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# INFLUENCE OF MICROHABITAT TEMPERATURE ON *COELAENOMENODERA ELAEIDIS* AND ITS NATURAL ENEMIES IN NIGERIA

T.I. ANENI, C.I. AISAGBONHI, B.N. ILOBA[1] and V.C. ADAIGBE
Entomology Division, Nigerian Institute for Oil Palm Research, Nigeria
[1]Department of Animal and Environmental Biology, University of Benin, Nigeria
**Corresponding author:** tomaneni1@yahoo.com

## ABSTRACT

Insect infestations are expected to increase in Sub-Saharan Africa with climate change, to levels that may cause rapid changes in vegetation with concomitant changes in microclimate. Microhabitats are niches whose dimensions are smaller than those of the macrohabitats in which they occur. The physical presence of many oil palm stands leads to existence of microhabitats within the macro-environment. This study examined the direct effects of microhabitat temperature on a major pest of the oil palm, *Coelaenomenodera elaeidis*, its parasitoids and predatory ants. Field plots for observations of microhabitat temperature were established to run through January 2009 to December 2010 at the main station of the Nigerian Institute for Oil Palm Research in Nigeria. The *C. elaeidis* and microhabitat temperatures were statistically analysed. In 2009, leaf miners were significantly different in the dry season; while in 2010 the predatory ants had the highest significant ($P \leq 0.05$) relationship in the rainy season. Generally, the dry season recorded greater abundance of leaf miners and predatory ants; while the rainy season recorded more of the parasitoids in both 2009 and 2010. This study has demonstrated that the oil palm ecosystem is becoming vulnerable to insect pest attack as a result of increasing temperature. We thus advocate for the strengthening of pest management systems to cope with increased threats.

*Key Words*: Insect pests, *Coelaenomenodera elaeidis*, oil palm, pest management

## RÉSUMÉ

L'infestation par d'insectes en Afrique Sub-saharienne est supposée d'être accrue par suite du changement climatique, à des niveaux qui pourraient induire un changement rapide de la végétation avec des changements concomitants dans le microclimat. Les micro-habitats sont des niches de plus dimensions que celles des micro-habitats dans lesquels ils se produisent. La présence physique de tant de palmiers d'huile conduit à l'existence des microclimats au sein du macro-environnement. Cette étude a examiné les effets directs de la température du microclimat sur les pestes majeurs du palmier d'huile *Coelaenomenoderaelaeidis,* ses parasitoïdes et ses fourmis prédatrices. Des parcelles en champs pour observations de la température du microclimat étaient établies au cours de Janvier 2009 à Décembre 2010 à la station principale de l'Institut de recherche sur le Palmier d'huile. Le C. *elaeidis* et les températures étaient statistiquement analysés. En 2009, les mineurs des feuilles étaient significativement différents dans la saison sèche, pendant que en 2010 les fourmis prédatrices étaient significativement ($P \leq 0.05$) corrélées dans la saison pluvieuse. Généralement, la saison sèche a enregistré une plus grande abondance de mineurs des feuilles et les fourmis prédatrices, pendant que la saison pluvieuse a enregistré plus de parasitoïdes en 2009 et en 2010. Cette étude a démontré que l'écosystème du palmier d'huile devient vulnérable aux pestes comme conséquence de l'augmentation de la température. Par conséquent, nous recommandons le renforcement des systèmes de gestion des pestes pour la maîtrise de ces menaces sans cesse croissantes.

*Mots Clés*: Peste d' insectes, *Coelaenomenodera elaeidis*, palmier d'huile, gestion de peste

## INTRODUCTION

Insect infestations are predicted to increase with climate change in Sub-Saharan Africa and can cause rapid changes in vegetation with concomitant changes in microclimate (Dale *et al.*, 2001; Logan *et al.*, 2003). Microhabitats are habitats whose dimensions are smaller than those of the macrohabitats in which they occur (Fatubarin, 2007). The physical presence of many oil palm stands has a major influence on the climatic conditions of the immediate environment leading to microhabitats. Such microhabitats are formed for instance by the crowns of the oil palm trees where they touch usually forms a continuous canopy. The canopy intercepts sunlight, thus causing a slightly dark environment within the oil palm plot. The trees also act as an effective windbreak, maintaining generally lower air temperatures than outside the plantation. The oil palm plantation microhabitat, serves as a natural environment where insect pests reside. This microhabitat provides the basic needs of these organisms.

Microhabitats normally exist within macro-habitats. Generally, globally averaged water vapor pressure, evaporation, and precipitation are projected to increase in Sub-Saharan Africa (Houghton, 2001). However, predicted changes in hydrologic variables are much less robust than the changes in temperature; hence, the focus on the potential effects of temperature on oil palm insect pests.

The oil palm ecosystem is affected in its distribution patterns and diversity by climate while it in turn modifies the local climate. The maximum air temperature is reduced as the oil palm canopy keeps out most of the intense radiation. Generally, when the crown canopy forms a more or less continuous layer, very little direct sunlight gets to the ground. The mean annual temperature within forests may be 1 to 2 $^0$C lower than in the nearby open ground (Ayoade, 2005).

Associations between climate variability and insect pests do not necessarily imply causation, but results from correlation studies can help separate the effects of climate from other components of global change. In particular, temperature, relative humidity, soil moisture, and their combined effects are believed to play a significant role in the likelihood that insect species will be able to establish a viable population (Baker, 2002; Dobesberger, 2002). The physical conditions in some environments are quite different from the general meteorological conditions, yet they are still related to them in a broad way, Even the vegetation, which considerably influences the physical conditions as well as dominating the environment in other respects, is itself determined in a general way by climatic influences (Solomon, 1949).

Existing study reports suggest that direct effects of temperature are likely to be larger and more important than any other factor (Bale *et al.*, 1997). Despite known impacts of insect pests, the combined effects of microhabitat temperature on leaf miners of the oil palm have not been considered. This study examined the relationships between microclimate temperature and *Coelaenomenodera elaeidis* population dynamics, its parasitoids and predatory ants.

## MATERIALS AND METHODS

**Study site.** The study was conducted at the main station of the Nigerian Institute for Oil Palm Research (NIFOR). The Institute lies 29 km north-west of Benin-City In Nigeria, latitude -6$^0$ 30' N and longitude -5$^0$ 40' E. It is located in the forest zone of south-west Nigeria. The natural vegetation was replaced by oil palm and coconut cultivation during the past 50 years. The study site was a young oil palm plot planted in 2000, whose crown canopy had not formed a continuous layer, and sunlight could still penetrate to the ground.

The site experiences two seasons; wet and dry seasons. Average mean temperature is 26.6 $^0$C; average mean rainfall is 162mm; while average mean relative humidity is 77%.

Between1961 and 2010, temperature increased by 1.56 $^0$C; average rainfall decreased by 8.2mm; while average relative humidity decreased by 3.4%. There has been incremental warming, with highest increase in the dry season, which implies further proliferation of the leaf miner.

**Soils.** The soils of the study area and the greater part of the Nigerian palm belt, both wild and planted, is on the 'Acid Sands' soils (Corley and

Tinker, 2003). 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 ‘fascs’ (Vine, 1956) 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 (1990) system, they are dystric nitisols and dystric cambisols (Ojanuga *et al*., 1981).

**Sampling technique.** The study involved simple random sampling surveys for leaf miner on a plot 9 years old. Data collection was monthly for 24 months. It involved observing and counting of *C. elaeidis* and natural enemies. 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. The larval, pupal and adult stages of the *C. elaeidis* were counted. The independent variables were temperature, rainfall and relative humidity. The dependent variable is *Coelaenomenodera elaeidis* counts and its natural enemies. At each point, *C. elaeidis* were counted on fronds inclining at 45º (number 17 and 25 on the phyllotactic spiral). 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.

Parasitoids of *C. elaeidis* were identified and counted. The plot was planted in 2000 and comprised of 443 palms (2.95 hectares). Harvesting of plot 54 began in 2005. The plot was divided into 7 blocks (1 – 31 palms; 2 – 58 palms; 3 – 68 palms; 4 – 68 palms; 5 – 72 palms; 6 – 63 palms and 7 – 83 palms). We carried out leaf miner counts on the mature trees within specified blocks. 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. The most common predatory ants, *Micromischoides* sp., were identified and counted. Census on the basis of damage was done monthly by walking the full length of a planted line, assessing damage on each palm and cutting 5 severely damaged leaflets from a palm frond with a harvesting knife. The leaflets were opened up in the laboratory and immature stages of *C. elaiedis* were counted.

Parasitoids of C. *elaeidis* were identified and counted using the direct count method. Sampling was conducted monthly between 7 - 11am. Methods for insect sampling included use of insect sweep net, direct handpicking and leaflet sampling.

Field microhabitat temperatures were recorded (15:00 hrs) using the maximum and minimum thermometer placed at the centre of the experimental plot.

*Coelaenomenodera elaeidis*, its parasitoids, predatory ants and microhabitat temperature were statistically correlated using the SPSS software. Correlations were drawn between temperature data with the insect pest data collected so as to establish links between temperature changes and the formation of microhabitats in the oil palm plantation.

## RESULTS

Correlation is a step in the data interpretation process. Correlations between microhabitat temperature, leaf miner and natural enemies (parasitoids and predatory ants) across the study period are presented in Table 1. It is clear that there were no significant difference ($P \geq 0.05$) between microclimate temperature, leaf miner, parasitoids and predatory ants for both 2009 and 2010.

TABLE 1. Correlation between Microhabitat Temperature, Leaf miner and Natural enemies for Jan. 2009 – Dec. 2010 at NIFOR in Nigeria

| Year/Temperature | Leaf miner | Parasitoid | Predator |
|---|---|---|---|
| Microhabitat temperature 2009 | 0.414(0.181) | - 0.301(0.342) | - 0.247(0.438) |
| Microhabitat temperature 2010 | - 0.037(0.908) | - 0.536(0.072) | 0.572(0.052) |

*Significance $P \leq 0.05$

Table 2 shows seasonal correlations between leaf miner and natural enemies (parasitoids and predatory ants) under given microhabitat temperatures. In 2009, leaf miners were significantly different (P = 0.018) in the dry season. In the rainy season, parasitoids were more significant (P = 0.085). In 2010, predatory ants were significantly different (P = 0.041) in the rainy season.

## DISCUSSION

There was no statistical difference between microhabitat temperature, leaf miner and natural enemies across the years of study (Table 1). It could be inferred that the use of annual total insect pest and natural enemy population counts for correlation with microhabitat temperature cannot indicate trends of population dynamics. This is however strikingly different for seasonal pest and natural enemy correlations.

The abundance of *C. elaeidis* was found to be related to the seasonal temperature patterns (Table 2). The increase in its population in the dry season could be attributed to higher seasonal temperatures. It could be inferred that the leaf miners are more responsive to microhabitat temperature than the natural enemies. This could be as a result of the parasitoids spending most of its life cycle in the leaf miner inside the oil palm leaflet mines; and the predatory ants residing mainly underneath palm leaflets and shrubs.

Generally, the dry season recorded more abundance in the leaf miner and predatory ants while the rainy season recorded more of the parasitoids in both 2009 and 2010. The abundance of leaf miners in the dry season could be attributed to an increase in temperature. Its control could be optimally effected during this period. Parasitoids (*Cotterellia podagrica)* were observed to be more abundant in the rainy season and would have a control effect on leaf miners which were in lower numbers during this period. Predatory ants (*Micromischoides* sp.) were observed to be visible on oil palm leaflets all year round. The ants were significantly different in the rainy season. This would also have a control effect on the leaf miners. Currently, the aseasonality of the insect pest fauna as a whole is attributed to the absence of severe weather

TABLE 2. Seasonal Correlation between Microhabitat Temperature, Leaf miner and Natural enemies for January 2009 – December 2010 at NIFOR in Nigeria

| Year/Temperature | Dry season | | | Rainy season | | |
|---|---|---|---|---|---|---|
| | Leaf miner | Parasitoid | Predator | Leaf miner | Parasitoid | Predator |
| Microhabitat temperature 2009 | 0.938*(0.018) | -0.018(0.977) | 0.388(0.518) | 0.036(0.939) | 0.692(0.085) | -0.173(0.711) |
| Microhabitat temperature 2010 | 0.117(0.851) | -0.563(0.323) | 0.421(0.480) | -0.726(0.065) | -0.278(0.546) | 0.775*(0.041) |

*Significance P≤ 0.05

variability conditions. This could change with higher mean temperatures.

The variations in the macroclimates of macrohabitats result from the physical presence of some habitat factors. The habitat factors, that are likely to give rise to microclimates in habitats, are the topography and vegetation of a habitat. Temperature in this oil palm microhabitat could help explain fluctuations in insect pest populations within and between years. Knowledge of microhabitat temperatures and insect pests of the oil palm would contribute to pest management techniques.

This study has shown relationships between leaf miner populations, its parasitoids, predatory ants and the temperature of its microhabitat. Links between temperature increase and insect pests will increase the severity of threats associated with climate change and variability.

The oil palm plays a dominant role in supporting rural livelihoods and economic growth over most of Southern Nigeria. The assessment of the sensitivity of leaf miner to variability in temperature conditions is important, so as to aid its control.

## CONCLUSION

This study has demonstrated that the composition and analysis of insect pest population dynamics and their seasonal abundance could provide a useful guide to a better understanding of space-time variability in oil palm ecosystems. Weather influences the seasonal population dynamics of *C. elaeidis*, its parasitoids and predatory ants facilitating early season build-up on oil palm which acts as a host crop. It indicates that the oil palm ecosystem is becoming vulnerable to insect pest attack as a result of increasing temperature, which if unabated would have severe consequences to its structure and function. There is need to strengthen pest management systems to cope with increased threats from insect pests.

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