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Rebounding Ability of Weaver Ants, *Oecophylla longinoda* Latreille (Hymenoptera: Formicidae) in Cashew Farming Systems in Tanzania

Wilson Nene[1] and Gration M. Rwegasira[2]

1. Tanzania Agricultural Research Institute-Naliendele, Box 509, Mtwara, Tanzania.
2. Department of Crop Science and Horticulture, Sokoine University of Agriculture, P. O. Box 3005 Chuo Kikuu, Morogoro, Tanzania

Abstract: The African Weaver ant *Oecophylla longinoda* holds a potential of being a vital component in Integrated Pest Management (IPM) programs. However, its exploitation in cashew production systems in Tanzania which relies heavily on the use of synthetic insecticides such as Lambda cyhalothrin for the control of cashew bugs (*Helopeltis* spp.) had been uncertain. This study examined the possibility of *O. longinoda* rebounding back after spraying Lamda cyhalothrin to control insect pests during cashew fruiting season. The population abundance of *O. longinoda* and their predation efficiency on *Helopeltis* spp was determined. The study findings suggest that two to three spraying regimes of the insecticide significantly (P<0.001) reduces *O. longinoda* population abundances. The average *O. longinoda* population declined from a range of 201-500 (average 350.5 insects) per cashew tree to 21-50 (average 35.5 insects) per tree. However, we recorded a quick recovery of *O. longinoda* population of up to >500 insects per tree (score index 5) when favourable conditions were restored immediately after the fruiting season. On predation efficiency, *O. longidoda* significantly (P<0.001) performed equally to Lambda cyhalothrine in reducing *Helopeltis* spp. Thus, under suitable conditions, *O. longinoda* has ability to quickly build up to high populations and adequately suppresses the cashew pests. Conclusively, the present study indicated that, *O. longinoda* as the predator holds great potential in transforming from conventional to organic cashew production system in Tanzania.

Keywords: Cashew, Insecticides, *O. longinoda*, Lambda cyhalothrin, Tanzania.

INTRODUCTION

In Tanzania cashew nuts has replaced tobacco as the leading agricultural cash crop (BOT 2016) and a major source of income for more than 500,000 households (NARI 2017). The crop plays multiple roles which include; being a source of nutritional to both human and live stocks (FAO 2001), reforestation and control of soil erosion (Adeigbe et al. 2015; Davis 1999), preservation of ecosystems, and carbon sequestration (Adjei and Alormu 2020). Production of cashew crop is however, severely constrained by insect pests among others (Nene et al. 2017; Anato et al. 2015). The crop is attacked by over 60 species of insect pests worldwide (FAO 2001). Two species of mirid bugs namely *Helopeltis anacardii* and *Helopeltis schoutedeni* are the most serious pests in Tanzanian cashew farms which causes significantly cashew nuts yield loss of about 60-100 % if they are not properly managed (Sijaona 2013; Nene et al. 2017).

Management of cashew pests has been a challenge for years since there is no single technique that has been found sufficiently and sustainably effective. Pesticide-based control strategy has been a dominant practice in Tanzanian cashew production systems despite its negative consequences associated with the environment and public health (Dix et al 1995; Christian et al. 2008; Hijeck 2004). The cost of purchase is also high (Christian et al. 2008; Ugwe 2020). Synthetic pyrethroids insecticides which contain lambda cyhalothrin or cypermethrin have been in the use by the majority of Tanzanian cashew growers since back in 1990s (NARI 2007). These are nerve poison insecticides that cause paralysis to death of the affected insect (Li-Ming et al. 2008; Beasley and Temple 2013).

Overwhelming side effects of synthetic insecticides such as pyrethroids has pushed the demand for organic produces by many consumers (ICSM 2009). These market forces have influenced farmers' demand for alternative approaches to insect pest control. In recent years, some African cashew growers have attempted the use of weaver ant, *O. longinoda* Latreille (Hymenoptera: Formicidae) in controlling cashew pests (Van Mele 2008). The approach was an emulation of the very successful use of the closely-related weaver ant species, *Oecophylla smaragdina* as biological control agents of more than 60 insect pest species in multiple crops including mirid bugs of cashew (Peng 2001; Peng et al. 2004). However, the intention by farmers to exploit *O. longinoda* in controlling cashew pests has been hampered by the fear of irrational use of synthetic insecticides (Van Mele and Vayssières 2007).

The use of broad-spectrum insecticides kills many of the natural enemies (Van Mele and Cuc 2007; Van Mele 2008). Avoidance of excessive use of organophosphates and synthetic pyrethroids has been suggested because they negatively affect population abundances of beneficial insects (Christian et al. 2008). Like other hymenopterans, *O. longinoda* is susceptible to synthetic pyrethroids such as lambda-cyhalothrin (Johnson et al. 2006; Longley 1995). The work by Christian et al (2008) in Vietnum, found no weaver ant on 15 cashew orchards which were sprayed with insecticides three times or more per year. However, Van Mele and Cuc (2008) indicated a rapid recovery and increased population of weaver ant under favorable environment. Furthermore, the Tanzanian farmers' interest in using *O. longinoda* is hampered by the available standard cashew pests' management protocol that emphasizes on the use of synthetic insecticides (NARI 2007). Information to determine the magnitude in which the currently recommended insecticide-based pest control approach affects *O. longinoda* population and their predatory efficiency has largely remained unknown. Therefore, we conducted this study to determine the effect of synthetic pyrethroid particularly Lambda cyhalothrin insecticides spraying regimes on the population abundance of weaver ants, *O. longinoda* in cashew fields and assessed their predatory efficiency in managing mirid bug particularly *Helopeltis spp* that attacks cashew trees.

MATERIALS AND METHODS

Location

Studies were carried out during the 2009/2010 cashew season and repeated in 2010/2011 season at Naliendele and Masasi (located approximately 150 km apart) in Mtwara Region. Selected experimental sites at Naliendele were; Naliendele1 (040^0 09' 15" E 10^0 22' 40" S, 141 masl), Naliendele2 (040^0 10' 04" E 10^0 20' 55" S, 131 masl), and Naliendele3 (040^0 09' 44" E 10^0 21' 00" S, 109 masl) whereas sites at Masasi included; Mwena1 (039^0 00' 34" E 10^0 31' 26" S, 401 masl), Mwena2 (039^0 00' 25" E 10^0 31' 25" S, 393 masl), and Mwena3 (039^0 00' 17" E 10^0 29' 20" S, 287 masl) (Fig. 1).

Experimental Set-up

Prior to experimentation, a baseline survey was undertaken in May, 2009 to identify the most suitable cashew fields that suited our experimental requirements. Existence of cashew crop naturally colonized by weaver ants and previous record of consistently same insecticide under similar spraying regimes in at least three consecutive seasons prior to experimentation guided the choice of the experimental fields. Considered insecticide type was pyrethroid particularly lambda cyhalothrin, mainly Karate® 5% EC and or her generics such as Ninja 5% EC and Mo-karate®. Insecticides spraying regimes considered in this study were; i) frequent application of insecticides (all cashew trees received three or more rounds of insecticides spray per season), ii) mild or occasional application (received one to two rounds of insecticides per season), and iii) natural (received no insecticides spray throughout the season). Additional criteria for the suitable cashew fields were; a minimum of 40 cashew trees (one and half acre or above) with at least 20 cashew trees (50 %) being colonized by *O. longinoda*, cashew trees had to be free from *O. longinoda* competitor ants such as *Pheidole megacephala* and *Anoplolepis* species. Following these criteria a total of six cashew farms (three cashew farms per location) were selected and similar experimental treatments were set at each location.

Experiments were conducted on actively flushing cashew trees that were approximately at the same growth stage and vigor. Other agronomic practices were done as per standard recommendations (NARI 2007). Each cashew field (which was also considered as block) was divided into three main sections (plots) from which ten trees were selected and tagged for assessments, hence a total of 30 trees per field. Each plot of 10 cashew trees spaced at 12 x 12 m was regarded as a replication. The whole experiment comprised of 180 trees.

In insecticide treatments, all cashew trees were covered with triadimenol (Bayfidan 250 EC®) a fungicide for the control of powdery mildew (*O. anacardii*) as recommended (NARI, 2007). The insecticide was applied as per treatment requirements at a recommended rate of 5 mls Lambda-cyhalothrin per a litre of water per tree (NARI 2007). Insecticide was applied between July and October for each of spraying regime. Maruyama® motorized mist blower (MD155DX) was used for insecticide application and the spraying was done early in the morning between 0600 and 0730hrs.

In the zero (no insecticide) treatment, the fields used belonged to farmers who have been using *O. longinoda* as the only means to control pests in their fields for nearly a decade. Sulphur dust (99 9% Sulphur) was used for the control of powdery mildew (*O. anacardii*). Sulphur is a non-systemic preventive fungicide which has been recommended for the control of Powdery Mildew in organic production systems (Biodiesel 2009).

Data Collection

Weaver Ants' Population Recovery and Effect of Insecticide Regimes

Data for population abundance of *O. longinoda* were collected at two stages as follows; (i) Population recovery; (a) Data collected in May 2009, seven months from last round of insecticide application (as farmers in the studied area stopped for insecticide application in October 2008) and (b) in May 2012, seven months post application of insecticide (October 2011) and (ii) effect of insecticide regimes on weaver ants; data collected during application of insecticide (July 2009 to October, 2011). The abundance of *O. longinoda* was determined according to Stathers (1995). Assessments were done fortnightly on cashew tree trunks and primary branches. Descriptively the score indices for *O. longinoda* were as follows: 0 = No ants; 1 = Few ants (1-20); 2 = Some (21-50); 3 = Many (51-200); 4 = Abundant (201-500); and 5 = Very abundant (>500). The number of visible and live *O. longinoda* nests on the tree canopies was counted to determine colony strength (Stathers 1995).

Population Abundance of *Helopeltis* Insect Pests

Population of *Helopeltis spp*. was determined by walking around the cashew tree canopy and slightly disturbing the branches and leaves by using a long stick (approx. 3 m). It was possible to count the number of observed individual insect because the two species are fewer in number and are not speedy.

Assessment on Damaged and Undamaged Nuts

Damaged and undamaged nut was determined by the use of sampling quadrat of 1 m2. All nuts enclosed within a 1 m2 quadrat were counted from four cardinal points of the tree canopy and recorded. Counting was done at fortnight intervals. Damaged nuts were determined in percentage using the fomular; % Nut damage = total damaged nuts/total number of all nuts within the quadrat x 100.

Data Analysis

All counts data for; Weaver ants population abundance, nests number and Helopeltis species were log transformed using the formula of log (Y+1), where Y is the original data, 1 is a constant number. A constant number was added because there were zeros to some of the data (Alan et al. 2001). Percent nut damage were square root transformed using the formula (Y+0.5), where Y is the original data and 0.5 is a constant number. The data were subjected to Kruskal-Wallis, a non- parametric One-way analysis of variance (ANOVA) test. The analysis was performed by using GenStat (VSN International Ltd). The group-wise Kruskal-Wallis comparison was performed followed by Bonferroni pairwise comparison between treatments by using Analyse-it program.

RESULTS

Weaver ant Population Recovery

We recorded relatively high population abundance of *O. longinoda* in seven months before and after the last round of insecticide application (Table 1).

An average population of 200-500 ants per tree suggesting a score index 4 (abundant) was recorded with a rear record of 512 (very abundant) during the 2012 post experimentation assessment. Colonization ranged from 47 % to 85 %, at Naliendele (N-2 & N-3) and Masasi (M-1) respectively. The average number of weaver ant nests per cashew tree pre and post application of insecticide ranged from 11 to 15. Although the experimental sites at Naliendele had relatively lower percentage colonization compared to Masasi, higher nest numbers per cashew tree were recorded.

Table 1: Pre and post experimentation abundance of *O. longinoda* in experimental fields

Assessment period	Farm site	# of trees assessed	# of colonized trees	Colonized trees (%)	Score index	Number of nests	Nests per tree
May, 2009	N-1	40	25	62.5	4	381	15.24
May, 2009	N-2	40	21	52.5	4	312	14.86
May, 2009	N-3	40	22	55	4	258	11.73
May, 2009	M-1	40	29	72.5	4	389	13.41
May, 2009	M-2	40	24	60	4	321	13.38
May, 2009	M-3	40	23	57.5	4	318	13.83
May, 2012	N-1	40	28	70	4	392	14.00
May, 2012	N-2	40	19	47.5	4	301	15.84
May, 2012	N-3	40	19	47.5	4	277	14.58
May, 2012	M-1	40	34	85	5	514	15.12
May, 2012	M-2	40	25	62.5	4	287	11.48
May, 2012	M-3	40	22	55	4	294	13.36

Fields numbers preceded by letter N are for Naliendele sites and letter M for Masasi sites. 1; unsprayed fields, 2; fields sprayed with two rounds of insecticide per season, and 3; fields sprayed with three rounds of insecticide per season. Score indices: 4=Abundant (201-500), 5=Very abundant (>500) weaver ant count

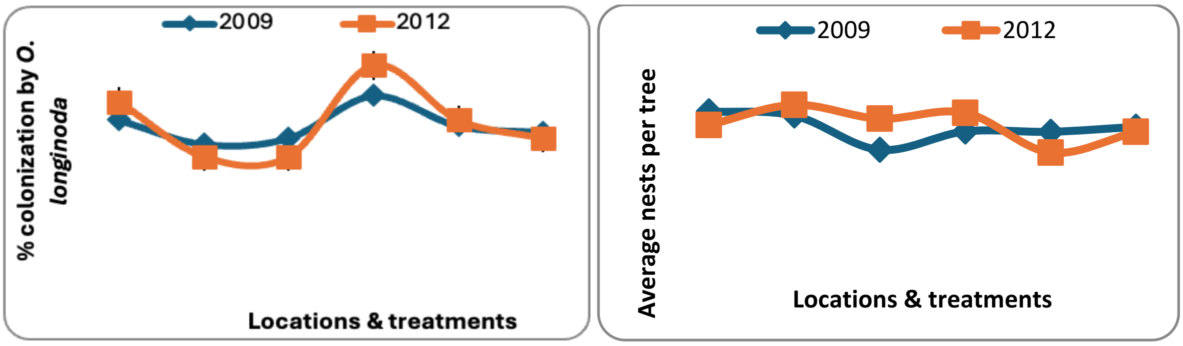
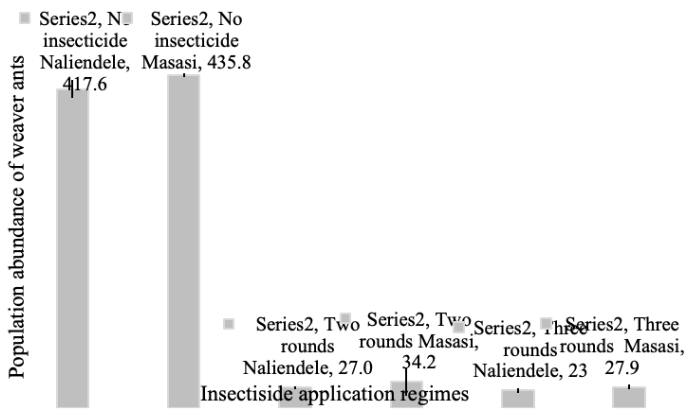


Figure 1: Comparative colonization and nesting of *O. longinoda* during pre and post experimentation at both Naliendele and Masasi sites (N=Naliendele & M=Masasi).

Effect of Spraying Regimes on *O. longinoda* Abundance

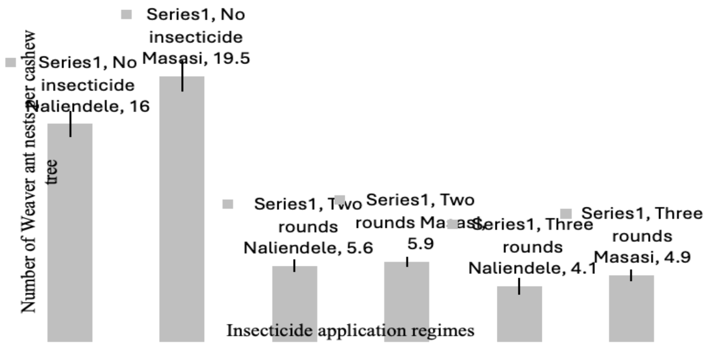
The effect of insecticide spraying regimes on *O. longinoda* was monitored by taking records of weaver ant population throughout the experimentation period (July–April), the period before cashew flowering and post harvesting. The recorded relative estimates of *O. longinoda* population under different insecticide spraying regimes in Masasi and Naliendele sites varied with respect to spray regimes (Fig. 2). Statistically, highly significant variability ($P<0.001$) in *O. longinoda* population was recorded between insecticide sprayed and non-sprayed cashew fields. The impact of insecticide to *O. longinoda* was apparent in all sprayed fields regardless of the spray regimes. Thus, the number of *O. longinoda* was equally suppressed under both two and three insecticide application regimes per season. High population level of *O. longinoda* (score index 4-5) which represents (201-512 insects per tree) was recorded in the fields that were completely not sprayed with insecticides throughout the season. Conversely, the score index 2 which matched (21-50 weaver ants per tree) was recorded in cashew fields which received two to three rounds of insecticide per season.



<u>Figure 2</u>: Abundances of weaver ants under different insecticide application regimes at Nalienele and Masasi sites (Kruskal-Wallis H value=122.6, df 5, x^2 probability <0.001)

Effect of Spraying Regimes on *O. longinoda* Nests

More *O. longinoda* nests counts were recorded in insecticide free treatments than in insecticide sprayed treatments at Masasi and Naliendele sites (Fig. 3). The impact of insecticide spray (regardless of spray regimes) on *O. longinoda* nesting was statistically highly significant (P ≤ 0.001). Nest numbers per tree ranged from 16-20 in non-sprayed treatments compared to 3-5 nests per tree in sprayed treatments.



<u>Figure 3</u>: Number of weaver ant nests under different insecticide application regimes at Nalienele and Masasi sites (Kruscal-wallis: H value 118.2, df 5, x^2 probability <0.001)

Effectiveness of *O. longinnoda* in Controlling *Helopeltis spp*

Table 2 shows mean population abundance of *Helopeltis spp* at Naliendele sites and Masasi-Mwena sites while pair wise comparison between treatments is shown (Table 3). Results suggested that cashew trees initially colonized by *O. longinoda* and thereafter applied with three rounds of insecticides had significantly (P < 0.05) lower counts of *Helopeltis spp.* than trees not colonized by *O. longinoda* and without insecticide application across all sites. There were no significant differences (P < 0.05) observed between trees with *O. longinoda* alone and those which received either two or three rounds of insecticide only. Also the differences observed between trees that received two rounds of insecticide application trees treated with *O. longinoda* as well as trees that received three rounds of applications against trees protected with *O. longinoda* were insignificant. Trees colonized by *O. longinoda* and supplemented with two to three rounds of insecticides had significantly (P<0.05) lower counts of *Helopeltis spp.* than the sole weaver ant treatments. When cashew trees with weaver ant alone were compared to all other treatments (Table 5), the results obtained was similar to Table 4. A highly significant difference (P < 0.05) was observed.

Table 2: Mean population of *Helopeltis spp.* in cashew trees under different treatments

	Location (experimental sites)	
Treatment	**Naliendele**	**Masasi**
Weaver ant alone	0.6123	0.6925
No weaver ants + No insecticide	0.9586	0.9850
2rounds + Weaver ants	0.3798	0.4582
Two rounds of insecticide only	0.6679	0.6179
3rounds + Weaver ants	0.2760	0.4047
3rounds of insecticide only	0.6448	0.6214
Kruskal Wallis H value x^2 statistic	59.65 <0.001	53.70 <0.001

Table 3: *Helopeltis* spp insect counts when cashew trees colonized by weaver ant alone is compared to the rest of the treatments

	Location (experimental sites)	
Treatment	**Naliendele (Probability values)**	**Masasi (Probability values)**
No W.a v W.a	<0.0001	<0.0001
2r with W.a v W.a	<0.0001	<0.0001
2r only v W.a	1.0000	0.4221
3r with W.a v W.a	<0.0001	<0.0001
3r only v W.a	1.0000	0.4849
x^2 statistic	61.05	55.69

Damaged Cashew Nuts

The recorded mean percentages of damaged nuts are presented (Table 4) as well as pair wise comparisons between treatment means (Table 5). Lowest percentage nut damages were recorded where colonization with weaver ants was coupled with two rounds of insecticide application. There were significant differences (P<0.05) in nut damages between weaver ant alone colonized trees and none insecticide sprayed trees (control) across all sites. Trees with weaver ant alone were insignificantly different (P<0.05) from trees applied with two or three rounds of insecticide application only. However, trees with combination of weaver ants and two or three rounds of insecticide had significant lower (P<0.05) percentage nut damage compared to trees with weaver ants only.

<u>Table 4</u>: Mean nut damage on cashew trees colonized by *O. longinoda* under different insecticide application regimes

Treatment	**Location (experimental sites)**	
	Naliendele (% nut damage)	**Masasi (% nut damage)**
Weaver ant only	2.226	2.604
No Weaver ants + No insecticide	3.509	3.811
Two rounds+Weaver ants	0.5741	2.021
Two rounds of insecticide only	2.228	2.942
Three rounds+Weaver ants	0.8532	1.604
Three rounds only	1.717	2.300
Kruskal Wallis H value Chi square P- value	149.4 <0.001	72.97 <0.001

<u>Table 5</u>: Pair wise comparison of percentage nut damage on cashew trees colonized by weaver ants under different insecticide application regimes

Treatment	Location (experimental sites)	
	Naliendele	Masasi
No W.a v W. a	<0.001	0.0006
No W.a v 2r with W.a	<0.001	<0.001
No W.a v 2r only	<0.001	0.0308
No W.a v 3r with W.a	<0.001	<0.001
No W.a v 3r only	<0.001	<0.001
W.a v 2r with W.a	<0.001	0.1284
W.a v 2r only	1.0000	1.0000
W.a v 3r with W.a	<0.001	0.0002
W.a v 3r only	0.5776	1.0000
2r with W.a v 2r only	<0.001	0.0035
2r with W.a v 3r with W.a	1.0000	1.0000
2r with W.a v 3r only	<0.001	1.0000
2r only v 3r with W.a	<0.001	<0.001
2r only v 3r only	0.1197	0.1431
3r with W.a v 3r only	0.0003	0.0664
x^2 statistic	**152.53**	**73.35**

<u>DISCUSSION</u>

This study evaluated the impact of recommended synthetic insecticides particularly pyrethroids containing lambda cyhalothrin on abundance of *O. longinoda* and their predatory efficiency in managing cashew pests particularly *Helopeltis spp*.

The ability of weaver ants to recover after insecticide was an important observation. The baseline data (pre-experimentation stage) in study sites showed that *O. longinoda* was abundant, with population ranging between 201-500 ants per tree. Similar level of *O. longinoda* population was recorded post-experimentation stage. Likewise, higher number of nests ranging between 11 and 16 were recorded seven months pre and post application of insecticide. This high population level of *O. longinoda* suggests their quick recovery after harsh conditions. Van Mele and Cuc (2007) reported on a quick increase of *O. longinoda* numbers under favourable conditions. In the context of this study, quick recovery could be associated with low persistence of synthetic pyrethroids which were applied. The work by Karnatak et al (2008) on persistent toxicity of insecticides on *Brassica campesris* showed that lambda cyhalothrin had toxicity of up to 4 days. Syngenta (2006) reported that Lambda cyhalothrin is not persistent in water and soil.

The effect of insecticide application regimes on *O. longinoda* abundance was apparent. Differences in abundance of *O. longinoda* between non-sprayed and sprayed cashew fields were significant. The number of *O. longinoda* in insecticide sprayed treatments dropped rapidly from score index level 4 (abundant; 201-500 weaver ants per tree) to level 2 (21-50 weaver ants per tree) while population in non-sprayed fields was maintained at level 4. Such rapid drop is associated with toxicity and quick knock down properties of Lambda cyhalothrin via inhalation route (Syngenta 2006). Negative effects of synthetic insecticides on *O. longinoda* have also been reported by other workers (Van Mele and Cuc 2007). Likewise, similar studies on the effects of broad-spectrum insecticides (Organophosphates and Synthetic pyrethroids) on natural enemies have been documented (Van Mele and Cuc 2007; Van Mele 2008) emphasizing on the need to avoid such chemical substances. Reports detailing on the need to avoid toxic chemicals particularly inorganic insecticide in order to maintain the existence of weaver ant in orchard (IITA-CIRAD 2008; Oberg and Ekbom 2006) are available.

Habitat manipulation through limited or less application of insecticides and fungicides for pest control helps conserve the *O. longinoda* (Van Mele and Van Lenteren 2002). Although the use of synthetic insecticides for the control of insect pest lead to the production of more crops (Dix et al. 1995), several concerns on insecticide usage have been registered particularly on the misuse of the products. Many insecticide users (small scale growers) in Tanzania lack adequate knowledge on the insecticide dosages, application techniques and the use of protective gears (Massomo 2019). Total dependency on synthetic insecticides often leads to resurgence, secondary outbreak of pests and development of resistance to the applied insecticide (Hajek 2004). Spraying of broad-spectrum synthetic pyrethroid kills many of the natural enemies triggering outbreak of secondary pests such as aphids, scales and mealybugs (Van Mele and Cuc 2007; Van Mele 2008). Such case of increased aphid flare due to the application of broad-spectrum insecticides to control Potato Tuber Moth caterpillars is a typical example (Horne and Page 2009). Increased incidences of eco-toxicology, acute and accidental poisoning, and strict trade barrier tied to minimal pesticide residues justifies their rampancy and misuse. Lambda-cyhalothrin products are slightly to highly toxic to both terrestrials and aquatic organisms including fish (Syngenta 2006). Lambda cyhalothrin are contact non-systemic stomach poison often preferred in agriculture because of low water solubility and nonvolatile nature which makes them remain effective for longer periods of time (LAMBDA-BIO 2003).

Predatory effectiveness of *O. longinnoda* on cashew insect pests particularly *H. anacardii* was apparent. Based on the ability of *O. longinoda* to reduce population of *H. anacardii*, a significant variation ($P<0.5$) was recorded between colonized cashew trees alone and uncolonized and none sprayed (control) cashew trees. The control (unprotected) plots recorded the highest mean number of *H. anacardii* about 0.9586 (8 pests per tree) and 0.9850 (9 pests per tree) at Naliendele and Masasi respectively. Therefore, in both locations, cashew trees colonized by *O. longinoda* significantly reduced *H. anacardii* population than uncolonized cashew trees. Similar observations were reported by other workers on different weaver ant species, the *O. smaragidina*. Peng et al (1995) observed the decrease of the population of four major cashew insect pests including *Helopeltis pemicialis* due to predatory effect of *O. smaragdina* in Northern Australia. Similarly, Way and Khoo (1989) observed that weaver ants (*O. smaragdina*) protected cocoa trees from damage by *Helopeltis theobromae*. On the other hand, insignificance in *H. anacardii* population was observed between *O. longinoda* colonized cashew trees alone when compared to cashew trees that receive two or three rounds of insecticide alone.

Although it has for long been considered that *O. longinoda* as a biological control agent is incompatible with insecticides application, the present study suggested that the two pest control meausres would work effectively against cashew pests when applied in the correct combination and sequence. Application of *O. longinoda* alone proved to be inferior to a combination of two to three rounds of insecticides with weaver ants as well as the application of insecticides alone in two to three rounds. The fact that *O. longinoda* rebounced back after insecticide application suggests limited insecticide residual affect and uncompromised ability of *O. longinoda* to reclaim their territories. This is contrary to (ICSM 2009) observation that the application and side effects of synthetic insecticides such as pyrethroids poses limitation to practicing organic farming in cashew. As such, the possibility of designing a weaver ant-insecticide IPM strategy against cashew pest could be a viable option. Most interesting is the fact that farmers who have been using insecticides against cashew pests could quickly switch to organic farming to tap on the organic cashew market opportunities.

The cashew nut damages by *Helopeltis* spp in *O. longinoda* colonized cashew trees was lower across all locations compared to the control (uncolonized and none sprayed cashew trees). Likewise, nut damages in trees with *O. longinoda* alone did not differ with trees that had received two or three rounds spray alone. This finding clearly indicates the protective effect of weaver ants in controlling insect pests from causing damage on cashew nuts as reported by other workers. The study by Christian et al (2008) in Vietnum showed that, cashew nuts in plots colonized by weaver ants were cleaner and shiner than those with no weaver ants. Also, Peng et al (1995) observed high nut quality from cashew trees colonized by high number of weaver ant, *O. smaragdina*. Nevertheless, the combination of weaver ants with regimes of insecticide spray was observed to be the best option in controlling insect pests as manifested by low damages on the nuts. The present study revealed that best treatments against cashew pests could be attained with judicious use of insecticides with limited residual effect combines with adequate promotion of *O. longinoda* abundance.

CONCLUSION

Based on the study findings, it is concluded that, initial start with adequate *O. longinoda* population coupled with application of two or three rounds of lambda cyhalothrin at the rate of 5 mls per litre of water per tree as currently recommended in Tanzania significantly reduces the cashew pests. Although insecticide application negatively impacts on *O. longinoda*, the quick recovery ability of the later from the effect of insecticide spray suggest that cashew farmers currently practicing conventional farming by relying on insecticides to manage pests can easily change and accommodate weaver ants as an alternative control strategy. The *O. longinoda's* ability to reduce damages caused by the pest holds a key to the future potential of incorporating the predator in IPM program.

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Statement and Declaration

The content presented in this paper is based on our original research work and findings. Authors express no conflict of interest with any other parties.

Authors' Contribution

WN: Conducted the experiments, collected and analyzed data & wrote the draft manuscript.

GMR: Conceptualized the research idea, solicited funding, confirmed the data analysis, reviewed & proof read the manuscript and submitted the paper for publication.

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