# Indigenous knowledge on ground-nesting stingless bees in southwestern Ethiopia

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## Abstract

While Ethiopia has several species of stingless bees, indigenous knowledge on them has not been well documented. Here, we document the indigenous knowledge of the Sheka community in southwestern Ethiopia on stingless bees. We used the snowball sampling technique to locate 60 experienced honey collectors, conducted semi-structured interviews, and complemented interviews with field observations during honey collection trips with interviewees. Honey collectors did not collect honey from aboveground nesting stingless bees, but only from stingless bees nesting belowground. To find the underground nests in the field, honey collectors used several methods, including direct observation of nest entrances and worker bee movement, attaching a thread to the worker bee, and listening for the humming sound of the bee's natural enemy (wasp). Nests were harvested destructively. Interestingly, a single farmer kept ground-nesting stingless bee colonies at his backyard using uniquely tailored squared box hives. Collected honey is used for home consumption, disease treatment, and the generation of income. Our findings illustrate the deep indigenous knowledge of the Sheka community on wild ground-nesting stingless bees. To facilitate the establishment of stingless bee beekeeping (meliponiculture) in the study area, we may build upon this indigenous knowledge by field research on the biology of stingless bees, taxonomic studies to assess the diversity and identity of ground-nesting stingless bees, and engineering studies to develop beekeeping practices. Together, this may allow for better income for local farmers and avoid the risk of overexploitation of wild stingless bee nests.

**Key Words**: ground-nesting stingless bees, honey collection, indigenous knowledge, meliponiculture, nest identification, Sheka zone, subterranean stingless bees

## Introduction

Stingless bees (Apidae: Meliponini) are mostly found in the tropical and subtropical regions of the world (Michener 2007). Like honeybees of the genus *Apis*, all stingless bees in Africa are eusocial, and live with many individuals in a single nest. They are ecologically, economically and culturally important. For example, stingless bees contribute to the pollination of crops and wild plants (Slaa et al. 2006), stingless bee honey can be sold for cash (Quezada-Euan et al. 2018), and stingless bee honey is used in the treatment of several diseases (Kumar et al. 2012, Rao et al. 2016). Meliponiculture, which is beekeeping with stingless bees, takes place across the world, but is most advanced, and has the longest history, in the Neotropics (Quezada-Euán et al. 2001, Cortopassi-Laurino et al. 2006).

In Africa, the honey of stingless bees is mostly collected from wild colonies (Eardley 2004, Cortopassi-Laurino et al. 2006). But there are exceptions, with a few communities in Tanzania and Angola using hollow logs or clay pots as hives (Cortopassi-Laurino et al. 2006). Furthermore, a keen interest to develop meliponiculture has existed in Ghana, Kenya, Botswana and South Africa (Cortopassi-Laurino et al. 2006). Despite this interest, the knowledge on the diversity and taxonomy of stingless bees in Africa is relatively low, with many species still to be discovered and described (Eardley 2004).

Only six species of stingless bees are known from Ethiopia (Fichtl and Admasu Adi 1994, Pauly and Hora 2013). While there is a long tradition of honey collection from wild stingless bees by different communities, meliponiculture is unknown from the country. Sheka Zone is one of the areas in Ethiopia with the highest forest cover, and the area may have potential for stingless bee honey production. However, while honeybees (*Apis mellifera*) are commonly kept in purpose-made hollow logs placed in large trees, the local community is known to collect honey from stingless bee colonies only from the wild (Shenkute et al. 2012).

Despite the potential for production of honey from stingless bees, the value of stingless bees and their products for the community is not recognized by the government and is not included in the agricultural extension system. Moreover, we lack documented information associated with indigenous knowledge on honey production practices and its use, even though stingless bee honey collection is considered an important activity in the culture of the Sheka community. Studying the indigenous knowledge on stingless bees may be a first important

step towards domestication and establishment of meliponiculture, which could provide pollination for crops and wild plants, honey as food and medicine, and cash income (Eardley 2004). Moreover, it would halt the destruction of wild stingless bee nests. In order to fill this knowledge gap and contribute to the effort to introduce meliponiculture, we documented the indigenous knowledge on stingless bees and the use of their products by the people in the Anderacha and Masha districts in Sheka zone, southwestern Ethiopia.

## Materials and Methods

### *Study area*

The study was conducted in the Sheka zone located in southwestern Ethiopia (Fig. 1). Sheka zone is divided into the three woredas (henceforth 'districts') Masha, Anderacha and Yeki (7°24'–7°52' N, 35°13'–35°35' E). The altitudinal range of the area falls between 900 and 2700 m a.s.l., and the area receives between 1800 and 2200 mm of rainfall per year. According to the Sheka Zone Administration Office, c. 47% of the 2175 $km^2$ is covered by natural forest preserved by the local community, and the remaining land area is cultivated, grazed by livestock, or otherwise used by humans. The main economic activities in Sheka zone are agriculture and livestock production. The Sheka community also earns cash from honey and spices collected from the natural forest.

### *Study design and methods*

A cross-sectional study design was employed to document the indigenous knowledge of the Sheka community on stingless bees and their products. The study was conducted during 2017 and 2018 in the Masha and Anderacha districts (Fig. 1). From each district, we selected three kebeles (the smallest administrative units, henceforth 'villages') based on prior information obtained from elderly inhabitants on the potential of the area for stingless bee honey production. Within each village, we then held informal discussions with the elders and local administrators to identify those persons knowledgeable about stingless bee's honey production. Using the snowball sampling method (Bailey 2007), we then selected ten

stingless bee experts from each village (n = 60 in total). Thereafter, we clarified the purpose of the study and received consent to interview the 60 honey collectors.

To complement the semi-structured interviews, we conducted field observations to describe in detail, and validate, the information obtained from individual honey collectors. For this, we joined local honey collectors in their search for, and harvesting of, wild stingless bee nests in each of the three villages. During our search, we found 18 wild stingless bee nests. We noted and recorded all activities such as searching for wild nests, digging out the nest from the ground, and harvesting of the products from the nest. One local honey collector kept stingless bees in wooden box hives, and we recorded this practice in detail.

## Results

### *Socio-economic characteristics of the respondents*

From the 60 honey collectors, 58 were male and 2 were female (Table 1). The majority was literate and married (Table 1). The most common occupation was farmer and local mead brewer, with a minority being government employee or student (Table 1). Honey collection from stingless bees was done by those with and without livestock, and those that own or do not own land (Table 1). The average age of the honey collectors was 43 years, but the age varied widely from 18 to 73 years (Fig. 2a). The respondents had collected stingless bee honey for 2 to 52 years (Fig. 2b). The age at which the honey collectors started to collect honey was highly variable, with ages ranging from 10 to 62 years (Fig. 2c). The respondents said that the knowledge of stingless bees and use of their products is obtained orally from their parents and neighbours and in this way transferred through generations, and that honey of ground-nesting stingless bees had been collected by their ancestors for centuries.

### *Knowledge on taxonomy and habitat*

The respondents distinguished between stingless bees that nested below- or aboveground. The stingless bees nesting below- and aboveground are referred to as *shaweti* and *bobbao*, respectively, in the local language shekinnono. The aboveground nesting stingless bees build their nests mainly in hollow tree trunks, cavities, under the roof of dwellings and in empty log

hives. The ground-nesting stingless bees build their nests in the soil, with only the nest entrance visible (Fig. 3ab). According to the respondents, they did not collect honey from aboveground nesting stingless bees, because these aboveground bees are mainly found in remote and inaccessible lowland areas. Hence, our study focused only on the ground-nesting stingless bees. The respondents stated that the ground-nesting stingless bees are abundant, and they frequently collected its honey. All honey collectors recognized two types of ground-nesting stingless bees, with the 'black type' characterized by a larger body size, higher number of nest inhabitants, and higher productivity than the red species. Moreover, they differentiated the two types of bee based on the nest entrance: the black type had a wider entrance, which protruded further from the ground, than that of the red species (Fig. 3ab).

The nests of ground-nesting stingless bees can be found in intact forest and on grazing and farming land. However, the respondents stated that most of the nests were found far away from residential areas, and nests were only rarely found near residences.

*Methods for locating wild stingless bee nests*

The honey collectors in the surveyed districts shared several methods to locate the nests of the ground-nesting stingless bees. First, when walking through the intact forest, disturbed forest, and other areas searching for wild stingless bee nests, they look for nest holes on the ground. Second, they look for the presence of stingless bees, and when they observe the bees, they will conduct a dedicated search within the vicinity. When observing any bee activity in such areas, they also silently squat down on the ground and look for forager stingless bees returning to or leaving their nest. Third, they catch stingless bee foragers on flowers of several plant species, and tie a coloured thread, which is most often red, around their petiole (i.e., the narrow waist). After tying the thread, they squat down on the ground, release the foraging bee, observe the flight direction of the bee, and then follow the bee in the direction of its nest. Fourth, when they search during the harvesting season (see below), they also use the nest smell to locate the nest: the honey has a strong smell that can be detected from a distance, and is very helpful to decide the searching area and for locating the nest. In addition to the aforementioned methods, the respondents from the Anderacha district used the

stingless bee enemy (a wasp) as an indicator to locate the nests, by listening for its humming sound at the stingless bee nest entrance.

According to the respondents, one can search for wild stingless bee nests between 8:00-11:30 and 13:30-17:30, but the most effective time of the day for searching of wild stingless bee nests is in the morning from 8:30-10:30 and in the afternoon from 14:00-16:30. The respondents thought that stingless bees prefer cool weather conditions for foraging, and do not exit the nest during the hottest time of the day.

The major period for harvesting of stingless bee honey was during March and April, with some of the respondents mentioning a minor harvesting period from November to January. All respondents described that when they find stingless bee nests outside of the honey-harvesting season, they place their own unique symbol around the nest, and then leave the nest untouched until the start of the harvesting season. They placed the nest markers in great secret, to avoid other people spotting the markings and harvesting the nest's honey. As markers, they used small sticks, stones, or any other unique objects that could serve as an indicator of the nest location, and would allow finding it back during the honey-harvesting season.

*Harvesting of the honey from wild nests*

Honey is a non-timber forest product that is highly appreciated by the local communities in the study area. Although the respondents recognized several types of products within the bee's nest (honey, pollen, propolis and cerumen), they mainly collected the honey, and only infrequently collected propolis.

To harvest honey from wild stingless bee nests, the respondents used different local materials, such as a spade, gejera (machete) and/or knife, a metal collection plate, and small plastic or glass bottles. To safeguard the nest entrance, the honey collectors started by placing an indicator at the nest entrance and cleaning the ground surface up to 35 cm from the nest entrance. They then dug around the nest until they reached the bottom of the nest, which is generally 35 to 40 cm deep (Fig. 3cd). Third, they pulled out the entire nest, and placed it on a broad leaf of false banana *Ensete ventricosum,* or on a flat piece of plastic. Fourth, they

removed dirt, like soil and other materials, from the external surface of the nest (Fig. 3e). Finally, they cut the nest from above and pulled out the brood areas to separate them from the honey pots (Fig. 3f).

The majority of the respondents (69%) strained the honey using *Ensete ventricosum* fibres locally known as *qacha.* After separating the brood areas from the honey pots, they placed the fibres on top of the metal plate, and then crushed and squeezed the honey pots with its content above it. The fibrous material is used to retain any impurities, and allows passing through of the pure, liquid honey. The other respondents (31%) pierced a hole in each individual honey pot, so that the pure honey flowed directly to the metal plate (honey container). However, they noted that if the nests were constructed between the roots of trees or shrubs, the nest could suddenly crush and become difficult to pull out of the ground. In such scenario, they would cut the nest, crush all of its contents together, and squeeze out the storage pots. They would then strain the impure honey later using *qacha*. The respondents did not give any attention to the broods, and during the harvesting the whole nest was destroyed, resulting in the bees absconding. In all study areas, honey was stored in a plastic or glass bottle. However, they stated that the small plastic bottles are hard to clean and are therefore less hygienic.

The average number of wild stingless bee nests harvested per respondent per year was 9.6 ± 8.7 (mean ± SD), and was higher in Masha district (12.4 ± 10.7) than in Anderacha district (6.77 ± 4.78; Fig. 4a; $t_{58} = 2.61$ and $P = 0.01$). The average amount of honey harvested per nest was similar in Masha (2.4 L ± 1.2) and Anderacha district (2.2 L ± 1.1; Fig. 4b; $t_{58} = 0.73$ and $P = 0.47$). According to the respondents, honey yield of wild colonies can differ based on nest age, and when a nest is older than one year it can produce up to 5 litres.

*Local meliponiculture*

All but one of the interviewees collected honey from wild stingless bee nests. According to these respondents, domesticating and managing colonies of ground-nesting bees using artificial hives is difficult, and they believed the reason is that the colonies obtained heat from the soil underground and were thus not adapted to hives placed aboveground.

However, one out of the sixty interviewees practiced meliponiculture, thereby illustrating that it is possible to establish meliponiculture. The interviewee lived in Anderacha district, and kept colonies of ground-nesting stingless bees in his backyard using square box hives (Fig. 5). The box hives were prepared in a traditional manner from wooden boards joined by nails, with each side of the box measuring 36 × 36 cm. Each box hive had a single small hole at the fixed upper wooden board, which served as the hive entrance (Fig. 5a). The bottom board of the hive is designed to be opened for the purpose of honey harvesting (Fig. 5b). To support the nest, each hive had four thin wires attached to the upper board and suspended towards the inner part of the hive. Two small sticks that crossed each other, and were joined by a nail, were prepared and attached to the wires, so it could hold the nest. The interviewee described that after he prepared the box hive, he collected a wild stingless bee nest, placed it on the supportive sticks and attached it using the wires to the upper board, so that the nest was hanging inside the hive (Fig. 5cd). Thus, the nest does not have contact with the sides of the hive, and this is mainly to avoid any difficulty during honey harvesting, when the hive is opened from its lower part. The stingless bee hives were placed at his backyard together with honeybee colonies (*Apis mellifera*). According to the respondent, he was able to harvest honey from the colonies in the wooden box hives twice a year, and opened the hives only during honey harvesting time. During the study, we observed many hives without colonies and the respondent told that 21 out of the 26 colonies had absconded for unknown reasons. The honey harvesting method from the stingless bee colonies kept in wooden hives was non-destructive, and only honey was harvested. The pure honey was harvested by using a purposively prepared dry sharp stick to penetrate each pot and letting the honey flow out.

*The use of products from stingless bees*

The reasons for honey collection were quite similar throughout the study area. The stingless bee honey is mainly used for home consumption. According to the respondents, honey is consumed either immediately after being extracted, or after storage, when it is drunk either pure or mixed with water or local drinks known as *borde* and *tella*. The honey is valued as a food supplement, and also used for the treatment of different types of diseases, like tuberculosis, coughing, malaria, constipation, asthma, tonsillitis and oral thrush. Propolis was used to seal or repair cracked clay pots, plastic containers and other home equipment.

Because of its medicinal and nutritional value, the price of honey of stingless bees was more than twice that of *Apis mellifera* honey at the local market (*c.* 150-200 versus 60-78 Ethiopian birr [ETB] per litre).

*Threats to stingless bees*

The respondents did not observe signs of brood diseases or diseased bees, suggesting that stingless bees are largely disease-free in the study area. However, they indicated that stingless bees are attacked by several natural enemies, which included, in order of their relative importance, honey badgers (21.2%), moles (19.8%), wasps (14.6%), termites (14.3%), ants (13.8%), foxes (13.1%), and snakes (3.2%). This matches with the findings from Shenkute *et al* (2012), who reported that ground-nesting stingless bee colonies in Sheka, Kaffa and Bench Maji zones were affected by honey badgers, ants and moles.

The respondents also noted that deforestation, forest and soil degradation, and pesticides posed a threat to the stingless bee colonies.

*Limitations to the adoption of local meliponiculture*

The respondents pointed out several obstacles that were limiting the development of improved stingless bee beekeeping practices or meliponiculture: stingless bees were not yet domesticated, stingless bees produced small amounts of honey, no extension services and training were provided, there was no appropriate technology for keeping stingless bees, and there was a general lack of knowledge on improved stingless bee honey harvesting, processing, handling and other management practices.

## Discussion

Using semi-structured interviews and detailed field observations, we characterized the traditional knowledge on stingless bees in Sheka zone, southwestern Ethiopia. We found deep

indigenous knowledge on honey harvesting and the usage of bee products from wild, underground stingless bee nests, which is part of a cultural tradition that has been passed on orally from one generation to the next. Honey collectors used several direct and indirect methods to find the wild stingless bee nests, and harvested the nests destructively. A single respondent maintained stingless bee nests in wooden boxes in his backyard, indicating the potential for meliponiculture.

*Socio-economic status of honey collectors*

Our findings indicate that the participation of women in stingless bee's honey collecting activities in the study areas is low, with only two out of sixty honey collectors being female. The major reason may be that nest hunting, just like the placement of hollow wooden logs for the honeybee *Apis mellifera* into large trees, are generally considered as the work of men. Hunting usually involves searching the wild bees in forests, far from residential areas, and roaming through forests alone is culturally considered as taboo for females. Interestingly, women participation may increase with the adoption of meliponiculture. Honey was collected mostly by married persons (85%), which the respondents attributed to the medicinal value of stingless bee honey for children. Interestingly, the honey collectors had a diverse economic background: honey was collected by both economically productive and economically dependent age groups (the latter defined in Ethiopia as ages below 15 and over 65), literate and illiterate persons, farmers and local mead brewers as well as students and government employees, those with and without livestock, and those with and without land. Overall, this indicates there is no restriction of honey collection to specific sub-groups within the local community.

The experience of the respondents with honey collection ranged from 2 to 52 years. The long experience of some honey collectors indicates that honey collection from wild stingless bees has been practiced for several generations. The short experience, and low age, of some of the honey collectors are a testimony that honey collection is a living tradition within the study area, and is not restricted to older generations. Of particular note is the fact that honey collectors started with harvesting stingless bee nests at a range of ages, indicating that both

younger and older people can acquire the necessary skills, and/or start the practice of honey collection.

*Stingless bee diversity and taxonomy*

As pointed out repeatedly, the diversity and distribution of stingless bees in Africa is poorly known (Eardley 2004, Eardley and Kwapong 2013, Pauly and Hora 2013). Within Ethiopia, only six species of stingless bees have been reported, which is most likely a strong underestimation (Pauly and Hora 2013). From the species recorded in Ethiopia thus far, only *Meliponula beccarii* is known to build its nests underground (Pauly and Hora 2013). We expect that the larger 'black type' corresponds to *M. beccarii*, which is widespread in Africa and has been documented very well (Pauly and Hora 2013). However, the identity of the 'red type' is unknown (Alain Pauly, personal communication). This lack of knowledge on the taxonomic identity and biology of stingless bees hampers progress (Eardley and Kwapong 2013), and we need future research to characterize the taxonomic diversity of stingless bee species within Africa and within the study area.

*The road toward meliponiculture*

As stated by Eardley (2004), meliponiculture in Africa is relatively uncommon, and harvesting of meliponine honey is mostly destructive. This matches the described cultural practices in Sheka: The local communities had a diverse and deep indigenous knowledge on local wild stingless bee nest identification, nest harvesting, and the use of its products, and this practice has for long been an integral part of the communities' culture. Despite this, only a single interviewee practiced beekeeping with stingless bees. It would be worthwhile to further explore the potential for meliponiculture. For this, we need to complement the valuable indigenous knowledge on ground-nesting stingless bees with field studies on the ecology and behaviour of stingless bees in the field, surveys that characterize the taxonomic diversity of stingless bees, and engineering studies that develop the technology necessary for improved beekeeping. With such improved knowledge at hand, we can harness the agricultural extension services to promote and spread knowledge on meliponiculture.

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**Table 1.** Socio-economic status of the stingless bee honey collectors interviewed during the study in Sheka zone (N = 60)

| Response variable | Categories | Number (%) |
|---|---|---|
| **Sex** | Male | 58 (97%) |
| | Female | 2 (3%) |
| **Marital status** | Married | 51 (85%) |
| | Single | 9 (15%) |
| **Educational status** | Literate | 54 (90%) |
| | Illiterate | 6 (10%) |
| **Occupation** | Farmer and local mead brewer | 53 (88%) |
| | Government employee or student | 7 (12%) |
| **Livestock possession** | Livestock keeper | 47 (78%) |
| | No livestock | 13 (22%) |
| **Land possession** | Land owner | 53 (88%) |
| | No land | 7 (12%) |

**Figure legends**

**Fig. 1.** Overview map of the study area. Shown are Ethiopia (top-right), Sheka zone (bottom-right) and the Masha and Anderacha districts (left)

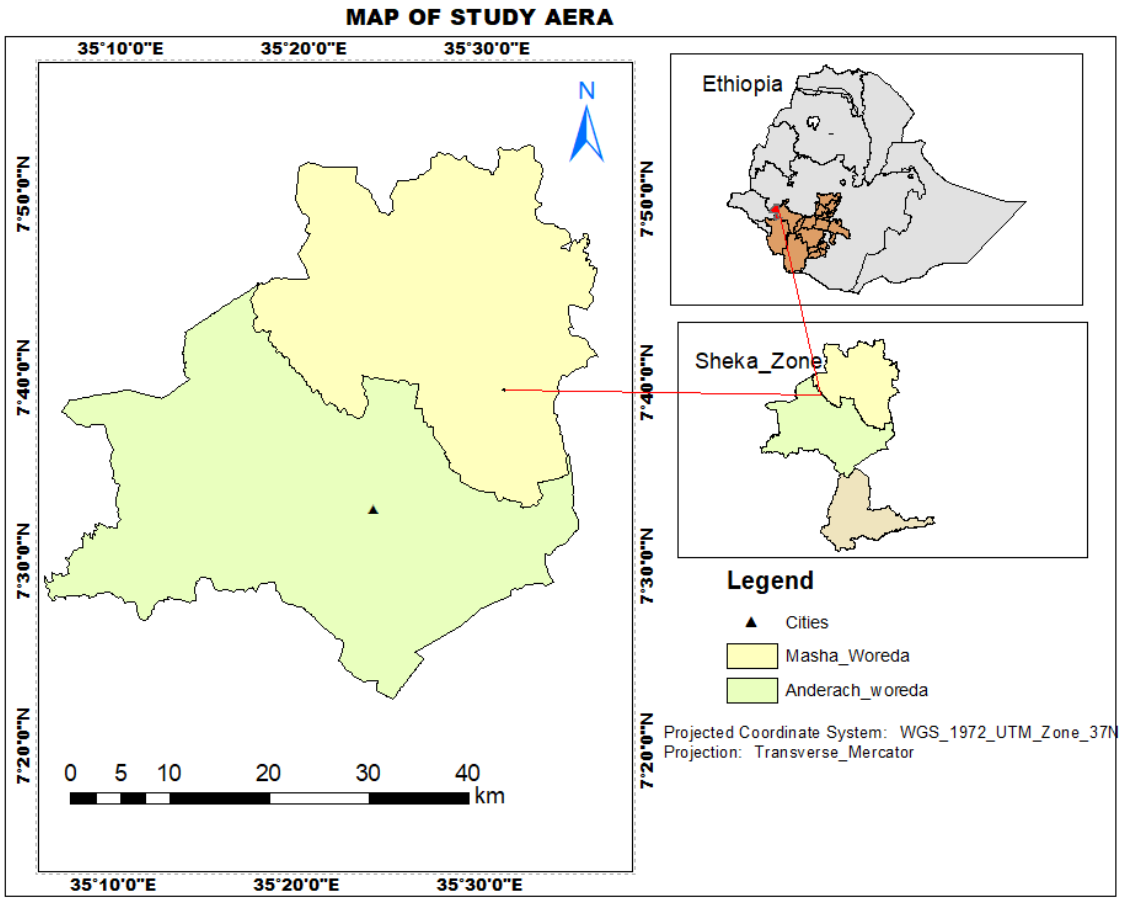
**Fig. 2.** Age and experience of 60 local honey collectors in Sheka zone, southwestern Ethiopia. Panel **a** shows the age of the honey collectors, panel **b** shows the number of years of experience with honey collection, and panel **c** shows the age at which the honey collectors started collecting honey

**Fig. 3.** Overview of the harvesting process. Panels **a** and **b** show the nest entrances of the red and black stingless bee type, respectively. Panel **c** shows the digging up of the underground nest using a spade. Panel **d** shows an excavated nest. Panel **e** shows the cleaned nest, with the brood surrounded by honey jars. Panel **f** shows the extraction of honey from the nest, with the metal collection plate in the background.

**Fig. 4.** The amount of wild stingless bee nests and honey harvested by 60 honey collectors in Sheka zone, southwestern Ethiopia. Shown are density plots for **a** the number of nests harvested and **b** the average amount of honey harvested per nest by the honey collectors from the Masha and Anderacha districts ('woredas')

**Fig. 5.** Wooden box hive for ground-nesting stingless bees. Panel **a** shows the wooden box hive from the upper side, with the arrow pointing towards the hive entrance (hole) in the upper board. Panel **b** shows the bottom board of the hive, which can be opened for the purpose of honey collection. The red arrow points towards the metal strip used to close the board. Panels **c** and **d** show how the stingless bee nest is placed inside the hive. The nest is placed on two crossed, supportive wooden sticks, which are attached to the inner surface of the upper board using wire.

**Figure 1**


MAP OF STUDY AERA
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Ethiopia
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Masha_Woreda
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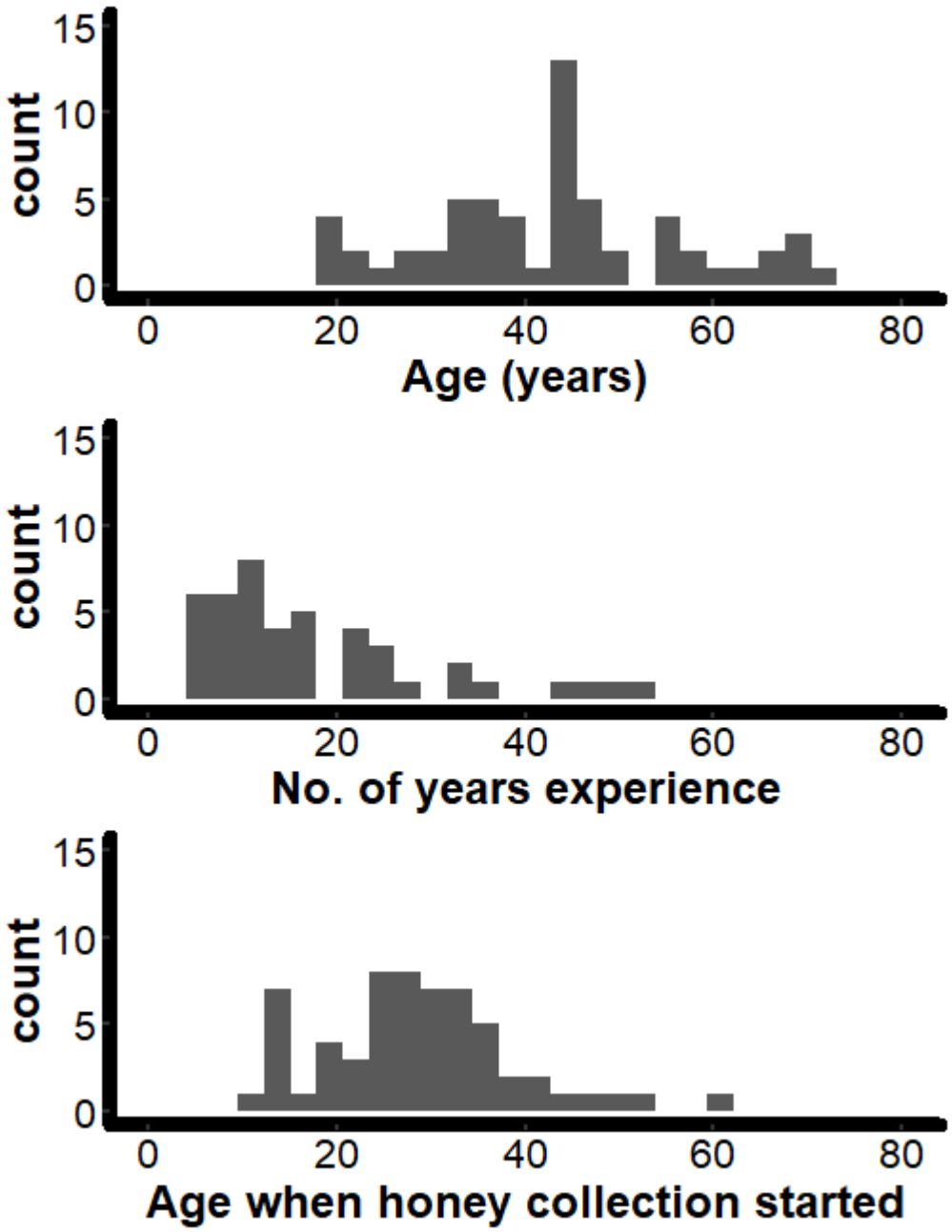
km

**Figure 2**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Age (years)
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No. of years experience
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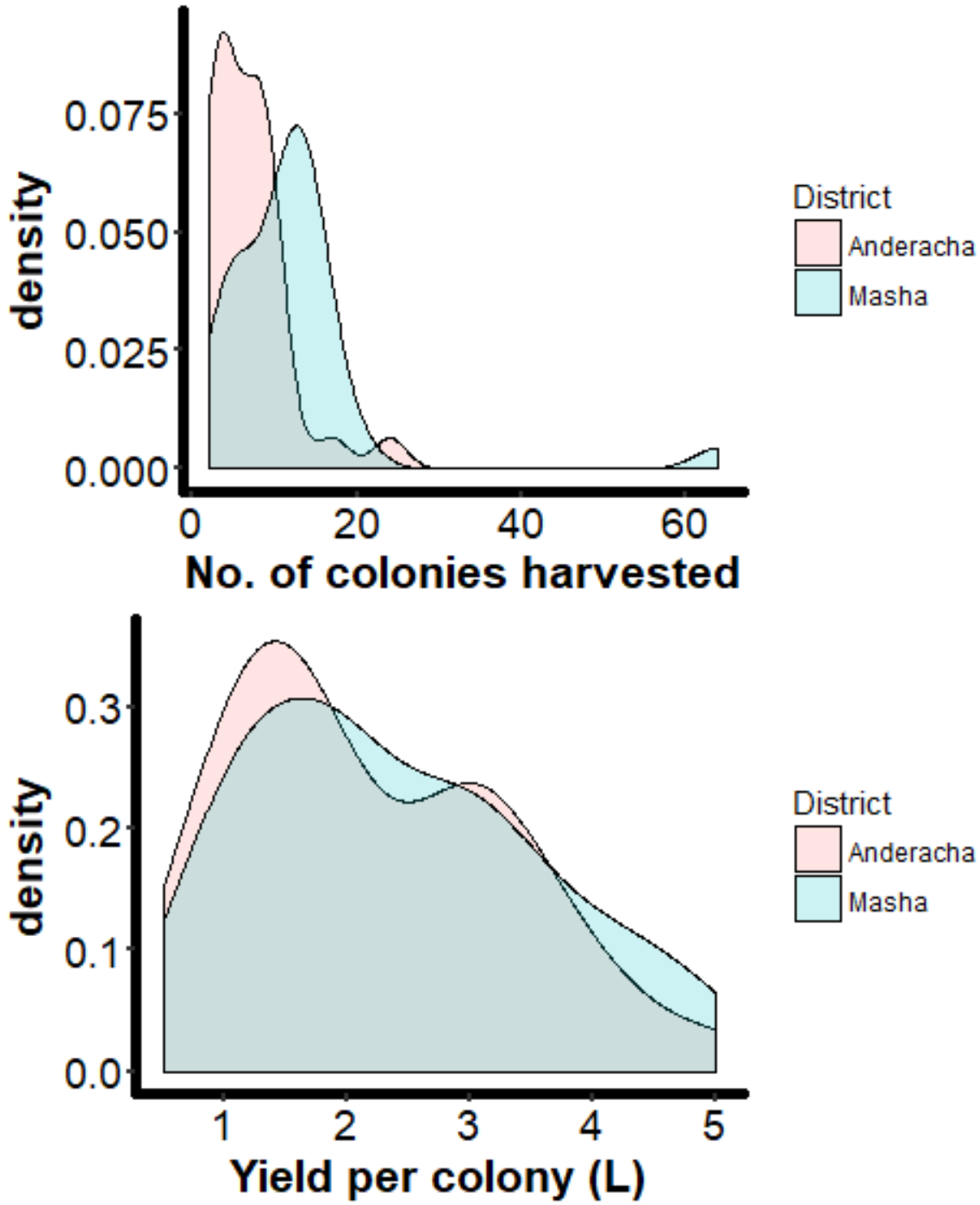
Age when honey collection started

**Figure 3**

**Figure 4**


density
0.075
0.050
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20
40
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No. of colonies harvested
District
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density
0.3
0.2
0.1
0.0
1
2
3
4
5
Yield per colony (L)
District
Anderacha
Masha

**Figure 5**