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Faunal survey, endemism and possible species loss of Scarabaeinae (Coleoptera: Scarabaeidae) in the western slopes of the moist South Western Ghats, South India

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Abstract

Species composition, distribution patterns and endemism are outlined for the dung beetles in the ecoregions of the western slopes of the moist South Western Ghats, South India. Among the 142 dung beetle species known, 35 are endemic to the Western Ghats; 29 are endemic to the moist South Western Ghats; 25 are regionally endemic to the South Western Ghats montane rain forests ecoregion; and one each to the Malabar Coast moist deciduous forest ecoregion and the South Western Ghats moist deciduous forests ecoregion. Five species, including the 3 flightless species, are local endemics to the upper montane tropical montane cloud forests. The montane rain forests ecoregion has the highest number of endemics in the moist south Western Ghats and the moist deciduous forests ecoregion and Malabar Coast moist deciduous forest ecoregion have the lowest levels of endemism. Of the 137 dung beetle species known prior to the deforestation and habitat modification of the region, only 87 have been collected recently.

Key words: Dung beetles, check list, the Western Ghats, local endemism

Introduction

The Western Ghats is a global hotspot of biodiversity in the southwest of the Indian subcontinent and is well known for the high endemism and species richness (Myers 2003). This area is divided into drier dipterocarp dominated North Western Ghats ecoregion and *Cullenia* forest dominated South Western Ghats ecoregion with Wyanad as the transition area (Rodgers & Panwar 1988, Wikramanayake *et al.* 2002). The South Western Ghats montane ecoregion, especially its moist western slopes, is considered as a region with the highest regional endemism and faunal diversity in the entire Western Ghats (Wikramanayake *et al*. 2002). A search for data on the biogeographic distribution patterns, endemism and flightless montane dung beetles in the South Western Ghats and in the adjoining Malabar Coast moist deciduous forest ecoregion revealed the high occurrence of dung beetles (Arrow 1931, Balthasar 1963) prior to extensive deforestation from 1970–1980 (Nair 1991). However, the use of inprecise locality names dating to the British administration makes it difficult to determine endemism using earlier publication such as Arrow (1931), Paulian (1945), Balthasar (1963, 1974) and Cambefort (1985). There are no data on the extent of species loss between 1970 and 1980 in the Western Ghats or on the current status of Scarabaeinae in the region. Hence it was considered useful to publish an updated checklist of the dung beetles in the moist South Western Ghats, following the classification system of Löbl and Smetana (2006). In addition, details are given of the distribution patterns, endemism, and probable species loss based on recent collection efforts across the ecoregion (Sabu & Vinod 2005; Anu 2006; Sabu *et al.* 2006, 2007; Vinod & Sabu 2007; Vinod 2009; Sabu 2011; Latha *et al*. 2011).

Study region

The study region consists of the windward moist western slopes of the south Western Ghats and the adjoining southern part of the Malabar Coast lying between the South Western Ghats and the Arabian Sea (Fig. 1). Wikra-

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manayake *et al.* (2002) refer to this region as the moist western slopes of the South Western Ghats, divisible into South Western Ghats moist deciduous forests ecoregion (MDF) and South Western Ghats montane rain forests ecoregion (MEF). The Malabar Coast is referred as Malabar Coast moist deciduous forest ecoregion (MCF). Isolated patches of stunted montane evergreen forests surrounded by vast montane grasslands referred to as tropical montane cloud forests (TMCF) or cloud forests (Bruijnzeel & Proctor 1995, Sabu *et al.* 2011) and regionally as Shola forests occur in the peaks of South Western Ghats montane rain forests ecoregion. The map (Fig. 1) depicting the three ecoregions in the moist south Western Ghats is adapted from Atree (2009).

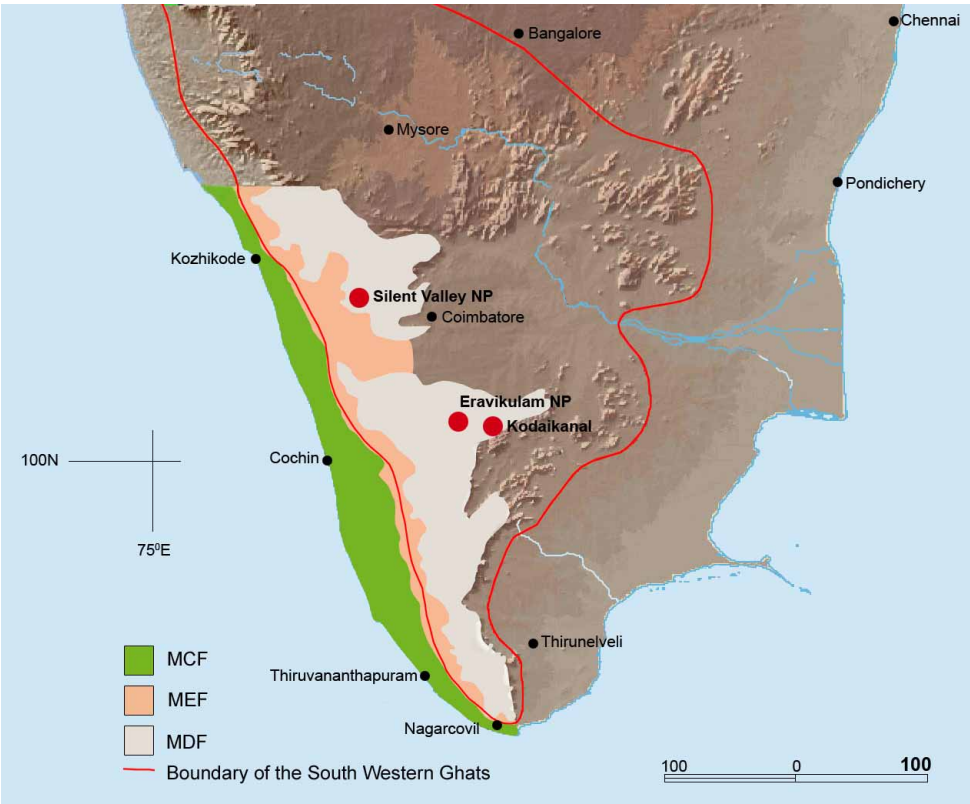

FIGURE 1. Ecoregions in the western slopes of the moist south Western Ghats and regions of local endemism.

Taxon information

Scarabaeinae have been determined following Arrow (1931), Paulian (1945, 1980, 1983), Balthasar (1963, 1974), Frey (1975), Cambefort (1985), Schoolmeesters (2005), Löbl and Smetana (2006) and Krikken (2009). Information on the distribution of scarab species was extracted from the studies made during 2000–2010 period (Sabu & Vinod 2005; Anu 2006; Sabu *et al.* 2006, 2007; Vinod & Sabu 2007; Vinod 2009; Sabu 2011; Latha *et al.* 2011). Records until 1980 are classed 'old collection effort' prior to the modification of Western Ghats and those of 2000–2010 'recent collection effort'. Two species, *Copris keralensis* collected in 1984 (Gill 1985) and *Onthophagus neocolobus* collected in 1982 (Scheuern 1996) are included in the old record as a matter of convenience.

All species are listed with their valid names, authority, and the year of description. Species are listed systematically by tribe, genus and subgenus. Within subgenera, species are listed alphabetically, and sequentially numbered. Species were broadly categorized as 'non endemic', 'endemic', 'regional', and 'local' based on distribution records. Species not recorded in the recent collections and are deemed extirpated are noted with an asterisk and wingless species with the symbol "#" in Table 1. Each species is assigned an alphabetical code (in bold type) corresponding to the distribution pattern and endemism.

TABLE 1. Checklist, species distribution patterns and endemism of Scarabaeinae by ecoregions in the western slopes of the moist South Western Ghats. Species not recorded in the recent collections and are deemed extirpated – *; Wingless species – #; EW: endemic to the Western Ghats; EMSW: endemic to the moist South Western Ghats; MCF: Malabar Coast moist deciduous forest ecoregion; MDF: South Western Ghats moist deciduous forests ecoregion; MEF: South Western Ghats montane rain forests ecoregion; TMCF: Tropical montane cloud forests.

SCARABAEINAE						
Tribe GYMNOPLEURINI						
Genus *Allogymnopleurus* Janssens, 1940						
1. *A. maculosus* (MacLeay, 1821)*				MDF		
2. *A. spilotus* (MacLeay, 1821)				MDF	MEF	
Genus *Garreta* Janssens, 1940						
3. *G. dejeani* (Laporte, 1840)*			MCF	MDF		
Genus *Gymnopleurus* Illiger, 1803						
4. *G. cyaneus* (Fabricius, 1798) *			MCF	MDF		
5. *G. gemmatus* Harold, 1871*				MDF		
6. *G. koenigi* (Fabricius, 1775)*			MCF	MDF		
Genus *Paragymnopleurus* Shipp, 1897						
7. *P. melanarius* (Harold, 1867)				MDF	MEF	
8. *P. sinuatus* (Olivier, 1789)				MDF	MEF	
Tribe SISYPHINI						
Genus *Sisyphus* Latreille, 1807						
Subgenus *Sisyphus*						
9. *S. araneolus* Arrow, 1927	EW	EMSW		MDF	MEF	
10. *S. crispatus hirtus* Wiedemann 1823*				MDF	MEF	
11. *S. longipes* (Olivier, 1789)			MCF	MDF	MEF	
12. *S. mendicus* Arrow, 1931*	EW	EMSW			MEF	
13. *S. neglectus* Gory, 1833			MCF	MDF	MEF	
Tribe CANTHONINI						
Genus *Cassolus* Sharp, 1875						
14. *C. humeralis* Arrow, 1907				MDF	MEF	
Genus *Ochicanthon* Vaz-de-Mello, 2003						
15. *O. devagiriensis* Sabu & Latha, 2011 #	EW	EMSW				TMCF
16. *O. gauricola* Cuccodoro, 2011*	EW	EMSW		MDF	MEF	
17. *O. laetus* (Arrow, 1931)	EW	EMSW		MDF	MEF	
18. *O. loebli* (Paulian, 1983)* #	EW	EMSW				TMCF
19. *O. murthy* Vinod & Sabu, 2011	EW	EMSW	MCF		MEF	
20. *O. mussardi* Cuccodoro, 2011*	EW	EMSW			MEF	
21. *O. nitidus* (Paulian, 1980)	EW	EMSW			MEF	
22. *O. tristis* (Arrow, 1931)	EW	EMSW			MEF	
23. *O. vazdemelloi* Latha & Sabu, 2011 #	EW	EMSW				TMCF
Genus *Panelus* Lewis, 1895						
24. *P. besucheti* Paulian, 1980*				MDF	MEF	TMCF
25. *P. keralai* Paulian, 1980	EW	EMSW		MDF	MEF	TMCF
26. *P. mussardi* Paulian, 1980*	EW	EMSW			MEF	TMCF

Tribe COPRINI						
Genus *Catharsius* Hope, 1837						
27. *C. capucinus* (Fabricius, 1781)*			MCF	MDF		
28. *C. granulatus* Sharp, 1875*					MEF	
29. *C. molossus* (Linnaeus, 1758)				MDF	MEF	
30. *C. sagax* (Quenstedt, 1806)				MDF	MEF	
Genus *Copris* Geoffroy, 1762						
Subgenus *Copris*						
31. *C. fricator* (Fabricius, 1787)*			MCF	MDF	MEF	
32. *C. repertus* Walker, 1858				MDF	MEF	
Genus *Paracopris* Balthasar, 1939						
33. *P. cribratus* (Gillet, 1927)				MDF	MEF	
34. *P. davisoni* (Waterhouse, 1891)			MCF	MDF	MEF	
35. *P. furciceps* (Felsche, 1910)					MEF	
36. *P. keralensis* (Gill, 1986)				MDF	MEF	
37. *P. signatus* (Walker, 1858)			MCF	MDF	MEF	
38. *P. surdus* (Arrow, 1931)					MEF	
Genus *Heliocopris* Hope, 1837						
39. *H. bucephalus* (Fabricius, 1775)					MEF	
40. *H. dominus* Bates, 1868					MEF	
Tribe ONTHOPHAGINI						
Genus *Anoctus* Sharp, 1875						
41. *A. myrmecophilus* (Arrow, 1907)*	EW	EMSW			MEF	
Genus *Caccobius* Thomson, 1863						
Subgenus *Caccophilus* Jekel, 1872						
42. *C. aterrimus* (Fabricius, 1798)*			MCF			
43. *C. gallinus* Arrow, 1907	EW	EMSW		MDF	MEF	
44. *C. indicus* Harold, 1867*					MEF	
45. *C. meridionalis* Boucomont, 1914			MCF	MDF	MEF	
46. *C. ultor* Sharp, 1875					MEF	
47. *C. unicornis* (Fabricius, 1798)					MEF	
48. *C. vulcanus* (Fabricius, 1801)			MCF	MDF	MEF	
Genus *Cleptocaccobius* Cambefort, 1984						
49. *C. arrowi* Cambefort, 1985				MDF	MEF	
Genus *Digitonthophagus* Balthasar, 1959						
50. *D. gazella* (Fabricius, 1787)				MDF		
Genus *Onthophagus* Latreille, 1802						
Subgenus *Onthophagus*						
51. *O. abacus* Boucomont, 1921*			MCF			
52. *O. abreui* Arrow, 1931*				MDF		
53. *O. amphicoma* Boucomont, 1914			MCF	MDF	MEF	
54. *O. amphinasus* Arrow, 1931	EW				MEF	
55. *O. andrewesi* Arrow, 1931	EW				MEF	
56. *O. bisectus* Arrow, 1931*	EW	EMSW				TMCF
57. *O. brevicollis* Arrow, 1907*					MEF	

58. *O. bronzeus* Arrow, 1907				MDF	MEF	
59. *O. brutus* Arrow, 1931					MEF	
60. *O. caesariatus* Boucomont, 1921*	EW	EMSW		MDF		
61. *O. castetsi* Lansberge, 1887				MDF	MEF	TMCF
62. *O. centricornis* (Fabricius, 1798)			MCF	MDF	MEF	
63. *O. cervus* (Fabricius, 1798)			MCF	MDF	MEF	
64. *O. coorgensis* Arrow, 1931*	EW	EMSW			MEF	
65. *O. deflexicollis* Lansberge, 1883				MDF	MEF	
66. *O. devagiriensis* Schoolmeesters & Sabu, 2006	EW	EMSW		MDF	MEF	
67. *O. difficilis* Walker, 1858*	EW	EMSW				TMCF
68. *O. duporti* Boucomont, 1914			MCF		MEF	
69. *O. elongatus* Frey, 1954	EW	EMSW			MEF	
70. *O. ensifer* Boucomont, 1914			MCF	MDF	MEF	
71. *O. falsus* Gillet, 1925			MCF	MDF	MEF	
72. *O. fasciatus* Boucomont, 1914			MCF	MDF	MEF	
73. *O. favrei* Boucomont, 1914			MCF	MDF	MEF	
74. *O. furcillifer* Bates, 1891				MDF	MEF	
75. *O. germanus* Gillet, 1927					MEF	
76. *O. griseosetosus* Arrow, 1931*					MEF	
77. *O. igneus* Vigors, 1825*					MEF	
78. *O. insignicollis* Frey, 1954			MCF	MDF	MEF	
79. *O. kanarensis* Arrow, 1931	EW				MEF	
80. *O. kchatriya* Boucomont, 1914			MCF	MDF	MEF	
81. *O. keralensis* Frey, 1975*	EW	EMSW	MCF			
82. *O. keralicus* Biswas & Chatterjee, 1986*	EW	EMSW			MEF	
83. *O. laborans* Arrow, 1931					MEF	
84. *O. laevigatus* (Fabricius, 1798)*				MDF		
85. *O. lemniscatus* Gillet, 1924	EW	EMSW			MEF	
86. *O. ludio* Boucomont, 1914			MCF		MEF	
87. *O. madoqua* Arrow, 1931	EW		MCF	MDF		
88. *O. malabarensis* Boucomont, 1919*			MCF	MDF	MEF	
89. *O. mauritii* Boucomont, 1919*			MCF		MEF	
90. *O. negligens* Walker, 1858			MCF		MEF	
91. *O. pacificus* Lansberge, 1885				MDF	MEF	
92. *O. parvulus* (Fabricius, 1798)*			MCF			
93. *O. porcus* Arrow, 1931					MEF	
94. *O. pygmaeus* (Schaller, 1783)			MCF	MDF	MEF	
95. *O. quadridentatus* (Fabricius, 1798)			MCF	MDF	MEF	
96. *O. rana* Arrow, 1931*						TMCF
97. *O. refulgens* Arrow, 1931	EW	EMSW			MEF	TMCF
98. *O. sahai* Biswas & Chatterjee, 1986	EW	EMSW			MEF	
99. *O. socialis* Arrow, 1931*					MEF	
100. *O. spinifex* (Fabricius, 1781)*					MEF	
101. *O. tarandus* (Fabricius, 1792)*					MEF	

102. *O. tritinctus* Boucomont, 1914				MDF	MEF	
103. *O. truncaticornis* (Schaller, 1783)*			MCF	MDF	MEF	
104. *O. turbatus* Walker, 1858			MCF	MDF	MEF	
105. *O. unifasciatus* (Schaller, 1783)			MCF	MDF	MEF	
106. *O. usurpator* Balthasar, 1960	EW				MEF	
107. *O. violaceotinctus* Gillet, 1925					MEF	
108. *O. vladimiri* Frey, 1957	EW	EMSW			MEF	
109. *O.*n.sp. (Nithya & Sabu, unpublished data)	EW	EMSW			MEF	
Subgenus *Micronthophagus* Balthasar, 1963						
110. *O. cavia* Boucomont, 1914				MDF	MEF	
111. *O. hystrix* Boucomont, 1914*			MCF	MDF		
112. *O. oculatus* Arrow, 1931				MDF		
Subgenus *Proagoderus* Lansberge, 1883						
113. *O. imperator* Laporte, 1840*	EW				MEF	
114. *O. vividus* Arrow, 1907			MCF	MDF	MEF	
Subgenus *Colobonthophagus* Balthasar, 1935						
115. *O. bengalensis* Harold, 1886*					MEF	
116. *O. dama* (Fabricius, 1798)			MCF	MDF	MEF	
117. *O. ephippioderus* Arrow, 1907*					MEF	
118. *O. neocolobus* Scheuern, 1996*					MEF	
119. *O. pardalis* (Fabricius, 1798)*					MEF	
120. *O. tragus* (Fabricius, 1792)					MEF	
121. *O. urellus* Boucomont, 1919					MEF	
Subgenus *Macronthophagus* Ochi, 2003						
122. *O. diabolicus* Harold, 1877					MEF	
123. *O. manipurensis* Arrow, 1907					MEF	
Subgenus *Paraphanaeomorphus* Balthasar, 1959						
124. *O. bifasciatus* (Fabricius, 1781)			MCF	MDF	MEF	
Subgenus *Serrophorus* Balthasar, 1963						
125. *O. rectecornutus* Lansberge, 1883				MDF	MEF	
126. *O. laevis* Harold, 1880				MDF	MEF	
Subgenus *Parascatonomus* Paulian, 1932						
127. *O. discedens* Sharp, 1875*					MEF	
128. *O. quaestus* Sharp, 1875				MDF		TMCF
Genus *Phalops* Erichson 1848						
129. *P. divisus* (Wiedemann, 1823)*				MDF		
Tribe ONITINI						
Genus *Onitis* Fabricius, 1798						
130. *O. falcatus* (Wulfen, 1786)			MCF	MDF	MEF	
131. *O. philemon* Fabricius, 1801*					MEF	
132. *O. singhalensis* Lansberge, 1875*					MEF	
133. *O. siva* Gillet, 1911			MCF		MEF	
134. *O. subopacus* Arrow, 1931					MEF	

135. *O. virens* Lansberge, 1875				MDF	MEF
Tribe ONITICELLINI					
Subtribe *Drepanocerina* Lansberge, 1875					
Genus *Tibiodrepanus* Krikken, 2009					
136. *T. setosus* (Wiedemann, 1823)			MCF		MEF
137. *T. sinicus* (Harold, 1868)					MEF
Subtribe *Oniticellina* Kolbe, 1905					
Genus *Euoniticellus* Janssens, 1953					
138. *E. pallipes* (Fabricius, 1781) *					MEF
Genus *Liatongus* Reitter, 1892					
139. *L. indicus* Arrow, 1908	EW	EMSW			MEF
Genus *Oniticellus* Dejean, 1821					
140. *O. cinctus* (Fabricius, 1775)			MCF		MEF
Genus *Tiniocellus* Péringuey, 1900					
141. *T. spinipes* (Roth, 1851)			MCF	MDF	MEF
Tribe ATEUCHINI					
Genus *Delopleurus* Erichson, 1847					
142. *D. parvus* Sharp, 1875*				MDF	

Results and discussion

Species richness: 142 species are known from the moist south Western Ghats including five new species reported in 2000–2010. The failure to find 50 species previously recorded indicates that they are either extirpated or have become rare. Maximal species richness occurs in MEF (123 species) and the minimal in MCF (45 species) (Table 2).

Endemism: 35 species (25%) were endemic to the Western Ghats and 29 (20%) to the moist south Western Ghats. High regional endemism of MEF (20 out of 29) indicates that MEF is the key centre for endemics in the South Western Ghats and the MDF and MCF with 1/29 species have the lowest levels of endemism. Five species – *Ochicanthon devagiriensis* Sabu & Latha, *O.vazdemelloi* Latha & Sabu, *O.loebli* Paulian, *Onthophagus bisectus* Arrow and *O.difficilis* Walker – are local endemics to TMCF. Among the five local endemics, the three *Ochicanthon* species (*O.devagiriensis; O.vazdemelloi; O.loebli*) are wingless and unique to the isolated and distantly placed peaks of the South Western Ghats (Eravikulam in the Anamalais, Kodaikanal in the Palani Hills and Silent Valley in the Nilgiris). This is indicative of the isolation, resource availability and stability in the respective regions.

Distribution: Among the eight tribes recorded from South India and the Indian subcontinent, Scarabaeini has not been recorded from the moist western slopes of the South Western Ghats. Prevalence of the tribe in the drier leeward eastern slopes of the South Western Ghats and in the dry central Indian plains (Arrow 1931, Balthasar 1963) indicates that Scarabaeini prefer drier habitats.

Species loss: Thirteen out of 30 of the species endemic to the Western Ghats and 12 out of 24 of the species endemic to the moist South Western Ghats were not found in the recent collection effort. Highest failure to record rates of endemic (11 species; 41%) and regional endemic species (10 species; 45%) were in MEF. *Anoctus* Sharp, *Phalops* Erichson, *Delopleurus* Erichson, *Garreta* Janssens, *Gymnopleurus* Illiger and *Euoniticellus* Janssens were poorly recorded prior to the modification of the Western Ghats (Arrow 1931, Balthasar 1963). Among these, myrmecophilous *Anoctus* were collected with flight interception traps (Krikken 1971, Krikken & Huibregts 2006). Habits of the other five genera, namely *Phalops*, *Delopleurus*, *Garreta*, *Gymnopleurus* and *Euoniticellus* remain unknown in this region. Therefore, these six genera not recorded in the recent collection efforts are categorized as the rarest dung beetle genera in the moist South Western Ghats and not as extirpated species, mainly because flight

interception traps were not used in the recent collection efforts. Highest species loss in the genus *Panelus* Lewis followed by *Copris* Geoffroy, *Catharsius* Hope and *Allogymnopleurus* Janssens (50%), may indicate that these are vulnerable genera that may disappear due to habitat modifications occurring intensely in the region. Rise in the species richness of *Ochicanthon* (4 to 9 species; 44%) could be due to poor sampling in upper montane forests (TMCF) during earlier collection efforts. *Heliocopris* Hope, *Paragymnopleurus* Shipp, *Paracopris* Balthasar, *Digitonthophagus* Balthasar, *Tiniocellus* Péringuey, *Tibiodrepanus* Krikken, *Liatongus* Reitter, *Oniticellus* Dejean, *Cleptocaccobius* Cambefort and *Cassolus* Sharp with no species loss are considered as the most adapted and less-at-risk groups in the region.

TABLE 2. Species loss of Scarabaeinae by ecoregions in the western slope of the moist South Western Ghats (**WGs**: The Western Ghats; **MCF**: Malabar Coast moist deciduous forest ecoregion; **MEF**: South Western Ghats montane rain forests ecoregion; **MDF**: South Western Ghats moist deciduous forests ecoregion; **TMCF**: Tropical montane cloud forests).

Region	Category	Period of collection							
		Recorded through 2010		Recorded through 1980		Recorded during the 2000-2010 period		Species deemed extirpated during 1980-2010	
		Number	%	Number	%	Number	%	Number	%
Moist south WGs	Species richness	142		137		87	64	50	36
	Endemic to WGs	35	25	30	22	17	57	13	43
	Non endemic to WGs	107	75	107	78	70	65	37	35
	Endemic to moist south WGs	29	20	24	18	12	50	12	50
MEF	Endemic & Non endemic to MEF	123	87	118	86	84	71	34	29
	Endemic to WG in MEF	32	23	27	20	16	59	11	41
	Regional endemic to MEF	25	18	22	16	12	55	10	45
MDF	Endemic & Non endemic to MDF	71	50	70	51	52	74	18	26
	Endemic to WGs in MDF	8	6	7	5	5	71	2	29
	Regional Endemic to MDF	1	1	1	1	0	-	1	100
MCF	Endemic & Non endemic to MCF	45	32	44	32	31	70	13	30
	Endemic to WGs in MCF	3	2	2	1	1	50	1	50
	Regional Endemic to MCF	1	1	1	1	0	-	1	100
TMCF	Endemic & Non endemic to TMCF	12	8	10	7	4	40	6	60
	Local Endemic to TMCF	5	4	3	2	0	-	3	100
	Wingless	3	2	1	1	0	-	1	100

Conclusions

Analysis of the distribution pattern of Scarabaeinae in the moist western slopes of the South Western Ghats indicates that the MEF is the most species-rich and endemic taxa rich area. The plausible explanation is that MEF is a transition-zone for species in the windward moist western and leeward dry eastern slopes of the MDF and is comparatively free of plantations activities. Exclusive presence of wingless species corroborates with other studies (Wikramanayake *et al*. 2002, Rice & Madhusudan 2009) that have identified TMCF as a key centre for local endemism.

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