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The hidden story in our nature: Dung Beetles in Hong Kong

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Content

1. Abstract

Dung beetles are insects which belongs to the Order *Coleoptera*. Several key ecosystem functions are provided by the dung beetles in the subfamily *Scarabaeinae* due to their coprophagous feeding habit. Both the adult dung beetles and larvae are fed on animal excreta.

In this report, our objectives are to carry out a community survey on invertebrates including dung beetles on different conditions of bovine dungs and to study the efficiency of recycling the bovine dungs by dung beetles.

Bovine dung samples were collected from hiking track (natural habitat) and roadside near Cheung Sheung, Sai Kung. The invertebrates found in dungs were recorded and identified up to family level. Dung beetle collected were identified to genus level and the morphology and behaviour were observed and recorded. A set up on the efficiency of recycling the bovine dung by dung beetles were done by comparing the weight of dungs with and without dung beetle for 10 days.

It is found that total 9 species of invertebrate were found and the dung beetle identified was *Aphodius* sp. (蜉金龜). The bovine dungs collected from roadside were found to have more number of species present than that from natural habitat. Types of species present were also greater in roadside bovine dungs. Possible reason was the fresher dungs collected in roadside provide a richer nutritive content for colonization of more invertebrates. It is confirmed that with the presence of dung beetles, there would be significant drop (-13.1% of weight) in bovine dungs compare to the dung without any dung beetles (+2.75% of weight).

2. Introduction

2.1 Introduction to the research topic

Initially, our team strongly believed that bovine dungs are one of the most notorious matters in the world. Yet, inspired by our biology teachers, Mr. Tong and Mr. Lo, we were able to get known of the creatures inside the dungs and know the tacit contributions the creatures in dungs have served the nature in various means, including recycling the wastes. We eventually found that the community living in dungs is actually diverse. Thus, we developed curiosity in the roles of different organisms as we believed that the organisms in dungs are totally different compare to those living outside. Nutrients, odour and many other factors may contribute to the different living conditions. Consequently, our team decided to set up our studies about dungs. Moreover, we have also set to investigate on a specific and well-known species in the dungs - dung beetles, after knowing their reliance on dungs.

Later on, advised by our teachers, we have compared different dungs, to name a few would be the dungs of dogs, cows and humans. At last, we chose to investigate the communities in bovine dungs due to the comparatively and averagely larger sizes, which are believed to be a factor affecting the diversity of community inside dungs. Also, we believed that bovine would be generally closer to the nature habitat than the others and that bovine dungs could also be easily found. Moreover, it is found that in parts of Texas, dung beetles bury about 80 percent of cattle dung[1].In light of that, we focus our research on bovine

[1] National Geographic kids, last retrieved 23 Mar 2014, from http://kids.nationalgeographic.com/kids/animals/creaturefeature/dung-beetle/

dungs.

In our field trips to Cheung Sheung of the Sai Kung West Country Park in particular, we observed the surrounding environment of bovine dungs, so as the conditions and the community of dung beetles and other organisms living inside.

2.2 Objectives

1. To investigate the communities and distribution of invertebrates in the bovine dungs collected.
2. To study the efficiency of recycling the bovine dungs by the presence of dung beetles.

2.3 Research Questions

1. What groups of invertebrates are living inside bovine dungs?
2. How do locations and water content (freshness) of the bovine dungs affect the population of dung beetles?
3. Do the dung beetles prefer to live in cow dungs found in natural habitats or along the roadside?
4. Do dung beetles speed up the recycling process of the bovine dungs?

2.4 Background information of dung beetles

"Dung beetle" is a common name applied to beetles in the subfamilies *Scarabaeinae*, *Geotrupidae* and *Aphodiinae*. Species in these groups often have specific ecological requirements. For example, *Dialytes* spp. and *Aphotaenius carolinus* (Van Dyke) (both Aphodiinae) are specialists on deer dung. Some dung beetles, the so-called "tumble bugs" (e.g., *Canthon pilularius* (L.) [Scarabaeinae]), form a ball of dung and roll it away from potential competition at a dung pat. Other dung beetles make a ball of dung under the dung pile (e.g., *Copris fricator* (Fabr.), *Phanaeus vindex* (MacLeay),*Onthophagus hecate* (Panzer), *Onthophagus cribricollis* Horn [all Scarabaeinae]). Scarab beetles that live in the nests of vertebrates include:*Onthophagus polyphemi* Hubbard (*Scarabaeinae*) that lives in the nest of gophers in Florida; *Ataenius brevinotus* Chapin (Aphodiinae) that lives in the nest of fox squirrels in Florida, and; many species of *Aphodius* (Aphodiinae) that live in the nests of prairie dogs and pocket gophers. Although most dung beetles feed on dung, some, such as *Onthophagus striatulus*(Beauvois) [Scarabaeinae], defy their common name and feed on fungi.[2]

Fig. 1 Copris fricator (Fabr.)

Dung beetles could generally be divided into three basic groups: rollers, tunnelers, and dwellers[3]. The relationship between dungs and dung beetles is also fascinating. Rollers shape dungs into balls and would bury their balls for either later use or for building as a place to lay their eggs. For tunnelers, dungs are buried by tunneling underneath the pile; while dwellers live inside dung piles.

It should also be noted that dung beetles could feed on dungs because animals could not digest all parts of their meals. And the undigested part could therefore provide food for dung beetles. According to

[2] Generic Guide to New World Scarab Beetles, last retrieved 23 Mar 2014, from http://museum.unl.edu/research/entomology/Guide/Scarabaeoidea/Scarabaeidae/Scarabaeidae-pages/Scarabaeidae-Overview/ScarabaeidaeO.html

[3] National Geographic kids, last retrieved 23 Mar 2014, from http://kids.nationalgeographic.com/kids/animals/creaturefeature/dung-beetle/

the Arthropods in Cattle Dung on Canada's Grasslands by Kevin D. Floate, the food-intaking mode of adult scarabs and their larvae are totally different. Adult scarabs are filter-feeders (Holter *et al.* 2002) which obtain nutrition mainly by ingesting the microorganisms present in the fluid component (Aschenborn *et al.* 1989). In contrast, their larvae mostly feed on undigested plant fibre from which nutrients are extracted through the action of symbiotic cellulose-digesting bacteria housed in the larval hindgut (Terra 1990). Meanwhile, about the reproduction behaviour of dung beetles, some dung beetles lay their eggs in dung balls that they have rolled as mentioned. When the eggs hatch, the larvae use the dung ball as their source of food.Some could even bury 250 times the weight in dung, thus helping to avoid attractions to pests like flies, or helping new trees grow.

About the sizes of dung beetles, they ranges from a length of 1mm to 6 mm. The colour of them also depends greatly on the species they belong. Most dung beetles are dark coloured, while some others may be shiny metallic in colour or with bright patterns. Dung beetles have wings hidden under their hard covers.In Hong Kong, there are about 31 identified species of Scarabaeidae latestly reported by Aston & Yiu[4].

According to the Agriculture, Fisheries and Conservation Department, the number of stray cattle and buffalo is 1250 and 130 respectively[5]. In addition, Sai Kung is one of the places that accommodate a relatively large number of cattles[6]. Therefore, our group chose Sai Kung, which is accessible and has a large quantity of cows, as our site of collection. Moreover, as suggested by our expedition teacher Ms. Yung, and the observation of our teammates last year, cows are frequently found along the track selected, and that we were determined to be able to collect bovine dungs of different conditions. Meanwhile, the bovine dungs collected should be from stray cattle to a large extent as predicted.

Fig. 2 Aphodius sp.

3. Materials and methods

3.1 Collection of dungs

The bovine dungs were collected in Cheung Sheung, Sai Kung West Country Park (refer to the red circle in Fig. 3). A total of 9 dungs were collected in roadside while 11 dungs were collected in the natural habitat. Using the convenient sampling method, the collection has taken place for three times, in the morning of 16 February, 24 February and 8 March, 2014. When cow dungs were seen, photos were taken of its size and the surrounding environment. Lengths of the dungs were roughly estimated according to the shoe the same teammate. Time of collection was immediately marked down on the zip-lock bag, which the dungs were put into later on. The dungs were collected by gloved hands generally. For larger-sized cow dung pats, shovel was used in order to keep the whole dung for investigation. Individual zip-lock bags were used in view of hygiene and to minimize the external pollutant to the set-up. Cow dungs

[4] A Photographic Guide to Hong Kong Beetles, by Hong Kong Entomological Society, page 10, published in 2011
[5] Q and A on AFCD's Policy for Handling Stray Cattle and Buffalo, by the Agriculture, Fisheries and Conservation Department, last retrieved 26 Mar, from http://www.afcd.gov.hk/english/quarantine/QandA_for_handling_stray_cattle_and_buffalo.html
[6] 為搵食闖住宅區「牛魔王」出沒注意, by Daily News, last retrieved 26 Mar, from http://news.stheadline.com/dailynews/content_hk/2013/04/19/234497.asp

with several pats nearby were collected as one sample. Different freshness of dungs were collected so as to facilitate the study of the effect of condition of dungs to the population of dung beetles. Freshness of cow dung was estimated by the soft texture and the presence of water on the surface of the cow dungs.

Fig.3 Map of Cheung Sheung

3.2 Invertebrate community survey in bovine dung

The weights of dungs collected were measured using an electronic balance. The weights were then recorded. The organisms presented in the dungs were collected by forceps and brushes. Organisms including both dead and alive found were collected and put in petri dishes. Fungi and plants were not collected. The number of invertebrate present in each dung was counted and recorded. Photos were taken for later identification.

3.3 Recycling efficiency by dung beetle

One of the cow dung pat was divided into three pieces of roughly equal weights. Two of them were frozen for two days and the other one was left in room temperature. After being frozen for two days, the two pieces of dungs were put in room temperature to allow them to defreeze for 30 minutes. The three pieces of dungs were then put in a specially designed flower pot covered with 10cm potting soil. The set-up was placed in the biology laboratory. The three pieces of dungs were separated by cardboards. The design of the flower pot was shown in the following figure (fig.4).

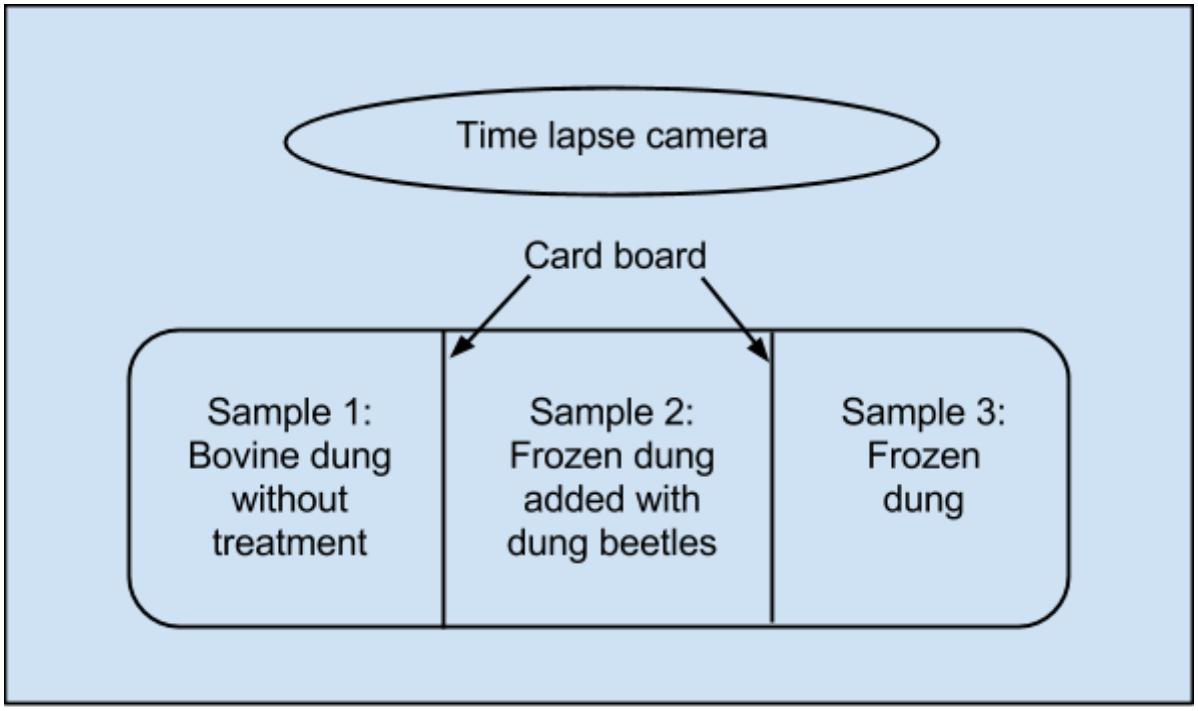


Fig. 4a Design of the flower pot

Fig. 4b The set-up in laboratory

Fig. 4c The set-up in laboratory

Twenty dung beetles were placed in one of the frozen dungs. The three dungs were then place in the flower pot and the appearances of the three dungs were monitored for 10 days using the time lapse camera. The three dungs were weighed again after 10 days. The recycling process carried out by dung beetles was determined by the change in appearances (e.g. size) and weights.

3.4 Working schedule

Date	Time	Venue	Event
16-2-2014	11:00-16:00	Cheung Sheung, Sai Kung	Collection of dungs
16-2-2014	16:30-18:30	Cheung Chuk Shan College	Analysis of communities of organism in bovine dung
24-2-2014	10:00-14:00	Cheung Sheung, Sai Kung	Collection of dungs
24-2-2014	15:00-18:30	Cheung Chuk Shan College	Analysis of invertebrate community survey in bovine dungs Placing treated dungs with dung beetles in soil
25-2-2014 to 14-3-2014	N/A	Cheung Chuk Shan College	Continuous observation of dungs remains
8-3-2104	09:00-14:00	Cheung Sheung, Sai Kung	Collection of dungs
8-3-2104	14:30-17:30	Cheung Chuk Shan College	Analysis of invertebrate community survey in bovine dungs
10-3-2014 to 20-3-2014	N/A	Cheung Chuk Shan College	Placing treated dungs with dung beetles in soil Continuous observation of dungs remains

4. Results

4.1 Dung beetle (*Aphodius sp.*) identified in cow dungs

Fig. 5 Dung beetle (dorsal view) (x50)

Fig. 6 Dung beetle (ventral view) (x50)

Fig. 7 Lavae

4.1.1 Identification of dung beetle collected and its Basic morphology

The dung beetles found were believed to be *Aphodius* sp. (蜉金龜) which belongs to the Family of Scarabaeidae (金龜科). By referring to Fig.5 & 6, features of the body could be seen. It has a shiny dark brown body. It gets reddish brown colour on its lateral wings, dorsal and ventral sides of the body and legs. Its tentacles are made up of 9 parts respectively, while its grill part is made up of 3 parts, which matches with the features listed out in authorities[7]. The beetles collected have a body length of about 7mm to 10mm. Little larvae of the beetles were also found and is shown in Fig.7. They are believed to feed on organic substances, for example animals' dung, for nutrition.

[7] A Photographic Guide to Hong Kong Beetles, by Hong Kong Entomological Society, published in 2011

4.1.2 Distribution and abundance of dung beetles

Most of them were found in fresher bovine dungs rather than dry dungs. All adult dung beetles were found in the dungs collected from the roadside. It is found that dung beetle larvae were more abundant in dungs (n=89) from roadside than from the natural habitats (n=35).

Fig. 8 Dung beetle being 'frightened'

4.1.3 Observable behaviour of dung beetles

It is discovered that when dung beetles were being 'frightened', they would hide and protect all their legs under hard elytras as shown in Fig.8. The membranous wings (alae) were folded for most of the time. Flying was uncommon during the observation. They were found to bury dungs down when they were put back to the dung surface. Fig.9 shows the situation when three dung beetles were hiding themselves by the dungs. When the dung beetles were put upside down as shown in Fig.6, and failed to return to right position, wings would be spread up as shown in Fig.10. With the help of their wings, they were able to turn over themselves as shown in Fig.11.

Fig. 9 Dung beetles putting back to fresh bovine dung

Fig. 10 Upside down dung beetle

Fig. 11 Dung beetle turning over itself

4.1.4 Phoretic mites on dung beetles

Phoretic mites were found on the dung beetle bodies. The mites were commonly found in many dung beetles as passengers without being a parasite. The relationship between mites and dung beetles was believed to be close. The mites would get on the dung beetle bodies which were ready to leave a local habitat. Dispersal of such mites would be achieved in this free ride.

Fig. 12 Phoretic mites on beetle

4.2 Invertebrate community survey on bovine dungs

Common name(order/family name)	Natural Habitat (n=11)	Roadside (n=9)
Dung beetle (Aphodiinae)	0	4
Dung beetle larvae	35	89
Millipedes (Diplopoda)	1	18
Woodlouse (Isopoda)	12	0
Ant (Formicidae)	1	1
Grasshopper (Orthoptera)	1	0
Centipedes (Chilopoda)	1	1
Earwig (Dermaptera)	1	0
Springtails(Collembola)	1	0
Spider(Araneae)	1	2
Total species found	54	115
Mean species per dung	4.91	12.7

Table. 1 Invertebrate community survey

Sample Habitat	Weight(g)	Length (cm)
Roadside 01	715.3	28.0
Roadside 02	396.5	20.1
Roadside 03	458.5	20.1
Roadside 04	175.2	14.2
Roadside 05	657.6	16.9
Roadside 06	1130.3	10.5
*Roadside 07	811.1	15, 7.5. 9
*Roadside 08	193.2	6.56, 10.3, 7.5, 6.56
*Roadside 09	289.4	5.54, 6.92
Total weight	4827.1	
Mean weight	536.3	

Sample Habitat	Weight(g)	Length (cm)
Natural Habitat 01	658.4	21.4
Natural Habitat 02	1059.5	31.4
Natural Habitat 03	526.2	20.9
Natural Habitat 04	805.2	28.5
Natural Habitat 05	1358.6	30.6
Natural Habitat 06	669.0	17.0
Natural Habitat 07	617.7	22.5
Natural Habitat 08	193.2	20.0, 8.55
Natural Habitat 09	347.4	20.9
*Natural Habitat 10	378.0	6.56, 10.3, 7.5, 6.56
*Natural Habitat 11	177.6	3.5, 2.8
Total weight	6790.8	
Mean weight	617.3	

*Multiple cowpats were collected and the lengths were measured separately

Table. 2 & 3 Weight of bovine dung collected

4.2.1 Photos of invertebrates found in bovine dung

Fig. 13 Dung beetle (Aphodinae)

Fig. 14 Dung beetle larvae

Fig. 15 Millipedes (Diplopoda)

Fig. 16 Woodlouse (Isopoda)

Fig. 17 Ant (Formicidae)

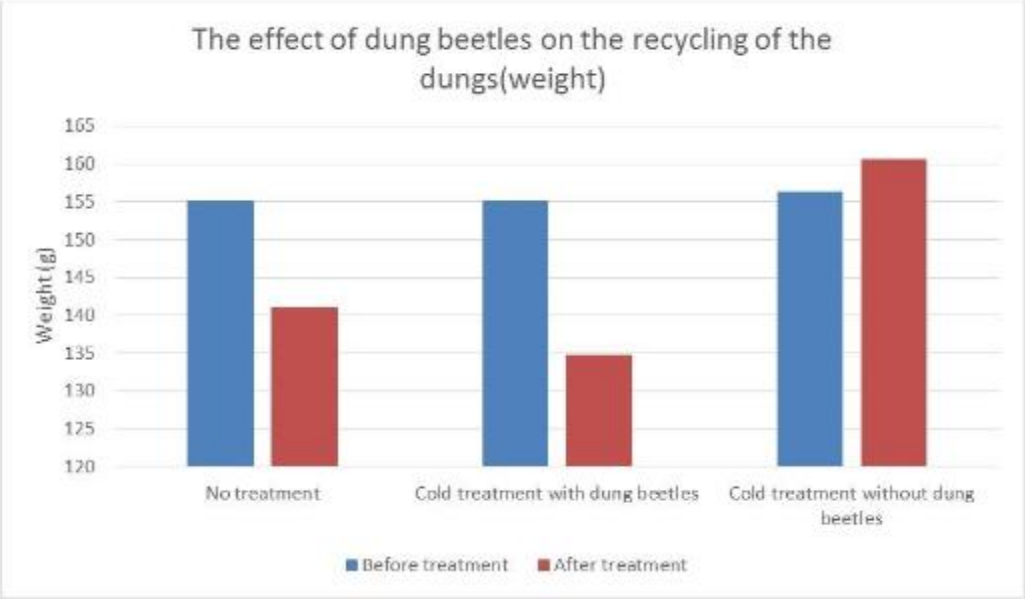
Fig. 18 Grasshopper (Orthoptera)

Fig. 19 Centipedes (Chilopoda)

Fig. 20 Earwig (Dermaptera)

Fig. 21 Springtails (Collembola)

4.3 The effect of dung beetle on decomposition of bovine dungs



	Sample 1 (No treatment)	Sample 2 (Cold treatment with dung beetles)	Sample 3 (Cold treatment without dung beetles)
Before treatment	155g	155g	156g
After treatment	141g	135g	161g
% change in weight	-9.15	-13.1	+2.75

Table. 4 The effect of dung beetles on recycling of dungs

	Decomposition rate (g/ day) *	Decomposition Percentage (%/day)#
Set-up 1	1.4	0.9
Set-up 2	2.0	1.3
Set-up 3	-0.5	-0.3

* Calculated by the formula: Decrease in weight ÷ Total day carrying out experiment
\# Calculated by the formula: Percentage Decrease of weight ÷ Total day carring out experiment

Table.5 Showing the decomposition rate of bovine dung per day

5. Discussion

5.1 Communities of invertebrates

When comparing the bovine dungs collected from the roadside with those from the natural habitats, it is found that more species could be found in the former environment. As most of the bovine dungs collected from the roadside were fresher and it is believed that fresher bovine dungs contain a higher water content and minerals content (Lee and Wall 2006). Therefore it could provide the organisms with more nutrients. Thus, the species could have a higher survival chance. And for those found from the natural habitats, they were much drier, which means that they might be older dungs. It is predicted that those invertebrates might have left the dungs and find for other richer in content. Species of narrower scope thus resulted.

According to Floate, K. D., there would be succession of invertebrate colonization according to the age of cow dung. The aged dung will have less chance to have dung beetles as dung beetles would usually be the second colonist after flies. Besides, other invertebrates visit or colonize the dung later the stage of decomposition. This shows the reason why fewer dung beetles could be found in aged dungs which were found in the natural habitats while dung beetles could be found in those along collected along the roadside, as they are fresher than the ones in the natural habitat. Additionally, the number of other invertebrates found in aged dung is comparatively small and does not include a wide variety of species. This is believed as stated above that aged dung has a relatively low water content and minerals content which cannot sustain the life of organisms, resulted in small amount of species found.

5.2 Efficiency of recycling of bovine dung

From the above results, we could see that the decomposition work of dung beetles is significant. The higher rate of decomposition can be observed from the bovine dungs with dung beetles whereas in the other set-ups without dung beetles, a lower rate of decomposition or even an increase of weight is observed. In set-up 1, which was not dealt with cold treatment or the presence of dung beetles, the weight had decreased by 9.15% within ten days. Its weight had dropped by 14 g. With the presence of dung beetles, the decomposition rate of bovine dungs in set-up 2, which was dealt with cold treatment, was higher. The weight of bovine dungs in set-up 2 have a percentage decrease of 13.1% and has a decrease of 20 g. While in set-up 3, the control set-up, the weight of bovine dungs has an increase of 5 g. It has a percentage increase of 2.75%.

Table.5 shows clearly the decomposition rate per day of bovine dung in each set-up. Set-up 2 had the highest rate of decomposition per day (2.0 g/day) and this proves that dung beetles have the ability of decomposing bovine dungs in terms of weight.

In the meantime, the appearances of the bovine dungs have no significant changes compared to their changes in weights. This shows that the changes or decomposition effect is internal and microscopic. The dung beetles discovered belongs to be dweller and they live inside dung piles and carry out decomposition work. Therefore, it's believed that the high decomposition rate of bovine dung in set-up 2 is due to the presence of *Aphodius* sp.

Interestingly, the weight of set-up 1 also decreases even without presence of dung beetles. This can be explained by the existence of microorganisms or other small invertebrates in the fresh bovine dung. A

fresh bovine dung contains water, undigested material, microorganisms and their by-product[8] , this suggests that microorganisms may assists the decomposition work. In fact, bovine dung are decomposed by insects, microorganisms and rainstorms. Normally, in a complete bovine dung, 13% of the content is decomposed by insects (mainly dung beetles) and rest of them is taken by microorganisms and rainstorms[9]. Therefore, the decrease in weight in set-up 1 may be due to the presence of organisms besides dung beetles.

The weight of set-up 3 has increased after 10 days for unknown reasons. Due to the limitation of resources, further study on the reason could not be conducted. The increase may be attributed to the measuring errors or invaders (small invertebrates) that present in the flower pot originally.

At the end of the experiment, bovine dung in set-up 2 is hard and dry. The dung beetles in set-up 2 are believed to have left the bovine dung as the water content and mineral content as aforementioned are declining and thus no longer capable to support their lives.

5.3 Limitations

5.3.1 Sampling Limitation

With the lack of human resources, the sampling size is limited.

As only three field trips had been carried out in order to collect bovine dung, weather conditions could not be controlled. During some of the field trips, poor weather conditions limits the sample dung we could be collected as cattle are not likely to be wandering around and thus fresher bovine dung could not be collected. This limits the available samples for investigation and experiment. The small sampling size results in a low reliability of this investigation and experiment. Therefore, invertebrate community survey will become incomplete and unrepresentative.

5.3.2 Experiment Limitation

Limitations can also be identified from the set-up for investigating the decomposition rate due to the work of dung beetles. As the three set-ups were placed into a same flowerpot, the dung beetles in the second portion (set-up 2) might have ‘escaped’ to the set-up besides through the bottom edges. Still, with lots of effort, for example obstructing the possible pathways by cardboard, had been done to avoid similar situation to occur, in order to reduce the probability of escaping of dung beetles. The escape of dung beetles to other set-up might lead to accidentally higher rate of decomposition of the other set-ups and a decrease in rate of decomposition in the experimental set-up. This limit will result in the error of final weight and thus affect the determination of the final decomposition rate of specific dung.

The freezing of bovine dungs was assumed to have killed all possible living organisms and thus frozen dung for set-up 2 and set-up 3 had not be double checked for any other existing invertebrates after the refrigeration.

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[8] Arthropods in Cattle Dung on Canada’s Grasslands, by Kevin D. Floate ,page 71 ,published in 2011

[9] Citizen Scientists Dig Up the Truth about Decomposing Dung, by Discover Magazine, last retrieved 27 Mar, from http://blogs.discovermagazine.com/inkfish/2013/11/15/citizen-scientists-dig-up-the-truth-about-decomposing-dung/#.UzL8OfmSySo

In order to ensure the completeness of the cow dungs and for sake of easy observation, the existence of any living organism in set-up 1 was not checked. The reason of decrease in weight of set-up 1 is not sure. To ensure the reduction of weight was due to the presence of organisms in dungs only, we put the whole set-up indoor (school biology laboratory). It is assumed that no other organisms would disturb the set-up but occasionally, flies could be observed in the biology laboratory. The external biotic communities' effect were not being assessed.

The work of microorganisms and fungal bodies are neglected in this experiment. Microorganisms like bacteria and fungi are well known for its role of decomposition in ecosystem. Therefore the negligence of them will also lead to an inaccurate result as the decrease in weight of bovine dungs is not only due to dung beetles. It is assumed that all organisms were killed in cold treatment, but some bacteria or fungi originally present in the flower potting soil were not removed. The accuracy of this experiment is thus lowered.

5.4 Possible error

5.4.1 Errors

As the weather and temperature during the period of experiment is not a constant, fluctuation of humidity and temperature can be distinguished. During the period of experiment was carrying out, it was having a relatively high humidity. As the conditions like temperature and humidity are believed to have an effect on the dung, which thus further affect the community of dung beetles and the decomposition rate of the dung per day, leading to some insignificant errors, probably a small difference in the decomposition rate is recorded.

Suitable precautions, for instant putting a translucent paper wrapping to cover the flower pot, are not carried out to prevent the external intervention in afraid of affecting the photographs taken by the time-lapse camera. Thus, the internal environment of the bovine dung can hardly to be retained and the escape of dung beetles out of the flowerpot might also take place. This added uncertainty to the experiment and thus might results in errors like unwanted external interruption (external insects may visit the dung) affecting the status of the bovine dung or decomposition rate.

5.4.2 Suggestion for improvement

Increase of sampling size: Enlarging the scope of investigation would help to enhance the reliability of the experiment. Meanwhile, as the dungs collected in the experiment are not diverse enough in terms of location etc. Bovine dungs in other places such as Lantau Island and other parts of Sai Kung could be taken into further investigation to draw a valid invertebrates community survey.

Detailed observation could be carried out: In the experiment, freshness is determined with the subjective appearance of dung beetles. Brief relations was drawn. Meanwhile, with a larger scope of investigation, a basket of factors, for example seasons, water content, biotic communities etc, could be drilled into. This could help bring a broader picture of the factors affecting the dung beetles and invertebrates distribution.

Investigation on the environment of the natural habitats and roadside**:** In the research, it is found that dungs beetles mostly appear in dungs collected along the roadsides. However, the rationale behind is not clear enough. Does the phenomenon appear due to the environment (eg. more pollution observed along

roadside). The dungs with similar freshness should be divided into two separate pieces and be put in both location. This could eliminate the factor of the possible less activity of cows in the natural habitat visited (resulting in aged dungs).

5.5 Conclusion

By investigating the amount of dung beetles of different species in each of the dung and observing the decomposition work done by the dung beetles, we can clear up our doubts stated above.

Dung beetles are more likely to be found in dung dropped along the road side and larvae of dung beetles can be more easily discovered than mature dung beetles in all dung samples. Finding dung beetles in complete natural habitats is difficult. Dung beetles and its larvae can hardly be found in stale dungs. They are more likely to be found in fresh dungs along the roadside. Besides, other species are also not likely to appear in stale cow dungs. Total 8 invertebrate species were found in the bovine dungs collected.

Dung beetles are confirmed to have the ability of decomposition of dungs. In the experiment demonstrated, the weight of the dung with dung beetles had been reduced by 13.1% after 10 days. The decomposition rate of the dung with dung beetles is larger than the two set-ups without dung beetles.

5.6 Further Studies and Questions

5.6.1 Succession of invertebrates on the organisms in the bovine dungs

Although it is mentioned by various authorities that once one type of organism colonize the dungs, others could not get in. However, in our research, many of the dungs possess a variety of organisms. Finding out the correlations between the organisms could help with knowing the mechanism behind the lives in dungs.

5.6.2 Investigate how the dung beetles could benefit the nature by recycling the dungs

According to the principle of ecosystem, there would be an energy flow from one organism to another in terms of energy. This could help find out the importance of dung beetles in Hong Kong, which raise doubts to another local problem, as the government is trying to constrict the number of cows in Hong Kong to rise[10], would this affect the whole ecosystem, which may be overlooked by the government?

[10] 漁農自然護理署處理流浪牛政策的背景資料, by the Agriculture , Fisheries and Conservation Department, last retrieved 26 Mar, from http://www.afcd.gov.hk/tc_chi/quarantine/cattlebuffalo.html

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