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BEHAVIOUR OF YOUNG RHINOCEROS BEETLES, *ORYCTES RHINOCEROS*

BY

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The behaviour of young adults of *Oryctes rhinoceros* was studied. In the field the young beetles remained at the site of pupation for 3—4 weeks after the adult moult. In the laboratory 3-week-old females and 5-week-old males were able to mate before the first feeding and before the first flight. However, in the field mating apparently took place after the young beetles had left the site of pupation and after the first feeding. In general, only the ovaries of females older than one month contained full-size eggs.

The Indian rhinoceros beetle, *Oryctes rhinoceros* L., is a serious pest of coconut and oil palms in South-East Asia and in some Pacific islands. The damage is caused by the adult beetles feeding on the young, unfolded fronds. The larvae and pupae develop in dead, decaying trunks of palms, in sawdust- or in compost heaps. The release of sterile males has been considered as a control method against the beetles. Hurpin (1969, 1971 and 1973) investigated means of sterilizing the males and made preliminary studies on the mating behaviour of the beetles under laboratory conditions. Hurpin (1971) reported that the young beetles can mate prior to their first feeding and before leaving the site in which they pupated. Females were able to lay eggs before their first feeding (Hurpin, 1973). It would interfere with a sterile male release program if under field conditions the young adult beetles mated before leaving the site of pupation. The aim of the present experiments was to extend Hurpin's observations by additional laboratory studies, and to investigate the behaviour of young adult beetles under field conditions.

MATERIAL AND METHODS

All studies were made in Western Samoa. *Oryctes rhinoceros* larvae and adults used in the laboratory experiments were reared from eggs on a 1 : 1 mixture of decaying kapok-wood and dried cow-dung.

In the field young adult beetles which had not yet left their sites of pupation were collected from dead, decaying trunks of coconut palms. These young beetles could be distinguished readily from older beetles which visited the trunks for egg-laying and mating. The young beetles had a shiny cuticular surface without scratches and abrasions, and often they were associated with mature third-instar larvae and pupae or with signs of the earlier stages such as larval faeces and pupal exuviae. Older beetles had a cuticular surface with numerous marks and abrasions and formed

characteristic galleries in the trunks (Cumber, 1957), where they were often associated with eggs.

The age of the young adult beetles could be determined if the deposition of the endocuticle had not been completed. During the first 40 days after the adult moult the number of endocuticle layers present in the pronotum of *O. rhinoceros* increases from 2.4 ± 0.4 to 22.9 ± 0.7 (SD) (Zelazny & Neville, 1972). In the following experiments twenty or less endocuticle layers present in the pronotum of an adult beetle were considered as evidence that the endocuticle growth was not yet completed, and the age of such beetles was determined using the age layer-number correlation given by Zelazny & Neville (1972). Twenty layers correspond to an age of 32 days.

The presence of sperm in the spermatheca of a female was used as an indication that mating had taken place.

In the laboratory the behaviour of young adult beetles was studied by keeping 60 cm long, partly hollowed out palm trunks in a cage and placing five male and five female larvae of the same age inside each trunk. The young beetles were collected as soon as they had left the trunks, their age was determined, and the females were dissected to see if mating had occurred. After an appropriate period of time the trunks were cut open and examined for eggs and larvae. Mating between young beetles of different ages was further studied by keeping couples together in about 1 l of sawdust for 48 hr, the females then being dissected to determine if mating had taken place.

The flight ability of young, unfed beetles of different ages and of both sexes was tested in the laboratory by tying them on a string. The beetles were stimulated to fly for 2 min by rotating them on the string.

To study the beetles after they had left the site of pupation, adults were collected from the crowns of live palms and from traps made out of dead, decaying palm trunks split in half (split log traps) which were visited by beetles for egg-laying and mating (Cumber, 1957).

When expressing the results deviations from the means were given as standard errors.

RESULTS

Fig. 1 shows age frequency histograms of (A) 65 field-collected young adult beetles which had not yet left their sites of pupation, (B) 56 young beetles leaving the dead palm trunks in the laboratory experiment, and (C) 36 less-than-33-day-old beetles found in the crowns of live palms. All beetles of group (A) and (B) were less than 32 days old. The youngest beetle in group (B) was 17 days old, and in group (C) 18 days old. In the laboratory experiment (group B) the beetles left the palm trunks in average 24.1 ± 0.4 days after their adult moult. There was no significant difference between the average ages of males and females from all three groups.

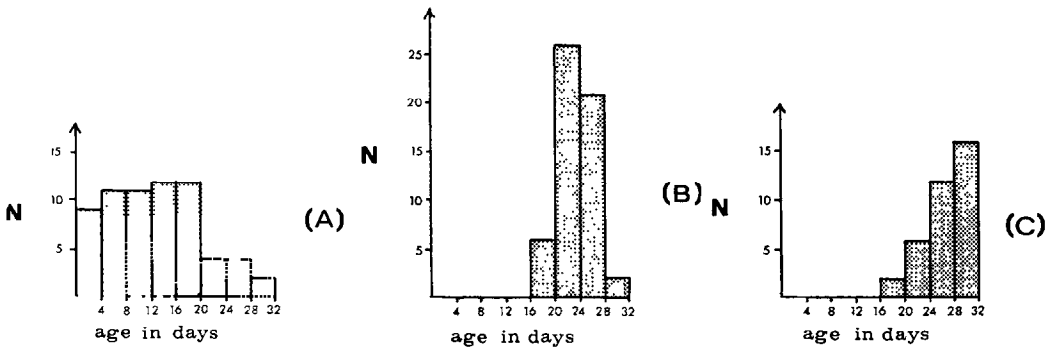

Fig. 1. Age frequency histograms of *Oryctes rhinoceros* adults obtained as: (A) field-collected beetles which had not left their sites of pupation, (B) beetles leaving their sites of pupation (laboratory experiment), (C) young beetles collected from palm crowns. Age determination of the beetles was only possible up to an age of 32 days.

TABLE I

Instances of mating in ten pairs of Oryctes rhinoceros *adults of different age combinations*

		Age of females (days)			
		7 (unfed)	21 (unfed)	35 (unfed)	35 (fed with bananas)
Age of males (days)	7 (unfed)	0	0	0	0
	21 (unfed)	0	1	1	4
	35 (unfed)	1	9	10	10
	35 (fed with bananas)	0	10	9	10

Table I shows the results of the laboratory experiment in which pairs of males and females of different ages were kept together for mating for 48 hr. Seven-day-old male beetles did not mate, 21-day-old males mated occasionally, but 35-day-old males mated in almost all pairs if the females were 21 days old or older. Mating with a 7-day-old female occurred only in one instance. Mating took place between unfed as well as fed beetles.

Table II gives the reproductive state of (a) field-collected young females which had not yet left the sites of pupation, (b) young females leaving the dead palm trunks in the laboratory experiment, (c) less-than-33-day-old females found in the

TABLE II

The reproductive state of Oryctes rhinoceros *females obtained from different sources*

	Number of females examined	Percentage of females mated	Average number of full-size eggs in the ovaries
Field-collected young females which had not yet left their sites of pupation	33	0%	0
Young females leaving their sites of pupation (laboratory experiment)	26	12%	0
Females less than 33 days old found in palm crowns	19	5%	0.6 ± 0.6
All females found in palm crowns	69	49%	10.2 ± 1.6
Females visiting split log traps	59	100%	19.1 ± 1.1

palm crowns, (d) all females found in the palm crowns, and (e) all females visiting the split log traps for egg-laying or mating. None of the 33 young females collected in the field before leaving their sites of pupation (group a) had mated previously. However, three out of 26 young females leaving the dead palm trunks (their sites of pupation) in the equivalent laboratory experiment (group b) had mated previously. Only one out of nineteen less-than-33-day-old females, found in the palm crowns had mated, but 49% of the total number of females present in palm crowns and all females found in the split log traps had mated previously.

In general females, when less than 33 days old, did not contain full-size eggs, and none out of 39 females visiting the split log traps for egg-laying was less than 33 days old. In the laboratory experiment no eggs or larvae were found in the trunks after the young beetles had left them.

The association of adult beetles in the field was recorded to establish where mating takes place. Table III shows that pairs of the opposite sex were found as

TABLE III

Association in the field of Oryctes rhinoceros *adults (not recently emerged from the pupae)*

Number of beetles found	in crowns of live palms	in dead palm trunks
Males singly	63 (37%)	13 (7%)
Females singly	80 (47%)	144 (77%)
Beetles as pairs of the opposite sex	20 (12%)	26 (14%)
Beetles as pairs of the same sex	2 (1%)	2 (1%)
Beetles in groups larger than two	6 (3%)	3 (1%)

frequently in the crowns of live palms as in dead, decaying palm trunks.

All of ten 7-day-old and all of ten 14-day-old beetles were unable to fly. Six of ten 21-day-old and all of ten 28-day-old beetles were able to fly for at least 3 min. No significant difference was noted between the flight ability of males and females.

DISCUSSION

The field studies as well as the laboratory experiments indicated that the rhinoceros beetles left their sites of pupation around 20-30 days after the adult moult, and that they then visited palm crowns for feeding. In the field beetles older than 20 days were found less frequently in the sites of pupation compared to younger ones suggesting that they start leaving the sites of pupation at this age. Indeed in the laboratory experiment the beetles left their sites of pupation between 17 and 32 days after the adult moult, and, starting with an age of 18 days, beetles appeared in the crowns of palms where they were feeding. The beetles also acquired their ability to fly at about 20 days after the adult moult. Since males and females did not have significantly different ages either when they were still in the sites of their pupation or when they first appeared in the palm trees, it is concluded that they leave the sites of pupation at the same age.

In the laboratory 7-day-old female beetles and 21-day-old males mated only rarely but 21-day-old females and 35-day-old males mated readily before their first feeding and without a previous flight. A similar experiment was conducted by Hurpin (1971), however, the author gives for each group of ten pairs only the time at which he observed the first incidence of mating in the group. This time was in general for females between 15 and 27 days and for males between 19 and 27 days after their adult moult which is in agreement with the results reported here. But in one instance Hurpin reported mating between 11-day-old males and older females.

The laboratory results suggested that under field conditions the young beetles might mate before leaving their sites of pupation. However, the studies with field-collected beetles did not confirm this conclusion. None out of 33 young females found still in their sites of pupation and only one out of nineteen less-than-33-day-old females found feeding in palm crowns had mated previously. In the laboratory experiment simulating the field conditions three out of 26 females leaving the site of pupation were found to have mated previously. However, in this experiment the beetles (males and females) were caught in a cage after they had left the palm trunks and were removed from the cage the next morning. So the three instances of mating could have occurred while the beetles were together in the cage. It is concluded that in the field the first mating of rhinoceros beetles usually occurs after the beetles have left the site of pupation. However, the results do not exclude the possibility that a small percentage of beetles mate before leaving the site of pupation. It should be remembered that dead palm trunks, in which pupation takes place, are frequent sites of mating for the older beetles (see Cumber, 1957 and result in Table III). If such early mating occurs occasionally then a sterile male release program could select for it. Also Hurpin (1971) reported that males and

females can mate several times under laboratory conditions. This too could interfere with a sterile male release program if it occurs in the field.

In the field only one out of nineteen females was found to have mated before the age of 33 days, but in the laboratory females were sexually mature long before this age. It is unknown when males start mating in the field. In the laboratory they became sexually mature later than the females, i.e., usually between the age of 21 and 35 days.

Cumber (1957) reported copulation of rhinoceros beetles in dead palm trunks. The results given in Table III suggest dead palm trunks, as well as the crowns of live palms as frequent sites of mating. Although no copulation was observed during these studies very few beetles were found associated together other than in pairs of the opposite sex, indicating that the couples came together for mating.

In the field egg-laying apparently took place only after the females had left their sites of pupation and fed at least once.

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ZUSAMMENFASSUNG

DAS VERHALTEN JUNGER NASHORNKÄFER, ORYCTES RHINOCEROS

Der Indische Nashornkäfer (*Oryctes rhinoceros*) ist ein wichtiger Schädling an Palmen in Südost Asien und in der Südsee. Im Rahmen von Untersuchungen, ob eine Bekämpfung durch Massenfreilassungen sterilisierter Männchen möglich wäre, wurde das Verhalten von jungen Käfern in Labor- und Freilandversuchen studiert. Mit Hilfe der Anzahl der Endokutikulaschichten konnte das Alter der jungen Käfer bestimmt werden, falls dieses nicht 32 Tage überschritt. Die Versuche ergaben, dass die Käfer nach der Häutung noch 3 bis 4 Wochen an dem Ort der Verpuppung verblieben, danach suchten sie die Palmen zum Fressen auf. Im Labor paarten sich 3 Wochen alte Weibchen und 5 Wochen alte Männchen vor dem ersten Füttern und ohne vorher zu fliegen. Hingegen im Freiland fanden die ersten Paarungen offensichtlich nach dem Verlassen der Verpuppungsorte und nach dem ersten Fressen statt. Die Käfer paarten sich sowohl in den Kronen lebender Palmen als auch in toten Palmstämmen. In der Regel wurden Eier in voller Grösse nur in den Ovarien von Weibchen gefunden, die älter als einen Monat waren.

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