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Parasitic mite, *Varroa* species (Parasitiformes: Varroidae) infesting the colonies of African honeybees, *Apis mellifera scutellata* (Hymenoptera: Apididae) in Tanzania

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ABSTRACT
Assessment of parasitic mites (*Varroa spp*) infesting the colonies of African honeybees (*Apis mellifera scutellata*) was conducted in 25 districts of Tanzania mainland from August, 2010 - May, 2012. The research investigated the occurrence, prevalence and examined diagnostic features of *Varroa* mite's infestation in colonies. Purposive sampling was used in each district; three apiaries and hives were randomly selected for inspection. Interviews, direct observation and experimental set up were the main data collection techniques used to gather the information. The results revealed the presence of *Varroa* mites in honeybee in 23 (92%) out of 25 studied districts. Out of 175 inspected honeybee colonies, 85 (48%) were found infected with mites. Infestation levels showed significant relationship with changing altitudes, being highest (219 mite count) at altitudes ranging between 1201 and 1500 m a.s.l. The study showed that bee colonies were performing well probably that the African honeybees is adaptive and co-exist with the mites. Authorities are advised to come up with an urgent monitoring programme to determine mite infestation levels and its effects to honeybee colonies in the managed and feral colonies.

Keywords: Varroa mites (*Varroa destructor*, *Varroa jacobsoni*), Honeybee (*Apis mellifera scutellata*), mites distribution, Tanzania.

1. Introduction

The *Varroa* mite is a parasite with the most pronounced economic impact on beekeeping industry (Bailey, 1968; [29] It is a major pest of the honeybee, spreads very quickly and causes serious damage to its host colonies where it reproduces inside the capped brood cells, protected from most acaricides [19, 29, 23]. The *Varroa* mite is therefore, if not controlled, a serious threat to the beekeeping industry in Tanzania. This parasitic mite may decimate the feral bee population that provide free pollination services to farmers; this requires a coordinated response that will address multiple needs [24, 5, 15, 11, 16].

The genus *Varroa* is the only genus in family Varroidae and currently is made of only four species namely *Varroa jacobsoni* Oudemans, which was firstly described to infest Asian bee *Apis cerana*, *Varroa underwoodi* found in *Apis cerana* in Nepal, *Varroa rinderi* found to infest *Apis koschevnikivi* from Borneo and *Varroa destructor* which was described to parasitize *Apis cerana* and *Apis mellifera* and also was once known as *Varroa jacobsoni* until 2000 [7, 14].

The *Varroa* mite (Fig. 1) is an external parasite of brood and adult honeybees. The size of adult female mite "*Varroa destructor*" varies, measuring 1.05 to 1.2 mm in length and 1.5 to 1.6 mm width (about the size of a pinhead), large, easily seen by the unaided eye, reddish-brown sclerotised cuticle, flattened, oval-shaped, and has eight legs [27, 17, 26, 4, 28].

Male adult *Varroa* mites are relatively smaller in size as compared to female mites; about 0.7 mm length by 0.7 mm width, pale or light tan-coloured, usually present only in capped broods before they die as mites copulate with an adult female while inside brood cell [17, 26]. Adult female mites cling between the body segments of adult bees where they pierce the inter-segmental membrane (thorax, head or between overlapping segments of the abdomen) and feed on the blood (haemolymph). In this situation they are partly hidden and not easily seen, feeding on both pupae and adult bees [27, 17, 26]. Mature female mites lay eggs on the bottom of cells or directly onto bee

Fig 1: An adult *Varroa* mite (courtesy of Ramadhan *et al*., 2008)

larvae shortly before the brood cell is capped. The life cycle of *Varroa* mites is spent inside sealed brood cells, feeding on the developing bee's larvae, with a preference for drone pupae at the edge of the brood nest before they come out to be transferred to another host as the honeybees emerge [26].

The *Varroa* mite (*Varroa destructor*), (Anderson and Trueman) is a native parasite of the Asian honeybee and was originally found only in Asia [8, 9, 12, 25, 4]. The mite, *Varroa destructor,* is one of the most destructive pests of the honeybee, *Apis mellifera mellifera* in the United States, first reported in North America in 1987 [8, 4] in United Kingdom (UK) in 1992. The first incidence of the presence of *Varroa* mite (*Varroa destructor*) was reported in Tanzania in 2005 [22] and later by [13]. It is not precisely known as to how *Varroa* mites spread so rapidly but it is known how mites can disperse from bees to bees, colony to colony and long range distances in a number of ways; (1) movement of honey bee colonies, (2) normal apiary manipulations, and, (3) through drifting bees [27, 17, 4].

2. Materials and methods

2.1 Study area

The study was conducted in 25 districts (Fig. 2) from thirteen regions namely; Arumeru, Monduli (Arusha Region), Babati, Hanang (Manyara Region), Bagamoyo, Kibaha, Pangani (Coast Region), Handeni, Lushoto (Tanga Region), Kibondo, Kigoma Rural, Uvinza (Kigoma Region), Kondoa (Dodoma Region), Ludewa, Makete (Njombe Region), Kilombero (Mororgoro Region), Manyoni (Singida Region), Mpanda, Mlele, Nsimbo (Katavi Region), Same, Siha (Kilimanjaro Region), Sikonge, Uyui, Urambo (Tabora Region). Tanzania covers an area of about 945,000 sq. km. of which the total land area is about 888,600 sq. km (URT, 2006). The country is situated between latitudes 01º00' and 11º36' S and longitudes 29º02' and 40º29' E (Baker and Baker, 2002). Tanzania's forests and woodlands cover 33.5 million hectares, or about 40% of its land area (Mugasha *et al*., [21] 2004; IUCN, 2011). The main vegetation types include Afro alpine heath and moorland, forests, woodlands and grasslands, bushlands, thickets, swamps, mangroves and man-made forests. Tanzania contains a range of geographical altitude from 0 m. a.s.l., in Indian Ocean to the Africa's highest point Mount Kilimanjaro at 5,895 m.a.s.l. Tanzania has a tropical climate. In the highlands, temperatures range between 10 and 20 ºC (50 and 68 °F) during cold and hot seasons respectively. The rest of the country has temperatures rarely falling lower than 20 °C (68 °F). The hottest period extends between November and February (25-31 °C/77-87.8 °F) while the coldest period occurs between May and August (15-20 °C/59-68 °F). Baker and Baker (2002) reported that, rainfall ranges between 2,500 mm to 350 mm per annum. The south has a unimodal rainfall from (November to May), the northern areas has bimodal rainfall (two peaks), (October - November and March - April).

2.2 Sampling design

Purposive sampling was used to select the studied Districts (Fig. 2). Simple random sampling was used in the selection of apiaries and honeybee colonies for inspection. In each District, three apiaries were randomly selected and from each apiary a maximum of three bee hives were randomly selected and examined for mites' presence.

2.2.1 Interviews

Beekeepers were interviewed by the use of check list of questions on different aspects such as number of hives per apiary, type of bee hives, number of harvesting seasons and honeybee pests and predators being encountered.

2.2.2 Direct observation

Varroa mites were identified and recorded the number on the surface of the combs, inside the comb cells, on the body of bees and on the walls of the hive during hive operations. The colony strength was assessed based on coverage of bees on top of the frames/bars, the percentage coverage on the surface of the combs, the amount of food stored and the brood pattern. All locations were monitored, geographically located and referenced for their position and altitudes using Global Positioning System (GPS).

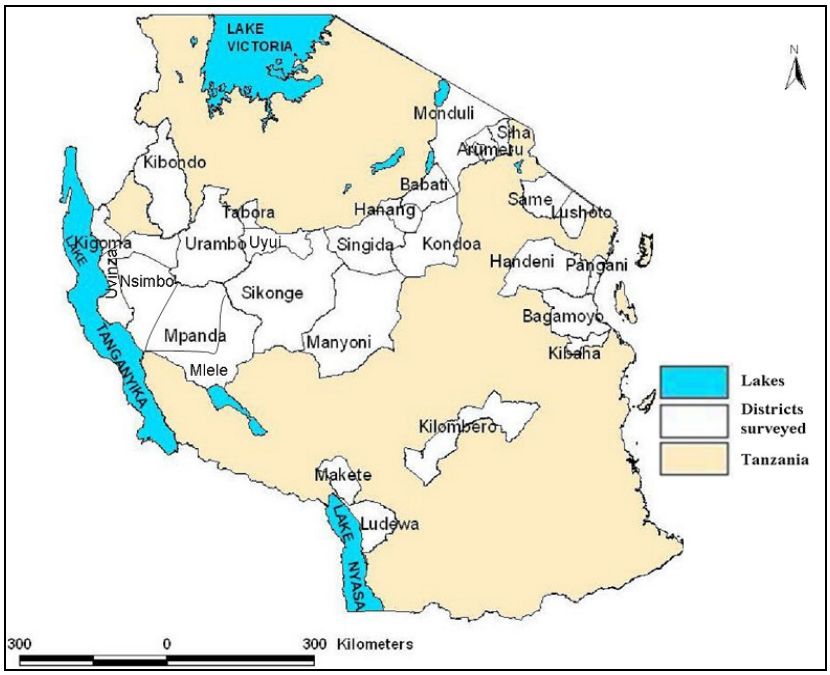

Fig 2: Map showing districts surveyed on *Varroa* mites prevalence in Tanzania

2.2.3 Experimental design (Powdered Sugar Roll Method)

The Powdered Sugar (Shake) Roll Method was adopted during this study as described by [9, 18, 17, 4, 23]. The method is considered superior over the other methods of Roll (e.g. Ether roll) since it separates up to 90% of the mites from bees [18, 17, 23] In a selected bee hive, bees were concentrated at the centre where selected brood combs were located. Using bee brush, the bees were concentrated in the bucket, and then about 100 to 200 bees were scooped and put into a wide mouth jar which later covered with a piece of wire mesh screen. Care was taken to make sure that, the queen was not taken during this exercise. Two tablespoons of powdered sugar were added into the jar through the mesh screen. The jar was rolled side to side repeatedly after every few minutes to distribute the sugar over all the bees. Five minutes later, the sugar was poured and mites dislodged through the mesh screen onto a white cloth. The mites were separated from sugar by sifting the sugar through the cloth, leaving the mites on the cloth surface (Figure 3, Plates a, b, c). Furthermore, the mites were counted and collected before the bees were released back to their original hive.

Fig 3: (Plate a). Mites inspection and colony evaluation process, (Plate b). *Varroa* mites screening on white cloth, (Plate c). *Varroa* mites as black spots on a piece of white cloth after sifting powdered sugar.

2.3. Data analysis

Data collected were summarized and analysed by using Microsoft Excel computer software and the results presented in percentages, tables and charts formats.

3. Results

3.1 Inspected honey bee colonies in studied Districts

A total of 175 colonies were inspected in 25 surveyed districts of Tanzania mainland from May 2010 to March 2011 (Table 1). There were different types of hives being used by the beekeepers; namely Langstroth Hive, Tanzania Top Bar Hive, Tanzania Commercial Hive, Log Hive and Bark Hive (Figure 4, Plates a, b, c).

Table 1: Number of inspected bee colonies and *Varroa* mites collected per district.

District surveyed	Number of honeybee colonies inspected	Number of infected colonies	Number of *Varroa* mites
Kondoa	9	5	44
Manyoni	7	6	41
Hanang	9	6	22
Lushoto	9	0	0
Handeni	9	0	0
Same	9	3	9
Arumeru	9	6	39
Siha	9	5	16
Monduli	4	1	2
Babati	9	2	7
Uyui	7	6	97
Urambo	8	5	32
Sikonge	7	4	76
Mlele	3	3	20
Nsimbo	3	3	7
Mpanda	3	1	1
Uvinza	3	2	7
Kigoma Rural	3	1	12
Kibondo	9	4	37
Makete	9	4	11
Ludewa	9	7	52
Kilombero	9	5	41
Kibaha	7	1	11
Bagamoyo	6	1	3
Pangani	6	3	3
	175	**84 (48%)**	**590**

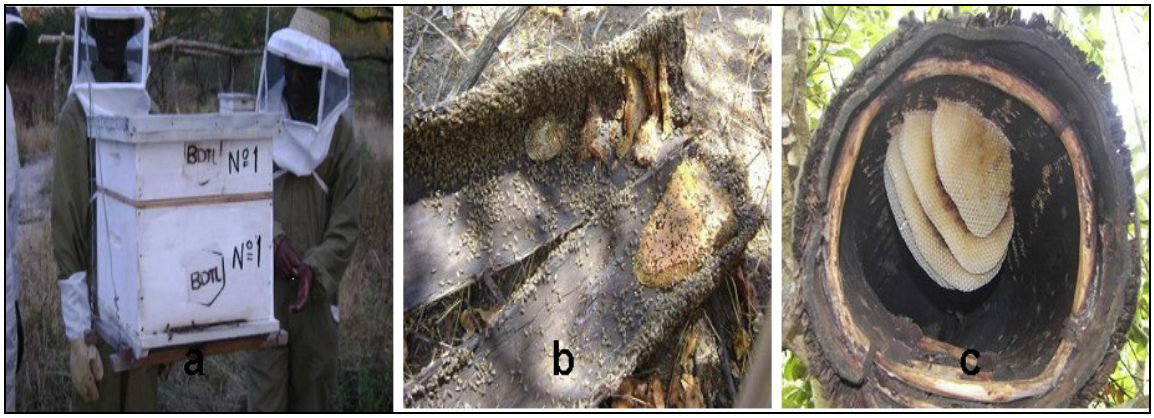

Fig 4: Plates (a) Langstroth hive (b) A split log hive (c) Bark hive with very few combs

3.2 *Varroa* mite infestation in the studied Districts

The results showed that, 23 (92%) districts had positive mites' infestation indicating a wide spread in many areas of the country where beekeeping is in-practice. Only 2 (8%) districts namely Lushoto and Handeni were not detected (Table 1, Figure 5). A total of 590 *Varroa* mites were collected from 84 (48%) infested bee colonies out of 175 (100%) sampled honeybee colonies (Table 1). This gives an average infestation level of 3 mites per colony.

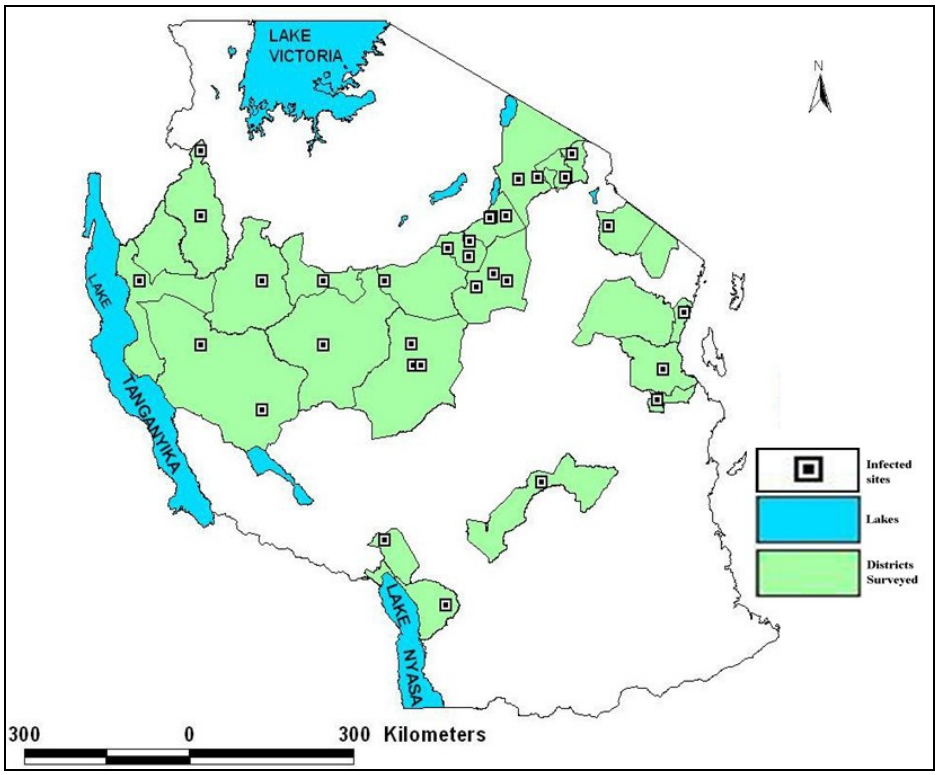

Fig 5: Map of Tanzania showing areas infested with *Varroa* mite

The highest mites count was 39 in a single bee colony in Sikonge District followed by 35 mites in Uyui District and 33 mites in Kilombero District. The lowest mites count was 1 mite per hive in Arumeru, Hanang, Kilombero, Ludewa, Makete Manyoni, Nsimbo, Pangani, Siha and Uvinza Districts (Table 1). The results revealed an uneven distribution of mites among districts. The highest mites count was observed in Kondoa (44), Manyoni (41) and Arumeru District (39) which give an average of 4 mites per bee colony in average (Figure 6, Table 2).

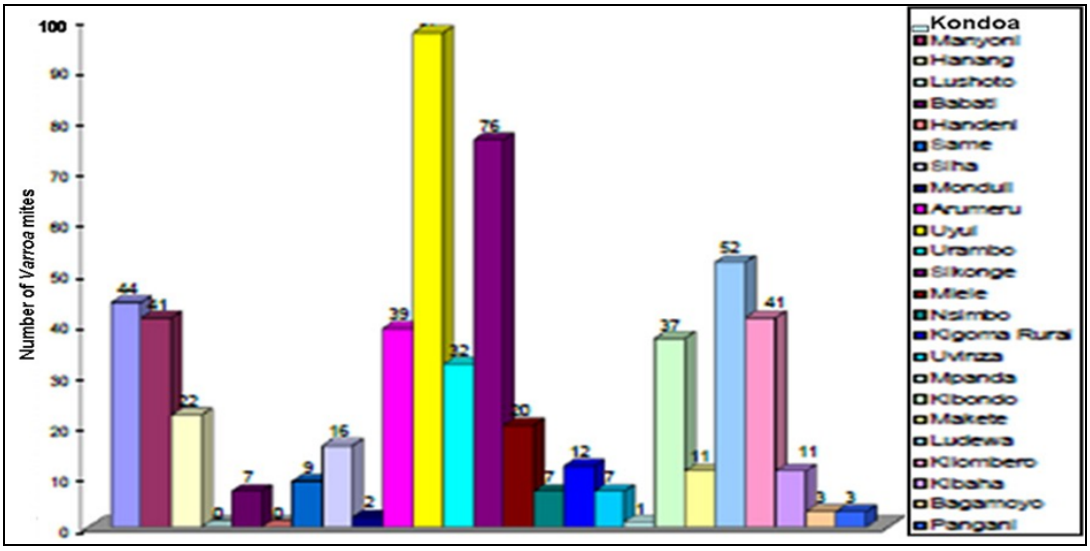

Fig 6: Mite counts in surveyed districts

Observing the mites load with altitudes, this study also revealed a significant relationship between mites count in honey bee colonies at different elevations. There was relatively higher mites count in areas with altitudes between 900 and 1800 m a.s.l as compared to areas with altitudes below 900 and above 1800 m a.s.l (Figure 7a, b).

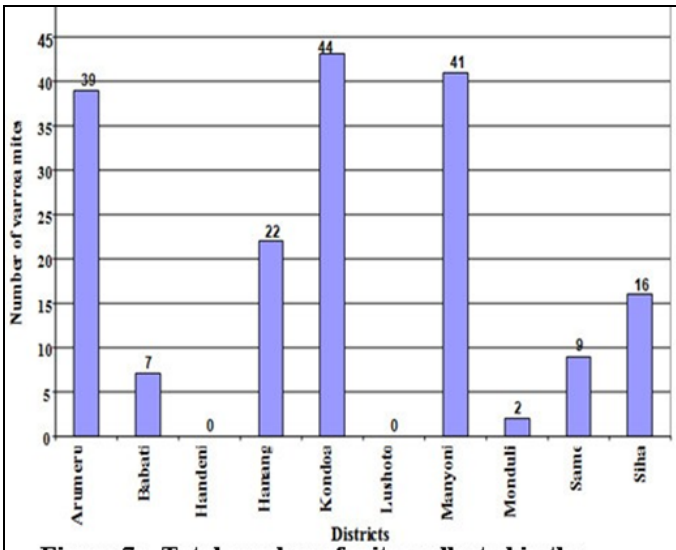

Figure 7a. Total number of mites collected in the selected districts

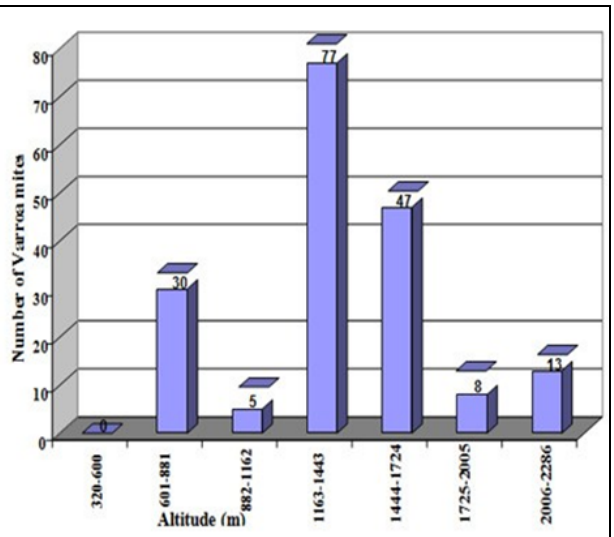

Figure 7b. Relative distribution or mites count in relation to altitude

Table 2: Mites infestation levels at various altitudes and vegetation types in the surveyed Districts

S/N	District	Altitude (m) a.s.l.	Vegetation type	Total number of mites collected
1	Kondoa	1146 - 1365	Acacia woodland, Mixed forest	44
2	Manyoni	867 - 1568	Thickets, mixed forest, miombo woodland	41
3	Hanang	1446 - 2042	Bushland, Farmland, Mixed forest, Sub-montane forest	22
4	Lushoto	1387 - 1473	Sub-montane forest	0
5	Babati	1521 - 1629	Sub-montane forest, farmland	7
6	Handeni	327 - 707	Acacia-Commiphora	0
7	Same	641 - 913	Savanna grassland, Riverine forest	9
8	Siha	1607 - 1673	Natural forest	16
9	Monduli	1315 - 1329	Scattered wooded grassland	2
10	Arumeru	1036 - 1324	Mixed forest, Scattered woodland	39
11	Uyui	1187 - 1248	Miombo woodland, Acacia	97
12	Urambo	1082 - 1139	Miombo woodland, plantation forest	32
13	Sikonge	1110 - 1215	Miombo woodland	76
14	Mlele	1110 - 1463	Miombo woodland	13
15	Nsimbo	1034	Miombo woodland	7
16	Kigoma Rural	797 - 1215	Miombo woodland	12
17	Uvinza	1016	Miombo woodland	1
18	Mpanda	1215	Miombo woodland	7
19	Kibondo	1242 - 1317	Miombo woodland	37
20	Makete	1707 - 2406	Miombo woodland, Sub-montane forest	11
21	Ludewa	1317 - 1759	Miombo woodland	52
22	Kilombero	271 - 315	Mixed forest, Miombo woodland	41
23	Kibaha	124 - 154	Plantation forest, Miombo woodland	11
24	Bagamoyo	38 - 212	Mixed forest	3
25	Pangani	78	Mangrove forest	3
			Total number of mites collected	**590**

3.3 The effects of Varroa mites in honeybees *Apis mellifera*

In the honeybee colonies examined during this research, 84 (48%) colonies were infested with *Varroa* mites (Table 1). However, none of these hives showed any significant ill conditions due to the mite's invasion despite of the poor management by beekeepers observed in most of the apiaries surveyed. Some of the infested bee colonies were weak, moderate and others strong with no noticeable clinical signs due to infestation of this serious honeybee pest (Figure 8). The same results were reported by [13] study in East African countries including Tanzania.

Table 3: Distribution of other honeybee pests in 25 surveyed districts

S. N	Districts surveyed	Other honeybee pests and predators											
		Hive beetles	Wax moths	Bee lice	Bee pirate	Squirrels	Ants	Honey badgers	Birds	Wasps	Rats	Lizards	Snakes
1	Kondoa	+	+	+	+	-	-	+	-	-	-	-	-
2	Manyoni	+	-	-	-	-	-	-	-	-	-	-	-
3	Hanang	-	-	-	-	-	+	-	-	-	-	-	-
4	Lushoto	+	-	-	-	-	+	-	-	-	-	-	-
5	Handeni	+	+	-	+	-	+	-	-	-	-	-	-
6	Same	+	-	-	-	+	+	+	+	-	-	-	-
7	Arumeru	+	-	-	+	-	+	-	-	+	-	-	-
8	Siha	+	-	-	-	-	+	-	-	-	-	-	-
9	Monduli	-	-	-	-	-	+	-	-	-	+	-	-
10	Babati	-	-	-	-	-	+	-	-	-	-	-	-
11	Uyui	+	-	-	+	-	+	-	+	-	-	+	-
12	Urambo	+	+	-	-	-	-	-	-	-	-	+	-
13	Sikonge	+	+	-	-	-	+	-	-	-	+	+	-
14	Mlele	+	+	-	-	-	-	-	-	-	-	-	-
15	Nsimbo	-	-	-	-	-	-	-	-	+	-	-	-
16	Mpanda	+	-	-	-	-	-	-	-	-	-	-	-
17	Uvinza	+	-	-	-	-	-	-	-	-	-	-	-
18	Kigoma(R)	+	-	-	-	-	-	-	-	-	-	-	-
19	Kibondo	+	+	+	-	-	-	-	-	-	-	-	-
20	Makete	-	-	-	-	-	+	+	-	-	-	-	-
21	Ludewa	+	+	-	-	+	+	+	-	-	-	-	-
22	Kilombero	-	-	-	-	-	+	-	-	-	-	-	-
23	Kibaha	+	+	-	+	-	+	-	-	-	+	+	-
24	Bagamoyo	+	+	-	+	-	-	-	-	-	-	+	+
25	Pangani	+	+	-	-	-	-	-	-	-	-	-	-
	Frequency	**19**	**10**	**2**	**6**	**2**	**14**	**4**	**2**	**2**	**3**	**5**	**1**
	Percentage (%)	**76**	**40**	**8**	**24**	**8**	**56**	**16**	**8**	**8**	**12**	**20**	**4**

* (+) indicates presence of the pest, (-) absence of the respective pest in the surveyed area

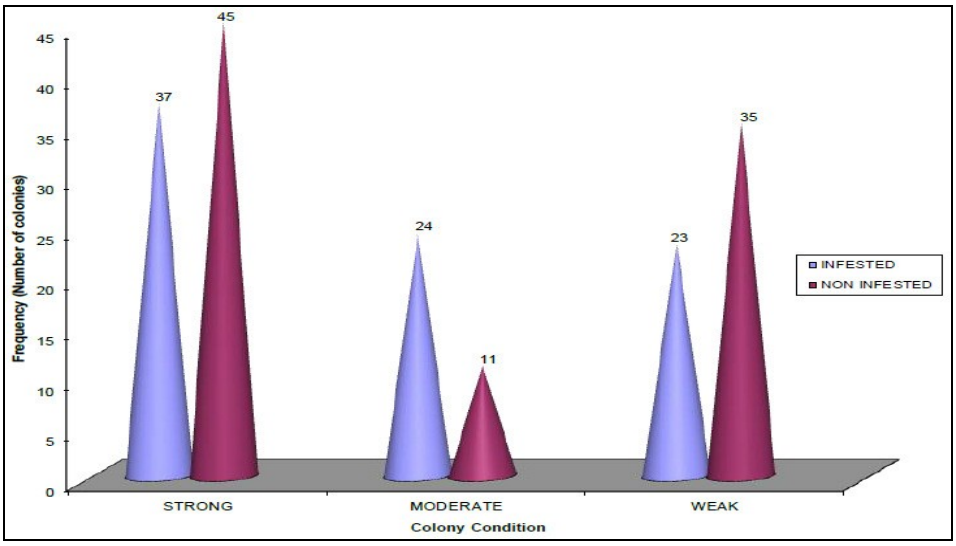

Fig 8: Status of honeybee colonies in surveyed site

3.4 Other bee pests and predators
The majority of the hives inspected had ants and beetles as common pests (Table 3). Other pests encountered were bee pirates, wasps, wax moths and honey badger. Some of the hives were heavily infected with these pests showing that, visits to the hives by beekeepers were very infrequent, a situation experienced in most apiaries sampled. It is therefore true that, beekeeping in terms of time devoted competes with other activities such as crop cultivation, hunting and fishing. This is because nearly all beekeepers were also farmers. This was supported by Clauss, (1991) in Zambia who reported that time spend on beekeeping is limited principally by other demands. This makes it difficult to apply optimal management to the preparation and maintenance of both stocked and non stocked hives, a situation which may impose a great risk to the colonies infested with *Varroa* mites [23].

4. Discussion
Generally, the study revealed that *Varroa* mite has spread in many areas of the studied districts in Tanzania. This shows tremendous infestation behaviour of mites (*Varroa spp*) since they were not obstructed by variations in vegetation type, climatic conditions, and elevation of an area. Mites were found in honeybee colonies in almost all these diverse ecological and geographical conditions with slight variation in mite infestation levels.

The survey on the mites was conducted during the end of honey flow season in most of the areas. A major unanticipated outcome from this study revealed that honeybee colonies were found performing well with stored food and very few brood combs for most of the bee hives sampled. Though, most of the beekeepers in the surveyed areas were neither aware of the mite's presence nor observed any negative impact on the survival and/or productivity of their bees, some beekeepers reported poor stocking rates to their hives in recent years, a situation associated with decline in population of feral bee colonies in their areas.

Despite the fact that, the mites have been found in 23 districts, the mites count per colony seems to be low as compared with other countries. In the UK researchers encouraged to keep the *Varroa* population below about 1000 mites; above this level the risk of damage from the mites, associated pathogens and the effect of feeding on the bees can quickly become very significant. In Europe and parts of the United States higher threshold levels of around 4000-5000 mites are generally used [12].

On the other hand, it is not certain how and when these mites invaded the honeybee colonies of Apis mellifera in the country especially in the districts where mites were found. However, some of the beekeepers interviewed at Barjomot village in Hanang District and Ruvu Darajani village in Same District, reported that, they were familiar with the pest "*Varroa* mite" on its presence in honeybee broods though they had no prior knowledge on its name "*Varroa* mite" or its impacts on honeybees. Many beekeepers reported that they eat broods as their favourite food (not recommended by professional beekeepers); the mites were easily seen on drone broods, which are in-fact the breeding sites for the mites. This might suggest that, certainly, *Varroa* mites have been in the country living with our honeybees for quite some time, but lack of adequate research could be the reason for lack of information about its presence in Tanzania. Likewise this was the case in other countries as reported by Aliano, (2008) and FA0, (2009).

[6] reported that, the differences in the levels and types of bees' viruses and other pathogens present in honeybee colonies and the bees' natural ability to tolerate *Varroa* mites can significantly contribute to the variations in its impacts it causes in honeybee colonies. The impact of the mite *Varroa* destructor is also said to be related to the climatic conditions and the races of Apis mellifera bees in each region where the pest exists [20].

5. Conclusion
Research findings also suggest that, mites' infestation levels can have detrimental effects to the beekeeping industry in Tanzania if proper control measures are not instituted. And its impacts can be noticed within a short period of time depending on the mites load. There is need to conduct thorough research on the impact of the parasitic mites on honeybees to obtain baseline data that will lead to their control. The management authorities; Forestry and Beekeeping Division and Tanzania Forest Service under the Ministry of Natural Resources and Tourism should come up with an effective *Varroa* mite monitoring system for detection and control.

6. Acknowledgement
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