

A Case Study on Seasonal Behaviour of *Aphodiuselegans* Allibert an Endocoprid Dung Beetle

Abstract

Dung beetles (Scarabaeidae) classified into endocoprid, paracoprid, and telecoprid beetles, are fascinating insects with various behaviors. The study focuses on behaviour of endocoprid beetles *Aphodiuselegans* Allibert, found in Bumdeling, Trashiyangtse, Bhutan. The observational and scan sampling methods were employed during the study. These beetles locate dung using antennae and dig inside it, resembling a boat propelled by oars. They are active during warm weather and bury themselves under dung during cold. Beetles defecate semi solid feces after dung foraging. They mimic death as defensive and antipredator behaviour. They prefer moist dung pats for burial and use repeated attempts and strongholds of hindwings to initiate flight. This study substantiates the diverse fascinating behaviors of a less-focused group of insects to gain a deeper understanding of their interactions with ecology.

Key words: *Aphodiuselegans* Allibert, Behavior, Dung beetle, Endocoprid.

Introduction

Dung beetles are insects of order Coleoptera, consisting the species of the subfamilies; Scarabaeinae, Geotrupinae, and Aphodiinae (Huerta, Oca, Rosales, & Favila, 2013) that partly or exclusively feeds on feces throughout their lifecycle (Holter & Scholtz, 2007; Huerta et al., 2013). They are found in every continent except Antarctica. Africa is considered to have the most diverse population of dung beetles (Whipple, 2011). Historically, since ancient Egyptian, dung beetles were believed as the representation of rebirth and rejuvenation (Hanski & Cambefort 1991). They were revered as the symbol of the god of the sun, who rolled the sun across the sky each day and buried it in the evening, only to emerge again the next morning (Whipple, 2011).

Ecologically, dung beetles are a major component of biological dung removal (Byk & Piętka, 2018) and controllers of pests and parasites that breed in dung (Fincher, 1975; Byk & Piętka, 2018). Dung beetles help farmers in agriculture production, by reducing the yield loss for pests, cost of pesticide applications, and fertilizer use. They are considered bioengineers of the environment and health giver for the population (Whipple, 2011). Besides their role as decomposers, dung beetles maintain biodiversity through its involvement in the Pollination and seed dispersal of some plants (Shepherd & Chapman, 1998; Griffiths, Bardgett, Louzada, & Barlow, 2016).

Dung beetles are adapted to a wide variety of ecosystems and many are highly specialized (Hanski & Cambefort 1991). Many specialist dung beetle species can feed on resources such as leaves, fungus, rotten fruits and small insects other than dung (Holter & Scholtz, 2007). Depending upon the species, dung beetles have a specific preference towards dung, dung condition, and the dung odor (Dormont, Epinat & Lumaret, 2004). Dung beetles can be segregated based on habitat and soil type. The activity and the behavior exhibition of dung beetles varies with species, the season and the seasonal activity, and the light and light intensity (Hanski & Cambefort 1991). Additionally, beetles respond differently to elevation and temperatures (Whipple, 2011).

Most dung beetles are generalist (coprophagous) feeders, however reduced dung availability sometime leads to specialization in dung beetles (Hanski & Cambefort 1991). Along with abiotic elements as weather and environment, feeding habits are also impacted by predatory and competitive variables (Whipple, 2011). Dung beetles have detritus-feeding habits and a dung resource contains all the nutrition that the beetles require. Adults have filtering mouth parts that feed on a “dung Slurpie”, the primary moisture within the dung (Hanski & Cambefort 1991). While larvae have biting mouthparts, that makes it possible to feed on both moisture and the fiber of the dung within the brood balls (Whipple, 2011).

Dung beetles are divided into three behavioral groups; rollers, tunnelers, and dwellers. The beetles that roll dung into round balls, used for food sources or brooding chambers are **rollers**. The **tunnelers** make a tunnel and bury the dung wherever they find it. The **dwellers** neither roll nor burrow the dung, but they simply live-in dung (Hanski & Cambefort 1991). The dung beetles are also known as Endocoprid (dwellers), Paracoprid (tunnelers) or Telecoprid (rollers) insects (Halffter & Edmonds, 1982; Hanski & Cambefort 1991; Byk & Piętka, 2018).

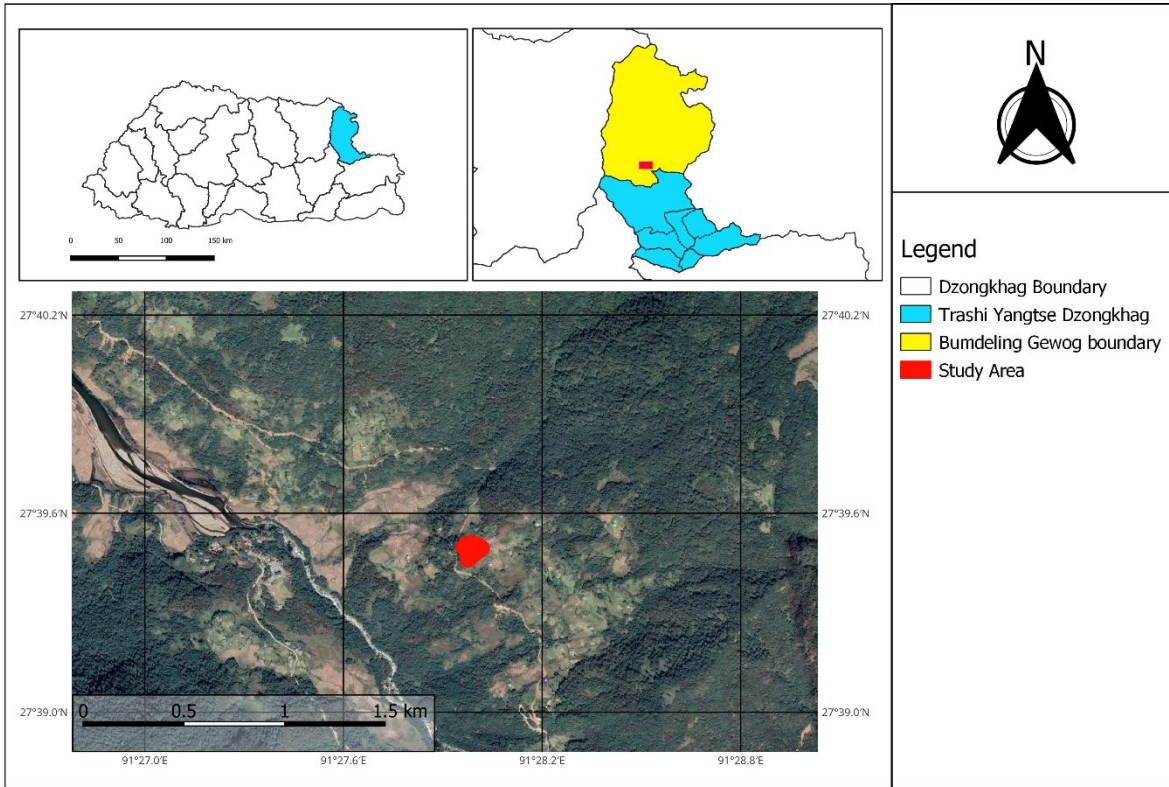
The fascinating behavior of the two groups of the dung beetle, the roller and tunneler were widely studied. Rollers form a bit of dung ball, roll it away and bury it. The dung balls are used either by females for laying the egg as a brood ball or as a food source for adults (Hanski& Cambefort, 1991; Holter& Scholtz, 2007). The male and female rollers establish a pair bond after encountering the dung pat. The male prepares the giant dung ball and offers it to the female as the brood ball. If she accepts, then they roll it away together or the female beetle rides on the top of the ball (Hanski&Cambefort 1991). They cooperatively defend their ball from stealing by other beetles (Baird, Byrne, Smolka, Warrant, & Dacke, 2012). The warfare and the battle between the males are fought to show strength and bravery (Halffter& Edmonds, 1982). The new pair bond and find a suitable and safe place to bury the ball before mating. The male leaves the scene, while the female lays a single egg and prepares another brood ball. The brood ball is then coated and sealed with a mixture of dung and saliva. Some mothers stay with the ball till the larvae hatch (Hanski&Cambefort 1991; Baird et al., 2012).

The tunnelers dive into the dung and tunnel directly into the soil to start the family (Bertone et al., n.d; Hanski&Cambefort 1991). Storing the dung underground helps to protect the developing larvae from predators and also to keep the nutrients, in the dung pile fresh and digestible (Holter & Scholtz, 2007). The female arranges and sorts the dung in the tunnel while the male carries the fresh dung to the home. The parents stay with the larvae until they are matured (Hanski&Cambefort, 1991; Dabrowski, Venter, Truter, & Scholtz, 2018). The dweller neither rolls nor makes tunnels. The female lays eggs on the top of the dung and the larval development takes place inside the dung pat (Whipple, 2011).

The behavior of the dweller beetles was not exclusively studied as it has no fascinating behavior like that of roller and tunnelers. Therefore, the study focuses on the different behaviors shown by the dweller dung beetle *Aphodiuselegans*Allibert. The different behaviors performed was observed and explained accordingly. The behaviors of hunting the dung pat, shoveling the dung pat and their burial, their feeding habits, the defecation of feces, and also their defensive behaviors were explained in the study.

Methodology

a. Study Site



The dung beetles were collected from the small cow herds of the Betsamang village, Bumdeling *gewog* (village block) under Trashi Yangtse *Dzongkhag* (district). The small study site was created by a collection of fresh dung pats of the cow. The dung inhabited with the *Aphodiuselegans* Allibert was collected and kept in the study site. The study was carried out during the spring season (March and April) of 2020. The region falls under Bumdeling Wildlife Sanctuary at elevations between 1500 meters (4,900 ft) and 6000 meters (20,000 ft). The mean annual summer temperature is 22.6 °C and the mean annual winter temperature is 15 °C.

b. Materials: Fresh dung pat, a spade, Gloves, Camera (Mobile camera).

c. Sample collection

The fresh cow dung and *Aphodiuselegans* beetles were collected at a specific site for observation. Field observational (Altmann, 1984), and scan sampling methods (Koster & McElreath, 2017) were used, and videos of their behaviors were recorded. Observed behaviours were described and verified with literatures available. Dung beetles were counted and identified, and then released in an open area.

d. Procedure to hunt dung beetles

Examine cow herds and pastures for dung pats, looking for holes or shredded surfaces. Look for adult beetles and larvae. Observe insect activity immediately after dung deposition. Dung beetles arrive within minutes at temperatures above 70°F (Bertone et al., n.d). *Aphodiuselegans* beetles appears twice a year in spring and summer (Bang, Han, Kang, & Lee, 2017).

Result and Discussion

a. General body anatomy of dung beetle

Body composed of 3 main segments; head, thorax and abdomen. A typical characteristic of beetles is the hard elytra that varies in color from black, brown, yellow or purple, depending on the species of dung beetle. A pair of wings folded under the elytra and hardened forewings covers the body. It possesses 3 pairs of legs terminated with appendages specialized for shoveling the dung and earth. Male of some species have a pair of horns on their head, used for defense. Antennae are typically characterized by elongated and segmented with a discernible curvature. The size of dung beetle varies from the smallest species 2mm long to the larger species up to 30mm long (Thomas & Darren, 2012).

b. Taxonomy of *Aphodiuselegans* Allibert

Class: Insecta

Order: Coleoptera

Superfamily: Scarabaeoidea

Family: Scarabaeidae

Subfamily: Aphodiidae

Genus: *Aphodius*

Species: *Aphodiuselegans* Allibert

c. Identification features of *Aphodiuselegans* Allibert

The identification features of the studied dung beetle are in accordance to Italian Entomologist Forum, (2017). *Aphodiuselegans* is identified by its auriculate genae with flat scutellum. Elytra interstices are nearly flat, shiny, sparsely or finely with distinct punctured. Blackish, elytra pale yellowish with bands usually widened till suture. The first segment of the hind tarsi conical, is slightly longer than the following three combined. Fore tibia, apical spur, in males outwardly hooked.

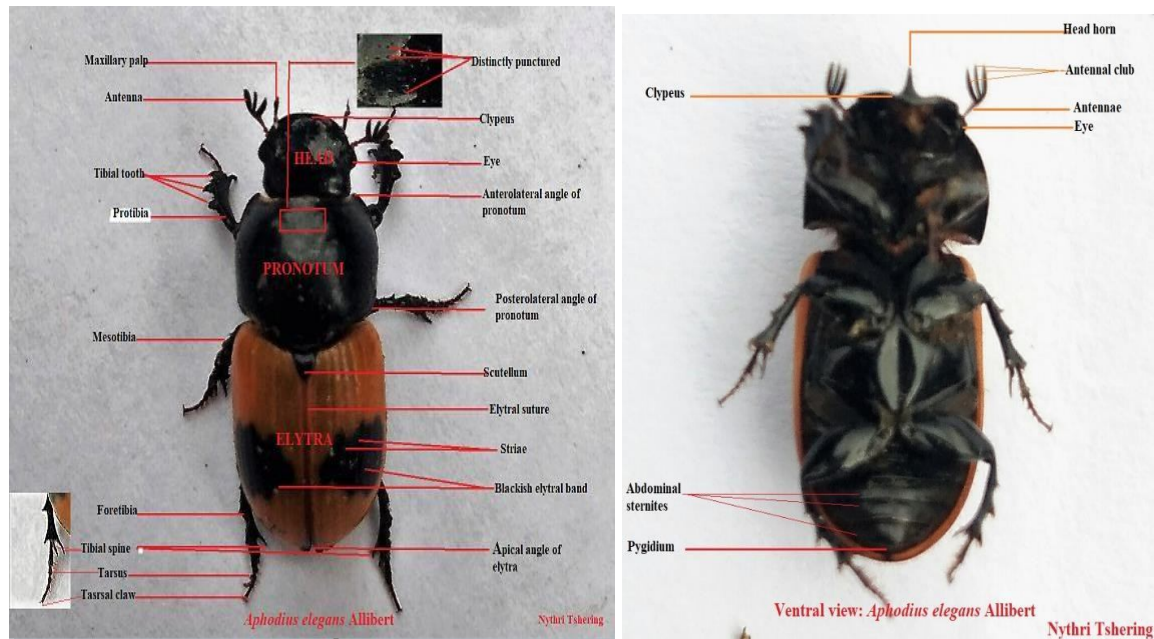


Figure 2: Morphological Feature of *Aphodiuselegans*Allibert.

d. Behaviors of *Aphodiuselegans*Allibert

i. Dung pat hunting behavior:

Adult beetles locate food sources by smell and detect it during flight using antennae. They eat in situ and may be transported for further consumption (Halffter & Edmonds, 1982). Adult *Aphodiuselegans* use antennae to locate dung pats and feed on liquid content (Finn & Gittings, 2003). Beetles actively move towards freshly scattered cow dung, occupying it on the second day of observation.

Aphodiuselegans migrate to new dung pats in summer, depending on weather and dung condition. Dormont et al., (2004), mentioned that different species have specific preferences of dung with dung condition and dung odor. *Aphodiuselegans* leave dung pats when it becomes hard and dry, leaving earlier inhabited ones 9 days after first observation. They rely on scattered dung for food.

ii. Dung excavation and shoveling behavior:

Adult dung beetles orient themselves towards the dung surface, quickly burying themselves under it. They prefer the fresh or soft part of the dung for their burial. They use antennae to detect food sources and examine the dung pat for entrance (Finn & Gittings, 2003). Beetles set their antennae in motion and explore dung pats, examining fresh and semisolid parts for entrance. Their morphological adaptive features aid in their successful habitation.

The *Aphodiuselegans* dung beetle buries its clypeus and head under the dung pat using protibial and mesotibial muscles. Its protibia, mesotibia, and metatibia help it enter the dung pat, clearing the path and propelling the body forward. The beetle's excavation and movement resemble boats propelled by oars, with each leg having an appendage for shoveling dung and earth. The dung beetle's legs are adapted for digging (Kerbtier, 2007).

iii. **Hibernating behavior:**

According to Yoshida & Katakura, (1985) and Finn & Gittings, (2003), Adult *Aphodiuselegans* are observed twice a year, in spring and autumn. The first flight occurs in July, with abundant synchrony, and the second flight occurs in September to October, containing mature eggs (Yoshida & Katakura, 1985).

Aphodiuselegans excavate chambers under dung pats to feed on liquid content. They retract their appendages and live motionlessly, storing energy and preventing cold. Adult dwellers are found in moist droppings and drying dung larvae. Beetles hibernate as mature larvae concentrating in early mornings and cold weather (Yoshida & Katakura, 1985).

iv. **Feeding behavior:**

Beetles scramble and consume dung, primarily derived from microorganisms. Their mouth part is well adapted for handling soft, pasty food dung (Miller, 1961; Hata & Edmonds, 1983). According to Hata & Edmond, (1983), mandibles in *Aphodiuselegans* grind particulates, while molae functions as a pestle mortar system. These actions are observed in adult *Aphodiuselegans* through the grinding and squeezing action of the dung beetle.

Aphodiuselegans beetles have a distinct maxillary palp for food scrapping, but prefer moist, fresh dung pats (Finn & Gittings, 2003), resulting in a "dung slurpie" feeding habits (Hanski & Cambefort 1991) making them scrapper and filter feeders.

v. **Defecating Behavior:**

The *Aphodiuselegans* dung beetle excretes waste and feces in its habitat, but their actions are unclear. They defecate while feeding on the dung pat, leaving dung traces of their movements on white paper. The dung beetle's path is marked with ink patterns of semi solid feces, turning the dung into fine soil.

vi. **Defensive behavior; the death mimic**

Aphodiuselegans beetles in open spaces orient towards dung and find hiding places to avoid danger. Touching their bodies retracts appendages and mimics death. Quick burial under dung prevents predation and environmental effects. Leg spurs and strong appendages aid fighting and digging. They prefer dark, shaded areas for quick burial under dung pats. They quickly reposition their bodies during sunny days to avoid danger and find fresh dung pats for burial.

vii. **Body repositioning and flight start behavior:**

Adult *Aphodiuselegans* use their tibia and appendages to regain their normal walking position when upside down or accidentally fallen from a dung pat. Their strong specialized tibia helps them attach to the ground surface.

Beetles attempt to reposition their body after initial failures using elytra and hindwings. The elytra, a hardened structure, uplifts the thorax and abdomen while pushing the head towards

the ground (Westheim et al., 2012). The fore tibia is stretched forward to hold onto supports, and the behavior is repeated at regular intervals until they succeed.

viii. **Flight behavior:**

Aphodiuselegans beetles are primarily observed during bright sunlight or warm weather, exhibit active flight behavior. Beetles hold out the forewing elytra and hindwing, generating lift (Westheim et al., 2012) and use the hindwing for rigorous flapping.

Conclusion

Dung beetles, coprophagous insects, exhibit fascinating behaviors. However, early studies had focused mostly on dung roller and tunneler beetles, and endocoprid dweller dung beetles require more focus. Thus, *Aphodiuselegans*, endocoprid dung beetles, are used for behavioral studies in the Bundeling region.

The adult beetle prefers moist, fresh dung pats for habitat. When near these pats, it sets its antennae to search for food. The adult *Aphodiuselegans* directs its body towards the dung, shoveling and burial. The protibia assists in quick burial, while the mesotibia and metatibia push the body forward, similar to a boat propelled by oars.

They use their specialized mouth to scrape and filter dung, using excretion to convert dung into fertile soil. They use defensive mechanisms like death mimics and retracting appendages under the hard elytra. Their elytra is used for repositioning and launching flight, with the tibia retracting to avoid sunlight and the strong outlet generating body lift.

Aphodiuselegans are active during warm weather, with their diversity varying with the season. However, extensive study on mating, competition, and lifecycle of these beetles is limited due to lack of tools for detailed anatomical studies and behavior analysis. The portrayal of other fascinating behaviors may be hindered by disturbances in their activity and habitat.

Further research is needed to understand mating, competition, and warfare battles among beetles. Studying feeding and flying behaviors of *Aphodiuselegans* is essential. Observing the dung beetle's behaviors twice a year, in spring and autumn, can provide insights into their hunting, excavation, shoveling, feeding habits, and flight techniques and bright sunny days are ideal for studying these fascinating behaviors.

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