

RESEARCH ARTICLE

Ecology of *Cotterelia podagrica* (Hymenoptera: Eulophidae): A Potential Parasitoid of the Oil Palm Pest, *Coelaenomenodera elaeidis* (Coleoptera: Chrysomelidae)

T.I. Aneni*, C.I. Aisagbonhi, V.C. Adaigbe and C.I. Okere
Entomology Division, Nigerian Institute for Oil Palm Research, Nigeria
tomaneni1@yahoo.com*; +234-80-55514010

Abstract

Coelaenomenodera elaeidis is one of the most deleterious insect pests of the oil palm in Nigeria. For the purpose of a detailed knowledge of the life cycle and ecology of the natural enemy of the *C. elaeidis*, field and laboratory studies were conducted in the main station of the Nigerian Institute for Oil Palm Research. Ambient air temperature and relative humidity was monitored in close proximity to the rearing cages in the laboratory. Parasitoids were reared on artificial media at temperatures fluctuating between 26-34°C and relative humidity from 52-92%. This study accumulates knowledge on *Cotterelia podagrica*, a parasitoid that can be used to develop sustainable control methods against *C. elaeidis*. Incubation period averaged 9 d and larval developmental period was 8 d. Pupal developmental period was 7.2±1.48 d and total average development period from incubation to adult was 23.2±3.56 d. Adult longevity was 3.9±0.76 d. This parasitoid appears to be a promising candidate for bio-control against *C. elaeidis* in oil palm plantations.

Keywords: Oil palm, *Coelaenomenodera elaeidis*, ecology, parasitoids, *Cotterelia podagrica*, bio-control.

Introduction

Oil palm is an important food and cash crop in Nigeria. Its cultivation and processing form a major economic activity in the oil palm belt. The main oil palm belt in Nigeria lies in the rainforest zone with an annual precipitation of about 1889-2560 mm. This region is characterized by an uneven annual rainfall distribution with three to five month periods of water deficit usually between November and March. Pests cause great losses to the oil palm industry by affecting both quality and quantity of production. Oil palm suffers from many pests that can have a serious impact on growth and yields. Lepesmes (1947), Wood (1968), Agwu (1981) and Hartley (1988) have accounts of the destructive insects of the oil palm and aspects of their control. Agwu (1981) presented a list of 70 species of insects injurious to the oil palm in Nigeria. These insects were found to belong to 28 families and 5 orders. *Coelaenomenodera elaeidis* (Coleoptera: Chrysomelidae: Hispinae) is endemic in almost all oil palm growing areas of West Africa and regarded as the most devastating pest of the oil palm. The larvae are the main cause of damage, especially during swarming when several individuals can be found mining into the epidermis of the leaflets, leading to direct destruction and desiccation of the leaf or reduced photosynthetic surfaces (Aisagbonhi *et al.*, 2004). Cotterel (1925) reported hymenopteran parasites of both eggs and larvae, as well as fungal infestation of the leaf miner. Parasitism of *Coelaenomenodera* was studied in detail by Morin and Mariau (1974), Mariau and Morin (1974) and Mariau *et al.* (1978).

The eggs are parasitized by the Chalcid fly, *Achrysocharis leptocerus* and by *Oligosita longiclavata* (Trichogrammatidae). There were three larval parasites: the eulophid flies *Sympiesis aburiana*, *Pediobus setigerus* and *Cotterellia podagrica*. None of these was sufficiently numerous to have much effect in outbreaks (Mariau *et al.*, 1978). The eulophid Wasp, *Chrysonotomyia* spp. was successfully introduced from Madagascar, but it failed to parasitize *C. lameensis* (Lecoustre *et al.*, 1980). In Cameroun, Timti (1991) found that leaf miner attacks were fewer where *Crematogaster* ants were present and suggested that the pest could be controlled by collecting these ants and distributing them in affected areas. Many herbivorous insects, mainly a variety of Lepidoptera and Hispine Coleoptera (Chrysomelidae) larvae, can also lead to a significant loss in oil production through the reduction of foliage surface (Delvare and Lasalle, 1993). Studies on the preimaginal stages of these herbivorous insects have shown that they have a variety of natural enemies, most of them belonging to the parasitic Hymenoptera (Genty *et al.*, 1978). Predicting the efficacy of natural enemies prior to their introduction for biological control of pests has been a major goal (Huffaker *et al.*, 1971). For success of the Integrated Pest Management, knowledge of the pest and its natural enemies is necessary for effective control. This study is of the view that understanding the oil palm pest-parasitoid relationship could have broad agricultural and food security implications.

The objective of this study is to accumulate knowledge on the life cycle of a parasitoid of *C. elaeidis* which is a major pest of the oil palm.

Materials and methods

Study site: The study site consisting of 443 mature palms at 9 m triangular spacing 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 and were 8 years old at the time of this study.

Field and laboratory studies: Pruned, damaged and infested fronds from the field were cut open and studied for presence of different life stages of *C. elaeidis* and their potential parasitoids and predators. Laboratory rearing of identified *C. elaeidis* parasitoids with artificial diets were conducted. Observations of the relationship between the life cycle of *C. elaeidis* and its parasitoids were undertaken. Predators and parasitoids were preserved in 70% alcohol. A Wild Heerbrugg M 3B Binocular Microscope and a Samsung S760, 7.2 Mega pixels were utilized.

Artificial diet: Fresh oil palm leaves were cut from the field, washed and oven dried at 70°C for 7 d in the gallenkamp size 1 incubator. When dried, it was pounded in a wooden mortar to a powdery substrate, weighed (20 g) and added to diet formulation. Pollen grains were collected from oil palm inflorescence, weighed and also added to the diet. Weights were measured using a Mettler P1210 weighing balance. Other components of the diet for *C. elaeidis* and its parasitoids (adapted from Jackai and Raulston, 1982) were made up of: Water (500 mL), Agar (15 g), Ascorbic acid (3 g), Menthol paraben (1 g), Sugar (10 g), Soy flour (10 g), Wheat flour (28 g), Potassium hydroxide (128.54 g), Acetic acid (5 mL), Vegetable oil (2 mL), Palm leaflet powder (20 g), Pollen grain (2.5 g), Formaldehyde (2 mL), Vitamin and salt mix (5 mL), Vitamin and mineral capsule (1 g). An electric blender was used to blend the diet items and left to cool. It was later stored in transparent plastic containers covered with serviette paper and lid. These cans were kept in plastic trays containing water to prevent ants from entering the containers. Diet with infested *C. elaeidis* is shown in Plate 1.

Plate 1. Shows diet with *C. elaeidis* (X100).



Larval and parasitoid rearing: The rearing cages and containers were kept in the laboratory. Prior to infestation, the glass vials were sterilized in a steamer and oven dried. The diet was poured in while hot. The glass vials were half filled. Larvae of *C. elaeidis* were put in one per glass vial. Infestation took place after the diet had cooled and its surface scarified to ease larval penetration. All infestation was done under a laminar flow station which ensures sterilized air. Serviette paper was used to cover the rearing cages to prevent humidity build-up and prevent larval escape. Cotton wool soaked with sugar solution was provided for feeding of *C. elaeidis* larva when placed in a plastic cage to observe parasitoid attack on it. Adult parasitoids were fed with sugar solution to observe longevity.

Preparation of sugar solution: One cube of sugar was dissolved in 150 mL of distilled water. Solution was stirred evenly. Cotton wool was immersed in the solution for 5 sec, removed and then placed in the insect rearing cage.

Results

Incubation period had a mean of 9 d; larval developmental period averaged 8 d while pupal developmental period had a mean of 7.2 d. The total developmental period of the parasitoid from incubation to adult emergence averaged 23.2 d (Table 1). Average longevity of the adult *C. podagrica* is 3.9 d (Table 2). Temperature was between 25-30°C and relative humidity of 81-86%.

Table 1. Developmental period of *C. podagrica* (means in d).

Incubation (d)	Larval duration (d)	Pupal duration (d)	Total (d)
9	8	7	24
9	8	5	17
9	8	9	26
9	8	7	24
9	8	8	25
Mean: 9	8	7.2±1.48	23.2±3.56

Number of observation (n) = 32

Table 2. Longevity table for *Cotterellia podagrica*.

No. of adult parasitoids (n)	Adult longevity (d)
5	3
3	4
1	5
5	3
3	4
10	4
4	3
Mean	3.9±0.76

Number of observation (n) = 31.

Leaf miner control by *Cotterellia podagrica*: Its larva is predominantly whitish, oval and translucent. The larva is averagely 3 mm, oblong at the anterior and posterior sections tapering at both ends. The head has an average of six tiny projections apparently used for feeding.

Plate 2. *Cotterellia podagrica* emerging from second instar larva (X100).



Plate 3. *Cotterellia podagrica* larva feeding on *C. elaeidis* host (X100).

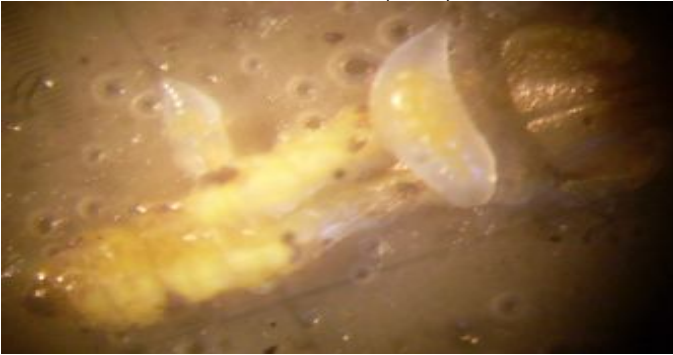


Plate 4. *Cotterellia podagrica* feeding on artificial diet from larva to pupa stage (X100).

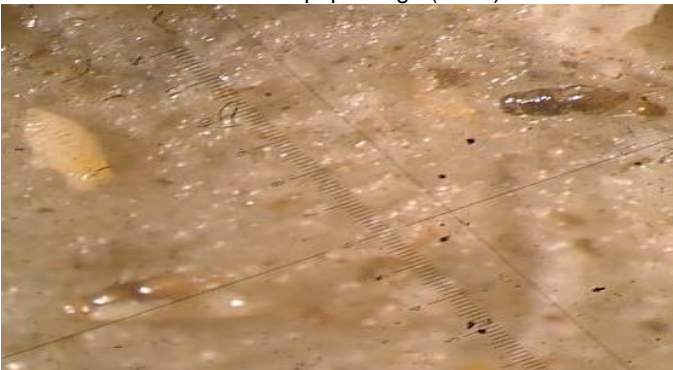


Plate 5. Adult *C. podagrica* (X100).



It feeds with the head burrowed initially into its host body and later into the artificial diet. The abdominal mid-section has a brownish gelatinous substance. The emerging *C. podagrica* larvae revolve around the point of emergence. It emerges from the posterior region of the *C. elaeidis* with the anterior region (head) inside the host (Plate 2). They emerged from different parts of the parasitized larva between the thorax and the posterior end of the abdomen. No emergence was observed from the head. After detachment from the body of the dead host, they continue feeding on it until it is finally consumed (Plate 3). It is at this point that they started feeding on the artificial diet until attainment of maturity (Plate 4). As they matured, color pigmentation changed until they became black at the adult stage (Plate 5).

Cotterellia podagrica action on *C. elaeidis*: On day 1, a second instar larva was introduced into a rearing cage containing 3 adult *C. podagrica*. On day 10, it was observed that the larva had been totally parasitized and killed.

Discussion

Biological control is often viewed as a promising alternative or complement to pesticides in integrated pest management programs (McDougall and Mills, 1997). Factors that can influence the effectiveness of biological control agents include agent specificity (generalist or specialist), the type of agent (predator, parasitoid, or pathogen), the timing and number of releases, the method of release, synchrony of the natural enemy with the host, field conditions and release rate (Collier and Van Steenwyk, 2004; Stiling and Cornelissen, 2005). Insect parasitoids have an immature life stage that develops on or within a single insect host, ultimately killing the host, hence the value of parasitoids as natural enemies. Major characteristics of insect parasitoids include (Hoffman, 1993):

- They are specialized in their choice of host
- They are smaller than host
- Only the female searches for host
- Different parasitoid species can attack different life stages of host
- Eggs or larvae are usually laid in, on or near host
- Immature remain on or in host; adults are free-living, mobile and may be predaceous
- Immature almost always kill host.

Cotterellia podagrica had an average total developmental period of 23 d. Thus, there are 13 to 14 generations of this natural enemy in a year. They were more abundant. Biological control can provide a sustainable and environmentally acceptable pest management, often at little or no direct cost in relation to imported chemical pesticides. It offers target specific pest control only to the leaf miner. Therefore, it is considered as a potential bio-control agent. A parasitoid is an insect whose larvae develop by feeding on the body of other arthropods,

invariably killing their host and completing their development. Only the female parasitoid seeks hosts (Prakash, 2010). On emergence, it was observed that the head is usually inside the parasitized larva. This could be attributed to need for attachment to a source of nourishment. The parasitoid develops within host body and larvae hatch out from host body killing it, thereby acting as its natural enemy. The adults are flying and active insects which seek their host in the natural environment by means of cues. The adult female lays its egg in the host by means of an ovipositor. Emerging adults usually mate based on availability of resources (food) and female adults search for hosts. In this study, artificial diets were important in aiding growth to maturity. This would also enable mass rearing parasitoids all year round for leaf miner control. The death of the host occurs when insect parasitoids emerge and the pupation of the parasitoid that follows is in or near the dead host. Observations from infested palm fronds show that larvae of different instars are present together. *Cotterellia podagrica* is known to be effective in pest populations, when host larvae of different instars were present together. This indicates that this parasitoid would be an effective bio-control agent.

Conclusion

In view of the long deleterious effects of the indiscriminate use of chemicals for pest control on the environment, there is need for more research efforts and adequate attention focused on bio-regulators of insect pests of the oil palm. The need to improve the environment for natural enemy activity is of paramount importance.

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