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## Dung inhabiting insects, their diversity, abundance and bio ecology of coprine beetles

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### Abstract

The insects most prominently colonized in a nutrient-rich fresh dung habitat are mainly beetles and flies and the group is termed collectively, the dung community. Coprophagous insects play an important role in tropical ecosystems by providing essential functions including mechanically breaking down excrement into smaller-sized particles, mixing of organic matter in the soil, soil aeration, nutrient cycling and to remove unhealthy materials from their surroundings. Against this backdrop, present study is an attempt to assess the insect diversity and abundance inhabiting dairy farm dung community in North & South 24 Parganas, West Bengal along with the study on the life cycle pattern of frequently encountered dung beetle taxa, *Oniticellus cinctus* (Fabricius) and to observe their role in the decomposition. Altogether 2 dung beetles, 4 dung loving beetles, 8 dung loving flies, 17 dung associated insects of different groups, one mesostigmatic mite species are recorded from cow and buffalo dung community during the study period. December is the period of maximum dung beetle abundance. Beetle activity gets greatly diminished with the rise of temperature above 30 °C. The brood ball made by the functional group 'Dwellers' is for oviposition. The brood balls provide the immatures with an assured food supply. Egg to adult developmental period ranges between 43-51 days. The teneral adult period observed under laboratory conditions is 2-3 days. Our findings show that extensive management practices result in more pats with higher insect abundances. Data proves that the members of these two orders, Coleoptera and Diptera are almost perfectly separated seasonally. Flies are most abundant in the premonsoon while beetles during monsoon and postmonsoon. Season is therefore the main temporal axis separating ecologically similar species of dung-inhabiting insects in tropical habitats, while succession aggregates species that may have similar environmental tolerances. This separation between ecologically similar taxa of beetles and flies may be attributable to either competition-based niche segregation or to temperature tolerance-based habitat filtering.

**Keywords:** Insect, diversity, abundance, dung community, dung beetle, *Oniticellus cinctus* (Fabricius), bio-ecology, West Bengal

### Introduction

Dung is a tidy word for an untidy substance-bovine animal poop or droppings or waste, a cheap and easily available bioresource on our planet [1]. Fresh dung is a nutrient-rich habitat that is quickly colonized by species and abundant assemblage of a large community of organisms and an arthropod community [2, 3]. Dung represents the end product of the animal's digestive process, containing a number of chemical, microbial and biotic materials. Manure is influenced both by the individual animal and by the nature of the consumed plant material [4]. It contains about 0.8% K, 0.4% Na, 2.4% Ca, 0.7% P, and 0.8% Mg [5]. Levels of nitrogen in dung DW (dry weight) range from 2.5 to 4.0% [6] which is comparable to that reported for many species of plants [7]. Unlike the nitrogen in plants, however, much of the nitrogen in dung is in the form of bacteria, which may comprise 10–20% of dung DW (dry weight) [5]. Other organisms present in dung at the time of its deposition may include protozoa, parasitic nematodes, trematodes (flukes) and cestodes (tapeworms). Dung usually appears as dark brown, often used as manure, an organic fertilizer in agriculture. It is used as compost, an organic matter that is decomposed in a process called composting. Compost can be used as an additive to soil, supplying humus and nutrients. Another use of dung is as fertilizer in agricultural field. Dry dung is used as fuel source, though using this kind of fuel increases air pollution. Dung is often used as power and electricity. It is supposed to be the source of biogas (rich in methane) to generate a renewable and stable source of electricity and heat.

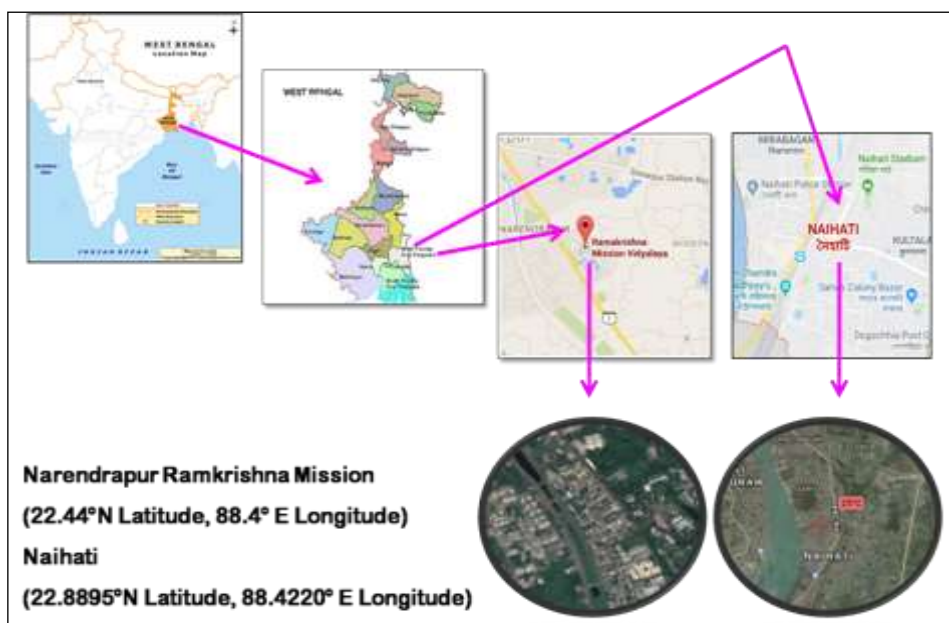
Nowadays, there is an increasing research interest in developing the applications of cow dung microorganisms for biofuel production and management of environmental pollutants [1]. Specially cow dung is a useful building material, a raw material for paper making, and an insect repellent [1]. Among the major hexapod groups (wingless arthropods and insects) involved in decomposition are springtails (Collembola), beetles (especially Scarabaeidae, Geotrupidae, Silphidae), and fly larvae (especially Calliphoridae, Sarcophagidae, Muscidae, and Fanniidae) [3]. Coprophilous (dung-loving) organisms include insects that use dung as their food source and breeding habitat [3]. A succession of insect species can be found in dung, from those that have adapted to very fresh dung, which arrive within seconds of a new dropping, to those which are more adapted to drier dung and arrive several days later. Above text raises several questions to hover around:

- 1) What are the community component with special reference to coprine fauna in fresh dung pats that are largely used as compost in Bengal?
- 2) The trophic relationships between the components?
- 3) Is there any seasonality in their abundance?
- 4) The biological traits of the coprine/s in particular?
- 5) Should they be encouraged in the preparation of compost?

Our attempt to unearth the story behind during the period August, 2018 to March, 2020 is presented in the following section, with the hope to share some more in the future days.

**Study area (Fig. 1)**

Survey was conducted once in a week since August, 2018-till 2<sup>nd</sup> week of March, 2020 in the Dairy Farm of Ramakrishna Mission Ashrama Campus, Narendrapur, South 24 Parganas & Naihati, North 24 Parganas, West Bengal.



**Fig 1:** Study Area



**Fig 2:** Study Sites

**Materials & methods**

Samplings were done by pit fall trap and hand picking

methods (Figs. 3A & B). Live forms encountered were killed and preserved in 70% alcohol as per existing recommendation

[8]. Necessary data regarding date of collection, no. of individuals, etc. were noted in a notebook in the field. The samples were then brought to the laboratory where stretching, pinning and labeling were done as per available guidelines [8]. The materials were studied using Stereo Zoom Binocular Microscope, model Olympus SZX-16. The measurements were in millimeters, made with an eye piece graticule. Specimens were identified following the available literatures [8, 9, 10, 11]. Materials are in the deposition of Post Graduate Department of Zoology, Barasat Government College,

Barasat, Kolkata. Most frequently encountered dung beetles were maintained under laboratory condition in convenient size earthen pots for recording the life stages (Fig. 4). Fresh dung as the required habitat were provided. Mouths of the earthen pots were covered with dark cloth in order to maintain darkness and prevent the escape of the beetles from the pots. The earthen pots were maintained at laboratory temperature from 22 °C to 25 °C. The beetles were regularly observed within the pots. All the experiments were carried out in three replicates.



**Fig 3A:** Field Work



**Fig 3B:** Dung beetles, brood balls & grub found within dung during sampling



**Fig 4:** Covered Earthen Pot

## Results & Discussion

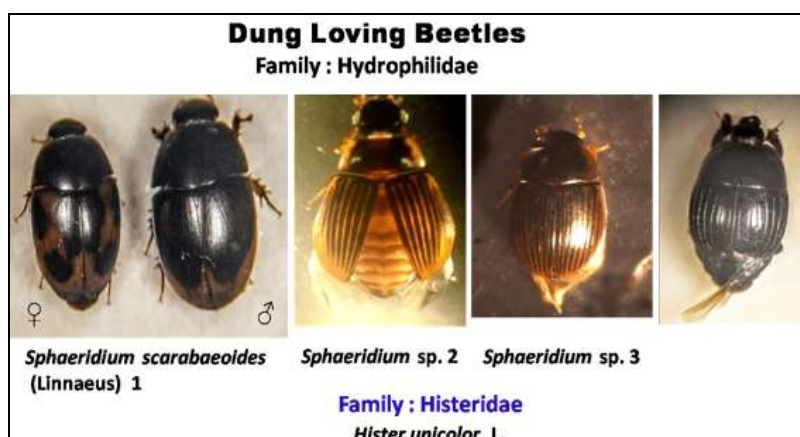
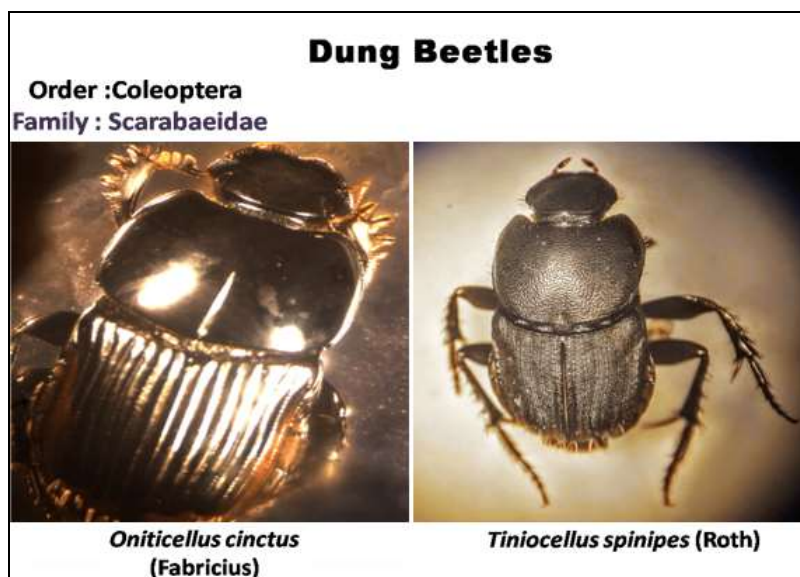
Many animals and plants perform a vital role in the nutrient cycle of pastures, particularly assisting in the conversion of the animal dung into humus. The organisms featuring most prominently in this role are insects, mainly beetles and flies and the group is termed collectively, the dung community. Dung-consuming insects play an important role in tropical ecosystems by providing important functions including mechanically breaking down excrement into smaller-sized particles, mixing of organic matter in the soil, soil aeration and nutrient cycling. They also serve to remove unhealthy materials from their surroundings<sup>[3]</sup>. Altogether two (2) dung beetles, four (4) dung loving beetles, eight (8) dung loving flies, 17 dung associated insects of different groups, one mesostigmatic mite species are recorded from cow and buffalo dung community during the study period (Table 1; Fig. 5). The findings are in conformity with the works done elsewhere<sup>[2, 12, 13, 14]</sup>. Narendrapur cattle farm and buffalo farm of Naihati are now known to accommodate two (2) coprine beetles, namely *Oniticellus cinctus* (Fabricius) and *Tiniocellus spinipes* (Roth)<sup>[15]</sup>. Scanning of habitat reveals that the dung beetle species belong to the functional group 'Dwellers' as the individuals make nest on the upper surface of heap of dung. The brood ball made by them is for oviposition. The diameter of brood ball ranges between 15-17 mm and depth 9-10 mm (Table 3). In the present investigation this beetle shows four (4) larval instars (Fig.7). The life stages passes through the brood balls, constructed by the parents. The brood balls provide the immature stages with an assured food supply and also provides other favourable conditions. The life cycle period indicates that egg to adult developmental period ranges between 43-51 days. The teneral adult period observed under laboratory conditions is 2-3 days (Table 2). The results are in conformity with the earlier works done<sup>[16]</sup>. However it is difficult to note the adult longevity as the individuals remain within the dung. The dark habitat is the constraint for recording the longevity. When dung is freely exposed to dung beetles, the dung weight decreases rapidly during the first seven days in all dung samples. On the seventh day, several holes on the surface of dung and buried brood balls in the soil are observed. When dung is freely

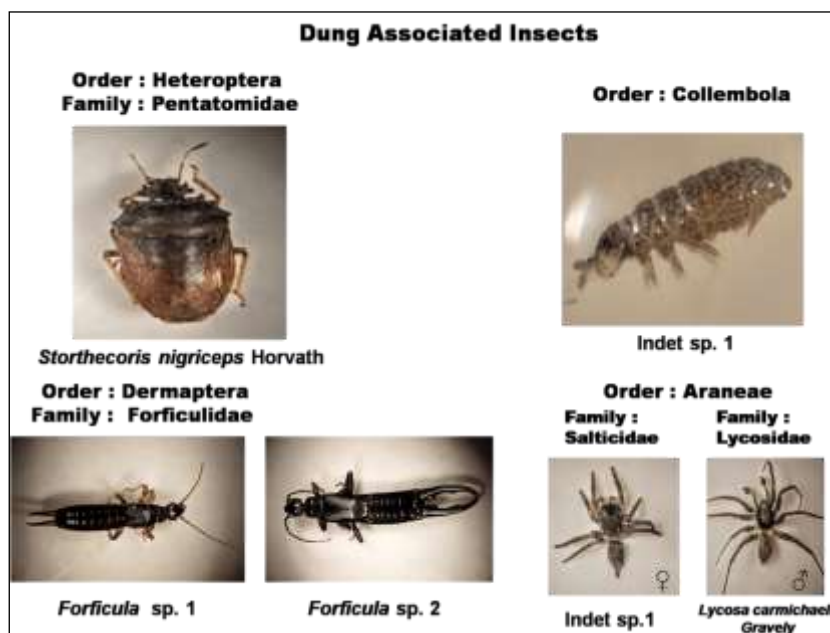
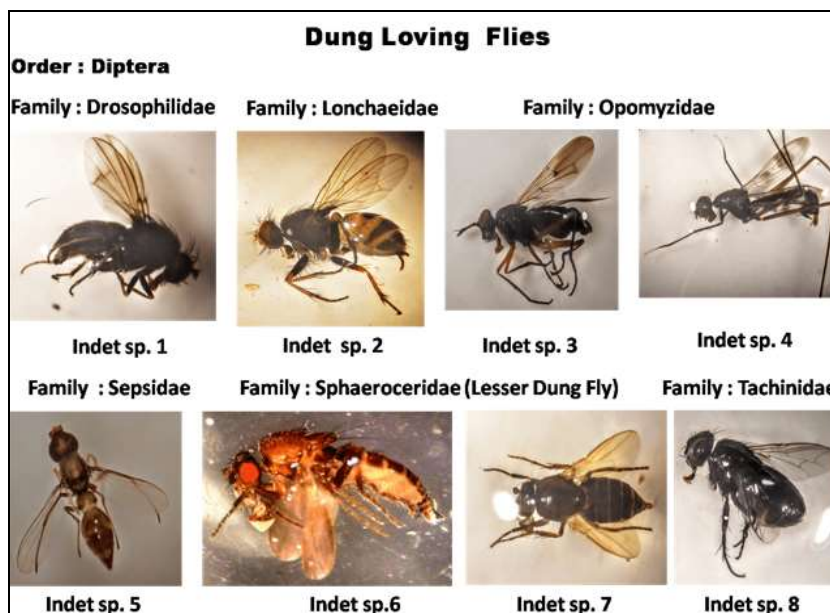
exposed to dung beetles 75% of the organic matter is found to be removed<sup>[17]</sup>. It is observed that in these study sites, dung beetles prove to be effective in the removal of dung from the habitats thus preventing the colonization of flies, maggots etc.<sup>[17]</sup>. A total of 1650 insect individuals are sampled from cattle farms throughout the period of survey. Of these 12.55% are dung beetles. Of these 86.47% are female morphs. They especially help manure recycling, fertilize soil, aerate soil, prepare land for grass to grow, control flies, disease, parasites, etc. Based on the number of individuals sampled, the period of maximum beetle population occurs from late September through late January. Very little numbers are found between April-July. December is found to be the period of maximum abundance of dung beetles (Fig.6A & B). Beetle activity gets greatly diminished with the rise of temperature above 30°C (Fig. 6A & B). More no. of dung beetles are encountered in Narendrapur Dairy Farm (98.07%), where dung are wet in nature. We guess some dung beetle species are dung specific. Future attempts are to be made so as to unfold the fact. Our findings show that intensive farming management has negative consequences for the insect abundance in cow/buffalo dung pats and that extensive management practices result in more pats with higher insect abundances<sup>[14]</sup>. Dung communities are assembled either through the biotic interactions of ecologically similar species, e.g. competition (Fig. 8), or by the abiotic separation of species along gradients of environmental conditions. Coprophilous adult and larval beetles compete with dung inhabiting dipteran larvae for food, whereas the larvae of hydrophilid beetles are important predators on dipteran larvae<sup>[18, 19, 20, 21]</sup>. Both competition and predation by coprophilous beetles reduce the fitness of many pest species that develop within dung<sup>[22, 23, 24]</sup>. Here, we have investigated the temporal segregation, succession and seasonality of dung-inhabiting Coleoptera and Diptera that utilize an identical resource in exactly the same way. Data proves that the members of these two orders are almost perfectly separated seasonally. Flies are most abundant in the premonsoon while beetles in the monsoon and postmonsoon. So, ecologically similar beetles and flies also display seasonal separation. Season is therefore the main temporal axis separating ecologically similar species of dung-inhabiting insects in tropical habitats, while succession aggregates species that may have similar environmental tolerances (e.g. dung moisture). This separation between ecologically similar taxa of beetles and flies may be attributable to either competition-based niche separation or to temperature tolerance-based habitat filtering, since flies have peak activity in warmer months while beetles have peak activity in cooler months<sup>[25]</sup>. Many groups of predatory mites have also evolved a specialised habitat association with mammalian dung. Because of the temporal and spatial isolated nature of dung pads, these mites often disperse by phoresy on coprophilous insects that have similar habitat requirements<sup>[26, 27]</sup>.

**Table 1:** Arthropod Species Encountered In Different Dung Communities

Sl. No.	Name of Species	Insects Encountered During Survey		State of Dung
		In Cow Dung	In Buffalo Dung	Wet/Dry
<b>A. Dung beetle</b>				
1.	<i>Oniticellus cinctus</i> (Fabricius)	√	√	W
2.	<i>Tiniocellus spinipes</i> (Roth)	x	√	D
<b>B. Dung loving insects</b>				
3.	<i>Sphaeridium scarabaeoides</i> (L.)	√	√	W + D
4.	<i>Sphaeridium</i> sp. 2	√	√	W + D

5.	<i>Sphaeridium</i> sp. 3	√	√	W + D
6.	Clown Beetle [ <i>Hister unicolor</i> L.]	x	√	D
7.	Fruit Fly: Drosophilidae: Indet sp.1	√	x	W
8.	Dung Loving Fly: Lonchaeidae: Indet sp. 2	√	√	W + D
9.	Dipteran Fly: Opomyzidae: Indet sp. 3	√	√	W + D
10.	Dipteran Fly: Opomyzidae: Indet sp. 4	x	√	D
11.	Dipteran Scavenger Fly: Sepsidae: Indet sp. 5	√	√	W + D
12.	Lesser Dung Fly: Sphaeroceridae: Indet sp. 6	√	√	W + D
13.	Lesser Dung Fly: Sphaeroceridae: Indet sp. 7	x	√	D
14.	Dipteran Fly: Tachinidae: Indet sp. 8	x	√	D
<b>C. Insects associated with dung</b>				
15.	Ground Beetle [ <i>Nebria</i> sp.]	√	√	W + D
16.	Ground Beetle [ <i>Dromius</i> sp.]	√	√	W + D
17.	Darkling Beetle [ <i>Gonocephalum tuberculatum</i> Hope]	x	√	D
18.	Scarab Beetle [ <i>Aphodius prodromus</i> (Brahm)]	√	x	W
19.	Staphylinid Beetle [ <i>Paederus riparius</i> (Linnaeus)]	√	√	W + D
20.	Ant [ <i>Camponotus (Tanymyrmex) compressus</i> (F.)]	√	√	W + D
21.	Ant [ <i>Crematogaster (Acrocoelia) hodgsoni</i> Forel]	√	√	W + D
22.	Ant [ <i>Diacamma scalpratum</i> (Smith)]	√	√	W + D
23.	Ant [ <i>Myrmecaria brunnea</i> Saunders]	√	√	W + D
24.	Ant [ <i>Pheidole (Pheidole) nietheri</i> Emery]	√	√	W + D
25.	Ant [ <i>Vollenhovia oblonga</i> (Smith)]	√	x	W
26.	Stink Bug [ <i>Storthechoris nigriceps</i> Horvath]	x	√	D
27.	Springtail (Indet sp. 1)	x	√	D
28.	Earwig [ <i>Forficula</i> sp. 1]	√	√	W + D
29.	Earwig [ <i>Forficula</i> sp. 2]	√	√	W + D
30.	Spider: Salticidae (Indet sp. 1)	x	√	D
31.	Spider: Lycosidae [ <i>Lycosa carmichaeli</i> Gravely]	√	√	W + D
<b>D. Mites associated with dung beetles &amp; dung loving beetles</b>				
32.	<i>Glyphtholaspis</i> sp.	√	x	W + D





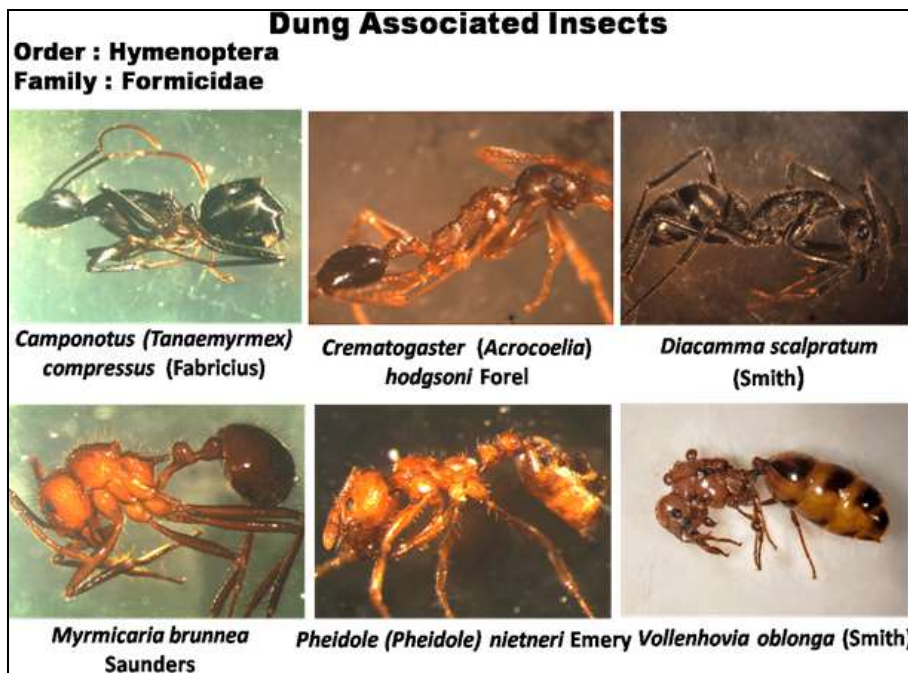


Fig 5: Insect species encountered during survey

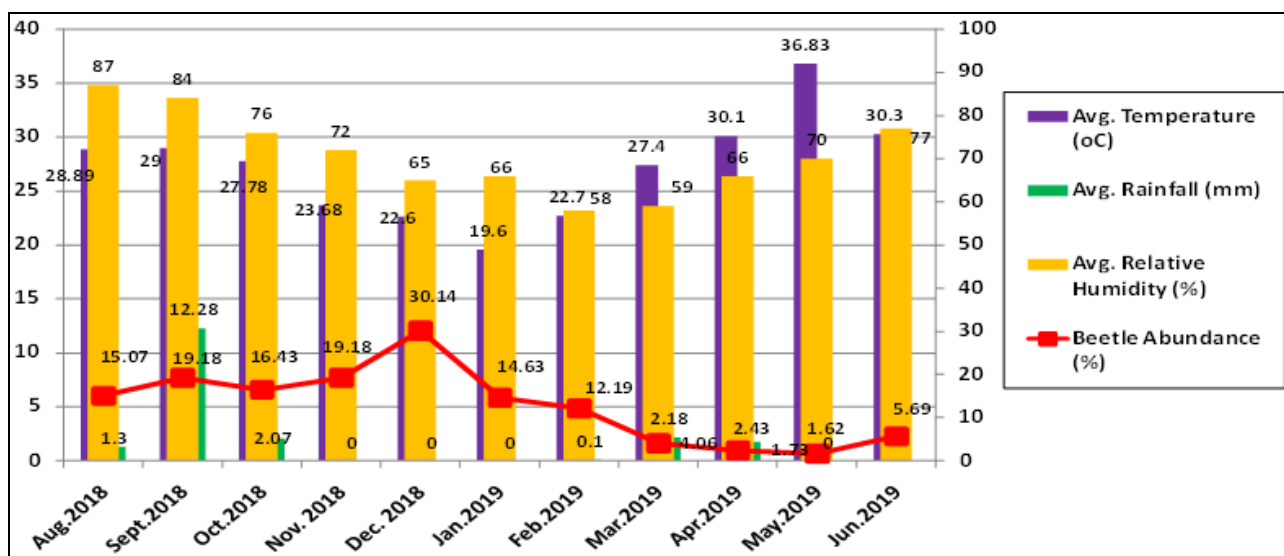
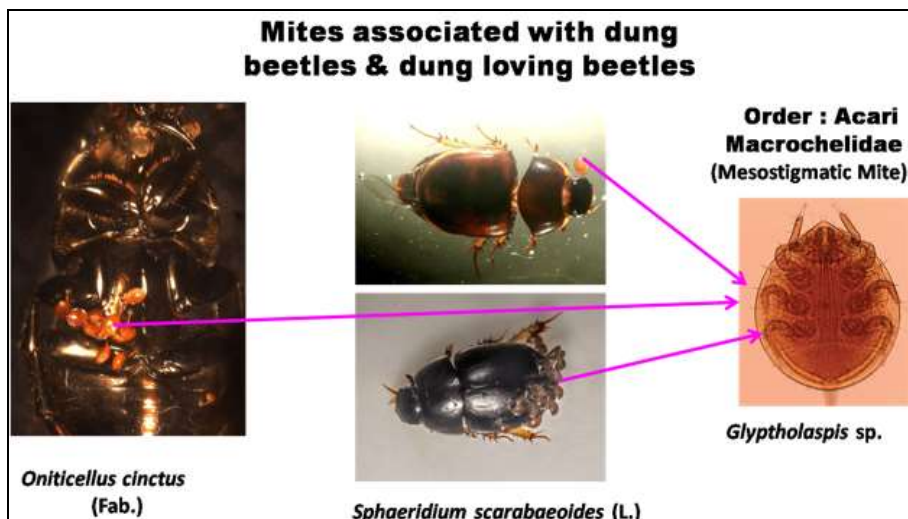


Fig 6A

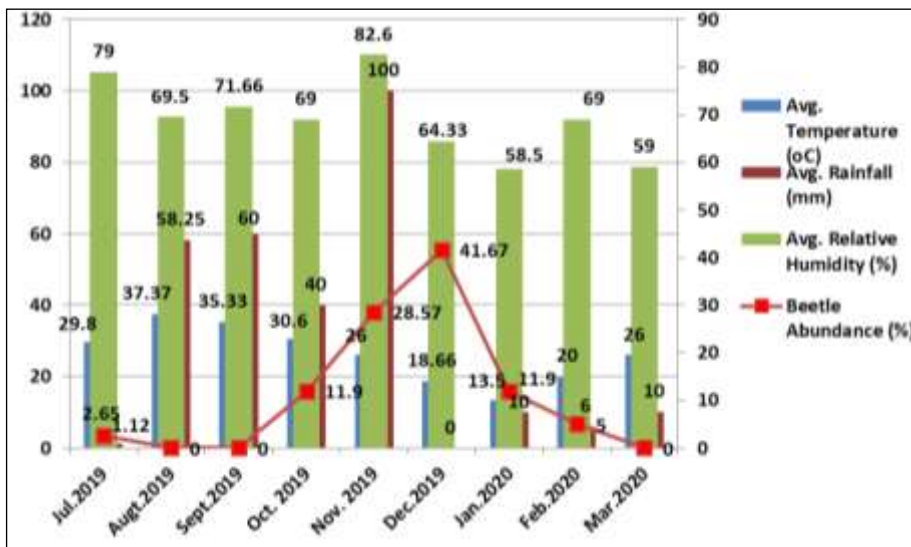


Fig 6B

Figs 6(A-B): Showing the relationship between dung beetle abundance (%) & abiotic factors



Fig 7: Life stages of dung beetle, *Oniticellus cinctus* (Fabricius)

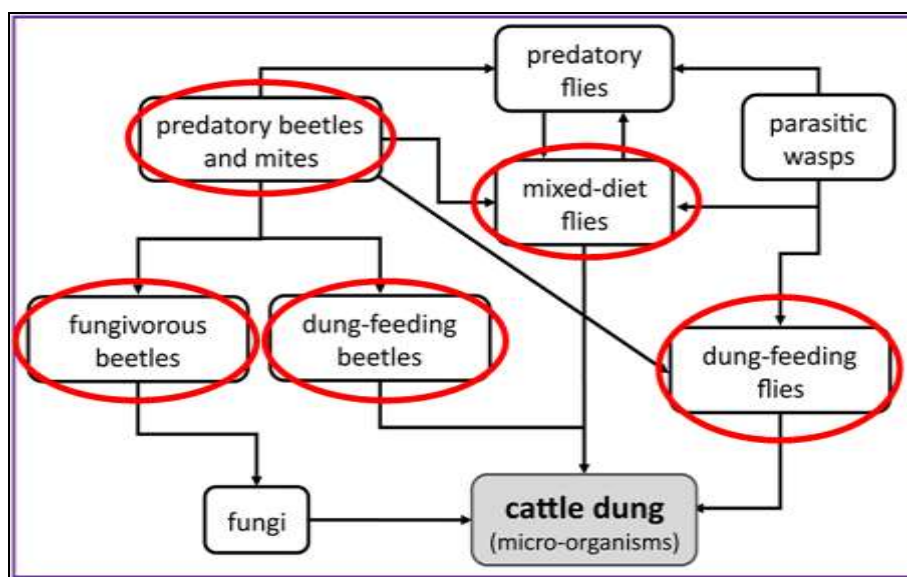
Table 2: Measurements of different life stages and brood ball

STAGES		RANGE (Length/Diameter in mm)	MEAN ± S.D	RANGE (Width/Depth in mm)	MEAN ± S.D
Egg		1.6-1.7	1.65 ± 0.05	0.1-0.8	0.73 ± 0.04
1st Instar Larva		10.8-11	10.9 ± 0.1	4.4-4.6	4.53 ± 0.36
2nd Instar Larva		16-16.1	16.03 ± 0.06	6.1-6.3	4.53 ± 0.19
3rd Instar Larva		19-19.8	19.43 ± 0.40	7.0-7.1	7.1 ± 0.1
4th Instar Larva		20.2-21.2	20.3 ± 0.85	7.5-7.6	7.53 ± 0.06
Pupa		8-8.1	8.06 ± 0.05	5.0-5.2	5.13 ± 0.11
Adult	Male	9-9.2	9.06 ± 0.05	4.5-5.0	4.9 ± 0.94
	Female	8.15-8.16	8.15 ± 0.05	4.3-5.0	4.3 ± 0.92
Brood Ball		15-17	15.66 ± 1.14	9-10	11 ± 0.1



**Table 3:** The development period for verious stages of life cycle of *Oniticellus cinctus* (Fabricius)

STAGE	NO.OF OBSERVATION	MINIMUM DAYS	MAXIMUM DAYS	MEAN $\pm$ S.D
Egg	3	2	4	3 $\pm$ 1.41
1st Instar Larva	3	3	5	4 $\pm$ 1.41
2nd Instar Larva	3	5	7	6 $\pm$ 1.41
3rd Instar Larva	3	6	8	7 $\pm$ 1.41
4th Instar Larva	3	15	17	16 $\pm$ 1.41
Pupa	3	12	14	13 $\pm$ 1.41
Adult Longevity	-----	-----	-----	-----
Egg to adult in brood ball	3	43	51	47 $\pm$ 2.82

**Fig 8:** Probable trophic relationship among the groups

### Conclusion

It would be interesting to expand this study to include the insect fauna in the dung of other animals in both natural and human altered (livestock farming) habitats, thereby applying this research to aspects such as dung beetles as bio-indicators for environmental risk assessment. In addition, monitoring of dung beetle insect habitat change, determining their suitability as a biological pest control agent and determining their chemical and physical impacts on the soil are potential areas for future research.

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