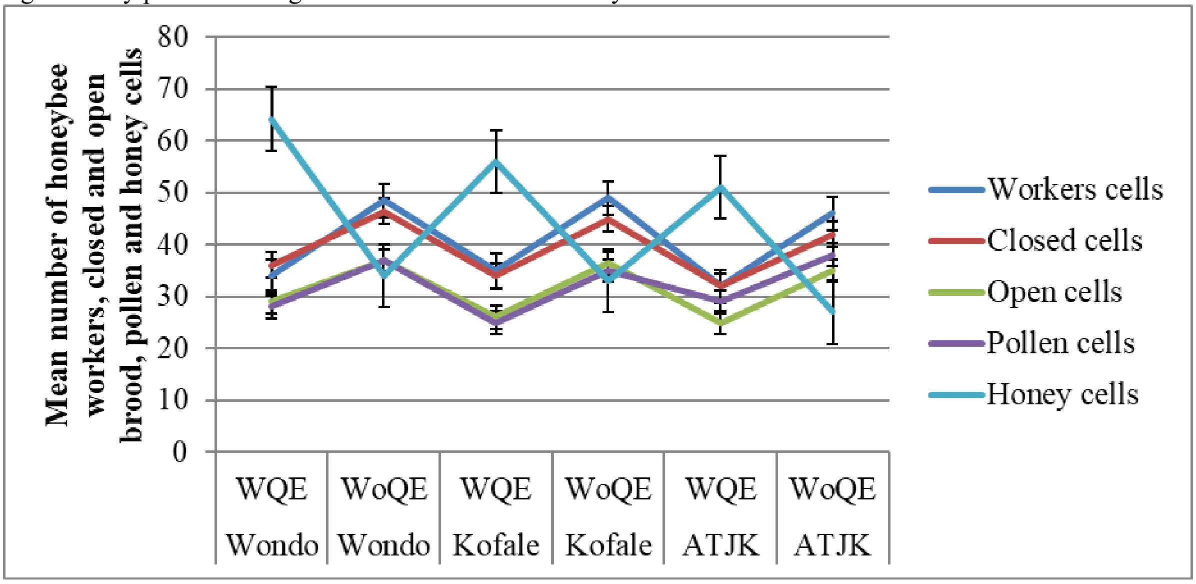
Week classes	workers	closed	open	pollen	honey
WK1	34.7±0.5^{a}	36.3±0.4^{a}	33.6±0.2^{a}	29.8±0.1^{a}	45.3±0.7^{c}
WK2	36.2±0.7^{a}	38.4±0.3^{a}	31.2±0.2^{a}	27.9±0.0^{a}	57.4±0.9^{a}
WK3	35.5±0.5^{a}	37.2±0.1^{a}	32.7±0.0^{a}	29.4±0.0^{a}	49.6±0.3^{b}
WK4	35.1±0.4^{a}	36.5±0.1^{a}	30.5±0.0^{a}	31.7±0.0^{a}	38.7±0.3^{bc}
Control	39.3±0.4^{b}	44.3±0.5^{b}	38.3±0.2^{b}	34.4±0.1^{b}	26.7±0.0^{d}
P-value	0.012	0.011	0.024	0.042	0.001

Note: Wk1 = Oct 1-7, 2020/21; WK2 = Oct 9-14, 2020/21; WK3 = Oct 10-22, 2020/21; WK4 = Oct 23-30, 2020/21; Control = Oct 1-30, 2020/21

Comparably upward trend was observed for most of hive parameters (worker area, closed brood area, open brood area and pollen area) except honey area in honeybee colonies for which queen excluder was not fixed in all agro ecologies (Figure 6.). However, higher mean number of comb area/ comb area was found for both worker honeybees and closed brood population as compared to open brood area and pollen area in both honeybee colonies for which queen excluder was fixed and for which queen excluder was not fixed across agro ecologies. Therefore, it can be concluded that while fixing of honeybee queen excluder certainly improves honey productivity, there will not be apparent effect on honeybee worker and honeybee brood comb area.

Response of hive paramers as influenced by weekly based placing of queen excluder

The purpose of this study was to determine the impact of inserting honeybee queen excluder into hives at various week intervals throughout the anticipated peak honey flow season in the study sites. As a result, the first, second, third, fourth, and full month of October 2020 through October 2022 were evaluated.While there was no significant difference (P>0.05) between treatments for other hive parameters (workers, brood, and pollen comb area) except in untreated honeybee colonies, the weekly based placement of the queen excluder showed significant variation (P<0.05) among all the experimental honeybee colonies in terms of honey productivity.The honeybee colonies for which queen excluders had installed during the second week of the honey flow season had significantly produced the greatest number of mean honey comb areas.



NB: WQE = with queen excluder; WoQE = without queen excluder; ATJK = Adami Tulu JidoKombolcha

Figure 6.Mean number of workers, closed and open brood areas, pollen and honey areas, and closed and open brood areas in hives with and without a queen excluder

Conclusion and Recommendation

Regardless of agro-ecological variations, honeybee colonies with queen excluders have significantly higher mean honey comb area/comb area compared to those without queen excluders. The mean number of honey comb area varied significantly among weekly time classes of honeybee queen placement although other hive parameters did not differ significantly. Also, the honeybee colonies for which queen excluders were installed between the second and third weeks of the honey flow season showed the highest number of honey comb areas.

On the basis of the data presented here, the following recommendation is possible to forward:

- Using a queen excluder for honeybees is helpful for increasing honey production, with no obvious negative effects on worker or brood populations.
- Installing queen excluders before the second or third weeks of the start of the honey flow is more practicable and economical
- It is crucial to give beekeepers practical training on better beekeeping techniques, including how to utilize honeybee queen excluders.

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