Biting ant, *Tetramorium aculeatum* (Hymnoptera: Formicidae) Responses to Food Lures and Poison Baits on Coffee, *Coffea arabica* Tree

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Abstract

Colony composition of biting ant, *Tetramorium aculeatum*, attractiveness of food lures and suitable insecticides for poison baiting were studied. Five coffee plants in cross diagonal line were randomly selected and number of nests recorded per canopy stratum. Colony composition was determined from one active nest on each of the randomly selected plants. Chopped beef, beef fat, mutton, sheep tail-fat, peanut butter and margarine (Remia®) were assessed for their attraction of the biting ant. The efficacy of poisoned bait prepared by mixing six different insecticides with chopped mutton was evaluated. Mean number of biting ant nests with active colony per plant ranged from 1 to 7, 0.4 to 7, and 0.5 to 1 in the upper, middle and lower canopy, respectively. The corresponding mean number of abandoned biting ant nests was 0 to 3, 0 to 1 and 0 to 1. On the average an active biting ant nest had a range of 0 to 10, 0 to 56, 9 to 68, 28 to 108, and 0 to 3 eggs, larvae, pupae, workers and queen/ king per nest, respectively. Mutton attracted significantly more number of biting ants (468 ants/ tree) than any of the tested food lures followed by sheep tail fat (271 ants/tree). Lower number of ants (10 ants/tree) were lured by Margarine, beef and beef fat. The average number of biting ants died in a poison bait varied between zero and 30 per tree. Mutton poisoned with carbaryl 85wp killed significantly more number of biting ants (30 ants/tree) than the other insecticides.

Introduction

Ethiopia is one of the top coffee, *Coffea arabica* producer countries and accounts about 4.2% of the world's coffee production (Waller *et al.* 2007). It produces coffee as forest, semi-forest, garden and intensive coffee production system. However, the average national yield is less than 5q/ha (Anteneh *et al.* 2008).

Review of insect pests attacking Ethiopian coffee is found in Million and Baysa (1985), Esayas *et al.* (2008) and Esayas *et al.* (2009). According to these authors about 47 different species of insect pests were recorded on coffee, but only antestia bugs (*Antestiopsis intricata* and *A. facetoides*) and coffee blotch miner (*Leucoptera caffeina*) have been considered as major insect pests of coffee particularly in intensive coffee production systems. Although Million and Baysa (1985) did not specify the species, they indicated the existence of nuisance

ants in Mizan Teferi area in southwestern Ethiopia. Recently, however, Tebkew *et al.* (2011) reported two arboreal ant species viz. the biting ant (*Tetramorium aculeatum)* and the weaver (trailing) ant (*Oecophylla longinoda)* at Bebeka and Tepi coffee plantations in southwestern Ethiopia. These ants were also recorded on coffee and other crops in some parts of Africa particularly in Congo, Tanzania and Uganda (de Pury 1968; Hill 1975). Both species do not cause direct damage to the coffee plant but because of their severe bite, workers refuse to undertake management practices like coffee berry picking and pruning in ant infested farms.

Adult of *T. aculeatum* is about 5 mm long, and despite the common name the biting ants does not bite, rather it stings which results in skin irritation lasting for several hours to days (McNutt 1963). The biting ant does not attend scale insects (McNutt 1963) whereas the weaver ant does (de Pury 1968). *T. aculeatum* makes nests with felted vegetable scrapings placed on the underside of leaf or sandwiched between two leaves (Leston 1973).

The insecticide malathion is recommended for frequent and large scale spraying of coffee against biting ant (McNutt 1963; Hill 1975). However, spraying such broad spectrum insecticides would disturb the semi-permanent coffee ecology and can have adverse effect on coffee flavor (McNutt 1963). Under such circumstances use of food lures for mass trapping or targeted insecticide application such as poison bait is a preferred method. Vanderwoude et al. (2010), for instance, used baits to eradicate the arboreal ant *Wasmannia auropunctata* in Hawaii. Food lures are natural chemical substances present in many plant or animal hosts that direct the insect pest towards suitable site for feeding and one of their principal uses is for trapping insects and poison bait preparation (Metcalf and Metcalf 1982). The objectives of this study were to generate information on the colony composition of biting ant, assess the attractiveness of some food lures to and identify suitable insecticide for poison bait making against biting ant.

Materials and Methods

Nest number and colony composition

The study was conducted in July 2010 at Bebeka Coffee Plantation, Bebeka, southwestern Ethiopia. In each farm approximately 20*20 sample trees (which is equivalent to 400 trees; the spacing between trees is about 1.5 to 2m) were selected at four different sampling sites each spaced at least 20m apart. From each 20*20 sample trees five sub-sample plants in a cross diagonal line were selected at random. Canopy of each tree was divided in to three approximately equal sections and labeled as upper, middle and lower. The total number of ant nests, nests with colony, and nest without colony in each canopy section was counted and recorded. One nest with colony per plant (replicated five times) was randomly sampled to determine the colony composition and the number of eggs, larvae, pupae, adults and reproductive forms. Observation on aggression was made by mixing ants from different nests on same tree, adjacent neighboring coffee tree or ground dwelling ants. Shade trees, volunteer tree crops and alley crops were also inspected for the presence or absence of biting ant nest.

Food lure evaluation

The trial was conducted on coffee variety Catimor at Bebeka Coffee Plantation where *T. aculeatum* infestation is severe. Treatments were beef (lean meat), beef fat, mutton, sheep tail fat, peanut butter and margarine (Remia® C. V. Den Dolder, Holland). Exactly 20 g of each food lure was placed in plastic petridishes (9 cm diameter and 1.5 cm depth). For each food lure a group of five trees (a tree was considered as one replication) each with at least five biting ant nests were used. A 'reference tree' with the required number of ant nests was selected and the remaining four trees were selected within 5m radius from this tree. The distance between tree groups was 25 to 30m. A petridish containing a food lure was placed in the upper, middle and lower canopy stratum between 6:00 and 6:30 pm. The petridish was collected early in the morning (between 5:00 and 6:00 am) and put in plastic bag (20 cm * 30 cm) and kept in deep freezer for an hour. The number of ants in each petridish was counted and identified to species

level. T-test was used to compare the difference between any two means.

Poisoned bait screening

The type, concentration, and the amount of insecticide used to make poisoned bait are indicated in Table 1. The mutton was chopped to approximately to 10mm diameter and weighted amount of chopped mutton was mixed with weighted/ measured amount of insecticide. The mutton and the insecticide were thoroughly admixed and the poison bait was used within an hour after preparation. Coffee tree selection, poisoned bait placement, and data collection and analysis procedures were similar to the procedure followed in food lure evaluation. The approximate concentration of an insecticide in a bait ranged from 0.5 to 5% (estimated based on Pearson square method).

Result and Discussion

Nest number and colony composition

The maximum number of biting ant nests was as many as 50 nests per tree. The mean number of biting ant nests with colony per plant ranged from 1 to 7 in the upper, 0.4 to 7 in the middle and 0.5 to 1 in the lower canopy (Table 2). The corresponding mean number of abandoned biting ant nests i.e. nests without colony per plant was 0 to 3, 0 to 1 and 0 to 1. This indicates that the biting ant prefers the upper and middle portion of the tree. Varieties that had open canopy, young and well managed canopy had few number of biting ant nests.

The biting ant dwells on heavily shaded coffee trees and its nest is not destructed by rainstorms. At Bebeka coffee plantation, bisana (*Croton macrostachus*), birbira (*Melletia ferruginea*), ses (*Albizia gummifera*), wanza (*Cordia africana*), *Grevillea robusta*, warka (*Ficus sp*) and several other tree species are used for shading coffee tree. It was observed that although *M. ferruginea*, *G. robusta* and *Ficus sp* harbor biting ant, coffee trees under heavy shade had greater number of biting ant nests than trees under light shade indicating that the intensity of shade is more important in determining coffee infestation by this ant than the contribution of tree specie. The biting ant also dwells on black pepper (*Piper nigrum*), rubber tree (*Hevea brasiliensis*), *Citrus* spp., guava (*Psidium guajava*) and other plant species.

Table 1. Insecticides used for poisoned bait preparation

Trade name of the Insecticide	Common name	Amount of insecticide used (g or ml)	Amount of baiting material (g)	Insecticide concentration in poisoned bait (%)
Ethiolathion 5 dust	Malathion	50	200	1.0
Ethiotrthion 50EC	Fenitrothion	8	200	2.0
Ethiothoate 40EC	Dimethoate	10	200	2.0
Thionex 35 EC	Endosulfan	12	200	2.0
Lamdex 5 EC	Lamdacyhalothrin	20	200	0.5
Ethiozinon 60 EC	Diazinon	19	200	5.0
Sevin 85WP	Carbaryl	13	200	5.0

Table 2. Mean number of biting ant nests per plant in different canopy strata

Farm	Variety	Canopy Type	Upper canopy		Middle canopy		Lower canopy		Sampled plants with ant nest (%)
			Nests with colony	Nests without colony	Nests with colony	Nests without colony	Nests with colony	Nests without colony	
B4	74110	Open	1.92	0.12	1.25	0.04	1.36	0.12	96
D10	7454	Open	2.16	1.80	1.64	1.08	0.84	1.12	72
J14	7454	Open	1.13	0.18	0.42	0.13	0.48	0.06	48
Gacheb	Catimor	Closed	7.16	0.00	6.56	0.0	1.16	2.28	100
H12	7440	Open	3.20	1.00	1.95	0.56	0.65	0.36	50
K9	Mixed*	-	0.84	0.24	1.36	0.24	1.4	0.68	84

* mixture of catimor, 7454 and 75225

The coffee farms Gacheb, B4, and J14 were poorly managed whereas D10, H12 and K9 were well managed. However, the highest proportion of coffee plants infested with biting ant was at Gacheb and lowest at J14 farm. The biting ant had aggregated distribution (Tebkew *et al.* 2011) therefore in well managed farms only parts of the farm with infested trees might have been sampled.

Table 3 shows the number of individuals at different life stage (eggs, larvae, pupae and adult) and castes (worker and reproductive forms) in a colony of biting ant. In most of the sampled nests eggs were absent but in one farm (H12) an average of 15 eggs/nest was found. However, with few exceptions, larvae and pupae were found in all sampled nests but either with or without reproductive forms (queen/ king). Average number of larvae varied between 0 and 56. Larvae were either large or small in size and early larval instars are acephal whereas older ones are cucephal, which suggests that the ant might undergo hyper metamorphosis. Mean number of pupae ranges from 9 to 68. Pupae are exarate form and their size is either small or large. The larger ones might destine to queen or king while the small sized pupae might destine to worker caste. Mean number of workers in a nest with colony varies from 28 to 108. In highly populated colonies the size of the worker ants was always smaller than colonies that were less populated. Mean number of queen/ kings per nest ranges from 0 to 3 (as many as 16 reproductive forms were found in a single nest) showing that a colony in a particular nest may or may not have reproductive forms (queen/ king). Queens and kings are larger in size (about 10mm). Queens dehisce their wing after mating but kings are always winged. The presence of large number of queens and kings in a nest reflects the polygynic nature of the ant or the coming of a swarming season. Moreover, when workers of biting ants from different nests on a single coffee tree or adjacent neighboring coffee trees were mixed, they did not exhibit aggressive behavior such as fighting. However, aggression commenced when they were mixed with ground dwelling ants. A colony of *T. aculeatum* can spread over twelve or more trees (Leston 1973; Mueller *et al.* 2001) and therefore it is polydomous species (Debout *et al.* 2007). Polydomy is the explanation for the lack of aggression when ants from different nests on same coffee tree or immediate neighboring trees are mixed.

Table 3. Colony structure of biting ant in a nest

Farm	Variety	Canopy	Life stage/ Cast				
			Egg	Larva	Pupa	Worker	Queen/king
B4	74110	Upper	0.0	6.0	8.6	87.6	3.4
		Middle	0.0	18.2	12.2	107.5	2.6
		Lower	0.0	11.4	11.4	104.3	2.0
D10	7454	Upper	0.0	21.4	35.8	35.0	0.2
		Middle	0.0	30.4	29.2	42.8	0.8
		Lower	0.0	23.6	36.6	40.6	0.4
J14	7454	Upper	0.0	34.8	42.4	93.2	1.3
		Middle	0.0	35.8	44.6	65.3	0.5
		Lower	0.0	36.0	30.0	82.0	0.5
Gacheb	Catimor	Upper	0.6	32.0	53.8	91.0	1.8
		Middle	1.4	55.8	68.0	88.7	2.0
		Lower	0.0	0.0	16.4	34.4	0.0
H12	7440	Upper	10.4	4.2	11.2	65.4	0.4
		Middle	14.4	10.6	20.0	54.2	0.4
		Lower	15.2	13.6	13.6	28.2	0.2

Food lure evaluation

Pair wise comparison of the six food lures for biting ant attraction revealed that mutton significantly ($p < 0.001$) attracted more biting ants (468 ants/tree) than any of the tested food lures (fig. 1). It was followed by sheep tail fat (271ants/ tree). Margarine, beef and beef fat lured nearly equal number of biting ants. The number of biting ants attracted to peanut butter was on the average less than four ants per tree. In all food lure types only ants from nests closer to the bait station were attracted indicating that the active area within which the food attracts the ant was very narrow and consequently large number of bait stations per tree will be required. The ants do not carry food to their nests and stored food was not found in their nests. Certain fungal mycelium growth was observed inside the nests of biting ants constructed from fine-vegetable debris. Wheeler (1922) noted myceĺia growth bearing fruitification in the nests of this ant specie, although he was not certain whether the fungus is used as ant food or not. However, Mueller et al. (2001 and references cited therein) considers the fungivory habit of *T. aculeatum* as speculation, but they believed that it is predaceous and occasionally honeydew feeder.

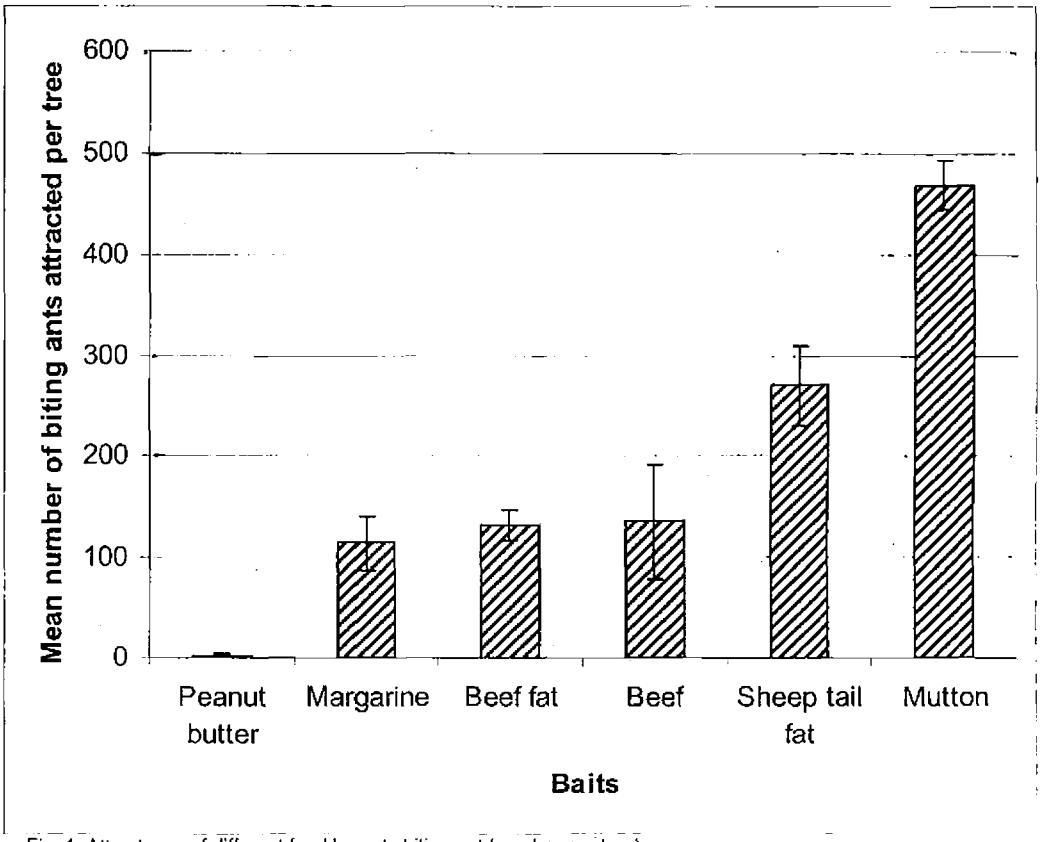

Fig. 1. Attractancy of different food lures to biting ant (number per tree)

Poisoned bait screening

The average number of biting ants that died in poisoned bait varied from zero to 30 per tree (fig. 2). Mutton poisoned with carbaryl 85WP killed significantly ($p < 0.01$) more biting ants per tree than the other insecticides. Thionex 35%EC and ethiotrothion 50%EC killed biting ant equally. Ethiolathion 5% dust did not kill biting ant. It is of offensive smell, which might have repelled the ants. The emulsifiable concentrate formulations didn't change the color of the mutton, but they melted the petridishes. On the other hand, dust or wettable powder forms changed the color of the mutton. As few ants entered the poison bait and died therein, other biting ants attempted to carry the corpse and then restrain themselves from entering to the poison bait. The probable reason why ants restrain themselves from entering the poisoned bait is that victimized individuals might have released certain chemical(s) that warns their live conspecifics. Therefore, the relative attractiveness of carbaryl 85WP poisoned bait was 15 times less than the attractiveness of un-poisoned mutton. When the concentration of carbaryl 85WP in the poisoned bait was reduced to 2%, the average number of biting ants that died was 40.5 on mutton and 23.1 on margarine based baits. This suggests that reducing the concentration of an insecticide to certain level in a poison bait will increase the efficacy of that insecticide. However, since the ant does not carry food and dies before returning to its nest, the use of poisoned bait is not recommendable control method for biting ant in coffee. Nor spraying foliar insecticides is advisable, since spraying will allow other species to assume dominance in the system (Leston 1973; Kenne *et al.* 2003). For instance, Kenne *et al.* (2003) found that spraying insecticide in *Citrus*, guava and mango tree plantations eliminated the dominant arboreal ant and favored ground nesting ant species that tend Hemipteran insects. Moreover, secondary

pest (mainly Hemipteran) outbreak was reported around Mizan Teferi after applying broad spectrum insecticides for the control of ants (Million and Bayisa 1985). Therefore, coffee tree management and sanitary measures such as removing cut offs from the farm, periodical striping of unwanted sucker growths, reducing intensity of shade, stumping old coffee trees and regularly collecting and immersing of ant nests in insecticide is recommended. Destroying nests with long stick enables to destroy broods (eggs, larvae and pupae) but usually the adults especially with queens rebuild the old nest or found new one.

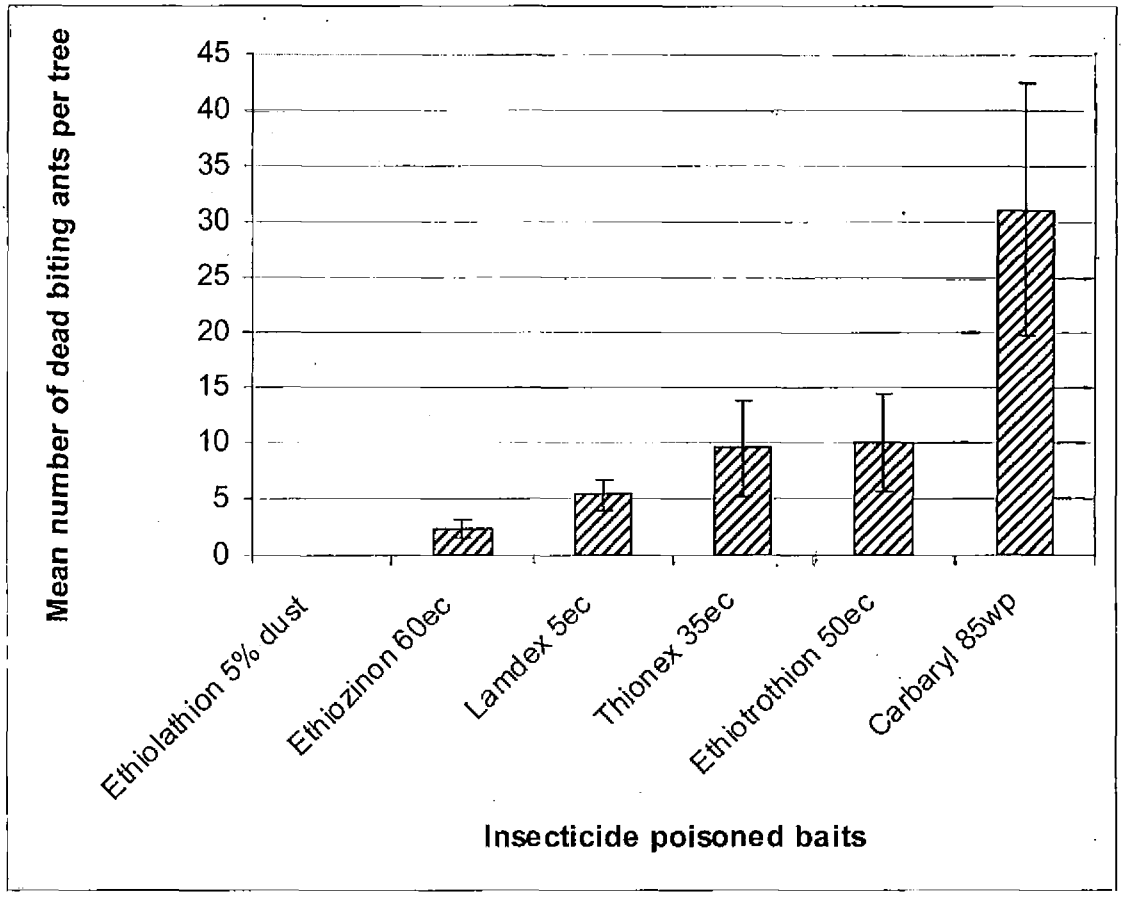

Fig. 2. Mean number of biting ants attracted and died in different poisoned baits

Conclusion

Whether canopy of a coffee variety is closed or open, coffee varieties were equally infested by biting ants and the ant preferred the middle and top portion of the tree. The stage and castes of the biting ants varied from one nest to the other. Although food lures such as mutton attracted large number of biting ants, the active area was very narrow. Moreover, because of the contact mode of action of the insecticides used to make the poison baits, the ants died before they reached their nest-mates and as a consequence nest-mates did not get poisoned food. Therefore, the use of poisoned bait with contact mode of action had no effect in controlling biting ant on coffee tree. Screening other insecticides that attract biting ant; understanding how the biting ants feed their broods, and evaluating the effect of routine coffee tree managements on biting ant incidence are future research areas.

Acknowledgement

We acknowledge crop protection staffs of Bebeka Coffee Plantation for their help during data collection and the Coffee Plantation Development Enterprise for the logistic and financial support.

References

Anteneh Netsere, Taye Kufa, Tesfaye Shimber, Endale Taye and Alemseged Yilma. 2008. Field survival rate, growth and yield response of coffee (*Coffea arabica* L.) to tillage and transplanting techniques. In: *Ethiopian Horticultural Science Society (EHSS), Proceedings of the first conference*. pp. 195-202. 23-24 March, 2006, Addis Ababa, Ethiopia.

Debout, G., Schatz B., Elias M., McKey D. 2007. Polydomy in ants: what we know, what we think we know, and what remains to be done. *Biological Journal of the Linnaean Society* 90: 319–348.

de Pury JMS. 1968. Crop pests of East Africa. Oxford University Press, Nairobi. 227pp.

Esayas Mendesil, Million Abebe, Chemeda Abdeta, Mekuria Tadesse. 2008. Coffee insect pest in Ethiopia. In: *Coffee Diversity and Knowledge*. eds. Girma et al. pp. 279-290. Proceedings of a national workshop for decades of coffee research and development in Ethiopia. 14-17 August, 2008, Addis Ababa, Ethiopia

Esayas Mendesil, Million Abebe, Chemeda Abdeta. 2009. Review of research on coffee, tea and spice insect pests in Ethiopia. In: *Increasing crop production through improved plant protection*. Vol. II. ed. Abraham Tadesse. pp. 117-139. Plant Protection Society of Ethiopia (PPSE). PPSE and EIAR, Addis Ababa, Ethiopia.

Hill, DS. 1975. Agricultural insect pest of the tropics and their control. Cambridge University Press, Cambridge. 516pp.

Kenne M, Djiéto-Lordon C, Orivel J, Mony R, Fabre A, Dejean A. 2003. Influence of insecticide treatments on ant-Hemiptera associations in Tropical Plantations. *Journal of Economic Entomology* 96:251-258.

Leston, D. 1973. The ant mosaic- tropical tree crops and the limiting of pests and diseases. *PANS* 19: 311-342.

McNutt, DN. 1963. The control of "biting ants" *Macromischoides aculeatus* Mayr (Formicidae) on Robusta coffee. *East African Agricultural and Forestry Journal* 29:122-124.

Metcalf, RL, Metcalf RA. 1982. Attractants, repellents, and genetic control in pest management. In: *Introduction to insect pest management*. eds. Metcalf RL, Luckmann WH. pp. 273-314. 2nd ed, John Wiley & Sons, New York

Million Abebe, Bayisa Mormene.1985. A review of coffee pest management research in Ethiopia. In: *A review of crop protection research in Ethiopia*. ed. Tsedeke Abate. pp. 163-177. Proceedings of the first Ethiopian Crop Protection Symposium. 4-7 December, 1985, Addis Ababa, Ethiopia.

Mueller, UG, Schultz TR, Currie CR, Adams RMM, Malloch D. 2001. The origin of the Attine ant-fungus mutualism. *The Quarterly Review of Biology* 76:169-197.

Tebkew Damte, Lidet Sitotaw, Mulugeta Negeri, Teferi Gedilu. 2011. Ant problem at Bebeka and Tepi coffee plantations. Paper presented at the third biennial conference of the Ethiopian Horticultural Science Society (EHSS), Jima University, Jima, Ethiopia.

Vanderwoude C, Onuma K, Reimer N. 2010. Eradicating *Wasmannia auropunctata* (Hymenoptera: Formicidae) from Maui, Hawaii: The use of combination treatments to control an arboreal invasive ant. *Proceedings of the Hawaiian Entomological Society* 42: 23-31

Waller JM, Bigger M, Hillocks RJ. 2007. Coffee Pests, Diseases and their Management. CABI, UK. 434pp.

Wheeler, WM. 1922. The ants collected by the American museum Congo expedition. Bulletin of the American Museum of Natural History 45: pp39-269.189 (accessed on internet).