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Farmers' perception of a biological control agent, *Oecophylla longinoda* Latreille (Hymenoptera: Formicidae) and its effects on the quality of citrus fruits in Ghana

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The red weaver ant, *Oecophylla longinoda* Latreille is a predator of many insect pests of tree crops and its presence in orchards is perceived to result in improved fruit quality. This study therefore sought to investigate farmers' perception of *O. longinoda* as a biological control agent for insect pests of citrus and its effect on fruit quality. A questionnaire-based survey was first used to investigate farmers' perception of *O. longinoda* in major citrus growing districts in Ghana. Field and laboratory experiments were also conducted to test the effect of the presence of the weaver ant at different densities on taste [total soluble solids (TSS), total acidity (TA) and juice volume (JV)]. The survey results showed that 56% of farmers regarded weaver ants as pests, while 40% considered them as beneficial insects. Seventy percent observed no difference in taste while 28% observed improvement in taste. With respect to fruit appearance, 42% of the respondents said *O. longinoda* had no effect on appearance while 50% reckoned that it negatively affected the appearance of citrus. Laboratory analyses of citrus fruits showed that *O. longinoda* had no significant effect on fruit qualities. The implications of these findings on the acceptance of *O. longinoda* by farmers and suggestions for overcoming the challenges of accepting this biological control agent are discussed.

Key words: Farmers' perception, predator, *Oecophylla longinoda,* orange, fruit quality.

INTRODUCTION

Weaver ants (Hymenoptera: Formicidae) are arboreal and build woven leaf nests in canopies of trees and shrubs (Offenberg, 2015; Crozier et al., 2010). Only two species are currently known and these are *Oecophylla longinoda* Latreille, 1802 and *O. smaragdina* Fabricius, 1775 (Bolton et al., 2007). In terms of habitat ranges, the former occurs across equitorial Africa and the latter in Sri Lanka and much of India through Indo-China and southern China to the Indomalayan region, northern Australia and Melanesia (Cole and Jones, 1948).

These weaver ants are important biological control agents for the management of over 40 tropical insect pests in plantations and forestry (Peng et al., 1995; Van Mele et al., 2007; Van Mele 2008). For example, Bharti and Silla (2011) found that mango and citrus trees with *O. smaragdina* nests, respectively produced 18 and 20% higher yields than those without the nest due to the predatory activity of this ant. A study in Tanzania showed that, shoot damage by mirid (*Helopeltis* sp. Signoret, 1858) decreased from 33 to 6.2% and nut damage by coreid bugs (*Pseudotheraptus wayi* Brown) decreased from 23.5 to 4.3% in cashew trees with *O. longinoda* compared to those without the insect (Olutu et al., 2013). In Ghana, *O. longinoda* was reported to prey on mirids and shield bugs, which are major pests of cocoa and on the cashew mosquito bug *Helopeltis schoutedeni* (Reuter) (Leston, 1973; Owusu-Manu, 1975; Dwomoh et al., 2009).

Apart from benefits derived from their predatory activities, *Oecophylla* sp. are thought to be associated with improved fruit quality. This is because of the absence of pesticide residues in fruits harvested from trees protected with *Oecophylla* sp. (Van Mele et al., 2007). A survey in Mekong Delta of Vietnam also found the presence of *Oecophylla* sp. on citrus trees to be associated with increase external shine, juiciness and overall appeal of its fruits (Barzman et al., 1996).

The numerous successful studies demonstrating the efficacy of *O. longinoda* and *O. smaragdina* for pest management suggests a need to promote its incorporation into pest management strategies for economically important tree crops such as citrus in Ghana. This is because citrus production is beset with important insect pests such as fruit flies, citrus aphids, psyllids, whiteflies, black flies, leaf miners, scales and mites (Kilalo et al., 2009), most of which are predated upon by *O. longinoda.* To achieve this goal, this study sought to assess farmers' current knowledge and perception of this insect as a biological control agent and to investigate the effects its presence in orchards may have on fruit quality. This will ensure that extension packages are tailored to meet the knowledge needs of Ghanaian farmers, thereby speeding up the adoption and integration of *O. longinoda* into current pests' management programmes.

MATERIALS AND METHODS

Farmers' perception of *O. longinoda*

A questionnaire-based field survey was conducted in the Eastern and Central Regions of Ghana from August, 2009 to January, 2010. Two of the major orange growing districts in these regions were selected for the survey. The selected districts were Kwaebibirem and West Akim in the Eastern region and Abora-Aseibu-Kwamankese and Mfantsiman in the Central region. In each district, four orange growing communities were selected and 10 orange farmers were interviewed in each community. A total of 160 citrus farmers were interviewed. Data collected from the questionnaire interviews included, farmers' perception of *O. longinoda* as a biological control agent, methods used by this ant to control insect pests, examples of insects predated upon by the ant and its role in citrus fruit quality. Focus group discussions were also held with farmers within the study area from February to April, 2010. There were 11 group discussions and each group consisted of 6 to 12 farmers. The discussions focused on the perceived benefits of *O. longinoda* to farmers and its effect on fruit quality.

Fruit quality

An experiment to test the effect of *O. longinoda* at different nests densities on the quality of citrus fruits was conducted in a Late Valencia Citrus block at the Agricultural Research Centre (now Forest and Horticultural Crops Research Centre), Kade. The treatments comprised 4 different *O. longinoda* nest densities and a control arranged in a randomized complete block design. There were four replications of each treatment. The *O. longinoda* used for the trial were transferred from an existing colony established at the research centre in 2007 for research purposes. Nest transfers were done at the time of flower initiation to ensure the establishment of *O. longinoda* colonies on the plots before fruits mature. The treatments tested were: A = 1 to 5 ant nests per tree, B = 6 to 10 ant nests per tree, C = 11 to 15 ant nests per tree, D = more than 15 ant nests per tree and E= no ant nest in trees (control).

Measurement of fruit quality parameters

Twenty fruits (that is, 5 per treatment per replication) were picked randomly from each treatment and squeezed to extract their juice. The procedures outlined by Ladaniya (2008) were then used to determine the total soluble solids and total acidity in the laboratory

Juice volume (JV)

Five fruits from each treatment and replication were peeled and the juice manually squeezed into a beaker. The juice was filtered into another beaker to remove fruit particles after which its volume was measured. The juice volume was calculated using the formula:

$$\text{Juice volume (\%)} = \frac{\text{Juice volume}}{\text{Fruit weight}} \times 100$$

Brix and total soluble solids (TSS)

The brix and TSS were measured by pipetting 5 ml of the pure juice onto an absolutely dry refractometer prism. Readings for both brix and TSS were taken directly at an angle of 20°.

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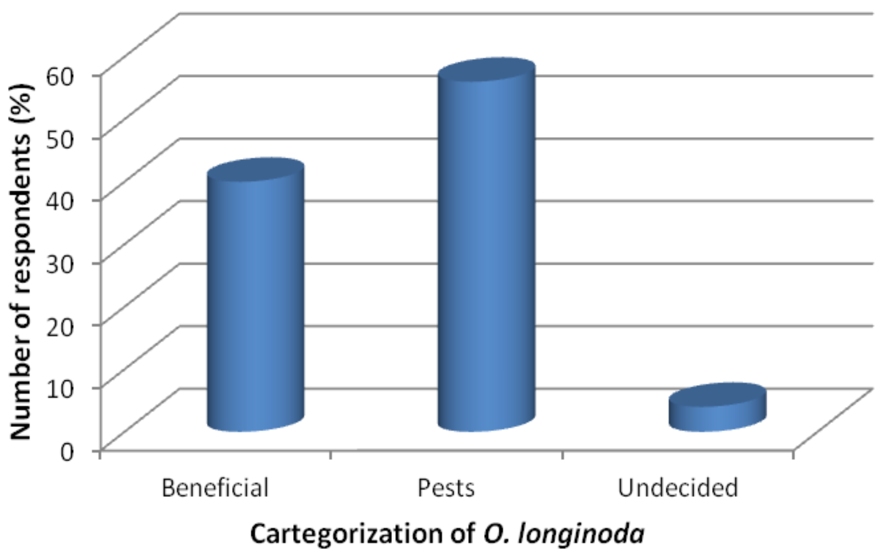

Figure 1. Classification of the status of *O. longinoda* in orchards by farmers.

Total acidity (TA)

Samples of juice (25 ml) were pipetted into a 250 ml beaker followed by adding 225 ml of distilled water and stirring. Diluted juice (50 ml) from each treatment and replication were then titrated against 0.1 M NaOH. The volume of 0.1 M NaOH was required to neutralize the acid in the juice was recorded. The formula used to calculate the total acidity was adopted from Ruck (1969).

Data analysis

Statistical package for social sciences (SPSS) 16 was used to summarize the data generated with questionnaire. Analysis of variance was performed on the data from the fruit quality analysis using the statistical package GenStat Release 9.2 edition. All statistical tests were conducted at 5% level of significance and the means were separated using Fisher's protected least significant difference ($P < 0.05$).

RESULTS

Farmers' perception of *O. longinoda*

The majority of the 160 respondents (56%) considered *O. longinoda* as pests, while 40% referred to them as beneficial insects. The rest (4%) were undecided (Figure 1). Of those respondents who considered *O. longinoda* as pests, 92% of them regarded it as a pest because of its nuisance and 12% indicated that the nests of *O. longinoda* reduced photosynthesis and fruit set. Some respondents (3%) indicated that *O. longinoda* destroyed the flowers of citrus. Out of the 64 respondents who considered *O. longinoda* as a beneficial insect, 71% regarded it as a predator and 3% said it was a pollinator. Other respondents (12%) attributed the beneficial activity of *O. longinoda* to its ability to prevent fruit theft and snakes from inhabiting their orchard. Also, 14% of the respondents indicated that the presence of *O. longinoda* improved yield. Further, 70% of respondents did not notice any difference between the taste of fruits harvested from citrus trees with or without *O. longinoda*. Of the remaining respondents, 28% indicated that *O. longinoda* improved the taste of the citrus fruit and the remaining 2% said it reduced fruit taste (Figure 2).

Farmers' perceptions of the effect of the presence of *O. longinoda* on the appearance of citrus fruits were varied. Fifty percent of respondents indicated that the appearance of fruits from trees with *O. longinoda* was not nice. However, 42% of the respondents said the appearance of their fruits was not affected by the presence of *O. longinoda*. Only 8% of the respondents observed improvements in the appearance of citrus fruits (Figure 3). Most respondents (95%) did not observe any difference between the volume of juice from trees with and without *O. longinoda* but 4% of respondents observed an increase in juice volume (Figure 4). *O. longinoda* was perceived as a biological control agent for insect pests of citrus by 40% of the respondents but the rest of the respondents had not observed this insect controlling insect pest in their orchards. Insects that respondents observed as being controlled by *O. longinoda* included fruit flies (Diptera), moths (Lepidoptera), grasshoppers/crickets (Orthoptera), aphids (Hemiptera), other ants (Hymenoptera) and mirids (Heteroptera). The methods by which *O. longinoda* controlled insect pests included direct predation (52% of

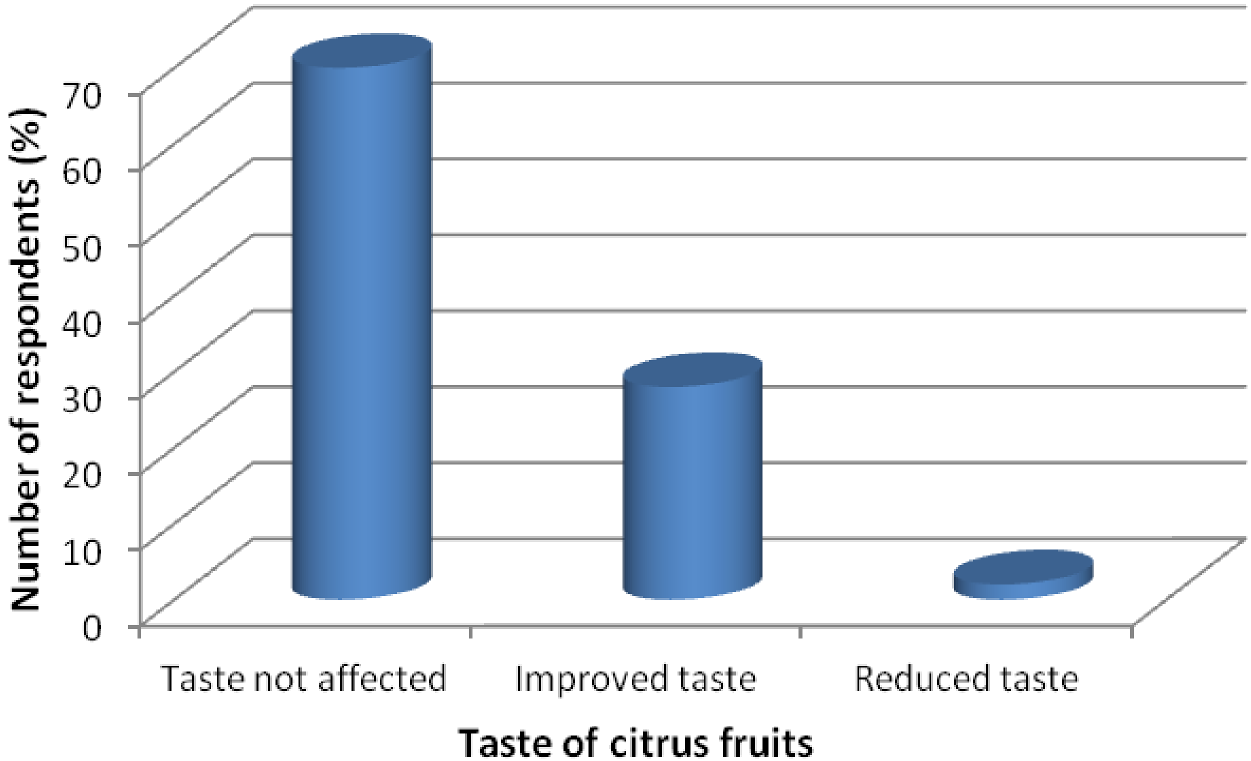

Figure 2. Perception of farmers' on the effect of *O. longinoda* on the taste of citrus fruits.

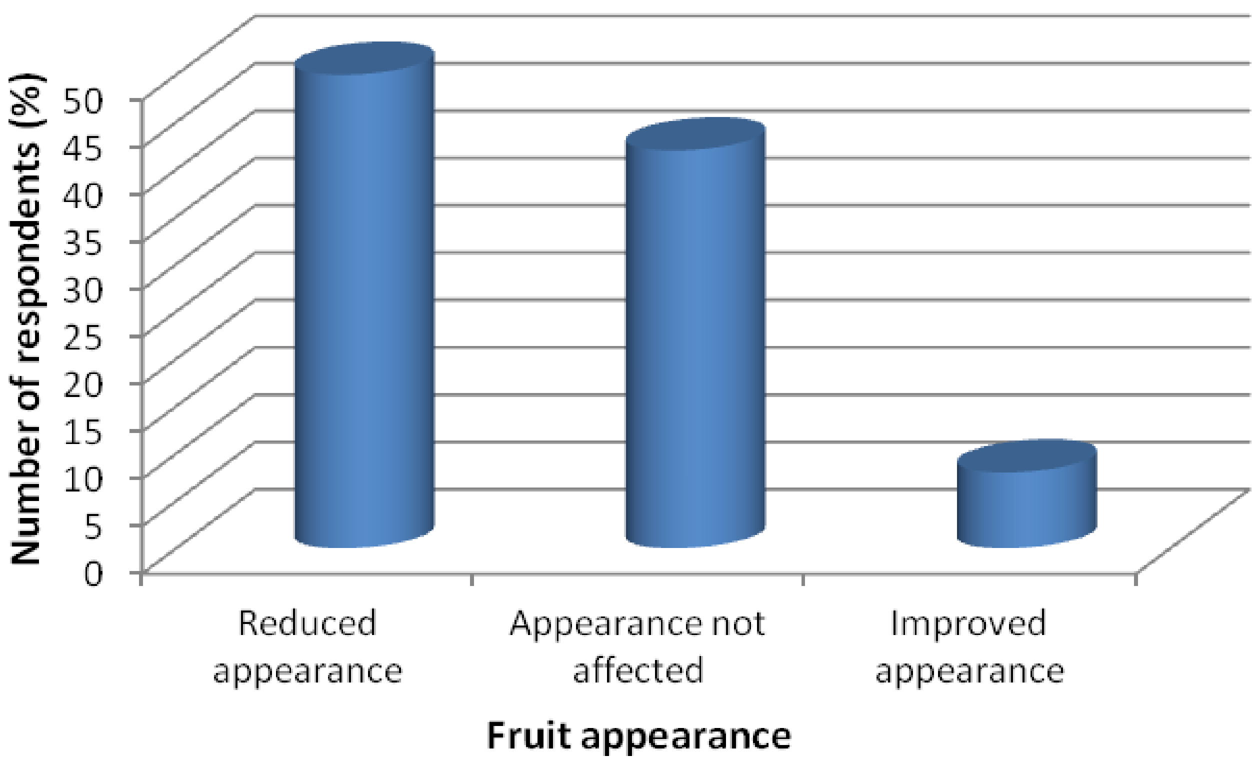

Figure 3. Farmers' peception of the effect of *O. longinoda* on the appearance of harvested fruits.

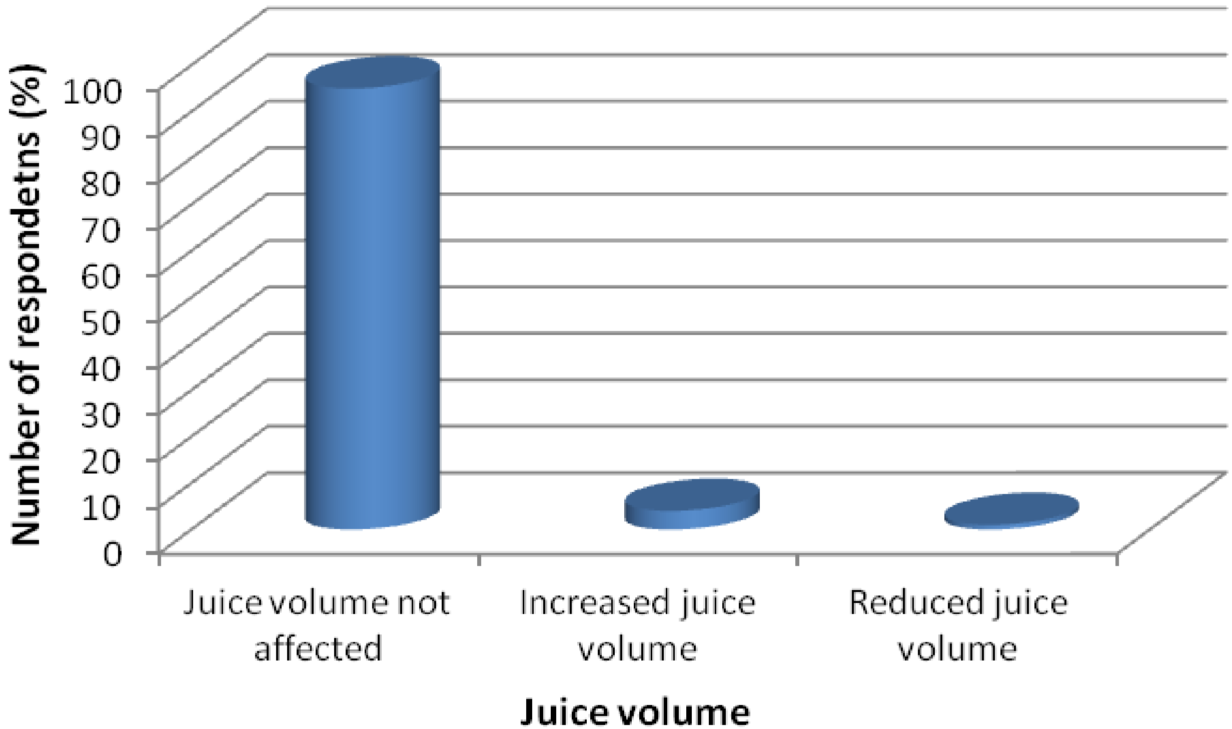

Figure 4. Farmers' perception of the effect of *O. longinoda* on the volume of citrus juice per fruit.

respondents), scaring them away with their aggressive behaviour (43% respondents) and secretion of volatiles (5% of respondents) (Figure 5).

Fruit quality analysis

The laboratory analysis of the quality of citrus fruits from the different treatments showed that the presence of the different *O. longinoda* nests densities did not significantly affect the total soluble solids (df = 4; *P* = 0.165), total acidity (df = 4; *P* = 0.219) and TSS: TA ratio (df = 4; *P* = 0.362). Similarly, juice volume (df = 4; *P* = 0.378) and fruit weight (df = 4; *P* = 0.133) (Table 1) were not significantly affected by the presence of *O. longinoda*.

DISCUSSION

In the present study, *O. longinoda* was regarded as a pest by most repondents. This was because farm operations such as prunning and removal of mistletoes, harvesting and picking of fruits were delayed due to bites farmers sustain from this insect. Thus, farmers decision to rank *O. longinoda* as a pest was mainly due to their nuissance. The inability of farmers to effectively undertake major agronomic operations due to this insect resulted in an indirect yield loss. Also, famers perceived that *O. longinoda* reduced yield because its activities impeded photosynthesis and damaged the inflorescens. These findings are similar to that of an ealier study in Guinea Bissau and Ghana in which most farmers interviewed also considered *O. longinoda* as a pest due its nuissance (Afreh-Nuamah, 1985, 1999; Van Mele, 2008b).

This notwithstanding, studies have shown that the *O. longinoda* is a predator of most insect pests in orchards (Leston, 1973; Sinzogan et al., 2008; Van Mele, 2008ab). Only 44% of our respondents thought *O. longinoda* preyed on some insect pests in their orchards in spite of it being a nuisance. The capacity of these farmers need to be built so that they can promote the benefits of this predator among their colleagues. They could train other farmers to overcome bites from *O. longinoda* thereby harnessing the benefits of its presence in their orchard. Rubbing an insect repellent on the body and the use of protective clothing prior to undertaking any agronomic activity are methods that could assist farmers to avoid the bites from this insect. Alternatively, farmers could consider undertaking these activities at periods of the day that this insect is less active (Van Mele and Cuc, 2007).

Studies (Sinzogan et al., 2008; Van Mele, 2008a) involving citrus farmers elsewhere found that farmers generally perceived that the presence of *O. longinoda* in

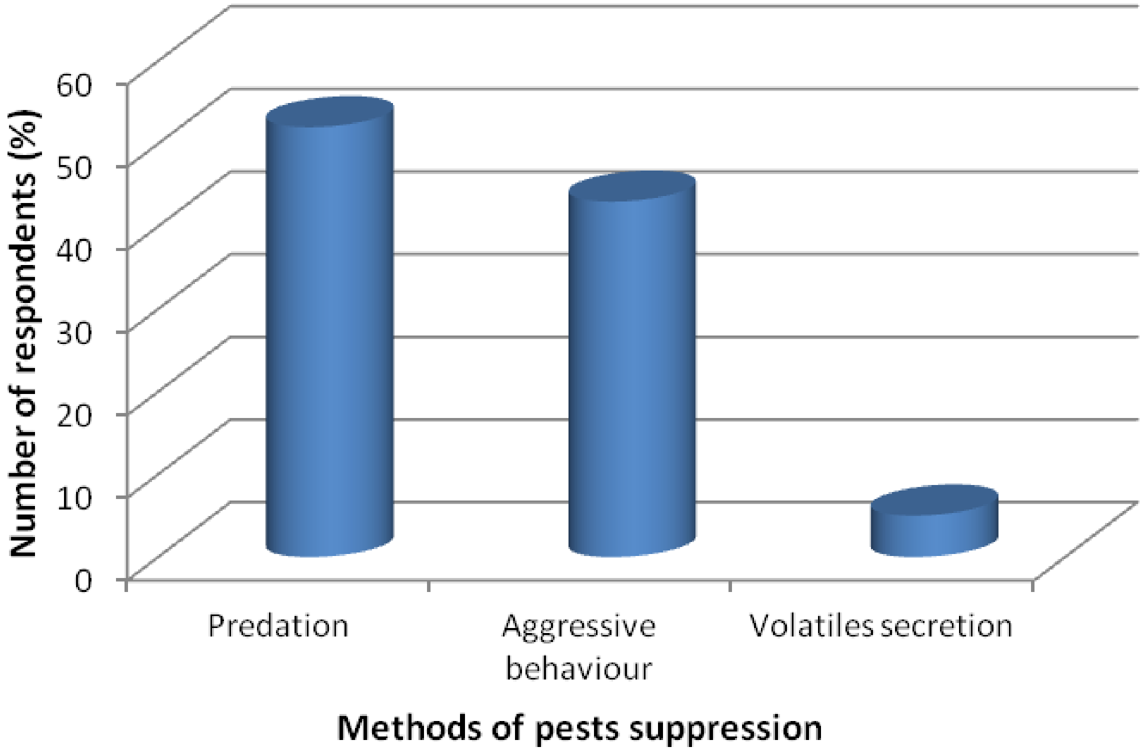

Figure 5. Farmers's perception of methods used by *O. longinoda* to suppress insect pests densities in orchards.

Table 1. Effect of presence of *O. longinoda* on the physico-chemical properties of orange fruits.

Number of ant nest (s) per tree	Total soluble solids (°)	Total acidity	TSS:TA	Juice volume (ml)	% juice volume (%)	Fruit weight (g)
1-5	9.5 ± 0.3	0.8 ± 0.0	12.5 ± 0.7	525.0 ± 32.3	38.6± 1.5	1370.0 ± 73.1
6-10	8.8 ± 0.3	0.6 ± 0.0	15.5 ± 0.9	516.0± 11.8	36.3 ± 1.8	1437.0 ± 76.5
11-15	8.4 ± 0.2	0.6 ± 0.1	13.9 ± 1.2	615.0 ± 46.6	37.1 ± 1.7	1632.0 ± 63.9
>15	8.8 ± 0.1	0.6 ± 0.1	14.4 ± 1.8	560.0 ± 53.4	38.4 ± 1.2	1473.0 ± 100.6
No nest	8.8 ± 0.5	0.7 ± 0.0	12.8 ± 0.3	558.0 ± 21.8	35.3 ± 0.9	1620.0 ± 81.5
LSD (5%)	NS	NS	NS	NS	NS	NS

Data are means±S.E. NS = not significant.

orchards improved fruit quality. However, most respondents in the present study did not observe any difference between the quality of fruits harvested from trees with and without *O. longinoda.* Also, our results from the laboratory analysis of brix, total soluble solids, titrable acid and juice volume which are important quality parameters confirmed that the presence of *O. longinoda* had no effect on these fruit qualities. The parameters analyzed contribute to the sweetness of citrus fruits and thus confirm findings by Barzman et al. (1996) that there is no difference between the sweetness of citrus fruits from trees with and without the weaver ant. Farmers perception corroborated by laboratory analysis suggests that the use of *O. longinoda* as a pest protectant will not result in any compromise on fruit quality.

The appearance of citrus fruits from trees with *O. longinoda* was less appealing compared to those from trees without this insect. This was because *O. longinoda* protected scale insects and mealy bugs in exchange for their sugary excrement (Ayernor et al., 2004; Van Mele, 2008b). The sugary excrement of scale insects and mealy bugs were observed to create black spots on the fruits, resulting in fruits from trees inhabited by *O. longinoda* appearing less attractive. Overcoming this challenge will require washing off these dark spots with water especially if the fruits are being prepared for the export market.

Conclusion

The results from this study suggests that adoption of strategies that integrate *O. longinoda* into pest management programmes of citrus farmers in Ghana is hampered by the percieved nuissance of this ant. Emphasis must therefore be placed on training farmers on how to avoid the nuisance from this ant in addition to promoting the numerous research findings on how to integrate it into farming systems. This will contribute immensely to the acceptance of *O. longinoda* for pest management by farmers. Also, laboratory analysis showed that the quality of citrus fruits is not altered by the presence *O. longinoda*.

Conflict of Interests

The authors have not declared any conflict of interests.

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