Review Article

A short review on morphology, biomass and economics and ecological distribution of *Scarabaeidae coleoptera* scarab beetles

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Abstract

Scarab beetles (Family Scarabaeidae) encompass a prominent module of beetle fauna. Adult individuals are evident because of their comparatively huge size, brilliant insignia, intricate decoration with fascinating life cycles. Scarabaeidae covers the African Goliath beetle from (*Goliathus goliathus* L.), and weighs nearest to 100 grams, hercules beetle (*Dynastes hercules* Fabr.) belongs to American tropical regions and acknowledged for its immense size range reaching to 160 mm and bears strong horns in males. Scarab beetles consist of over 27,800 species throughout the world and stimulating the display of the life cycles and many exciting adaptational capacities. Dung beetles are systematically and physio-ecologically very significant components of the land ecosystem. They are natural scavengers, adding amounts of dung into the soil, thus washing up the earth's surface from excretory material of large and medium sized herbivorous mammals. The species are extremely specialized and beneficial for community due to consuming definite primate dung. Several aspects have been recognized about their particular use of different dung beetles in multiple nutrients cycles such as nitrogen cycle, organic matter decomposition, CH₄ emissions, NH₃ volatilization, greenhouse gases emission, waste management, forest and agro pasture ecosystem stability as well as soil and agricultural cycles. They act as sanitation agents suppressing agents of parasites and as bioindicators. This review paper aims to describe the population distribution of scarab beetles Scarabaeidae in multiple areas of the world to assist the scientific community with their ecological services.

Keywords: Coleoptera; Population studies; Scarab beetles; Scarabaeidae

Introduction

Scarab beetles belong to sub-order polyphaga, family Scarabaeidae, order Coleoptera of class Insecta. For the ancient Egyptians, scarab species from which the family name Scarabaeidae has been derived was a holy symbol of resurrection [1]. As per

Egyptian spiritual belief, sun rays radiated from the head of scarab, and its dung ball was the whole world, caught in an eternal cycle of daily renewal foundation that leads to a significantly sustainable system. Scarab beetles (Family Scarabaeidae) 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 [2]. Scarabaeidae covers the African Goliath beetle from (*Goliathus goliathus* L.). It weighs nearest to 100 grams, hercules beetle (*Dynastes hercules* Fabr.) belongs to American tropical regions and acknowledged for its immense size range reaching to 160mm and bears strong horns in males. Scarab beetles consist of over 27,800 species throughout the world and stimulating display of the life cycle, and many exciting adaptational capacities [3]. According to the arrangement of the posterior spiracles, family Scarabaeidae is bifurcated into two big units, Laparosticti (coprophagous, dung beetles) and Pleurosticti (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, and carrion, use fibrous material of dung to nourish their larvae [4]. Dung beetles are systematically and functionally play a significant role in the terrestrial ecosystem; they work as natural scavengers by adding large amounts of dung, thus cleaning up earth surface to great extent. Two-third of the human excreta produced in India is buried by scarabs. Scarabs are capable of burying human and bovine excreta into soil by moulding it into root nodules and rounded balls [5].

Economic importance of scarab beetles

The scarab beetles of the order Coleoptera include both beneficial and harmful insects. The agro-dung beetles, commonly called Laparosticti (dung beetles) perform vital role in cleaning the dung of cattle and mammals, and the phytophagous beetles, generally called chafers, are serious pests of crops, plants and forest vegetations. [6]. Dung beetles are systematically and physiologically very significant components of land ecosystem. They are natural scavengers,

adding amounts of dung into the soil thus washing up the earth surface from excretory material of large and medium sized herbivorous mammals. The dung beetle communities are outstanding models to assess and observe that at rate the changes in the vegetation significantly disturb animal communities [7].

Group pleurosticti (Chafers) are phytophagous scarabs with polyphagous nature; some species do not feed during the adult stage. Pleurostict chafers are grouped in nine subfamilies of the family Scarabaeidae which are Sericinae, Melolonthinae, Euchirinae, Rutelinae, Hoplinae, Dynastinae, Valginae, Cetoniinae and Trichiinae [8]. Males of Dynastinae are equipped with prominent horns which attack stems and roots of plants where as Cetoniinae have a preference for nectar, sap and juice of ripened fruits and vegetables. Rutelinae and Melolonthinae infest fresh leaves while Cetoniinae along with few genera of Rutelinae used to visit flowers where they consume nectar and pollen. Larvae of Melolonthinae, Rutelinae and Dynastinae are clear white grubs having soil-dwelling nature and feed on live plant roots and dangerous to agriculture [9]. Few Cetoniinae and Dynastinae grubs survive in the humus of soil while other Cetoniinae, Trichiinae and Valginae live in wood and debris gathered in the holes found in trees. Many species of the pleurosticti scarabs are already reported as pests of various agricultural crops [10].

Most of the scarab species are injurious pests of turfgrass 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 the United States including the considerable number of exotic species as *Cyclocephala* spp also called masked chafers [11]. Dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae) occupy rich communities in most of the terrestrial ecosystems where they donate key

ecological services like recycling of nutrients, soil fertilization, pest control and secondary seed dispersal [12]. In addition to this dung beetles are recognized as useful indicators of habitat fluctuations mainly in tropical rain forests. Their community structure is susceptible to many kinds of environmental alterations and allied with mammal communities [13].

Taxonomic and distributional surveys on scarab beetles of the Oriental region, especially in sub-continent were carried by Arrow [8], Balthasar [9, 10]. In Pakistan scarab beetles studies were conducted by Lohar and Mecci [11] Zahoor, Suhail, Zulfiqar, Iqbal and Anwar [12], Ratcliffe and Ahmed [13], Siddiqui, Ahmed and Khatri [14] Ahmed and Delcasa [15], Ali, Naeem, Baig, Shahzad and Zia [16], Ahmed and Ratcliffe [17]. All these studies were mainly based on distribution and taxonomy, so there is a need for work, especially in Sindh, regarding the abundance of scarab fauna regarding the food, habitat, guild composition, temperature and humidity.

Family Scarabaeidae is a speciose group of beetle's fauna and consists of more than 30000 species across the world. These beetles exhibit great variation in body size, form and habitats, adults of scarabs are famous for having a large size and brightly ornamental colours with interesting life histories. Most of the scarab beetles are small, bodied and shiny colored. One of the distinguishing characters of these beetles is their antennae which are lamellate form hence called lamellicorn beetles [13].

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 contaminants [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 plants can spread it and it can nourish other valuable soil microorganisms. It also prompts chemical and micro-organismal 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 was found that dung beetles can reduce the emission of methane up to 12% which is the most significant greenhouse gas [15]. In different conventional feedlots, the dung beetles 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 dungs into the soil as a result of burying the dungs interconnected to their lifecycle histories [18]. The influence of dung beetles on dungs' nutrients has been

recognized to comprise improved yields of crops and forage and upsurges in the nitrogen and other soil nutritional elements [19]. Dung beetles are 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].

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 [21]. Dung beetles have also been concerned in growing seed mortality and scattering pathogens natural functions which 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 [22].

Factors affecting abundance and biomass of scarab beetles

Many factors including fauna, temperature pH and most specially the type and quality of dung play their significant parts in the distribution of dung beetles in a given area. Some dung beetles are selective in terms of the dung selection of specific mammals so mammalian diversity can be affiliated with the variety of dung beetles therefore dung beetles can be used as biodiversity indicators in agro ecosystem. Chafers are phytophagous exclusively with variety of feeding habits; even some adult chafers do not feed at all. Chafers feed upon stems as well as roots of plants, some feed upon nectar of ripened fruits and vegetables. Larvae of some chafers

are white grubs which are ground dwellers and serve as serious pests of crops [18].

Description of body and distribution of scarab beetles

Its length is from 2.0 to 180.0 mm. Shape variable to great extend from oval, quadrate to cylindrical color reddish, brownish to tang brownish with or devoid of metallic radiations. Antennae mostly with 10-segmented (occasionally 9) having 3 to the 7-segmented club with apex segments more or less smooth in case of Melolonthinae, or hairy bristles as found in Scarabaeinae. Eyes medially separated by canthus, Clypeus bears horns or not, Labrum typically clear and Mandibles uneven, shaped or maybe not. Maxillae together with 4 segmented palpi. Labium having palpi contains 3 segments. Pronotum having horns or tubercles. Elytra bowed or expanded. Pygidium in Scarabaeinae is covered with elytra and uncovered in Melolonthinae and Rutelinae, scutellum triangular or parabolic in the form [19, 20].

Legs with sloping or lessened coxae; protibiae with 3 or 2 dentates, or hollow out on exterior margin; mesotibia and meta-tibia slim or hard, apex having single or double spurs; 5 tarsi, frontal may be absent in some Scarabs; claws alike in range or not, bare or notched. Abdomen comprised 6 liberated sternites; 7 efficient spiracles placed within pleural covering in case of scarabaeinae or in sternites and in tergites while in case of melolonthinae and outline. Wings highly enriched, fore wings are strong elytra and hind wings are reduced alae, disconnected vein present. Male genitalia bilobed or merged. Genital segment sclerotized, aedagues curved, phallobase is triangular and extended, parameres curved. The larva is C-shaped or cylindrical. Color off-white and yellow but the posterior portion appear dark due to deposited feces [20, 21].

Cranium highly sclerotized, testaceous to brownish or blackish, and Antennae are

having 4-segments, last segment bearing 1 or more sensory cerci, ocelli absent mostly, present or present with distinctive pigmented spots. Fronto-clypeal suture present and labrum variable or rounded or lobed apically. Epi-pharynx may be curved or lobed. Maxilla along with galea and lacinia, which are specifically split in case of Scarabaeinae proximally merged and distally free in case of Melolonthinae, or fused in Rutelinae, maxillary palps 4 segmented. Abdomen with fused 9th and 10th segments by dorsal side in Cetoniinae. Spiracles are cribriform and venter of final abdominal segment possesses fleshy lobes. 2-segmented legs in Scarabaeinae and 4-segmented in Melolonthinae and Rutelinae; claws may be present along with single or 2 setae. Scarabaeidae encompasses about 600 genera and 27,800 species all over the world. Among Scarabaeidae, subfamilies scarabaeinae and aphodinae comprise about 6,850 species (25% of total scarab beetle fauna). Melolonthinae, Rutelinae and other subfamilies include around 20,950 species (75% total scarab beetle fauna) [22].

Ecology and economic importance

Life cycles of scarab beetles are very diversified, and adults feed upon dung, carrion (coprophagous) hence called dung beetles whereas 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 [23].

Scarab beetles have significant economic and ecological importance. Adults, as well as larvae of a little species, cause considerable damage to the plants due to defoliation and root-feeding (sub-family Rutellinae). Numerous scarabs are useful because they are plant pollinators, reprocess plant material,

and work as dung recycling agents. In 1968, a number of species of coprophagous beetles were brought in Australia from Africa to organize cattle excreta, these beetles consume cattle dung, and make grasses to thrive. They also destroyed breeding sites for pestiferous, dung-breeding flies. In 2000, the role of *Digitonthophagus gazelle* was observed in the *B.decumbens* pastures of Brazil as cleaning agent of cattle dung [24, 25].

"Dung beetle" is a familiar name used for the beetles of Scarabaeinae as well as Aphodiinae. Dung beetles have specific ecological status. Species of genus *Dialytes* and *Aphotaenius* are known to feed upon deer manure, *Canthon pilularius* forms dung balls and throws it far away from a dung pad (dung roller) while *Copris fricator*, *Onthophagus hecate*, *Onthophagus cribricollis* forms dung balls and stay confined to the dung pat. Scarabs that live in the nests of mammals include *Ataenius brevinotus*. *Onthophagus striatulus* is a rare species of subfamily scarabaeinae that is non-coprophagous and feed on fungi [26].

Euparia castanea (Aphodiinae) and species of genera *Cremastocheilus* reside in the ant nests. Species of in the genus *Valgus* live in the tunnels of termites. Most of the species of Melolonthinae and Rutelinae are phytophagous and consume various plant parts. Larvae of many rutelines feed upon rotting logs. Larvae of many melolonthines and rutelines feed upon grassy roots as member of genus *Anomala*. Some of these larvae may act as garden or lawn pests (*Popillia japonica*, *Cyclocephala borealis*). Adults feed upon leaves and fruits. *Listrochelus falsus* is are best known as pine defoliator. Several adults of melonothinae and rutellinae survive on plant and flower saps flows [27].

The development of most scarab larvae is quite similar. Adult females deposit eggs in

soil, dung, manure or in other organic material. C-shaped white grubs appear after measuring and start to feed and grow two successive attempts of molting occur. In areas with high winters, larvae undergo diapause, as temperature rises in spring, larvae become active and start to feed. The emergence of the adult from the pupa occurs in response to environmental conditions such as rainfall, temperature, and humidity. After emergence, adults start to mate and begin the cycle [27].

Biomass and abundance of scarab beetles

Population size means the real number of individuals or living organisms within a population. Population density is a tool of the amount of population size per unit area that can be obtained by dividing population size by total area. Abundance means the relative account of a species in a particular ecosystem. Population density may vary as an outcome of natural disasters like earthquakes, floods or human-induced factors. Calculation of all individuals present at a given period and at a given location is impossible because animals are not easily detectable by so many means so the sampling method is applied to determine population size, density and abundance. Abundance estimates can be obtained by sampling a subset of the population of interested individuals. A major postulation is that the sample is the whole area's envoy, including threats, landscape, flora, and altitude. Superlatively, assessment and monitoring data allow the valuation of the sources and impacts of hazards, such as hunting, habitat degradation, and fragmentation [28, 29].

Biomass is the accumulation of living biological organisms in a given vicinity or ecosystem at a specified time. Biomass can moreover be referred as species biomass, which is the mass of lone or more species, or to community biomass, which is the heap of all species in the community. Estimating biomass in animals is necessary to study

many ecological aspects, including abundance, diversity, and richness. Apart from that, biomass estimation is also an important parameter for population studies, especially energy-mineral transfer, and prey-predator links. Biomass estimation of small animals, including insects (beetles) is highly laborious and times yielding with the chances of the destruction of rare specimens, to overcome these problems, general length-dry weight relationships have been established [30].

Conclusion

The scarab beetles of the order Coleoptera included both useful as well as destructive insects. The agro-coprophagous beetles, commonly known as *Laparosticti* (dung beetles) play a vital role in nature's sanitation by consuming the dung, and the phytophagous beetles widely known as chafers, are serious pests of crops, plantation as well as forests. Dung beetles are systematically as well as functionally very significant components of the terrestrial ecosystem. They are nature's scavengers and add dung quantities into the soil, thus cleaning up the earth's surface from excretory material left by large and medium-sized herbivorous mammals. The dung beetle communities are outstanding models to assess and observe that the vegetation changes alter the animal communities at the rate.

Author's contributions

Analyzed and conceived the outcomes: NA Shah, Collected the data and the overall paper write: N Shah, Proofread and finalized the paper: HMZ Raza.

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