Mass rearing the coconut rhinoceros beetle, Oryctes rhinoceros L. (Scarab., Dynastinae)

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With 2 figures

Abstract

An improved larval diet and temperature-induced pupation has resulted in a shortening of the larval growth period by six weeks on an original period of 27 weeks. A strain of *Oryctes rhinoceros* was selected of which the longevity of the females was increased by four weeks, and which laid 29 % more eggs than the unselected strain.

1 Introduction

The coconut rhinoceros beetle, *Oryctes rhinoceros* L., is one of the most important pests of the coconut palm, *Cocos nucifera* L. In 1964, the United Nations Special Fund supported a regional project for research on the control of the coconut palm rhinoceros beetle in the South Pacific, designating the Food and Agriculture Organization of the United Nations as executing agency. FAO subcontracted the implementation of the project to the South Pacific Commission until 1971. Mass rearing the beetle was attempted in Western Samoa but not effectively. A mass rearing unit for the beetle was established in early 1973.

The breeding of the rhinoceros beetle is characterized by long lived adults that produce few eggs over a long period. The larvae require large amounts of food. They need much space and have a long growth period.

Attempts were made to obtain a higher egg production and to shorten the larval growth period.

2 Methods and results

2.1 General

Last instar larvae were taken from decaying trunks and stumps of coconut palms in Western Samoa. The larvae were kept singly in 400 ml tin cans for six weeks, and fed on a 50:50 mixture of ground dried cowdung and rotten kapokwood (HURPIN and FRESNEAU

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1970, 1973). During this period the larvae were checked for diseases at weekly intervals. The surviving larvae were considered healthy and groups of twenty were transferred to plastic containers (23 × 32 × 53 cm) which were closed with a wooden lid. Fresh food was given at monthly intervals.

Adult females were collected from attractant traps and natural breeding places, and kept in 2000 ml tin cans on sterilized sawdust. They were fed with sugarcane twice a week. If the females laid viable eggs ten to thirty days after collecting, they were transferred in groups of twenty to plastic containers (23 × 32 × 53 cm). A seven cm thick layer of moist sterilized sawdust was added. The adults were fed one peeled banana and a 10 cm piece of sugarcane twice per week per group. For each breeding container a cumulative average number of eggs per female per week was calculated and if this number became > 3.0 the beetles were kept as parents of a selected strain. Pupae were collected from breeding places and considered healthy if no visible signs of the green muscardine fungus *Metarrhizium anisopliae* (Metsch) were noticed. From those field collected animals a strain for mass rearing was obtained.

Eggs were sorted from the sawdust by hand, records being kept of the number of eggs and the surviving males and females. To faciliate counting and to minimize cannibalism the eggs were placed in holes punched in a one cm thick plastic sheet which rested on a 5 cm thick layer of larval food. Each sheet had 200 holes, 1.5 cm in diameter and the sheets were placed on larval food in breeding containers. The sheets with the eggs were covered with 3 cm larval food and the container was closed with a wooden lid.

Three to four weeks later the hatched larvae were transferred to plastic rearing containers, 23 × 32 × 53 cm, filled with larval food. Each container received twenty larvae. After six weeks further larval food was added and the containers were thereafter cleaned out and supplied with fresh food at monthly intervals until the onset of pupation. Surplus young larvae could be held on larval food in 200 l drums, 200 per drum, for three months, food being added when needed. Pupae and prepupae were gently removed from their cocoons and placed individually on larval food in 400 ml tin cans. The materials used, gloves and spoons, were washed and rinsed in a Dettol (R) suspension between inspecting breeding containers.

2.2 Larval food

Tests were made using different food media. The tests were done in tin cans which were three-quarters filled with the appropriate medium, four replicates being used for each medium. Twenty eggs, varying from 0 to 7 days old, were added to each can and the cans were then closed with cheese cloth and a metal lid.

Twenty three days later the developing larvae were examined. The instar of each larva and its weight were recorded. The results are summarized in table 1.

Table 1. Effect of diet on larval mortality and weight

Medium	% water	Number of instars from 80 eggs		Average weight of larvae in mg
		1st inst.	2nd inst.	
Fermented				
Kapok and Cowdung	70	33	14	401
Unfermented				
Kapok and Cowdung	60	7	54	687
Kapok and Cowdung	70	3	52	1178
Kapok and Cowdung	80	1	53	1165
Cowdung	70	0	49	1766
Kapok	70	8	0	150

From table 1 it is evident that the rate of growth was much greater on the unfermented food mixtures and on the cowdung than it was on the

fermented food mixtures. With the unfermented food mixtures containing different amounts of moisture, the most rapid growth was obtained with the moisture contents between 70 % and 80 % water. The rate of development of the larvae, judged by the percentage of second instar larvae present at the time of inspection, was also greater on the unfermented food mixture and on the cowdung.

2.3 Factors affecting pupating

The main mass rearing room in which the larvae were normally reared was, at 28° C, generally 3° C warmer than an adjacent open insectary.

Batches of twelve containers each with 20 young larvae of known age, were set up at weekly intervals over a period of seven weeks, using fermented medium as food.

Some 5½ months later, when the youngest larvae were 21 weeks and the oldest were 27 weeks old, half of each batch of boxes were transferred to the cooler insectary. The other half remained in the warmer insectary. The boxes were then examined at monthly intervals to determine the presence of pupae. The number of boxes found to contain pupae is given in table 2.

Table 2. Dependence of pupation on temperature

Pupae kept	% containers with pupae after one month	Total % containers with papae after two months
cooler	36 % (n = 36)	56 % (n = 36)
warmer	0 % (n = 35)	7 % (n = 35)

From table 2 it can be seen that keeping older larvae about 3° C cooler than during their growth period induced pupation at least one month earlier.

Observations were made on the onset of prepupation in a number of boxes containing insectary reared larvae differing in age by not more than one week. Although the onset of prepupation between individual boxes might differ by up to three months it was noted that within any given container, 95 % of the individuals became prepupae within a week of each other.

It was thought that larvae in a breeding site or in a rearing container might only pupate when all had reached the same physiological stage, those not yet fully developed preventing the pupation of the fully grown larvae. This hypothesis was examined in the following manner.

Larvae aged 104 days and larvae aged 77 days were divided among

Table 3. Effect on the age of larvae on pupation

		% Pupae after			Expected % pupation		
Age of larvae	n	26 d	40 d	52 d	26 d	40 d	52 d
77 days	79	0	8	44	0	8	44
104 days	120	75	99	100	75	99	100
104 and 77 days	114	11	75	99	38	54	72

sixteen rearing containers, the containers receiving ten old and ten young larvae, or 20 old or 20 young larvae. Records were kept on the number of larvae that pupated in each container (see table 3).

Similar results occured with field collected larvae, where it was estimated that the larvae in any container might vary in age by up to two months. From table 3 it can be seen that the younger larvae prevented the older larvae from pupating at first. Later the pupation of the younger larvae was faster in the presence of older larvae. It is not yet known if the results are due to mechanical and/or to biochemical activity.

2.4 Selection for higher egg production

Of all breeding containers 9.8 % (n = 82) reached an cumulative average number of eggs per female per week of > 3.0 and from those females a first generation was bred. The egg production and the longevity of the selected strain and the unselected strain was compared (see figures 1 and 2). The egg production of the selected strain was 29 % higher than that of the unselected strain.

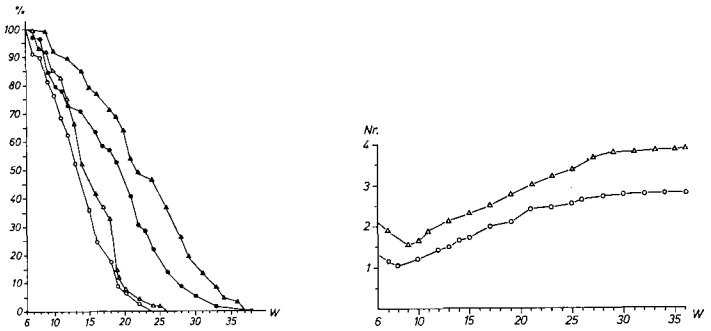

Fig. 1 (left). Longevity of a selected and an unselected strain; ○ = unselected ♂ (n = 213); ● = unselected ♀ (n = 705); △ = selected ♂ (n = 80); ▲ = selected ♀ (n = 230); W = weeks; % = survival. – *Fig. 2 (right).* Number of eggs per ♀ of a selected and an unselected strain. ○ = unselected strain; △ = selected strain; W = weeks; Nr = number of eggs

The cumulative average egg production of the selected strain was 3.52, and for the unselected strain 2.72, eggs per female per week. The females of the selected strain lived an average of 4 weeks longer than the females of the unselected strain.

3 Discussion

Since the cumulative average number of eggs per female per week reached 3.0 only after several months, the selection for higher egg production also selected for adult longevity. To avoid other imperceptible selections that might occur in breeding programmes after several generations, field collected larvae were added to the strain under selection and all bred subsequent generations of the selected beetles were mixed.

It had been customary to ferment the cowdung kapokwood food medium at 70° C for several days before use as this was found to free it from the major beetle diseases and predators. The faster rate of growth on the unfermented larval food medium suggested the destruction of a larval growth factor during fermentation.

Metarrhizium anisopliae, formerly the most important disease encountered in the mass rearing, has virtually disappeared from field breeding sites in Western Samoa. Strict sanitary measures have kept the *Rhabdionvirus oryctes* infections to a minimum, while the various predators were killed during the mechanical mixing of the food components. Finally it was decided as a routine measure that freshly hatched larvae should be fed on cowdung for the first four weeks and then later with 50:50 mixture of unfermented cowdung and kapokwood.

The synchronisation of pupation in a rearing container was also found in field breeding sites.

The temperature-induced pupation and the faster rate of growth on the unfermented cowdung and cowdung kapokwood resulted in a shortening of the egg to adult growth period from 6.2 to 4.7 months.

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Zusammenfassung

Verbesserung der Massenzucht von Oryctes rhinoceros L.

Die Entwicklungszeit von *Oryctes rhinoceros* vom Ei bis zum Käfer konnte mit Hilfe eines verbesserten Futters für die Larven und durch Temperatur-Beeinflussung der Verpuppung von 6,2 auf 4,7 Monate verkürzt werden. Ein Stamm wurde gezüchtet, dessen Weibchen 4 Wochen länger als normal lebten und 29 % mehr Eier legten. Die Verpuppung fand statt, wenn alle Larven den gleichen physiologischen Zustand erreicht hatten. Jüngere Larven konnten das Verpuppen älterer Larven verzögern, falls sie in derselben Brutstätte lebten.

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