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# People's Knowledge and Perceptions Towards Bee–Pollinators in the Southern Highlands, Tanzania: Conservation Implications and Strategies

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# People's Knowledge and Perceptions Towards Bee–Pollinators in the Southern Highlands, Tanzania: Conservation Implications and Strategies

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## Abstract

**Background and research aims:** Bees are important pollinators of flowering wild plants and agricultural crops that contribute significantly towards food security, improving people's livelihoods, and maintaining genetic diversity in plant communities. However, the decline of the bee population due to anthropogenic changes and limited knowledge of bees is threatening bee diversity, particularly in sub–Saharan Africa. Negative perceptions, that is, fear and disgust, are common emotions that lead to a lack of support for bee conservation. Understanding local people's perceptions is vital as it can help in bee conservation decision making and proper protection actions.

**Methods:** We conducted the study in the Mbeya and Songwe regions of Tanzania to assess the knowledge and perception of local people about bee–pollinators and conservation using a structured questionnaire

**Results:** We found that the majority of respondents (91%) have heard about bees ($\chi2 = 6275$, $p < 0.001$) and their conservation initiatives (71%), and about 84% of respondents consider bees to be important ($\chi2 = 168.9$, $p = 0.001$). Moreover, *Apis mellifera* had the highest identification rate, with 52.7% of respondents. A binary logistic model revealed that respondents' knowledge of bee–pollinators and pollination is not influenced by their age (except for respondents aged 15–18 years, $p = 0.012$) and education level. While 74% of respondents claimed to be afraid of bees, 79% stated that bees are dangerous to humans. The most common cause is personal experience with bee stings. Poor farm management practices, for example, use of fire and deforestation, were noted by 79% of respondents as the most human activities threatening bee–pollinators.

**Conclusion:** Overall, the respondents were more familiar with A. mellifera compared to non–Apis bee species.

**Implications for conservation:** Thus, we suggest that implementation of pollinator management programs is vital to ensure their survival and reduce the perceived threat by dispelling myths and encouraging interest in bees.

## Introduction

Bees pollinate a variety of flowering plants (Patel et al., 2021; Saunders et al., 2018) including crops that need pollinators to set seeds and/or fruits (Arnold et al., 2021; Elisante et al., 2020). Smallholder farmers in rural and urban agricultural landscapes in sub–Saharan African countries such as Tanzania depend on bee–pollinators to enhance crop production

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(Arnold et al., 2021; Elisante et al., 2020; Tommasi et al., 2021). Despite their contribution on livelihoods and food security, bee–pollinators are under increasing pressure, and thus, they continue to decline worldwide (Tirado et al., 2013; Zattara & Aizen, 2021). The major causes of their decline are linked to agricultural intensification, land–use change or conversion, anthropogenic change, and habitat loss (Leweri & Ojija, 2018; Tommasi et al., 2021; Zattara & Aizen, 2021), diseases and pests (Chakuya et al., 2022), pathogens, pesticides, and climate change (Marques et al., 2017; Nicholls et al., 2020; Silva & Minor, 2017) as well as invasive species (Albrecht et al., 2016; Armfield, 2006; Lopezaraiza–Mikel et al., 2007; Ojija et al., 2019). Bee population declines and/or fluctuations in agroecosystems and natural or semi–natural ecosystems threaten crop production and biological diversity (Elisante et al., 2020). Thus, dwindling global bee populations would have negative impacts on food security (Elisante et al., 2020; Gemmill-Herren & Ochieng', 2008) and essential micronutrients, that is, iron and folate (Chaplin-Kramer et al., 2014) in developing countries, particularly in sub–Saharan Africa, where agriculture represents the major source of livelihoods (Tommasi et al., 2021).

However, previous studies are also reporting that the decline of bees may be influenced by the limited knowledge and negative perceptions of people towards bees (Burns et al., 2021; Marques et al., 2017; Mpondo et al., 2021; Nicholls et al., 2020). This is because there is a correlation between the public perceptions towards a species and their knowledge of that species (Burns et al., 2021; Fančovičová & Prokop, 2011; Prokop et al., 2008; Silva & Minor, 2017; Sumner et al., 2018; Trip et al., 2020). For instance, the lack of general public knowledge of bees, as a result of a lack of education or awareness about the role of bee–pollinators, may lead to a lack of support for conservation and proper protection actions (Nicholls et al., 2020; Schönfelder & Bogner, 2017; Trip et al., 2020). Owing to a lack of understanding of bee–pollinators, land–use practices that do not consider bee–pollinators could result in bee decline. This is due to the fact that some people's perceptions toward insects, particularly bees, are frequently characterized by hatred, fear, and revulsion, possibly because some bees have the ability to hurt humans (Elisante et al., 2019; Mpondo et al., 2021; Schönfelder & Bogner, 2017; Tarakini et al., 2020). But, people who understand bees and their role in the ecosystem, on the other hand, would not be afraid of them and would take steps to protect them from anthropogenic activities (Schönfelder & Bogner, 2017). Such a situation has been shown in some countries in sub–Saharan Africa, where there is a general paucity of pollinator research and conservation awareness compared to European and American countries (Arnold et al., 2021; Elisante et al., 2019).

As a result, increasing public awareness through education programs to improve knowledge and perceptions toward bee pollinators and, consequently, land–use practices is a critical tool for combating pollinator neglect (Burns et al., 2021; Tirado et al., 2013; Trip et al., 2020). In order to support bee conservation and protection actions, transforming people's negative perceptions about bees through education is imperative (Schönfelder & Bogner, 2017; Trip et al., 2020). However, prior to raising bee conservation awareness, the key step is to evaluate the knowledge and perceptions of local people towards bees and pollinator conservation (Elisante et al., 2019; Silva & Minor, 2017; Sumner et al., 2018; Trip et al., 2020). This could encourage local people to practice positive bee conservation behaviors and provide insight into the challenges that bee–pollinators face and how they can be overcome. In addition, age, gender, and education have been shown to influence the knowledge and/or identification skills of pollinators (Elisante et al., 2019; Mpondo et al., 2021; Schönfelder & Bogner, 2017; Silva & Minor, 2017). For instance, Mpondo et al. (2021) found that men correctly identified solitary bees, *Lasioglossum* sp, compared to women. They also showed that respondents of 30–39 years old had good pollinator identification skills than the other age groups, and education level, particularly primary education significantly influenced correct identification of *Eumenidae*. Therefore, understanding the knowledge and perceptions of local people with respect to their age, gender, and education toward bees is critical for effective bee and/or pollinator conservation (Elisante et al., 2019). As such, research on pollinator knowledge and perceptions is still needed in many areas in sub–Saharan Africa.

While research on pollinators is becoming more frequent, local Tanzanians are not informed about bee–pollinator ecology and therefore bees, excepting honey bees, are poorly understood (Elisante et al., 2019; Mpondo et al., 2021). Based on our knowledge, the local people in the Southern Highland of Tanzania (SHOT), particularly in Mbeya and Songwe regions have not been trained about of the importance, types, and dynamics of bee–pollinators. Though these regions cultivate mostly bee–pollinated crops (i.e., watermelon, sunflowers, and beans), there is no initiative that has been taken to promote conservation and protect pollinators, for instance, by assessing people's knowledge, and perceptions concerning bees. As a result, the knowledge, and perceptions of people towards bees are unknown. Our study assessed the knowledge, and perceptions of local people about bee–pollinators, and conservation with respect to their age, education level, and gender. Additionally, we assessed people's perceptions of threats, conservation initiatives, and the consequences of bee–pollinator loss, as well as their knowledge of the techniques needed to conserve bees and other pollinators. The overall objective of the study was to assess public knowledge and perceptions toward bee–pollinators, their conservation, and importance with respect to age, education level, and gender. We hypothesized that local people (i) have limited knowledge about bees, bee–pollinators, bee conservation, and the role of bees and (ii) their

knowledge and perceptions differ with age, education level, and gender.

## Materials and Methods

### Study Site

The study was conducted in 11 villages located in the Mbeya (8.5° S 33°E) and Songwe (9.1° S 32.9°E) regions (Figure 1). The areas were selected because they are found in the agro–ecological regions, with agriculture being the main economic activity. Their subsistence agriculture mostly entails growing pollinator dependent crops, that is, beans (*Phaseolus vulgaris*), sunflowers (*Helianthus annuus),* and watermelon (*Citrullus lanatus*). They also cultivate maize (*Zea mays* L.), rice (*Oryza sativa* L), and wheat (*Triticum aestivum* L.). Based on our knowledge, there is no study that has been done in these villages to establish bee–pollinators' knowledge and perception of people. Thus, these regions, particularly the study villages with high crop production and pollinator diversity, are understudied in the pollination literature and should be priority areas for research related to pollinator awareness and perceptions. The climate of the two regions is largely tropical with marked seasonal and altitudinal temperature variations (Leweri & Ojija, 2018). The regions experience dry and cold weather from June to October, with temperatures ranging from 16°C to 30°C. The rainfall season starts from December to May, with ca. 900 mm per year. The Mbeya (approximately 2 million people) and Songwe (approximately 998,862 people) regions have natural and semi–natural ecosystems with low levels of management. These ecosystems are subjected to anthropogenic changes due to habitat degradation, fuel wood collection, grazing, and uncontrolled cultivation and burning.

## Methods

We used purposive sampling (non–probability sampling) to select the villages located nearby the towns. Overall, we had a total of 373 respondents, that is, 270 and 103 respondents in the Mbeya and Songwe regions, respectively. Though we aimed at surveying a total of 400 respondents, we ended up with a total of 373 respondents because we did not obtain the exact number of people living in the study villages. Also, it was not possible to use the formula to compute the population sample. Respondents that were willing to answer the questionnaire were randomly selected following a pilot study. This was conducted before the survey in some of the study villages to familiarize themselves with the areas and village leaders. This was a systematic random sampling whereby a respondent or household at a distance of about 20 m from the former was selected during the survey. If there were more than two
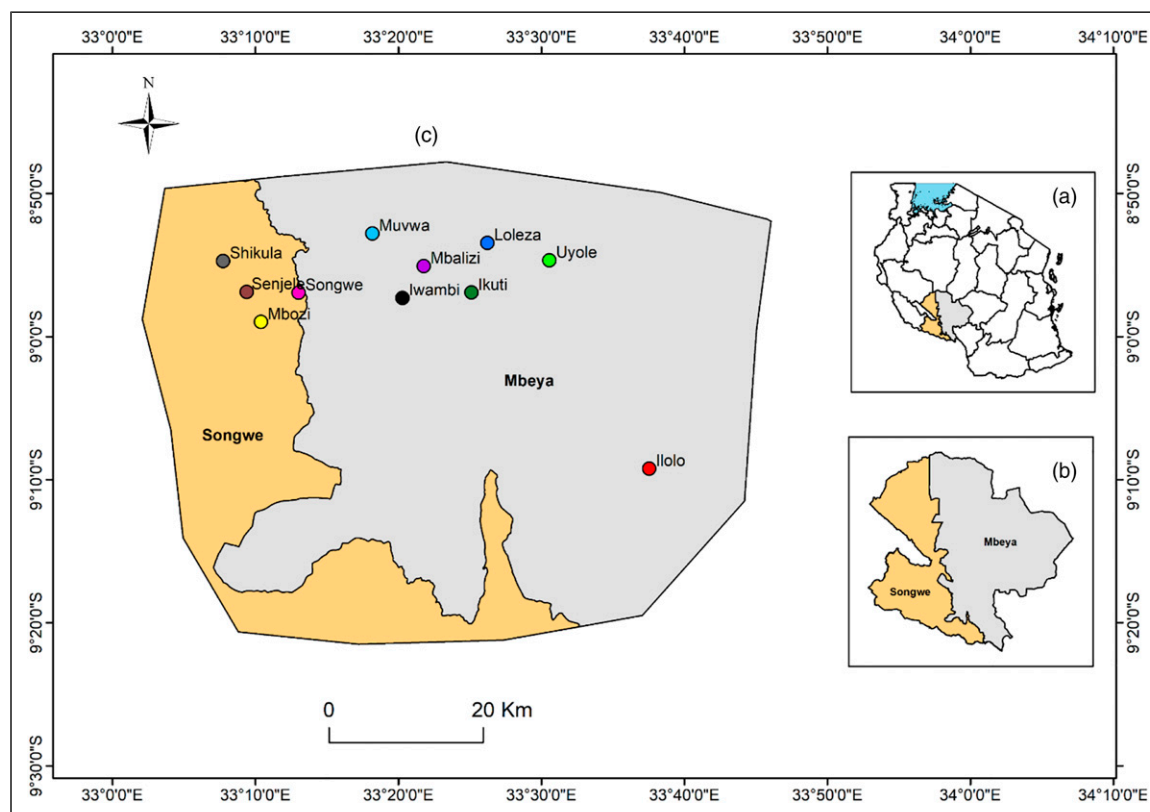


**Figure 1.** The (a) map of Tanzania showing (b) the Mbeya and Songwe regions, and (c) areas or wards surveyed in each region.

respondents or households, only two individuals or households were asked to fill in the questionnaire. The minimum age requirement of the respondents was 15 years old assuming that they are aware of environmental related issues such as the impact of anthropogenic activities. Face–to–face interviews were used to complete questionnaires (see Supplement Appendix A: Survey), despite the fact that each respondent was given one questionnaire form to fill out. Both Swahili and English were used to clarify some difficult issues and make questionnaires well understood. To test the ability of local people to identify bees, we provided them with 8-color printed pictures of bee (*Apis mellifera* scutellata*, Xylocopa iris, Xylocopa caffra,* and *Xylocopa* spp), African monarch butterfly *(Danaus chrysippus),* and beetle species (*Kheper aegyptiorum*), and we asked the respondents to identify the bees from the provided pictures (see Supplement Appendix B: pictures). Many Xylocopa bees were used because they are so abundant in the regions. A series of questions were developed to assess local residents' knowledge and perceptions of the importance of bees, bee identification, pollinators, and conservation. Example of questions were; "which types of bee–pollinators can you name?" "what is the importance of bees for agriculture?" "what bee–pollinators would you protect and why?" "do you think that human activities affect bee populations? If so, which human activities? "what would happen if bee–pollinators are lost from the local system?" and "how and why do we need to protect and manage bees and other pollinator species?" "what things do you think people should do in order to conserve bees?". Questions about the respondents included their age, gender and education level. The survey was conducted between March and July 2021.

## Data Analysis

Knowledge of bees was categorized as an insect which visits flowers to collect pollen and nectar for food (we only used this knowledge when a respondent chose that answer for bee, not butterfly or any other insect), an insect that eats plant leaves, an insect that eats plant flowers, and *I don't know*. The importance of bees was categorized as pollination services, that is, they pollinate plants, including crops, support the world's food production by one–third, support our life on the planet, and maintain ecosystem health, that is, they are the indictors of the wider environmental health, honey production, income generation, and medicinal purposes. Descriptive analysis for the structured (closed) household questionnaire was performed using frequency tables. A Chi-square ($\chi^2$) frequency and one-way ANOVA tests were used to investigate the differences between those who know bees and those who do not know; those who have heard about bee conservation and those who have not; those who perceive bees as important and those who regard them as not important, as well as between those who consider bees as dangerous or safe insects. We used logistic regression analysis to determine factors influencing knowledge of bee–pollinator identification. The independent variables were age, gender, education level, fear of bees,

and perception of the importance of bees. The post-hoc Tukey–Kramer test (Tukey's honest significance test was used to separate the means at $p \leq 0.05$. All the data was analyzed using the R statistical package version 3.5.1.

## Ethics Consideration

The Tanzania Commission for Science and Technology gave permission to perform this study through the Tanzania Wildlife Research Institute (TWRI/RS-331). We then delivered the permit to the district, ward, and village officials. We sought verbal agreement from all respondents prior to the interviews to guarantee their willingness to participate. To protect confidentiality, respondents' names and personal information are kept anonymous.

## Results

### Communities' Knowledge on Bees, Conservation, and Ability to Identify Bee–Pollinators

A total of 206 males (55%) and 167 females (45%) respondents with different ages and education levels were interviewed using a structured questionnaire (Table 1). The majority of respondents (91%, 340) claimed to have heard about bees ($\chi^2 = 6275$, df = 3, $p < 0.001$) and their conservation initiatives (71%, 263), and 84% (312) of respondents considered bees to be important ($\chi^2 = 168.9$, df = 4, $p = 0.001$). Moreover, 98% (366) of respondents correctly identified the four bee–pollinators out of the eight pollinator species provided to them. *Apis mellifera* had the highest identification rate with 52.7% (196) respondents, followed by *Xylocopa cafra* (39.8%, 148) and *Xylocopa iris,* which was identified by 5.7% (21) of the respondents (Figure 2). The least identified bee species was the other Xylocopa *spp.,* which was identified by 1.9% (7) of the respondents (Figure 2).

### Perception Towards Bee–Pollinators and Their Socio–Ecological Role

A binary logistic model revealed that respondents' knowledge of bee–pollinators and pollination is not influenced by their age

**Table 1.** Characteristics of Respondents Surveyed.

| Characteristic | Category | Percent abundance |
|---|---|---|
| Gender | Male | 55% (206) |
| | Female | 45% (167) |
| Age | 15–18 | 57% (211) |
| | 19–30 | 19% (70) |
| | 31–45 | 16% (58) |
| | Above 45 | 9% (34) |
| Education level | Primary education | 3% (10) |
| | Secondary education | 63% (236) |
| | Diploma | 6% (21) |
| | University | 28% (106) |

(except for respondents aged 15–18 years, $p = 0.012$) and education level (Table 2). However, it seems to be influenced by the sense of the value of bees as pollinators ($p = 0.000$, Table 2). Moreover, 74% (274) of respondents claimed to be afraid of bees and 79% (295) stated that bees may harm humans, especially the honey bee which is dangerous if disturbed or provoked. Some of the respondents who claimed that bees are dangerous species were also stated to be allergic to them (Likelihood ratio test = 3.6, $p = 0.05$), get stung by bees (Likelihood ratio test = 0.9, $p = 0.34$), and some have heard of deaths associated with bees (Likelihood ratio test = 1.9, $p = 0.16$).

Furthermore, the majority of respondents (69%, 259) knew about bee pollination ($\chi^2 = 56.367$, df = 9, $p = 0.001$, Figure 3), and the socio–ecological roles of pollinators (F = 7.108, df = 6, $p = 0.004$, Figure 4). About 93% of the respondents correctly acknowledged the significance of bee–pollinators and their conservation initiatives (Figure 4),

## People's Perception on Threats, Conservation Initiatives and Loss of Bee–Pollinators

The perception of local people about the impacting of pollinator loss differed significantly (F = 5.37, df = 3, $p = 0.001$). The respondents perceived that poor farm management practices and the use of fire (53%, 198), deforestation (26%, 98), and the use of pesticides on farms (12%, 45) are the threats that can cause loss of bee–pollinators (Figure 5). Only 9% (32) of respondents could not identify any possible threats to bee–pollinators. Moreover, the pollinator conservation initiatives, that is, planting flowering trees and wild flowers for pollinators to forage, were agreed to by nearly half of the respondents (49%). Allocating
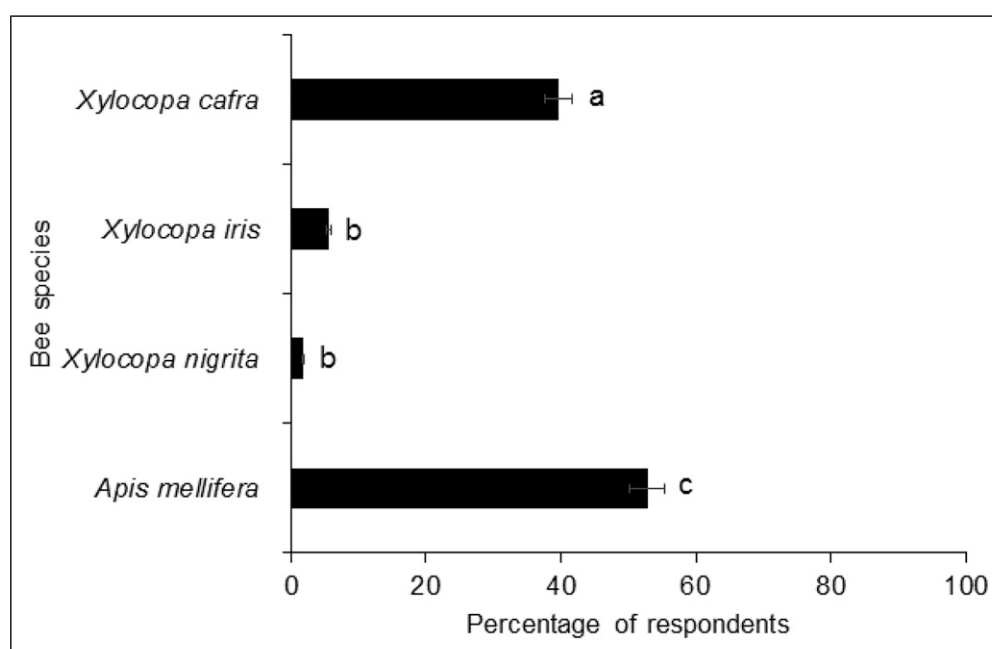


**Figure 2.** The percentage of respondents that correctly identified bee–pollinators according to the questionnaire survey in the Southern Highlands of Tanzania. Bars with dissimilar letters are significantly different by Tukey–Kramer test at $p \leq 0.05$.

**Table 2.** Logistic Regression to Determine Factors Influencing Knowledge of Pollination.

| Variable | Estimate | SE | z value | Level of Significant ($p$) |
|---|---|---|---|---|
| Intercept | 1.616 | 0.617 | 1.560 | 0.119 |
| Age (15–18 years) | 1.363 | 0.542 | 2.515 | 0.012 |
| Age (31–45 years) | −1.916 | 0.446 | −4.297 | 0.000 |
| Age (above 45 years) | −1.647 | 0.519 | −3.171 | 0.002 |
| Education (primary school) | −0.036 | 0.876 | −0.041 | 0.012 |
| Education (secondary school) | −2.311 | 0.765 | −3.022 | 0.003 |
| Education (university) | −1.461 | 0614 | −2.382 | 0.017 |
| Perceived bee important | 1.859 | 0.409 | 4.544 | 0.000 |

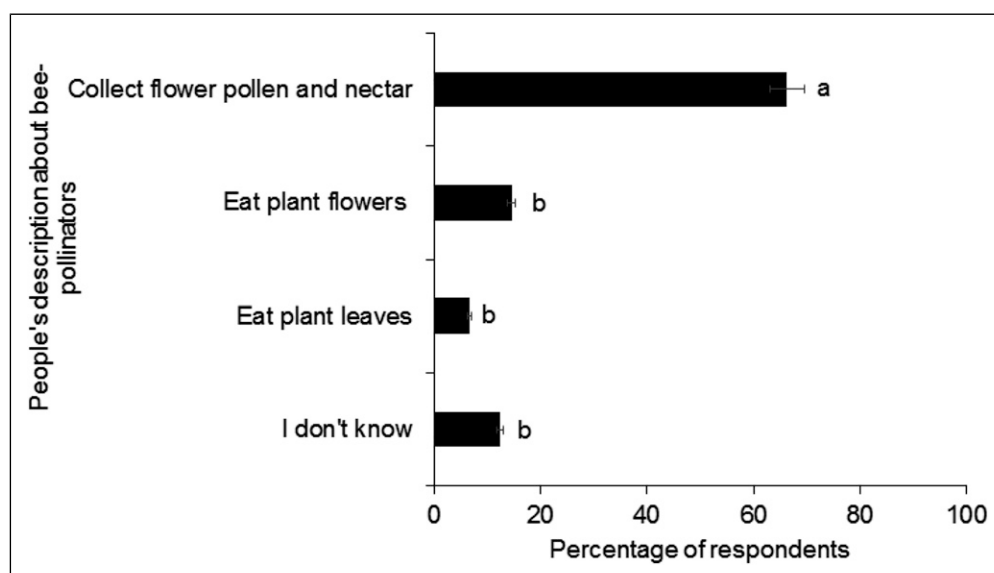Present significant levels at $p < .05$.

**Figure 3.** Knowledge of respondents about the role of bee–pollinators as recorded during the questionnaire survey in the Southern Highlands of Tanzania. Bars with dissimilar letters are significantly different by Tukey–Kramer test at $p \leq 0.05$.



**Figure 4.** Knowledge of respondents about the importance of bees recorded during the questionnaire survey in the Southern Highlands of Tanzania. Bars with dissimilar letters are significantly different by Tukey–Kramer test at $p \leq 0.05$.
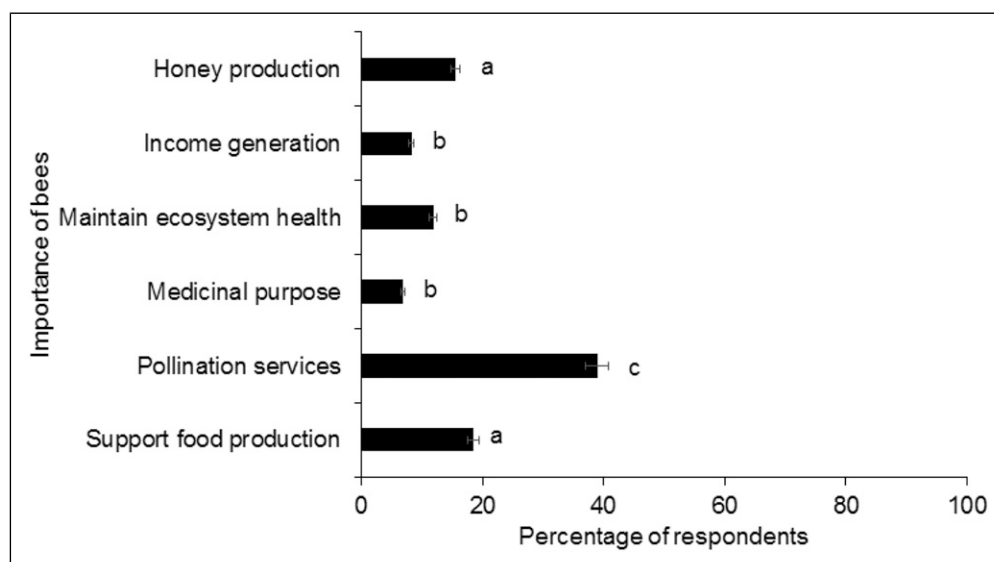
some areas uncultivated to attract bees as well as other pollinator insects and reducing pesticide use on farms were chosen by 29% and 9% of respondents, respectively.

## Discussion

Our study found that most local people in the study villages in Tanzania have knowledge about pollinators, especially the *A. mellifera*. While respondents were able to identify some of the more common bee–pollinators, overall, non–Apis bee

species were not well known. Some knew carpenter bees (*Xylocopa* spp.) as pollinator insects, but they were not aware that they were also bees. Thus, the correct identification of *A. mellifera* compared to non–Apis bees indicates that the knowledge of local people about the latter is limited. This could be due to the fact that in Tanzania, pollination and/or pollinator topics are taught in agriculture schools and very little in other secondary schools. Consequently, this knowledge has been retained by the respondents after completing their secondary and/or primary education. Similar findings
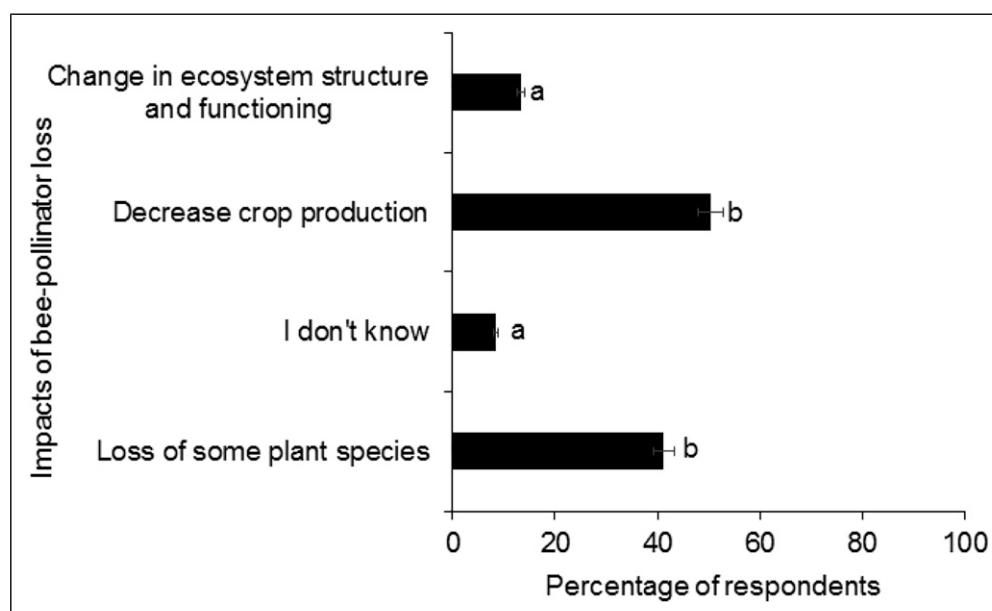
**Figure 5.** Percentage of respondents that identified the effects of loss of bee–pollinators from the local ecosystem according to the questionnaire survey in the Southern Highlands of Tanzania. Bars with dissimilar letters are significantly different by Tukey–Kramer test at $p \leq 0.05$.

were reported in the country by Elisante et al. (2019) in Moshi Rural District, Mpondo et al. (2021) in Simanjiro District, and Sawe et al. (2020) in the Kilimanjaro and Arusha regions in northeast Tanzania. Apart from Tanzania, comparable results were also described from other countries, suggesting limited knowledge of non–Apis bee species compared to *A. mellifera* by the local people (Bhattacharyya et al., 2017; Burns et al., 2021; Misganaw, 2017). For instance, Tarakini et al. (2020) in Zvimba district, Zimbabwe, reported that *A. mellifera* was the pollinator species that was correctly identified by the respondents overall. A study in Ethiopia's Amhara region (Misganaw, 2017), West Bengal, India (Bhattacharyya et al., 2017), and Ireland (Burns et al., 2021) found that local people had little knowledge of non–Apis bee species when compared to *A. mellifera*. This reveals that a limited knowledge of wild bee species is not only found in Tanzania but also in other countries. Therefore, pollinator–focused education to community is important because it may result in a good understanding of bee–pollinators.

The respondents' ability to identify the honey bee could be due to the fact that it is a very common, charismatic, and managed species by some people for honey production, and thus, it is always in contact with people in diverse environments (Balbuena et al., 2015; Burns et al., 2021; Elisante et al., 2019; Quinlan et al., 2021; Saunders et al., 2018). This makes *A. mellifera* more familiar to local people compared to wild bee–pollinators. Also, the species' being a social generalist forager pollinator that visits various flowering plants (Ojija et al., 2019; Quinlan et al., 2021; Saunders et al., 2018; Tirado et al., 2013) might have contributed to its correct identification. Furthermore,

inability to identify non–Apis species could be due to the perception that the name "bees" ("Nyuki" in Swahili) refers to *A. mellifera* and stingless bees, while the rest are just normal insects ("Wadudu" in Swahili). Furthermore, during our survey, we found that most of the local people were aware of the ecological roles of pollinators, mostly *A. mellifera*. Similarly, they were able to identify bee–pollinators as insects that collect flower pollen and nectar for food. They asserted that they learnt about pollinators and pollination in primary and secondary schools. However, education level seemed not to influence their identification ability of non–Apis bees except for the respondents aged less than 19 years old. Based on this age (15–18 years), we suspect that most of them have perhaps completed or are still in secondary school, and hence they are still aware of pollinators. Since the knowledge of local people about bee–pollinators other than *A. mellifera* is limited, a much greater risk is that a poor understanding of them could result in land–use practices that negatively affect them continuing or being implemented. Hence conservation responsiveness of wild bee species is important.

Moreover, local people perceived bee–pollinators, especially *A. mellifera*, as important. They claimed that *A. mellifera* provides honey, income, and medicine and supports food security through pollination services. However, they were unable to describe the roles of non–Apis bees. They knew the factors that threaten bee–pollinators, for example, poor farm management practices, the use of fire and pesticides on farms, and deforestation, were identified by the majority of the respondents.

They also affirmed that the loss of bee–pollinators from local systems would likely harm the environment. This is not different from other studies conducted in Tanzania by Elisante et al. (2019), Mpondo et al. (2021), and Sawe et al. (2020), which reported almost similar findings. Additionally, planting flowering trees and wild flowers in the field for bees to forage, reducing pesticide use on farms, and allocating some uncultivated areas to attract *A. mellifera* and other pollinator insects were perceived by local people as important conservation initiatives. This suggests that local people have a good understanding of the negative impacts of anthropogenic activities on the environment and pollinators.

Some of the respondents perceived that bees, especially *A. mellifera*, are dangerous, and thus, they are not safe species. This was associated with fear, which was justified by previous deaths heard from within and outside their communities. Though they were not sure whether *Xycopa* spp are also bees, they stated that they were afraid of them as they do sting as well. In general, our respondents were afraid of bees based on their experience of being stung by them. This corroborates with the study conducted by Schönfelder and Bogner (2017) in Bavaria, Germany, which found that the most common cause of expressing anxiety was the respondent's experience with bee stings. Nevertheless, other respondents stated that while bees are generally safe, they can only be dangerous if disturbed or provoked. Hence, the negative perceptions indicated by respondents stem from a generalization of the behavior attributed to some of these species, which is frequently based on the belief that bees sting most of the time. Several authors have also described such a mindset (Marques et al., 2017; Schönfelder & Bogner, 2017; Silva & Minor, 2017; Trip et al., 2020).

In general, our study is supported by that of Armfield (2006), which found that local people believed bees were dangerous. Also, a study by du Toit-Prinsloo et al. (2016) in South Africa reported that local people are afraid of bees due to deaths resulting from wasps and bee stings. Our results, therefore, suggest that local people, not only in Tanzania but also in some other countries, consider bees as harmful. In order to protect bees and other pollinators from threats related to land–use, forest loss, and pesticides, such people's negative perceptions toward bees must urgently change in the study area. This could be achieved by educational initiatives concentrating on lessening the perceived threat by dispelling myths and fostering interest in the species (Schönfelder & Bogner, 2017). Our study reveals further that people understand the role of bees in the environment and the potential threats they face. Also, it shows that local people are aware of the techniques needed to conserve bee–pollinators. However, there are factors that were not considered by our study that could have affected the results, such as income, occupation, household size, and beekeeper status, and how these parameters could influence people's knowledge and perceptions towards bee identification and conservation. Also, we did not consider the population of the Mbeya and Songwe regions during our surveys.

## Conservation Strategies to Alleviate Decline in Pollinators

Both managed and wild pollinators are declining globally, hence conservation strategies and raising awareness to protect bees are the major concern (Saunders et al., 2018; Tarakini et al., 2020; Tirado et al., 2013; Zattara & Aizen, 2021). Bee conservation awareness bridges the knowledge gap in communities to fully understand the role of bee–pollinators and their conservation strategies and implication. During our study, the respondents showed awareness on the threats that could potentially endanger bee–pollinators. Some of these threats are associated with agricultural activities, for instance, farm management practices that involve burning of remnant crops and/or vegetation, deforestation and forest degradation that reduce forage and nesting sites for pollinators, and the application of agrochemicals. The application of agrochemicals leads to death of insects including bee–pollinators. In addition, human activities, that is, honey harvesting was also stated by local people to destroy colonies of bees and their nesting sites. This is because some people use fire to chase bees during harvesting process. As a result, some respondents showed willingness to adopt various conservation strategies in order to protect bees and other pollinators. These strategies include maintaining flowering plants in the fields for pollinators to forage; planting trees and wild flowers to improve habitat and foraging sites for pollinators; minimizing the application of herbicides or pesticides in the environment; leaving some parts of farms/habitats uncultivated for pollinators; and teaching tomorrow's bee stewards. Some of these strategies are consistent with those described in Tarakini et al. (2020) and Arnold et al. (2021). Planting flowering trees and wild flowers, for example, fruit trees and vegetable crops for pollinators to forage was a conservation strategy preferred by most respondents. This could be due to the reason that the respondents perceive this activity as compatible with their agricultural crops (Arnold et al., 2021; Elisante et al., 2020). Further, this conservation strategy could meet the diverse needs of smallholders (i.e., crop pollination and obtaining fruits, medicine, seeds, and vegetables) while also hosting diverse pollinators by providing them with specialty requirements (Arnold et al., 2021; Elisante et al., 2020). In addition to the proposed strategies, we also suggest that conservation authorities adopt some of the strategies explained by Baldock (2020), Patel et al. (2021), and Tommasi et al. (2021) to protect bees and other pollinators.

## Conservation Implications

Conservation of bees has implication on socio–economic growth of society through improved ecosystems services (e.g., pollination), agriculture, cultural, and social values of people. If bees and other pollinator are protected, they could

potentially contribute towards food security and income by increasing agricultural production and beekeeping. The bee–keeping promotes biodiversity conservation since it is an eco–friendly economic activity. As a result, it could lead to improved socio–economic development and poverty reduction in the society. Furthermore, our study demonstrates the importance of comprehending community perceptions and knowledge in improving pollinator conservation. While bee–pollinator conservation could influence the socio–economic growth of local people, the knowledge concerning non–Apis bee–pollinators is limited to the majority of our respondents. This implies that local people could be bee–pollinator conservation ambassadors and actively participate in protecting their environments only if they are educated about bee species and how to protect them. The understanding of bees and emphasizing their environmental services would also reduce fear of bee species and increase willingness to protect them. This can further be done by training local people to distinguish between dangerous and non–dangerous bee species (Arnold et al., 2021), and be involved in pollinator conservation programs as well as engage safely with bee–pollinators and avoid bee stings. Moreover, local communities should be well informed about benefits of all different species of bees instead of *Apis* spp alone e.g. honey bees. This will enhance sustainable conservation of bees, and other pollinator species (Patel et al., 2021). Overall, raising awareness about bee–pollinators to local communities, will bridge the existing knowledge gap, and thus, promote their conservation in the Southern Highlands of Tanzania.

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## Declaration of Conflicting Interests

## Funding

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## Supplemental Material

Supplemental material for this article is available online.

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