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INFESTATION LEVELS OF SOME PESTS, PREDATORS AND ENEMIES OF HONEYBEE (*Apis mellifera* L.) IN TWO AGRO-ECOLOGICAL ZONES OF UGANDA

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. Authors MC and DCDG designed the study. Author MC collected data. Authors MC, HO and PK performed the statistical analyses and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Globally, honeybees are threatened by human-mediated factors like pests, diseases and pesticides. In this study, 370 honeybee colonies were surveyed for selected invertebrate and vertebrate pests in wet and dry seasons (December 2014 to September 2015). Observations were made on human activities, apiary characteristics, landscape and land use type. Counts of selected pests were made by carefully opening, smoking hives before physically searching for the target pests. The pests recorded included; rats (*Graphiurus* sp.), lizards (*Agama* sp.), small hive beetle (*Aethina tumida*), wax moth (*Galleria mellonella*) and ants (*Dorylus* sp.). Infestation levels of wax moths were significantly higher in wet season (0.6 ± 2.9) than in the dry season (0.0 ± 0.0) ($P < 0.01$). In addition, there was a significant negative correlation between wax moth infestation level and elevation ($\rho = -0.194$, $n = 161$, $P = 0.014$). Furthermore, wax moths infestation levels varied significantly across apiaries of different dominant vegetation types ($P = 0.001$). Old farmlands had significantly higher infestation level of pests wax moths, ant and lizard compared to new farmlands and protected areas ($P < 0.05$). The results support locating apiaries in less disturbed habitats to reduce pest infestation.

Keywords: Beekeeping; bee pests; East Africa; Mount Elgon; Rwenzori.

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1. INTRODUCTION

Honeybees contribute more than one third of the world food production through pollination services [1]. Additionally, honeybees provide hive products of nutritional, medicinal and cosmetic uses for generating increased income [2], besides providing employment to the rural poor. Honeybees also play a key role in the conservation of environment [3,4]. Their immense role in the conservation of floral diversity and importance for human beings notwithstanding, honeybees are currently facing numerous threats including parasites, pathogens, pests and pesticides [5]. As a result, there has been an increase in the loss of managed honeybee colonies globally [5]. Although such threats have been extensively studied in Europe, North America and parts of Asia, limited research has been carried out in Africa [6].

In Uganda, the beekeeping with honeybee (*Apis mellifera*) is practiced mostly for the hive products including honey, propolis, beeswax, and more recently honeybee venom [7]. However, the role of honeybees in pollination is gradually being understood and appreciated. Globally, beekeeping has now been characterised as an input in agriculture [8]. Therefore, in Uganda too, honeybees are currently used by some farmers for pollination of fruit orchards and vegetable crops [9]. As a consequence, the beekeeping sector in Uganda is gradually developing. For the success of beekeeping and strategic planning for future beekeeping development in Uganda, it is important to understand the year round performance of the honeybee colonies and status of their, enemies, pests, predators and enemies.

At present, Uganda harvests only 1% of its estimated production potential of 500,000 tonnes of honey per year [2]. This low production may be associated with the present state of honeybee pests and diseases [10]. Recently, *Varroa destructor*, *Nosema* spp., *Paenibacillus larvae* and five honey bee viruses were detected in Uganda highlighting the need for monitoring the bee health [11].

Based on land topography, vegetation type, climatic conditions and the agricultural activities, Uganda is divided into ten production or agro-ecological zones [12]. Despite the known varying altitudes and land uses in Uganda, no studies have been made to investigate the potential influence of these factors on the distribution of honeybee pests in the country. Knowledge of these parameters could be useful in planning for the management of honeybee pests and pathogens in the country to reduce their likely risks. In an effort to provide some insights into the pests of

honeybees in Uganda, this study was conducted in two highland agro-ecological zones having varying altitudinal gradients and land uses in order to document variations in these bio agents in relation to environmental and anthropogenic factors.

2. MATERIALS AND METHODS

2.1 Study Area and Sample Collection

We conducted this study in the eastern and western highlands agro-ecological zones (AEZ) of Uganda. Honeybee colonies were surveyed for selected pests (based on pest ranking following discussion with beekeepers in the study sites). A total of 175 colonies were sampled during the dry season (December 2014 to March 2015) and 195 during the wet season (July 2015 to September 2015) from the two AEZs of Uganda. Detailed description of the study area is provided elsewhere [13].

Apiaries that were sampled were selected based on altitudinal gradients and land uses. The sampled apiaries were situated at altitudes ranging from 920 – 2,400 m above sea level. The distance between the individual apiaries was at least 3.5 km to minimize the intermingling of sampled honeybees in the foraging areas. The geographical coordinates and elevation at each apiary or feral colony nest site were taken using a global positioning system (GPS) receiver.

Observations were recorded on human activities, apiary characteristics and landscape features such as the distances to the nearest potential honeybee water source. For this study, a potential water source is defined as the nearest stream/pond to the apiary. In the sampled apiaries, there were between 3 to 64 honeybee colonies. Therefore, at each apiary, at least six honeybee colonies were randomly selected and sampled whenever it was possible. Beekeepers managed their apiaries in different ways. Based on this, apiaries were divided into four categories viz., i) apiaries without any management; ii) occasionally slashed apiaries; iii) well slashed apiaries; slashed and regularly inspected apiaries. Furthermore, land use type around the apiaries also varied. Accordingly, apiaries were divided in three categories depending on the type of land use around them namely: i) protected area (National Park), ii) farmland area, and iii) *Eucalyptus* plantation area.

Also, agricultural intensity too was different at various places in the study sites. On this basis, apiaries were divided into four categories namely: i) protected area; ii) new farmland; iii) old farmland with tree plantation; and iv) old farmlands without tree plantations. Here, new farmlands refer to areas that were made cultivable recently (< 5 years) and still

have remnants of natural vegetation. Old farmlands with tree plantations are areas that were made cultivable more than five years ago but have parts that were reclaimed with tree plantations. On the other hand, old farmlands without tree plantations are sites that were made cultivable more than five years ago but no efforts were made to replant trees in them.

2.2 Record of Pests of Honey Bee (*A. mellifera*)

To detect and evaluate pest (wax moths, hive beetles, ants, rodents and lizards) infestation, colonized beehives were carefully smoked and opened. Presence of pests of honey bee (*A. mellifera*) was ascertained by physically searching of each sampled beehive. When a pest was noticed, counts were made on its numbers and samples were collected. Samples of these pests were transported to Department of Zoology, Entomology and Fisheries Sciences, Makerere University, for their identification.

2.3 Estimating Colony Performance

During fieldwork, colony performance was estimated by making observations and/or measurements on the strength and productivity of each sampled colony. The following indicators of honeybee colony performance were used: number of top-bars/frames with honey, brood, pollen, covered with bees, and harvested honey yield.

2.4 Data Analyses

Data were analyzed using SPSS statistical program (version 21). To compare the number of individual pest in honeybee colonies in areas of varying farming intensities/land use areas and apiary management, Kruskal-Wallis tests were performed as the data was not normally distributed. When significant results were found, *post hoc* analysis with Mann-Whitney tests were used to compare pairs of categories. Mann-Whitney test was also used to compare the number of honeybee pests in honeybee colonies in the two AEZs of Uganda and two seasons (dry and wet). Spearman's rank correlations were derived to establish the relationships between the number of honeybee pests with i) altitude (meters above sea level), ii) distance to the nearest water sources, iii) height of beehive placement (apiary) and iv) colony performance. All tests were two tailed.

3. RESULTS

Many pests were detected in honeybee colonies in both the eastern and western highland AEZs of Uganda. These included; the rat (*Graphiurus* sp.), lizards (*Agama* sp.), small hive beetle SHB (*Aethina*

tumida), wax moth (*Galleria mellonella*) and ants (*Dorylus* sp.) (Table 1 and Fig. 1). The infestation level of wax moths in beehives was significantly higher during the wet season compared to dry season ($U = 2538.0$, $Z = -3.552$, $P < 0.01$). However, no seasonal differences in infestation levels of other pests were found (SHB, $U=3.089$, $Z = -0.257$, $P = 0.797$; ants, $U = 2.608$, $Z = -1.510$, $P = 0.131$; rats, $U=8.118$, $Z = -1.472$; $P=0.141$; lizards, $U = 5.560$, $Z = -0.255$, $P = 0.799$).

The infestation levels of some pests varied with landscape factors. For instance, there was a significant weak negative correlation between the infestation level of wax moths and elevation ($\rho = -0.194$, $n = 161$, $P = 0.014$) while there were no significant correlations recorded between the infestation levels of other pests with elevations (SHB; $\rho = -0.081$, $n = 172$, $P = 0.292$; lizard; $\rho = -0.026$, $n = 241$, $P = 0.341$; rats; $\rho = -0.035$, $n = 273$, $P = 0.562$; and ants; $\rho = 0.028$, $n = 159$, $P = 0.725$).

Infestation levels of wax moths in beehives varied significantly across different dominant vegetation types ($X^2(df = 7) = 24.209$, $P = 0.001$). Colonies under Eucalyptus/pine vegetation type had significantly higher wax moths infestation levels than all other vegetation types ($P < 0.05$) (Fig. 2). For all the other investigated honeybee pests, no significant differences in infestation levels were recorded across the different vegetation types (SHB: ($\chi^2(df = 7) = 6.985$, $P = 0.430$); ants: ($\chi^2(df = 7) = 13.340$, $P = 0.064$); rats: ($\chi^2(df = 9) = 13.158$, $P = 0.156$ and lizards; ($\chi^2(df = 9) = 9.189$, $P = 0.42$).

There were no significant correlations between pest infestation and distances to potential water sources (small hives beetles: $\rho = -0.114$, $n = 172$, $P = 0.136$; wax moths: $\rho = 0.139$, $n = 161$, $P = 0.078$; lizard: $\rho = 0.05$, $n = 241$, $P = 0.386$; ants: $\rho = 0.075$, $n = 159$, $P = 0.349$; rats: $\rho = 0.071$, $n = 273$, $P = 0.244$).

Five different types of beehives namely; Kenyan top bar, Tanzanian top bar, Johnson's, Traditional and Langstroth beehive were used by beekeepers. Evaluation of pest infestation in these beehive types showed that there were no significant differences in the infestation levels of different pests under different beehive types. In addition, there were no significant correlations between pest infestation and height of beehive placement (small hives beetles: ($\rho = -0.004$, $n = 172$, $P = 0.956$), ants: ($\rho = -0.004$, $n = 159$ and $P = 0.961$); wax moths: ($\rho = 0.000$, $n = 161$, $P = 0.999$; lizard: ($\rho = 0.073$, $n = 241$, $P = 0.257$) and rats: ($\rho = 0.025$, $n = 273$, $P = 0.677$).

Table 1. Honeybee pest infestation levels in the two agro-ecological zones of Uganda during the two seasons (Mean± s.d. or s.e of – observations)

Pest	Eastern AEZ		Western highlands AEZ	
	Dry season	Wet season	Dry season	Wet season
Small hive beetles	1.4±4.1	1.7±3.3	1.3±4.1	5.3±13.0
Wax moth	0.0±0.0	1.1±4.3	0.0±0.0	0.3±0.8
Ants	0.0±0.0	73.9±23.0	3.4±17.3	0.0±0.0
Rats	0.2±0.5	0.1±0.5	0.1±0.6	0.0±0.0
Lizards	0.1±0.4	0.1±0.4	0.1±0.3	0.0±0.0



Fig. 1. Pictures of selected honeybee pests (rats, wax moths and ants) observed during the study

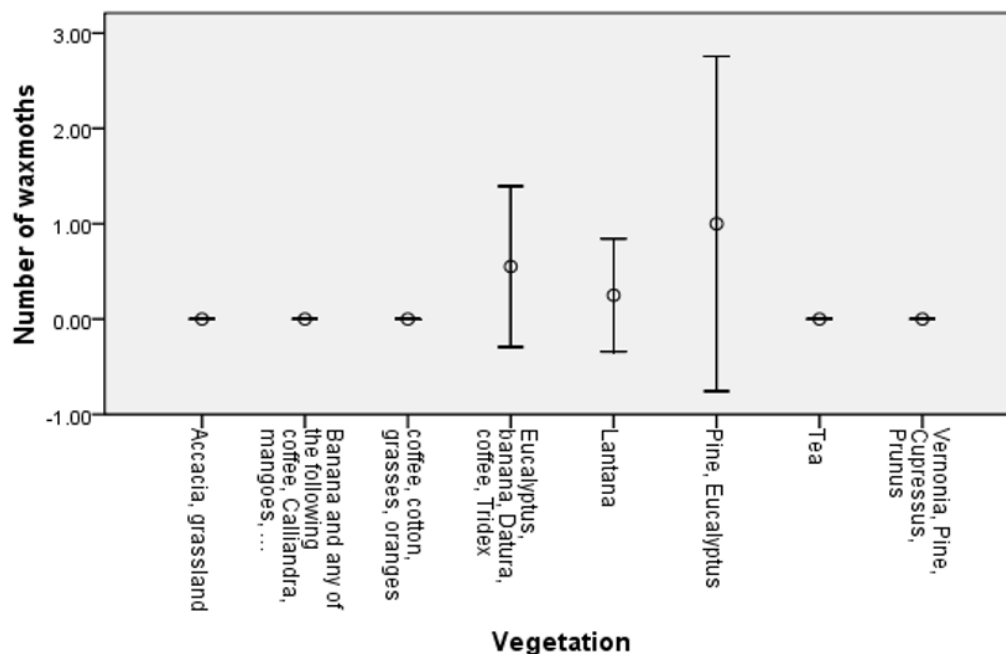


Fig. 2. Wax moth infestation in honeybee colonies under different vegetation types

3.1 Farming Intensity and Pest Infestation Levels

Wax moths, ant and lizard pest infestation levels in honeybee colonies varied with the level of farming

intensity around the apiaries. Honeybee colonies under old farmlands had significantly higher ranks of these pest infestation compared to colonies in new farmlands and protected areas ($P < 0.05$). No significant differences were recorded in the infestation

of other pests: small hives beetles ($P = 0.725$) and rats ($P = 0.163$).

3.2 Apiary Management and Pest Infestation Levels

There were no significant differences in pest infestation in apiaries under different apiary managements (small hives beetles: $(X^2(df = 3) = 2.349, P = 0.53)$; wax moths: $(X^2(df = 3) = 1.684, P = 0.64)$, ants: $(X^2(df = 3) = 2.668, P = 0.446)$; lizard: $(X^2(df = 3) = 4.191, P = 0.242)$, and rats: $(X^2(df = 3) = 5.414, P = 0.144)$).

4. DISCUSSION

Several honeybee pests have been reported across African countries [3,14,15] which include both vertebrates and invertebrates. The vertebrates include amphibians, reptiles, birds and mammals [16]. On the other hand, the invertebrates include *Varroa destructor* [10], small hive beetles, ants and wasps [17].

The present study recorded rats (*Graphiurus* sp.), lizards (*Agama* sp.), small hive beetle (*Aethina tumida*), wax moth (*Galleria mellonella*) and ants (*Dorylus* sp.) in the two AEZs of Uganda. These pests are similar to what was reported in Congo [18] and Pakistan [19]. Although the effect of these pests on colonies is not well documented in many African countries, their infestations may affect colony productivity. For instance, infestation by ants can lead to absconding in the infested colonies resulting in huge losses to the beekeepers.

The two honeybee races, *A.m. scutellata*, and *A.m. adonsonii* which have been confirmed in Uganda [20], abscond from beehives more frequently when disturbed than other races of *A. mellifera* [21,22]. In this study, anthropogenic and environmental factors influenced infestation levels of some pests. For instance, wax moth infestation was significantly higher in wet season compared to dry season. This may be attributed to the absconding and swarming behaviours of *A.m. scutellata*, and *A.m. adonsonii* as a result of disturbance (honey harvesting) toward the end of the dry seasons [10]. Harvesting all the honey from the colony leads to weak colonies due to lack of food stores, thus making the colony susceptible for wax moth infestation.

In this study, increase in elevation was associated with reduced infestation level of wax moths. This can be attributed to the influence of temperature on the

life cycle of wax moths which lay eggs on empty combs of weak colonies [23]. At higher elevation, temperatures are lower which do not favour the development of wax moth larvae but enhance colony strength hence reducing chances of wax moths attack. Infestation levels of the wax moths varied with vegetation type; with colonies under *Eucalyptus* and pine having the highest infestation levels. These vegetation types might be providing conditions that favour the survival of this pest. However, the exact mechanism through which these vegetation types influence wax moths infestation requires further investigation.

5. CONCLUSION

In conclusion, the infestation levels of honeybee pests recorded here seemed to be influenced by both environmental and anthropogenic factors. The placement of apiaries in less disturbed habitats is recommended to reduce the pest infestation. Detailed understanding of mechanisms through which *Eucalyptus* and Pine plantations influence wax moths infestation levels need to be investigated.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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