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Queen rearing and colony multiplication for promoting beekeeping in Tigray, Ethiopia

Teweldemedhn Gebretinsae Hailu* and Alem Tadesse

Department of animal science and ecotourism, Aksum University Shire campus, Shire, Ethiopia.

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ABSTRACT

Although Ethiopia is working hard to exploit its enormous potential of beekeeping through the introduction of improved hives and capacity building, the country has been challenged by absence of appropriate queen rearing practice. This paper tries to review existing situations of queen rearing and colony multiplication in Tigray region of Ethiopia. In order to bridge gaps and promote beekeeping in the region, higher education and research institutions should focus on the establishment of bee centers committed for research and bee breeding programs whereas the extension should target on capacity building for beekeepers to accomplish queen rearing and bee breeding effectively.

Introduction

A colony of honeybees contains a queen, drones and workers in which the queen controls productivity and behavior of the colony. These castes are developed as a result of preferential feeding during their larval stages. Ones the queen started egg laying, there will be no longer mating and consequently a queen remains economically productive for only one to two years (Akyol *et al*, 2008). While colony of bees rear queen naturally to replace a lost queen, replace the queen when swarming or to supersede a failing queen, beekeepers manipulate a colony to duplicate one or more of these natural circumstances (Johnstone, 2008). Generally, queen rearing is done to allow beekeepers reproduce good stock for replacing old or undesirable queens in their colonies or to start new colonies.

Different techniques of queen rearing have been developed. But all methods are based on the fact that nurse bees can turn young female larvae into queen by feeding royal jelly (David, 2008). Splitting method is recommended to be suitable for Ethiopia (Nuru and Dereje, 1999). On the other hand, colony multiplication and marketing using swarming colonies is an important business in the Northern parts of the country (Nuru, 2008). Thus, splitting and swarming are the only methods of queen rearing and colony multiplication in Tigray region. Splitting method of queen rearing was started since the past decade at demonstration centers and recently scaled up. This paper aims to review existing situations in Tigray as compared to what should be done, why and how regarding queen rearing, colony multiplication and bee breeding.

The need for queen rearing

Endowed with diverse agro-ecologies, Ethiopia is regarded as highly suitable for beekeeping (Jacobs *et al*, 2006). The country is a home for 10 million colonies (Girma, 1998), of which 5.15 are domesticated (Central statistical agency [CSA], 2009). Ethiopia has produced 54,000 tons of honey in the production year 2010/2011 (CSA, 2012). Tigray is one of the potential centers for beekeeping in the country and it is known as the source of the famous brand "white honey of Tigray" (Taddele and Nejdan, 2008). Development endeavors are trying to modernize the traditional beekeeping of Tigray through provision of equipment and capacity building. As a result the percentage of bee colonies nested in movable frame hives has reached 21% as contrasted to the national status, where movable frame hives contribute to less than 3%. Honey yield of the traditional hives in Tigray is 10 Kg per hive per year while that of modern system (movable frame hive) is 16 kg per hive per year (CSA, 2012), which reflects the rewarding results of development interventions.

These efforts are being challenged by limited access of bee colonies for beginners in association with absconding and high prices of colonies. The population of domestic colonies has declined from 5.15 million in 2009 (CAS, 2009) to 4.99 million in 2011 (CAS, 2012). Some of the reasons for the decline in the population of honeybee colonies in Ethiopia include absconding and reduction of swarming due to introduction of movable frame hives (Yigzaw et al, 2010). Hence, the demand for honeybee colonies is skyrocketing. Colony multiplication and selling at local markets is an important business for some beekeepers. Through this system, bee colonies are being transported across the region without considering the risks of genetic mix-up, disease transmission, and adaptation difficulties (Teweldemedhn and Yayneshet, 2014). On the other hand, replacement of old and undesirable queens is not practiced in the Ethiopian beekeeping. Replacing queens older than 3 years was reported to have improved honey yield in Turkey by 150% (Akyol *et al*, 2008).

The queen via its progeny controls the performances of a colony including its productivity and behavior (Johnstone, 2008). Ones a queen started egg laying, there will be no longer mating and consequently a queen remains economically productive for only 1-2 years (Akyol et al, 2008).

Tele: +251 913 422164

E-mail address: teweldeg2008@gmail.com

While bee colony rears queen naturally to replace lost queen, replace the queen when swarming or to supersede a failing one, beekeepers manipulate their colonies to duplicate one or more of these natural circumstances (Johnstone, 2008). Queen rearing is done to allow beekeepers reproduce good stock for replacing old or undesirable queens or to build up new colonies. Beekeepers can get replacement queens either by purchasing or by rearing (Somerville, 2009) but it is preferable to rear queens at self apiary because of cost, time, availability, quality, diseases and mites (Bush, 2007). Queen rearing enables beekeepers to select and reproduce colonies out of their stock. Queens can be reared out of colonies that have demonstrated better performances among the stock although such outstanding traits are less likely to be maintained and inherited for generations under natural mating, where there is no control of the several drones that met with a queen.

Successful implementation of queen rearing, queen replacement and colony multiplication can lead towards performance evaluation and establishment of breeding programs. This can transform the traditional beekeeping, conserve genetic diversity by avoiding colony transporting across agro-ecologies and improve honey production thereby enhance food security.

Conditions for queen rearing

Successful queen rearing requires suitable conditions. Attempting to rear queens at the wrong time of the year results in poor quality queens (Johnstone, 2008) or failure to rear queens at all (Nuru and Dereje, 1999). Ideal conditions are a light nectar flow and good supplies of at least three sources of pollen (Johnstone, 2008). If pollen is in short supply and there is stored pollen collected by trapping during periods of availability, it can be supplemented with high quality pollen. Whenever the bees are close to swarming, conditions are ideal for rearing quality queens. A research conducted at Holeta Bee Research Center has showed the month October to be the most suitable for queen rearing in the area (Nuru and Dereje, 1999). However, beekeepers in Tigray region accomplish queen rearing and colony multiplication through splitting early in the summer (rainy) season no matter its suitability for queen rearing. Beekeepers are egger to have new colonies in June and July in order to have adequate time for the new colonies be established well and become productive or sold before the active season ends up. This results in less developed and less productive queens or queens that are not mated and hence lay only drones to perish the colony soon. This can be aggravated by the fact that no adequate research on identifying suitable season for queen rearing and colony multiplication is conducted in the region. This implies the need for research to identify suitable season of queen rearing for the different agro-ecologies in region.

Caste development and labor division

A colony of honeybees is a combination of one queen, few drones and thousands of workers. These are resulted from differential feeding of larvae in which queen-destined larvae are fed large amounts of royal jelly during the entire larval feeding phase and worker-destined larvae receive an altered diet during the last larval phase. The major differences between the queen and the workers reside in the reproductive system. A queen has about 200 ovarioles per ovary (Cristino *et al*., 2006) and it is capable of producing up to 1000 eggs/day (Johnstone, 2008). Workers in contrast have 2-12 ovarioles per ovary, which do not carry out oogenesis as long as the queen is present (Cristino et al., 2006). If the queen is lost, a number of workers can activate their ovaries and produce haploid eggs that will develop into drones. Drones are fertile haploid males of a colony. A queen is mated 6 to 10 days after her birth in the air with up to 20 drones from diverse genetic lines. This indicates the challenges for controlled mating and genetic improvement (Robinson and Toth, 2004; Cobey, 2007; Johnstone, 2008). The queen produces pheromones that is used to inhibit queen rearing, suppress oogenesis in workers and attracts drones during nuptial flight (Rekwot et al., 2001). On the other hand, workers are responsible for nursing, defending and foraging in sequential shift with age (Robinson and Toth, 2004). Labor division based on age and physiological differences of worker bees have significant implications for artificial queen rearing. Nurse bees have pivotal role for queen rearing while drones are essential for fertilizing the queen.

Colony multiplication and marketing

Colony multiplication and marketing using swarming colonies is an important source of income for sellers and source of bee colony for purchasers in the Northern part of Ethiopia (Nuru, 2008, Teweldemedhn and Yayneshet, 2014). Colony marketing is a common practice in Tigray. This is an important source of income for many sellers, both traders and producers, and an important source of colony for beekeepers; for startup, expansion and replacement. In other parts of the country, colony trapping using bait hives has remained as the main source of colony (Tesfaye and Tesfaye, 2007; Solomon, 2009). Colony marketing is carriedout at apiaries and central market places in Tigray region. Thus, colonies are being transported across the region, which can cause several consequences as discussed previously. Moreover, bee colonies are fragile; at the same time they can cause disasters to people and animals if safety rules are not followed during transport. Adverse effects may happen when large population of bee colonies are assembled at markets. Colony markets in Tigray are usually established near crowdedly residing town dwellers that are less familiar to bees.

Bee breeding and genetic improvement

Beekeepers involved in queen rearing should select stock colonies needed for queen rearing and colony multiplication based on desired traits (Bush, 2007). Through the selection and multiplication of queens, several colonies can be produced from few, genetically superior queens using appropriate queen rearing techniques. This can be facilitated by the short generation interval and large litter size of honeybees. Lineage breeding and hybrid breeding programs can be applied to achieve genetic improvement in honeybees (David, 2008). Considering the haplo-diploid nature of drones and queens, uncontrollable mating behavior, lack of instrumental insemination and research gaps in the local honeybee races; the feasibility of bee breeding seems to be difficult in the short run.

Comprehensive study is needed to identify the local races because reports published so far are contradicting each other. Honeybees of Ethiopia are described as a new race of *Apis* mellifera and named as *Apis mellifera simensis*, on the basis of morphometrical analyses (Meixner et al., 2011) as contrasted to the several races reported by earlier researches (Smith, 1961; Ruttner, 1975; Radloff and Hepburn, 1997a; Amsalu et al., 2003). These imply that there is a need to conduct reliable research in the subject. Knowing the bees will enable to further study their performances and behavior in the different agro-ecologies and seasons. This in turn will help to identify appropriate method of bee breeding for the local bees.

Thus, honey production in particular and food security in general can be enhanced in the region. Besides, it may play a role to the genetic conservation of the honeybee races.

Conclusion and recommendation

By implementing queen rearing, which needs research on identifying suitable seasons, race classification and performance evaluation, the beekeeping sector in Tigray can be enhanced. Higher education and research institutions should focus on the establishment of bee centers committed for research and breeding programs whereas the extension should target on capacity building for beekeepers to accomplish queen rearing and bee breeding effectively.

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