https://doi.org/10.33451/florafauna.v29i2pp349-355
FLORA AND FAUNA ISSN 2456 - 9364 (Online)
2023 Vol. 29 No.2 PP 349-355 ISSN 0971 - 6920 (Print)

Review

Ecological role of dung beetles (Coleoptera: Scarabaeidae) and their diversity in India

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Received **:** 23.08.2023; ***Accepted*** : 22.09.2023

ABSTRACT

India has an incredibly rich biological diversity as a result of its unique biogeographic locations, varying climatic circumstances, and significant ecological and geographic adaptations. The family Scarabaeidae, which includes scarab beetles, is a significant group of beetle species. Scarab beetles can be found in many places in India due to differences in geographic regions as well as variations in latitude and altitude. In India, 1590 species of scarab beetles belonging to 203 genera were reported. The relatively enormous size, bright insignia, complex decorating, and fascinating life cycles of adult individuals make them easy to identify. The role of dung beetles to nitrogen cycling, enhancing plant development, secondary seed distribution, bioturbation, and parasite control are outlined here. There are a few crucial coprophagous beetles belonging to Scarabaeinae subfamily that support ecosystems by consuming animal faeces both as adults and larvae. Despite extensive research on many facets of the environmental history of dung beetles, little is recognized about their precise contribution to the nitrogen cycle, CH_4 emissions, organic matter decomposition, greenhouse gas emissions, NH_3 volatilization, waste management, ecosystem stability, forest and agro-pastoral cycles of nutrients, and the soil and agricultural cycles. This review is aimed to summarize the scarab beetle distribution status in India and their ecological contribution to the scientific community in a wide range of areas.

Figure : 01 References : 44 Table : 01
KEY WORDS : Coleoptera, Diversity, Dung beetles, Insecta, Scarabaeidae, Soil fertility

Introduction

Insect account for more than half of all known species in the animal kingdom and they contribute significantly to global biodiversity. This range of variation is related to the unique genetics, morphological, and functional characteristics and various insect species have evolved to deal with the diverse and dynamic environments in which they survive[16]. India contributes for around 6.90 percent of the total number of species in the Phylum Arthropoda, with 59,393 species in the class Insecta. The Coleoptera order (Gk. Coleos–sheath, ptera-wing) is the biggest group of organisms at the order level. The order Coleoptera includes around 3, 50,000 out of 8, 00,000 insect species that have been classified into four sub-orders and 177 families. Coleopteran diversity appears to have reached its peak in the late Jurassic period, around 155-160 million years ago[15].They are found all throughout the world and have a wide range of environmental adaptations. Every member of the family Coleoptera, which includes beetles and weevils, is referred to as a coleopteran. The Coleoptera order is further subdivided into four suborders; Adephaga, Archostemata, Myxophaga, and Polyphaga (largest suborder) enclosing 90% of beetle families. A beetle is found in more than one out of every four listed animal species[42]. Scarab beetles are members of the order Coleoptera of classified under the class Insecta, suborder Polyphaga, superfamily Scarabaeoidea, and family Scarabaeidae. The species of scarab that gave rise to the family name Scarabaeidae served as a sacred representation of resurrection for the ancient Egyptians[41]. Currently, there are 12 families, 43 subfamilies, 118 tribes, and 94 subtribes under the super- family Scarabaeoidea[39]. According to some estimates, there are over 600 genera and 30,000 species of beetles in the family Scarabaeidae, which is the largest, most diversified, and most extensively dispersed group of beetles[13].

The comparatively large size, brilliant colors, typically complex ornamentation, and unique life histories of the adults of these beetles make them distinctive. The last three antennomers of the antennae are expanded into plate like structure, the front legs have large front coxae and tibias with a series, of teeth and the eighth tergite forms a true pygidium that is not covered by the seventh tergite, all of which are

adaptations for borrowing[14]. Beetle species under Aphodiinae and Scarabaeidae family are referred as "dung beetles" and also known as dung chafers or tumble bugs. They use their scooper like heads and paddle shaped antennae to mould waste into a ball. Grazing animal type, pasture continuity, habitat type (forest or open pasture), soil type, and humidity all have an impact on dung beetle groups. Depending on the species, adults can range in length from 0.3 to 4cm and are typically dark in colour, while some have a metallic sheen. Dung beetles typically have spherical bodies and short wing covers (elyptra) that show the end of the abdomen. A cylindrical or C-shaped larva is present. Off-white and yellow in appearance, with a darker posterior from excrement deposits[38].

The most species of the subfamilies Melolothinae, Rutelinae, Cetoniinae, and Dynastinae (Rhinoceros beetle) feed on plant products and agricultural pests of many cash crop. Many species of scarab beetles have a wide range of feeding preferences; many species eat manure or decaying plant matter, while others eat developing roots or leaves and a few fungi. The majority of scarab species destroy turf grasses when they are in the larval stage; the larvae are milky grubs that eat root and damage artificial turf grasses[36]. The phytophagous beetles, also known as Chafers are major pest of crop, plant and forest vegetation. The Laparosticti (agro dung beetles), play a decisive function in cleaning the faeces of mammals and cattle. The scarab family can either be helpful or dangerous in nature[10]. This review work aims to summarize the scarab beetle status and population dispersal. Scarabaeidae provide ecological contributions to the scientific community in a wide range of areas.

Types of dung beetles

Dung beetles are a crucial part of the land ecology both systematically and biologically. They are biological scavengers, cleaning away the soil climate from the excrement of large and medium-sized grazing animals by burying masses of faeces in the soil[30]. In the majority of terrestrial habitats, dung beetles live in dense colonies and provide vital ecological services such nutrient recycling, insect control, and secondary seed distribution, soil fertilization[23]. Dung beetles are also known to be helpful markers of habitat changes, particularly in tropical rain forests. Their population is associated with animal communities and vulnerable to many ecological changes[19].

Diversity and distribution in India

All continents are home to dung beetles except for Antarctica, where they are found in agricultures, forests, grasslands, and desert ecosystems. There are approximately 6,000 species of tunnellers and rollers (actual dung beetles) (Geotrupidae, Scarabaeidae) in the world, including approximatly 2,000 dwellers species (Aphodiidae: Aphodiinae)[41]. In India, there are 1590 species of scarab beetles belonging to 203 genera. They have range in size from small to large, and the structure of their antennae makes them easily identifiable.

Ecological function and services

Dung beetles are essential eco-friendly arthropod because they help with nutrient recycling, decomposition, soil fertility, soil aeration and seed dispersal. Dung

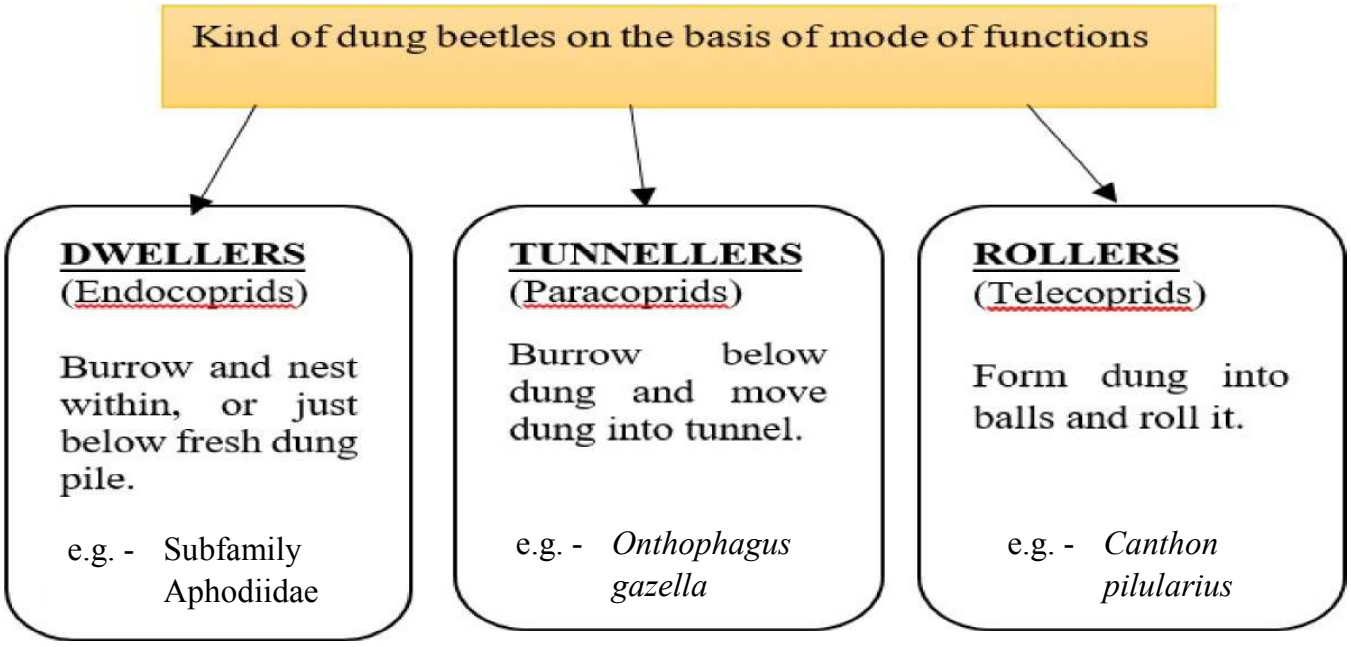

Fig. 1: Types of dung beetles according to their function

TABLE-1: Dung beetle species throughout India with respect to their habitat and locations

S. No.	No. of species	Regions	Habitats	Family: subfamily	References
1.	58	Madhya Pradesh	Forest, grassland, agriculture, wetland	Scarabaeidae	(1)
2.	15	Madhya Pradesh	Forest, grassland, agriculture, wetland	Scarabaeidae: Scarabaeinae	(27)
3.	89	Maharashtra	Forest, grassland, agriculture, wetland	Scarabaeidae	(18)
4.	24	Western Uttar Pradesh	Forest, grassland, agriculture	Scarabaeidae: Scarabaeinae	(35)
5.	02	Western Uttar Pradesh	Forest, grassland, agriculture	Scarabaeidae: Aphodiinae	(35)
6.	61	Bangalore, Karnataka	Agriculture, grassland, wetland, forest	Scarabaeidae: Scarabaeinae	(43)
7.	87	Western Ghat	Forest	Scarabaeidae	(31)
8.	09	G.N.H.P. , Himachal Pradesh	Forest	Scarabaeidae	(7)
9.	43	Chhattisgarh	Forest	Scarabaeidae: Hybosoridae	(22)
10.	36	Southern Western Ghat	Forest	Scarabaeidae	(38)
11.	14	Kolkata	Salt Lake Wetland	Scarabaeinae, Rutellinae, Dynastinae	(42)
13.	29	Rajasthan	Forest, grassland, agriculture	Scarabaeidae	(21)
14.	09 (Genera)	Rajasthan	Forest	Scarabaeidae	(34)
15.	09 (Genera)	Rajasthan	Agriculture land, grassland	Scarabaeidae	(11)

beetles contribute significantly to the health of ecosystems by trying to aid in or directly removing animal dung, although other elements like moisture, pair cooperation, soil type and dung quality also matter, a beetle species' mean female size is mostly correlated with the quantity of dung it buries.

(a) Nutrient enrichment and role in plant growth

Dung beetles are significant in recycling nutrients and the restoration of nutrient enrich organic matter to the soil due to their primary functions in faeces breakdown, dung processing and faeces incorporation into the soil. Dung beetles are crucial controls over nitrogen cycle processes in both agricultural and natural habitats. Dung beetles play a crucial role in increasing soil porosity. They add to the biomass, herbage feed value, and nutritional value of the plant by transferring and relocating nutrients in the soil from dung. The activity of the dung beetle is significant because it relocates manure by collecting dung particles from the dung pads and burying them in the soil[24]. Despite the importance of organic compounds in improving soil enrichment, nutrient release depends on organic matter breakdown in the soil[5]. Nest ball creation prevents ammonia volatilization, enhancing soil fertility by promoting nitrogen absorption by plants. It also accelerates manure moisture loss promotes aerobic bacterial in dung as well as on the soil surface leftovers. Dung beetles are also helpful to minimize soil compaction and promote soil aeration, which facilitates nitrogen mineralization, by creating burrow tunnels lignin from animal waste. These are common in rangelands with significant livestock loads, as a result, grazing-induced soil disruption and vegetation loss enhance nitrogen losses to the atmosphere and subsoil, resulting in a net reduction in total organic matter and nitrogen in the soils in these locations[25].

Plant biomass is produced in soil with hand-mixed dung, dung beetle-mixed dung, and chemical fertilizer treatments. According to studies, dung with dung beetles results in considerable improvements in plant height, above-ground biomass, grain yield, protein levels, and nitrogen content. Dung beetles deliver nutrient enrich organic material to the region where plant roots may spread, and they can also nurture other beneficial soil micro- organisms by burying newly dumped faeces. It also promotes chemical and microbiological changes in the upper soil layers, increasing the speed of nitrification, ammonification, denitrification, and nitrogen fixation[2].

(b) Secondary seed dispersal

It is observed that interactions between secondary seed dispersal and these post-primary dispersion risk factors have a substantial impact on plant recruitment. Since they take up some space in the dung pats and are not ingested by the larvae, the majority of seeds detected in dung simply represent pollutants from a dung beetle's viewpoint. Despite the fact that competition for dung is often fierce and burial occurs quickly, dung beetles frequently bury seeds, sometimes unwittingly, as they deposit dung for its young ones brood balls. Sometimes, dung beetles eliminate seeds after burying the dung. These insects actively disperse the seeds by cleaning the dung around the seeds and leave it on the soil surface[28].

(c) Bioturbation and reduction in emission of greenhouse gases

Bioturbation (the displacing and merging of suspended particles by plants or animals) can impact soil organisms and plant production by improving water porosity and soil aeration. Tunneller dung beetles contribute to bioturbation by transporting a large amount of earth to the soil profile during breeding. Although the unique nesting habits of distinct tunneller species differ greatly, the bulk create underground tunnels with branched brooding chambers. Tunnel depths and soil removal are both closely linked to beetle body size. Although it is commonly anticipated that tunneling behavior would increase water porosity and soil aeration in the upper layers of soil, these impacts have rarely been actually investigated[26]. According to studies that examined the effects of dung beetles on soil porosity under dung pats. Only the species having a larger body size *Coprisochus* had out of three species *C. tripartitus* and *Onthophaguslenzii* had a considerably favorable effect on permeation[28]. Dung beetles have also been recognized as greenhouse gas sources and other gases that indicates an ecosystem's deficiency of nutrients. Dung beetle activity has been found to effectively minimize a few kinds of greenhouse gas emissions from dung deposits, like NH_3 volatilization and CH_4 emission[3]. Dung beetles have been found to be able to significantly reduce methane emissions, the most significant greenhouse gas, by burying and aerating cattle manure on grassland[29]. It was found that the dung beetles in several conventional feedlots nominally diminished the greenhouse gas by at least 0.05 percent[33]. The total measure of dung beetle activities on nutritional dissipation in the form of greenhouse gas emissions is complicated, but research suggests that the activity of dung beetles elevates CO_2 and N_2O release from dung. In contrast to several reactions of nutrient cycling, which are mostly caused by the burial of dung contents under soils, the impacts of dung beetles on greenhouse gas emissions are believed to be driven by the enhanced aeration of dung material from tunnels generated by dung beetles[38].

(d) Fly control and parasite suppression

Dung beetles and various types of dung-breeding flies depend on fresh mammal faeces as a food source. Following the introduction of livestock worldwide, several harmful, species of dung-dwelling fly have emerged, primarily *Musca vetustissima, M. autumnalis, Haematobia exigua, H. irritans, and H. thirouxipotans.* Some species are found among the dung-breeding flies; those are parasites of livestock and suck blood or the area surrounding the cow's nose, mouth and eyes. These pests are difficult to eradicate and harm the development of cattle. Fortunately, dung beetles can rapidly bury the cattle dung, preventing the development of fly larvae and eggs. It emphasizes the significance of dung beetles as biological pest management[5]. Additionally, these dung kinds serve as a source of food for pest species. Numerous studies in Western Australia have found that dung beetle introductions resulted in an 80%reduction in pest populations of the *Musca vetustissima*[36].

The foraging and breeding activity of both larval and adult dung beetles decreases the abundance of detrivorous and hematophagic dung-breeding flies, along with dung-dispersed protozoa and nematodes. These biological systems have the potential to have a considerable impact on the well-being and welfare of humans and livestock[28]. Through the feeding and consumption of fresh faeces for the purpose of establishing their nests, dung beetles suppress the dung-dwelling diseases and parasites that are present in cattle and people. Certainly, calves feeding on pastures with healthy dung beetle populations have 75% reduced parasites[36].

(e) Ecosystem services

The component of ecosystems that has a direct influence on or benefits individuals is known as ecological services[12]. The significance of the ecosystem services provided by the dung beetle to the livestock sector has been mainly highlighted in some investigations that have done so, especially in terms of the project of the Australian dung beetle[28]. Parasite fly populations proliferated as a consequence of the enormous faecal accumulation, which cause severe pasture damage since cattle resisted foraging in the contaminated sites around the dumps[13]. However, introduced beetles occurred to have unsuccessful in their attempts to lower populations of fly at the spatial scale, despite their effectiveness in boosting the amount of excreta cleaning services[17]. Dung beetles are vital to the long-term survival of large-scale cattle agriculture around the world. Vast grazing systems cover approximately 2 billion hectares, or 15% of the world's ice-free territory, and contribute approximately 78% of all agricultural uses[38].Their long-term feasibility relies on natural systems to mitigate pasture contaminants, monitor cattle pests, and sustain forage production efficiency by attempting to prevent N-evaporation because chemical agents and therapeutic vet care are quite often logistically and financially unrealistic in such areas[26].

Conclusion

This review has made an effort to collect all the data currently available on the status, abundance, and ecology of the dung beetle fauna. Key elements include understanding how non-random extinction orders exacerbate and safeguard compensating mechanisms at the community level from the functional significance of species loss. Dung beetles appear to be crucial in maintaining ecological integrity in natural system, particularly through secondary seed dispersal and nutrient cycling. Dung beetles are crucial to agricultural system because they boost primary yield and control animal parasites. It is possible to effectively regulate the environmental correlations to success or failure potential and relate these parameters to ecological performance using trait-based attitudes. The accessibility of food and habitat for Scarabaeinae dung beetles is deteriorating globally, which is extremely concerning. To fully understand the magnitude of biodiversity deprivation in natural-dominated ecologies and human, it is helpful to have a better understanding of the environmental significance of dung beetles.

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