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Population dynamics of coconut rhinoceros beetle (*Oryctes rhinoceros* L.) and correlation with weather parameters

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Abstract
Coconut rhinoceros beetle, *Oryctes rhinoceros* (L.) is a serious pest of coconut plantations in all coconut growing states. Rhinoceros beetle feed on growing point of the tree and cause yield loss. It also attacks coconut seedlings through collar region (or) spear leaf and cause lethal to seedlings. Studies on population dynamics of rhinoceros beetle were carried out in juvenile (6 months old) and established coconut garden (10 years old) from March 2021 to August 2021 at Madukkur block and Orathanadu block of Thanjavur District affected by Gaja cyclone. The study on population dynamics revealed that maximum number of rhinoceros beetles/ trap was recorded during 33rd standard week (August, 2021) in Madukkur block and 32nd standard week (August, 2021) in Orathanadu block whereas less number of rhinoceros beetles/ trap was recorded during 14th standard week (April, 2021) in both Madukkur block and Orathanadu block. In Madukkur block, the average number of adult beetles trapped per week in juvenile garden was negatively correlated with maximum temperature (-0.4104) and positively correlated with rainfall (0.6829). In established garden, the weekly mean trap catches was negatively correlated with maximum temperature (-0.5282) and wind velocity (-0.5030) whereas positively correlated with rainfall (0.8164). Plant damage (%) was positively correlated with minimum temperature (0.5521) and rainfall (0.4356), whereas negatively correlated with relative humidity morning (-0.5414) in juvenile garden. In established garden, plant damage (%) was positively correlated with minimum temperature (0.5480) and rainfall (0.4493) whereas negatively correlated with relative humidity morning (-0.5520). In Orathanadu block, the average number of adult beetles collected in traps per week was positively correlated with rainfall (0.7506) in juvenile garden. In established garden mean trap catches positively correlated with rainfall (0.6563) and negatively correlated with wind velocity (-0.4265). Plant damage (%) was positively correlated with rainfall in both juvenile (0.5919) and established garden (0.5811). The results showed that there was significant relationship between rainfall, trap catches and plant damage (%). This study revealed that the rainfall was a main factor that influences the population dynamics of *O. rhinoceros*.

Keywords: correlation, plant damage, population dynamics, rhinoceros beetle and weather parameters

1. Introduction
Coconut (*Cocos nucifera*) is one of the most important plantation crops in India, with a total cultivated area of 1975.81 thousand hectares and production of 21,665 million nuts which makes India stand third largest producer (Raghavi *et al*., 2019) [8]. The coconut palm is susceptible to a variety of pests viz., rhinoceros beetle, red palm weevil, leaf-eating caterpillar, eriophyid mite, whitefly, white grub, and rodents all of which can cause significant crop damage. The rhinoceros beetle often known as the black beetle, is a major pest of coconut in all coconut growing countries around the world (Rajan *et al*., 2009) [10]. The coconut rhinoceros beetle (*Oryctes rhinoceros* L.) is a major pest in Southeast Asia infesting primarily young coconut palms in the age of one to six years (Bedford, 1980) [2]. Adult beetles bore into the spindle leaf, spathe and young petioles of juvenile palms and cause injury. When the attack is on the unopened spathe, the inflorescence is severely harmed resulting in a 10% annual yield loss. The chewed up fibrous material protrudes from the entry point or bore hole as the results of adult beetle feeds on soft tissues (Nirula, 1955) [6]. The damaged spindle leaf when unfold the leaf lamina displays "V" shaped cuts (Hinckley, 1966; Giblin-Davis, 2001) [5, 4]. Repeated attacks cause reduction in leave size and tree becomes stunted (Sadakathulla *et al*., 1990) [10]. The rhinoceros beetle causes havoc on young coconut palms. Rhinoceros beetles attack replanted young seedlings through a specific entry point near the collar in Gaja cyclone

affected areas of Tamil Nadu. When the collar region of the affected young palm is split open presence of adult beetle is noticed and bore holes near the collar region of coconut seedlings can be seen. The extent of damage caused by rhinoceros beetle in young seedlings in Gaja cyclone affected areas ranged from 21.0 to 30.0% (Mathirajan, 2020). In this context, the present study was investigated to generate information about the population dynamics of the coconut rhinoceros beetle in juvenile (6 months old) and established gardens (10 years old) and correlation with weather parameters.

2. Materials and Methods

The field study was carried out from March 2021 to August 2021 in Madukkur and Orathanadu Block of Thanjavur Dt. affected by Gaja cyclone. Pheromone traps were installed @ 2/ac at 2-3 feet (60-90cm) height from ground level. The traps were installed in six months old juvenile coconut garden and ten years old established garden in Alanpallam (Madukkur block) and Kulamangalam (Orathanadu Block). Rhinolure was inserted in the slot provided on the under surface of the lid of the trap. The bucket of the trap was filled with water to prevent the escape of the beetles from trap. Lure was changed at monthly interval. Total number of adults collected in the traps was recorded at weekly intervals. Leaf damage and shoot damage was observed. The details of weather parameters viz., maximum temperature, minimum temperature, relative humidity morning, relative humidity evening, wind speed and number of rainy days of Madukkur block and Orathanadu block was collected from March 2021 to August 2021. The weekly mean trap catches of rhinoceros beetle adults in the pheromone traps were recorded. The plant damage (%) was assessed based on shoot damage in juvenile garden and leaf damage in established garden. Correlations study was made between the average number of rhinoceros beetles trapped per week and plant damage (%) in juvenile and established garden with weather parameters.

3. Results and Discussion

3.1 Madukkur block

In this study, mean trap catches of rhinoceros beetle was high 5.5 nos/trap was recorded in 20th standard week (May) and 33rd standard week (August) in juvenile garden. In established garden, trap catches recorded was high 6 nos/trap in 33rd standard week (August). Low mean trap catches of 2 nos/trap was observed in 10th standard week (March) and 23rd standard week (June) in juvenile garden. In established garden, trap catches recorded was low 2.5 nos/trap in 14th standard week (April) and 25th standard week (June). Charles (1963) [3] reported that the arrival of the rains in April or May start rhinoceros beetle activity. Number of rhinoceros beetles trapped in pheromone traps at weekly intervals and plant damage (%) was significant correlation with the weather parameters. Rhinoceros beetles trapped was negatively correlated with maximum temperature (-0.4104*) and positively correlated with rainfall (0.6829**) in juvenile garden. In established garden, mean trap catches was negatively correlated with maximum temperature (-0.5282**) and wind velocity (-0.5030**) whereas positively correlated with rainfall (0.8164**). Plant damage (%) was positively correlated with minimum temperature (0.5521**) and rainfall (0.4356*), whereas negatively correlated relative humidity morning (-0.5414**) in juvenile garden. In established garden plant damage (%) was positively correlated with minimum temperature (0.5480**) and rainfall (0.4493*) whereas negatively correlated with relative humidity morning (-0.5520**). This study concludes that when rainfall is increased, number of adult beetles trapped and plant damage (%) increased in both juvenile and established gardens. Norman and Basri (2004) observed that there was a significant relationship between rainfall and flight occurrence, implying that rainfall may have encouraged the beetle to fly in search of wet mating locations. The beetles were reported to be particularly active during the wet season. Trap catches of rhinoceros beetles, damage and weather parameters at weekly intervals in Madukkur block from March 2021 to August 2021 presented in table 1. Correlation study between weather parameters with mean trap catches and incidence of rhinoceros beetle (Madukkur block) at weekly intervals are presented in table 2.

3.2 Orathanadu block

In this block, mean trap catches of rhinoceros beetles were high 5.5 nos/trap in 32nd standard week (August) in juvenile garden and 6.5 nos/trap in 21st standard week (May) in established garden. Low mean trap catches of 1.5 nos/trap was observed in 13th standard week (March) and 15th standard week (April) in juvenile garden. In established garden, trap catches was low 2.0 nos/trap in 14th standard week (April) and 29th standard week (July). This study was supported by the findings of Charles (1963) [3], the arrival of the rains in April or May start rhinoceros beetle activity. Number of rhinoceros beetles trapped in pheromone traps at weekly intervals and plant damage (%) was significant correlation with the weather parameters. The mean trap catches per week was positively correlated with rainfall (0.7506) in juvenile garden. In established garden mean trap catches positively correlated with rainfall (0.6563) and negatively correlated with wind velocity (-0.4265). Plant damage (%) was positively correlated with rainfall in both juvenile (0.5919) and established garden (0.5811). This study revealed that the number of beetles catches and plant damage (%) increases with rainfall. Bedford (1975) [1] reported that the rhinoceros beetle captures were increased as a result of rainfall in New Britain. Trap catches of rhinoceros beetles, damage and weather parameters at weekly intervals in Orathanadu block from March 2021 to August 2021 presented in table 3. Correlation study of weather parameters with mean trap catches and incidence of rhinoceros beetle (Orathanadu block) are presented in table 4.

Table 1: Trap catches of rhinoceros beetles, damage and weather parameters at weekly intervals in Madukkur block from March 2021 to August 2021

Standard week	Weekly mean trap catches		Plant damage (%)		Maximum Temp. (^{0}c)	Minimum Temp. (^{0}c)	R.H. Morning (%)	R.H Evening (%)	Wind Velocity (km/hr)	Rainfall (mm)
	Juvenile garden (6 months old)	Established garden (10 years old)	Juvenile garden (Shoot damage)	Established garden (Leaf damage)						
09	4.0	4.5	15.71	25.71	34.00	20.92	80.00	65.64	2.71	0
10	2.0	4.0	17.14	27.14	36.00	23.28	95.42	62.65	3.04	0
11	3.0	3.5	20.00	28.57	35.57	22.00	93.71	62.42	2.55	0
12	4.0	4.0	22.85	30.00	36.14	24.85	91.57	69.78	2.41	0
13	3.0	3.0	24.28	31.42	36.14	24.85	91.57	69.78	2.41	0
14	2.5	2.5	27.14	32.85	36.57	22.92	87.92	69.00	3.97	0
15	4.5	4.5	30.00	34.28	35.57	24.85	87.35	68.30	3.57	1.45
16	2.5	3.0	32.85	35.71	34.00	25.78	89.85	76.21	2.16	0
17	4.5	4.5	34.28	37.14	36.32	25.77	88.42	70.57	2.59	1.40
18	2.5	3.5	35.71	38.57	35.07	26.85	85.71	76.85	2.58	0
19	5.0	4.0	37.14	40.00	34.72	25.21	84.00	80.14	3.24	1.42
20	5.5	4.5	31.42	41.42	33.85	26.00	85.42	78.42	4.30	1.94
21	4.5	3.5	40.00	42.85	35.28	24.85	80.00	69.85	3.40	0.97
22	4.0	3.5	42.85	44.28	37.50	25.85	78.28	67.71	4.32	0.40
23	2.0	3.0	44.28	45.71	37.07	26.50	75.00	71.28	4.99	0
24	3.5	4.5	47.15	47.15	36.85	25.57	79.85	71.85	3.13	0.45
25	3.0	2.5	48.57	48.57	37.64	25.00	79.14	65.14	5.08	0
26	2.5	3.0	50.00	50.00	35.71	26.28	79.42	73.57	3.70	0
27	3.0	3.0	52.85	51.42	36.85	25.92	84.00	68.00	3.19	0
28	3.5	4.0	54.28	52.85	36.28	25.85	82.85	72.00	3.39	0.31
29	2.5	3.0	57.14	54.28	36.64	25.71	80.57	75.42	3.81	0
30	3.0	3.5	58.57	55.71	32.85	25.21	76.42	68.28	4.55	0
31	3.5	3.0	60.00	57.14	36.14	26.21	74.85	68.57	4.08	0
32	4.5	5.5	62.85	58.57	36.00	25.50	81.00	69.00	3.46	5.54
33	5.5	6.0	64.20	60.00	32.00	24.00	82.00	82.00	1.13	5.71
34	4.0	5.0	67.14	61.42	32.83	25.66	92.66	74.16	2.26	2.45

Table 2: Trap catches of rhinoceros beetles, damage and weather parameters at weekly intervals in Orathanadu block from March 2021 to August 2021

Standard week	Weekly mean trap catches		Plant damage (%)		Maximum Temp. (^{0}c)	Minimum Temp. (^{0}c)	R.H. Morning (%)	R.H Evening (%)	Wind Velocity (km/hr)	Rainfall (mm)
	Juvenile garden (6 months old)	Established garden (10 years old)	Juvenile garden (Shoot damage)	Established garden (Leaf damage)						
09	2.5	4.0	11.42	18.57	33.80	23.80	85.70	83.00	6.40	0
10	2.0	3.5	12.85	20.00	33.80	23.80	80.60	86.00	6.30	0
11	3.5	4.5	14.28	21.42	33.70	23.60	78.00	77.60	6.40	0
12	2.5	3.5	15.71	22.85	33.80	24.30	76.60	75.30	6.40	0
13	1.5	2.5	17.14	24.28	31.30	28.80	80.70	76.10	6.30	0
14	2.0	2.0	18.57	25.71	36.40	25.60	78.40	72.90	6.60	0
15	1.5	2.5	20.00	27.14	36.50	24.80	77.10	75.60	6.40	0
16	2.5	3.5	21.42	28.57	37.20	25.60	78.10	77.70	6.40	0
17	4.0	4.0	22.85	30.00	36.40	24.60	76.60	74.10	6.70	0
18	2.0	3.0	24.28	31.42	37.10	25.30	72.90	70.00	6.50	0
19	4.0	4.0	25.71	32.85	36.90	25.10	69.00	68.90	6.70	0
20	4.5	6.0	27.14	34.28	35.80	24.70	73.30	73.60	6.40	2.85
21	5.0	6.5	28.57	35.71	35.80	25.60	78.60	74.10	6.60	3.57
22	2.0	3.0	30.00	37.14	37.10	25.70	72.60	68.60	6.70	0
23	3.5	4.0	31.42	38.57	36.60	25.10	75.10	73.30	6.80	1.14
24	3.0	2.5	32.85	40.00	36.50	25.30	75.60	76.30	6.90	0
25	3.0	3.5	34.28	41.42	35.70	25.50	73.10	74.70	7.30	0.42
26	2.0	3.0	35.71	42.85	36.00	24.60	78.30	77.00	7.40	0
27	4.0	4.0	37.14	44.28	35.90	25.20	78.70	79.30	6.60	3.28
28	3	2.5	38.57	45.71	36.00	24.90	81.60	78.90	7.30	0
29	2.0	2.0	40.00	47.14	35.50	24.80	80.60	77.60	8.30	0
30	3.0	2.5	42.85	48.57	35.10	24.60	78.00	77.70	7.30	0.74
31	4.0	3.0	44.28	50.00	34.21	24.08	81.57	83.57	6.42	2.14
32	5.5	5.0	45.71	51.42	34.42	23.71	81.42	83.14	6.42	5.71
33	3.0	4.0	47.14	52.85	34.57	23.85	81.14	83.28	6.57	3.18
34	3.5	4.5	48.57	54.28	34.42	23.85	80.14	81.57	6.00	3.28

Table 3: Correlation matrix of weather parameters with mean trap catches and incidence of rhinoceros beetle (Madukkur block)

Treatment	Weather Parameters					
	Temperature (ºC)		Relative humidity (%)		Wind velocity (km/hr)	Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Trap catches in juvenile garden (6 months)	-0.4104*	-0.0373 NS	-0.0449 NS	0.3760 NS	-0.2461 NS	0.6829**
Trap catches in established garden (10 years)	-0.5282**	-0.1358 NS	0.1389 NS	0.2969 NS	-0.5030**	0.8164**
Shoot damage (%) in juvenile garden	-0.1405 NS	0.5521**	-0.5414**	0.3478 NS	0.1614 NS	0.4356*
Leaf damage (%) established garden	-0.1618 NS	0.5480**	-0.5520**	0.3586 NS	0.1913 NS	0.4493*

Note: Correlation Co-efficient 1% = 0.496, 5% = 0.388
* - Significant at 5% level, ** - Significant at 1% level, NS - Non Significant

Table 4: Correlation matrix of weather parameters with mean trap catches and incidence of rhinoceros beetle (Orathanadu block)

Treatment	Weather Parameters					
	Temperature (ºC)		Relative humidity (%)		Wind velocity (km/hr)	Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Trap catches in juvenile garden (6 months)	0.0454 NS	-0.3284 NS	-0.0506 NS	0.1145 NS	-0.1775 NS	0.7506**
Trap catches in established garden (10 years)	-0.0638 NS	-0.2806 NS	-0.0723 NS	0.0573 NS	-0.4265*	0.6563**
Shoot damage (%) in juvenile garden	0.1179 NS	-0.2195 NS	0.1155 NS	0.2601 NS	0.3468 NS	0.5919**
Leaf damage (%) established garden	0.1382 NS	-0.2061 NS	0.1010 NS	0.2416 NS	0.3679 NS	0.5811**

Note: Correlation Co-efficient 1% = 0.496, 5% = 0.388
* - Significant at 5% level, ** - Significant at 1% level, NS - Non Significant

4. Conclusion

In Madukkur and Orathanadu blocks of Thanjavur District, the average number of rhinoceros beetle collected in pheromones trap per week and plant damage (%) were significantly correlated with weather parameters. The number of adult rhinoceros beetles trapped and plant damage (%) increased with high rainfall in juvenile and established garden.

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