Short Communication

Cocoon construction by larvae of *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae)

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Abstract

The older larvae of the red palm weevil *Rhynchophorus ferrugineus* construct cocoons made from the discarded chewed fibres of the tender parts of the coconut palm for pupation. The larvae stop feeding prior to pupation and wander around the medium to find a suitable place for cocoon construction. They start constructing cocoons by picking up fibres by the mandibles and these are then packed into a cylindrical structure with both ends open. The packing is done by the random rotatory movement of the body and head. During this time the larva discharges the gut contents to moistens the fibres. The gut contents thus discharged serve to glue the fibres and provide a coating on the inner surface of the cocoon to give it a smooth finishing. The openings of the cylinder are eventually closed by pulling fibres from the rim of the cylinder using mandibles. The mechanism of closing the open ends of the cylinder is demonstrated here in this study using a pair of needles.

Keywords: *Rhynchophorus ferrugineus,* coconut pest, cocoon construction, pupation

Introduction

The red palm weevil *Rhynchophorus ferrugineus* is one of the most injurious pests of coconut, date and oil palms. It is a holometabolous insect. The life cycle *of Rhynchophorus ferrugineus* comprises seven larval instars when reared in the laboratory on sugar cane.[1] It takes 70-60 days to complete the larval life. When about to pupate, the larvae construct cocoons made of fibrous chewed materials of the host plant. The fibres are mostly oriented circularly and are packed tightly towards the interior. The inner surface is smooth and has a glistening appearance.[2] The fibres covering the top appear somewhat loosely packed which may facilitate the exit of the adult after eclosion. It is intriguing how the apodous larva, with no appendages except a pair of mandibles (Figure 1), constructs a cocoon with such perfection. After cocoon construction the larva becomes the prepupa. The prepupal period ranges from 2 to 11 days and is terminated by the act of pupation. The pupal period lasts for 11 to 21 days.[3]

The cocoon construction by larvae of *Rhynchophorus ferrugineus* was observed in this study by introducing older larvae of the late instar into a glass tube (15 cm x 2.5 cm diameter) containing coconut husk fibres. The cocoons collected from the field were composed of fibres measuring 2-4 cm in length. Hence, coconut husk fibres cut into pieces, 2-4 cm long, were provided as the material for cocoon construction. The mouth of the tube was closed with cloth. The tubes with larvae and coconut husk fibres were kept undisturbed until they completed the cocoons.

The series of events associated with cocoon construction can be broadly recognized into 4 stages: wandering stage, packing stage, closing the open ends, and plastering stage.

Wandering stage

The first stage is known as the wandering stage. The older larvae of the final instar consume little or no food prior to cocoon construction. The larva

now enters the wandering stage during which it exhibits vigorous crawling movements and occupies the surface of the rearing medium.

Figure 1: Developmental stages of Rhynchophorus ferrugineus. 1.Egg, 2. Larva, 3. Prepupa, 4. Pupa, 5. Adult

It lasts for about 3.25 ± 1.19 days. At this time a gradual decrease in body weight occurs from 5.03 ± 0.47 g to 4.40 ± 0.48 g. The wandering stage enables the larva to find a suitable site for cocoon construction, probably near the exit that may facilitate easy escape of the adult after eclosion. Detection of light and airflow may provide this clue to the larva. It is observed in this study that in almost 95 % of instances, the larvae have constructed cocoons towards the mouth of the tube The foregut and midgut of the larva contain a clear brown coloured fluid having sticky nature. At the end of the wandering stage, the larva purges the gut. It then starts packing the fibres in the form of a cylinder.

Packing stage

The larva takes 2.30 ± 1.03 days for packing the fibres. This is achieved by pulling the fibres with mandibles and pushing them with the head. The fibres are rolled into a cylinder with both ends open (Figure 2). It then presses the hind end of the body against the cylindrical mass of fibre. The packing is usually carried out at night. After packing the larva enters a brief period of quiescence lasting for 5 to 10 min. It then starts to orient the fibres of the inner layer around its body by pulling the fibres with mandibles accompanied by random rotation of the body. During this time the larva discharges the gut contents to moisten the fibres. The secretion serves to glue the fibres. The larva then pushes the roll of fibres against the tube to make it more compact. The partially completed cocoon is now open at both ends. Packing is completed by mid or late night. After packing the larva becomes inactive and enters a resting period for a few hours or one or two days. Then it closes the two open ends of the cocoon. In 90% of the cases the larva closes the top end of the cocoon first. But very rarely, it closes the bottom first. Usually, the bottom end is closed 1 to 2 hr after the closure of the top end. One of the stimuli for closing cocoon may be the light as it happens mostly at dawn. The larvae can be induced to close the cocoon by flashing a torch towards the open end. Closing is completed within a few minutes. The adult emerges out of the cocoon through the top end.

Mechanism of closing

The closing of the two open ends needs some expertise. The larva bites on the rim of the open end and holds 2-4 fibres with the mandibles. It then strongly pulls these fibres towards the centre of the cocoon so that the circularly oriented fibres of the rim now become vertical in position. This process is repeated until the cocoon is closed with a dome of fibres. The larva then turns about by a somersault movement and strongly pushes the interior of the dome with the abdominal tip. By this action the fibres become compactly packed. The method of closing the open ends of the cocoon is simulated in figure 3, using a pair of needles.

Plastering stage

It includes the finishing works such as pasting of the fibres and plastering the interior of the cocoon. The larva regurgitates the gut contents which by now have turned highly viscous probably due to the presence of disintegrated peritrophic membrane, for plastering the inner wall of the cocoon. The peritrophic membrane is made of chitin fibres set in a protein-carbohydrate matrix. It protects the midgut epithelium from mechanical damage caused by food particles and also serves as a barrier against the entry of microorganisms.[4] In many coleopterans, the peritrophic membrane is used to coat the pupal cocoon.[5] It is observed in this

study that the secretions of the mandibular glands are also added to the gut contents for plastering. The mandibular secretion is found to have antifungal properties. During plastering, the larva knocks on the wall of the cocoon 5-9 times at a stretch, probably to sense the sturdiness of the cocoon. The larva exhibits a variety of movements which include somersaults, wriggling and rotation

for plastering the cocoon. The larva then becomes quiescent, settles down and becomes immobile for pupation. The entire process of cocoon construction takes 7.80 ± 2.48 days.

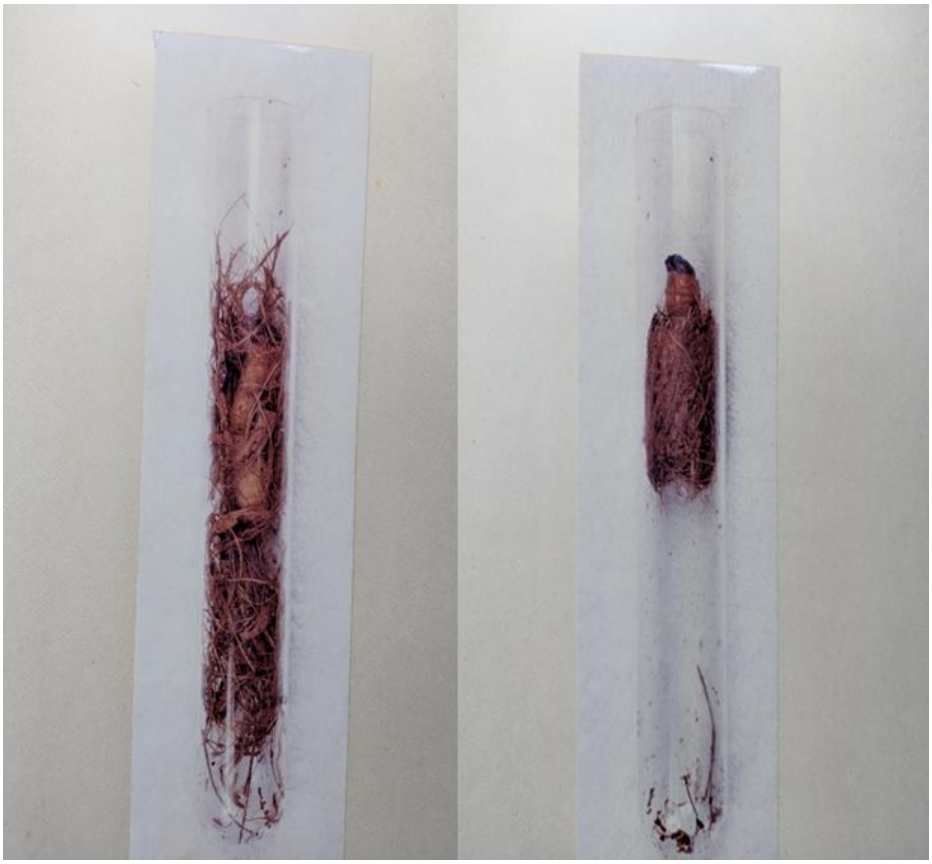

Figure 2. (Left) Initial stage of packing, (Right) Final stage of packing.

Figure 3: Mechanism of closing the open ends of the cocoon using a pair of needles

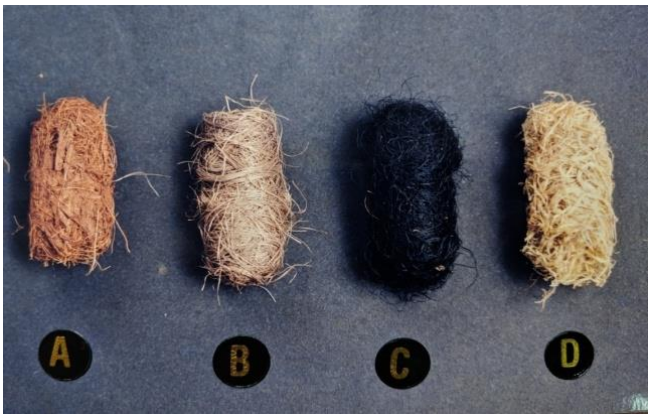

Figure 4: Cocoons made of substitute materials (A) Used fibres, (B) Jute fibres, (C) Thin plastic fibres, (D) Thick plastic fibres

The optimum length of fibres for cocoon construction is found to be 2-4 cm. The larvae fail to construct cocoons when short fibres of 0.5 to 1 cm long are provided. However, they can utilize very long fibres (10 to 15 cm) after cutting them into pieces of varying length.

When larvae were placed in a specially designed chamber with a temperature range between 26^0 and 32^0 C from bottom to top, the larvae preferred a temperature of 28- 30^0C for cocoon construction. The larvae maintained at total darkness required 7.80 ± 2.30 days for cocoon construction. Larvae exposed to continuous light showed random movements and they spent more time for wandering, packing and closing. These larvae closed the open ends incompletely and reopened it several times before making the final attempt. The duration was found to be 12.1 2.66 days.

It is observed in this study that the larvae can make use of a variety of substitute materials such as thick and thin plastic fibres, jute fibres and used fibres (fibres detached from completed cocoons) for cocoon construction (Fig. 4). No significant variation in duration for cocoon construction is observed with the above-mentioned materials. In the cocoon made of plastic, the fibres are not properly oriented especially those forming the inner layer of the cocoon. The fibres appear irregularly packed but strongly glued. During eclosion the adults make a hole near the upper end of the cocoon with their mouth parts and snout to find a way out. It is known that the behaviour of the larva during cocoon construction and pupal moult are influenced by hormones. In Lepidopterans, a surge in ecdysone, called the commitment peak, switches on the behavioural responses from feeding to wandering activity and potentiates tissues for the pupal moult.[6] The second much larger prepupal peak controls the pupal moulting.

The pupae of coleopterans are inactive forms and during this period locomotion ceases, feeding is suspended, respiration slows down and externally they look quiescent, but internally probably as active as any period subsequent to embryonic development. All available energy is used for establishing totally different adult morphology and anatomy with modifications in physiology. In other words, in the life cycle of insects, growth has all been relegated to the larval stage and transformation from larva to adult is greatly abbreviated into a single and short stage, the pupa.[7] The pupa being the most vulnerable stage in the life cycle of the insect, it needs to be often protected by an outer casting, which are made of different materials in various groups of insects. For example, in more advanced group of flies, (Diptera) the skin of the last instar is hardened into a seed like case called 'puparium'. The caterpillars of most Lepidoptera, Neuroptera, Trichoptera and some members of other orders often construct cocoon entirely by secreting silk. For providing strength, extra materials will be added from the surroundings such as bits of leaf, particles of sand or even faecal pellets. The majority of coleopterans, however, construct cocoons using extraneous materials such as soil or the food medium itself (e.g., *Oryctes rhinocer*os) or the chewed fibrous materials of host plant as in the case of *Rhynchophorus ferrugineus*.

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Conflict of interest

There are no conflicts of interest.

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