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Review Article

Ecological Benefits of Scarab beetles (*Coleoptera: Scarabaeidae*) on Nutrient Cycles: A Review Article

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Abstract

Scarab beetles also known as dung beetles is considered the most significant insect assemblies in the tropical zones because of their vital role in the nutrient recycling, helminthes control and seed dispersion as they use dung of herbivorous and omnivorous mammals as a food reserve. Many species of dung beetles can be functional on the wide range of food sources from flesh to dung or more particular means like mushrooms, diplopods, fruits, eggs vegetation and detritus. The species are extremely specialized, consuming definite primate dung. Though, varied aspects of the ecological history of dung beetles have been extensively studied, little is recognized about their particular use of different dung beetles in multiple nutrients cycles such as nitrogen cycle, organic matter decomposition, CH_4 emissions, NH_3 volatilization, greenhouse gases emission, waste management, forest and agro pasture ecosystem stability as well as soil and agricultural cycles. For this reason, this review paper offers a study likening the use of primate dung species by congregation of dung beetles in the ecological regions. Dung beetles and their functions are not consistently disseminated across the time and space that will present challenges to understand the crescendos of service assembly, even in those environments where environment service standards can be evidently delimited. The deteriorating global trends in food and habitat accessibility for Scarabaeine dung beetles are of inordinate review concern.

Keywords: Scarab beetles; Dung beetles; Nutrients cycles; *Scarabaeidae*; Ecological benefits

Introduction

Scarab beetles belong to order Coleoptera, sub-order polyphaga, family *Scarabaeidae* and class Insecta. For the ancient Egyptians, scarab species have been derived and considered a holy symbol of resurrection [1]. According to Egyptian spiritual belief, sunrays radiated from head of scarab and its dung ball was the whole world, caught in an eternal cycle of daily renewal foundation that leads to a greatly sustainable system. Most of the scarab species are injurious pests of turf grass during their larval phase, these larvae are milky grubs and consume roots and destroy cultured turf grasses. These grubs are serious pests of turf within United States including considerable number of exotic species like *Cyclocephala* spp also called masked chafers [2].

Scarab beetles encompass a prominent module of beetle fauna. Adult individuals are evident because of their comparatively huge size, brilliant insignia, and complex decoration with fascinating life cycles. Scarab beetles consist of over 27,800 species throughout the world and stimulating display of life cycle, and many exciting adaptation capacities [3]. It encompasses about 600 genera and 27,800 species all over the world. Life cycles of scarab beetles are very diversified, adults feed upon dung, carrion (coprophagous) hence called dung beetles where as some feed upon fungi, vegetations, pollen grains, fruits, dung manure, or roots (phytophagous) so also called chafers. Some scarab beetles inhabit inside the nests of ants, termites, rodents and birds. Adults of few scarabs are diurnal and seen on flowers or vegetation or got fully or partially buried in dung while many species are nocturnal [4].

According to the arrangement of the posterior spiracles, family *Scarabaeidae* is bifurcated into two big units, Laparostici (coprophagous, dung beetles) and Pleurostici (agricultural pests, chafers). Coprophagous scarab beetles likely to feed upon microorganism containing sap of mammalian dung and occasionally on the dung of other vertebrates, rotten fruits, fungi, carrion and fibrous material of dung to nourish their larvae [5]. Scarab beetles are systematically and functionally play significant role in terrestrial ecosystem; they work as natural scavengers by adding large amount of dung thus clean up earth surface to great extent. Scarabs are capable of burying human and bovine excreta

into soil by molding into root nodules and rounded balls [6].

In the insect families such as *Geotrupidae* and *Scarabaeidae*, the dung beetles play a significant role in the nutrient cycles of pastures partially by the burial and elimination of dung from the soil surfaces in the forms of nourishment for their undeveloped stages [7]. Dung beetles shows ever all kinds of nesting behaviors such as rolling in telecoprids, tunneling in paracoprids and dwelling in endocoprids (Figure 1) [8]. Tunneling is one of the most common nesting behaviors among the dung beetles that refer to the species which burrow underneath the dungs, either digging a chamber which houses one to many dung balls or packing the tunnels by dung masses. These dung caches comprise the young and developing beetles with provided shelter and food [9].

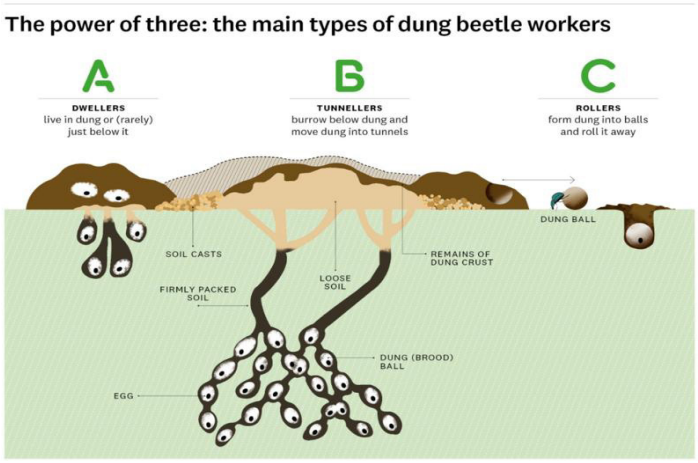

Figure 1: Kinds of dung beetles based on their mode of functions (source https://www.nswfarmers.org.au/)

Dung beetles repress the dung-dwelling pathogens and parasites within livestock and humans through fresh feces feeding and consuming them for the establishment of their nests. Certainly, calves foraging on pastures with healthy populations of dung beetles ought to 75% less parasites [10]. Similarly, dung beetles can also exterminate pathogenic *E. coli* inside the buried dung, make it less probable for other pathogens to produce contaminates [11]. By means of eating both human pathogens and parasites, dung beetles can expand livestock and human health significantly. It must be well known that dung beetles nourish on fresh feces, so pathogenic microbes found in indecorously composted manure might be less prospective to be expended by dung beetles [12].

Several dung beetle species bury dung beneath the soil as nutrition for their bugs. This digging movement makes holes in the soil which enhances permeability, ventilating the soil and letting water to diffuse rather than escaping out the surfaces [13]. Through burying newly dumped feces, dung beetles transfer nutrients-rich organic material to the location where roots of the plant scan spread it and it can nourish other valuable soil microorganisms. It also prompts chemical and microorganism variations in the top most soil layers, which accelerates nitrification, ammonification, denitrification, and nitrogen fixations [14].

Through burying and aerating the cattle dung on pasture, it is found that dung beetles could reduce the emission of methane up to 12%, which is the most significant greenhouse gas [15]. The dung beetles in different conventional feedlots had been found to reduce the greenhouse gas nominally about 0.05% minimum [16]. There are few flies among dung-breeding species, which are cattle pests and feed upon the blood or around the cows' mouth, nostrils and eyes. Such pests' hinder the cattle development and are costly to control. Luckily, dung beetles can easily bury the cattle feces before any chance to develop the eggs and larvae of flies. It shows that dung beetles are imperative natural controls of pest flies [17].

Dung beetles can manage efficiently the nutrients cycles of dung into the soil as a result of burying the dungs interconnected to their lifecycle histories [18]. The influence of dung beetles on the nutrients of dungs has been recognized to comprise improved yields of crops and forage and upsurges in the nitrogen and other soil nutritional elements [19]. Dung beetles also identified as a source of greenhouse and related trace gases that represent deficits of nutrients in the ecosystem. It has been revealed that the influence of activities by dung beetles can efficiently decrease emissions of few forms of greenhouse and trace gases from dung pats for example CH_4 emissions and NH_3 volatilization [20].

The net scale impact of activities of dung beetles on the nutrient loss in the way of greenhouse gases emission is complicated, but, there are also evidences that recommend dung beetle activity enhance the emissions of CO_2 and N_2O from dung pats [21]. The effects of dung beetles on the emissions of greenhouse gases are supposed to be triggered by accelerated aerations of dung materials from tunnels which created by dung beetles, contrary to other responses of nutrient cycles which are in big part because of the burying of dung materials inside the soils [22]. However, the diversity of dung beetles can differ with the changing of seasons and thus their activities and related effects on the decomposition of dung may be probable to differ by the species, which exist at multiple points in time all over the growing seasons (Figure 2) [23].

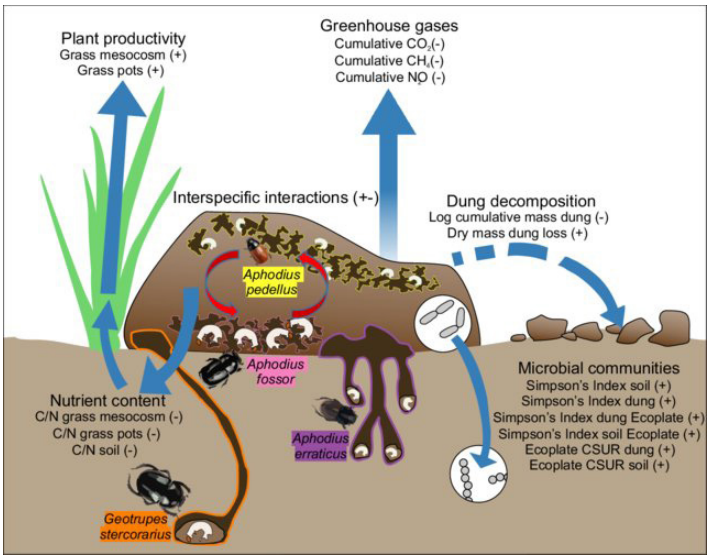

Figure 2: Impact of dung beetles on greenhouse gasses emission and plant productivity (source [24]).

Coprophagous beetle specie helps as an intermediate host for a diversity of nematode parasites. They show an imperative role in the agricultural and natural ecosystems by eliminating feces from the top most soil surfaces at a degree which far surpasses other natural procedures [25]. In the tropics, feces found to be on the surface nearly 3 times lengthier in the lack of dung beetles compared to when they exist [26]. The most of the dung beetles completely feed upon the feces, and depend upon it to construct the brood balls, which are buried and inoculated with eggs. Such usual breeding and feeding conducts related with dung-processing benefit in dispersion of seeds and support in preserving the regenerating capability of the forestry [27].

As well, these beetles change directly their ecology by eliminating feces from the surfaces of soil where it would or else aid as breeding habitats for parasitic flies, nematode, and related invertebrate spices. Dung beetles also participate to the vigor of ecology by enhancing the degree of nutrient cycles and fertilizing by aerating the soil. Due to such roles individually, dung beetles are recognizing as the environmental engineers. Specifically, they are organisms, which modulate indirectly or directly the accessibility of resources to other living organisms by initiating physical state variations to abiotic or biotic components. Specified the significance of dung beetles in environmental function, the probability that parasites can change the activity of their ecosystem becomes extremely pertinent when implemented to land management performs.

Restraining the large mammals within the small areas causes challenging problems regarding waste management [28]. In the United States, the cattle production delivers a predominantly relevant instance, as approximately 100 million cattle head are in production, and every animal can release more than 9000 kilograms or around 21m^3 of solid waste annually [29]. Luckily, insects particularly *Scarabaeidae* beetles are very proficient in waste decomposition. The significance of this provision is demonstrated by the effectiveness of dung beetles to deal the dung of nonnative cattle taken to that landform in 1788 [30]. Earlier to introducing the dung beetle species, which were modified to nourish on cattle dungs, there had not any insect fauna in Australia for the processing of cattle feces. Subsequently, the land throughout the state was polluted by gradually decomposing dungs [31].

Furthermore, these kinds of dung's provide feedstuff for the pest species. Several researches in Western Australia have exposed that pestiferous populations of the *Musca vetustissima* (bush fly) have been decreased by 80% following to introduction of dung beetles [32]. An additional significant service offered by dung beetles is endorsing the dung decomposition into labile nitrogen forms which can be integrated by plants and consequently functions as the fertilizers after burying the dung's [33]. In the deficiency of dung beetles, animal feces which remain on the surfaces of pastures till they dry lose a great percentage of their inorganic nitrogen to the open environment [34]. Trialsin the United States and South Africa have revealed that about 2% of the composition of cattle dung is of nitrogen while remaining 80% of this nitrogen is lost given conditions of pats dry in the sun before burying [35].

The significance of dung beetles for the different ecosystems especially agro-pasture has been identified and debated on the broad ranges. However, most realistic researches have only concentrated on their efficiency of dung removing or some limited ecological functions (such as, grass growth, seed dispersion and dung elimination) [36]. Furthermore, very limited studies have reconnoitered the effects of dung beetles on the soil related chemical properties. Soil debris feeding creatures is an imperative ecosystem element in managing the community structure and microbial abundances, and therefore the procedures regulating the decomposition of Organic Matter (OM) and nutrient discharge [37]. Dead OM offers both habitat and resources for diverse elements of the decomposing food web which consecutively, affect the processes of ecosystem by monitoring the accessibility of plant growth-restraining nutritional elements throughout the OM decomposition, and thus the aboveground vegetation communities [17].

In addition, dung beetles are principally sensitive to anthropogenic turbulences of natural environments and can be effective as biological indicator in the monitoring programs. Particularly in the tropics, the forest species of dung beetles are commonly incapable to tolerate open atmospheres and do not endure after the intrinsic forest is substituted by livestock or

crops systems. In the Central Europe, the dung beetle activities are pretentious by the conversion of anthropogenic habitats from forest to grassland and by land use escalation inside the grasslands and forests. Such as in the forests, the proportion of harvested timber decreases the rates of dung elimination by 20% [16].

Dung beetles are a miscellaneous detritus-feeding class that performs quite a lot of ecological roles associated with the recycling mechanisms of nutrients. These functions comprise bio distribution, biological control, organic matter burial, and dispersion of secondary seeds [19]. A number of species of dung beetles are specific-habitat classes, incompetent to colonize ecosystems with diverse environmental settings for reproduction and endurance [20]. These habitat-concomitant vicissitudes affect the structure and composition of dung beetle with costs to their environmental functions. Such as, the body size and richness of dung beetle species reduces with overall poor-sites and enormous mammal biomass while little-bodied species enhances the abundance in the complete dung beetle community. Nevertheless, little bodied dung beetles are not as much of proficient in performing parallel ecological functions as like large-bodied type (Figure 3) [15].

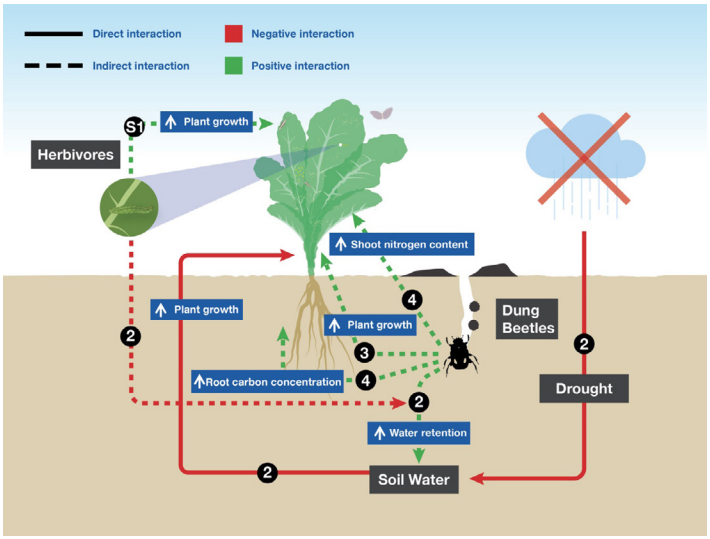

Figure 3: Mode of action of dung beetles on plant growth (source [38])

The thermal regime, biogeographic context, spatial attributes, and landscape conditions found as significant driving factors behind the distributions of dung beetle species at moderate to comprehensive scales [39]. Such as, elevation and latitude drive the richness of dung beetles because of variations in climatic organizations, particularly with a decline in temperature because of both elevation and latitude intensification. Landscape characteristics like spatial heterogeneity are vital in sustaining both matrix-tolerant and forest-dependent species [2]. In contrast, drastic fluctuations in land use damage the assemblages of dung beetles and their environmental functions reported that the variety of forest dependent dung beetles brusquely declines when the forest protection is decreased to less than 25% of the landscape [40].

Spatial characteristics are also essential as they can be applied as substitutions for biotic dispersal, interactions, unmeasured ecological variables and historic events since numerous environmental processes are spatially organized [41]. Therefore, causal communities of environmental driving dung beetles and their roles are dependent on native settings, along with climatic and spatial courses which influence assemblages of grassland and forest inhabiting species at middle to wide spatial scales [34]. In biological systems, dung beetles seem to play the central role in sustaining integrity of ecosystem, expressly secondary seed dispersion and nutrient cycles. With the higher sensitivities of dung beetles to several forms of human actions and habitat disruption, it is imperious to understand and guard these developments [42].

In agricultural structures, dung beetles also play a significant role in upgrading the primary productivity and defeating the livestock parasites. Better-quality understanding of the associations between dung beetle environmental functions and ecosystem facilities is life-threatening to the future administration of these facilities [43]. Dung beetles have also been concerned in growing seed mortality and scattering pathogens natural functions that integrally cannot deliver ecosystem provisions, as they are not valuable to human beings. Greater stress on the functional systems of responses to environmental variation can help to foresee the biological implications of dung beetle biodiversity forfeiture [44].

Conclusion

The knowledge about how the functional significances of species loss are protected by compensatory mechanisms functioning at the community level and aggravated by non-random extinction orders are key components. Trait-based attitudes are a palpable way to regulate the ecological relates to success or extinction proneness and directly narrate these factors to environmental function. The economic worth of dung beetles is significant and stirring area for prospect study. Dung beetles and their functions are not consistently disseminated across the time and space that will present challenges to understand the crescendos of service assembly, even in those environments where environment service standards can be evidently delimited. Revisions which eloquent the demand and supply for the services of dung beetles in the different socio-ecological contexts like environmental restoration and forest management will be exclusively beneficial. The deteriorating global trends in food and habitat accessibility for Scarabaeine dung beetles are of inordinate review concern. Abettor-quality understanding of the environmental significance of dung beetles is

useful involvement to understand the magnitudes of diversity loss in human and natural dominated ecologies.

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