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Full Length Research

Alternate host plants of *Phenacoccus manihoti)* Matile - Ferrero (Homoptera : Pseudococcidae), the cassava mealybug

Essien, Rosemary Anietie[1]*, Odebiyi, Johnson Adebayo[2] and Ekanem, Mfon Sunday[3]

[1]Department of Crop Science, Akwa Ibom State University, P.M.B 1167, Uyo, Akwa Ibom State, Nigeria.
[2]Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria.
[3]Department of Zoology, University of Uyo, Uyo, Akwa Ibom State, Nigeria.

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Thirteen alternate host plants of *Phenacoccus manihoti* were identified during a field survey of cassava plots in Ibadan, Nigeria. The host plants were screened in the laboratory to determine their attractiveness to *P. manihot.* More eggs were laid by *P. manihoti* on two host plants *Talinum triangulare* (Portulacaceae) and *Ageratum conyzoides* (Compositae). These two host plants were found to support all life stages of the pest. Further laboratory studies to compare *P. manihoti* preference to *T. triangulare (water leaf), A. conyzoides* (goat weed) and the primary host plant, *Manihoti esculenta* (cassava) showed that while pre and post-oviposition periods were similar and shorter in *P. manhoti* fed with *T. triangulare* and *M. esculenta,* the periods were significantly longer (P<0.05) with *A. conyzoides.* The larval sizes of *P. manhoti on A. conyzoides* were significantly smaller and developmental period significantly (P<0.05) longer than those fed with *T. triangulare* and *M. esculenta*. The total life span of *P. manihoti* on *A. conyzoides* was significantly shorter, and its mortality rate higher than those fed with *T. triangulare* and *M. esculent*a. There was similarity between the growth rates on *T. triangulare* (5.40) and *M. esculenta* (5.10) while on *A. conyzoides* there was a significantly lower rate (3.10). Egg laying was significantly (P<0.05) lower on *A. conyzoides* (140 eggs) than on *T. triangulare* (393) and *M. esculenta* (370). Of the two alternate hosts, *T. triangulare* is the most attractive alternate host of *P. manihoti* in the Ibadan area. This study shows that some weeds could harbour the pest, pending when the primary host is available. Therefore, weeds and some vegetables especially T.*triangulare* should not be allowed in cassava farms.

Key words: Alternate host, goatweed, Larvae, *M. esculenta P. manitoti,* waterleaf.

INTRODUCTION

Most insects are polyphagous, thus apart from their host plants, they also have alternate hosts which may support their population when the major host is scarce. This habit may enable them to breed throughout the year, or survive in adverse seasons until the major host is in abundance. Consequently in most cases, planting of a different crop, or leaving of some weeds is usually essential in maintaining the insect population during adverse periods. *Phenaccocus manihoti* (cassava mealybug) is a serious pest of cassava (Egho *et al*., 2013). Le Ru *et al. (*1993) had reported that infestation of cassava by mealybug resulted in yield losses ranging between 52 and 58% in 12 months old plants in Nigeria.

Although Cox and Williams (1981), and Akinlosotu (1983,) had reported that *P. manihoti* appeared to be specific on *manihoti spp.* Iheagwam (1981), Umeh (1983), and Souissi (1998) had also observed *P. manihoti* on other plants, mainly shrubs. Egho *et al,* (2013) had recorded nine (9) host plants of *P. manihoti* in Osimeli

*Corresponding author: E-mail: rosemary.essien@yahoo.com Tel: +234-8027022191

cassava producing area of Nigeria. Thus understanding of the host range of *P. manihoti* would help farmers to adopt good cultural practices, such as removing alternate host plants within and around their farms, knowing that these alternate hosts serve as targets for *P. manihoti* (David *et al.,* 2011). Jago (1993) had reported that weeds not only compete for water and nutrients with the crop, but also provide hiding places for insect pests. This study was therefore designed to investigate the alternate hosts of *P. manihoti* and their significance in the survival of this insect pest.

MATERIALS AND METHODS

Survey of *P. manihot alternate* host plants

Weeds in the cassava plots under study were examined monthly for *P. manihoti* and its various life stages. This observation continued until the cassava was harvested. Since the plots were routinely weeded, the weeds were carefully examined for *P. manihoti* before weeding. Weeds with *P. manihoti* infestation were noted, collected, and taken to the laboratory in paper bags for identification and screening.

Screening

Thirteen alternate host plants of *P. manihoti* identified during the general survey were subjected to screening in the laboratory, (Table 1). In order to maintain regular supply of weeds for screening, seedlings of the desired weeds, were collected from the field and planted on small beds in the crop garden of the Department of Crop Protection and Environmental Biology of the University of Ibadan, Nigeria. Leaves used for the screening were obtained from this nursery. Screening was done in 18.3 × 8.8 × 6.3cm plastic rearing units with transparent lids and perforations on four sides. Three of the perforations were covered with fine nylon mesh for aeration. Whamann filter paper, 11.0cm in diameter was placed on the bottom of the rearing unit to absorb excess water, and control humidity.

From 8 weeks after planting, the expanded leaves of the weeds in the nursery were excised and screened as follows: A specimen tube 2.5cm in diameter was filled with water. The cut end of the screened leaves were wrapped in cotton wool and inserted into the specimen tube. The cotton wool held the leaf in place without damaging the petiole as well as preventing spilling of the water. The specimen tube was placed in the rearing unit and the closed end pushed out through the remaining perforation of the rearing unit. The lid was then put in place to complete the unit. Day old adults of *P. manihoti* were placed individually on each of the host leaf and the transparent plastic lid was then put in place to complete the rearing unit. The units were observed daily for eggs which were removed and counted. The insects were allowed to oviposit for 14 days. There were 10 replicates for each of the alternate host plants. At the end of screening, host plants that supported large number of eggs of *P. manihoti* were selected for further biological studies (Table 1).

P. manihoti culture for life cycle studies

To establish a culture of *P. manihoti* on each selected host plant, the host plant was initially planted in plastic pots filled with garden soil and placed in the screen house of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria, and watered regularly. Four to six weeks after sprouting, the selected plants were inoculated with 24 hours old *P. manihoti* first instars (crawlers) obtained from the egg masses collected from the respective screening materials. The infested plants were observed from time to time and more crawlers were added when needed until the population of *P. manihoti* became established on each of the selected host plants. Old and dying plants were replaced with fresh clean ones inoculated from the infested plants. In this way, the *P. manihoti* culture was maintained and formed the source from which specimen needed for this experiment were collected.

Comparative biology of *P. manihoti* on three host plants

The comparative biology of *P. manihoti* was studied on the two host plants selected from the general screening experiment (Table 1) along with the primary host, *M. esculenta* (cassava).The other two hosts were, *Talinum triangulare* (water leaf) and *Ageratum conyzoides (*goat weed*)*. The cassava variety used was the local type 'Odongbo'. Each of the clean test plant raised in plastic pots, was individually placed in a cage, and infested with 24 hour old adult *P. manihoti* collected from the mass culture. The number of eggs laid on each test plant was noted daily and subsequently incubated in a second rearing unit which consisted of a plastic Petri dish of about 8.5cm diameter and a lid with an opening of about 3cm in diameter. The opening was covered with fine nylon mesh for aeration. Whatmann filter paper 8.5cm in diameter was placed on the floor of each petri dish before use. The first nymphal instars which emerged were transferred individually with a wet camel hair brush onto the excised leaves of each host plant in the plastic rearing unit. The development of ten (10) of these *P. manihoti* crawlers on each host plant was studied, and each host plant was replicated three (3) times. A total of the developments of 30 crawles were thus studied per host plant. Their development to adult stage was followed

Table 1. List of alternate host plants of *P. manihoti* and mean number of eggs laid on each host plant in the laboratory.

Host Plant/Families	Plant type	Mean eggs laid/female
Compositae		
Aqeratum conyzodies (L).	Weed	17.0± 3.80 *
Sydrella nodiflora (L).	Weed	2.0± 1.50
Aspilla spp.	Weed	2.0± 0.71
Chromolaema odorata	Weed	2.0± 1.18
Euphorbiaceae		
Euphorbia heterohylla (L)	Weed	5.0± 1.48
Euphorbia hirta (N.E.Br).	Ornamental	2.0± 0.84
Phyllanthus amarus (L).	Weed	2.0± 0.84
Tiliaceae		
Corchorus spp. (L).	Vegetable	3.0± 1.26
Portulacaceae		
Portulaca oleracea (L).	Weed	8.0±.2.20
Tainum triangulare (Jacq).	Vegetable	22.0± 5.38 *
Rubiaceae		
Oldenlandia corymbosa (L)	Weed	1.0₊ 0.40
Uriticaceae		
Fleurya aestuans (L).	Weed	1.0± 0.54
Amaranthaceae		
Amaranthus spp (L).	Vegetable	4.0± 1.55

*Selected for biological studies

daily by observing for exuvium which was an indication of moulting. The rearing units were cleaned and new food plant supplied daily. Developmental data taken were the average duration of nymphal instars (av), percentage larvae producing adults (n), the growth index as (n/av),

$$\text{Where Growth Index, } = \frac{\%\ \text{Adult obtained (\%n)}}{\text{Mean larval period (av)}}$$

(Rao and Patel, 1974) and percentage mortality at each stage of development.

The immature stages were measured under a stereomicroscopes equipped with a micrometer.

RESULTS

Results from the general survey (Table 1) showed that 13 plants belonging to 7 families were found to harbour *P. manihoti.* This number included mainly weeds which accounted for about 69% of the total host plants, vegetables accounted for 23%, and ornamentals l8%.

Among the plants, *T. triangulare, A. conyzoides, Euphorbia heterophylla* and *Portulacea olearacea* had haboured all the developmental stages in the field. However, the characteristic curling of the apical leaves found in cassava was absent on these host plants. Apart from these four host plants, others had contained only one or two stages of development of the *P. manihoti*. They were latter considered as fortuitous hosts.

The result of the general screening of the host plants (Table 1) showed that the highest number of eggs (22) was laid by *P. manihoti* on *T. triangulare* a vegetable commonly found in cassava plots. This was followed by *A. conyzoides* on which 17 eggs were laid. The less attractive hosts for oviposition were *O.corymbosa* and *F. aestum* with about one egg respectively laid within a period of 14 days.

Life cycle

The developmental periods of the different stages of *P. manihoti* on three different host plants are shown in Table 2. There was no significant difference between the total

Table 2. Developmental Period (days) of different life stages of *P. manihoti* reared on excised leaves of 3 selected host plants (Range in Parenthesis)

Host plants	Egg	n*	1st instar	n*	2nd	n*	3rd	n*	4th instar (preovipositing adult)	n*	Mean period of nymphal development
Talinum triangulare	5.90 ± .04a (4-8)	30	6.46±.04a (4-8)	29	4.48 ± 04a (3-6)	28	6.32 ± .04a (5-8)	27	5.01 ± 03a (4-6)	27	17.26 ± .12a (12-22)
Ageratum conyzoides	8.47 ± .05b (6-10)	30	9.52 ± 07b (7-11)	25	7.08 ±.06b (5-9)	20	6.72 ± 06a (6-8)	18	6.68 ± 06a (5-8)	18	23.43 ± .19b (18-28)
Manihoti esculenta (control)	6.07±.04a (5-8)	30	6.0 ± .05a (3-9)	27	4.83 ±.04a (3-6)	26	6.0 ± .05a (4-8)	24	4.56 ± .04a (3-6)	23	16.83 ± .14a (10.23)

n* number observed
Mean followed by the same letter in a column are not significantly different (P<.05) (Duncan Multiple Test)

duration of the immature stages of *P. manihoti* reared on *T. traingulare* and *M. esculenta* but this total duration was significantly higher on *A. conyzoides* than on the other two host plants. Except for the 3rd larval instar, the developmental period of each life stage of *P.manihoti* was significantly higher on *A. conyzoides* than on both *M. esculenta* and *T. triangulare.* The total nymphal developmental period of 23.4 days on *A. conyzoides as* compared with 17. 3 days on *T. triangulare and* 16.8 days on *M. esculenta* was significantly lower (Table 2). More adults resulted from the initial number of larvae reared on *T. triangulare* than on *A. conyzoides*. (Table 2)

Larval growth on the different host plants

The mean lengths of larval instars reared on the three host plants are shown in Table 3. The mean length of the first larval instars reared on *M. esculenta* were significantly longer than those on the other host, but there was no significant difference in the mean length of the second instars on the three host plants. There were no significant differences between the lengths of the third and fourth instars reared on *T. triangulare* and *M.esculenta*. These instars were significantly smaller on *A. conyzoides* than on the other two host plants. The lengths of the third instar ranged from 0.87mm on *A. conyzoides* to1.28mm on *M. esculenta,* while the fourth instar length ranged from 1.28 to 1.82mm, respectively.

There was no significant difference between the Growth Index (Rao and Patel, 1978) of *P. manihoti* on *T. triangulare* (5.40) and on the major host *M. esculenta* (5.10). However, the growth index of *P. manihoti on A. conyzoides* (3.10) was lowest (Table 4). A 40% higher mortality was observed among immature stages of *P. manihoti* reared on *A. conyzoides,* while 23% mortality was recorded on *M. esculenta,* and the lowest mortality of 10% was recorded on *T. triangulare (*Table 4).

Effects of different host plants on the reproductive parameters and longevity of *P. manihoti*

The influence of host plants on the reproductive parameters and longevity of *P. manihoti* are presented in Table 5. The preoviposition, oviposition and post-oviposition periods of *P. manihoti* were not significantly different between the primary host, *M. esculenta,* and *T. triangulare.* However, the preoviposition period of 6.7 days on *A. conyzoides* was significantly higher (P < 05) than on *M. esculenta* (4.7days) and *T. triangulare* (5 days) respectively. The oviposition period of *P. manihoti on* A. conyzoid (10days) was about half that on the other two host plants (Table 5), while the post oviposition period (4days) was significantly higher on *A. coryzoides* than on the other two host plants. Similarly, the fecundity of *P. manihoti* on *A. conyzoides* (140eggs) was significantly lower than the number of eggs laid on *M. esculenta* (370 eggs) and on *T. triangulare* (393 eggs) respectively.

The daily oviposition pattern of *P. manihoti* on *M. esculenta* (Figure 1) commenced on the fifth day of adult life, reached a peak (69 eggs) on the second day and oviposition continued for an average of 20.9 days, during which a total of 370 eggs were laid per female at an average rate of 17.7 eggs per day. Egg laying on *T. triangulare* also started on the fifth day of adult life and reached a peak of 56 eggs on the fourth day. Oviposition lasted for 21.7 days during which a total of 393 eggs were laid per female at an average rate of 18 eggs per day (Figure 2). The daily pattern of egg laying by *P. manihoti* on *A. conyzoides (*Figure 3) shows that egg laying started on the seventh day of adult life and reached a peak of 32 eggs on the second day of oviposition. Oviposition continued for 10 days, during which period a total of 140 eggs per female were laid at an average rate of 14 eggs per day. There was no significant difference between the life span of the adult *P.*

Table 3. Measurements (mm) of the immature stages of *P. manihoti* reared on three selected Host Plants (Range in Parenthesis).

Host plants	N*	Egg	N*	1st Instar	N*	2nd Instar	N*	3rd Instar	N*	4th Instar (Pre-ovipositing adult)
Talinum triangulare (waterleaf)	30	Length 0.36 ± .006a (0.31-0.40)	30	Length 0.50 ± 01a (0.42-0.73)	27	Length 0.71±014a (0.55-0.94)	27	Length 1.21±.017a (0.88-1.48)	27	Length 1.78±.023a (1.04-2.81)
		Width 0.20 ± .005 (0.18-0.23)		Width 0.25 ±.00 (0.18-0.39)		Width 0.36 ±.011 (0.26-0.57)		Width 0.66±.015 (0.47- 0.96)		Width 0.85±.017 (0.55-1.40)
Ageratum conyzoides (Goatweed)	30	Length 0.35±.005a (0.29-0.39)	30	Length 0.47±.011a (0.39-0.70)	20	Length 0.64±.017a (0.42-0.81)	18	Length 0.87±.013b (0.65-0.99)	18	Length 1.28 ±. 022b (0.96-1.64)
		Width 0.20 ±.005a (0.16-0. 21)		Width 0.21±. 007 (0.18-0.34)		Width 0.30±. 0.11 (0.23-0.42)		Width 0.46±.015 (0.36-0.68)		Width 0.69±. 021 (0.55-0.89)
Manihoti esculenta (cassava)	30	Length 0.36 ±.01a (0. 31-0.42)	30	Length 0.67 ±.01b (0.49-0.75)	24	Length 0.78±.02a (0.52-1.12)	23	Length 1.28 ± .023a (0.91-1.59)	23	Length 1.82 ± 026a (1.17- 2.37)
		Width 0.20±.05 (0.16-0.23		Width 3.33 ±009 (0.18-0.42)		Width 0.40 ± .011 (0.29- 0.52)		Width 0.59 ± .015 (0.47-0.83)		Width 0.89 ± .018 (0.68-1.17)

N*Number of Insects
Means followed by the same letter (s) in a row are not significantly different (p<.05) (Duncan's Multiple Range Test)

Table 4. Growth Index of *P. manihoti* reared on different host plants.

Host plants	No. of Larvae Observed (n)	Mean Larvae Period days (AV)	Adult obtained No.	Adult obtained %(n)	Growth Index
T. triangulare	29	17.26± .12a	27	93.10	5.40
A.conyzoides	25	23.43± .19b	18	72.0	3.10
M. esculenta	27	16.83±.14a	23	85.19	5.10

Means followed by the same letter (s) in a column are not significantly different at P<.05. (Duncan's Multiple Range Test).

manihoti reared on *M. esculenta* (28days) and *T. triangulare* (29 days) (Table 5). However, the longevity of *P. manihoti* on *A. conyzoides* was significantly shorter (21 days) than of the two other host plants.

DISCUSSION

Although 13 alternate host plants for *P. manihoti* had initially been identified, after the preliminary screening these were finally narrowed down to two (2). It may be suggested that 11 out of the 13 plants are not preferred by *P. manihoti,* but rather, were used to tide over a difficult period pending a favourable time when the preferred host plants will be available. This result agrees with Hsiao and Fraenkel (1968a) who had postulated that the initial acceptance of a plant as food by an insect does not necessarily mean that the plant will support growth and development. The period during which the *P. manihoti* were found on other hosts coincided with a period of leaf fall from cassava due to high *P. manihoti* population, and therefore a high competition for space and food among the insect. As a result, there was probably a spillover of *P. manihoti,* and the victims had to take refuge on the substrate which they fell on.

Larvae reared on *A. conyzoides* were generally smaller

Table 5. Effects of the different host plants on the reproductive parameters and longevity of *Phenacoccus manihoti*. Data in Mean±standard deviation with range in parenthesis.

Host Plant	Preoviposition period	Oviposition period	Post oviposition period	Fecundity period	Longevity
Talinum triangulare	5.01± 83a (4-6)	21.69 ±6.79a (7-30)	2.70±0.72a (2-4)	393± 105a (109- 546)	29.34± 8.34a (13-40)
Ageratum conyzoides	6.69± 1.07b (5-8)	10.0± 4.14b (5-21)	4.0± .87b (3-5)	140 ± 60b (53-289)	20.69b±6.08b (13- 34)
Manihoti esculenta	4.72±.78a (3-6)	20.85± 6.53a (8-28)	2.54± 60a (2-4)	370± 118a (148-508)	28.11± 7.9a (13-38)

Means followed by the same letter with same column are not significantly different (P<05) (Duncan Multiple Range Test)

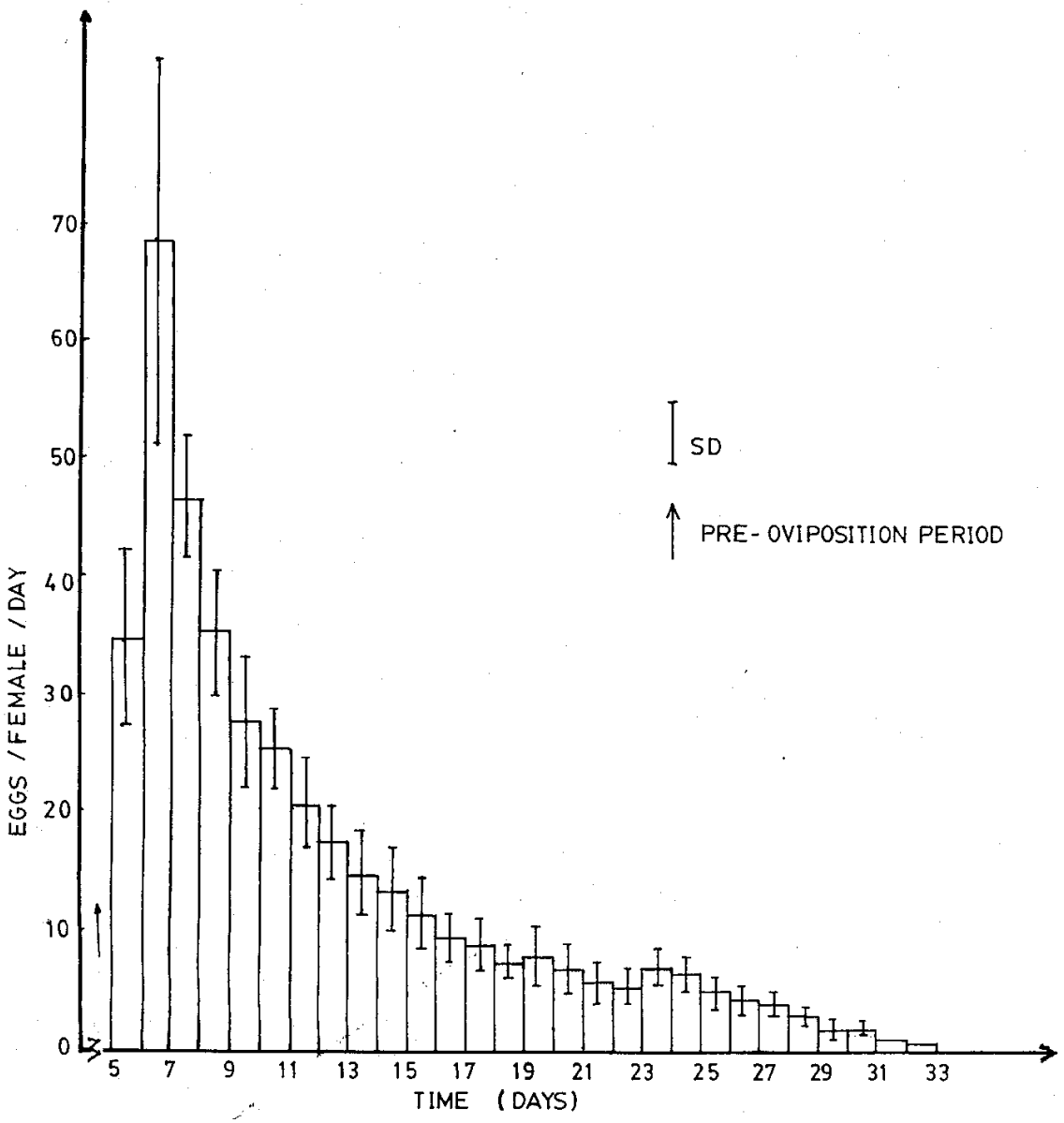

Figure 1. Daily oviposition pattern of *P. manihoti* reared on *Manihot esculenta* (cassava).

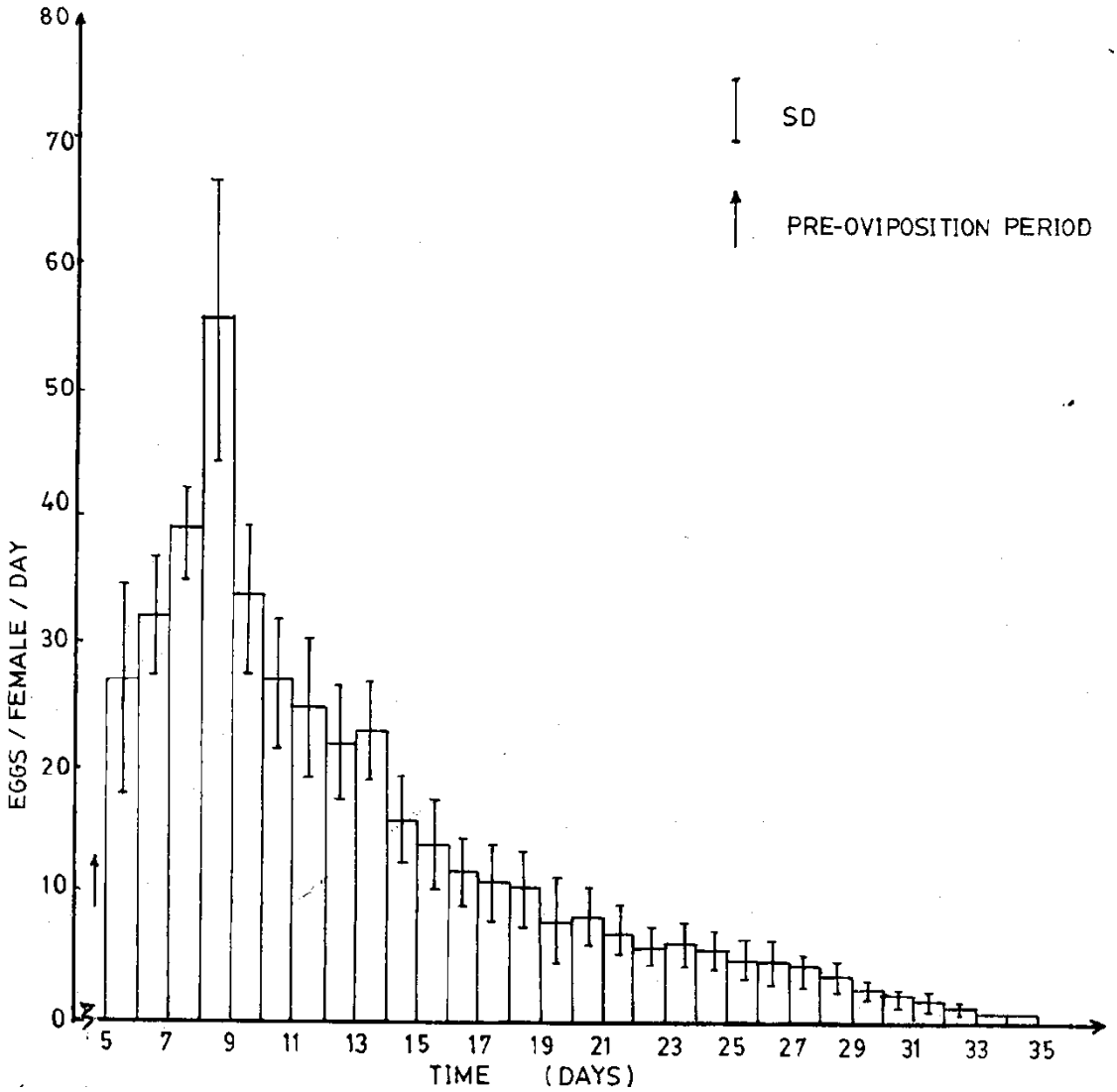

Figure 2. Daily oviposition pattern of *P. manhoti* reared on *Talinum triangularie* (water Leaf).

and required a longer period to complete development. Although the biochemical properties of the weed hosts were not investigated, it is possible that the long larval period of *P. manihoti* on *A. conyzoides,* could be as a result of the quality of the nutrients available in this weed which did not promote rapid growth of the immature stages. This may also explain the high mortality rate recorded among larvae reared on this weed. Insect larvae have to grow to a certain size for adult organs to be well developed. Wigglesworth (1965) and Chine and Highland (1985), have explained that all the requirements for growth and development in adult insects depend upon the adequacy and quality of its nutrition during the larval stages. Hsiao and Fraenkel (1968b) had also found a similar longer larval period in the potato beetle fed on secondary host plants, than when fed on the major host plant.

The high Growth Index of *P. manihoti* larvae reared on *T. triangulare* showed that this vegetable is the best diet among the three tested host plants for effective rearing of *P. manihoti* in the laboratory. This agrees with the findings of Souissi *et al.* (1998), who had observed a high population of *P. manihoti* on *T. triangulare* than on other *Manihot species*. He further reported that *T. triangulare* would be a better host plant for mass rearing of *P. manihoti* in the laboratory. However, rearing the insect with the major host also gives a satisfactory growth response. The acceptance of *T. triangulare* by *P. manihoti* probably means that this shrub commonly shares compounds of the same chemical classes with cassava the major host plant, although they are not related taxonomically. Enrlich and Raven (1964), and Renwick and Radke (1981) reported that the adaptation of an insect to a particular compound in one host plant confers similar adaptation to colonizing other plants containing similar compounds. Also, the leaf of *T.*

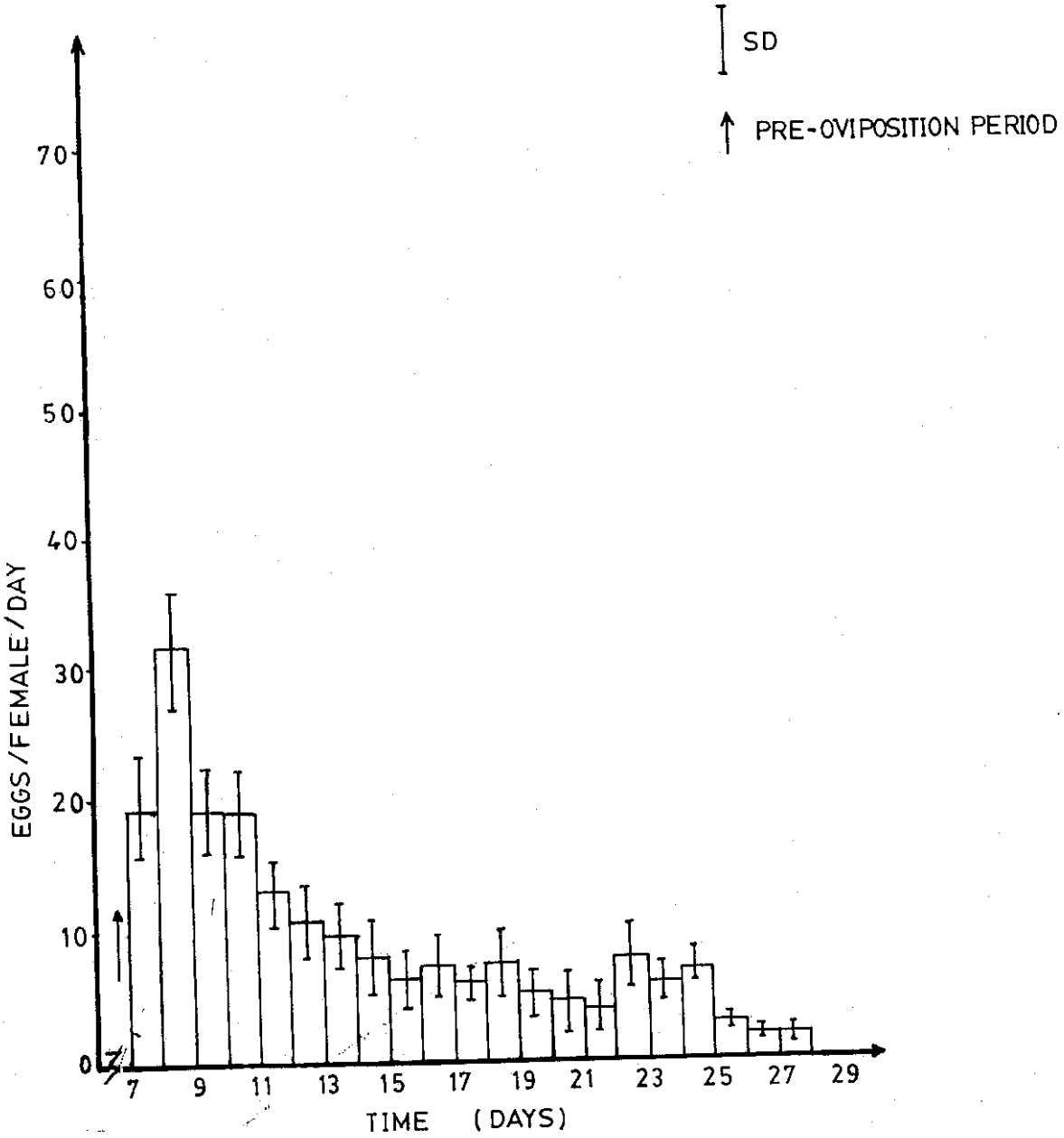

Figure 3. Daily ovipostion pattern of *P.manihoti* reared on *Ageratum conyzoides* (Goat weed).

triangulare is heavier than that of cassava and is known to contain a lot of water which is essential for growth and development in insects.

The preoviposition and post oviposition periods were maximum and the oviposition period minimum when the insect was fed on *A. conyzoides.* This was also reflected on its egg laying capacity which was the poorest. The poor egg production could probably be related to the size of the adults resulting from the larvae reared on this weed. In spite of this, the results indicated that the weed can support the tide over of one generation to the next when the primary host is unavailable. The differences in the production of egg by *P. manihoti* on the different host plants used in this study has also confirmed the finding of Wigglesworth (1965), Engelmann (1970), Chine and Highland (1985), that the food an insect has eaten as a larva helps to determine the oviposition responses of the adult female. It is known that for a variety of insect species, feeding is essential for egg maturation and increased egg production. According to Geering and Coaker (1960), who worked on the natural food for *Dysdercus superstitious*, insects may lay eggs when fed

on secondary hosts but their egg production may be rather poor.

Although in this study, there was no significant difference between the average number of eggs laid by *P. manihoti* reared on the primary host and those reared on *T. triangulare,* the slightly higher egg production recorded among adults fed on *T. triangulare,* may be as a result of longer ovipositional period of *P. manihoti* on this vegetable. Trouvelot and Grison (1935) in studying the influence of solanaceous plants on the fecundity of potato beetles, had found that egg production varied significantly when different plants were used.

There was no significant difference between the longevity of adult *P. manihoti* reared on *M. esculenta* and *T. triangulare.* However, the life span of this insect on *A. conyzoides* was significantly shorter than on both *M. esculenta* and *T. triangulare*. The differences in the longevity of *P. manihoti* reared on the different host plants probably reflects the differences in the quality of food on which they were reared. Chine and Highland (1985) had observed similar variations in the life span of stored product insects on various food components. Lukefahr and Martin (1964) had also observed variations on the life span of adult bollworm reared on three different diets. Variation in the longevity of adult dark sided cutworm *Euxoa messoria* was also noticed when they were fed on different substrates (Cheng 1973).

This study showed that weeds in the cassava farm are capable of supporting the growth and development of *P. manihoti* and form the initial inoculums from where the pest will move onto the cassava plants (Alex *et al.,* 2000). Weeds should not be ignored in cassava plots, especially in late planting cassava plots. Weeds should be removed to discourage the pest from gathering in the farm and subsequently attack the crops and cause damage and losses. Braima *et al*. (2000) had suggested that cassava farms should be weeded about three times before harvest. This way, the weeds habouring the pest are removed. *T. traingulare* is a cherished vegetable and is usually cultivated in most parts of Nigeria for culinary purposes. However, because of its role as an important secondary host plant of *P. manihoti*, its cultivation should not be mixed with cassava on the same plot.

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