THE RED PALM WEEVIL (RHYNCOPHORUS FERRUGINEUS OL.) IN CEYLON

PART I.—INTRODUCTION, DISTRIBUTION AND LIFE HISTORY

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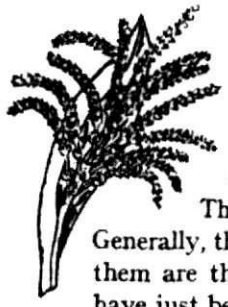
Introduction



The Red Weevil was declared a pest in Ceylon, by Ordinance in 1907. This dangerous pest which is prevalent in all coconut growing areas of Ceylon has not yet been brought under control, due mainly, to the difficulty of chemically treating the attacked palms and to the absence of any known control through natural enemies, such as predators or parasites of the Weevil. The larvae of the Red Weevil are capable of killing young palms outright. Generally, the palms that are attacked and killed as a result of the Weevil breeding in them are those palms which are either just about to come into bearing or those that have just begun to bear. A palm may be attacked anywhere from the crown to its base. Injury to the crown is invariably fatal. This study was undertaken with a view of finding some method or methods for controlling this extremely dangerous pest of the coconut palm. To this end, it was thought that a beginning be made to obtain, a detailed overall picture of the life cycle of the pest.

Distribution

(The pest is known in Ceylon as well as in other coconut growing countries). The details of the distribution of the pest are as follows :—

Rhyncophorus Sp. (are) known to be serious pests in coconut growing countries such as India, Ceylon, Philippines, Burma, Indonesia, Malaya, Thailand, New Guinea, American Tropics, East Africa.

The data of the distribution of the pest are tabulated below.

Name of Pest	*Distribution*
Rhyncophorus ferrugineus Ol.	India, Ceylon, Philippines, Burma, Indonesia and Thailand.
Rhyncophorus schach Oliv.	Malaya, Philippines, Indonesia and Thailand.
Rhyncophorus papaunaus Kirsch	New Guinea.
Rhyncophorus palmarum L.	American Tropics.
Rhyncophorus phoenicis	East Africa.

External Morphological Features

General.—The Red Weevil or the Palm Weevil is one of the largest of the snout bearing Weevils. In size, it ranges from 27 mm. to 35 mm. from anterior to posterior end. It is of a reddish brown colour with variable black markings (spots, lines curved as well as straight) behind the head. The thorax is of a lighter colour than the elytra. Dark spots are present on the thorax but the numbers of these spots vary within one species and between species. Definite variations in size, colour and markings usually occur.

In both sexes the mouth parts lengthen to form a slender and a slightly curved proboscis, which carries at its base a very small pair of jaws adapted for biting and a pair of antennae near the base of the proboscis.

Sex Differentiation.—Identification of the sexes can be done from external morphological features. The snout of the female is slender than that of the male. The male carries a 'brush or pad' of short hairs on the upper side of its snout. This pad or brush extends for about 4 to 6 mm. on the snout. There can be a difference in sizes amongst sexes but this difference may not be strictly applicable.

Habits.—The Weevils in the adult stage are not found to feed actively. In the laboratory, they have been found to live for an average of 56 days after emergence, the range being 53-61 days. Generally, Weevils are seen to fly about during the day and become progressively less active after sun-set. Besides, the coconut palms in India, the Weevil has been found to breed on the Sago palm. In India, the Weevil was first found as a pest on Sago palm and has now spread to the Coconut palm. It has also been found on Screwpine (Pandanus sp.) and various other palms. From what has been said above, it will be seen that the Weevil has a large range of host plants.

Predisposing factors of Palm to Red Weevil attack

The coconut palms that are most susceptible to attack by Red or Palm Weevil are those which bear some injury, such as a knife wound, a disc harrow cut, wind damage, black beetle damage. It is seldom that an intact palm is attacked by Red Weevil.

The Weevils being strong flyers, can actively seek out a damaged palm. It is known that they are capable of flights up to ½ to ¾ mile.

Mode of entry into the palm.—Palms ranging in age from 2 to 15 years can be attacked by Red Weevil. The point of oviposition and subsequent entry of the larvae varies with the age of palms. Generally in young palms the point of initial entry is through the 'bole'. In palms of 5 to 8 years of age the point of entry is usually along the stem or trunk. In older palms, the point of entry is usually found in the crown.

Symptoms of damage.—Palms attacked by Red Weevil show an unhealthy appearance. The bud-leaves show signs of wilt. The leaves in the outer-most whorl show signs of premature drying. This premature drying could be differentiated from natural drying in that generally there are 4 to 5 leaves in the outer whorl showing symptoms of drying in Weevil infested palms, whereas in the case of natural drying in healthy palms, there may be 1 or 2 leaves showing symptoms of drying.

It is quite easy to co-relate these external manifestations of the palm to Weevil attack with actual attack, by placing one's ear to the trunk of a palm and listening to the crunching of the tissues by the actively feeding larvae.

In cases where the trunk or base is attacked, one can see tissue sap exuding from variou holes at the points of attack. The tissue sap could also exude from emergence holes of Weevils- i.e. to holes through which the adults escape after completion of the life-cycle within the palm.

Life Cycle studies.—These studies were carried out in the laboratory and the followin procedure was adopted.

Procedure.—A single male and a female were caged in a glass jar, (dimensions 23 × 14 cm with a piece of coconut leaf petiole from which the epidermis was removed (Plate 1). Oviositio took place quite readily within 6 to 7 days of emergence from the cocoon. The eggs laid wer then inserted into another piece of cleaned coconut leaf petiole, and there left to hatch (Plate 2 The larvae on hatching were then transferred to coconut bud (Plates 3 and 4), and carried throug in this medium until the pre-pupal period was reached whence they were re-introduced int coconut leaf petiole, to pupate (Plate 5).

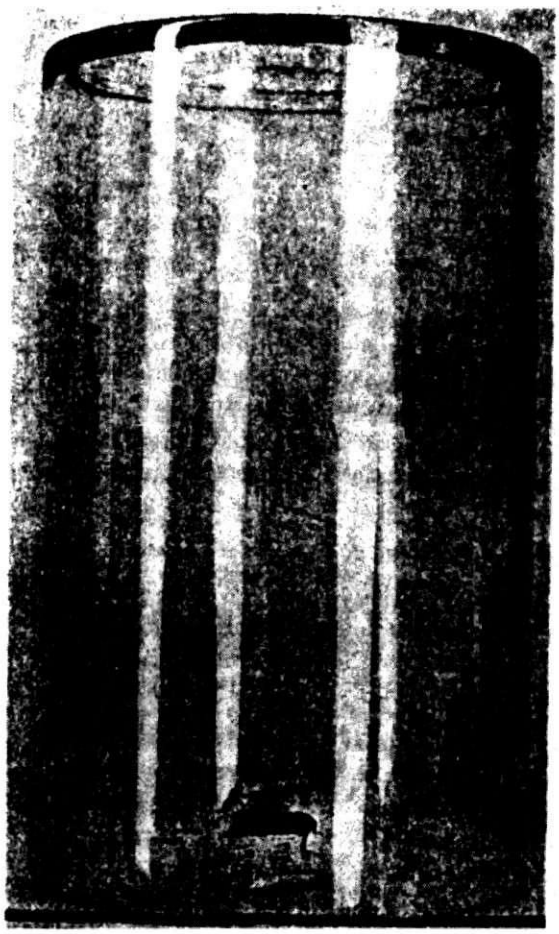


PLATE 1

A piece of coconut leaf petiole from which the epidermis is removed, measuring 1 × 1½ ins. is placed on a glass sheet. A pair of weevils is introduced, and they are covered over with a glass jar. Oviposition takes place in the piece of leaf petiole.

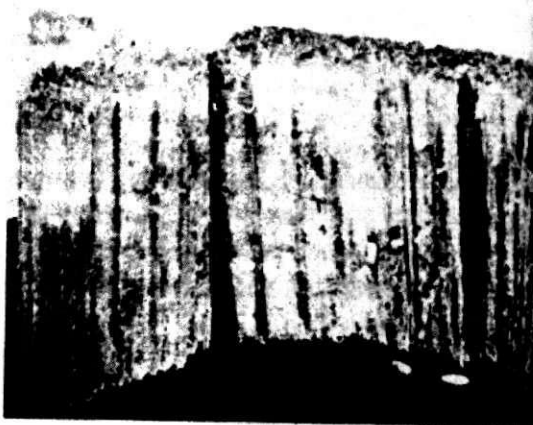


PLATE 2 (× 1½)

Shows eggs inserted into a piece of leaf petiole for ha the piece of leaf petiole is placed in a petri dish of diameter.

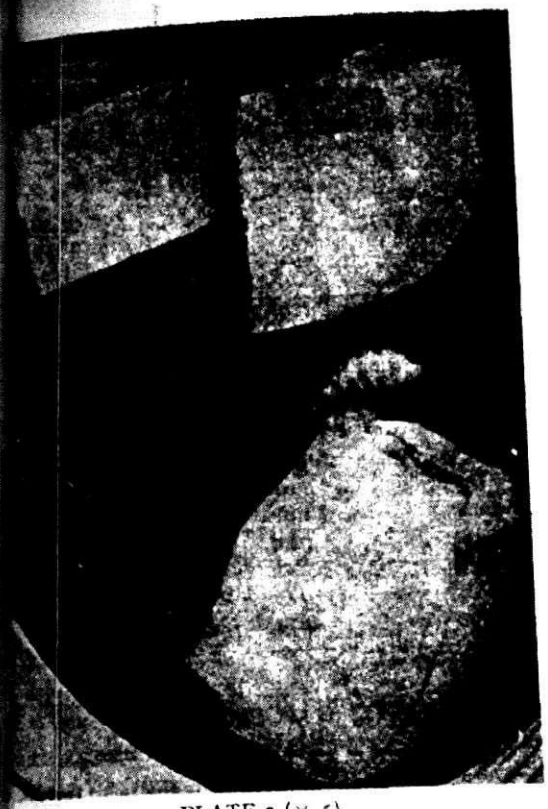


PLATE 3 (× 5)

cond instar larvae feeding on coconut cabbage, in petri dish.

PLATE 4

Third instar larvae feeding on coconut cabbage. The larvae are fed on this medium until they complete their 8th instar.

PLATE 5

Pre-pupae introduced into a coconut leaf petiole without epidermis, $3\frac{1}{2} \times 1\frac{1}{2}$ ins. square at the ends. An 800 ml. beaker is used to place the piece of leaf stalk. It is necessary to damp the piece of leaf petiole periodically. The pupal cocoon is made within the piece of leaf petiole. The entrance hole is effectively clogged up by frass or debris.

A. EGGS

1. (*a*) *Size.*—Samples of 10 freshly laid eggs were used in this study and the following results were obtained :—

Table 1

No.	*Length of Egg*	*Breadth of Egg*
1	2·0 mm.	1 mm.
2	2·0 mm.	1 mm.
3	2·5 mm.	1 mm.
4	2·0 mm.	1 mm.
5	2·0 mm.	1 mm.
6	2·0 mm.	1 mm.
7	2·5 mm	1 mm.
8	2·4 mm.	1 mm.
9	2·4 mm.	1 mm.
10	2·2 mm.	1 mm.
Average	2·2 mm.	1 mm.

The eggs showed no increase in size just prior to hatching. The overall dimensions (length and breadth) remain the same as when freshly laid.

(*b*) *Shape.*—The egg is small, slender and somewhat elongated to resemble a strap-like structure (Plate 6).

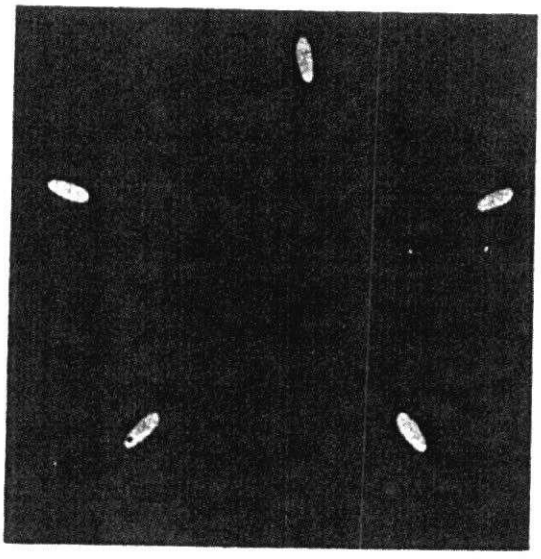


PLATE 6 (× 2½)

Illustrates the shape of size of freshly laid eggs of the Red Weevil.

(c) *Colour.*—The colour of the egg is white or creamy white and during the incubation period shows no change in colour from that of a freshly laid egg.

2. Number of Eggs laid per Female

A sample of 4 females was used in this study. One was a field collected female and the other 3 were laboratory bred females. Each of these females was caged with a single male.

Table II

Particulars	*Date of caging*	*Date of 1st laying*	*Date of final laying*	*Date of death*	*No. of eggs laid by single female*	*% of eggs hatched out*
Field collected * ..	10-5-57	—	26-6-57	3-7-57	265	—
Laboratory emerged ..	20-6-57	26-6-57	24-8-57	25-8-57	80	58·75
Laboratory emerged ..	20-6-57	27-6-57	16-8-57	18-8-57	79	60·74
Laboratory emerged ..	20-6-57	27-6-57	15-8-57	18-8-57	97	62·88
Average ..					130·25	60·79
Range ..					79–265	58–63

*This female laid on 30 of the 48 days that she was alive in the laboratory. The male which was caged with her died on 30th May, 1957, i.e. 20 days after being caged. This female continued to lay fertile eggs after the death of the male. Up to the death of the male, she had laid 155 eggs and after that a further 110 eggs. In the 48 days she was in the laboratory, she stopped laying only for 7 days and those 7 days preceded her death on 3rd July, 1957.

3. Percentage Fertility of Eggs

The table above gives details of 256 eggs laid by 3 females—approximately, an average of 60% of the eggs hatched out.

A further sample of 76 eggs were used with the hope of making this study as comprehensive as possible. 66 of these eggs were kept under laboratory conditions and 10 were kept in an incubator run at 29°C. Of the total eggs incubated 92·1% hatched out. Only 6 eggs failed to hatch out. Of the 10 eggs that were placed in the incubator only 8 hatched out, i.e. 80%.

Table III

No. of eggs laid per single female	*% of eggs hatched out*
80	58·75
79	60·74
97	62·88
76	92·1
Total 332	274·47
Average 83	68·62
Range 76–97	58·75–92·1

Therefore we could say as a result of our studies that a single Red Weevil female will lay on an average 83 eggs of which 69% are fertile. Perhaps the percentage of fertile eggs laid by a single female can be expected to be slightly greater than this if we consider that 13 out of 256 eggs were damaged whilst transferring, i.e. 5% were damaged.

B. LARVAE

General Description

The newly hatched larvae have a similar general appearance to the full grown larvae. They are characterised by a brown head with powerful jaws that are adapted for biting and chewing. The body is white in colour, fleshy and apodous. In the laboratory we have found that the larvae pass through 8 instars before they reach the sequence prepupal, pupal and adult stage. The detailed findings regarding the various instars of the larvae are set out below.

1. Instars

(Plates 7-15). From this study the following was obtained :—

(*a*) Duration of the Instars—Appendix *A* and *C*.

(*b*) Rate of growth—Appendix *B*.

(*a*) *Duration of Instars.*—For this study 10 eggs were set up in an incubator run at 29°C. Results obtained are given in Appendix ' *A* '.

Although these larvae were reared under constant temperature, parallel observations were made simultaneously on other larvae reared under laboratory conditions. The results obtained from these studies reveal no significant difference in the duration of the various instars. The duration of the instars of the laboratory reared larvae in every case fitted into the ranges that were obtained in the incubator reared cultures.

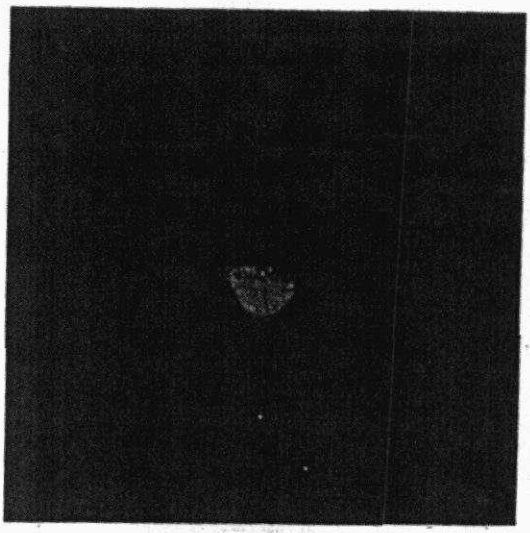


PLATE 7 (× 4)

A newly hatched larva with the egg shell (1st instar) still attached to it.

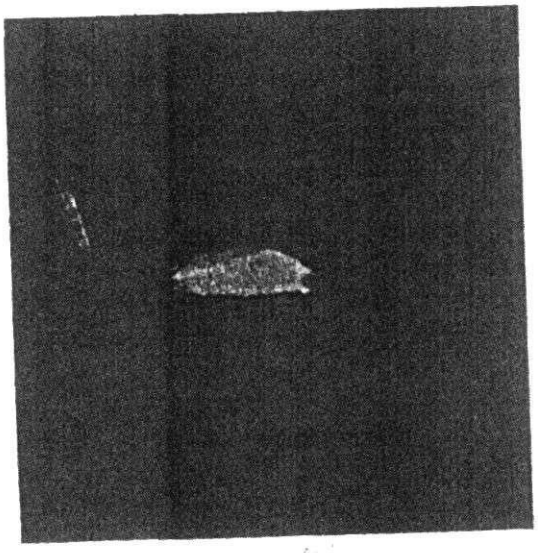


PLATE 8 (× 5)

Second instar larva.

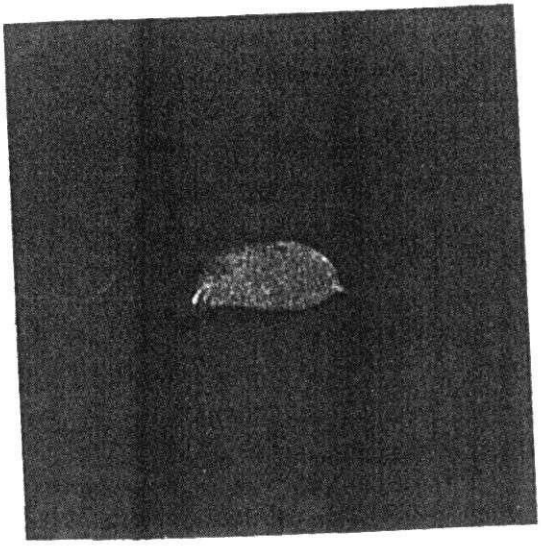


PLATE 9 (× 4)

Third instar larva

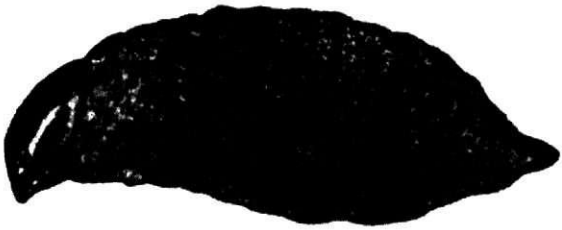


PLATE 10 (× 6)

Fourth instar larva.

PLATE 11 (× 4½)

Fifth instar larva.

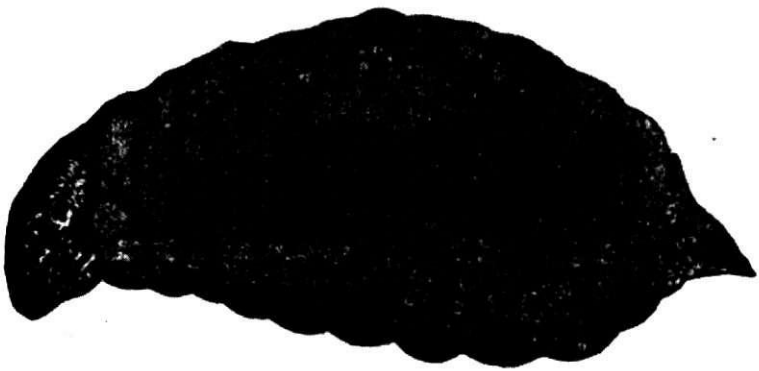


PLATE 12 (× 5)

Sixth instar larva.

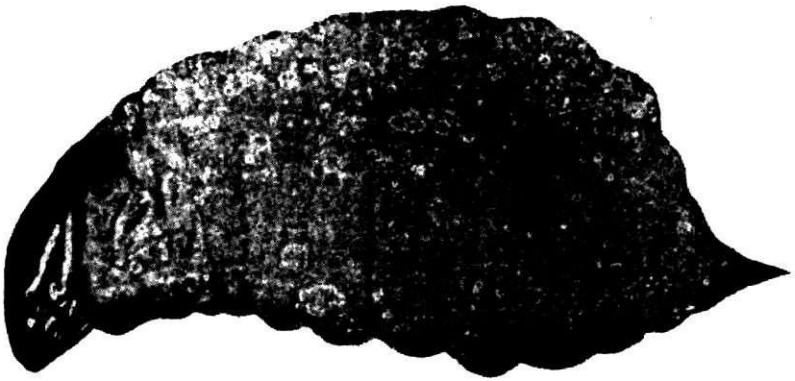


PLATE 13 (× 4)

Seventh instar larva.

PLATE 14 (× 3)

Eighth instar larva.

PLATE 15 (× 2)

An intact cocoon.

We thus see that from egg to the completion of the 8th Instar, it takes on an average of 44·41 days, the range being 32 to 59 days.

(*b*) *Rate of growth.*—In this study 5 eggs were incubated and the increase in length during the various instars were taken. (An idea of the comparative sizes of the larvae in the various instars of the larval stage can be found by reference to Plates 7-15). For details of results obtained—See Appendix '*A*'.

2. Prepupa and Pupa

The prepupal stage is characterised by the cessation of feeding. During this period the larvae shrink to about 2/3rd of their former size. Following on the prepupal stage is the pupal stage. The pupa is pale brown at first but becomes slightly darker prior to emergence. The cocoons (Plates 16 and 17) are of an oblong shape and are formed by closely weaving together the fibrous part of the palm at which site pupation takes place. The dimensions of the cocoons are 5 to 8 cm. long and 3 to 4 cm. in diameter.

To study the duration of the prepupal and the pupal period the 10 eggs that were over-incubated were used and the results obtained are given in Appendix '*C*'.

The pupal period lasts on an average for nine days, after this the adult emerges from its pupal stage, but does not emerge from the cocoon for a further period of 7 to 14 days—the average being round about 10 days.

PLATE 16 (× 2)

A cocoon exposed to show the pupa. This picture also shows the close weaving together of the fibrous strands of leaf petiole in the formation of cocoon.

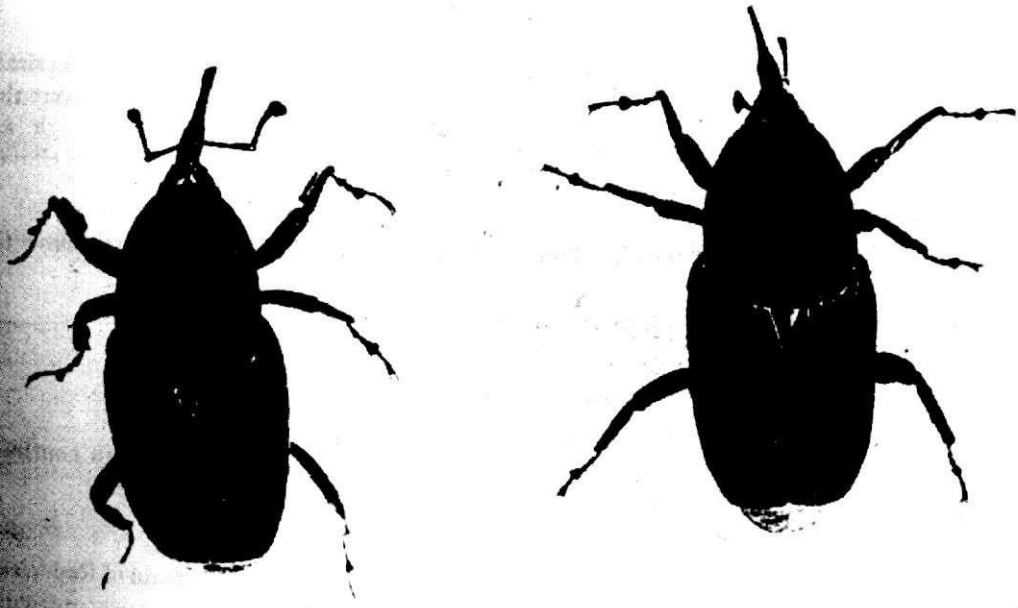


PLATE 17 (× 2½)

[illegible] and the female is on the right.

In all 76 eggs were incubated to determine the time interval from egg to emergence. 66 of these eggs were held under laboratory conditions and 10 in a thermostatically controlled incubator at 29°C. Of the 76 eggs that were set up 22 failed to complete the life cycle. Of these 22, 3 died in the pupal stage. These deaths resulted from the cocoons being too tightly woven and consequent mechanical pressure on the pupae.

Period from Egg to Adult

Of the 76 eggs initially set up, 54 emerged as adults, taking an average of approximately 54 days, the range being from 43 to 66.

Sex Ratio

Of the 54 adults that emerged, there were 20 males and 34 females. That is a ratio of 1 male to 1·7 females. The males took slightly longer than the female in that they took on an average of 55·5 days to emerge, the range being from 66 to 52 whereas the females took on an average 53·6 days the range being 43-59 days.

Discussion

Hutson writing in the Coconut Planters' Manual (5th Edition, 1923), states that at Peradeniya, Ceylon, a single Red Weevil female, in one instance laid a maximum of 231 eggs and the range being 50-200, before the insects were killed by disease. In our work, it will be seen that the maximum number of eggs obtained from a single female was 265 eggs and the average being about 85 eggs. We found that death resulted from natural causes and not from any disease. It is also reported that in the Dutch East Indies, the maximum number of eggs obtained from a single female was 531. All these reports and our work indicate that the Red Weevil female is a prolific layer and is sexually mature at emergence from the cocoon and then starts to lay eggs at a prolific rate in a few days after emergence.

Our observations are that no forms of natural control of Red Weevil, such as predators or disease, exists.

In our studies the only losses incurred in rearing larvae have resulted from physical injuries and from asphyxiation. The larvae when given coconut cabbage for feeding convert this into a thick viscous fluid which if not displaced will result in the death of the larvae through asphyxiation. In our work as a result of this finding such losses of larval cultures were eliminated by renewing the food medium every day.

If one were to think out methods of controlling this pest, then one would have to bear in mind the following facts :—

(*a*) The Red Weevil female is a prolific layer of eggs.
(*b*) That it lays over 60% of fertile eggs.
(*c*) That it completes a generation in 16-17 weeks.
(*d*) That it has a sex ratio of 1 male to 2 females.
(*e*) That a female can copulate with more than one male and that she can continue to lay fertile eggs even after the death of the males.
(*f*) That there is a marked absence of natural control.

Because of the above mentioned facts there is only one avenue of control of Red Weevil open to us and that is chemical control.

Hatching to first laying.—In this study 3 females were used and the results obtained are recorded in Table IV.

Table IV

No.	*Date of Emergence*	*Date of 1st Laying*	*No. of Days from Emergence to 1st Laying*	*Date of Last Laying*	*No. of Days from Emergence to Last Laying*	*No. of Eggs Laid*	*Date of Death*	*Adult Period*
1	20th June, 1957	26th June, 1957	7	24th Aug., 1957	65	80	25th Aug., 1957	61
2	20th June, 1957	27th June, 1957	8	16th Aug., 1957	57	79	18th Aug., 1957	53
3	20th June, 1957	27th June, 1957	8	15th Aug., 1957	56	97	18th Aug., 1957	53
Average			7·6		59·3	85·3		55·6
Range			7–8		56–65	79–97		53–61

If we are to resort to biological control, we will have to find an egg parasite which will actively seek out the egg which is placed deep in the tissues of the host plant or a larval parasite which is able to seek the larvae out after finding its way through the large amount of debris that the larvae use to block up their tunnels so effectively or a pupal parasite that is able to get through the tightly woven fibrous cocoon or an adult parasite. Because the requirements of the parasite are so demanding, it is unlikely that biological control will be successful. Whatever method is adopted it is essential that the pest must be controlled soon after the attack has commenced. We feel that control can best be got by chemical means and we have now undertaken a series of laboratory toxicity trials, using various insecticides some of which may be of value in getting rapid control of Red Weevil.

One school of thought is of the opinion that inactivation of a female by a sterile male will give control of Red Weevil. This is unlikely because our studies revealed firstly, that the Red Weevil is *polygamous*, in the same that a single female will copulate with *one or more males*. The duration of the act of copulation does not extend for more than a few minutes i.e. 2 or 3 minutes. During a 2-hour period of observation it was observed that the act of copulation was repeated as much as 15 to 20 times and the repetition of the act in this short period was done with more than one male.

Therefore any system of control that embrace the theory of inactivating a single female through copulation is bound to fail even if the practical difficulties in carrying out such a programme are overcome. The theory behind this is that a sterile male (resulting from irradiation) using X'rays can inactivate a normal female.

It is also interesting to note that rearing of cultures on Screwpine (*Pandanus, kaida kura*) which is recorded as being an alternative host plant of Red Weevil is not as satisfactory as using coconut bud. The larvae do not thrive at all on screwpine.

Summary

Under laboratory conditions :—

(*a*) A single female was found to lay 85 eggs, the range being 79 to 97.

(*b*) The average dimensions of the eggs are as follows :—

(i) 2·2 mm. in length

(ii) 1 mm. in breadth.

(*c*) Of the eggs laid there are about 69% fertile eggs.

(*d*) Duration of the larval period (that is from laying to the end of the 8th instar) is on an average 44·42, the range being 32 to 59.

(*e*) The longest instars are the 7th and 8th, lasting 12 days or more.

(*f*) The larvae during their life cycle increase in length on an average from 2·24 mm. to 37·4 mm. i.e. 16·69 times the length at hatching, the range being 2 to 41 mm.

(*g*) The prepupal period and the pupal period combined takes on an average of 12·0 days, the range being 9 to 17 days.

(*h*) The adult spends 10 to 14 days in the cocoon prior to emergence.

(*i*) Therefore from egg to adult the period taken is 68·42 days, the range being 51 to 90 days.

(*j*) From egg to first laying it takes an average of 60·66, the range being 60 to 61 days.

(*k*) The adult period lasts for 62.33 days, the range being 60 to 67 days.

(*l*) The whole life cycle from egg to death—i.e. one generation takes on an average of 116·3 days the range being 114 to 121 days.

(*m*) The sex ratio is 1 : 2 (male : female).

Acknowledgements

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Appendix 'A'—Duration of the various instars of Rhynocophorus ferrugineus

No.	Date of Egg Laying	Date of Hatching	No. of Days for Hatching	Date of 1st Moult	No. of Days for 1st Instar	Date of 2nd Moult	No. of Days for 2nd Instar	Date of 3rd Moult	No. of Days for 3rd Instar	Date of 4th Moult	No. of Days for 4th Instar	Date of 5th Moult	No. of Days for 5th Instar	Date of 6th Moult	No. of Days for 6th Instar	Date of 7th Moult	No. of Days for 7th Instar	Date of Formation of Prepupa	No. of Days for 8th Instar	REMARKS
1	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	31-5-57	2	9-6-57	9	—	—	—	—	*—Died of the
2	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	31-5-57	2	—	—	—	—	—	—	*—Died of the
3	21-5-57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Infertile egg
4	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	31-5-57	2	23-6-57	23	22-6-57	9	7-7-57	15	
5	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	31-5-57	2	5-6-57	5	20-6-57	15	9-7-57	19	
6	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	1-6-57	3	10-6-57	9	25-6-57	15	6-7-57	11	
7	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	31-5-57	2	—	—	—	—	—	—	*—Died of thermal
8	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	1-6-57	3	25-6-57	24	29-6-57	14	9-7-57	10	
9	21-5-57	23-5-57	2	25-5-57	2	26-5-57	1	27-5-57	1	29-5-57	2	31-5-57	2	5-6-57	5	14-6-57	9	22-6-57	8	
10	21-5-57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Infertile egg
Total			16		16		8		8		16		18		55		62		63	
Average			2		2		1		1		2		2·25		9·17		12·4		12·6	
Range			2		2		1		1		2		2-3		5-23		9-15		8-19	

APPENDIX 'B'—Rate of Growth of Rhyncophorus ferrugineus during the various Instars

No.	*1st Instar*	*2nd Instar*	*3rd Instar*	*4th Instar*	*5th Instar*	*6th Instar*	*7th Instar*	*8th Instar*
1	2·0 mm.	5·0 mm.	10·0 mm.	13·0 mm.	20·0 mm.	28·0 mm.	31·0 mm.	41·0 mm.
2	2·0 mm.	6·0 mm.	10·0 mm.	12·5 mm.	21·0 mm.	27·0 mm.	33·0 mm.	36·0 mm.
3	2·5 mm.	6·0 mm.	9·0 mm.	13·5 mm.	22·0 mm.	26·0 mm.	32·0 mm.	35·0 mm.
4	2·4 mm.	5·4 mm.	9·0 mm.	13·5 mm.	22·0 mm.	28·0 mm.	33·0 mm.	37·0 mm.
5	2·3 mm.	5·8 mm.	9·5 mm.	12·5 mm.	20·0 mm.	26·0 mm.	31·0 mm.	38·0 mm.
Total	11·2 mm.	28·2 mm.	47·5 mm.	65·0 mm.	105·0 mm.	135·0 mm.	160·0 mm.	187·0 mm.
Average	2·24 mm.	5·64 mm.	9·5 mm.	13·0 mm.	21·0 mm.	27·0 mm.	32·0 mm.	37·4 mm.
Range	2·0–2·5 mm.	5·0–6·0 mm.	9–10 mm.	12·5–13·5 mm.	20·0–22·0 mm.	26·0–28·0 mm.	31·0–33·0 mm.	35·0–41·0 mm.

It will be seen from the table that the larvae are very small on hatching. The size being only 2·24 mm. on an average and at the range from 2·0—2·5 mm. The rate of elongation or growth is very rapid in that the larvae measuring at hatching an average of 2·24 mm. grow to a length of 37·4 mm. on an average in a matter of 44·41 days (Plates 7–15) representing the various stages of growth.

APPENDIX 'C'—Duration of Prepupal and Pupal periods of Rhyncophorus ferrugineus

No.	*Date of Formation of Prepupa*	*Date of Formation of Cocoon*	*Prepupal Period in Days*	*Date of Emergence*	*Pupal Period in Days*	*Remarks*
1	—	—	—	—	—	Died on completion of 6th Instar
2	—	—	—	—	—	Died on completion of 5th Instar
3	—	—	—	—	—	Infertile egg
4	7th July, 1957	9th July, 1957	2	16th July, 1957	9	
5	9th July, 1957	13th July, 1957	4	26th July, 1957	13	
6	6th July, 1957	9th July, 1957	3	—	—	Failed to pupate
7	—	—	—	—	—	Died on completion of 5th Instar
8	9th July, 1957	12th July, 1957	3	20th July, 1957	8	
9	22nd June, 1957	25th June, 1957	3	3rd July, 1957	8	
10	—	—	—	—	—	Infertile egg
Total			15		36	
Average			3		9·0	
Range			2–4		7–13	

It will be seen from above that the prepupal period of Red Weevil takes on an average of 3 days—the range being from 2–4. The pupal period takes on an average of 9 days the range being 7–13.