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Diversity of light attracted phytophagous scarabs in cardamom agro-ecosystem

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Abstract
A study was conducted in cardamom agro-ecosystem during 2015 and 2016 in Mudigere to ascertain the diversity of light attracted scarabaeoids. Scarabaeoids being one of the speciose groups represent almost an estimated 10 per cent of the beetle fauna. The scarabs exhibit varied ecosystem. Pestiferous or phytophagous scarabs cause damage to cardamom, shade trees and black pepper grown as intercrop in cardamom by inflicting damage to the roots in their larval stage and leaves in their adult stage resulting in considerable loss of the crop. The results revealed that 1318 individuals and 81 species were recovered through light traps. Among these 627 individuals and 45 species were phytophagous and rest were non-phytophagous scarabs. The most abundant species was *Maladera* sp 2 which was followed by *Anomala varicolor* (Gyllenhal), *Sophrops karschi*, *Anomalachela bicolor* (Brenske), *Maladera* sp 3 and rest were represented by few individuals.

Keywords: Phytophagous scarabs, diversity, cardamom, species

Introduction
Cardamom is one of the spice crops that have medicinal properties *viz*., antiseptic (pulmonary), antispasmodic (neuromuscular), aphrodisiac, expectorant, anthelmenthic, antibacterial, cephalic, cardiotonic, diuretic, enmenagogue, sialogogue and stomachic. Besides, it is also used as anti-inflammatory, antidote to snake venom, hepatoprotective and anti-ulcerogenic (Rajathi *et al*., 2017) [10]. Cardamom is usually grown under shade trees and it is attacked by plethora of insects which limits the successful cultivation of the crop. Among the insect pests, white grubs or root grubs are major pests in nurseries and main fields. They damage the roots and rhizomes by feeding. As a result, the plants turn yellow and remain stunted and severely infested plants die (Rajeev and Thomas, 2015) [11]. Further, the damage by insects may alter the quality and quantity of raw materials and the therapeutic values of cardamom. Besides, they also feed on the roots and leaves of shade trees, black pepper and weeds as larvae and adults, respectively. Whitegrubs commonly known as chafers are pests of agricultural crops, fruit, plantation and forests, as both larvae and adults (Chandra, 2000 [3]; Lawrence *et al*., 2000 [6]; Mehta *et al*., 2010 [7]). Increased incidence of root grubs was noticed since from 2000 in cardamom plantations (Murugan *et al*., 2011 [8]).
Much of the studies on scarabs in India have been concentrated on their management in agricultural ecosystems. However, a very few studies have reported only one species, *Basilepta fulvicorne* affecting cardamom (Murugan *et al*., 2011[8]; Rajeev and Thomas, 2015 [11]; TNAU agriportal [5]). Yet, surprisingly little is known about the diversity, distribution and life histories of the majority of the scarabs in cardamom plantation. This study attempts to provide information on the diversity of phytophagous scarabs that are found in cardamom ecosystem in Mudigere.

Materials and Methods
The study was conducted in Mudigere. Mudigere is located at an altitude of 982 m above mean sea level (13º7'29" N; 75º37' E) under agro-climatic region-VI and zone-9 (Hill zone) of Karnataka along the Western Ghats, in south India. It receives an average annual rainfall of > 2400 mm and is recognised as a biodiversity hotspot.
Insects were collected using a funnel and vane type of light traps fitted with two 8 watt Philips

actinic BL UV tubes. The light trap was hung between the shade trees just above the cardamom canopy. The traps were run from January 2015 till December 2016 at periodic intervals for 12 hours from 6.00 pm in the evening till 6.00 am in the next morning. The insects catch was processed and scarabs were sorted. Further, the scarabs were again processed and sorted into different morpho-types. The details of collections were noted. Later, the specimens were identified using available literature.

Results

Cardamom agro-ecosystem was interspersed with various shade trees, weeds and black pepper.

Taxonomic composition of scarabs

A total of 1318 individuals and 81 morpho-species were caught in cardamom ecosystem. Among these, 627 individuals and 45 species (Table 1) were phytophagous scarabs and the rest were non-phytophagous scarabs. These phytophagous scarabs were represented by only one family, Scarabaeidae and four subfamilies *viz*., Cetoniinae, Dynastinae, Melolonthinae and Rutelinae. The predominant subfamily was Melolonthinae with 451 individuals and 24 species followed by Rutelinae (174 individuals and 19 species). Cetoniinae and Dynastinae each included only one individual and one species (Table 2). The taxonomic composition was generally similar during both the years of catch. During 2015, a total of 316 individuals and 37 species were caught while during 2016, a total of 311 individuals and 37 species were caught.

Relative abundance, species richness and diversity of scarab species

The abundances of 45 phytophagous species trapped to UV light in cardamom agro-ecosystem varied greatly, so also the number of individuals per species varied from one to 99. The abundances of 37 phytophagous scarab species during each year also varied greatly. The number of individuals per species varied from one to 57 during 2015 and from one to 42 during 2016. In each year during 2015 and 2016 and in totality from both the year together, *Maladera* sp 2 was the abundant species (Table 1). During 2015 the next abundant species was *Anomalochela bicolo*r, followed by *Maladera* sp. 1, *Anomala varicolor*, *Tetraserica* sp. 1 and so on. The next abundant species encountered during 2016 was *Sophrops karschi*, *Anomala varicolor*, *Maladera* sp. 3, *Anomala* sp. 1 and so on. However, from both the years together, the next abundant species was *Anomala varicolor*, *Sophrops karschi*, *Anomalochela bicolor*, *Maladera* sp.1 and so on.

Table 1: List of phytophagous scarabaeoid species collected in cardamom agro-ecosystem with their abundance.

Sl. No.	Species	Number of individuals			Sl. No.	Species	Number of individuals		
		2015	2016	Total			2015	2016	Total
1	*Anomala varicolor*	20	28	48	24	*Anomala* sp 6	1	2	3
2	*Anomala* sp 1	10	19	29	25	*Apogonia* sp 4	8	6	14
3	*Maladera* sp 1	25	13	38	26	*Serica* sp 1	1	0	1
4	*Maladera* sp 2	57	42	99	27	*Sophrops* sp 1	3	2	5
5	*Maladera* sp 3	17	26	43	28	*Anomala bengalensis*	2	4	6
6	*Tetraserica* sp 1	11	3	14	29	*Anomalophylla* sp 1	11	4	15
7	*Anomalochela bicolor*	30	16	46	30	*Hoplia* sp 1	12	4	16
8	*Clyster* sp 1	0	1	1	31	*Apogonia* sp 5	3	2	5
9	*Sophrops karschi*	10	38	48	32	*Mimela* sp 3	10	2	12
10	*Anomala* sp 2	4	2	6	33	*Miridiba excisa*	12	2	14
11	*Maladera* sp 4	2	0	2	34	*Maladera* sp 5	13	11	24
12	*Adoretus* sp 1	4	2	6	35	*Maladera* sp 6	1	13	14
13	*Apogonia* sp 1	3	5	8	36	*Maladera* sp 7	1	0	1
14	*Anomala* sp 3	4	0	4	37	*Serica* sp 2	4	17	21
15	*Mimela* sp 1	2	6	8	38	*Maladera* sp 8	2	0	2
16	*Anomala* sp 4	5	0	5	39	*Leucopholis burmeisteri*	0	5	5
17	*Apogonia* sp 2	1	0	1	40	*Adoretus versutus*	0	3	3
18	*Apogonia* sp 3	6	18	24	41	*Anomala* sp 7	0	1	1
19	*Anomala* sp 5	2	2	4	42	*Oreoderus* sp 1	0	1	1
20	*Mimela* sp 2	2	0	2	43	*Adoretus* sp 3	0	1	1
21	*Holotrichia* sp 1	3	3	6	44	*Mimela* sp 4	0	1	1
22	*Adoretus* sp 2	2	1	3	45	*Serica* sp 3	0	1	1
23	*Anomala helleri*	12	4	16	Total		316	311	627

The species richness of phytophagous scarabs in cardamom agro-ecosystem during 2015 and 2016 was same with 37 species in each year. However, the diversity of phytophagous scarabs was high during 2015 compared to 2016 with Shannon-Weiner index value of 0.83 and 0.79 during 2015 and 2016, respectively while the values of Simpson's reciprocal index was 2.73 and 2.61 during 2015 and 2016, respectively. Further, from the point of view of taxonomic diversity, as evidenced by the Avalanche index, the index values were almost similar during 2015 and 2016 with 1.42 and 1.43 values, respectively (Table 3).

Table 2: Relative abundance and species richness of phytophagous scarabaeoid beetles in cardamom agro-ecosystem

Subfamily	2015		2016		Total	
	# Species	Abundance	# Species	Abundance	# Species	Abundance
Cetoniinae	0	0	1	1	1	1
Dynastinae	0	0	1	1	1	1
Melolonthinae	22	224	19	227	24	451
Rutelinae	15	92	16	82	19	174
Total	37	316	37	311	45	627

Circular distribution of scarabaeoid species richness

The circular mean azimuth 'μ' and 'r' in cardamom agro-ecosystem for scarabaeoid species was 98.45° and 113.10° during 2015 and 2016, respectively. The relative azimuths 'α' were not evenly distributed during both the years (Rayleigh test, Z= 22.30, n = 172, p<0.001 and Z= 6.95, n = 162, p<0.001 for 2015 and 2016, respectively) (Figure 1).

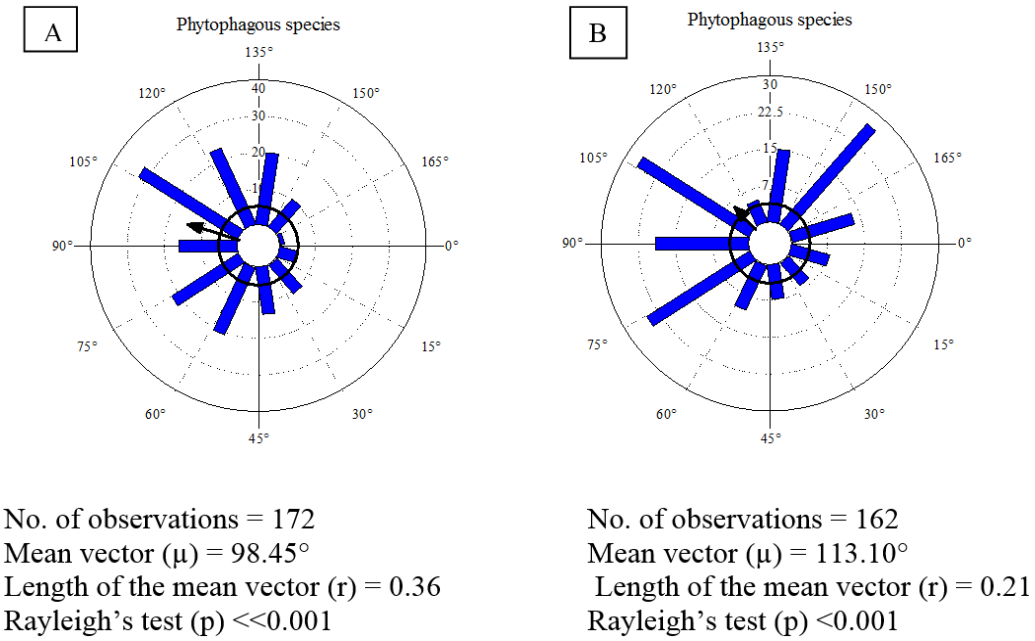

Fig 1: Circular bar graph of phytophagous scarab species and relative azimuth, α, collected from cardamom agro-ecosystem during 2015 (A) and 2016 (B).

Table 3: Diversity indices values of phytophagous scarabaeoid beetles in cardamom agro-ecosystem

Diversity index	2015	2016
Shannon-Weiner index (H')	0.83	0.79
Simpson's reciprocal index (1/D)	2.73	2.61
Avalanche index	1.42	1.43

Discussion

In the present study Melolonthinae was the predominant subfamily with respect to abundance and species richness followed by Rutelinae. Similar results were obtained in earlier works (Dadmal and Khadakkar, 2014 [4]; Pathania *et al*., 2015 [9]; Aparna, 2015 [1]; Bhattacharyya *et al*., 2017 [2]; Sreedevi *et al*., 2017 [12]). The most abundant species during 2015 and 2016 was *Maladera* sp 4 that accounted for 18 and 14 per cent of all the phytophagous scarabs, respectively among 45 species. The Rayleigh's test signified that a significant and specific directionality existed with respect to phytophagous scarabaeoid species during both the years as 'r' value was not equal to zero.

Conclusion

The diversity of phytophagous scarabaeoid species was high in cardamom agro-ecosystem rather than a single species which was earlier reported on cardamom. However, the damage by these phytophagous scarabaeoid species on cardamom is yet to be established.

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