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Biology of *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) on Five Yam Varieties in Storage

Emmanuel Asiedu, Jakpasu Victor Kofi Afun, Charles Kwoseh

Department of Crop and Soil Sciences, College of Agriculture and Natural Resources,
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
Email: knustasiedu@yahoo.com

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Abstract

Yam is an important staple cash crop, which constitutes 53% of total root and tuber consumption in West Africa. It is a cheap source of carbohydrate in the diets of millions of people worldwide and in tropical West Africa. However, attack by *Planococcus citri* results in shriveling of the tubers, making them become light and unpalatable. They also lose their market value. The total number of eggs laid, incubation period, developmental period and adult longevity of *P. citri* on stored yam *Disocorea* species were studied on five yam varieties namely *Dioscorea rotundata* var. Pona, *Dioscorea rotundata* var. Labreko, *Dioscorea rotundata* var. Muchumudu, *Disocorea alata* var. Matches and *Dioscorea rotundata* var. Dente in the laboratory with ambient temperatures of 26.0˚C - 30.0˚C and relative humidity of 70.0% - 75.0%. The mean life spans of the female insect that is from hatch to death on *Dioscorea rotundata* var. Pona, *Dioscorea rotundata* var. Labreko, *Dioscorea rotundata* var. Muchumudu, *Disocorea alata* var. Matches and *Dioscorea rotundata* var. Dente were 62.4, 63.5, 66.8, 67.3 and 69.8 days, respectively and those of the male were 23.8, 25.3, 29.6, 30.2 and 33.5 days, respectively. The adult female lived longer than the adult male. The findings showed that citrus mealybug preferred *Dioscorea rotundata* var. Pona to the rest of the varieties, as it developed faster and laid more eggs (497.0 eggs) on it than on the other varieties. This implies that citrus mealybug multiplies faster and destroys *Dioscorea rotundata* var. Pona tubers in storage faster than on the other varieties. Therefore, *Dioscorea rotundata* var. Dente should be the preferred yam for long-term storage.

Keywords

***Planococcous citri*, *Dioscoreaceae*, *Dioscorea rotundata*, *Dioscorea alata*, Developmental Period**

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1. Introduction

Planococcus citri commonly known as citrus mealybug is a polyphagus species known from all zoogeographical regions [1]. It belongs to the Class Insecta, Order Hemiptera, Family Pseudococcidae, Genus *Planococcus* and Species *citri* [2]. The citrus mealybug (a short-tailed mealybug) is a soft-bodied pseudococcid. Its life cycle (egg-to-egg-laying adult) duration ranges from 20 to 44 days [3]. The citrus mealybug female can produce about 600 eggs that are laid in groups in cottony structures called ovisacs. Generally, within two to 10 days, new mealybugs (crawlers) emerge and start to go out of the ovisac [4].

The male *P. citri* has four nymphal stages during its development and each larval stage is separated by a molt. The male nymph is more elongated or narrower and often occurs in a loose cocoon. Based on laboratory studies on coffee leaves, the first male nymphal stage lasts for seven to 14 days, the second, six to 16 days, the third, two to three days, and the fourth, one to six days [4]. Approximately four days into the male second instar, a black tinge that is easily discernible develops around the insect body. Two days later, the nymph starts spinning cocoon around itself. This cocoon is continuously spun increasing in density until the winged adult mealybug is ready to emerge two molts later [4]. The adult *P. citri* male is a tiny two-winged gnat-like insect. It has an elongated body**,** reddish in colour and has two long filaments at the rear end. Male mealybugs live for two to four days after the final larva molt (a short-lived insect) [3] [4].

The female has three nymphal stages called instars with each larval stage separated by a molt. The immature or nymph resembles adult female in appearance except that it is smaller. The first nymphal stage lasts seven to 17 days, the second five to 13 days, and the third five to 14 days [4]. Females live for about 88 days as adults and may start laying eggs 15 to 26 days into her adult life [4].

The eggs are oblong in shape, pale yellow or pink in color and are in clumps of five to 20 inside egg sacs composed of white cottony-waxy filaments. The first-instars (crawlers) are very active, oval in shape, yellow in color with six segmented antennae which lack waxy coating on the body and are often found congregated upon the egg sac. The second-instar larva is bigger than the first instar. It is oval in shape, yellow in color and has six segmented antennae. The third-instar larva resembles the larger adult female and is recognized readily by its yellowish body colour, seven segmented antennae and its larger anal ring; [3] [5].

The adult *P. citri* female has an elongated oval body about 3 mm long and 1.5 mm in width, flat with 18 pairs of short-waxy filaments around the margin of the body 17 of which are equal and the anal one slightly longer (no more than double the length of the others). The body color is mainly brownish yellow, covered with powdery wax through which distinguished transverse lines of segmentation appear. It is wingless and has eight-segmented antennae [3].

The citrus mealybug attack new shoots and leaves of a wide range of greenhouse and indoor plants including apple, avocado, citrus, English ivy, ficus, gardenia, jasmine, oleander and orchard crops in many temperate and tropical regions [6]. The nymphs and adult females damage hosts by sucking out plant sap, by excreting honeydew on which sooty mould can grow and by causing distorted growth and premature leaf senescence with their toxic saliva [7] [8]. A very late but major sign of their presence is the appearance of sooty mould on infested hosts. Black sooty mould fungi are detrimental to plants because they cover leaves, thus reducing photosynthesis and inducing plant stress.

Yams are monocotyledonous of the family *Dioscoreaceae* and genus *Dioscorea* and consist of more than 600 species but only six species are important as staple crops consumed in West Africa [9] [10]. *Dioscorea rotundata* Poir (White yam) and *Dioscorea alata* L. (Water yam) together make up about 90% of world production of food yams [11]. The preferred yam species in West Africa is the white yam (*D. rotundata*) since this generally produces tubers with a high dry-matter content that is good for pounding *fufu* [9]. Water yam (*D. alata*, native to Southeast Asia) is gaining popularity in sub-Saharan Africa because it is easier to propagate than the native white yam [9].

In Ghana, yam is a very important indigenous subsistence and cash crop that is now the most popular non-traditional export food crop, despite years of scientific neglect [12]. *P. citri* is now one of the major pests of stored yam tubers in Ghana. Infestation of stored tubers by *P. citri* results in shriveling of the tubers, making them become light, fibrous and unpalatable and therefore, lose their market value. Their attack also predisposes the yams to fungal infection leading to rotting of tubers, and badly affected tubers fail to sprout if planted [13].

Generally, control of mealybugs with insecticides is difficult because they tend to hide in protected locations and form dense colonies. The mealybugs' waxy covering also helps to protect them from chemical contact, successful control requires repeated insecticide applications directed against immature stages of mealybugs [14].

There is, however, not much information on the biology of *P. citri* on stored yam either locally or from the West African sub-region. The goal of this study therefore, was to determine the relative susceptibility of the five major yam varieties in Ghana to *P. citri* attack. The specific objectives were to determine the incubation period, development, longevity, and reproduction parameters of *P. citri* on the yam varieties. The results obtained in this study may provide useful information for designing a comprehensive pest management program for citrus mealybug on stored yam.

2. Materials and Methods

2.1. Test Yam Samples

Four varieties of *D. rotundata* (Pona, Labreko, Dente and Muchumudu) and one of *D. alata* (Matches) were selected based on consumer preference for the studies. These varieties were randomly selected from improved yam barns in Ejura in Ejura-Sekyedumase District a predominately yam growing area in the Ashanti Region and were maintained in the screen house of Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi.

2.2. Laboratory Culture of *P. citri*

P. citri adults were collected from yam barns and introduced onto tubers of *D. rotundata* var. Dokoba to ensure that mealybugs used for subsequent experiments developed from a common food source (standardization of mealybugs). Three tubers of *D. rotundata* var. Dokoba were placed in 30 × 30 × 60 cm wire mesh cage with five replications and the mealybugs allowed to oviposit for 72 hours after which the mealybugs were removed from the tubers with a standard aspirator leaving the egg sacs "*in situ*".

The eggs were allowed to develop into adults and produced ovisacs. 50 eggs were collected using a paintbrush (No.000) (American Painter 4000, Loew-Cornell Incorporated Englewood Cliffs, New Jersey) and placed on the head region of each of the five test yam varieties (*D. rotundata* variety Pona, *D. rotundata* variety Labreko, *D. rotundata* variety Dente, *D. rotundata* variety Muchumudu and *D. alata* variety Matches) in 30 × 30 × 60 cm wire mesh cage with five replications. The eggs were allowed to develop on the test varieties into adults and the resulting eggs from them were used for the experiment. This was to ensure that any changes in behavior associated with the change in host varieties were eliminated [15].

2.3. Inoculation of Test Varieties

The test yam tubers were infested with 24-hour-old mealybug ovisacs. The ovisacs were teased open with blunt probes under a stereo microscope (×15) and 10 eggs were counted and refolded into the cottony ovisac and placed on the head region of each of the five test yam varieties (*D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Dente, *D. rotundata* var. Muchumudu and *D. alata* var. Matches) in the 30 × 30 × 60 cm wire mesh cage. Each 30 × 30 × 60 cm wire mesh cage had three tubers of each variety with five replications.

The development times of individuals were determined for each nymphal instar. They were observed daily under a dissecting microscope and the presence of exuviae was used to identify each stage. Daily monitoring continued until maturity. Upon emergence of adult females, one male was added with a fine hairbrush. The onset of oviposition was ascertained by the presence of an elongated white cottony egg sac extending beneath and behind the female. During the oviposition period, freshly laid eggs in ovisac were removed daily and counted until all the females died. Different parameters such as the incubation period, developmental period, adult longevity, total number of eggs laid and life span were determined.

2.4. Experimental Design and Data Analyses

The experimental design used for the biology of *P. citri* was completely randomized design with five treatments (varieties) and five replications. The data were analyzed by analysis of variance (ANOVA) using the statistical Package GenStat (GenStat Software for Personal Computer/Windows XP Release 7.22 DE, 2008, VSN International Limited).

3. Results

3.1. Female Egg Incubation Period

The mean incubation periods of female eggs (eggs that developed into females) on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 10.8 and 11.4 days (**Table 1**). The longest mean incubation period of female egg was recorded on *D. rotundata* var. Dente and the shortest on *D. rotundata* var. Pona. There were no significant differences (P > 0.05) among the mean incubation periods of *P. citri* female eggs on the yam varieties.

3.2. First Female Instar

The duration of *P. citri* female first instar on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 7.9 days and 12.8 days (**Table 1**). The duration of the first instar was longest on *D. rotundata* var. Dente (12.8 days) and shortest on *D. rotundata* var. Pona (7.9 days). There were significant differences (P < 0.05) among all the yam varieties but there was no significant difference (P > 0.05) between the duration of *P. citri* female first instar on *D. rotundata* var. Muchumudu (11.1 days) and *D. alata* var. Matches (11.2 days).

3.3. Second Female Instar

The mean duration of *P. citri* second instar female on *D. rotundata* var Pona, *D. rotundata* var Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 6.9 and 11.2 days (**Table 1**). The longest mean duration of second instar female was recorded on *D. rotundata* var. Dente and the shortest on *D. rotundata* var. Pona. There was no significant difference (P > 0.05) between the duration of the second instar female bred on *D. rotundata* var. Muchumudu and *D. alata* var. Matches but this differed significantly (P < 0.05) from the rest of the yam varieties which also differed significantly (P < 0.05) from one another.

3.4. Third Female Instar

The mean duration of *P. citri* third female instar on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 9.6 and 12.9 days (**Table 1**). The longest mean duration of the third female instar was recorded on *D. rotundata* var. Dente and the shortest on *D. rotundata* var. Pona. There was no significant difference (P > 0.05) between the duration of the third instar female bred on *D. rotundata* var. Muchumudu and *D. alata* var. Matches (**Table 1**) but this differed significantly (P < 0.05) from the rest of the varieties. There was no significant difference (P > 0.05) between the duration of the third instar female bred on *D. rotundata* var. Pona and *D. rotundata* var. Labreko.

3.5. Total Female Larval Developmental Period

The total *P. citri* female larval developmental period on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D.*

Table 1. Mean duration (in days) of female *Planococcus citri* reared on tubers of five different yam varieties.

Yam varieties	Duration of stage (days) ±s.e				
	Incubation Period	Instar I	Instar II	Instar III	Total developmental period
D. rotundata var. Pona	10.8 ± 0.2	7.9 ± 0.2	6.9 ± 0.1	9.6 ± 0.2	24.4 ± 0.2
D. rotundata var. Labreko	11.0 ± 0.2	9. 6 ± 0.2	7.3 ± 0.1	9.9 ± 0.1	26.7± 0.2
D. rotundata var. Muchumudu	11.1 ± 0.3	11.1 ± 0.2	9.6± 0.2	11.2 ± 0.2	31.9 ± 0.5
D. alata var. Matches	11.2 ± 0.2	11.2 ± 0.2	9.8 ± 0.1	11.6 ± 0.2	32.7 ± 0.3
D. rotundata var. Dente	11.4 ± 0.2	12.8 ± 0.3	11.2 ± 0.1	12.9 ± 0.1	37.0 ± 0.5
lsd (5%)	0.69	0.7	0.3	0.5	1.1
CV (%)	4.7	4.8	3.2	3.1	2.6
P-value	0.44	0.027	0.033	0.015	0.012

lsd = least significant difference. CV = Coefficient of Variation. P = Probability of ANOVA.

rotundata var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 24.4 days and 37.0 days (**Table 1**). The longest total larval developmental period was recorded on *D. rotundata* var. Dente and the shortest on *D. rotundata* var. Pona. There was no significant difference (P > 0.05) between the total larval developmental period on *D. rotundata* var. Muchumudu and *D. alata* var. Matches (**Table 1**) but this differed significantly (P < 0.05) from the rest of the varieties which also differed significantly from one another.

3.6. Mean Number of Eggs Laid

The mean number of eggs laid by *P. citri* on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 257.0 and 497.0 eggs (**Table 2**). The highest mean number of eggs was laid on *D. rotundata* var. Pona and the lowest on *D. rotundata* var. Dente. There were significant differences (P < 0.05) among the mean number of eggs laid on all the yam varieties (**Table 2**).

3.7. Adult Female Longevity

The mean adult female longevity on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente was between 32.9 and 38.1 days (**Table 2**). *D. rotundata* var. Pona recorded the longest mean adult female longevity and *D. rotundata* var. Dente the shortest. The difference between the mean adult female longevity on *D. rotundata* var. Muchumudu and *D. alata* var. Matches was not significant (P > 0.05); but was significantly different from the rest of the varieties which also differed significantly (P < 0.05) from one another.

3.8. Male Egg Incubation Period

The mean incubation periods of male eggs (eggs that developed into males) on *D. rotundata* var Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 10.5 and 11.2 days (**Table 3**). The longest mean incubation period of male egg was recorded on *D. rotundata* var. Dente and the shortest on *D. rotundata* var. Pona. There were no significant differences (P > 0.05) among the mean incubation periods of *P. citri* male eggs on the yam varieties (**Table 3**).

3.9. First Male Instar

The mean duration of *P. citri* first instar male on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 7.6 and 11.5 days (**Table 3**). The duration of the first instar male was longest on *D. rotundata* var. Dente (11.5 days) and shortest on *D. rotundata* var. Pona (7.6 days). The difference between the duration of the first instar male *P. citri*

Table 2. Mean numbers of eggs laid and mean longevity (in days) of female *Planococcus citri* reared on tubers of five different yam varieties.

Yam Varieties	Duration of stage (days) ± s.e	
	Mean eggs laid by 50 adult females	Mean longevity of 50 adult females
D. rotundata var. Pona	497.0 ± 5.5	38.1 ± 0.3
D. rotundata var. Labreko	402.8 ± 5.4	36.8 ± 0.6
D. rotundata var. Muchumudu	373.0 ± 7.1	34.9 ± 0.4
D. alata var. Matches	292.0 ± 7.2	34.6 ± 0.3
D. rotundata var. Dente	257.0 ± 6.8	32.9 ± 0.5
lsd (5%)	19.0	1.3
CV (%)	4.0	2.8
P-value	0.017	0.026

lsd = least significant difference. CV = Coefficient of Variation. P = Probability of ANOVA.

Table 3. Mean development time (in days) of male *Planococcus citri* reared on tubers of five different yam varieties.

Yam Varieties	Duration of stage (days) ± s.e.				
	Incubation Period	Instar I	Instar II	Pre-pupa	Pupa
D. rotundata var. Pona	10.5 ± 0.3	7.6 ± 0.2	8.7 ± 0.2	2.3 ± 0.1	2.7 ± 0.1
D. rotundata var. Labreko	10.7 ± 0.2	8.0 ± 0.1	10.1 ± 0.4	2.4 ± 0.1	2.9 ± 0.1
D. rotundata var. Muchumudu	10.8 ± 0.3	9.7 ± 0.2	11.6 ± 0.1	2.8 ± 0.1	3.9 ± 0.1
D. alata var. Matches	11.0 ± 0.2	10.0 ± 0.2	11.8 ± 0.1	2.9 ± 0.1	4.0 ± 0.1
D. rotundata var. Dente	11.2 ± 0.2	11.5 ± 0.1	12.5 ± 0.2	3.3 ± 0.1	4.7 ± 0.1
lsd (5%)	0.71	0.4	0.5	0.2	0.2
CV (%)	5.0	3.5	3.4	4.3	3.5
P-value	0.330	0.031	0.017	0.028	0.019

lsd = least significant difference. CV = Coefficient of Variation. P = Probability of ANOVA.

on *D. rotundata* var. Muchumudu and *D. alata* var. Matches was not significant (P > 0.05) but it was significantly different from the rest of the varieties which also differed significantly (P < 0.05) from one another (**Table 3**).

3.10. Second Male Instar

The duration of *P. citri* second instar male on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 8.7 and 12.5 days (**Table 3**). The duration of the second instar male was longest on *D. rotundata* var. Dente (12.5 days) and shortest on *D. rotundata* var. Pona (8.7 days). The difference between the duration of the second instar male *P. citri* on *D. rotundata* var. Muchumudu and *D. alata* var. Matches was not significant (P > 0.05) but it was significantly different from the rest of the varieties which also differed significantly (P < 0.05) from one another (**Table 3**).

3.11. Duration of Prepupa (3rd Instar)

The mean pre-pupa duration on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente was between 2.3 and 3.3 days (**Table 3**). The longest pre-pupa duration was recorded on *D. rotundata* var. Dente and shortest on *D. rotundata* var. Pona (**Table 3**). There was no significant difference (P > 0.05) between *P. citri* pre-pupa duration on *D. rotundata* var. Muchumudu and *D. alata* var. Matches but this differed significantly (P < 0.05) from the other varieties. There was also no significant difference (P > 0.05) between *P. citri* pre-pupa duration on *D. rotundata* var. Pona and *D. rotundata* var. Labreko but this differed significantly (P < 0.05) from the pre-pupa mean duration on *D. rotundata* var. Dente.

3.12. Duration of Pupa (4th Instar)

The mean pupa duration on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente was between 2.7 and 4.7 days (**Table 3**). The longest pupa duration was recorded on *D. rotundata* var. Dente and shortest on *D. rotundata* var. Pona (**Table 3**). There was no significant difference (P > 0.05) between *P. citri* pupa duration on *D. rotundata* var. Muchumudu and *D. alata* var. Matches but this differed significantly from the other varieties. There was also no significant difference (P > 0.05) between *P. citri* pupa duration on *D. rotundata* var. Pona and *D. rotundata* var. Labreko but this differed significantly (P < 0.05) from the mean pupa duration on *D. rotundata* var. Dente (**Table 3**).

3.13. Mean Male Larval Developmental Period

The mean male larval developmental period of *P. citri* on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente ranged between 21.3 and 32.0

days (**Table 4**). The mean male larval developmental period was longest on *D. rotundata* var. Dente (32.0 days) and the shortest on *D. rotundata* var. Pona (21.3 days). There were significant differences ($P < 0.05$) in the mean male larval developmental period of *P. citri* among all the yam varieties but there was no significant difference ($P > 0.05$) between the mean male larval developmental period on *D. rotundata* var. Muchumudu (28.0 days) and *D. alata* var. Matches (28.7 days).

3.14. Adult Male Longevity

The mean longevity of adult *P. citri* males on *D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente was between 1.52 and 2.46 days (**Table 4**).

The longest mean longevity was recorded on *D. rotundata* var. Pona and the shortest on *D. rotundata* var. Dente. There were no significant differences ($P > 0.05$) among the mean longevity of *P. citri* adult male on *D. rotundata* var. Muchumudu, *D. alata* var. Matches and *D. rotundata* var. Dente but these differed significantly ($P < 0.05$) from the mean longevity of *P. citri* adult male on *D. rotundata* var. Pona and *D. rotundata* var. Labreko which also differed significantly ($P < 0.05$) from one another (**Table 4**).

4. Discussion

The different parameters measured differed on the different yam varieties. It is clearly seen that *D. rotundata* var. Pona was the best of the five hosts studied for the development and total number of eggs laid by *P. citri*. *D. rotundata* var. Dente was the least suitable compared to the other hosts.

Several researchers including Woets and van Lenteren [16] have reported variations in biological parameters such as oviposition period, developmental period and longevity of insects on different hosts [17]. These researchers attributed differences in whitefly populations on different host plants to a combination of the effect of the host plant on lifespan and the developmental rate of the insect.

Sakurai *et al.* [18] reported that the quality of food and environmental factors like temperature and humidity play an important role in the different aspects of the biology of coccinellid beetles. Metspalu *et al.* [19]) also observed that the amount and composition of nutrients particularly vitamins contained in plants considerably influence the development of caterpillars of Large White Butterfly (*Pieris brassicae*).

Hogendrop *et al*. [20] showed that leaf nitrogen concentration affected citrus mealybug life history parameters with those mealybugs, which fed on plants containing the highest leaf nitrogen being the most fecund, being the largest in size and having the shortest developmental times. Working with *P. citri*, Yang and Sadof [21] reported that growth, development and fecundity of the mealybug differed substantially when fed on red, yellow, or green leafed *Coleus blumei* (Bentham).Therefore, the difference in parameters of *P. citri* reared on the five yam varieties might be due to the difference in the physical and chemical qualities of the different yam varieties.

The nutrient compositions of the five yam varieties (*D. rotundata* var. Pona, *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu, *D. rotundata* var. Dente and *D. alata* var. Matches), although not determined in this experiment, may be different from one another. Several researchers have shown that the nutrient compositions

Table 4. Mean total larval developmental period and longevity of *P. citri* males reared on tubers of five different yam varieties.

Yam Varieties	Duration of stage in days ± s.e.	
	Total larval developmental period of *P. citri* males	Mean longevity of 50 adult males
D. rotundata var. Pona	21.3 ± 0.4	2.46 ± 0.04
D. rotundata var. Labreko	23.4 ± 0.2	1.94 ± 0.02
D. rotundata var. Muchumudu	28.1 ± 0.2	1.62 ± 0.02
D. alata var. Matches	28.7 ± 0.2	1.54 ± 0.05
D. rotundata var. Dente	32.0 ± 0.2	1.52 ± 0.04
lsd (5%)	0.7	0.11
CV (%)	2.0	4.5
P-value	0.012	0.014

lsd = least significant difference. CV = Coefficient of Variation. P = Probability of ANOVA.

of white and water yams differ slightly [22]-[25]. These differences in the nutrient compositions can influence the performance of *P. citri* on the five yam varieties to varying degrees in terms of oviposition period, developmental period, longevity, and total eggs laid.

In this experiment, the larval developmental periods of female *P. citri* on the five test varieties were in the increasing order of *D. rotundata* var. Pona (24.4 ± 0.2 days), *D. rotundata* var. Labreko (26.7 ± 0.2 days), *D. rotundata* var. Muchumudu (31.9 ± 0.5 days), *D. alata* var. Matches (32.7 ± 0.3 days) and *D. rotundata* var. Dente (37.0 ± 0.5 days). These differences in the developmental periods might be due to difference in the nutrient contents of the varieties.

Goldasteh *et al.* [26] observed that the mean duration of first instar, second instar and third instar female of *P. citri* bred on red variegated coleus, *Solenostemon scutellarioides* (L.) Codd [previously *Coleus blumei* (Bentham)] in the laboratory lasted 6.40 ± 0.21, 8.72 ± 0.25, 9.48 ± 0.31 days, respectively with the mean female larval period, that is (1st instar to 3rd instar), being 24.6 ± 0.66 days. These durations are similar to those obtained on *D. rotundata* var. Pona but shorter than the results obtained on the other varieties. However, Cloyd [27] reported 33.7 days as the development period of *P. citri* on red variegated coleus, and this is comparable to the mean female larval period on *D. rotundata* var. Muchumudu (31.9 ± 0.5 days) and *D. alata* var. Matches (32.7 ± 0.3 days) but shorter than that on *D. rotundata* var. Dente (37.0 ± 0.5 days).

According to Goldasteh *et al.* [26] the mean female longevity of *P. citri* bred on coleus in the laboratory was 32.70 ± 0.89 days. This result is similar to the result obtained on *D. rotundata* var. Dente (32.9 ± 0.5 days) but shorter than the results obtained on the other varieties.

The mean male longevity of *P. citri* bred on coleus in the laboratory lasted for 1.67 ± 0.10 days [26]. This result is comparable to the results obtained on all the varieties except *D. rotundata* var. Pona, which had the highest adult male longevity of 2.46 ± 0.04 (**Table 4**). Based on laboratory studies on coffee leaves, adult male mealybugs lived for two-four days after the final nymphal molt [4] and this is comparatively similar to the results of this study.

5. Conclusion

The results indicate that the development, longevity, and the total number of eggs laid by *P. citri* are influenced by yam variety and the order of preference of *P. citri* for development, longevity and oviposition is *D. rotundata* var. Pona followed by *D. rotundata* var. Labreko, *D. rotundata* var. Muchumudu then *D. alata* var. Matches and the least being *D. rotundata* var. Dente.

6. Recommendation

From the studies, *D. rotundata* var. Dente was less susceptible to *P. citri* infestation. Research can be carried out to ascertain the shelf life of *D. rotundata* var. Dente when infested with *P. citri*. Also *D. rotundata* var. Pona was the most susceptible to *P. citri* infestation. Investigation can be carried out to ascertain the shelf life of *D. rotundata* var. Pona when infested with *P. citri*.

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