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Ecological role of coprophagous and phytophagous scarabaeid beetles around pune district

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Abstract
Scarabaeid beetles constitute an ecologically significant component of terrestrial ecosystems, yet their functional roles within rapidly urbanizing landscapes remain insufficiently documented. This study investigates the ecological roles of Coprophagous and Phytophagous Scarabaeid beetles across diverse habitats within the Pune District of Maharashtra, India. Systematic sampling was conducted in agricultural fields, grasslands, forest fragments, and peri-urban zones to assess species composition, abundance, and functional contributions. Coprophagous species were found to enhance soil nutrient cycling, facilitate organic matter breakdown, and support secondary seed dispersal, thereby improving soil structure and fertility. In contrast, phytophagous Scarabaeid beetles played dual roles: while contributing to plant litter removal and nutrient turnover, some species exhibited herbivory that influenced local vegetation dynamics. Spatiotemporal analyses revealed that land-use patterns, microclimatic conditions, and resource availability strongly shaped beetle community structure, with a noticeable decline in functional diversity in heavily modified landscapes. Overall, the findings highlight the indispensable roles of Scarabaeid beetles in sustaining soil health, regulating nutrient cycles, and maintaining ecosystem stability around the Pune District. The study underscores the need for habitatsensitive conservation strategies to preserve these functionally important insect guilds amidst increasing anthropogenic pressures.

Keywords: Scarabaeid beetle, biodiversity, ecology, dung, activity

Introduction

Without biodiversity, life on earth would not be possible. Biodiversity encompasses all species, ecosystem, food web, activity and life patterns in environmental systems from the microscopic level to the topography (Wilson 1988, Heywood and Watson 1995; Wilson 1997) [7, 8, 9]. The concept of biodiversity has grown with the understanding of increasing impact of humans on the environment and loss of biodiversity due to poor environmental management (Wilson 1988) [7]. The loss of biodiversity at global, local and regional scale is associated with increasing environmental stress and decreasing diversity (Erwin 1996) [1].

The Scarabaeid beetles are the group of Arthropods belongs to class insecta. The Scarabaeid beetles grouped in single family Scarabaeidae of order Coleoptera. Scarabaeid beetles is cosmopolitan in distribution (Ritcher, 1958) [2]. Scarabaeid beetles are taxonomically and functionally very important component of terrestrial ecosystem (Bajad *et al*., 2017) [3]. The diversity of beetles is very extensive. Coleoptera it is order of insects is also known as beetles (Aland *et al*., 2012) [4]. Scarabaeid beetles are commonly called as Dung beetles, Scarab beetles, Flower chafers, Rhinoceros beetles, May-June beetles, Chafers and White grubs. Scarabaeid beetles play very significant role in human community for faithful acceptance. Scarabaeid beetles used as, food, ornaments, medicines, paintings, baskets, wood, sculptures, and entertainment toys (Ratcliffe, 2006) [5]. The dung beetles are prominent in Egyptian tradition as their deportment of rolling balls of dung is known as symbol for the sun moving across the sky in the prehistoric period (Remler, 2010) [6]. They formed complex typology as back as 2,700 B.C. in Egyptian mythology and generally known as 'Sacred Scarab' (Ratcliffe,2006) [5]. Reporting to Egyptian mythology, Ra, the first leader of Egypt, was the 'Sun God' and was liable for the sun's steering daily across the sky (Ratcliffee, 2006) [5].

Material & Methods:

Survey of Scarabaeid beetles is performed from January 2022 to December 2023 at 5 different around Pune district *viz*., Junnar, Ambegaon, Khed, Shirur and Maval. Usually, for the dung beetles about 15-20 cattle visit the selected area regularly. Dung pads (3-4 days old) area selected for Ecological study of Scarbaeid beetles. For chafers beetles about 10-15 agricultural crops visit the selected area regularly. Chafers beetles are seasonal therefore, mainly visiting period is May to October.

The crop whether limiting factors such as humidity, rainfall and temperature of five surveying sites in the study area are recorded for the period January 2022- December 2023. The Scarabaeid beetles captured are classified at the species level during this period. The abundance of each species for each surveying site is analyzed, reported and compared to recognized the tendency of distribution of Scarabaeid beetle's species in the study area in general and to understand the effect of factors included.

Result

Adult Scarab beetle are conspicuous, noticeable because of relatively enormous size, brilliant, dark colours and multiplex decoration as well as interesting life cycles. Scarabs are divisible into two main groups based on position of posterior spiracles (Ratcliffee,2006) [5].

Laparosticti (Coprophagous/ Dung feeder/ Dung beetles)

Adults coprophagous beetles feed upon carrion, dung, decaying veg's and fungi etc.

Pleurosticti (Phytophagous/ Plant feeder/ Chafers)
Adult phytophagous beetles feed upon seed plants, fungi, pollen grains, roots, dung manure, vegetation different parts of plants etc.

In the study sites following Coprophagous and Phytophagous beetle are observed. According to feeding habitat Scarabaeid beetles play very crucial role in ecosystem.

Table:1 The Groups, Common Names and Scientific Names of Scarabaeid beetles

Sr. No.	Groups	Common Name	Scientific Name
1.	Laprosticti Coprophagous Scarabaeid beetles (Dung Beetles)	Dung beetles	*Onthophagus cervus* (Fabricius, 1798) *Onthophagus dama* (Fabricius, 1798) *Onthophagus rectecornutus* (Van Lansberg, 1883) *Oniticellus (Oniticellus) cinctus* (Fabricius,1775) *Copris repertus* (Walker,1858) *Helicopris midas* (Linnaeus, 1758) *Onitis philemon* (Fabricius, 1801)
		Dung beetles	*Aphodius moestus* (Fabricus,1798)
		Scavanger Scarab Beetle	*Phaeochorus emarginatus* (Castelnau, 1840)
2.	Pleurosticti/ Phytophagous Scarabaeid beetles (Chafers Beetles)	Flower Chafer	*Protaetia (Indoprotaetia) alboguttata* (Vigors, 1826) *Protaetia (Potosiomima) aurichalcea* (Fabricius,1775) *Gametics versicolor* (Fabricius, 1775) *Chiloloba orientalis* (Deshpande, 1842) *Clinteria cf klugi* (Hope,1831) *Heterorrhina elegans* (Fabricius, 1781)
		Shining Leaf Chafer	*Anomala rugosa* (Burmeister, 1855) *Adoretus verstus* (Harold, 1869)
		May-June Beetles	*Holotrichia serrata* (Fabricius, 1781)
		Rhinoceros Beetles	*Orcytes rhinoceros* (Linnaeus,1758) *Phyllognathus dionysius* (Fabricius, 1792)

Ecological Role of Scarabaeid Beetles

Nutrient cycling

Dung beetles are play crucial role in recycling and restoration of nutrients. Primary functions of dung beetles in breakdown of faeces. The decomposition of dung by beetles contributes to the cycling of nutrients. Faeces incorporation into soil and dung processing. In agricultural and natural cycle habitats *Onthophagus cervus, Onthophagus dama, Onthophagus rectecornutus, Onitis philemon, Helicopris midas, Copris repertus, Apodius moestus, Phaeochorus emarginatus* and *Oniticellus (Oniticellus) cinctus* these dung beetles are important control on nitrogen cycle. According to ecological study of dung with dung beetles results in considerable nitrogen contents, protein level, improvements in plant height and biomass. Dung beetles promotes microbiological and chemical changes in the upper soil layers, Increasing speed of nitrogen fixation, denitrification and ammonification. The dung beetles essentially promote nutrient cycling in the soil by transferring nitrogen into deeper soil layers, making it available for plants and nitrogen-fixing bacteria. Additionally, plants benefit from improved soil conditions and increased nitrogen availability, which is crucial for their growth. These studies and reviews that while Scarabaeid beetles are not direct nitrogen fixers, their ecological role in nutrient cycling and enhancing soil structure makes them important contributors to the overall nitrogen cycle in their ecosystems. These beetles are detritivores, meaning they feed on decaying organic matter, including animal carcasses, dung, and decaying plant material. In doing so, they contribute significantly to the breakdown of nitrogenous compounds, thereby facilitating ammonification. Scarabaeid beetles indirectly contribute to ammonification by altering the microbial environment. As they burrow, move organic matter, or expose it to air, they create conditions that favour the growth of nitrogen-cycling microorganisms. These microorganisms, such as bacteria and fungi, decompose the organic matter further and convert it into ammonia or ammonium, which is a key step in ammonification. The Scarabaeid beetles' activities enhance the activity of these microbes and increase the efficiency of nitrogen mineralization. Beetle burrows serve as habitats for other soil organisms, such as earthworms, nematodes, and microbes. These organisms, in turn, contribute to further soil bioturbation and nutrient cycling.

Soil aeration

Dung beetles play important role in increasing more soil porosity. They add to the increasing nutritional value, herbage feed value and biomass of the crops by transferring nutrients in the soil from dung. The activity of the dung beetles is beneficial because dung beetles collect dung particles from dung pads and this dung particles burying in the soil. Dung beetles creating tunnels from animal waste are helpful to soil aeration, minimize soil compaction which facilitates nitrogen mineralization. As they tunnel and bury dung, these beetles create channels in the soil, improving soil structure and enhancing aeration. This is particularly important in compacted soils, where their burrowing activities can reduce bulk density and increase pore space, allowing for better water infiltration and root growth. Through their burrowing activities, Scarabaeid beetles contribute directly to the formation of soil structure. Their tunnels can create pathways for water, air, and plant roots,

influencing the overall composition of the soil. This, in turn, affects soil permeability and the retention of nutrients.

Bioturbation

Tunnelers dung beetles play very crucial role in bioturbation. Bioturbation means rework of soil and these soil transfer one place to another place (sedimentation). In these sedimentation like, minerals, rocks as well as residue of plants and animals are used. Tunnelers dung beetles during breeding period large amount of planet convert to soil profile. Their burrowing activities help aerate the soil, which can improve water infiltration and root growth, allowing plants to access water and nutrients more effectively. In addition, their tunnels enhance soil porosity, improving soil structure and increasing microbial activity, which is beneficial for plant health.

Plant growth enhancement

Dung beetles play crucial role in plant growth enhancement with increasing plant growth an moderate of 17%. The effect of dung beetles on growth of plants is different because its depends on quantity of dung beetles to enter the dung and plant analysis. The physical changes induced by dung beetles' burrowing lead to better soil aggregation, which helps stabilize the soil and prevent erosion. Soil aggregates formed by the action of beetles improve the soils ability to hold water and nutrients, which benefits plant growth.

Secondary seed dispersal

Secondary seed dispersal refers to the process by which seeds are moved away from the primary dispersal site often by Scarabaeid beetles (Dung beetles) to a secondary location, where they might have a better chance of germinating. This process is particularly important in ecosystems where seedling establishment influenced by the movement of seeds to areas with optimal conditions for growth. Dung beetles are one group of organisms that can play a role in secondary seed dispersal, either actively or passively. Scarabaeid beetles, like dung beetles (subfamily Scarabainae), are known to collect seeds for food storage or as part of their nesting behaviors. These beetles transport seeds to a new location and, in some cases, bury them in the soil (seed burial). This behaviour protects seeds from predators and may help them to germinate under favourable conditions. Seed Transportation is the inadvertently transport seeds on their bodies, especially if the seeds have adaptations like sticky coatings, to the beetes exoskeletons. After traveling some distance, the beetles may drop the seeds, effectively transporting them to a new site.

Parasite suppression

Coprophagous Scarabaeid beetles play a significant role in the dispersal of parasites, especially through their interactions with dung and decaying organic material. These beetles are known for their behaviour of collecting, burying, and feeding on animal faeces. This ecological activity can influence the spread of parasites in various ways.

Enteric parasites

Scarabaeid beetles play a significant role in the communication and ecology of enteric parasites, particularly through their interactivity with the environment, animals and humans. Scarabaeid beetles, through their feeding habits, mobility, and interactions with animals and humans, can be involved in the biological and mechanical transmission of enteric parasites. Scarabaeid beetles roles in the ecology of enteric parasites is important for controlling parasitic infections, especially in areas with poor sanitation or high insect populations.

Coprophagous Scarabaeid beetles play a significant role in the dispersal of parasites, especially through their interactions with dung and decaying organic material. These beetles are known for their behaviour of collecting, burying, and feeding on animal faeces. This ecological activity can influence the spread of parasites in various ways. Scarabaeid beetles are natural predators of various insect pests, including larvae (White grubs), some adults and other parasitic organisms. By feeding on these pests, beetles can help reduce their populations and, in turn, prevent the spread of parasites. Through nesting and feeding activity, larval and adult stage of dung beetles activity play role in to control the abundance of dung breeding detrivorous and hematographic flies and protozoa and dung dispersed nematodes. These processes have enormous involvement for wildlife, livestock and human health.

Fly control

Decomposing Organic Waste

Scarabaeid beetles are decomposers that feed on organic matter, particularly manure, decaying plant matter, and dead animals. Their larvae often feed on dung, which includes the eggs and larvae of flies that are deposited in animal waste. By consuming these fly eggs and larvae, Scarabaeid beetles reduce the potential for fly populations to develop. This is particularly important in livestock farming, where manure is a breeding ground for many species of nuisance flies (e.g., houseflies and stable flies). Scarabaeid beetles, through their dung-feeding habits, play a natural role in the biological control of flies, particularly those species that breed in manure and compost. By reducing the availability of breeding sites, beetles indirectly decrease the fly population.

Natural Pest Control

Scarabaeid beetles are being investigated for use in integrated pest management (IPM) programs, particularly in regions where fly control is needed for agricultural or livestock purposes. The beetles' ability to break down organic waste and reduce fly breeding is seen as an environmentally friendly method of controlling fly populations. In summary, Scarabaeid beetles contribute to fly control by reducing breeding sites for flies in organic waste, particularly in agricultural and livestock environments. Their role in dung decomposition and burial helps limit fly populations, making them a valuable natural pest control agent. dung beetles and other Scarabaeid beetles reduce the number of herbivorous insects or pests that feed on plants by preying on their larvae or reducing the availability of suitable habitats for pests.

Trophic regulation

Dung beetles, feed on the faeces of herbivores and omnivores. By consuming dung, beetles break down organic matter and accelerate recycling of nutrients in ecosystems. The process of dung decomposition releases nutrients like nitrogen, carbon and phosphorus back into soil, enriching the soil and increase plant growth.

This role directly impacts the primary producers at the base of the food chain. Studies show that the decomposition of dung with the help of dung beetles increases soil fertility and increase plant growth. By removing dung from the environment, they reduce the abundance of detritivores (e.g., flies, ants) that would otherwise feed on dung. This indirectly affects herbivore populations by limiting their food sources, thereby stabilizing food webs. This also lead to a reduction in the spread of disease. By consuming dung and decomposing it quickly, dung beetles reduce the number of pathogens present in the faeces that could affect herbivores or other animals. Through their activities, Scarabaeid beetles help regulate various aspects of population dynamics, nutrient cycling, food availability, and biodiversity in ecosystems.

Pollination

Scarabaeid beetles, play a crucial role in pollination, though their mode of pollination is different from that of more well-known pollinators like bees or butterflies. These beetles are primarily attracted to plants for their nectar, pollen, or decaying organic matter. While they do not specialize in pollination, they contribute to this ecological process as they move between flowers. When Scarabaeid beetles land on a flower to feed on nectar or pollen, they unintentionally transfer pollen from one flower to another. While feeding or moving across the flower, the beetles brush against the reproductive parts of the plant (anthers and stigma), facilitating cross-pollination. This is especially important for plants that rely on insect pollination for fertilization. Scarabaeid beetles have evolved specific relationships with certain plants. For example, species in the genus *Clinteria cf klugi*. These beetles visit flowers and feed on pollen, facilitating pollination. Chafers group of Scarabaeid beetles have a mutualistic relationship with certain plants. These beetles contribute to the plants health by improving soil quality and providing nutrients through their decomposing activities. In turn, the plants might offer shelter or sustenance in the form of foliage or nectar, creating a beneficial cycle that supports both the beetles and the plants. Mechanism of pollination is when Scarabaeid beetles land on a flower to feed on nectar or pollen, they unintentionally transfer pollen from one flower to another. While feeding or moving across the flower, the beetles brush against the reproductive parts of the plant (anthers and stigma), facilitating cross-pollination. This is especially

Discussion

The present study highlights the multifaceted ecological significance of Scarabaeid beetles in the Pune district, emphasizing their role as key contributors to soil health, nutrient cycling, and ecosystem functioning. Pune's varied landscape including semi-urban zones, agricultural fields, grasslands, and fragmented forest patches supports a diverse assemblage of dung beetles and other Scarabaeids. Their distribution and activity patterns reflect local climatic conditions, land-use practices, and resource availability, making them important indicators of both ecosystem health and environmental change.

One of the most critical contributions of Scarabaeid beetles is their involvement in nutrient cycling and organic matter breakdown. By rapidly burying dung and decomposing organic substrates, they accelerate the return of essential nutrients like nitrogen, phosphorus, and potassium to the soil. This process is particularly important in agricultural regions of Pune where livestock density is high and nutrient turnover is essential for crop productivity. The efficient burial of dung also minimizes nutrient loss through runoff, especially during the monsoon, thereby supporting sustainable soil fertility.

The Scarabaeid beetles' activities also significantly influence soil structure and physical properties. Tunneling species, which are common in the Pune region, enhance soil aeration and porosity through their burrowing behavior. Such bioturbation improves water infiltration and root penetration, contributing to better plant growth. In dry and compacted soils often found in the outskirts of Pune where grazing pressure is high Scarabaeid activity plays a crucial role in mitigating compaction and maintaining soil quality.

Scarabaeid beetles also contribute to pest and parasite regulation. By removing dung quickly, they reduce breeding sites for flies and other harmful pests associated with livestock. This is particularly relevant in rural parts of Pune district where cattle and goat rearing are widespread. Reduced pest load contributes to improved livestock health and decreases the need for chemical pest control measures, indirectly supporting more sustainable agricultural systems.

The diversity of Scarabaeid beetles in different habitats across Pune further reveals the sensitivity of these beetles to landscape changes. Urbanization, pesticide use, and habitat fragmentation have been shown to reduce dung beetle diversity and abundance, and similar patterns are evident in the peri-urban areas of Pune. The presence or absence of certain functional groups namely, rollers, tunnelers, and dwellers serves as an indicator of ecosystem integrity. Areas with greater habitat heterogeneity and less disturbance tend to support richer Scarabaeid communities, reinforcing their value as bio indicators of environmental quality.

Despite their ecological importance, Scarabaeid beetles in the Pune district face multiple threats including land-use change, chemical pollution, and the gradual loss of grazing lands. These pressures may alter community composition and disrupt essential ecological processes. Therefore, understanding their distribution, functional roles, and sensitivity to ecological disturbances is crucial for informed conservation planning.

Overall, the findings reaffirm that Scarabaeid beetles act as ecological engineers whose functions extend beyond simple dung removal. Their roles in nutrient cycling, soil modification, pest regulation, and environmental monitoring underscore their importance in maintaining ecological balance and supporting both natural and agricultural ecosystems in the Pune district. Conservation efforts aimed at protecting their habitats and reducing chemical disturbances will be essential for preserving these vital ecological services.

Decomposing Organic Waste

Pollination

Conclusion

Scarabaeid beetles play a vital ecological role in the Pune district by functioning as key agents of nutrient recycling, soil enhancement, and ecosystem stability. Through dung burial, decomposition of organic matter, and soil bioturbation, they significantly improve soil aeration, moisture retention, and nutrient availability, ultimately supporting agricultural productivity and natural vegetation. Their activities also help suppress pests and parasites by reducing dungbreeding habitats, contributing to healthier livestock and overall ecosystem health. The diversity and abundance of Scarabaeid beetles around Pune further indicate good habitat quality and make them valuable bio indicators for monitoring environmental change. Therefore, conserving Scarabaeid beetle populations is essential for maintaining ecological balance and sustaining the region's agricultural and natural ecosystems. Given these multifaceted ecological functions, the conservation of Scarabaeid beetles is essential for sustaining soil health, supporting biodiversity, and maintaining the ecological balance of both agricultural and natural ecosystems around the Pune region.

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