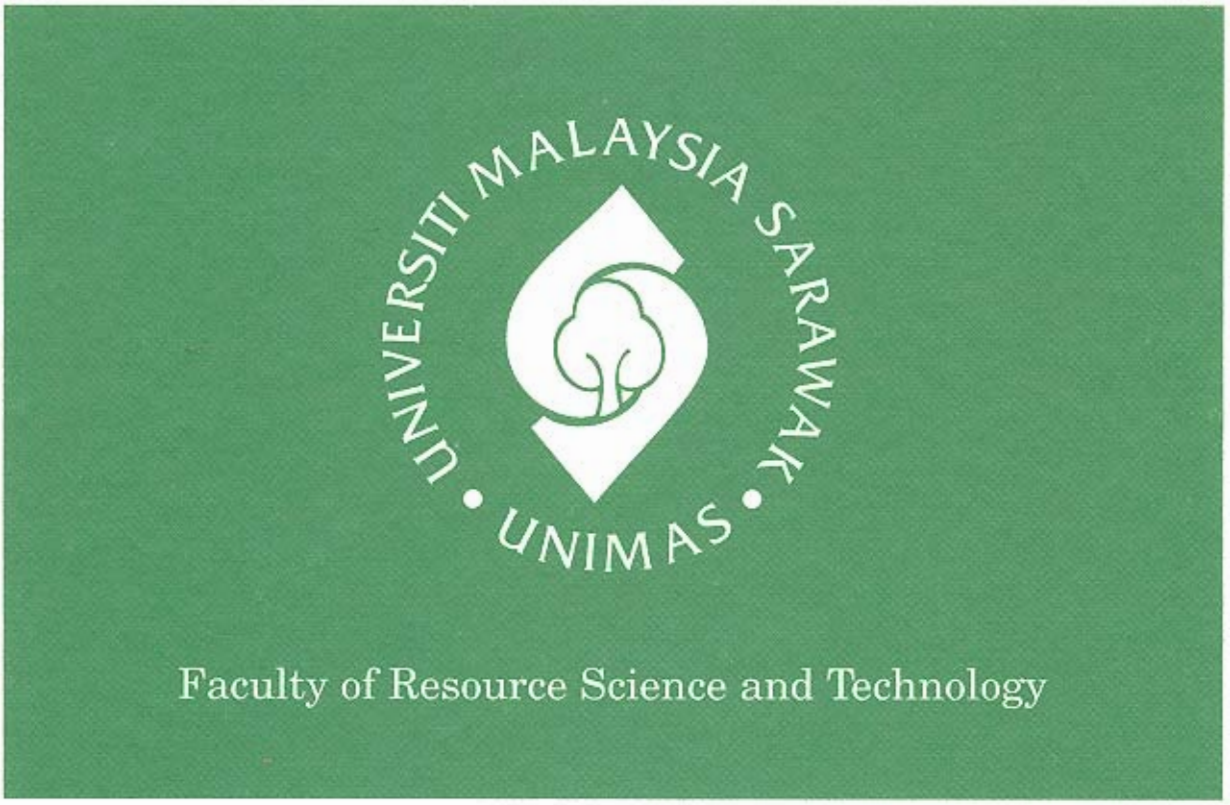

OVIPOSITION PERFORMANCE OF THE SAGO BORER, *RHYNCHOPHORUS SCHACH* OLIVIER (COLEOPTERA : CURCULIONIDAE) ADULT IN CAPTIVITY AND SUBSEQUENT POST EMBRYONIC DEVELOPMENT OF THE EGGS

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Bachelor of Science with Honours
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This project is submitted in partial fulfillment of the requirements for the degree of
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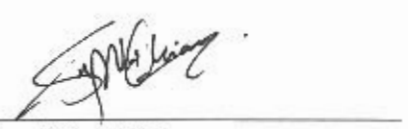
DECLARATION

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.



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Oviposition Performance of the Sago Borer, *Rhynchophorus schach* Olivier (Coleoptera: Curculionidae) Adult in Captivity and Subsequent Post Embryonic Development of the Eggs

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ABSTRACT

Rhynchophorus schach Olivier is a serious pest of a variety of palms, especially sago palms in Sarawak. Despite its destructive behaviour, the larvae of *R. schach* (sago worm) served as a high-nutrient delicacy among most Sarawak local tribes. Therefore, its economic importance leads to the study on the species to document their behaviour and adaptation in captivity. Observation on the oviposition performance of female adults showed that they laid viable eggs in captivity although they have not being mating for a long time. Eggs were deposited and scattered singly in the container. The eggs successfully hatched under room temperature but those under various controlled temperature regimes of 15, 10 and 0°C failed to hatch although treatment was performed. The egg took 3 days to hatch. Changes in colour from yellowish white to yellow and the formation of black spot on a rounded end indicated the morphological transformation during post embryonic development of the egg. The black spot was the formation of its mandible. No eggs were left in the ovaries of female adults after the completion of its life span with the assumption that either all the eggs were laid or some of the eggs were reabsorbed. Newly emerged adults both from the wild or reared in captivity were not collected because the larvae died before they reached the adult stage. Therefore, no abdomen dissection was performed for total egg count. There were 9 larval instars observed by a frequency distribution of head capsule width from a sample of larvae (n=237) collected from the field.

Key words: *Rhynchophorus schach*, oviposition, mandible, post embryonic development, abdomen dissection, instar

ABSTRAK

Rhynchophorus schach Olivier merupakan sejenis perosak serius bagi pelbagai jenis pokok palma, terutamanya pokok sagu di Sarawak. Selain daripada sifatnya sebagai perosak, peringkat larva R. schach (ulat sagu) merupakan makanan dengan kandungan zat yang tinggi bagi kebanyakan kaum peribumi di Sarawak. Dengan adanya kepentingan dari segi ekonomi kajian tentang spesies ini juga dijalankan untuk mendokumentasi ciri-ciri dan adaptasinya dalam kurungan. Pemerhatian terhadap kumbang betina menunjukkan bahawa ia boleh menghasilkan telur yang subur dalam kurungan walaupun setelah beberapa lama mengawan. Ia menelurkan setiap telurnya berasingan dan dalam keadaan yang berselerak. Telurnya berjaya menetas dalam suhu bilik tetapi gagal menetas dalam suhu terkawal pada 15, 10 dan 0°C walaupun telah dirawat. Telur menetas selepas 3 hari. Perubahan morfologi pada akhir perkembangan embryo pada telurnya dapat diperhatikan dengan perubahan warna daripada putih kekuningan kepada kuning dan perbentukan bintik hitam pada satu hujung bulatnya. Bintik hitam akan terbentuk menjadi mandiblenya. Didapati tiada telur tertinggal dalam ovari kumbang yang telah mati dengan anggapan bahawa kumbang menelurkan semuanya atau menyerap balik sesetengah telurnya. Pengiraan jumlah telur dalam ovari dengan pembedahan abdomen bagi kumbang betina liar dan dipelihara yang baru menetas tidak dilakukan disebabkan oleh kegagalan larva-larvanya hidup sampai di peringkat kumbang. Terdapat 9 instar di peringkat larva dengan taburan frekuensi daripada lebar kepala kumbang dalam sample (n=237) yang diperolehi dari lapangan.

Kata kunci: Rhynchophorus schach, bertelur, mandible, akhir perkembangan embryo, pembedahan abdomen, instar

CHAPTER 1

INTRODUCTION

The Red Stripe Weevil *Rhynchophorus schach* Olivier (Coleoptera: Curculionidae) is one of the destructive pests of a variety of palms, such as coconut, oil palm, nipah, (Khoo *et al.*, 1991) in other parts of Asia but in Sarawak its presence may be due to the abundance of sago palm (Gumbek and Jong, 1991). The larva of the *R. schach* is, therefore, referred to as sago worm or sago borer due to its existence as the common pest of sago palm (Gumbek and Jong, 1991). This larva effectively damages the palm by feeding and boring activity into the crown and trunk of palm (Khoo *et al.*, 1991).

Although, the larvae are serious pests of sago palm, they served as food for human consumption. This larva is served as special a high-nutrient delicacy among most Sarawak tribes (Gumbek and Jong, 1991) and they are regularly on sale in Kuching market. The larva is often consumed raw, smoked or fried. According to Sim (cited in Gumbek and Jong, 1991) the worm contains 63.7% fat, 14.3% protein and 22% water and others.

1.1 Justification

In Sarawak, sago palm is a perennial crop traditionally cultivated on semi-wild basis (Gumbek and Jong, 1991). The total area of land under cultivation is 19,720 ha and 75% is concentrated mainly in Oya-Dalat, Mukah, Igan and Balingian areas (Tie *et al.*, 1991). *Rhynchophorus schach* is widely distributed and regarded as a serious pest of sago.

However, the larva is highly prized by local tribes especially Melanau because it is considered a delicacy to them (Ling, 2005). Each larva can be sold up to RM 0.50 during high demand period.

Up to now, there are few records or documentations on rearing and mass production of the weevils in captivity. Therefore, it is the purpose of this project to study reproductive behaviour of adult weevils and developmental event of the eggs under laboratory conditions for commercial purposes. In addition, controlled hatching of the eggs might be applied to ensure continuous supply of larvae in the market.

1.2 Objectives

The following are some of the aims of this study:

i. To study oviposition performance of female adults in captivity.

ii. To observe eggs viability in captivity.

iii. To study the effect of temperature regimes upon post embryonic development of the eggs.

iv. To compare fecundity of female adults in captivity with those living in the wild.

v. To identify the number of larval instars through head capsules size.

CHAPTER 2

LITERATURE REVIEW

2.1 Classification

Sago worm or sago borer belongs to phylum Arthropoda, class Insecta and the largest order – Coleoptera. Sago worm is also known as Red Stripe Weevil or Asiatic Palm Weevil (Thampan, 1993).

There are various kinds of weevils which fall under the family Curculionidae, which are characterized by the following distinguishing features: antennae are nearly always geniculate, trochanters very elongated, and the ventral surface of mentum has a projecting seta or tuft of bristles (Richard and Davies, 1997). One of the genera under family Curculionidae is *Rhynchophorus*.

Besides *Rhynchophorus schach* Olivier, other species that belong to this genus are *R. ferrugineus, R. bilineatus*, *R. cruentatus*, *R. palmarum*, *R. papuanus*, *R. phoenicis* and *R. vulneratus* (Alhudaib, 2005).

2.2 Characteristics

Rhynchophorus schach is a terrestrial insect. Like other species under the order Coleoptera, the adult weevil is divisible into three distinct regions: head, thorax and abdomen. The head, antennae, thoracic sclerites, legs, elytra and abdomen are the primary

characteristics of beetles used in identification and occasionally characteristics such as size, shape and colour are used as well (Borror *et al.*, 1989).

As one of the species under family Curculionidae, their head is prolonged forward into a snout, the mouthparts are reduced in size and located at the tip of the snout; the antennae arise on the sides on it. The basal antennae segment often fits into a groove on the snout (Borror *et al.*, 1989).

This weevil can be distinguished from the closely related species especially *R. ferrugineus* (the red palm weevil) by the morphological characteristics which are shiny black in colour, red orange club of the antennae and a red orange median stripe on the thorax (Thampan, 1993) as shown in Figure 4 (Appendix 1).

There are some characteristics to distinguish between the male and female adult weevils. According to Ayyar (1984), the male weevil has a tuft of soft reddish brown hairs along the dorsal surface of the snout; it is absent in the female where the snout is more slender, curved and a little longer (Figure 5 in Appendix 1).

2.3 Life History

Rhynchophorus schach undergoes holometabolous development which is defined as complete metamorphosis with the immature instars being drastically different from the adult (Romoser and Stoffolano, 1994). *R. schach* spends the whole life history (egg, larva, pupa and

adult) on the palm tree itself (Ayyar, 1984) with a maximum life span of about 4 months (Khoo *et al.*, 1991).

The study of the development and growth of insects is as important as any other aspect pertaining to insect life. The beginning of the development and growth is indicated by the start of growth within the egg and followed by a series of changes that take place until the emergence of adult stage. These changes involve morphological and physical features.

Insects lay eggs at the sites which are usually hidden to ensure maximum survival (Saxena, 1992). As for this weevil, the female first scoops out a small hole on the injured palm tree by using its snout and deposits numerous eggs each in a separate hole (Ayyar, 1984). The female is able to deposit about 300 eggs over its life span (Khoo *et al.*, 1991) and about 70% of the eggs will successfully hatch (Ibrahim and Chung, 1989). The egg is small usually light yellow, cylindrical in shape with average weight of 0.0013g (Nyaun, 1998). Normally the egg can be found at a depth of 3mm and will take 3 to 4 days to hatch into soft whitish grubs.

The larva/grub is vermiform (Ibrahim and Chung, 1989). It bores into the interior of the palm, moving by peristaltic muscular contractions of the body and feeds on the soft succulent tissues and discarding all fibrous material (Ayyar, 1984). It is able to grow up to a length of 50-60mm (Gumbek and Jong, 1991). The grub has a brown head and rigid mandible (Ibrahim and Chung, 1989) as it feeds a lot during this stage which takes 55 days on average (Thampan, 1993) with 9 instars according to Sivapragasam *et al.* (cited from Nyaun, 1998) but Nyaun (1998) observed only 6 instars. The fully grown grub is light brown in colour, stout

and fleshy and slightly bulged in the middle with pointed ends with a length of about 50mm and width of 20mm (Thampan, 1993).

Before pupation, the grub constructs an elongated oval and cylindrical cocoon over its body with fibrous matter and then changes into pupa inside the cocoon (Ayyar, 1984). The prepupal stage lasts for about 3 days and the pupal stage ranges from 15 to 28 days (Thampan, 1993).

At the end of the pupation period the adult weevil emerges from the cocoon. The male weevil emerges earlier than the female (Nyaun, 1998) and is ready to mate just after the emergence. Meanwhile, the female weevil only begins to lay eggs 5 days after the emergence from pupa (Thampan, 1993). According to Thampan (1993), this weevil flies and crawls during day time but it can also be active at night.

2.4 Dormancy

There are two kinds of dormancy related to abiotic environment in insect development. The phenomenon of dormancy can be through quiescence and diapause (Gullan and Cranston, 1994). According to them, quiescence can be referred to as a halted or slowed development as a direct response to unfavourable conditions, with the development resuming immediately when favourable condition returns. In contrast, diapause involves arrested development combines with adaptive physiological changes, with development recommencing not necessarily on the return of the suitable conditions but only following particular physiological stimuli.

Diapause may occur at any of the stages in different insect species (Romoser and Stoffolano, 1994). In many insects, diapause is obligatory where they enter this state every generation in spite of variation in environmental conditions. While those species display facultative diapause can go on several generations before entering diapause (Romoser and Stoffolano, 1994).

According to Gullan and Cranston (1994), the major environmental cues that induce and terminate diapause are photoperiod, temperature, food quality, moisture, pH, and chemicals including oxygen, urea and plant secondary compounds. The length of diapause varies from species to species and it is triggered by physiological mechanism as well (Saxena, 1992).

Research on diapause has been carried out on the silkworms (*Bombyx mori*). The complex mechanisms that promote and break diapause in this species are now well understood. All these research led enormous contribution in sericulture industry worldwide since silk has played an important role in the economic life of man (Gullan and Cranston, 1994).

2.5 Distribution and Habitat

Rhynchophorus schach is regarded as a destructive pest and can be found in various palm plantations. Coconut palm is found distributed in all major coconut growing countries like Malaysia, the Philippines and Indonesia (Thampan, 1993). Sago palm is widespread in Malaysia, Indonesia, Mindanao and New Guinea (Rauwerdink, 1986). Therefore, this species

has a wide distribution over these places. They are able to widen their distribution if more suitable food is made available to them (Saxena, 1992). They are attracted to wounded young palm trees by the smell of palm juice which flows as a result of wound caused to the soft parts in various ways (Ayyar, 1984). Then, the oviposition and post embryonic development may take place.

2.6 Economic Importance

The Red Stripe Weevil is regarded as pest of various palms because it can cause serious damage especially coconut palm below 10 years of age (Khoo *et al.*, 1991) and common pest of sago palms (Gumbek and Jong, 1991). The damage by this species to the palm is due to the boring and feeding activity of the larvae into the crown and trunk of the palms (Khoo *et al.*, 1991) and secondary infections may occur to cause the death of the tree eventually (Gumbek and Jong, 1991). It rarely attacks healthy palms as the mouth of adult weevil is rather weak and not adapted (Ayyar, 1984) to cause any direct damage to the tree but only lays eggs in wounds. These wounds often predisposed by cutting instruments, rhinoceros beetle (*Oryctes rhinoceros)* and other animals (porcupines, wild pigs), diseases and wind or lighting (Zimmerman, 1994).

According to Gullan and Cranston (1994), insects are regarded as pests when they are in conflict with human welfare, aesthetic or profits. In this context, this species causes reduction and even loss of food-plant yields like sago palms since the pith of the palms are rich in carbohydrate (Rauwerdink, 1986).

The larvae of the weevils make nutritious human food and they are cooked in many ways like poached or fried with soya sauce and even eaten raw. According to Gullan and Cranston (1994), the mature larvae of *Rhynchophorus* species have been appreciated by many people in tropical areas of Africa, Asia and Neotropics for centuries. They are rich in animal fat with substantial amounts of riboflavin, thiamine, zinc and iron.

According to Tan (1977) (extracted from Nyaun, 1998), the nutritional values of *R. schach* are as shown in Table 1.

Table 1. Nutritional values of larva *R. schach*.

Nutrient (average)	Composition on dry matter (%)
Protein	14.3
Fat	63.7
Water content	22

Source: First International Sago Symposium, 1977.

CHAPTER 3

MATERIALS AND METHODS

In this study, oviposition performance of the adult weevil in captivity was closely examined as well as the post embryonic development of the eggs. According to Romoser and Stoffolano (1994), oviposition is defined as the passage of the eggs out of the ovarioles into the oviduct and the placement of the eggs into or onto a substrate. Post embryonic development on the other hand refers to the developmental events that occur between the hatching of the individual from the eggs until the emergence of adult insects.

3.1 Materials

Rearing box, sand, paper towel, cotton wool, cotton pad, paint brush, mineral water cap, small tube, petri dish, sago trunk, adult *Rhynchophorus schach,* dissecting set, ruler, caliper, weighing scale, magnifying glass, thermometer, microscope, refrigerator and hygro/thermograph.

3.2 Methods

Observation 1: Oviposition performance of females in captivity.

Female adults collected from the field, were reared in captivity at room temperature and under normal day light. The rearing box was a transparent plastic box with good ventilation. In each box, pieces of paper towel were stretched over it. The paper towels served

as a medium for egg laying and were kept in moist condition. The glucose solution was placed on the cotton wool in a mineral water cap as food for weevils. Each female adult was placed in a rearing box and paired by a male adult in order to let the mating process took place. The rearing boxes were cleaned daily by changing the paper towels. The eggs deposited were counted and collected daily.

Observation 2: Viability of eggs produced by female adults in captivity.

Freshly deposited eggs were carefully collected and placed on moist cotton pad in a petri dish by using clean and moist paint brush. The development of the eggs was carefully observed until they hatched. Newly hatched larvae were transferred to small containers with small cubes of sago logs to let them fed on. The development of the larvae was observed and every instar level was identified by head capsule width and the appearance of exuviae.

Observation 3: Effect of temperature on the post embryonic development of the eggs.

Freshly deposited eggs were collected from the rearing box and each egg was transferred into a tube. The eggs were handled with care to avoid any retardation. Each of the tube was put under various controlled temperatures of 15°C, 10°C and 0°C. After 1 to 3 weeks, eggs were taken out from the refrigerator and placed in room temperature. The eggs were carefully observed for post embryonic development. Some eggs were treated by surface sterilization as excessive fungal or bacterial growth may destroy the eggs. The surface sterilization of the eggs was performed by placing in weak Clorox solution (0.5%) or Hydrochloric acid (HCl) (0.1%) for 1 minute, and rinsed a few times in clean water.

Observation 4: Fecundity of female adults.

Female adults from wild brood were reared in the oviposition containers. Dead female adults from the wild and those reared from captivity were collected and dissected. Eggs left in the ovaries were counted and compared. Alternatively, the newly emerged female adults from pupae were collected from the wild and from those reared in captivity. They were then dissected for total egg count in their ovaries. This was done to apprehend the fecundity of females.

Additional Observation: Head capsule measurement of larvae from different instars.

Head capsules from various larval instars were measured using caliper. The data obtained were plotted as to indicate the number of larval instar which was subsequently used for the identification of larval stage.

CHAPTER 4

RESULTS

Observation 1: Oviposition performance of females in captivity.

There were six female adults reared for their oviposition performance observation as shown in Table 2. All of them were from wild brood (hatched and grown in the wild). Female adults either paired or non-paired with male adults laid eggs in captivity. However, there were two females that did not lay any eggs. From the total eggs, only 48.2% hatched.

Table 2. Oviposition performance of female adults from the wild.

Female adult	Duration in captivity (days)	No. of egg laid	No. of egg hatched	Remarks
1	36	60	30	A male adult was placed with it.
2	3	/	/	Died on the 4th day in captivity.
3	25	5	1	A male adult was placed with it and mating process was observed.
4	11	/	/	No male adult was placed with it
5	11	43	20	No male adult was placed with it.
6	27	2	2	No male adult was placed with it.

The eggs were deposited singly and scattered on the paper towel (Figure 1) and on the cotton wool with the glucose substance. Throughout this observation in the laboratory, the mean temperature was 25°C and mean humidity was 70% daily (refer to Appendix 2).

Figure 1. Eggs were laid singly and scattered on the paper towel.