

# Predatory Efficiency of Two Predator Ants on *Coelaenomenodera Elaeidis* (Coleoptera: Chrysomelidae)

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## Abstract:

The predatory efficiency of *Micromischoides sp.* (Hymenoptera: Formicidae) and *Oecophylla longinoda* (Hymenoptera: Formicidae) collected from an oil palm field in the main station of the Nigerian Institute for Oil palm Research for the control of the leaf miner larvae, *Coelaenomenodera elaeidis*, was investigated in the laboratory at ambient temperature of  $27^{\circ}\text{C} \pm 0.5$ ;  $80\% \pm 2.5$  relative humidity and 12:12 h photoperiod. Predatory efficiency of the ants was tested on leaf miner larvae at 4, 24, 48 and 72 h. These were compared with untreated leaf miner larva (control). Chi-square test of significance was used to analyze predatory efficiency and time on the two ant species. Variation in seasonal predator abundance was evaluated. The results show that *Micromischoides sp.* destroyed the leaf miner larvae after 72 hours while *Oecophylla longinoda* were not observed to attack the larvae. This study identifies *Micromischoides sp.* as a predator which offers potential as a biocontrol agent for *C. elaeidis*.

## Keywords:

Predatory Efficiency, *Micromischoides sp.*, *Oecophylla longinoda*, Leaf Miner

## 1. Introduction

Social insects are ecologically successful. Ants, social bees, social wasps, and termites may make up 75% of the world's insect biomass, they play a major role in soil turnover and nutrient cycling, and they often surpass vertebrates in their biomass in a habitat [1]. Ants can affect soil properties [2], and function as seed dispersals [3], herbivores [4], and predators [5]. The ants (Hymenoptera: Formicidae) are social insects and they constitute the largest group among the insects. Their colonies usually live in nests that have tunnels and chambers. The ant societies are organized into castes (groups where there is division of labor). The caste system enables execution of multiple tasks. In the society of ants sterile castes (workers and soldiers) are responsible for maintaining the colony (obtaining food, protection and care of

offspring). The fertile castes (queens and drones) have reproductive function [6], [7]. In agroecosystems there are species of ants which are pest and others which are predators and they act as natural enemies. Ants are generalist predators and they usually have other insects as their main prey. Ants prey on insects of various orders such as Coleoptera, Diptera, Hemiptera, Lepidoptera and Orthoptera. Ants are important predators of insect pests in annual and perennial crops such as fruits, vegetables, ornamental plants, grain crops, coffee, sugar cane and cotton. The story of ants as biological control agents of agricultural pests is from 300 B.C. However there are many aspects about the role of ants as predators of agricultural pests that need to be studied, especially in tropical regions, to enable the preservation of these agents of biological control [8], [9], [10]. The ant community (Formicidae), which is frequently used as a bio-indicator of the level of diversity and environmental changes in the ecosystem, in comparison with other invertebrates [11], [12]. In fact the Formicidae family is the most commonly cited family in publications on the topic due to its diversity and functional importance [13] but also to its abundance in the ecosystem and to its ubiquity [14]. Even though many studies mention the importance of these generalist predators in controlling pest populations [15] particularly in agrosystems [16]; [17]; [18]; [19]; [20], there is a paucity of information on the agricultural importance and role of ants in the oil palm ecosystem, and their ability to maintain pest damage under economic thresholds.

The leaf miner – *Coelaenomenodera elaeidis*, adult beetle feeds on the lower surface of the leaflets leading to the partial drying up of the fronds [21]. In severely affected plantations, the lower canopies of most palms appear scorched, grey-brown with desiccated rolled – in leaflets. Later, the withered laminae shatter, leaving the leaflets midribs only. The foremost recorded outbreak of the beetle in Nigeria was at Oyo in 1966 [22]. Both the adult and larval forms of the leaf miner cause damage to the palm [23]. [24] [25] gave accounts of the incidence, life cycle and damage of this pest. The developmental periods are: eggs, 20; larvae, 44; pupae, 12; adult to egg laying 18; total 94 days (about 3 months). The adult lives on the under-surface of the leaf for 3-4 months after egg laying. There are thus 3 to 4 generations of this pest in a year. The adults are tiny pale-yellow beetles which scoop and feed in longitudinal grooves on the lower-surface of leaflets, the females laying their eggs in pits at the ends of the grooves and covering these with mounds of debris. The larvae that hatch out, mine or tunnel within the leaflet tissue between the upper and lower epidermal layers. The larvae attain about 6.8mm in length, with brownish thorax fused to the head. They mine longitudinally under the upper epidermis of leaflets of mature palms, except those below 3 years old. Their mined galleries attain 15 cm length and 1 cm breadth. Severely attacked palms look scorched from a distance, the young leaves remain green, while the others are grey-brown, and desiccated. The pupae are mobile and are visible in the center of the galleries, when the dried furrows are teased out. The adults are pale yellow with reddish wing cases. These adults in cases of severe attack can be observed flying within the crown, and show preference for migrating to the higher leaves. Heavily attacked trees may have up to 90% of the fronds defoliated which can result in about 50% loss in yields of fresh fruit bunch (ffb) over a two year period. [26] Reported yield reduction of 40 to 50% in oil palm in the first year, after severe attacks of leaf eating pests. A severe leaf miner infestation greatly reduces the yield of palm bunches for several years [27]. Successive cycles of infestation by the leaf miners could lead to inflorescence abortion, bunch failure and considerable economic loss [26]. Research in control has been directed at both the larvae and the adults, which are identified as the harmful stages of the pest. Methods of control over

the years have been cultural, biological and chemical [28]. In visibly heavy outbreaks, control measures become necessary. The use of an integrated pest management (IPM) strategy holds promise for the sustainable management of the oil palm leaf miner. The IPM approach requires a good knowledge of the biology of the pest and its environment including the effect of the host plant on the development of the pest [29]. Cultural control by pruning and heaping of all affected leaves during the rains has been reported to be very effective [30].

Biological control is the use of natural enemies to reduce insect pest populations. The reason biological control is so effective and safe is that a high degree of host - specificity for the targets is sought before a potential control organism can be released into the environment. Predators are free-living organisms that feed on other animals and sometimes devouring them completely and usually rapidly. The two predatory ants associated with the *C. elaeidis* are *Oecophylla longinoda* (Hymenoptera: Formicidae) and *Micromischoides sp.* (Hymenoptera: Formicidae). All larval and pupal stages of *C. elaeidis* are affected by both ants [29]. The results of predator-prey interaction are different depending upon whether the predator has a threshold of prey abundance below which it cannot harvest prey often enough to meet its basic metabolic requirements, or whether the predator is capable of completely exterminating the prey. In the latter case, oscillations in predator-prey system become one in which local extinctions and emigrations are responsible for general overall patterns of distribution and abundance. In the former case, the prey is vulnerable to predation only when above threshold densities and is not exterminated even locally by their predators [31]. It has been recognized as early as 1962 that insecticides were causing pest attacks in oil palms, by upsetting the ecological balance between the pest and its natural enemies [32]. One alternative method for management of insect pests is through predators.

The objective of this project is to study the predatory efficiency of *Micromischoides sp.* (Hymenoptera: Formicidae) and *Oecophylla longinoda* (Hymenoptera: Formicidae) for control of *Coelaenomenodera elaeidis*.

## 2. Materials and Methods

### 2.1. Study Site

The study site consisting of 443 mature palms at 9m triangular spacing is located at the main station of the Nigerian Institute for Oil Palm Research (NIFOR) near Benin, Edo State, Nigeria. The palms were planted in the year 2000. There are two seasons; wet and dry seasons. Average mean temperature is 26.6 °C.

### 2.2. Soil

The soil of the experimental field is slightly acid (pH 6.8) and texture is sandy loam to clay loam. The greater part of the Nigerian palm belt, both wild and planted, is on the 'Acid Sands' soils [33]. These are developed on tertiary and cretaceous sediments, and the most recent parts, on which most of the palms grow, are largely unconsolidated sandstones or 'Benin sands'. These soils were classified as 'fasc's' [34] which are accepted as equivalent to soil families in present terminology. Under the soil taxonomy system, they are Paleudults and dystropepts, and under the FAO-UNESCO [35] system, they are dystric nitisols and dystric cambisols [36].

### 2.3 Sampling Technique

The study in NIFOR involved random sampling surveys for leaf miner on a plot planted in 2000 and comprised of 443 palms (2.95 hectares).

### 2.4. Arrangement on Palm Field

No pesticides were applied during the study period, purposely to simulate a natural ambience in the sample plot. A sampling intensity of 21 palms was used, selecting 1 palm per line. In shorter palms, fronds were pulled down by a stick, but in taller ones a ladder was used. A different palm was used at successive counts. Leaf miner counts were on the palm leaflets within the field plot. NIFOR palms are planted in a triangular pattern, so census lines ran in three directions. Access points were marked with reference to field boundaries and harvesting paths. Sampling was conducted monthly between 7 - 11am.

### 2.5. Field and Laboratory Studies

As candidate predator biocontrol agents, *Micromischoides sp.* and *Oecophylla longinoda* were chosen based on their availability all year round in oil palm plantations. Pruned, damaged and infested leaflets from the field were cut open and studied for presence of different life stages of leaf miner. *Micromischoides sp.* were handpicked with hand gloves as they crawled on the palm fronds while *Oecophylla longinoda* were collected from a nest on the frond. Data was collected monthly from January 2009 – December 2010. Predatory efficiency at one prey density was evaluated in the laboratory at ambient temperature of  $27^{\circ}\text{C} \pm 0.5$ ;  $80\% \pm 2.5$  relative humidity and 12:12 h photoperiod, by placing 3rd instar larvae leaf miner larvae (5) in insect cages (11.5cm x 4.5cm) along with 5 ants each of the two species. Control was larvae not confined with ants. Five replicates were conducted for each predator: prey combination and each prey density.

Prey mortality and signs of predator attack were assessed at the following times following introduction: 4, 24, 48 and 72 h. Cotton wool was immersed in distilled water for five seconds, removed and then placed in the insect cages. A Wild Heerbrugg M 3B Binocular Microscope, and a Samsung S760, 7.2 Mega pixels were used. Temperature and relative humidity records were recorded daily with the digital Thermometer W/Hygro IT-202 model. Chi-square test of significance was used to analyze predatory efficiency and time on the leaf miner.

## 3. Results and Discussion

Table 1 shows the efficiency of *Micromischoides sp.* and *O. longinoda* against the leaf miner. Chi-square test of significance for predatory efficiency and time on both predatory ants was 13.500 with a significant value of 0.001. This indicates that the predatory ability depends on time. Table 1 indicates total mortality for the leaf miner larvae by the *Micromischoides sp.* (figure 1). *Oecophylla longinoda* (Figure 2) is considered to be a poor candidate for leaf miner control.

The *Micromischoides sp.* starts attacking the larvae one at a time by biting using their mandibles. The use of their mandibles enhances their predatory efficiency.

**Table 1.** Predatory efficiency of two predators against the leaf miner larva.

Predator	Time of Exposure						Mortality (%)
	Predator density	Prey density	4h	24h	48h	72h	
<i>Micromischoides sp</i>	5	5	Alive	Alive	Immobile	Dead	100
<i>Oecophylla longinoda</i>	5	5	Alive	Alive	Alive	Alive	0
Control	0	5	Alive	Alive	Alive	Alive	0

**\*\*Significance  $P \leq 0.05$**   
 Chi-square value – 13.500  
 Significance value – **\*\*0.001**  
 Number of replicates – 5



**Figure 1.** *Micromischoides sp.*



**Figure 2.** *Oecophylla longinoda.*

### **3.1. Assessments of Prey Mortality and Signs of Predator Attack Are Described Below**

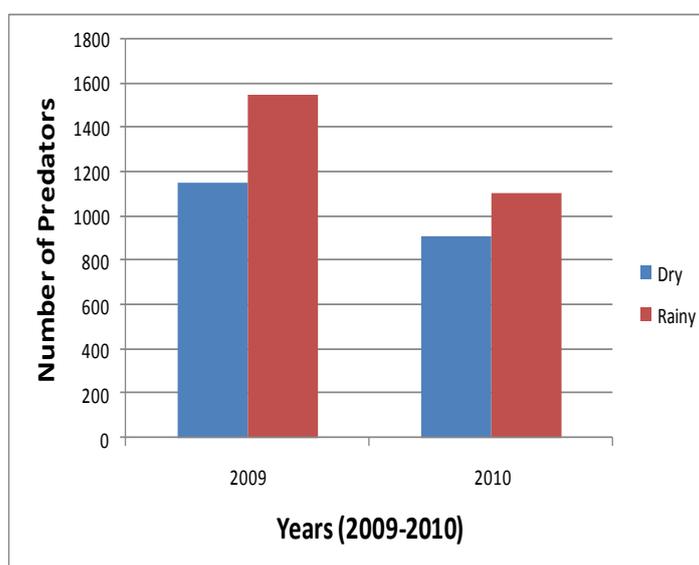
After 4 hours, the ants moved rapidly about in the cages away from the leaf miner larva for both ant species. After 24 hours, *Micromischoides sp.* (Figure 1) starts attacking the larvae one at a time by biting using their mandibles. *O. longinoda* (Figure 2) show no sign of attack towards the larva. After 48 hours, *Micromischoides sp.* is observed to climb larvae and pierce with its ovipositor and biting also continues. The larvae are now immobile. Feeding of *Micromischoides sp.* on leaf miner larva is shown in figure 3. *O. longinoda* are all dead with no visible sign of having attacked the leaf miner larvae. After 72 hours, all the larvae in cages with *Micromischoides sp.* confirmed dead, while larvae in cages with *O. longinoda* alive. Leaf miner larvae not confined with predatory ants were alive after 72h for both predatory ants.



**Figure 3.** *Micromischoides sp.* feeding on leaf miner larva.

### 3.2. Seasonal Predator Abundance

Variation in seasonal predator abundance from Jan. 2009 – Dec. 2010 is presented in figure 4. The predatory ants were most abundant in the rainy season in both 2009 and 2010.



**Figure 4.** Seasonal variation in predator abundance (Jan. 2009 – Dec. 2010).

## 4. Conclusions

The results show that *Micromischoides sp.* destroyed the leaf miner larvae after 72 hours while *Oecophylla longinoda* were not observed to attack the larvae. Therefore, *Micromischoides sp.* is an effective predator that serves for leaf miner control. The trend indicates that the *Micromischoides sp.* were more abundant in the rainy season across the years of study, which improves leaf miner control before the dry season starts. The widely available ant population complements other control measures. The continuous use of insecticides will affect beneficial insects such as insect pollinators and natural enemies of oil palm pests. It has been recognized that insecticides are causing pest attacks in oil palms, by upsetting the ecological balance between the pest and its natural enemies. One alternative method for management of insect pests is through predators. This study has identified *Micromischoides sp.* as a predator which offers potential as a biocontrol agent for *Coelaenomenodera elaeidis*. The ant is widely available, especially in the dry season. Preservation of biodiversity within oil palm plantations is vital as beneficial soft weeds and herbaceous plants provide a source of food for natural enemies, helping to maintain a balance between insect pests, and natural biological control agents. Natural enemies could be conserved by avoiding use of insecticides during flowering and less regular mowing of field edges to maintain habitat and alternate food sources for their populations.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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## References

- [1] Holldobler, B.; Wilson, E.O. The ants: Harvard University Press. 1990, 732.
- [2] Jones, C.; Lawton, J.; Shachak, M. Organisms as ecosystems engineers. *Oikos*, 1994, 69(3), 373-386.
- [3] Bennet, A.; Krebs, J. Seed dispersal by ants. *Trends Ecol.* 1987, 2, 291-292.
- [4] Vasconcelos, H.L.; Cherrett, J.M. Leaf-cutting ants and early forest regeneration in Central Amazonia: Effects of herbivory on tree seedling establishment. *J. Trop. Ecol.* 1997, 13, 357-370.
- [5] Sheppe, W. Invertebrate predation on termites of the African savanna. *Insectes Soc.* 1970, 17, 205-218.
- [6] Hölldobler, B.; Wilson, E.O. The ants. 1990. Cambridge: Harvard University.
- [7] Ross, K.G.; Keller, L. Ecology and evolution of social organization: Insights from fire ants and other highly eusocial insects. *Annual Review of Ecology and Systematics*, 1995, 26, 631-656.
- [8] Way, M.J.; Heong, K.L. Significance of the tropical fire ant *Solenopsis geminate* (Hymenoptera: Formicidae) as part of the natural enemy complex responsible for successful biological control of many tropical irrigated rice pests. *Bulletin of Entomological Research*, 2009, 99, 503-512.
- [9] Fernandes, F.L.; Picanço, M.C.; Fernandes, M.E.S.; Xavier, V.M.; Martins, J.C.; Silva, V.F. Controle biológico natural de pragas e interações ecológicas com predadores e parasitoides em feijoeiro. *Bioscience Journal*, 2010, 26, 6-14.
- [10] Choate, B.; Drummond, F. Ants as biological control agents in agricultural cropping systems. *Terrestrial Arthropod Reviews*, 2011, 4, 157-180.
- [11] Lawton J.H.; Bifnel D.E.; Bolton B.; Blowmers G.F.; Eggleton P.; Hammond P.M.; Hodda M.; Holt R.D.; Larsen T.N.; Mawdsley N.A.; Stork N.E.; Srivastava D.S.; Watt A.D. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature*. 1998, 391, 72-76.
- [12] Underwood E.C. and Fisher B.L. The role of ants in conservation monitoring: If, when and how. *Biological Conservation*, 2006, 132, 166-182.
- [13] Mc Geoch M.A. Insects and Bioindication: Theory and Progress. In Stewart A.J.A., New T.R. & Lewis O.T. (Eds). *Insect Conservation Biology*, CABI, Wallingford, United Kingdom. 2007, 144-174.
- [14] Abera-Kalibata A.M.; Gold C.S.; Van Driesche R.G.; Ragama P.E. Composition, distribution, and relative abundance of ants in banana farming systems in Uganda. *Biological Control*, 2007, 40, 168-178.
- [15] Symondson W.O.C.; Sunderland K.D.; Greenstone M.H. Can Generalist Predators be Effective Biocontrol Agents. *Annual Review of Entomology*, 2002, 47, 561-594.
- [16] Negm A.A.; Hensley S.D. Evaluation of certain biological control agents of the sugarcane borer in Louisiana. *Journal of Economic Entomology*, 1969, 62, 1008-1013.
- [17] Roche R.; Abreu S. Control del picudo del plátano (*Cosmopolites sordidus*) por la hormiga *Tetramorium guineense*. *Ciencias de la Agricultura*, 1983, 17, 41-49.

- [18]Way M.J.; Khoo K.C. The role of ants in pest management. *Annual Review of Entomology*, 1992, 37, 479-503.
- [19]Rossi M.N.; Fowler H.G. Ant predation of larval *Diatraea saccharalis* Fabricius (Lepidoptera: Crambidae) in new sugarcane in Brazil. *Journal of Applied Entomology*, 2000, 124(5-6), 245-247.
- [20]Rossi M.N.; Fowler H.G. Predaceous Ant Fauna in New Sugarcane Fields in the State of São Paulo, Brazil. *Brazilian Archives of Biology and Technology*, 2004, 47(5), 805-811.
- [21]Natural Resources Institute (NRI). Insect pests of Nigerian Crops: identification, biology and control. Natural Resources Institute Chatham, U.K. 1996, 253.
- [22]Gerald, B.M. A review of 50 years applied entomology in Nigeria: Tree Crops. *Ent. Soc. Nig.* 1967, 25-38.
- [23]Afhreh-Nuamah, K. Insect pests of tree crops in Ghana. Identification, damage and Control measures. Buck press. Inc. 1999, 65.
- [24]Morin, J.P. and Mariau, D. Sur la biologie *Coelanomenodera elaeidis*. IV. La dynamique des populations du ravageur et ed ses parasites. *Oleagineux*, 1972, 27(10), 469-472.
- [25]Hartley, C.W.S. The Oil Palm. Third Edition. Longman London. 1988, 761.
- [26]Wood, B.J. Pest-Introduction and Ecological Considerations. In:Oil Palm Research. Developments in Crop Science. 1976. (1). Eds. R.H.V. Corley, J.J. Hardon and B.J. Wood. Elsevier Scientific Publishing company, Amsterdam. pp. 334-346.
- [27]Daodu, Y.U. Survey for oil palm pests at Kus and Bunso conducted during May and June 1974. 1974. Annual Report, Crops Research Institute, 11.
- [28]Appiah, S.O. A review of research on *Coelaenomenodera minuta*, Uhmman (Coleoptera: Hispididae) in Ghana. Proceedings of the International Conference On Palms and Palms Products, 1989, 1, 453-457.
- [29]Appiah, F.O.; Kolade, K.; Airede, C.E.; Osagie, I.J. Development of cost Effective integrated pest management techniques for the control of *Coelaenomenodera elaeidis* and *Homophylotis catori* and other pests of oil palm, NIFOR Report, 2007, 153-164.
- [30]Agwu, S.I.; Appiah, F.O.; Aisagbonhi, C.I. The occurrence and control of the Oil palm leaf miner, *Coelaenomenodera elaeidis* Mlk. 1986. In Nigeria. Proceedings of International conference on oil palm, Port – Harcourt, 9th – 15th November, 1986.
- [31]Huffaker, C.B. (ed.) Biological Control. Proc. Amer. Asso. Adv. Sci. Symp. Biol. Control. Plenum Press, New York. 1970, 511.
- [32]Wood, B.J. Development of integrated control programs for pests of tropical Perennial crops in Malaysia. In: Biological control (Ed. By C.B. Huffaker). 1971, 422-457, Plenum press, New York.
- [33]Corley, R.V. and Tinker, P.B. The Oil Palm. Fourth Edition. Blackwell Science Ltd. 2003, 562.

- [34] Vine, H. Studies of soil profiles at the WAIFOR main station and other sites of oil palm experiments. *J. W. Afr. Inst. Oil palm Res.* 1956, 1(4), 8-59.
- [35] FAO-UNESCO. 1990. Soil map of the world. 1: 5000,000, Legend, FAO, Paris.
- [36] Ojanuga, A.G.; Lekwa, G.; Akamigbo, F.R. Survey genesis and classification of acid sands. In: Acid sands of Southern Nigeria. SSSN Special Publication Monograph. *Soil Sci. Soc. Nigeria.* 1981, 1, 1-18.



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