ENT. VII (813): STUDIES ON RHIZOME MAGGOTS IN GINGER AND THEIR ROLE IN RHIZOME ROT

(1984 — 1986)

FINAL REPORT

NATIONAL RESEARCH CENTRE FOR SPICES
CALICUT - 673 012, KERALA

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Introduction :

Ginger (Zingiber officinale Rosc.) is an important spice crop grown in Kerala in 13,113 ha with a production of 32,889 tonnes annually and is an important foreign exchange earner. Among the various pests infesting ginger, rhizome maggots such as Calobata sp. (Micropezidae) (Fletcher, 1914), Chalcidomyia atricornis Mall and Formosina flavipes Mall (Chloropidae) (Malloch, 1927), Celyphes sp. (Celyphidae) (Nair, 1975), Mimegralla sp. nr. Coeruleifrons Macquart (Micropezidae), Eumerus sp. (Syrphidae) (Anonymous, 1977) and Eumerus albifrons Walker (Sathiamma, 1979) have been recorded. Premkumar, Sarma and Gautam (1982) studied the association of Mimegralla sp. and Eumerus sp. and reported their association with Pythium infected and bacterial wilt affected rhizomes, 42% of the samples examined had Pythium, 58% had Pythium and maggots and none with maggots alone. Iyer, Koya and Banerjee (1981) reported that the presence or absence of maggots did not make any difference in the initial incidence of the disease. Radke and Borle (1982) while studying the status of Mimegralla coeruleifrons on ginger reported that rotting of rhizomes due to disease began first and later the flies preferred such rhizomes for egg laying. Ghorpade, Jadav and Ajri (1983) conducted survey in Maharashtra and reported that infestation by M. coeruleifrons was

endemic in Sangli and Satara districts and that the infestation was less in light and well drained soils.

Though considered to be primary pests of ginger the maggots are generally seen in rhizomes affected by rhizome rot disease caused by Pythium spp., Fusarium spp. and Pseudomonas solanacearum.

In view of the suspected involvement of the maggots in the etiology of rhizome rot disease, detailed studies were undertaken during 1984-86 and a survey was conducted throughout Kerala, to study the distribution, nature and extent of damage by the maggots and also micro organisms associated with the maggots. Studies were also undertaken on the bio-ecology and the role of maggots in the etiology of rhizome rot in the field as well as in the green house conditions.

11. Technical Programme :

(1) Survey in major ginger growing areas of Kerala for collection and identification of maggots and to study the nature and extent of damage and the micro-organisms associated with the disease.

(2) Bio-ecology of major species.

(3) Role of maggots in rhizome rot of ginger.

(a) Pot culture studies.

(b) Field studies.

12. Materials and Methods :

(i) Survey :

A survey was carried out in Wynad, Cannanore,

Pathanamthitta, Idukki, Kottayam and Ernakulam District of Kerala during November 1984 and Quilon, Trivandrum, Malappuram, Palghat, Trichur and Calicut districts during September to December, 1985 to record the incidence of rhizome maggots in ginger growing areas. During the survey 195 gardens selected at random were visited and 767 samples collected for detailed study. Each sample garden was divided into four blocks and one bed from each block was selected at random and observations on the incidence of rhizome rot and the maggots associated with them were recorded. Samples of healthy and diseased rhizomes were collected and brought to the laboratory for examination. The maggots in the samples were extracted and cultured for identification. The pathogens were isolated on potato dextose agar and corn meal agar media and identified.

(ii) Bio-ecology :

(a) Life history of Mimegralla coeruleifrons :

Females of M. coeruleifrons were collected from the field and released in nylon mesh cages of 1 x 1 x 1 m size containing glass troughs filled with soil for egg laying. The adults were fed with diluted honey solution soaked in cotton wool. The eggs that were laid in the soil were separated using a Camel hair brush after soaking the soil in water. The eggs were then placed in petri-plates of 20 cm diameter for hatching. Crushed ginger rhizome was

provided as feeding material, for the maggots. Adequate moisture was provided in the petri-plates by placing cotton wool soaked in water. As the moulten skin of the maggots could not be traced out from the feed material, measurement of the mouth hook of the maggots were recorded from the first day of hatching up to pupation to determine the different instars. Measurements of the egg, larva, pupa and adults were also recorded.

(b) Mating and oviposition :

The mating behaviour of M. coeruleifrons was studied in the field as well under green house conditions inside large cages. Oviposition was studied by observing the gravid females after mating.

(c) Alternate hosts :

The alternate hosts of M. coeruleifrons were recorded by observing the presence of the maggots in various decaying plant materials collected during different seasons from NRCS, experimental farm, Peruvannamuzhi as well as from various locations during the survey conducted under this project.

(d) Mode of survival during off-season :

The mode of survival of the maggots as well as the adults was studied by observing them in the field in different decaying plant materials during the off-season.

(e) Natural enemies :

The pupae of M. coeruleifrons were collected from the field and placed in glass vials to record the emergence of natural enemies which were subsequently identified by the Commonwealth Institute of Entomology, London.

(iii) Role of maggots in rhizome rot of ginger :

(a) Studies under pot culture :

Ginger plants (C.V. Maran) were raised in earthen pots of 25 cm diameter filled with 3 kg of sterilized soil. Seed ginger @ 25 g per pot was sown after surface sterilization with 0.1 per cent mercuric chloride. The pots were maintained inside insect proof cages of 1 x 1 x 1 m size. The treatments included (T1) release of adult M. coeruleifrons, (T2) inoculation with Pythium aphanidermatum and release of adult insects and (T3)inoculation with P. aphanidermatum alone. The treatments were effected two months after sowing. The pots (15 numbers) under each treatment were enclosed in separate cages. The occurrence of the disease and the maggots in ginger rhizomes under various treatments was recorded. The experiment was conducted for two years (1985 and 1986).

(b) Field studies :

The field trial was laid out at Chelavoor, Calicut in a CRD with eight treatment combinations replicated four times under controlled conditions. Ginger plants (c.v.Maran) were raised in beds of 1 x 1 m size with 16 plants per bed.

The treatment combinations were T1 - drenching fungicide. + release of adults M. coeruleifrons under cage, T2 - release of M. coeruleifrons alone under cage, T3 - drenching fungicide alone, T4 - release of M. coeruleifrons alone in the open condition, T5 - drenching fungicide under cage, T6 - ginger plants under cage alone, T7 - drenching fungicide + spraying insecticide and T8 - spraying insecticide alone during 1985. As there was no natural infection in the experimental plot during 1985, the ginger beds under treatments, T2 viz., M. coeruleifrons alone and T8 viz., insecticide alone were inoculated with P. aphanidermatum during 1986. The ginger beds under treatments T1, T2, T5 and T6 were covered with nylon mesh cages of 1 x 1 x 1 m size immediately after sowing. The treatments with Dithane M-45 0.3% and insecticide methyl parathion 0.05% were carried out at monthly intervals from July to October. Observations on germination were recorded initially. The number of diseased clumps and those containing maggots were recorded during November-December.

(iv) Life history of E. pulcherrimus :

The eggs of Eumerus pulcherrimus that were collected from the field were utilised to study the life history. The soil and mulch materials from the area where the female laid eggs were collected and the eggs were separated after soaking them in water in petri-plates.

The eggs after separation were kept in petri-plates of 20 cm diameter. Sufficient moisture was provided by keeping cotton wool soaked in water. Diseased ginger rhizomes collected from the field was crushed and provided as food for the hatching maggots.

To study the natural enemies of E. pulcherrimus pupae were collected from the field and kept in glass vials in the laboratory.

Results and discussion : (1) Survey :

The association of dipteran maggots in healthy and diseased samples collected from different districts of Kerala is furnished in Table 1. M. coeruleifrons Macquart and E. pulcherrimus Brunetti were the common species recorded during survey. An unidentified species of Gymnonerius (Neriidae) was also recorded from a single sample collected from Wynad district. Maggots were present in 33.6 per cent of the diseased samples. Among the various species, M. coeruleifrons was the dominent one occurring in 26.4 per cent of the diseased samples. E. pulcherrimus was observed only in 1.0 per cent of the diseased samples. The combined infestation of both the species was observed in 5.9 per cent of the diseased samples. Infestation by M. coeruleifrons occurred first and that by E. pulcherrimus occurred subsequently especially in rhizomes which were in an advanced stage of rotting. The diseased rhizomes yielded pathogens such as

Table 1. Distribution of dipteran maggots and pathogens associated with ginger rhizome in Kerala.

District	No.of samples examined		No. and percentage of diseased samples				Pathogens isolated from diseased samples
	Total	Diseased	With MC alone	With EP alone	With MC and EP	Without maggots	
Trivandrum	28	6	4(66.7)	-	-	2(33.3)	Pythium spp. Pseudomonas solanacearum
Quilon	34	10	3(30.0)	1(10.0)	-	6(60.0)	P. solanacearum
Pathanam-thitta	55	40	11(27.5)	2(5.00)	1(2.5)	26(65.0)	Pythium spp. P. solanacearum Fusarium spp.
Kottayam	10	7	1(14.3)	-	-	6(85.7)	Fusarium spp.
Ernakulam	15	13	2(15.3)	-	-	11(84.6)	Pythium spp.
Idukki	43	-	-	-	-	-	Nil.
Palghat	43	12	6(50.0)	-	5(41.7)	1(8.3)	Pythium spp. P. solanacearum
Trichur	105	32	-	-	-	32(100.0)	Pythium spp. P. solanacearum
Malappuram	39	16	6(37.5)	-	5(31.3)	5(31.3)	Pythium spp. P. solanacearum Fusarium spp.
Calicut	200	3	-	-	-	3(100.0)	P. solanacearum Pythium spp.
Wynad*	162	126	33(26.2)	-	3(2.4)	89(70.6)	Pythium spp. P. solanacearum Fusarium spp.
Cannanore	33	23	10(43.5)	-	3(13.0)	10(43.5)	Pythium spp. P. solanacearum
Total	767	288	76(26.4)	3(1.0)	17(5.9)	191(66.3)	

*Gymnonerius sp. was recorded from a single sample.
MC = Mimegralla coeruleifrons.
EP = Eumerus pulcherrimus

Pythium aphanidermatum, Pseudomonas solanacearum and Fusarium spp. indicating that maggots cannot be considered as primary pests of ginger. Maggots were not observed in samples which had just taken up the disease indicating that the/disease occurs first and the maggots infest the diseased rhizomes.

Radke and Borle (1982) while studying the status of M. coeruleifrons also reported that rotting of the rhizomes due to disease began first and later the flies preferred such rhizomes for egg laying. However, Ghorpade, Jadav and Ajri (1983) conducted survey in Maharashtra and reported that infestation by M. coeruleifrons was endemic in Sangli and Satara districts and that the infestation was less in light and well drained soil. The present studies indicated that maggots are associated only with rot affected ginger and they were absent in healthy rhizomes.

(ii) a) Life history :

Egg : Eggs were white, spindle shaped and sculptured with longitudinal lines, the posterior end being round and the anterior end pointed. Eggs measured on an average 0.776 x 0.171 mm in size (range 0.752-0.800 mm x 0.160 mm-0.184 mm) (Table 2). The egg hatched in 3-4 days. Hatching occurred through a longitudinal split of the egg shell that extended from the anterior end to three fourth of the egg. The process of hatching took 8-10 minutes.

Table 2. Measurements of egg, larval, pupal and adult stages.

Stage	Mean (mm)	Range (mm)	No. observed
Egg (length x width)	0.776 x 0.171	0.752-0.800x 0.160x0.184	20
Larva (length)			
I instar	2.607	1.224-3.980	5
II instar	5.256	6.756-9.012	5
III instar	10.224	9.340-10.920	5
Mouth hook of larva (length)			
I instar	0.036	0.030-0.040	7
II instar	0.077	0.075-0.080	7
III instar	0.167	0.140-0.185	11
Pupa (length x width)	7.783 x 1.616	7.50-8.00 x 1.50 x 1.75	15
Adult male (length x width)	11.95 x 1.50	11.00-12.50 x 1.75	10
Adult female (length x width)	13.65 x 1.75	13.00-15.00 x 1.50 - 2.00	10
Adult male wing span	16.60	15.50-17.50	10
Adult female wing span	17.85	17.50-19.00	10

Larva : Newly hatched larvae were transparent and pale white measuring 2.607 mm in length (range 1.224-3.980 mm). The second and third instars measured 5.256 mm and 10.224 mm respectively (range 6.756-9.012 mm and 9.340-10.920 mm respectively)(Table 2).

Based on the change in the dimensions of the mouth hook the number of instars was fixed as three.

Nature of damage :

In the field the maggots were observed to tunnel inside the rhizomes and feed on the inner contents. In severely infested rhizomes only the outer skin remained after feeding.

Pupa : Pupation occurred generally within the infested rhizome and rarely in the soil. The pupae were elongated and measured 7.783 x 1.616 mm in size (range 7.50-8.00 mm x 1.50-1.75 mm respectively)(Table 2). Nascent pupae were pale brown which soon turned dark brown.

Adult : Males were slightly smaller than females. Females could be easily identified by the presence of a long tubular structure formed out of the last segment of the abdomen. The measurements of adults male and females including wing span were recorded and are presented in Table 2.

b) Mating and oviposition :

The actual process of mating was preceded by a brief courtship. The mating pairs remained in copulation upto

13 minutes. Copulation occurred 4-7 times at intervals of 4-6 minutes. The various stages in the mating behaviour was studied in detail. After mating the eggs were laid by the female singly in the soil upto a depth of 1 cm around the base of the pseudostem near the rhizomes. However, under laboratory conditions the gravid females laid the eggs even on the sides of the glass troughs.

c) Alternate hosts :

The maggots of M. coeruleifrons were observed in the rhizomes of diseased turmeric (Curcuma longa), wild arrow root, Colocasia sp., wild ginger (Zingiber sp.). They were also seen breeding on fallen and decaying banana flowers especially during the off season (January-May).

d) Mode of survival during off season :

The maggots of M. coeruleifrons were observed to breed on fallen and decaying banana flowers, rejected bits and roots of ginger during January-May. The duration of life cycle was prolonged on banana flowers in the laboratory (35-45 days). Adults were also observed in the field in moist and shady areas during this period and exhibited normal activities such as mating, egg laying etc.

e) Natural enemies :

Two parasites were recorded from the pupae of M. coeruleifrons and were identified as Trichopria sp. (Diapriidae) and Spalangia gemina (Pteromalidae) the latter

being recorded for the first time. In the case of the former, 12-20 adults emerged out of a single pupa and in the latter a single parasite emerged from one pupa.

iii) Role of maggots in rhizome rot of ginger :

a) Studies under pot culture :

Studies under pot culture were carried out during 1985-1986. The results of the experiment are presented in Table 3.

Table 3. Pot culture experiments to determine the role of rhizome maggots in rhizome rot of ginger.

Treatment	No.of plants treated	No.of plants diseased		No.of plants healthy		No.of plants with maggots	
		1985	1986	1985	1986	1985	1986
T1 - Releasing M. coeruleifrons	15	0	0	15	15	0	0
T2 - Inoculation with Pythium + Releasing M. coeruleifrons	15	9	15	6	0	7	15
T3 - Inoculation with Pythium	15	12	15	3	0	0	0

The ginger plants which were inoculated with adult Mimegralla alone remained healthy and the rhizomes of these plants did not contain maggots. Nine and twelve plants (60 and 80 per cent) under treatments with Pythium + adult insects and Pythium alone respectively took up disease

during 1985 and rhizomes of ginger plants which received Pythium + adult insects only contained maggots. However, during 1986 all the ginger plants which received Pythium contracted disease and the rhizomes of plants treated with Pythium + adult insects contained maggots also. The absence of maggots on the plants which were inoculated only with adult insects indicated that they are not primary pests of ginger and could not infest healthy plants. The presence of maggots in the plants which were inoculated with Pythium + adults which subsequently took up the disease also indicated that they could infest diseased and rotting rhizomes. Similar observations were also made during the survey where maggots were not observed in healthy rhizomes.

b) Field studies :

The data collected from the field studies is presented in Table 4.

In the field trial also disease occurred only in treatments where Pythium was added and 58.8 and 50 per cent of the diseased clumps under T2 and T8 respectively contained maggots. The results of the field trial confirm the findings of the pot culture studies. On the ginger plants which were kept exposed, neither disease nor insect incidence was noticed, although they were exposed to the floating population of the adult insects. The results of these studies indicated that the insects lay eggs and multiply on diseased

Table 4. Field experiment to determine the role of maggots in Rhizome rot of ginger.

Treatment	% germination	% clumps diseased	% diseased clumps with maggots
T1 - Cage + insects + fungicide	98.4	0.0	0.0
T2 - Cage + insects + *Pythium*	100.0	26.5	58.8
T3 - Fungicide alone	96.8	0.0	0.0
T4 - Insects alone	87.5	0.0	0.0
T5 - Fungicide + cage	100.0	0.0	0.0
T6 - Cage alone	96.8	0.0	0.0
T7 - Fungicide + Insecticide	95.3	0.0	0.0
T8 - Insecticide + *Pythium*	100.0	65.6	50.0

rhizomes. Moreover it was also observed that maggots were not present in rhizomes which had just taken up the disease.

iv) Bio-ecology of E. pulcherrimus :

The females of E. pulcherrimus were observed to survey a certain area in the ginger field before depositing the eggs. The females laid eggs singly on dried leaves and twigs around the diseased ginger clumps. Some eggs were deposited near the rhizomes in the soil.

The eggs were white, the newly hatched larvae were dirty white and later turned brown. The egg, larval and pupal periods lasted for 3-4, 13-16 and 12-15 days respectively. The maggots were mostly seen in rhizomes that were in an advanced stage of rotting.

No parasite could be recorded even though 800 pupae were collected and kept in the laboratory.

Conslusion :

Studies conducted under laboratory and field conditions on the role of maggots in rhizome rot of ginger and also observations made during the survey in various locations indicated that M. coeruleifrons is not a primary pest infesting healthy ginger. However, ginger rhizomes that were either infested by another sub-terrannean pest or by pathogens resulting in rotting were invaded by the maggots. The maggots were also found to breed in decaying organic debris and fallen decaying banana flowers indicating the saprophytic nature of the maggots.

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13. Approximate expenditure incurred in the Project (Give reasons for variation if any, from original estimated cost) :

Rs. 50,000/-

14. Publications and material (one copy each to be supplied with this proforma) :

a) Research papers :

K.M. Abdulla Koya. Distribution of Dipteran maggots associated with ginger (Zingiber officinale Rosc.) in Kerala. (Accepted in J. Plant. Crops).

b) Popular articles :

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c) Reports :

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d) Seminars and Workshops (Relevant to the Project) in which Scientist have participated :

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e) Material developed such as new varieties of crops or b breeds of farm animals, implements, products etc.:

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15. Details (Nos., etc.)of field/laboratory note books and final material and their location.

i)	Field note books	- 2 Nos.	All the materials are available in the Entomology Section, NRCS, Calicut.
ii)	Log book	- 1 No.	
iii)	Project File	- 1 No.	

16. Comments/suggestions of Project leader regarding possible future line of work that may be taken up arising of this project :