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CAUSES OF HONEYBEE COLONY DECLINE IN SOUTH ETHIOPIA

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ABSTRACT: The purpose of this study was to identify the major causes of colony decline in the Gedeo Zone, South Ethiopia. Three districts, namely, Yirga Cheffe, Wonago, and Dilla Zuria, were purposefully selected based on beekeeping potential. A cross-sectional survey was conducted to collect data from 135 beekeepers and 15 key informants using a semi-structured questionnaire, focus group discussion, and personal observation of apiary sites. The results revealed two main causes of colony declines in the Gedeo zone: colony management-related factors and natural factors. Seventy percent of beekeepers lack the practical skills to perform hive inspection; 47% do not feed their colonies; 45% spray pesticides and insecticides near their apiaries; and 82% fail to control swarming. As a result, 87% of sampled beekeepers have experienced frequent colony absconding. The trends of colony decline showed an increase from 2008 to 2020 in the highlands and from 2008 to 2017 in the midlands and lowlands, respectively. The number of households facing colony declines increased in all agro-ecologies from 2008 to 2020. Pests and predators, like wax moths, and small hive beetles were take the first rank followed by ants, the inherent behavior of honeybees, a shortage of flora, and the presence of poisonous plants were the top five challenges among natural factors, respectively. Therefore, we strongly recommend educating beekeepers on scientific methods of colony management and planting bee flora. Laboratory diagnostics are required to identify bee diseases.

Keywords: Apiary management, Apiculture, Bee diseases, Colony decline, Swarm.

INTRODUCTION

Apiculture is an important agricultural sub-sector that allows for the use of natural resources that would otherwise be wasted and contributes to national food production through pollination (Melaku et al., 2008). Due to their effectiveness and widespread distribution over the world (Durazzo et al., 2021) honey bees are regarded as one of the most significant pollination agents globally (Klein et al., 2007; López et al., 2017; El-Naggar et al., 2022). Furthermore, they are essential pollinators for agricultural crops (Aizen et al., 2009; Verde, 2014; Robinson et al., 2021). Honey bees play a vital function and have a positive impact on the environment by keeping the balance of ecosystems through enhanced pollination (Gidey and Kibrom, 2010; Famuyide et al.,2014). Recent studies (Aryal et al., 2020; Kline and Joshi, 2020; Patel et al., 2021) have also appreciated the pollination effort performed by wild pollinators. As a result, more seeds and plants (Gidey and Kibrom, 2010) provide food for wildlife (Bradbear, 2009) and aid in reducing soil erosion and degradation (Ahmad et al., 2003) through ensuring the preservation of floral diversity. Pollination services support biological diversity and ecological harmony (Toni and Djossa, 2015). Therefore, apiculture is the most important intervention area for countries like Ethiopia to increase crop yield and for sustainable development (Gibbon, 2001).

In Ethiopia, apiculture has been practiced for centuries throughout the country (Melaku et al., 2008). Despite long-standing beekeeping practices, more than 96% of apiculture is still conducted in a backyard and traditional system (CSA, 2019). This implies the need for modernization (Melaku et al., 2008). Ethiopia is home to an estimated 10 million honeybee colonies; 60 percent of which are managed in various hives (MoARD, 2007). Unfortunately, the MoARD report indicated a 50% decrease in colony population (4,993,815). However, the recent report of the CSA (2019) showed that there are 7,075,188 colonies in the country, with 96.1 percent, 2.8 percent, and 1.1 percent being kept in traditional, modern, and transitional hives (Kenyan Top bar hive), respectively. Beekeeping employs an estimated one million beekeepers, thousands of honey collectors and traders, and thousands of "Tej" (local beverage) makers in urban areas of Ethiopia (Beyene and David, 2007).

Despite Ethiopia's vast beekeeping potential, numerous studies have found that deforestation, agrochemical poisoning, pests and predators, and a lack of bee flora are major challenges in the apiculture sub-sector, resulting in colony declines and a decline in honey yield (Ejigu et al., 2009; Mengistu and Beyene, 2014; Beyene and Verschuur, 2014). The colony decline has been increasing because of unwise pesticide application to crop fields (Fikadu, 2020). Poor honey harvesting techniques that result in the complete destruction of brood comb, honeybee disease, and pests and predators such as ants, wax moths, and small hive beetles are major destructors of honeybees, leading to colony absconding (Kenesa, 2018). Except for a very few studies that identified general challenges in the beekeeping sub-sector, there is a lack of scientific information about the causes of colony decline in the Gedeo zone. Therefore, the primary purpose of this study was to identify the causes of colony decline and the status of declines in the Gedeo zone.

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MATERIALS AND METHODS

Description of study area

The study was conducted in Gedeo Zone, Southern Ethiopia, which is about 360 km from Addis Ababa and 90 km from Hawassa, the capital of Sidama Region, and the South Nations Nationality and People Region (SNNPR). The Gedeo zone lies approximately between 5^0 53'N and 60 27'N latitude and from 38^0 8' to 38^0 30' E longitude (Figure 1). The average monthly temperature is 21.5 degrees Celsius, with maximum and minimum monthly temperatures of 25 degrees Celsius and 18 degrees Celsius, respectively (CSA, 2006).

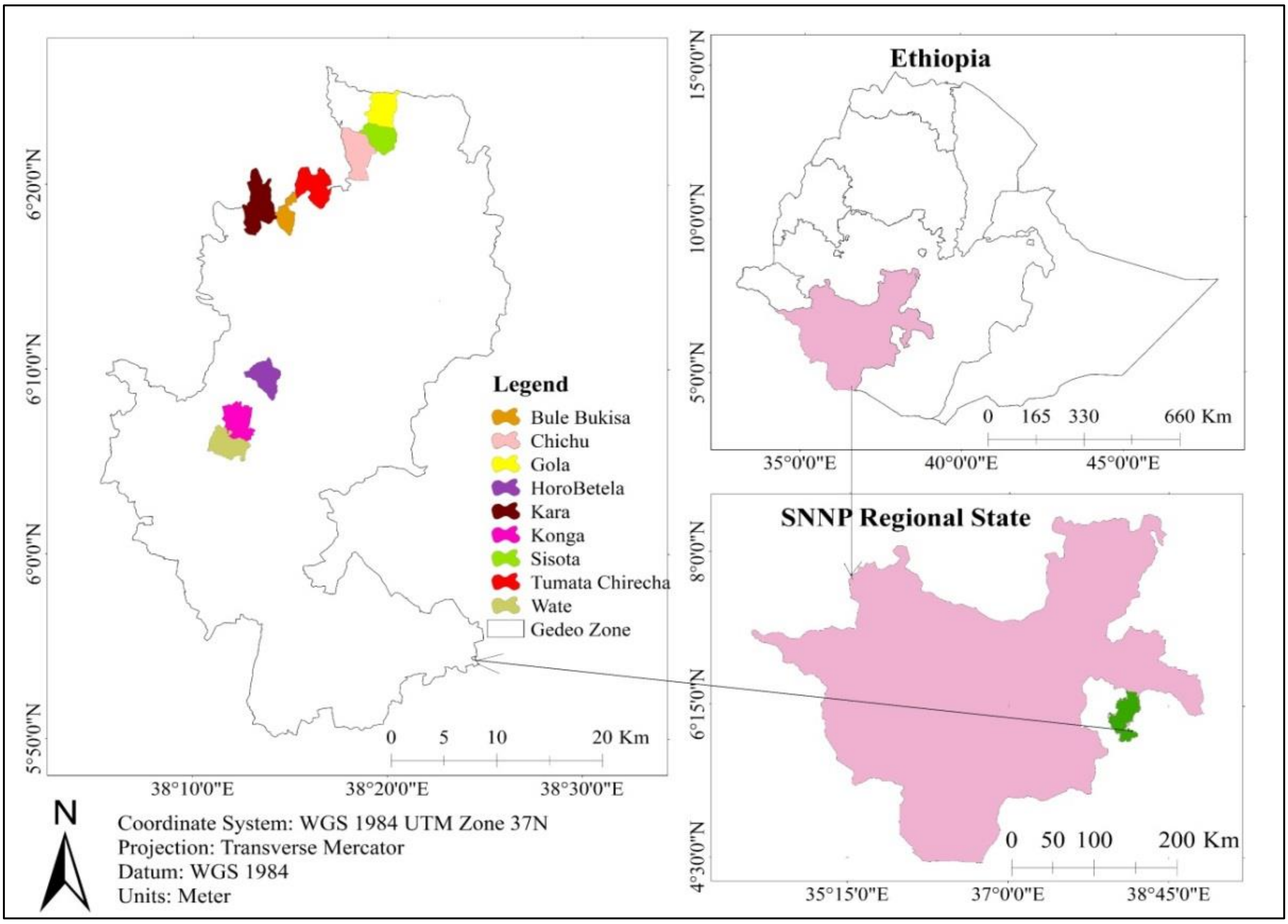

Figure 1 - Map of the study area

Sampling techniques and sample size

Three districts, namely Yirga Cheffe (highland), Wonago (midland), and Dilla Zuria (lowland), were purposefully chosen based on their beekeeping potential in the Gedeo zone. From each district, three Kebeles (the smallest administration unit in Ethiopia) were selected based on agro-ecology: highland, mid-altitude, and lowland. From each kebele, fifteen respondents were randomly selected, and the primary information regarding all beekeeping management and the history of colony decline was gathered from different agro-ecological regions. A total of 135 sample respondents and 15 key informants were involved in this study.

Data collection methods

Before the commencement of the survey questionnaire, the districts' livestock and fishery bureau officers were consulted regarding the accessibility of intended information from farmers and key informants, which include knowledgeable local leaders of the peasant association, district beekeeping experts, and development agents. Five key informants were contacted from each district. Finally, primary data from respondents was gathered using a semi-structured questionnaire and personal observations of the apiary sites.

Statistical analysis

The data generated through the survey questionnaire was analyzed using SPSS software, version 20. Then descriptive statistics such as mean, tables, percentages, and figures were used to analyze the data. The rate at which constraints contributed to colony decline in the study area was determined by the relative importance index (Tam and Le, 2006).

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$$RII = \frac{\Sigma w}{AN} = \frac{10n_{10}+9n_9+8n_8+7n_7+6n_6+5n_5+4n_4+3n_3+2n_2+1n_1}{10N} \quad (1)$$

Where RII is Relative Importance Index w is the weighting given to each factor by the respondent, ranging from 1 to 9. n_1 = number of respondents for little important, n10 = number of respondents for very important. A is the highest weight (i.e. 10 in the study area) and N is the total number of respondents (Tam and Le, 2006).

RESULT

Demographic characteristics of respondents

The mean age of the entire respondents was 46.6 years. Males were the dominant owners of bee colonies (91.1%) in the study area (Table 1). The majority (65.9%) of the respondents were attending from elementary school to college level and about 30.4% were able to read and write. Regarding beekeeping experiences, 72% of sampled farmers had more than ten years of experience in beekeeping while 27% of respondents had less than five years of experience. The mean colony holding per household was 10.5 (Table 1). A male (54.1%) house head mainly carried out colony management activities. However, about 36.3% of respondents reported that all family members equally participate in the colony's management, while only 5.2% of children and 4.4% of women reported that they manage their colony independently. As shown in the result, the majority (60.7%) of the respondents receive consultation services from extension workers during active (honey flow) and dearth seasons. Nonetheless, 39.3% of beekeepers reported receiving no assistance from extension workers (Table 1). Seventy-seven percent of the entire group of respondents reported that they obtained their colonies from swarm bees, and the remaining 22% of beekeepers obtained them from both swarms and parental gifts. The main purpose of beekeeping in the studied area was only for honey production (Table 1).

Management related factors contributed to colony decline in the study area

According to the results (Table 2), nearly half of the respondents (46.7%) did not provide supplementary feed to their colonies during the dearth season. In terms of hive inspection, 68.9% of respondents stated that they did not perform internal hive inspections during drought seasons. Besides, 45% of sampled respondents reported that pesticides were sprayed close to their apiary sites for cash and cereal crops. Furthermore, 82% and 87% of sampled beekeepers reported the occurrence of frequent swarming during honey flow season and absconding of their colony in all seasons, respectively (Table 2). On the other side, farmers ranked natural factors that had the main contribution to colony declines based on their relative importance (Table 3). According to the results, pests and predators, ants, the inherent behavior of honeybees, a shortage of flora, and the presence of poisonous plants were ranked as the top five challenges, respectively, in the study areas. The incidence of collective death of honeybees, external disturbances, indiscriminate agrochemical application, frequent hive inspection, and disease prevalence were ranked from six to ten causes for colony declines, respectively (Table 3).

Trends of colony decline in study area

The number of colonies lost from 2008 to 2012 was the lowest in all agro-climatic zones (Figure 2). However, between 2013 and 2017, the number of colonies lost increased fourfold in the highlands and mid-altitudes, while it increased eightfold in the lowlands (Table 4). In the highland area, the declines continued to increase until 2018–2020, but in the mid- and low-altitude zones, a slight decline was observed in the years 2018–2020 compared to the previous five years (Figure 2). Our results showed that the overall colony decline was highest in the highlands (439), followed by the midlands (325), and relatively lowest in the lowlands (201) in the study area (Figure 2).

The majority of entire respondents reported that they experienced colony declines in the years 2013–2017 (79.26%) and 2018–2020 (83.7%). One hundred percent of sampled households in the highlands and above 90% in the midlands reported that they lost their colonies between the years 2013 and 2020. Colony declines increased from 2008 to 2020 in the highlands and from 2008 to 2013 in the midlands and lowlands, with a slight decline between 2018 and 2020 in the mid and lowlands areas (Figure 3).

Types of hive colony declines most occurred in the study area

The types of hives and colony declines most frequently observed are presented in Table 5. As shown in the result, 54% of the sampled respondents reported that the colony decline most frequently occurred from traditional hives (Table 5). The highest colony declines in the traditional hives were reported in the midland and highlands, respectively, compared to lowland areas. The results further revealed that the lowest colony declines occurred in frame and transitional hives, respectively. However, 32% of beekeepers reported that the colony decline did not depend on the types of hives but happened in all types of hives.

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Table 1 - Demographic characteristics of respondents (n = 135)

Variable \ Topography	Highland	Mid land	low land	Overall
Mean Age (Range)	51(30-68)	44(19-66)	45(24-65)	46.6(19-68)
Gender	n(%)	n(%)	n(%)	n(%)
Male	42(93.3)	41(91.1)	40(88.9)	123(91.1)
Female	3(6.7)	4(8.9)	5(11.1)	12(8.9)
Education status	n(%)	n(%)	n(%)	n(%)
Illiterate	0(0)	3(6.7)	2(4.4)	5(3.7)
Read and write	12(26.7)	16(35.6)	13(28.9)	41(30.4)
Elementary school	21(46.7)	14(31.1)	11(24.4)	46(34.1)
Secondary school	12(26.7)	7(15.6)	18(40)	37(27.4)
College and above	0(0)	5(11.1)	1(2.2)	6(4.4)
Experience on beekeeping	n(%)	n(%)	n(%)	n(%)
0-5 year	9(20)	12(26.7)	16(35.6)	37(27.4)
5-15 year	8(17.8)	15(33.3)	14(31.1)	37(27.4)
15-25 year	15(33.3)	11(24.4)	9(20)	35(25.9)
25-40 year	13(28.9)	7(15.6)	6(4.4)	26(19.3)
Colony holding status /HH (Mean)	11.86	7.74	11.63	10.51
Family participation in colony management	n(%)	n(%)	n(%)	n(%)
Male	26 (57.8)	25(55.6)	22(55.6)	73(54.1)
Female	0(0)	3(6.7)	3(6.7)	6(4.4)
Children	3(6.7)	0(0)	4(8.9)	7(5.2)
All members equally	16(35.6)	17(37.8)	16(35.6)	49(36.3)
Source of colony	n(%)	n(%)	n(%)	n(%)
Parents gift	1(2.2)	1(2.2)	11(24.4)	13(9.6)
swarm and parent gift	1(2.2)	4(8.9)	12(26.7)	17(12.59)
Swarm	43(95.6)	40(88.9)	22(48.9)	105(77.8)
Consultation from extension workers	n(%)	n(%)	n(%)	n(%)
Yes	23(51.1)	27(60)	32(71.1)	82(60.7)
No	22(48.9)	18(40)	13(28.9)	53(39.3)
Purpose of beekeeping	n(%)	n(%)	n(%)	n(%)
Honey production	44(97.8)	45(100)	45(100)	134(99.3)
Wax production	1(2.2)	0(0)	0(0)	1(0.7)

Table 2 - Management factors led to colony decline in the study area (n = 135)

Factors \ Topography	Highland	Mid land	low land	Overall
Supplementary feeding	n(%)	n(%)	n(%)	n(%)
Yes	25(55.6)	26(57.8)	21(46.7)	72(53.3)
No	20(44.4)	19(42.2)	24(53.3)	63(46.7)
Hive inspection at active season				
Yes- external inspection	45(100)	33(73.3)	32(71.1)	110(81.5)
No- external inspection	0(0)	12(26.7)	13(28.9)	25(18.5)
Yes- internal inspection	29(64.4)	23(51.1)	17(37.8)	69(51.1)
No- internal inspection	16(35.6)	22(48.9)	28(62.2)	66(48.9)
Hive inspection at dearth season				
Yes- external inspection	42(93.3)	33(73.3)	23(51.1)	98(72.6)
No- external inspection	3(6.7)	12(26.7)	22(48.9)	37(27.4)
Yes- internal inspection	10(22.2)	23(51.1)	9(20)	42(31.1)
No- internal inspection	35(77.8)	22(48.9)	36(80)	93(68.9)
Pesticide sprayed close to apiary	n(%)	n(%)	n(%)	n(%)
Yes	23(51.1)	34(75.6)	4(8.9)	61(45.2)
No	22(48.9)	11(24.4)	41(91.1)	74(54.8)
Frequent swarming occurred	n(%)	n(%)	n(%)	n(%)
Yes	45(100)	38(84.4)	27(60)	110(81.5)
No	0(0)	7(15.6)	18(40)	25(18.5)
Absconding occurred	n(%)	n(%)	n(%)	n(%)
Yes	45(100)	42(93.3)	30(66.7)	117(86.7)
No	0(0)	3(6.7)	15(33.3)	18(13.3)

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Table 3 - Natural factors led to colony decline in the study area (n = 135)

Variable	Highland	Midland	Lowland	Overall average	Overall Rank
Shortage of flora	0.798	0.80	0.84	0.813	4
Ants	0.80	0.840	0.96	0.8667	2
External disturbance	0.56	0.53	0.77	0.62	7
Indiscriminate agrochemical application	0.56	0.61	0.61	0.593	8
Disease	0.48	0.38	0.52	0.46	10
Inherent behaviour of honey bees	0.91	0.76	0.78	0.817	3
Other pests and predators	0.93	0.93	0.84	0.9	1
Frequent inspection	0.58	0.48	0.71	0.59	9
Poisoning plants	0.81	0.51	0.65	0.657	5
Collective death of honey bee	0.62	0.62	0.65	0.63	6

Table 4 - Number of household facing colony declines in the study area

Topography / Household faces colony declines	Highland	Mid land	low land	Overall
	n(%)	n(%)	n(%)	n(%)
2008-2012	17(37.78)	11(24.4)	12(8.89)	40(29.63)
2013-2017	45(100)	41(91.11)	21(46.67)	107(79.26)
2018-2020	45(100)	40(88.89)	28(62.22)	113 (83.7)

Table 5 - Proportion of colony declines in the different types of hives in the study area

Topography / Variable	Highland	Mid land	low land	Overall
	n(%)	n(%)	n(%)	n(%)
Traditional hive	30(66.7)	34(75.6)	9(20)	73(54.1)
Traditional and Transitional hive	2(4.4)	1(2.2)	0(0)	3(2.2)
Transitional hive	1(2.2)	5(11.1)	8(17.8)	14(10.4)
Transitional and Frame hive	0(0)	0(0)	1(2.2)	1(0.7)
Frame hive	0(0)	1(2.2)	0(0)	1(0.7)
Do not depend on type of hive	12(26.7)	4(8.9)	27(60)	43(31.9)

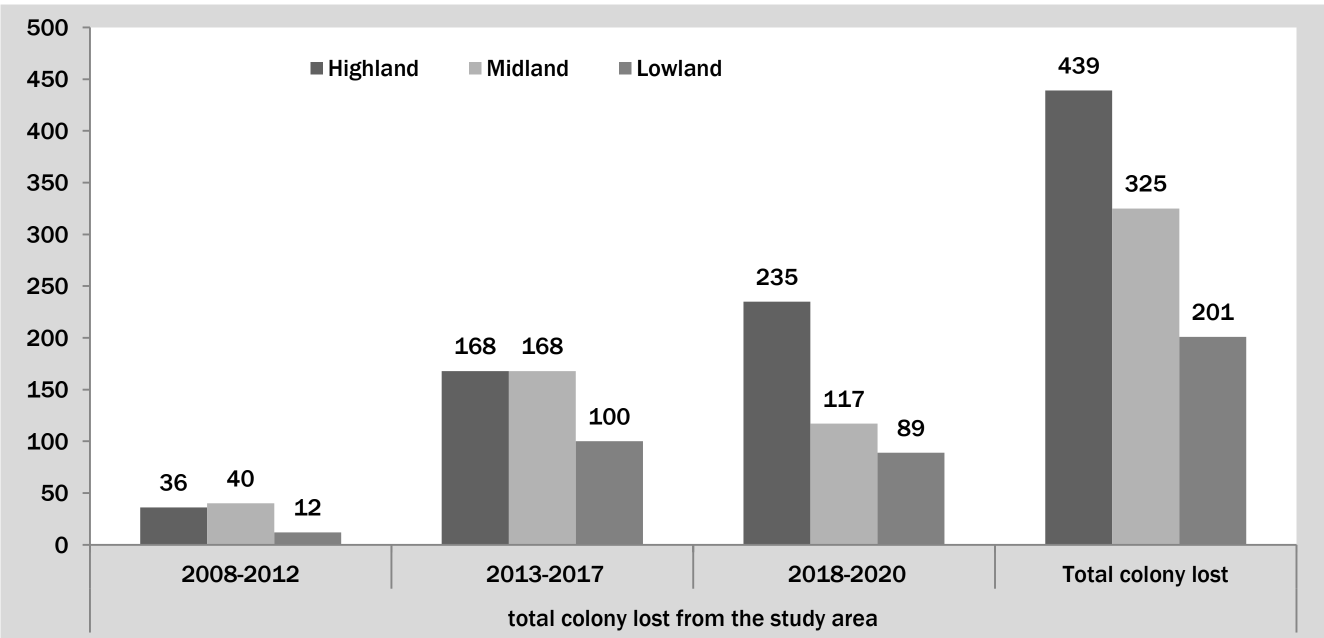

Figure 2 - Lost colonies during different years of production (2008 to 2020)

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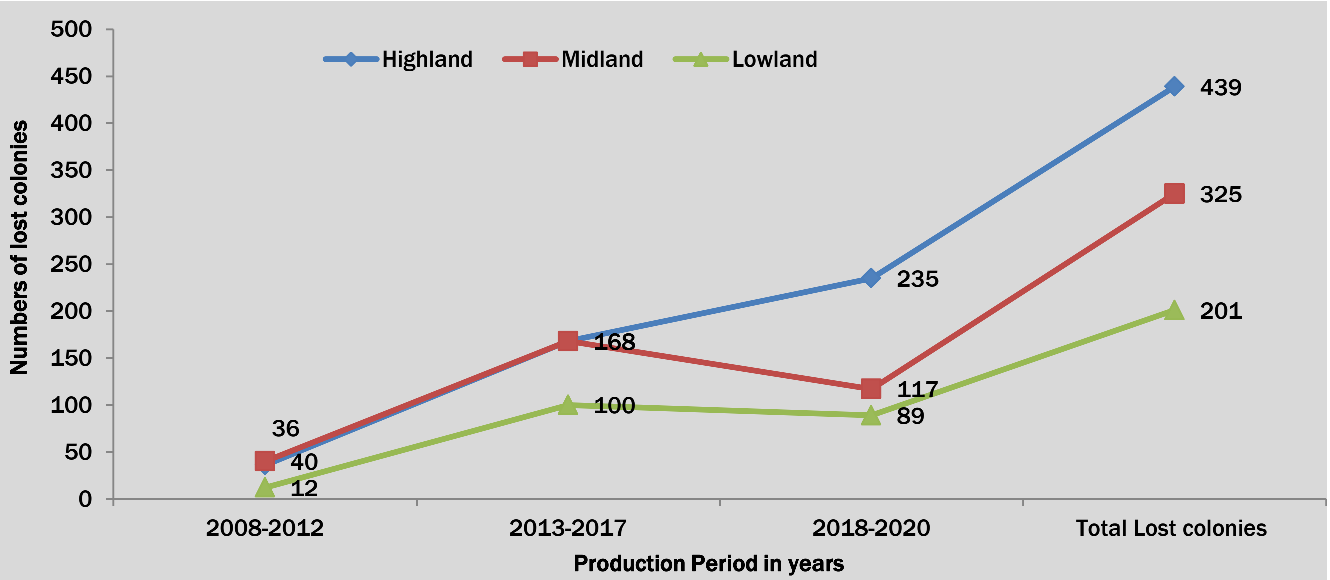

Figure 3 - Trends of colony in the study area

DISCUSSION

In Ethiopia, the Gedeo Zone is well known for its natural forest conservation heritage and agroforestry practices. The zone has a wide range of agricultural climates that are suitable for beekeeping practices. Beekeepers in the Gedeo zone can easily catch swarm bees by hanging bait hives over long tree branches and under their house roofs and rearing bees is the most common method. Catching swarms of bees to start beekeeping is a very common practice in the south and southwest parts of Ethiopia. For instance, beekeepers in Kaffa, Sheka, and Bench-Maji Zones attract honeybees to new and previously used hives by hanging bait hives on the trees (Awraris et al., 2015). Some farmers in the Gedeo Zone get started in the beekeeping business by receiving bees as a gift from their parents. Similarly, different authors noted that beekeeping is a long tradition and an indigenous practice that is passed down from parents to sons in Southwest Ethiopia (Hartmann, 2004) and in the Guji and Borana Zones of Oromia Region (Birhanu, 2016). Unlike in the north and central parts of the country, there is no colony market or queen multiplication center to start beekeeping in the Gedeo zone.

Despite having long beekeeping experiences and traditions, most beekeepers in the study area had been losing a huge number of colonies every year due to a lack of scientific and practical skills and because of many socio-economic reasons. In the last ten years, beekeepers and local government officials have repeatedly reported colony declines in the Gedeo zone. However, little was known about the causes and extent of colony declines. This study indicated major causes of colony decline, the status of the decline, and the types of hives from which most declines occurred in the different agro-climatic zones of the studied areas. Sampled farmers had different ages and educational backgrounds, varied beekeeping experiences, and accessed different levels of extension advice in the highland, midland, and lowland agro-ecologies. For example, sampled respondents in the Highlands were more educated, older in age, had more beekeeping experience, and had more colonies per household than beekeepers in other agro-ecologies. Nonetheless, the total number of colonies lost over time and the number of families affected were higher in the highland agro-ecology. This is clearly revealed by the differences in the extension services provided for beekeepers among various agro-climatic zones and their lack of scientific knowledge and practical skills to manage their colonies. Besides, the majority of cereal crops are grown in the highlands and mid-altitude regions of the zone. All farmers in the studied area practice a crop-livestock mixed farming system; in fact, they apply a varied level of pesticides, insecticides, and fungicides to their crops near their apiary sites. This could have resulted in colony declines, either entirely or partially. This result was in line with the findings of Steinhauer et al. (2018) and Dolezal et al. (2019) that hives bounded by more cultivated land result in higher colony declines. According to Tesfaye et al. (2017), pesticide and herbicide application is the leading cause of colony decline in the Bale Zone of Southeast Ethiopia. The colony declines in the lowlands were lower than those in the highlands and mid-altitudes. This is because of better extension service provision for beekeepers and less intensity of agrochemical application, hence better management of their colonies. This finding is consistent with Rasa (2020) and Markos and Samuel (2021), who stated that beekeepers who were more frequently visited by extension workers managed their colonies better and adopted improved hive technologies.

The study conducted elsewhere speculated whether a combination of the stressors, including mites, disease, and nutritional stress, are interacting to weaken bee colonies and allowing stress-related pathogens such as fungi, thus causing a final collapse (Kluser, 2007). Colony mortality can be caused by a number of interrelated factors, such as the unavailability of forage (Decourtye et al., 2010), pesticide exposure (Zhu et al., 2014), problems associated with the ectoparasitic mite, Varroa destructor (Neumann and Carreck, 2010), other pests, parasites, and diseases (Berthoud et al., 2010), as well as various socioeconomic factors (Gallai et al., 2009).

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The current study identified two main causes of colony declines in the Gedeo zone: colony management-related factors and natural factors. Management-related factors such as lack of seasonal colony inspection, feeding, swarm control, unwise use of agrochemicals, and poor honey harvesting techniques are the most responsible contributors for colony decline in the Gedeo zone. Nearly half of the sampled beekeepers, for example, did not perform hive inspections during active or dearth seasons, nor did they provide supplementary feed during dearth season. Consequently, the colonies weakened due to frequent swarming during the active season and pests and predators attacking in all seasons. Farmers are unable to control reproductive swarming by adding supers, removing old and black combs that are not used by worker bees, and controlling pests and enemies that compete for comb space, such as wax moths (*Galleria mellonella*). The common honey harvesting practice in the studied area was the complete destruction of brood and honeycombs in all types of hives. Finally, due to a lack of food reserves during the scarce periods, such poor management practices resulted in colony absconding. Pathogens, parasites, environmental pressures, and bee management stresses such as insufficient feeding were the focus of the earliest scientific investigation into the potential causes of colony collapse disorder (van Engelsdorp et al., 2008). The study conducted by Kumsa and Takele (2014) at Jimma Zone revealed that high absconding rates are characteristics of poor bee management practices (absence of supplementary feed during dearth periods, cleaning, and inspection).

Among natural factors identified as major causes of colony declines, beekeepers ranked the factors based on the relative index of importance from very worst to least worst. Pests and predators (such as wax moths, small hive beetles, large hive beetles, and termites) were ranked in the first position by causing the highest colony declines in the study area. Ants were the colony's second-largest destroyers, trailing only the combined damage of other pests (wax moths and small hive beetles) and predators (lizards). According to Gidey et al., (2012), honey bee pests and predators include ants, insects, spiders, monkeys, snakes, and lizards; the wax moth (*Galleria mellonella*); bee-eater birds; bee lice (*Braula coecal*); honey badgers (*Mellivora capensis);* and small hive beetles. Inherent behaviors of honeybees (absconding and swarming tendencies), shortage of bee flora, and the presence of poisonous plants were ranked third to fifth, respectively, in the study areas. Numerous studies (Workneh and Ranjithan 2011, Kinati et al., 2012, Assemu et al., 2013, and Kenesa, 2018) performed in different regions of Ethiopia noted that pest, predator, and disease incidence, shortage of flora, drought, and deforestation are major factors for colony absconding and migration. However, other factors that were ranked from six to ten had a relatively smaller contribution to colony declines in the study area. This finding is consistent with Teklu (2016), who stated that pests and predators are major challenges in the Sidama and Gedeo zones of the selected districts.

The colony declines showed increasing trends from 2008 to 2020 in the highlands and from 2008 to 2017 in the mid- and lowlands. The reason for this increase may be the increased use of farm inputs such as agrochemicals and clearing forestland for food crop production. Agrochemical applications have been dramatically increased in Ethiopia to improve crop productivity (Nigatu et al., 2016). However, they have a negative effect on the honeybees and other pollinators (Fikadu, 2020). On the other hand, even if there was a slight decline in the trends of colony declines between 2018 and 2020 in the mid- and low-land areas, the number of families reporting colony declines increased in all agro-ecologies from 2008 to 2020. In a similar way, several authors (Oldroyd, 2007; EFSA, 2008; Van Engelsdorp, 2008) have reported unexpected and alarming colony declines in various parts of the world over the last few years. Numerous variables, including beekeeping techniques, temperatures, human activities, the genetic makeup of honey bees, enemies, forage shortages, and others, can be implicated in the variations of colony declines among different regions (Le et al., 2010; Büchler et al., 2014; Goulson et al., 2015).

Traditional hives accounted for more than half of colony declines, especially in mid- and highland agro-ecologies. This is due to the smaller size of local hives, their design, and their inability to protect bees from the rain, sun, heat, and enemies. Internal hive inspection and other colony management practices are not common in traditional beekeeping (Gebremedhn, 2015). One of the factors driving colony declines in the current study is a lack of colony inspection. Traditional hives, which were suspended from long trees in the forest or in the backyard, were only visited when beekeepers anticipated honey harvesting during an active season. The studies conducted in the southwest parts of the country revealed that traditional hives were more affected by disease and pests (Solomon et al., 2021). The same authors concluded that Nosema *apis* disease prevalence was most pronounced in highland agro-ecology (Abi, 2017; Bizuayehu Ayele et al., 2020). On the other hand, some of the surveyed beekeepers believe that colony declines can happen in any type of hive due to many reasons (Stokstad, 2007; Stanimirović et al., 2019). Disorganization, depopulation, and mortality of honeybee colonies are caused by a variety of environmental variables, including nutritional imbalances and pathogen infections (Dolezal and Toth, 2018). Despite the fact that the declines were lowest in the frame and transitional (Kenyan to bar) hives compared to traditional hives in the Gedeo zone, this finding is also in agreement with Solomon et al., (2021).

CONCLUSION

This study identified two major sources of colony declines in the Gedeo zone: one resulting from poor colony management practices and the other from natural factors. High absconding and swarming rates, a lack of internal and external colony (hive) inspection during active and dearth seasons, a lack of supplementary feeding during the dearth period, and the indiscriminate application of agricultural chemicals were identified as major management-related factors causing colony

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decline in the study area. Among natural factors, pests and predators, like wax moths, and small hive beetles(together) were take the first rank followed by ants, the inherent behavior of honeybees (absconding), a shortage of bee flora, and the presence of poisoning plants were the top five challenges that are causing colony declines. Whereas disease was not an important issue in the study area, it was ranked last of all constraints leading the colonies to decline. The traditional hive is one of the most commonly reported hive types, and colony declines frequently occur. In general, colony declines and the number of beekeepers dealing with these issues is increasing in all agro-ecologies. Therefore, we strongly advise educating beekeepers about practical scientific methods of colony management. Even though the respondent ranks the disease as least constrained, conducting laboratory examinations to test the prevalence of diseases would bring additional information regarding colony losses. We also suggest local governments widely disseminate improved hive technologies to avoid the limitations of traditional hives associated with their dimensions and designs.

DECLARATIONS

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Authors' contributions

A. Diriba: design and acquisition of data, analysis and interpretation of data; and write up

M. Fisaha: acquisition of data, drafting the article, revising; and approval

D. Andualem: analysis and final approval of the version to be published

Competing interest

There is no potential conflict of interest between the authors.

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