EVALUATION OF ABSCONDING RATE, FORAGING AND DEFENSIVE BEHAVIOUR IN *APIS MELLIFERA MONTICOLA*

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ABSTRACT

Honey bee colonies display a wide range of behavioural variations based on their genetic origin and environmental factors. It is crucial to evaluate the absconding, foraging, and defensive behaviour of different honey bee races to lay the groundwork for future selection and improvement in Ethiopia. For this study, we kept 90 colonies of *Apis mellifera monticolla*, with 30 colonies/ agroecology, in improved box hives. These colonies were similar in terms of the resources contained in the hive. During the active seasons of September to December 2021 and April to June 2022, an assessment of the foraging activity, defensive behaviour, and absconding rate was done. The study revealed that colonies of *A.m.monticola* exhibited an average response time of 53.29 sec to disturbances, indicating their defensive behaviour. Additionally, these colonies demonstrated a willingness to pursue intruders for distances of up to 182.42 m. These colonies were excellent foragers, beginning their activities at 8:13 a.m. and returning to the hive by 10:04 p.m. Moreover, *A.m. monticolla* showed an absconding rate ranging from 1.90 to 4.28% when faced with disruptions. To ensure optimal colony health and productivity, it is advisable to conduct further research on the selection of high-performing colonies.

Key words: *Apis mellifera monticolla,* Absconding, defensiveness, evaluation, disease, foraging, ability, on-farm, agroecology, South Wollo, Ethiopia

Recent studies have focused on behaviours related to colony health and disease control, such as hygienic behaviour and grooming. These behavioural traits can be influenced by environmental factors and beekeeping management techniques. Furthermore, different honey bee subspecies and populations exhibit distinct variations in these behaviours. For instance, the honey bees of Ethiopia form a unique population that is separate from other African honey bees (Meixner et al., 2013). In terms of size and behaviour, honey bees in the highland areas of Ethiopia are larger and more docile, whereas the small lowland honey bees are aggressive and more productive (Tarekegn et al., 2022). Additionally, honey bee colonies within the same agroecological Zone can also differ in their performance (Mossie and Biratu, 2019). Honey bees exhibit colony defense behaviours, which involve predator recognition, nestmate alertness, and anti-predator behaviour. These behaviours have been extensively studied and are well known among honey bee colonies. Beekeepers have traditionally used breeding strategies to reduce swarming and defensive behaviours in their colonies. While swarming is a natural means of reproduction for honey bee colonies and is linked to their overall fitness, beekeepers generally prefer colonies that do not engage in swarming. Defensive behaviour, though discouraged, is still important for the survival of honey bee colonies, as even docile colonies can be targeted by natural enemies such as wasps, birds, or mammals (Tarekegn et al., 2022).

The study area, located in South Wollo, encompasses three agro-ecological zones characterized as "Dega" (elevated above 2,500 m), "Weynadega" (situated between 1,600 and 2,500 m above sea level), and "Kolla" (ranging from 1,300 to 1,600 m). The topography predominantly consists of mountains, with scattered hilly regions. For this particular study, the Tehulederie (middle), Kalu (lowland), and Dessie Zuria (highland) districts were specifically chosen due to their suitability for beekeeping, convenient accessibility, and proximity to honey marketing and processing routes (Bihonegn and Begna, 2021). South Wollo emerges as a crucial region for beekeeping, boasting substantial potential. The abundant and diverse honey bee flora in South Wollo accounts for 11.73% of the total share, with 25,291 bee hives. In terms of honey production, the region yielded an impressive 10,172,964 kg, with South Wollo contributing 693,005 kg, equivalent to 6.81% of the overall production (CSA, 2022). In Ethiopia, the color, size, and distribution of honey bee races have been documented, but their performance has not been extensively researched. It is crucial to evaluate the performance of local honey bees within their natural agroecological distribution. This evaluation will not only help assess their potential but also establish a foundation for future selection and improvement of the local honey bee population. Given this background, the objectives of this study were to assess the absconding rate, foraging ability, and defensive behaviour of honey bee colonies in the study area.

MATERIALS AND METHODS

South Wollo Zone, one of the 11 Zones in the Amhara region, covers a total area of 17,067.45 km^2. It is situated between 10.20^0 and 11.71^0 N and 38.41^0 and 40.02^0 E. The administrative center of the Zone is Dessie town. Within the Zone, there are 20 districts, and for this study, Tehulederie (middle), Kalu (lowland), and Dessie Zuria (highland) districts were specifically selected based on their potential for beekeeping, accessibility, and proximity to honey marketing and processing routes. In most areas of the South Wollo zone, rainfall is bimodal, with longer 'kiremt' rains from July to September and short 'belg' rains from March to April. The Zone receives an average annual rainfall of 1162 mm (Bihonegn et al., 2017). The monthly minimum and maximum temperatures are recorded as 15.2°C and 31.4°C, respectively (Dalle et al., 2023). In this study, 90 colonies were uniformly spread out across three distinct agroecologies situated in different farms. The goal was to examine the performance of honey bee colonies in terms of foraging activity, defensive behaviour, and absconding rate, as well as assess the presence of diseases, predators, and pests. The evaluation of colony performance was conducted from September to December 2021 and April to June 2022, covering the active season of the colonies and the sunrise and sunset periods were available (https://www.timeanddate.com/sun/ethiopia/dessie). Several parameters were considered in this evaluation. The absconding rate was determined by calculating the ratio of colonies that evacuated to the total number of colonies used in the experiment. It is important to note that all colonies were exposed to the same environmental conditions throughout the study, following the methodology described by Alemu et al. (2014). Additionally, data on early foraging and late foraging times were also collected. The time of data recording followed the universal time Zone.

To assess the defensive behaviour of honey bee colonies, an experiment was conducted using a test of aggressiveness. A black leather ball with a diameter of 2 cm was abruptly moved in front of the colony's entrance for 60 sec, maintaining a distance of 5 cm. The observer, wearing gloves, positioned their hands 1 m above the leather ball. The right glove hand was responsible for maneuvering the thread that controlled the leather ball's movement, while the left glove hand remained stationary. Once the first sting occurred on the leather ball, several parameters were recorded, including the time taken for the colony to become highly aggressive, the number of stings on the observer's gloves, the number of stings on the leather ball, and the distance the bees pursued the observer. Afterward, the remaining stingers in the gloves worn by the observer were counted. This procedure was repeated five times for each colony, with a 10-minute interval between tests. The experiments were carried out during the active period of the day, specifically from 1:00 p.m. to 2:00 p.m. (Tarekegn et al., 2022). Additionally, data regarding the presence of diseases, predators, and pests were recorded. The process of identifying diseases included closely observing the scientific symptoms exhibited by the honey bees based on the FAO (2006) guidelines. On the other hand, identifying predators involved comprehensive inspections of both the exterior and interior of the colony, while pests were identified by internal inspections (Somerville and Laffan, 2015; Nagaraja and Rajagopal, 2019).

RESULTS AND DISCUSSION

Table 1 presents the foraging habits and absconding rate of honey bee colonies in different agroecologies or districts. Significant differences were observed in the foraging time during both early and late periods. Dessie Zuriya had a longer early foraging time (8:55± 0.07), while Kalu had a longer late foraging time (10:04± 0.0). There was no significant difference between Tehuledere (8:23± 0.01) and Kalu (8:13± 0.01) during the early foraging period. Additionally, there was no statistically significant difference between Dessie Zuriya and Tehuledere during the late foraging time (9:55± 0.05 and 9:59± 0.05, respectively). Colony foraging ability was shown to be higher in the Kalu agroecology, as colonies from this area exhibited earlier awakening and later returned to their hives compared to colonies

Table 1. Foraging, absconding rate and defensive behaviour of honeybee colonies in the study area

Traits	Agroecology (study districts)			P-value
	Kalu (L)	Dessie Zuria (H)	Tehuledere (M)	
Foraging behavior				
EFT (am)	8:13± 0.01[b]	8:55± 0.07[a]	8:23± 0.01[b]	0.001
LFT (pm)	10:04± 0.01[a]	9:55± 0.05[b]	9:59± 0.05[b]	0.001
Absconding rate	1.90± 0.84	2.38± 0.92	4.28± 1.70	0.353
Defensive behavior				
TtfFs_sec	53.29± 0.70[b]	89.43± 0.63[a]	87.85± 1.04[a]	0.001
Tt_sec_mag	142.28± 0.66[b]	258.86± 0.62[a]	259.28± 0.81[a]	0.001
TNoS__B_	21.28± 0.70	21.71± 0.52	21.71± 0.66	0.860
TNoS_G	12.28± 0.66[b]	15.00± 0.65[a]	7.28± 0.62[c]	0.001
TDF_m_	187.57± 0.89[b]	192.57± 1.00[a]	182.42± 0.51[c]	0.001

L: Lowland; H: Highland; M: Midland; EFT: Early foraging time; LFT: Late foraging time; TtfFs-sec: Total time for the first sting in seconds; Tt-sec-mag: Total time in seconds for mass aggressiveness; TNoS-B: Total number of stings on the leather ball; TNoS-G: Total number of stings on the glove; TDF-m: Total distance followed to the observer in meters; [a-c] Means with different superscripts letters across a raw are significantly different.

in the other districts. Honey bees in the study area were found to be early foragers in both seasons (8:13 am for early foraging time and 10:04 pm for late foraging time) (Joshi and Joshi, 2010). A comparison with *A.m. Scutellata* showed that *A.m. monticolla* displayed a longer cessation time. Previous research by Solomon and Likawent (2015) demonstrated that honey bee races assigned to different agroecologies foraged as early as 8:25 am and returned as late as 10:04 pm, indicating high competence in utilizing natural resources. Various studies have reported different foraging timings in response to geographic and environmental conditions. Temperature has been noted to have the greatest impact on colony activity and bee vitality (Alqarni et al., 2014). The availability and timing of floral resources also influence foraging behaviour (Mossie and Biratu, 2019). Moreover, larval nutrition quality can impact metabolic function and potentially affect foraging efficiency (Nichols and Ricigliano, 2022). Honey bee colonies adapt their foraging behaviour promptly when internal parameters change (Sihag and Kaur, 2018).

Regarding the absconding rate, agroecology did not have a significant impact. The absconding rates in Kalu, Dessie Zuriya, and Tehuledere were 1.90± 0.84, 2.38± 0.92, and 4.28± 1.70, respectively. The highest absconding rate observed in this study was 4.28%. This rate was lower compared to previous studies reporting absconding rates of 63.3% for *A.m. scutellata* (Negash and Argaw, 2022), 54% for *A.m. bandansii* (Hunde and Hora, 2022), 27% for *A.m. scutellata* (Alemu et al., 2014), 26% for *A.m. scutellata* (Aleme et al., 2017), 30% for *A.m. scutellata* (Tarekegn et al., 2022), and 37.5% for *A.m. monticolla* (Merssa et al., 2016). Factors such as disturbances, pest attacks, lack of bee forage during the rainy season, and pesticide use in crop production could contribute to higher absconding rates (Dubale, 2017). High absconding may also occur during the transfer of colonies from traditional hives, potentially due to inadequate internal feeding and the absence of a queen cage (Tesfaye, 2019). Predators, pests, diseases, changes in bee flora seasonality, and environmental changes are among the main triggers of bee colony absconding (Shitaneh et al., 2022). Table 1 presents the findings on colony defensiveness, and except for TNoS-B, which showed a significant difference ($p < 0.05$) with values of 21.28± 0.70 in Kalu, 21.71± 0.52 in Dessie Zuriya, and 21.71± 0.66 in Tehuledere. Dessie Zuriya (89.43± 0.63 and 258.86± 0.62) and Tehuledere (87.85± 1.04 and 259.28± 0.81) recorded higher values in ttffs_sec and tt_sec_mag without a statistically significant difference. Kalu had significantly lower results compared to the other two agroecologies (53.29± 0.70 and 142.28± 0.66). Dessie Zuriya recorded the highest tnos_g_and tdf_m with values of 15.00± 0.65 and 192.57± 1.00 followed by Kalu (12.28± 0.66 and 187.57± 0.89) and Tehuledere (7.28± 0.62 and 182.42± 0.51), with a statistical difference between them.

Being aware of the bees' aggressiveness levels is important. The findings suggest that the *A.m. monticolla* displayed less aggressiveness, indicating that the race struggled to establish strong colonies throughout the active season. This led to good hygienic behaviour and high-quality honey production. Additionally, the race's aggressive behaviour serves as a strong defense against pests. However, this behaviour may not solely be attributed to genetic traits but rather to better apiary management, improved bee forage, and optimized carrying capacity. The temperaments of the colonies in the current study were influenced by the agroecology. In comparison to other studies, the maximum time for the first sting was 89.4 sec, the time taken for mass aggressiveness was 259.3 sec, the total number of stings on the ball was 21.7, the total number of stings on the glove was 17, and the total distance followed was 192.5 m. Valter et al. (2014) found that the average observer's following distance ranged from 23.33 to 216.6 m. Merssa et al. (2016) reported similar results for *A.m. monticolla* with a total time for the first sting of 89.7 sec, a total time for mass aggressiveness of 260 sec, the number of stings on the glove of 16.6, several stings on the leather ball as 22.3, and the total distance followed as 188.4 m. Mossie and Biratu (2019) reported that *A.m. bandansii* took 3.9 sec for the first sting, 152 sec for mass aggressiveness, 282 stings on the ball, and 283.2 m to follow. Tarekegn et al. (2022) reported aggressive behaviour in *A.m. scutellata* with a sting distance of 400 m and a sting time of 40 sec. They also observed 281 stings on the glove and 29 stings on the leather ball. Aleme et al. (2017) noted a total of 80 stings on the ball and a total distance of 115 m for *A.m. Wayi Gambela*. Alemu et al. (2014) found that environmental factors, genetics, colony strength, honey and pollen stores, and alarm signaling volume contribute to variation in aggression. Different honey bee races are distributed across the nation based on climatic conditions, vegetation cover, altitude, and other abiotic and biotic factors.

During the data collection period, the study area experienced various diseases, pests, and predators, as shown in Table 1. Honey bee diseases such as chalkbrood, nosemosis, and varroa were observed. Predators included ants, termites, spiders, birds, lizards, and wasps. bee lice and wax moth were among the pests observed. Similar diseases, predators, and pests were reported in East and West Gojjam according to Ayele et al. (2020). Tsegaye (2015) and Jatema and Abebe (2015) also reported similar findings in the eastern regions of the Amhara region, Gomma woreda, and the Walmara district, respectively. According to various studies by Adeday et al. (2012), Godifey (2015), Haftu et al. (2015), and Tsegaye (2015), the top three honey bee pests are ants, wax moths, and bee-eater birds. This study found that bee colonies in the Kalu agroecology demonstrated a stronger foraging capability compared to other districts. The impact of agroecology on the absconding rate was not significant, but Tehuledere had a higher absconding rate of 4.28%. Interestingly, variations in colony defensiveness were observed among Kalu, Dessie Zuriya, and Tehuledere, with Tnos-b showing notable differences. Predators, pests, and diseases were identified as major factors contributing to colony absconding. To ensure optimal colony health and productivity, it is advisable to conduct further research on the selection of high-performing colonies.

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AUTHOR CONTRIBUTION STATEMENT

Wubalem Alebachew: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing - original draft. Prof. Berhan Tamir: Supervision, Methodology, Visualization, Writing - review editing and validation. Dr. Tadesse Amare: Supervision, Methodology, Visualization, Writing - review editing and validation. Dr. Amsalu Bezabih: Supervision, Methodology, Visualization, Writing - review editing and validation.

CONFLICT OF INTEREST

No conflict of interest.

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