Coconut Rhinoceros Beetles (Coleoptera: Scarabaeidae) Develop in Arboreal Breeding Sites in Guam

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Coconut rhinoceros beetles (Coleoptera: Scarabaeidae) develop in arboreal breeding sites in Guam

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The coconut rhinoceros beetle (CRB), *Oryctes rhinoceros* (L.) (Coleoptera Scarabaeidae), is a major pest of coconut palm, *Cocos nucifera* L. (Arecales: Arecaceae). Adult beetles defoliate and kill palms when they bore into crowns to feed on sap. When Pacific Islands are invaded by this pest, coconut palm mortality may reach greater than 50% within a few years (Gressitt 1953). In contrast to adults, CRB larvae feed on decaying vegetation and do no economic damage. They usually are found in dead standing coconut palms, fallen coconut logs, and rotting coconut stumps. They also are found commonly in piles of sawdust and manure where these materials are available.

CRB first was detected in Guam in the Tumon Bay tourist hotel area in Sep 2007, and an eradication project was launched. The project relied on pheromone trapping, using ethyl 4-methyloctanoate (Oryctalure, P046, ChemTica Iternacional, Heredia, Costa Rica), to capture adults, and sanitation to remove rotting vegetation used as breeding sites. Despite these efforts, CRB damage in central Tumon Bay remained high, with about 50% of coconut palms in this area showing signs of recent attack.

The major source of CRB adults in Tumon Bay was presumed to be breeding sites in several unmanaged, vacant lots interspersed among hotel properties. Dead, standing coconut palms and severely damaged palms were felled and removed along with many tons of rotting coconut debris from vacant lots. Even though thorough searches of the Tumon Bay area detected no new breeding sites after the sanitation campaign, there was not a significant reduction in trap catch, and the incidence of new damage to palms remained high.

CRB eggs and larvae had occasionally been found developing in detritus captured in the crowns of coconut palms in Guam, but we had considered this to be a rare occurrence. To investigate the potential of arboreal sites as a significant source of CRB adults, we felled mature coconut palms and dissected their crowns at 2 sites. The 1st site, the former Fujita Hotel site, is in the area where the CRB first was discovered in Guam. This lot had been sanitized thoroughly, and we had not found new breeding sites on the ground for several months. The 2nd site, Agana Springs, is a swampy area that had been infested by the CRB for about 2 yr. We had begun sanitation work in this area, but it was not complete, and we were still discovering new breeding sites on the ground. At both sites, palms were not selected at random. We chose plants that had CRB injury and an accumulation of debris in their crowns.

We found all life stages of the CRB in crowns of 26 palms that we felled (Table 1). Larvae were found feeding in accumulated detritus held in the crowns. We saw no evidence of immatures feeding on live tissues. The proportion of trees harboring immature CRBs was 50% (6 out of 12) at the old Fujita Hotel site and 29% (4 out of 14) at the Agana Springs site. These proportions were not significantly different (P = 0.42; Fisher's exact test). However, the mean number of immatures per tree differed significantly between sites (8.5 immatures per tree for the 12 trees felled at the old Fujita Hotel site; 0.6 immatures per tree for the 14 trees felled at the Agana Springs site; P = 0.015; Wilcoxon rank sum test).

Most adults recovered from crowns appeared very healthy. They were very active and strong, and their exoskeletons showed no signs of wear. Due to their pristine appearance, we suspected that at least some of these beetles had recently developed in situ. To test this hypothesis, we applied a method developed by Vander Meer (1986). This method estimates physiological age of CRB adults using size and mass measurements. According to Vander Meer (1986), CRB adults are at a maximum mass at eclosion, and they pass through 3 behavioral phases, which are correlated with body mass. During the 1st phase, lasting about 30 d, the beetle does not feed and continually loses weight. When the adult's weight is down to about 65% of its emergent weight, the beetle flies up to a coconut palm crown, bores into the stem, feeds on sap, and increases its weight to about 80% emergence weight. The 2nd phase, which starts at first feeding, lasts about 120 d during which the beetle goes through several flight and feeding episodes. Body weight oscillates between about 60% and 80% of its emergent mass. In a final, senescent stage, the beetle stops feeding, and its weight continually declines until death occurs at about 40% of its emergent mass. Estimated emergent mass (EEM) was calculated by an equation from Vander Meer & McLean (1975), which expresses emergent weight as a linear function of elytral area. We classified beetles collected from palm crowns into the 3 behavioral phases based on percentage of EEM. Beetles weighing greater than 80% EEM were placed in the "Pre-flight" category, beetles between 60 and 80% EEM were placed in the "Active" category, and beetles less than 60% EEM were placed in the "Senescent" category. Our estimates indicated that 9 out of 16 adults from coconut palm crowns were in the "Pre-flight" phase of their adult life (Table 2). Thus, they probably had developed from egg to adult in situ. Whereas CRB adults typically fly up into palm crowns, it is hard to explain how larvae and pupae would arrive in this microhabitat other than having developed from eggs laid in the crown.

Development of CRB larvae in palm crowns has been reported previously but seems to be rather a rare behavior except in Guam. In the Palau

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Table 1. Coconut rhinoceros beetle life stages and other animals found during dissection of crowns of mature coconut palms in Guam.

	Coconut rhinoceros beetle life stages[b]								Other inhabitants
Tree number[a]	E	L1	L2	L3	PP	P	Am	Af	
1	0	0	0	0	0	0	0	0	brown treesnake (*Boiga irregularis*), crab, centipedes (*Scolopendra*), ants
2	12	7	0	1	4	0	2	0	
3	0	0	5	0	0	0	1	0	
4	2	15	6	1	0	0	4	2	ants, crab
5	0	0	0	3	0	0	1	1	
6	0	1	0	1	1	0	5	0	brown treesnake (*Boiga irregularis*), bird nest
7	1	1	0	0	0	0	1[c]	0	ants
8	0	0	0	0	0	0	0	0	ants
9	0	0	0	0	0	0	0	0	
10	0	0	0	0	0	0	1[c]	0	ants, flower beetle (*Protaetia pryeri*)
11	0	0	0	10	0	0	0	0	ants, click beetle (*Lanelater bifoveatus*)
12	6	17	3	5	0	0	1	0	
13	0	0	0	0	0	0	0	1[c]	
14	0	1	0	0	0	0	4	0	
15	0	0	0	0	0	1	0	0	Brown treesnake (*Boiga irregularis*), ants
16	0	0	0	2	0	0	0	0	ants, roaches, praying mantis
17	0	0	0	5	0	0	0	0	
18	0	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	1	2	termites, ants, lizard
21	0	0	0	0	0	0	0	1	
22	0	0	0	0	0	0	0	0	roaches, ants, lizard
23	0	0	0	0	0	0	0	1	roaches, ants, lizard
24	0	0	0	0	0	0	0	0	centipedes (*Scolopendra*)
25	0	0	0	0	0	0	0	0	ants, roaches
26	0	0	0	0	0	0	1	1	ants, roaches, termites

[a]Trees 1–12 were felled at the old Fujita Hotel site, Tumon Beach, on 2–4 Jun 2010. Trees 13–26 were felled at Agana Springs on 17–24 Jun 2010.
[b]Coconut rhinoceros beetle life stages: E = eggs, L1–3 = larval instars 1–3, PP = prepupae, P = pupae, Am = adult males, Af = adult females.
[c]Found dead.

Islands, Gressitt (1953) found larvae developing in live coconut palms, which had been injured seriously either by adult feeding, or by some injury to the palm that caused local rotting, or by the accumulation of debris among petiole bases of fronds that were delayed in falling. In India, Nirula (1955) reported that CRB larvae occurred in rubbish in the axils of living palms when ground breeding sites were unavailable.

Table 2. Size, mass, and behavioral status of coconut rhinoceros beetle adults removed during dissection of crowns of felled coconut palms at the old Fujita Hotel site, Tumon Beach, Guam, on 2–4 Jun 2010.

Beetle number	Sex[a]	EL Elytra length (mm)	EW Elytra width (mm)	EEM[b] Estimated emergent mass (g)	Mass (g)	Estimated percentage emergent mass	Behavioral status
904	m	22.06	17.44	4.499	4.558	101%	pre-flight
900	m	19.98	15.79	3.045	2.953	97%	pre-flight
908	m	21.16	17.29	4.103	3.922	96%	pre-flight
889	m	22.29	16.44	4.115	3.869	94%	pre-flight
906	m	24.85	20.39	7.061	6.211	88%	pre-flight
888	m	25.44	20.14	7.180	6.166	86%	pre-flight
911	m	21.30	17.29	4.154	3.505	84%	pre-flight
896	f	23.79	18.93	5.877	4.828	82%	pre-flight
905	m	22.31	18.01	4.858	3.959	81%	pre-flight
903	m	23.99	19.10	6.042	4.651	77%	active
902	m	23.76	19.76	6.279	4.595	73%	active
898	m	24.69	21.08	7.350	5.339	73%	active
897	m	25.93	20.92	7.812	5.547	71%	active
901	f	23.98	20.29	6.638	4.216	64%	active
890	m	24.87	19.17	6.432	3.923	61%	active
899	m	23.58	18.57	5.615	3.412	61%	active

[a]Sex: f = female, m = male.
[b]EEM = 0.021 ´ EL ´ EW − 3.580.

Our observations indicated that arboreal development of CRB grubs in Guam is a common occurrence. This habitat extension may be due to almost total absence of predation by insectivorous birds and mammals as a result of heavy predation of the latter by the brown tree snake, *Boiga irregularis* (Bechsterin) (Squamata: Colubridae). Elsewhere, rats are commonly found in the crowns of coconut palms and are known to prey on CRB larvae (Gressitt 1953; Hinkley 1967). In the crowns we dissected, we found 3 tree snakes and no evidence of rats (Table 1). There are rats in Guam, but they are rare. Ten rat snap traps baited with peanut butter where nailed to trunks of coconut palms at the Fujita Hotel site. No rats were caught during a 2 wk trapping period. It should be noted that arboreal breeding sites were not found in palms that had inflorescences, nuts, and old fronds removed, which is a standard management practice in hotel and golf course landscapes.

Following the discovery that arboreal breeding sites were common in Guam, we included removal of unmanaged coconut palms in our sanitation program. Palms were felled, inspected for the CRB, chipped, and disposed of by deep burial or burning. Stumps also were removed. In 121 coconut palms felled in our sanitation program, we found 510 CRB (99 eggs, 40 first instars, 72 second instars, 201 third instars, 25 pupae, 34 adult males, and 30 adult females).

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Summary

Coconut rhinoceros beetle (CRB; *Oryctes rhinoceros* [L.]; Coleoptera: Scarabaeidae) grubs feed only on decaying vegetation and usually are found in dead standing coconut trees and decaying coconut debris on the ground. However, in Guam, a significant proportion of the CRB population develops in detritus caught within the crowns of live coconut palms. This habitat extension may be due to almost total absence of predation by insectivorous birds and mammals as a result of heavy predation by the brown tree snake, *Boiga irregularis* (Bechsterin) (Squamata: Colubridae).

Key Words: brown tree snake; *Cocos nucifera*; *Oryctes rhinoceros*; detritus; emergent weight; physiological age; rat

Sumario

Las larvas del escarabajo rinoceronte del coco (ERC; *Oryctes rinoceros* [L.]; Coleoptera: Scarabaeidae) se alimentan sólo de la vegetación en descomposición y por lo general se encuentran en palos de coco muertos pero todavia parados y en los escombros de coco en descomposición en el suelo. Sin embargo, en Guam, una proporción significativa de la población de ERC se desarrolla en detritus atrapado dentro de las coronas de las palmas de coco vivas. Esta extensión de hábitat puede ser debido a la ausencia casi total de la depredación por aves y mamíferos insectívoros, como resultado de la depredación pesada por la culebra marrón de árbol, *Boiga irregularis* (Bechsterin) (Squamata: Colubridae).

Palabras Clave: culebra marrón de árbol; *Cocos nucifera*; *Oryctes rinoceros*; detritus; peso emergente; edad fisiológica; ratas

References Cited

Gressitt JL. 1953. The coconut rhinoceros beetle (*Oryctes rhinoceros*) with particular reference to the Palau Islands. Bernice P. Bishop Museum Bulletin 212: 157 pp.

Hinckley AD. 1967. Associates of the coconut rhinoceros beetle in Western Samoa. Pacific Insects 9: 505-511.

Nirula KK. 1955. Investigations on the pests of coconut palm. II. Indian Coconut Journal 8: 161-180.

Vander Meer RK. 1986. Percent emergent weight: a roadmap to adult rhinoceros beetle, *Oryctes rhinoceros*, behaviour. Journal of Insect Physiology 33: 437-441.

Vander Meer RK, McLean JA. 1975. Indirect methods of determining the emergent weight of *Oryctes rhinoceros* (L.). Annals of the Entomological Society of America 68: 867-868.