Journal of Plantation Crops 9 (1): 34–41 June, 1981

BIOLOGY OF *PENTALONIA NIGRONERVOSA* F. *CALADII* VAN DER GOOT, VECTOR OF 'KATTE' DISEASE OF CARDAMOM*

P. RAJAN

Central Plantation Crops Research Institute Research Centre, Appangala, Heravanad 571 201, Coorg, Karnataka, India.

ABSTRACT

In cardamom (*Elettaria cardamomum* Maton), the aphid *Pentalonia nigronervosa* f. *caladii* van der Goot was found in small colonies underneath the leaf sheaths of older or partially dried pseudostems. The aphid is viviparous and reproduces parthenogenetically. It completes its life cycle in 10–15 days with four instars. The longevity of the adult ranges from 8 to 26 days, with 26–36 overlapping generations during an year under Coorg conditions. The percentage of transmission of 'katte' virus showed a positive correlation with the increase in the age of the nymph. In the field, winged (alate) forms of the aphid were found maximum during December – May. In addition to cardamom, the aphid was found breeding on plants like *Colocasia* sp., *Alocasia* sp. and *Caladium* sp. The Coccinellid beetles *Pullus* sp. and *Coccinella transversalis* and maggots of Syrphid flies *Ischiodon scutellaris, Paragus tibialis* and *Episyrphus viridaureus* and an unidentified Hemorobiid were recorded as predators of this aphid.

INTRODUCTION

'Katte' or mosaic disease of cardamom has been responsible for the low yields and rapid decline in area under cardamom in South India. Uppal, Varma and Capoor (1945) observed that the banana aphid *P. nigronervosa* was responsible for the spread of the disease. Earlier, Magee (1927) established the involvement of aphid *P. nigronervosa* as the specific vector of 'bunchy top' disease of banana. Varma and Capoor (1958) and Varma (1962) studied the virus-vector relationship in 'katte' disease of cardamom and concluded that the virus is of semi-persistent type and different from the bunchy top virus of banana or abaca mosaic virus transmitted by the same species of aphid. Varma and Capoor (1964) further observed that *P. nigronervosa* also transmits 'Foorkey' disease in large cardamom (*Amomum subulatum* Roxb.). Eastop(1966) found taxonomic differences in *P. nigronervosa* f. *caladii* van der Goot found on Araceae and *P. nigronervosa* f. *typica* seen on Musaceae. Ayyar (1963) reported that the aphids found on *Colocasia* sp. in South India belongs to *P. caladii*. Siddappaji and Reddy (1972) reported that the aphids occurring in banana belong to the form *typica* and those of cardamom and *Colocasia* sp. belong to the form *caladii*. Rao and Naidu (1973) and Rao (1977a and 1977b) further confirmed that *P. nigronervosa* f. *caladii*

* *Publication No. 204, Central Plantation Crops Research Institute, Kasaragod.*

was the potent vector of 'katte' disease in small cardamom. Nair (1975) gave a brief account of the biology of *P. nigronervosa* as a pest of banana. A detailed study on the biology and bionomics of the aphid form *caladii*, the most potent vector of 'katte' disease of small cardamom was lacking and hence the present investigation was taken up.

MATERIALS AND METHODS

Aphids used in the investigation were obtained from the pure culture maintained in potted plants in the laboratory. Just born nymphs were transferred on to the fresh bits of cardamom leaves and enclosed individually in glass tubes of 7.5 cm length and 2.5 cm diameter. Each month, twentyfive nymphs were kept and studied individually till their death for one year, during 1978. The leaves were changed on alternate days. Nymphal instars were identified by the presence of exuviae. Observations were made at an interval of 24 hr. during the period of investigation. Longevity and fecundity were studied using aphids reared individually from nymphal stage. Details of the temperature and relative humidity recorded during the course of investigation are given in Table I.

Morphological characteristics of instars and adults were recorded from permanent mounts.

Surveys were undertaken in fields around Appangala, Coorg and alternate host plants were collected and got identified.

In transmission studies with different instars and adults, 15–20 aphids were inoculated to cardamom seedlings of 4–5 leaf stage. The aphids were given

Table I. *Biology of the aphid* Pentalonia nigronervosa *f.* caladii

Month	No. of days required for				Adult longevity (days)	Total life period of the aphid (days)	Fecundity range (No. of offsprings)	No. of generations/month	Room temperature		Relative humidity	
	I instar	II instar	III instar	IV instar	Total					Minimum (°C)	Maximum (°C)	Minimum %	Maximum %
January	3–4	3–4	3–4	2–3	11–15	11–20	22–35	10–20	2.07–2.82	17.0	22.0	22	88
February	2–4	3–4	2–3	3–4	10–15	10–22	20–37	9–21	1.87–2.80	17.0	21.5	27	89
March	2–3	3–4	2–3	3–4	10–14	10–17	20–31	9–17	2.22–3.10	19.0	24.0	23	90
April	3–4	3–4	2–3	2–3	10–14	9–20	18–34	8–22	2.14–3.00	21.5	26.0	31	92
May	2–3	3–4	2–3	3–4	10–14	9–26	19–40	8–28	2.22–3.10	21.5	25.0	50	89
June	2–3	3–4	2–3	3–4	10–14	9–17	19–31	9–21	2.14–3.00	19.5	21.5	65	90
July	2–3	3–4	2–3	2–3	10–14	9–16	19–30	9–15	2.22–3.10	19.5	21.0	72	90
August	2–3	3–4	2–3	3–4	10–14	10–19	19–33	9–17	2.22–3.10	19.0	21.0	71	89
September	2–3	3–4	2–3	3–4	10–14	9–17	19–31	8–17	2.14–3.00	19.5	22.0	55	90
October	2–4	3–4	3–4	2–3	10–15	8–15	18–30	8–18	2.07–3.10	20.0	23.0	35	88
November	2–4	3–4	3–4	2–3	10–15	8–18	18–33	8–20	2.00–3.00	17.0	21.8	50	87
December	3–4	3–4	2–3	2–3	10–14	8–16	18–30	8–17	2.22–3.10	17.5	21.5	35	88
Average	2.9	3.5	2.8	3.0	12.2	13.9	26	14.0	2.57				

a pre-acquisition fasting of two hours, acquisition feeding of 30 minutes and transmission period of one hour. Thereafter the aphids were killed by spraying 0.05% quinalphos.

To find out the emergence of winged forms, population counts of aphids and winged forms were taken at fortnightly intervals from a total of 150 cardamom clumps from five locations (30 clumps/location).

Predators were recorded by collecting the adults emerging from immature forms found associated with the aphids.

RESULTS AND DISCUSSION

Habit

On cardamom plants the nymphs and apterous adults were found colonising in groups of 20-30. They were seen underneath the leaf sheaths of older or partially dried pseudostems. Often ants were associated with the aphid colonies. In addition to pseudostems, occasionally they were found in capsules infested with capsule borers. The alate forms were very active in their movements but they seldom flew. Constant disturbance or irritation only made them to fly.

Reproduction

Oviparous reproduction was not observed either in laboratory or field conditions. At the time of giving birth to young ones, the mother firmly held the substrate and slowly ejected out the nymph from her genital pore. Initially the abdomen with all the legs and antennae of the nymph strongly appressed to it was expelled from the mother's body followed by the thorax and head. The time required for complete ejection of a nymph varied from 15 to 25 minutes. The mother was found to withhold the new born nymph in protruded conditions until the latter was capable of movements, and then placed slowly on the substrate.

First instar nymph

New born nymph is reddish brown and oval at first, becoming slightly elongated later. It is 0.160 mm in length and 0.330 mm in width. Antennae are longer than the body width, 4 segmented, tapering towards the tip; first, second, third and fourth antennal segments measuring 0.053 mm, 0.046 mm, 0.150 mm and 0.350 mm respectively in length. Compound eyes are small reddish black placed just behind the base of the antennae. Rostrum extends beyond the hind coxae and is 0.395 mm in length. Lengths of the fore, mid and hind legs are 0.547 mm, 0.564 mm and 0.651 mm respectively. Siphunculli brown, club-shaped towards the apex and 0.093 mm in length. Cauda is very small, 0.024 mm long with small hairs.

The nymph is very sluggish, shuns light and hides underneath the substrate (leaf). The first instar period varies from 2 to 4 days with an average of 2.9 days. Duration of different instars under each month is given in Table I.

Second instar nymph

Body is reddish brown, slightly elongated, 0.726 mm in length and 0.362 mm in width. Antennae are four segmented, measuring from base to apex respectively 0.065, 0.046, 0.226 and 0.434 mm with a clear bulging on the third segment, 0.093 mm behind the distal end. This is characteristic of the

second instar and indicates the extra segmentation of the antennae in the next instar. Compound eyes similar in colour and shape to first instar except for a dot like triommatidia at the posterior end. Rostrum extends beyond the third pair of coxae and 0.439 mm long. Siphunculli 0.028 mm in length.

The duration of the second instar nymph varies from 3 to 4 days with an average of 3.5 days.

Third instar nymph

The body is light brown, 0.876 mm in length and 0.446 mm in width. Antennae are five segmented with fifth segment, bearing process terminalis; relative lengths of the segments from base to apex being 0.065, 0.046, 0.156, 0.107 and 0.444 mm. Compound eyes are bigger, reddish black with slightly enlarged triommatidia. Rostrum is 0.462 mm long and four segmented. Fore, mid and hind pairs of legs are 0.046, 0.693 and 0.850 mm respectively in length. Siphunculli pale brown and 0.167 mm long. Cauda is 0.042 mm long.

The third instar period extends from 2 to 4 days with an average of 2.8 days.

Fourth instar nymph

Body is elongated and pyriform, 1.188 mm long and 0.691 mm wide. Antennae are six segmented, relative lengths of the antennal segments from base to apex being 0.076, 0.062, 0.139, 0.139 and 0.576 mm. Compound eyes have well developed triommatidia. Rostrum is 0.629 mm in length and extends beyond hind coxae. Fore, mid and hind pairs of legs are 0.940, 0.966 and 1.177 mm respectively in length. Siphunculli uniformly pigmented and 0.215 mm in length. Cauda is small and 0.066 mm in length.

The duration of fourth instar varies from 2 to 4 days with an average of 3 days. The fourth instar nymph is similar to adult except that it is light brown and smaller in size.

Nymphal period

The total nymphal period varies from 10 to 15 days with an average of 12.2 days. Based upon the antennal segments, a key for the identification of different instars is outlined below:

Antennae four segmented	First instar and second instar
Antennae without bulging of third segment	: First instar
Antennae with bulging of third segment	: Second instar
Antennae five segmented	: Third instar
Antennae six segmented	: Fourth instar and adult

Apterous adult

It is dark brown, pyriform, 1.340 mm long and 0.834 mm wide. Antennae are six segmented, and longer than the body length (1.556 mm). Antennal tubercles are well developed. Compound eyes are slightly oval in shape, reddish black, bulging and prominent with many facets. Rostrum is four segmented, 0 639 mm long extending beyond hind coxae.

Legs are stout and long, covered with hairs. Fore, mid and hind legs are 1.302, 1.326, 1.663 mm respectively in length.

Abdomen is dark brown, shining, slightly bulged; siphunculli brown, uniformly pigmented, 0.296 mm long with middle portion narrower and apex club shaped. Cauda is nipple shaped, pale and 0.082 mm long.

Alate adult

It is dark brown, elongated pyriform, 1.410 mm long and 0.722 mm wide.Alate forms are longer than the apterous forms with less body width. Antennae are 6 segmented, 1.748 mm in length with a well developed process terminalis; antennal tubercles are also well developed. Compound eyes are similar to those of apterate forms. Rostrum is 4 segmented and 0.772 mm long.

Legs are similar to those of apterate. The lengths of the fore, mid and hind legs are 1.461, 1.470 and 1.790 mm respectively. Forewing is oblong with black veins, 1.98 mm long and 0.069 mm wide; hind wing small, 0.81 mm long and 0.25 mm wide. At the anterior margin of the hind wing, wing coupling mechanism is seen.

Abdomen is similar to that of apterate. Siphunculli elongated, middle portion slightly narrow, apex club shaped, uniformly pigmented and 0.339 mm long. Cauda is nipple shaped and 0.075 mm long.

Longevity and fecundity

The longevity of adult varies from 8 to 26 days with an average period of 13.9 days. The number of offsprings laid by a single female varies from 8 to 28 with an average of 14 offsprings. The maximum number of offsprings produced by a single female during a period of 24 hr. is four. Adult lives for 22-75 hours without food. In the laboratory, colonies of *P. nigronervosa* f. *caladii* could be established at a temperature range of 23-28°C and relative humidity of 70-90%.

Reproductive period

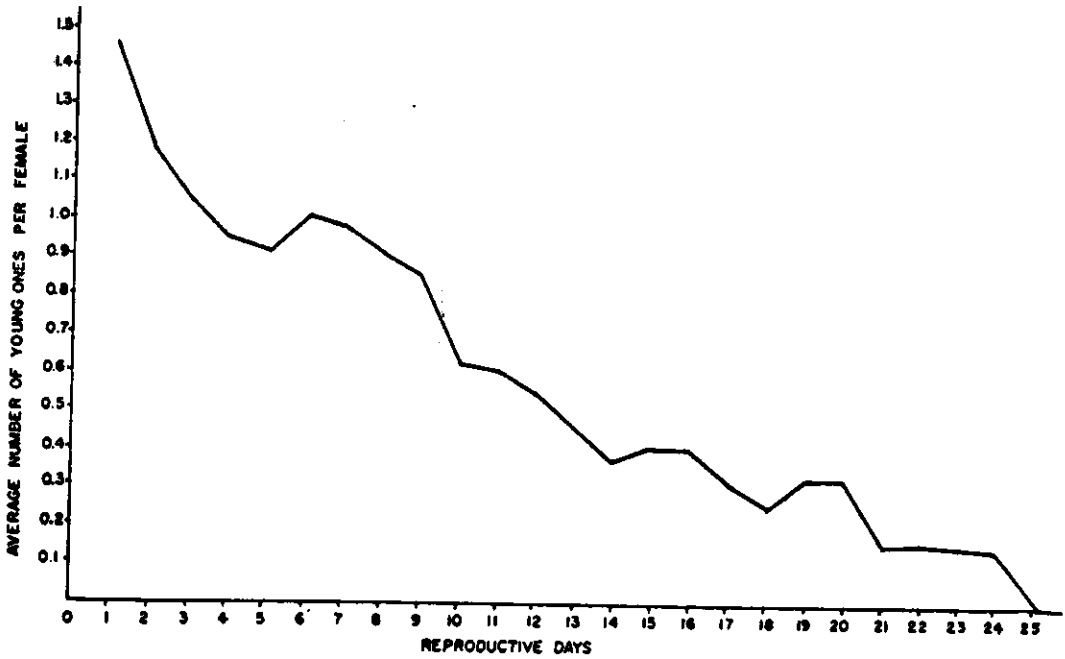
The aphid starts viviposition after 24 hours of attaining adulthood. The reproductive period is found to vary from 8 to 25 days with an average of 13.1 days. Fig. 1 shows that 83.9% of the total offsprings are produced in first 15 days whereas 10.6% in the next five days and only 5.5% during last five days. The maximum number of young ones produced during the reproductive period was on the first day (1.45) and thereafter the reproduction decreased till the last day.

Total life period

The total life period varies from 18 to 40 days with an average of 26 days. The aphid completed 26-35 overlapping generations per year with an average of 2.57 generations per month.

Nair (1975) reported that *P. nigronervosa* Coq. undergoes four instars of 2-3 days duration each and total life cycle takes 8-9 days. He reported a fecundity range of 35-50 nymphs and a life span of 27-37 days with 30-40 overlapping generations per year. The differences observed in the biology and bionomics of *P. nigronervosa* f. *caladii* reported in this paper may be due to the differences in the form of the species, the crop and also the agroecological conditions under which the investigations were carried out.

FIG. 1. FECUNDITY OF THE APHID *PENTALONIA NIGRONERVOSA* F. *CALADII* VAN DER GOOT



Emergence of alate forms

In the field, winged forms were found throughout the year. The total number of winged forms were found maximum during the months from December to May. Percentage of alate forms under each month is presented in Table II.

Transmission studies with different instars and adults

It was found that all the instars of this aphid could transmit the 'katte' virus to test plants. But the efficiency of transmission ranged from 60 to 76% with the increase in the age of the nymph. The apterate adults were highly potent in transmission (92%) as compared to the nymphs. The transmission by alate form was maximum with 94%.

Alternate hosts

The survey of the adjoining fields at Appangala, Coorg indicated that this aphid feeds and breeds on *Colocasia* sp., *Alocasia* sp. and *Caladium* sp. Aphids which feed and breed on banana plants were identified as *P. nigronervosa* Coq. by Commonwealth Institute of Entomology, London.

Natural enemies

In the laboratory when the aphids were reared on *Colocasia* sp. and cardamom, a large number of them were predated upon by spiders. In addition to this during the monsoon period heavy mortality of the aphid population was observed due to the growth of the entomogenous fungus *Verticillium intertextum*. Deshpande, Viswanath and

Table II. *Population fluctuation of the winged forms of the aphid* P. nigronervosa *f.* caladii *in the field*

Months (1978)	No. of cardamom clumps on which population counts were taken	Total number of aphids	Total number of alate aphids	Percentage of alate forms in the population
January	150	7549	112	1.48
February	150	8577	127	1.48
March	150	3844	46	1.19
April	150	1761	36	2.04
May	150	2542	31	1.21
June	150	673	11	1.63
July	150	508	6	1.18
August	150	534	3	0.56
September	150	928	16	1.72
October	150	1369	20	1.46
November	150	1457	25	1.71
December	150	2229	41	1.83

Rahiman (1972) reported heavy colonisation of this fungus on banana aphid *P. nigronervosa* at Mudigere, Karnataka State. In the field, the colonies of this aphid are fed upon by *Pullus* sp. and *Coccinella transversalis* (F.) (Coccinellidae), *Ischiodon scutellaris* Fab; *Paragus tibialis* and *Episyrphus viridaureus* (Wied.) (Syrphidae) and an unidentified Hemerobiid. Of these, *I. scutellaris* Fab. was reported as a predator on *P. nigronervosa* Coq. by Nair (1975). A list of natural enemies of this aphid under field conditions is given in Table III.

Table III. *Natural enemies of the aphid* P. nigronervosa *f.* caladii

Name of the predator	Family-Order	Stage of the insect predatory on aphids	Stage of the host fed upon	Season of occurrence
Pullus sp.	Coccinellidae–Coleoptera	Grubs	Adults and nymphs	Throughout the year
Coccinella transversalis	,,	Adults and grubs	,,	January–March
Ischiodon scutellaris	Syrphidae–Diptera	Maggots	,,	March–May
Paragus tibialis	,,	,,	,,	March–May
Episyrphus viridaureus	,,	,,	,,	April–May
Unidentified	Hemerobiidae–Neuroptera	Larvae	,,	March–May

ACKNOWLEDGEMENTS

The author thanks Dr. O. P. Dubey, Scientist - in - Charge, CPCRI Research Centre, Appangala for encouragement during the course of investigation, and Dr. N. M. Nayar, Director, Central Plantation Crops Research Institute, Kasaragod and Mr. G. B. Pillai, Entomologist, CPCRI Regional Station, Kayangulam for critically going through the manuscript. He is grateful to the Director, Commonwealth Institute of Entomology, London, and Professor of Entomology, University of Agricultural Sciences, Hebbal for identifying the aphids and predators.

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