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Diversity and Relative Abundance of Pleurostict Scarabaeidae (Coleoptera) in Achanakmar-Amarkantak Biosphere Reserve, Central India

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Abstract: Diversity and relative abundance of Pleurostict Scarabaeidae (Coleoptera: Scarabaeidae; Rutelinae, Melolonthinae, Dynastinae, Cetoniinae) were studied and analyzed in Achanakmar-Amarkantak Biosphere Reserve (AABR), Chhattisgarh. Scarab sampling during the years 2004 and 2008 yielded a total of 426 beetles belonging to 26 species distributed in 13 genera and four subfamilies. Between the two selected study areas viz. Atariya and Chhaparwa, the highest numbers of scarabs (n=346) were observed in Chhaparwa constituting 24 species under 12 genera and accounting 81.22% of the total number of beetles collected from the biosphere reserve. While from Atariya, 80 scarabs, comprising 13 species belonging to five genera and four subfamilies were collected. The subfamily Rutelinae with 16 species (71.12% of the total individuals) was dominating over other subfamilies. *Anomala* (9 species) was found the most dominant genus in the scarab population of the biosphere reserve, accounting 57.51 % of the total scarabs collected from the study area.

Key words: Species Diversity · Pleurostict Scarabaeidae · Achanakmar-Amarkantak Biosphere Reserve and Central India

INTRODUCTION

The family Scarabaeidae is one of the largest, most diverse and widely distributed families of largest order Coleoptera. On the basis of the position of the posterior spiracles, the family is generally divided into two major groups, Laparosticti (dung beetles) and Pleurosticti (chafers) [1]. The latter group is strictly phytophagous with various feeding habits, including some species that do not feed at all in the adult stage. In India, Pleurostict chafers are included in nine subfamilies of the family Scarabaeidae *i.e.* Sericinae, Melolonthinae, Euchirinae, Rutelinae, Hoplinae, Dynastinae, Valginae, Cetoniinae and Trichiinae [2]. Dynastinae, with conspicuous horns in males, usually attack stems or roots of plants, whereas Cetoniinae prefer nectar, sap, or juice of ripening fruits and vegetables [1]. Rutelinae and Melolonthinae mostly attack fresh leaves while Cetoniinae and few genera of Rutelinae are common visitors to flowers, where they feed on nectar or pollen. Larvae of Pleurosticti, such as Melolonthinae, Rutelinae and Dynastinae are soil-dwelling white grubs that feed on living roots and destructive to crops. Some Cetoniinae and Dynastinae grubs feed in soil humus or litter, whereas other Cetoniinae, Trichinae and Valginae live in decaying wood or in debris accumulated in the hollows of trees [1]. Many species of the Pleurosticti scarabs have been already reported as pests of various crops in India by many researchers [3-11].

The most exhaustive account on the Pleurostict scarab fauna of India and adjacent countries was published by Arrow [4, 5] in two volumes of the 'Fauna of British India' where in 690 species under five subfamilies namely Cetoniinae (241 species), Dynastinae (46 species), Rutelinae (398 species), Desmonychinae (1 species) and Euchirinae (4 species) were included. Concentrating on the scarab diversity in Central India, comprehensive research has been made by Chandra [12-14], Chandra and Ahirwar [15], Chandra and Singh [16], Chandra and Gupta [17]. Chandra and Ahirwar [15] recorded 124 species/subspecies of the scarab beetles belonging to 45 genera under 11 subfamilies from Madhya Pradesh and Chhattisgarh. Recently Chandra and Singh [16] reported 22 species of these beetles belonging to 11 genera and 6 subfamilies from Achanakamar Wildlife Sanctuary, wherein 11 species of the Pleurostict scarabs were included.

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In the present study the diversity and relative abundance of the phytophagous (Pleurostict) scarabs (Melolonthinae, Rutelinae, Dynastinae and Cetoniinae) in Achanakmar-Amarakantak Biosphere Reserve are discussed because these beetles serve as a useful indicator for measuring species diversity in a particular region and they can be easily collected quantitatively by light trapping method due to their nocturnal flying activities [18]. In addition, their food habits are generally well known; adults tend to feed on flowers, leaves, fruits and tree sap, whereas larvae feed on plant roots under the ground and rotten wood [18, 19]. The objective of the study was to analyze and assess the diversity of the phytophagous scarab beetles in Achanakmar-Amarkantak Biosphere Reserve.

MATERIALS AND METHODS

Study Area: The study was conducted in Achanakmar-Amarkantak Biosphere Reserve (AABR), located in Shahdol and Dindori districts of Madhya Pradesh and Bilaspur district of Chhattisgarh. Geographically, the biosphere reserve lies between 22° 15' to 22° 58' N Latitude and 81° 25' to 82° 5' E Longitude and covers an area of 3835.51 sq. km. The main forest covers identified in AABR are closed forests, open forests, degraded forests and forest blank. Champion and Seth [20] classified the forests of AABR as tropical moist deciduous, Northern moist deciduous and Southern dry mixed deciduous forests. On the basis of terrain and vegetation characteristics the forests and non-forest areas have been divided into various habitat types, like Sal forest, mixed forest, Bamboo forest, Pine plantation, Eucalyptus plantation, grasslands, riverine forests and sacred groves. The soil of the area is generally lateritic, alluvial and black cotton type, derived from granite, gneisses and basalts. AABR has a typical monsoon regulated climate, with three distinct seasons, summer from March to June, rainy from July to October and winter from November to February. Total annual rainfall recorded in 2004-2005 was over 1373 mm.

Sampling Design: The scarabs were sampled for one week during the years 2004 and 2008 from two different localities viz. Atariya and Chapparwa in AABR by the scientific teams of Zoological Survey of India (ZSI), Jabalpur. The diversity of these beetles depends on the availability of larval and adult food sources, weather conditions and soil type. Thus in order to reduce the seasonal effects, beetle sampling was done only for a week in June in both the surveys (2004 and 2008) for assessing the true diversity of the scarab beetles in the biosphere reserve. Beetles were collected using light trap and thereafter pinned and preserved in the lab. Light trap consist of a white sheet hung between two poles and a mercury bulb in front it. In order to obtain the most complete species list of the Pleurostict scarabs for AABR, the specimens were compared with the reference collections present in ZSI, Jabalpur and identified using available literature [4, 5, 2]. Species are listed with their valid names and the photographs of species which were not damaged are also provided (PLATE- I, II & III). Voucher specimens were deposited in Zoological Survey of India, Jabalpur, India.

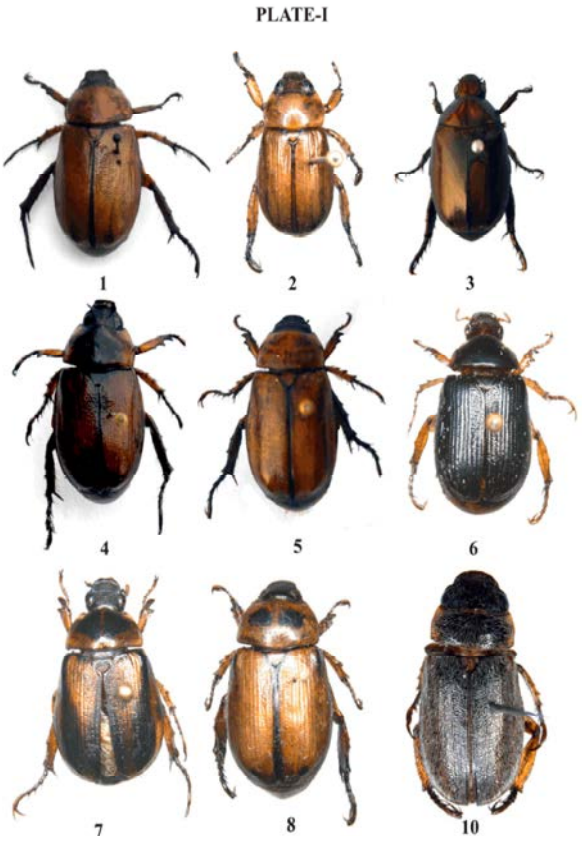

Plate I: (1) *Anomala bengalensis* (Blanchard), (2) *A. biharensis* Arrow, (3) *A. cantori* (Hope), (4) *A. dorsalis* (Fabricius), (5) *A. polita* (Blanchard), (6) *A. ruficapilla* Burmeister (7) *A. rugosa* Arrow, (8) *A. varicolor* (Gyllenhal), (10) *Adoretus lasiopygus* Burmeister.

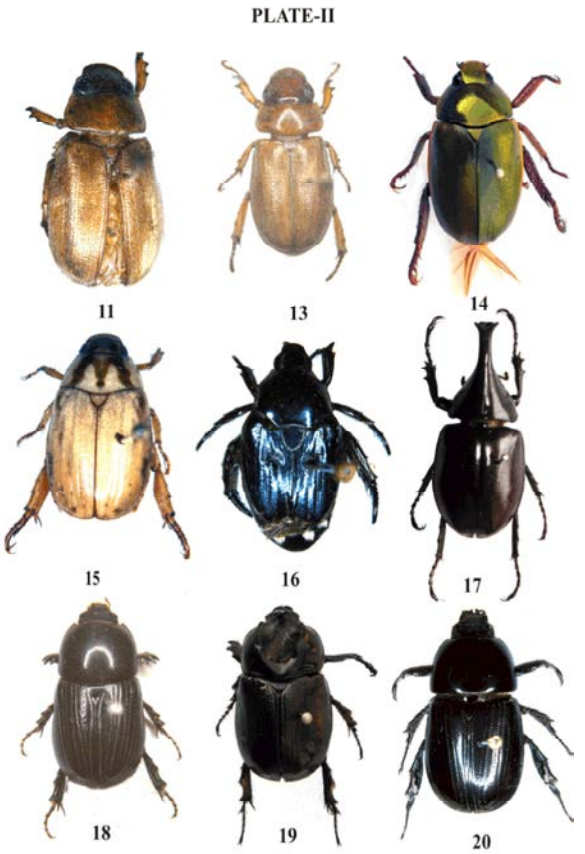

Plate II: (11) *Adoretus bicolar* Brenske, (13) *A. bimarginatus* Ohaus, (14) *Mimela macleayana* (Vigors), (15) *M. inscripta* (Nonfr.), (16) *Popillia laevis* Burmeister, (17) *Xylotrupes gideon* (Linnaeus), (18) *Alissonotum simile* Arrow, (19) *Phyllognathus dionysius* (Fabricius), (20) *Heteronychus lioderes* Redtenbacher.

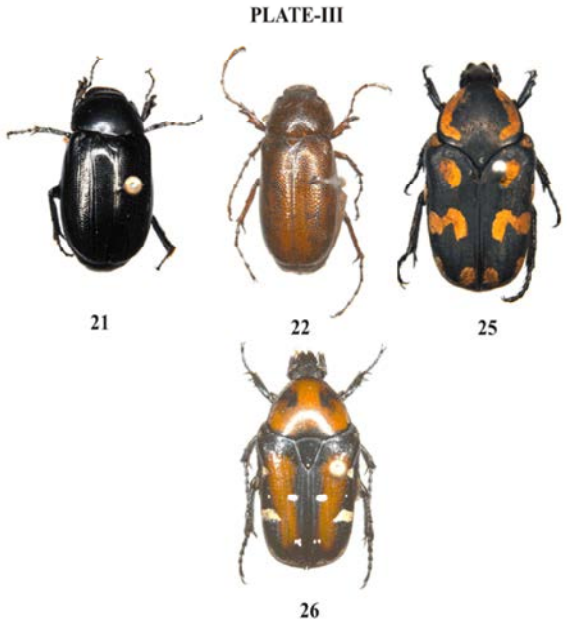

Plate III: (21) *Apogonia proxima* Waterhouse, (22) *Schizonycha ruficollis* (Fabricius), (25) *Clinteria klugi* (Hope), (26) *Oxycetonia versicolor* (Fabricius).
*Numeric code for each species corresponds to as in Table 1.

Data Analysis

Alpha Diversity: Number of observed species per site, were considered as alpha diversity. EstimateS 8.2.0 [21] was used to obtain the estimated value of species richness for each of the sampling site in AABR. To assess the true species richness for each habitat two non-parametric estimators ACE (Abundance-based Coverage Estimator) and Chao1 was estimated with the help of EstimateS 8.2.0 software package [21]. These non-parametric estimators are considered more accurate and less sensitive to problems related to sample coverage and variation in species capture probability [22]. Diversity dominance plots were drawn to assess changes in abundance per species in each locality. In order to provide instantly comprehensive expressions of diversity, other indices viz. Shannon index, Simpson index and Fisher alpha index were also calculated using EstimateS 8.2.0 software package [21]. Shannon index takes into account the evenness of the abundance of species and assumes that individuals are randomly sampled from a large population while Simpson index is less sensitive to species richness and more sensitive to the most abundant species.

Beta Diversity: Beta diversity was calculated Bray-Curtis index to estimate species similarity between two habitats. The index is sometimes called as Sorension quantitative index,

$$C_N = \frac{2jN}{(N_a + N_b)}$$

Where N_a = the total number individuals in site A_j N_b= the total number of individuals in site B_j and 2jN = the sum of the lower of the two abundance for species found in both sites. The index value ranges from one (or 100) when two samples are identical, 0 when there are no shared species between them. The index is selected because it reflects differences in total abundance rather than relative abundance [23].

RESULTS

A checklist of the studied Phytophagous scarab beetles (Coleoptera: Scarabaeidae) from two different localities in AABR is summarized (Table 1). In total, 426 scarab beetles belonging to 26 species distributed in 13 genera and four subfamilies were collected. Between the two study areas, the highest numbers of scarabs were observed in Chhaparwa which constitute 346 beetles representing 24 species under 12 genera and accounting 81.22% of the total beetles collected from the biosphere reserve. While from Atariya, 80 scarabs comprising 13 species belonging to five genera and four subfamilies were collected. The highest numbers of beetles were collected from the subfamily Rutelinae (303) followed by Melolonthinae (95), Cetoniinae (18) and Dynastinae (10). In terms of richness, the subfamily Rutelinae includes 16 species followed by Dynastinae (4 species), Melolonthinae (4 species) and Cetoniinae (2 species) (Table, 1). *Anomala* was the most species rich genus (8 species), followed by *Adoretus*, *Mimela* and *Holotrichia* (2 species each), *Popillia*, *Xylotrupes*, *Alissonotum*, *Phyllognathus*, *Heteronychus*, *Apogonia*, *Schizonycha, Clinteria* and *Oxycetonia* (one species each).

Dominance diversity plots show differences in the scarab beetle populations between these two habitats (Fig. 1). There is an importance difference in the abundance of many species. The relative abundance of the scarabs in the biosphere reserve was quite variable with some species showing high abundance in correlation with other less abundant species. The six most common species were *Anomala ruficapilla* (31.45%),

Table 1: Number of individuals collected for each species of Pleurostict Scarabaeidae per site in Achanakmar-Amarkantak Biosphere Reserve during 2004 and 2008:

Name of species	Atariya	Chhaparwa	Total individuals	% of individuals
Subfamily: Rutelinae				
1.*Anomala bengalensis* (Blanchard)	1	2	3	0.70%
2. *Anomala biharensis* Arrow	5	35	40	9.38%
3. *Anomala cantori* (Hope)	0	1	1	0.23%
4. *Anomala dorsalis* (Fabricius)	7	9	16	3.75%
5. *Anomala polita* (Blanchard)	1	0	1	0.23%
6. *Anomala ruficapilla* Burmeister	20	114	134	31.45%
7. *Anomala rugosa* Arrow	5	20	25	5.86%
8. *Anomala varicolor* (Gyllenhal)	14	10	24	5.63%
9. *Anomala* sp.	0	1	1	0.23%
10. *Adoretus lasiopygus* Burmeister	0	4	4	0.93%
11. *Adoretus bicolar* Brenske	1	1	2	0.46%
12. *Adoretus limbatus* Blanchard	1	2	3	00.70%
13. *Adoretus bimarginatus* Ohaus	6	31	37	8.68%
14. *Mimela macleayana* (Vigors)	0	6	6	1.40%
15. *Mimela inscripta* (Nonfr.)	0	2	2	0.46%
16. *Popillia laevis* Burmeister	0	4	4	0.93%
Subfamily: Dynastinae				
17. *Xylotrupes gideon* (Linnaeus)	0	2	2	0.46%
18. *Alissonotum simile* Arrow	2	1	3	0.70%
19. *Phyllognathus dionysius* (Fabricius)	0	4	4	0.93%
20. *Heteronychus lioderes* Redtenbacher	0	1	1	0.23%
Subfamily: Melolonthinae				
21. *Apogonia proxima* Waterhouse	0	83	83	19.48%
22. *Schizonycha ruficollis* (Fabricius)	4	0	4	0.93%
23. *Holotrichia sculpticollis* Blanchard	0	5	5	1.17%
24. *Holotrichia problematica* Brenske	0	3	3	0.70%
Subfamily: Cetoniinae				
25. *Clinteria klugi* (Hope)	13	4	17	3.99%
26. *Oxycetonia versicolor* (Fabricius)	0	1	1	0.23%
Total species=26	Total individuals		426	100%
Species richness per site	13	24		
Total individuals per site	80	346		

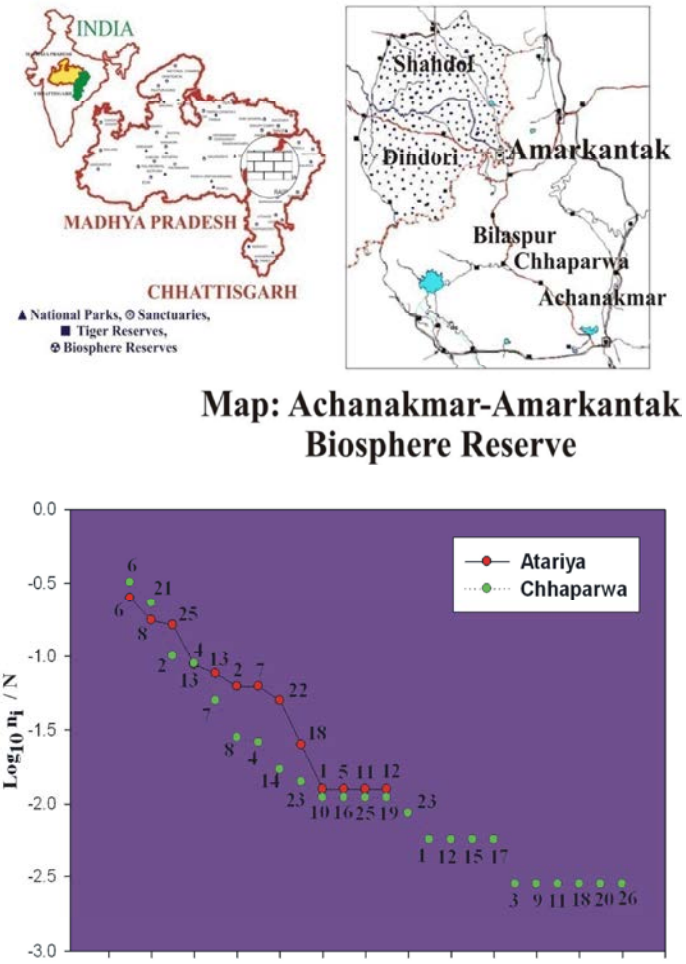

Fig. 1: Dominance diversity plot. Numeric code for each species correspond to those in table, 1

Table 2: Data matrix with beta diversity value obtained through Bray-Curtis index with number of species per site and number of shared species:

First sample	Second sample	Species observed in Atariya	Species observed in Chhaparwa	Shared species	Bray-Curtis
Atariya	Chhaparwa	13	24	11	0.286

Table 3: Diversity parameters at two localities in AABR:

	Fisher 'Alpha'	Shannon	Simpson
Atariya	5.1	2.14	6.44
Chhaparwa	6.1	2.27	6.18

Apogonia proxima (19.48%), *Anomala biharensis* (9.38%), *Adoretus bimarginatus* (8.68%), *Anomala rugosa* (5.86%) and *Anomala varicolor* (5.63%) (Table 1). Five species viz. *Anomala polita, Anomala cantori*, *Anomala* sp. *Heteronychus liioderes* and *Oxycetonia versicolor* were the least abundant in the biosphere reserve and each was represented by a single specimen. Out of the total 26 species, 13 species viz. *Anomala cantori*, *Anomala* sp., *Adoretus lasiopygus*, *Mimela macleayana* , *Mimela inscripta*, *Popillia laevis*, *Xylotrupes gideon*, *Phyllognathus dionysius*, *Heteronychus liioderes*, *Apogonia proxima*, *Holotrichia sculpticollis*, *Holotrichia problematica* and *Oxycetonia versicolor* were exclusively collected from Chhaparwa while only two species viz. *Anomala polita* and *Schizonycha ruficollis* were collected only from Atariya (Fig, 1). The general diversity for the two sites in AABR is shown in Table 3. Among the diversity indices calculated, the two diversity indices (Shannon and Alpha) estimate that Chhaparwara harbor the highest diversity over Atariya.

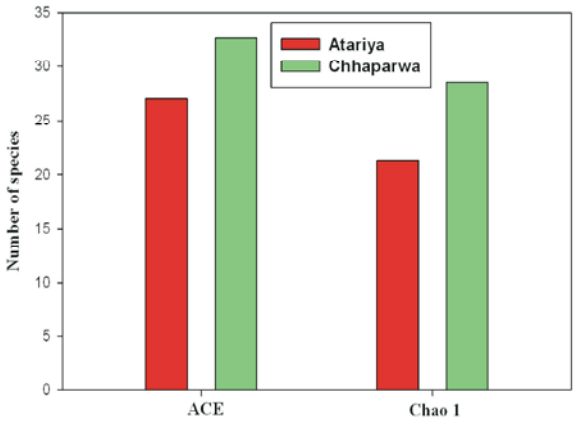

Fig. 2: Values of estimators used to evaluate the accuracy of inventor for the two localities in AABR

Shannon and Alpha diversity measures were found higher in Chhaparwa, while Simpson index was found little higher in Atariya. The shared species statistics between different collection localities are given in Table 2. For comparison of diversity between two sites Bray-Curtis index is calculated. The Bray Curtis index resulted in a similarity of 28.6 % between Atariya and Chhaparwa with 11 shared species between the two habitats.

DISCUSSION

The first report on the diversity and relative abundance of the phytophagous scarab beetle community, in one of the protected areas of Central India viz. AABR is provided. In the present study, an attempt has been made to assess species diversity and abundance of the scarab beetles in two different localities of AABR. As a result, the inventory of the beetles incorporates 26 species belonging to 13 genera and four subfamilies. Forty seven species of the phytophagous scarab beetles have been reported from Madhya Pradesh and Chhattisgarh [15, 16]. In comparison to the overall diversity of these beetles from these two states, the scarab diversity in AABR comes out to be more than fifty percent, representing four of the major chaffer subfamilies of the family Scarabaeidae. After Chandra and Singh's [16] publication on the scarab diversity of Achanakmar Wildlife Sanctuary, the present report added 15 more species of these beetles from the whole biosphere reserve of which *Popillia laevis* is new to the beetle fauna of Central India.

The subfamily Rutelinae (n=303) was reported to be dominating (71.12%) the total population of scarab beetles in the biosphere reserve and includes 16 species distributed in 4 genera. The genus *Anomala* was found to be dominating the overall population of the biosphere reserve, accounting 57.51 % of total abundance and represented by nine species of economical and ecological importance. The population fluctuations in the phytophagous scarab beetle population might be due to the availability of larval and adult food sources, weather conditions and soil type. Studies on the economic and ecological significance of the phytophagous scarabs in India, especially of Madhya Pradesh and Chhattisgarh are still to be done. Summary of the host plants of major chaffer species in India are given in Table, 4.

Table 4: Host plants of some Phytophagous scarabs of India:

Species	Host plants	References
Anomala bengalensis (Blanchard)	*Cassia fistula*, *Lagerstroemia, Mangifera indica,* phalsa (*Grewia asiatica*) and Chillies (*Capsicum annuum*), rose and guava; larvae injurious to sugarcane	[9, 11, 10, 24]
Anomala dorsalis (Fabricius)	Ber	[25]
Anomala polita (Blanchard)	*Cassia fistula*, *Lagerstromia* spp., *Rouwolfia serpentine*; Larvae feed on fine roots of small plants and vegetable matter.	[9]
Anomala ruficapilla Burmeister	Acacia; larvae occur in clayish soil with roots and grass.	[9, 25]
Anomala rugosa Arrow	Polyphagous, *Cassia fistula*. Larvae feeding on fine roots and decaying matter	[9, 10, 26].
Adoretus lasiopygus Burmeister	*Bombax malabaricum*, *Cassia fistula*, *Mangifera indica* and other dicotyledonous trees.	[9, 10]
Adoretus bicolar Brenske	Acacia, ber, neem, rose and grape.	[24, 25]
Adoretus bimarginatus Ohaus	*Bombax malabaricum*, *Cassia fistula* and other dicotyledonous trees. Larvae feeding on roots of herbs and grasses	[9, 10]
Xylotrupes gideon (Linnaeus)	*Acacia mearnsii, Hevea brasiliensis* and *Toona australis*, Polyphagous	[10, 27]
Phyllognathus dionysius (Fabricius)	Rice	[3]
Heteronychus lioderes Redtenbacher	Sugarcane	[4]
Schizonycha ruficollis (Fabricius)	*Cassia fistula*, acacia, ber, neem, rose and tamarind other dicotyledonous trees	[10, 24, 25]
Holotrichia sculpticollis Blanchard	Coffee, ginger, rose, *Ficus* sp. and cinnamon	[9, 10]
Holotrichia problematica Brenske	*Cassia fistula*, *Shorea robusta, Terminalia bellerica* and other dicotyledonous trees	[9, 10]
Clinteria klugi (Hope)	*Tectona grandis*	[9]
Oxycetonia versicolor (Fabricius)	Rose and brinjal	[24]

Nevertheless, based upon the published literature [3-11, 24-27], species in the genera *Anomala*, *Adoretus*, *Xylotrupes*, *Phyllognathus*, *Heteronychus*, *Schizonycha*, *Holotrichia*, *Clinteria* and *Oxycetonia* have been reported as agricultural pests of various commercial crops and having great economical and ecological significance.

Biodiversity surveys provide fundamental information needed for conservation planning, protected area justification and design and development of management plans [28]. To conclude, species collected in this study represents patterns of diversity, richness and abundance and variations in the scarab beetle assemblage in AABR. The study will no doubt help in the conservation plans in the newly formed biosphere reserve and in the maintenance of biological health of the ecosystem. This preliminary information on the scarab diversity in Central India may be utilized in future to assess diversity and conservation problems from the region and also help in solving the scarab pest problem along with in formulating effective control strategy.

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