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Diversity status and richness of scarabaeidae (Coleoptera: Polyphaga) in Bhavnagar city, Gujarat, India

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Abstract
Dung beetles are a wide-ranging group that feed mostly on the faecal of terrestrial vertebrates. They get their names because they feed partially or exclusively on faecal. True dung beetles of the *Scarabaeidae* family, which includes 16 Tribes 0in the world. In India approx 400 species of dung beetles are classified into 30 genera and 9 tribes. This is the first comprehensive survey of *Scarabaeidae* from the Bhavnagar City. This field study was done between January-2022 to January-2023 at Bhavnagar city, Gujarat, India, which is situated at 21º45′53″N and 72º08′59″E. This study indicated that the 39 Species of Family *Scarabaeidae* belonging to 6 different Subfamily, 14 Tribe and 17 Genus were identified and recorded. The six different Subfamily are *Aphodiinae, Cetoniinae, Dynastinae, Melolonthinae, Rutelinae* and *Scarabaeinae.* Pitfalls, Manual collection & the use of Light traps were chosen among the many techniques of collecting. The Light trap method discover the greatest diversity of species among the collection techniques used. This study discover that Shannon H index is 2.655 for diversity, Margalef's for richness is 5.608 and Pielou's index for evenness is 0.3649 for *Scarabaeidae* fauna in Bhavnagar city, Showing demonstrating a diverse and rich study area. This present checklist of species of Dung beetle fauna cannot be considered as a final picture and it seems that many species still remain to be described for which more surveys are needed. They were previously not recorded highlight the necessity for long-term studies in the area.

Keywords: *Scarabaeidae*, diversity, richness, evenness, Bhavnagar city

Introduction
Dung beetles are a wide-ranging group that feed mostly on the faecal of terrestrial vertebrates. They get their name from the fact that they either entirely or mostly consume faeces. Dung beetles are divided into three different kinds: tunnelers, rollers and dwellers. The dung ball is buried while tunnelers create enormous, often several meters-deep tunnels. The excrement are formed into round balls by rollers, which are then utilized as food sources or as brooding chambers. Dwellers simply dwell among the waste; they don't move it [1]. *Scarabaeidae* beetles are a universally widespread insect group with tropical forests & savannas having the highest diversity [2]. Recent fossils of dung-provisioned burrows support the hypothesis that, the evolution of coprophagy in dung beetles through interaction with dinosaurs may have occurred even before the diversification of mammals [3].
Globally distributed Scarabaeid dung beetles carry out essential tasks for Terrestrial ecosystems like secondary seed distribution and Nutrient Cycling, according to Davis and Scholtz (2001) [4]. According to McGeoch *et al*. (2002), they make great Ecological Indicator species [5]. True dung beetles of the *Scarabaeinae* family, which includes 16 Tribe in the world [6, 7, 8, 9]. *Scarabaeinae*(his Coprinac) was divided into four divisions (=tribes) by arrow (1931): Scarabaeini, Sisyphini, Coprini and Panelini [10]. However, due of the 12-tribe classification that is now accepted internationally [11, 12].
In India Approx 400 species of dung beetles are classified into 30 genera and 9 tribes. These include 78 species from the moist southern western ghats, 19 of which are endemic to the western ghats [13] and 194 species from 29 genera that have been documented from the western ghats biodiversity hotspot [14]. However, because to insufficient representation in world wide databases, India's dung beetles are underrepresented in global biogeography and phylogeny research [15, 16]. *Scarabaeinae* is divided into 12 tribes according to Balthasar (1963). It is most typical tribal level classification with 6 tribes from rollers & tunnellers each. Balthasar (1963) classified 551 *Onthophagus* species into 16 subgenera from the oriental and palaearctic regions. Since then, no significant efforts have been undertaken to do comprehensive research on Indian dung beetles [17]. Sewak (2003) identified 96 *Onthophagus* species from the Indian states of Gujarat, Arunachal Pradesh and Rajasthan [18]. Following that, lists of *Scarabaeinae* beetles collected from several western ghats locations were made accessible [14, 19, 20, 21]. It is extremely difficult to successfully classify the countless species of this genus using morphological features. It is difficult to identify traits that are shared by both species since they are sexually dimorphic [10].

Materials and methods

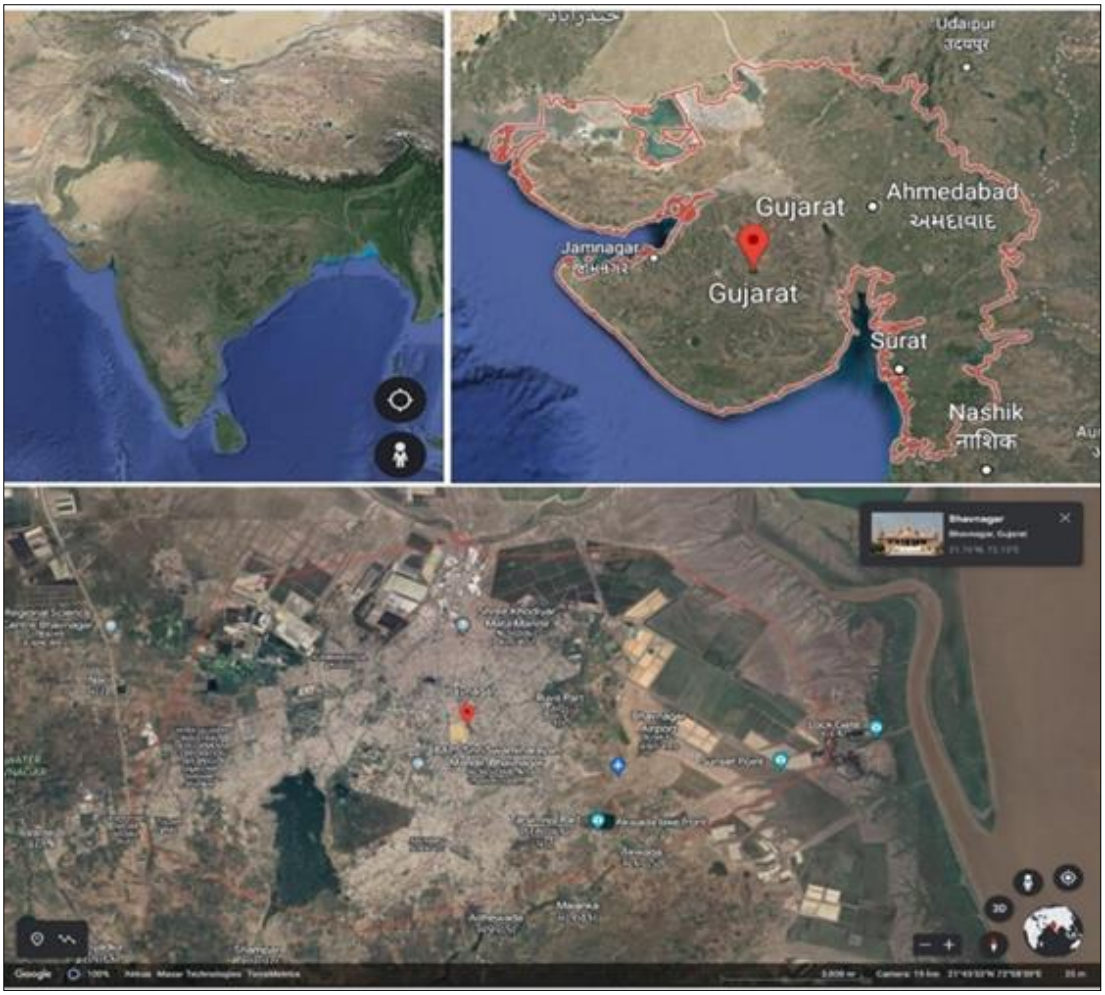

Plate 1: Map of Bhavnagar city [23]

Study site

This field study was done between January-2022 to January-2023 at Bhavnagar city, Gujarat, India, which is situated at 21º45′53″N and 72º08′59″E (Plate 1). Bhavnagar's weather is hot and dry. The average Temperature ranges from 20 to 45 degrees Celsius. Bhavnagar city is closer to ocean so, throughout the entire year, the climate is quite humid [22]. Pitfalls, Manual collection & the used of the Light traps were chosen among the many techniques of collection during the field study.

Plate 2: Study site: Coleoptera species were collected using different sampling methods. (1. & 2.) Bhavnagar city, (3.) Manual Collection, (4.) species observed under Stereo zoom Microscopes, (5.) Light Traps.

Photography
photography was clicked by the digital camera (Nikon COOLPIX W300) and smartphone camera. For more identification of the collected Coleopterans observed under Stereo zoom microscopes (Carl Zeiss Stemi-305-cam).

Identification
The available literature, books, journals, research papers and standard monographs were used to identify all specimens. Identification was done based on the anatomical features of different parts of the body [24, 25, 26, 27].

Data analysis
Using the software PAST (Paleontogical statistics tool) version 4.03, following Indexes were calculated.

1. Shannon H index
It is calculated by taking both the number of individuals in a community and the number of different taxa. [28]. The formula used to calculate it was as follows:

$H = -\sum P_i * In (P_i)$

Wherein, $P_i = \frac{S}{N}$

S stands for individual species
N is the entire population of the all individuals.
In is base-e logarithm

2. Margalef's index
It turned out to be an easy-to-understand way to evaluate species richness [29].

$D_{Mg} = \frac{S-1}{In\ N}$

When, S for over all species count
N is total number of those involved in the species
In is natural logarithm

3. Pielou's index
The evenness of species was calculating using Pielou's Index [30].

$e = H/In\ S$

Where,
H = Shannon H Index
S for total count of species in the species.

Results & discussion
During the study period a total number of 39 Species were recorded belonging to Family *Scarabaeidae* of the Coleopterans order. The *Scarabaeidae* checklist presented in Table no: 1. This study indicated that the 39 Species of Family *Scarabaeidae* belonging to 6 different Subfamily, 14 Tribe and 17 Genus were identified and recorded. The six different Subfamily are *Aphodiinae, Cetoniinae, Dynastinae, Melolonthinae, Rutelinae* and *Scarabaeinae*. The distribution of *Scarabaeidae* subfamily chart present in figure no: 1. Among the *Scarabaeinae* found dominantly comprising 3 different Tribe, 3 different Genus and 19 species of total species were recorded. Followed by *Aphodiinae* with 6 Species, next in *Cetoniinae, Melolonthinae* and *Rutelinae* with 4 Species. *Dynastinae* represented by 2 Species. Photographic images are given in *Rhyssemus sp.1 (Mulsant, 1842)* was the most dominant species, probably due to the adults of these beetle are attracted to the light trap. The second dominant species observed during the current analysis was *Gametis versicolor (Fabricius, 1775)*. The study site is diverse with vegetation, and due to their size and vivid colours, these beetles are easier to spot. *Rhyssemus sp.2 (Mulsant, 1842), Aphodiinae sp. (Leach,1815), Protaetia sp.1 (Burmeister, 1842), Protaetia sp.2 (Burmeister, 1842), Diplotaxis sp. (Kirby, 1837), Cyphochilus sp. (Waterhouse, 1867), Adoretus sp. 1 (Laporte, 1840), Adoretus sp. 2 (Laporte, 1840), Adoretus sp. 3 (Laporte, 1840), Adoretus sp. 4 (Laporte, 1840), Onthophagus sp.1 (Latreille, 1802), Onthophagus sp.2 (Latreille, 1802), Onthophagus sp.3 (Latreille, 1802), Onthophagus sp.4 (Latreille, 1802)* and Unidentified species had a very less number of species Showing in figure no: 2.
Pitfalls, Manual collection & the use of Light traps were chosen among the many techniques of collecting. The Light trap method discover the greatest diversity of species among the collection techniques used. This study discover that Shannon H index is 2.655 for diversity, Margalef's for richness is 5.608 and Pielou's index for eveness is 0.3649 for *Scarabaeidae* fauna in Bhavnagar city (Table 2), showing demonstrating a diverse and rich study area. Understanding the diversity & richness of the Scarabaeidae in this region was the goal of the current study. Chandra K, Gupta D. (2012) describe that the family *Scarabaeidae* helping ecological functions like cycling of nutrients, aeration of the soil, control of parasites & dissemination of secondary seeds [31]. When dung beetles were around, plants could absorb more nutrients, according to yamanda *et al*. (2007) [32]. The rate of dung breakdown and the flow of nutrients from dung to soil were both improved by dung beetles. Dung beetles have been proven in studies to reduce that much nitrogen was lost through volatilizations, which helps to maintain more nitrogen in the soil and encourage plant growth [33]. If massive amounts of faeces from herbivores must be removed, dung beetles might be useful for utilizing dung in the soil.
Balthasar classified *onthophagus* species in India was conducted in oriental and palaearctic regions in 1963. Since that time, no significant initiatives have been made to conduct extensive research on Indian dung beetles. Sewak studied the Onthophagus species from the Indian states of Gujarat, Rajasthan & Arunachal Pradesh in 2003. Checklist of *Scarabaeidae* beetles collected from several western ghats regions were then made accessible [14, 19, 20, 21]. After that, the state published very few records of *Scarabaeidae*. This shows that the study of *Scarabaeidae* is occurring very slowly. This is the first comprehensive survey of *Scarabaeidae* from the Bhavnagar city, including a checklist of 39 species. With additional work in the future, there is a good probability that this checklist will include many more species.

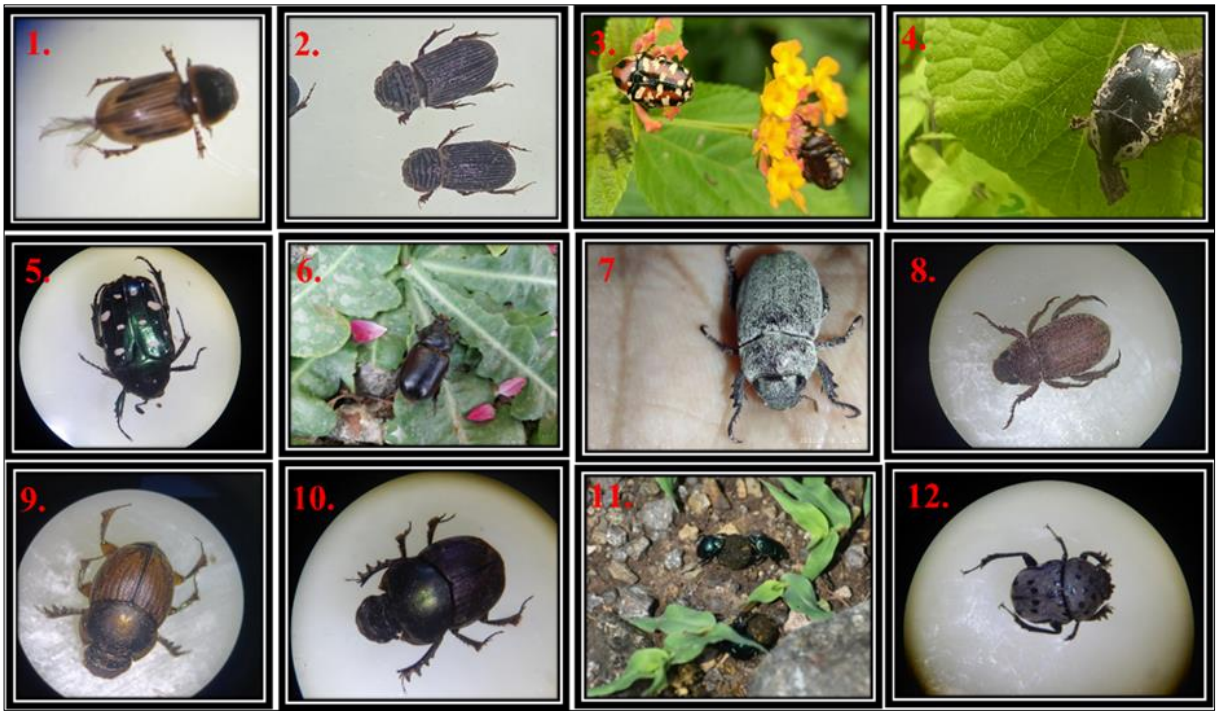

Plate 3: *1. Labarrus sp. (Mulsant and Rey,1870) 2. Rhyssemus sp.1 (Mulsant,1842) 3. Gametis Versicolor (Fabricius,1775) 4. protaetia aurichalcea (Fabricius,1775) 5. Protaetia sp.1 (Burmeister, 1842) 6. Oryctes Rhinoceros (Linnaeus,1758) 7. Cyphochilus sp. (Waterhouse, 1867) 8. Adoretus sp. 4 (Laporte,1840) 9. Onthophagus gazella (Fabricius, 1787) 10. Onthophagus Taurus (Schreber,1759) 11. Gymnopleurus cyaneus (Fabricius,1798) 12. Gymnopleurus miliaris (Fabricius, 1775)*

Table 1: Checklist of scarabaeidae species collected from Bhavnagar city

Family	subfamily	Tribe	Genus	Species
Scarabaeidae	*Aphodiinae*	*Aphodiini*	*Acrossus*	*Aphodius rufipes (Linnaeus, 1758)*
			Labarrus	*Labarrus sp. (Mulsant and Rey, 1870)*
		Eupariini	*Ataenius*	*Ataenius sp. (Harold,1867)*
		Psammodiini	*Rhyssemus*	*Rhyssemus sp.1 (Mulsant, 1842)*
		Psammodiini	*Rhyssemus*	*Rhyssemus sp.2 (Mulsant, 1842)*
		-	-	*Aphodiinae sp. (Leach,1815)*
	Cetoniinae	*Cetoniini*	*Gametis*	*Gametis versicolor (Fabricius, 1775)*
			Protaetia	*Protaetia aurichalcea (Fabricius, 1775)*
				Protaetia sp.1 (Burmeister, 1842)
				Protaetia sp.2 (Burmeister, 1842)
	Dynastinae	*Oryctini*	*Oryctes*	*Oryctes rhinoceros (Linnaeus, 1758)*
		Pentodontini	*Heteronychus*	*Heteronychus arator (Fabricius, 1775)*
	Melolonthinae	*Diplotaxini*	*Diplotaxis*	*Diplotaxis sp. (Kirby, 1837)*
		Melolonthini	*Cyphochilus*	*Cyphochilus sp. (Waterhouse, 1867)*
			Holotrichia	*Holotrichia sp. (Hope, 1837)*
		Sericini	*Maladera*	*Maladera castanea (Arrow,1913)*
	Rutelinae	*Adoretini*	*Adoretus*	*Adoretus sp. 1 (Laporte, 1840)*
				Adoretus sp. 2 (Laporte, 1840)
				Adoretus sp. 3 (Laporte, 1840)
				Adoretus sp. 4 (Laporte, 1840)
	Scarabaeinae	*Coprini*	*Heliocopris*	*Heliocopris gigas (Linnaeus, 1758)*
				Unidentified sp. 1
				Unidentified sp. 2
				Unidentified sp. 3
				Unidentified sp. 4
		Onthophagini	*Onthophagus*	*Onthophagus gazella (Fabricius, 1787)*
				Onthophagus ovatus (Linnaeus, 1767)
				Onthophagus sp. 1 (Latreille, 1802)
				Onthophagus sp. 2 (Latreille, 1802)
				Onthophagus sp. 3 (Latreille, 1802)
				Onthophagus sp.4 (Latreille, 1802)
				Onthophagus taurus(Schreber, 1759)
				Unidentified sp. 1
				Unidentified sp. 2
				Unidentified sp. 3

				Unidentified sp. 4
				Unidentified sp. 5
		Scarabaeini	*Gymnopleurus*	*Gymnopleurus cyaneus (Fabricius, 1798)*
				Gymnopleurus miliaris (Fabricius, 1775)

Table 2: Species diversity, Richness and Evenness of study site

Shannon H Index	2.655
Margalef Index	5.608
Pielou's Index	0.3649

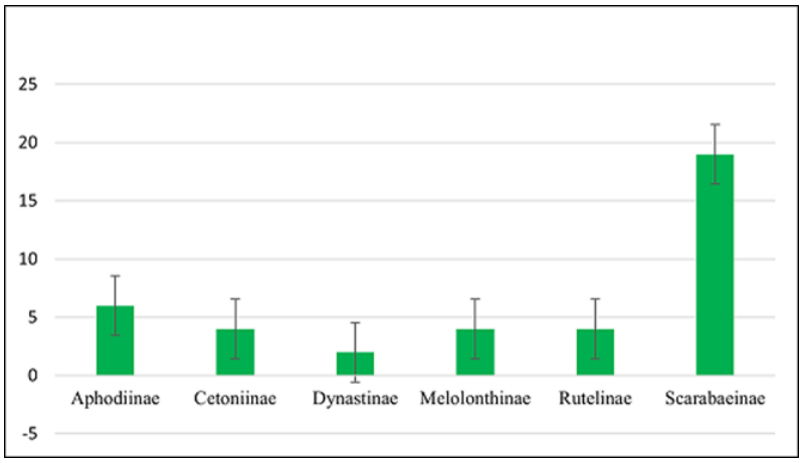

Fig 1: Distribution of scarabaeidae subfamily in Bhavnagar city

Fig 2: Number of individual different species of scarabaeidae

Conclusions

The current analysis reveals an extremely diverse population of *Scarabaeidae* in Bhavnagar city. This study gives the diversity and richness on the Family *Scarabaeidae* of the Bhavnagar City, which is beneficial for upcoming research on specific species and their species-level identification. The present checklist of species of Dung beetle fauna cannot be considered as a final picture and it seems that many species still remain to be described for which more surveys are needed. They were previously not recorded highlight the necessity for long-term studies in the area. In the future, comparisons with faunal lists from other places will be possible using this checklist as a baseline for the dung beetles fauna in the city of Bhavnagar. The Light trap method discover the greatest diversity of species among the collection techniques used. More research could be done to investigate the microorganisms in the *Scarabaeidae*, mechanism of digestion might be investigated, they feeds faeces and must have the appropriate microbes to do so. *Scarabaeidae* larvae consume the dung as well and research into their digestive tracts may reveal how the dung decomposes.

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