UNDER THE SAME ROOF

Investigating the relationship on light, invertebrates and decomposition rate

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1. Abstract

The nitrogen cycle was introduced to us at school. However, the part of decomposition by bacteria was only briefly introduced in our DSE syllabus. We would like to look into some factors that may affect the decomposition rate. In this study, we investigated the relationship between light, invertebrate population and decomposition rate. Soil samples were collected from more exposed and less exposed areas. Then, their conductivities were measured which is an indicator for soil fertility. Before and after a period of time, the population of invertebrates were counted in bright and dark areas in different time of the day. It is found that the species richness and the number of invertebrates is higher in areas with a lower light intensity. Also, the decomposition rate is higher in places with a lower light intensity.

2. Introduction

2.1 Introduction to research topic

The world where we are living in stresses a lot on the concept of cycle, examples include water cycle, carbon cycle and nitrogen cycle. Cycles are important because they can maintain the stability of a habitat. Plant litter plays a vital role in material recycling, and there is a fascinating biodiversity in this special habitat.

However, today in Hong Kong, the government treat plant litter as rubbish rather than a source of fertilisers. A remarkable sum of money is spent on transferring the plant litter to landfills, as well as buying artificial fertilizers. Chemical fertilizers can only serve as a remedial measure, which is not sustainable in the long term. There is not much study about plant litter in Hong Kong too. Inspired by an online article talking about the fate of plant litter in Hong Kong, we feel that we should look more into this topic.

Originally, we would like to study the decomposition rate of the plant litter of *Ficus elastica* and *Ficus microcarpa.* These two species are abundant in Hong Kong and belong to the same genus, but their leaves are very different. It is known that there is a chemical called ficuselastic acid (KiemVanPham, 2012)which can be beetle-resistant. But we cannot find a good site for studying *Ficus microcarpa* as most of the sites we found were regularly maintained and pesticides were sprayed on it. As a result, we changed the focus to studying the relationship between invertebrates and light and decomposition rate.

2.2 Objectives

1. To investigate the difference in invertebrate population in different light intensities
2. To investigate the soil fertility in different light intensities

2.3 Introduction of plant litter as a habitat

According to Satchell, plant litter is the layer of dead plant material which is present on the surface of the soil. Dead plant materials which are not attached to a living plant is also a kind of plant litter. (Satchell, 1974) The Oxford English Dictionary defined decomposition as "The action or process of decomposing, separation or resolution (of anything) into its constituent elements; disintegration; putrescence". Decomposition is done both physically and chemically. Physically means breaking the tissues into smaller parts, while chemically is to convert materials from one form to another, like from cellulose to sugar.

Bacteria and protozoa takes up the main role as decomposers. For example, the *cellvibrio* bacteria are capable of cellulose degeneration. (Gyllenberg & Eklund, 1974) Macroarthropods has a larger size than bacteria and has the ability to move, they facilitate decomposition and recycling by physically disintegrate plant tissues to increase surface area for decomposition, decomposing sugar, cellulose and lignin, transforming tissues into humic materials and forming complex aggregates between organic and inorganic fractions of soil. (Edwards, 1974) Earthworms, or Oligochaetes, facilitate mixing of matter by its burrowing and feeding actions.

Visible invertebrates in the habitat which are involved in litter breakdown are woodlice, flies, millipedes, booklice, earthworms and beetles. Ants are also common.

2.4 How do insects respond to light

Insects have two types of photoreceptive organs, compound eyes and ocelli. It is common to see moths, who are positively phototactic, to fly around street lamps at night. On the other hand, negatively phototactic organisms such as cockroaches lives in dark places. (Life Science- Why are bugs attracted to light?, unknown date) Insect larvae also hide away in the dark so as to hide away from predators.

3. Materials and Methods

3.1 Field study

The site we have chosen was located on 11th Cloud View Road, opposite to Cheung Chuk Shan College. It is mainly covered by a *Ficus elastica.* The site can be divided into two parts. One is more exposed to light (or referred as ‘more exposed’ in the paper) and the other one less exposed to light (or referred as ‘less exposed’ in the paper). The red circle in the below figure is the area with less light, while the blue one is more exposed to light. The site suffers from little human disturbance and has a big contrast between the two areas. Also, there is little plant cover under the tree and the leaves under the tree are only from *Ficus elastica*, minimizing impacts from other plants.

Therefore, we chose this site to do our study.

Fig 1 Location of sample collection.

3.2 Soil pH

The pH meter (Brand: Philip Harris System)is designated to be both a sensor and a meter. The pH probe was immersed into pH 7 buffer and press the set pH 7 button to buffer and calibrate the Sensor Meter. 20cm^3 of the soil collected was mixed with 100cm^3 water. The mixture was then stirred for 30 minutes to get a homogeneous solution. The solution was placed for 3minutes for the saturation of the soil. Then the pH of the solution was measured and recorded by immersing the pH probe into the upper part of the solution with no soil. The reading of pH was recorded.

3.3 Soil Conductivity

Conductivity is the ability to conduct an electric current, which is defined as, $k = \frac{l}{Ra}$ where k is the conductivity, l is the length, R is the resistance and the a is the cross sessional area. The conductivity is measured in S/m and here it is

used as an indicator for soil fertility. (Department of Sustainable Natural Resources, 2006) The Conductivity Probe can be used to measure either solution conductivity or total ion concentration of aqueous samples of the soil. The calibration of the cell constant is done by immersing the sensor probe into 1 M potassium chloride and the constant at 25℃ is 117 S/m. 20cm^3 of the soil collected was mixed with 100cm^3 water. The mixture was then stirred for 30 minutes to get a homogeneous solution. The solution was placed for 3minutes for the saturation of the soil. The upper part of the solution with no soil was tested by the conductivity Sensor Meter (Brand: Philip Harris System).

3.4 Invertebrates population survey

The number of invertebrates were counted and recorded within 10 minutes in the sites. Photos of the invertebrates were taken to enhance the credibility. To increase the reliability, three replications were taken.

3.5 Soil Collection

The soil from more exposed area and less exposed area were collected to compare their difference in decomposition rate. The area of soil collected was selected by random sampling using a 10cm x 10cm quadrat, then the soil is dug and collected, with leaves or anything on the surface, with 5cm depth.

3.6 Measuring Light Intensity

The light intensity was measured using a light sensor. Since the reading is not stable, three readings were recorded and an average was taken to be the final light intensity. The unit is lux.

3.7 Working Schedule

Date	Time	Location	Event
16th Feb 17	15:45-15:55	The hill opposite to CCSC	Collection of soil under *Ficus elastica* in a more exposed area and sheltered area
13th Mar 17	12:45-13:15	The hill opposite to CCSC	Counting of invertebrates in more exposed area and sheltered area
27th Mar 17	16:10-17:00	The hill opposite to CCSC	Counting of invertebrates in more exposed area and sheltered area
13th Apr 17	18:00-19:00	The hill opposite to CCSC	Counting of invertebrates in more exposed area and sheltered area

4. Results

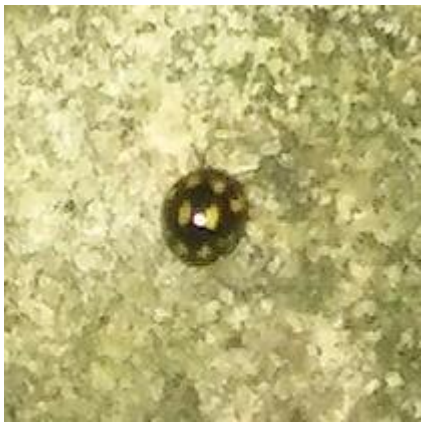
4.1 Tables of Results

		Afternoon (Less Exposed)				Night (Less Exposed)				Night (More Exposed)			
		Trial 1	Trial 2	Trial 3	average	Trial 1	Trial 2	Trial 3	average	Trial 1	Trial 2	Trial 3	average
Light intensity (lux)		1735	1829	1920	1828	102.4	122.5	92.7	105.867	1320	1472	1340	1377.333333

Table 4.1 Record of Light Intensities

Ant (red)

	More exposed	Less exposed
Morning	0	20
Afternoon	9	142
Evening	56	194



Ladybird

	More exposed	Less exposed
Morning	0	0
Afternoon	0	0
Evening	0	9

Small black bug

	More exposed	Less exposed
Morning	0	1
Afternoon	1	1
Evening	5	1

Spider

	More exposed	Less exposed
Morning	0	1
Afternoon	1	1
Evening	3	1

Centipedes

	More exposed	Less exposed
Morning	0	0

Booklice

	More exposed	Less exposed
Morning	1	0

Afternoon	0	0
Evening	1	4

Earthworm

	More exposed	Less exposed
Morning	0	0
Afternoon	3	0
Evening	0	1

Butterfly

	More exposed	Less exposed
Morning	0	0

Afternoon	0	1
Evening	1	2

Fly

	More exposed	Less exposed
Morning	0	0
Afternoon	1	2
Evening	1	0

Ants (black with a white ring on the tail)

	More exposed	Less exposed
Morning	0	0

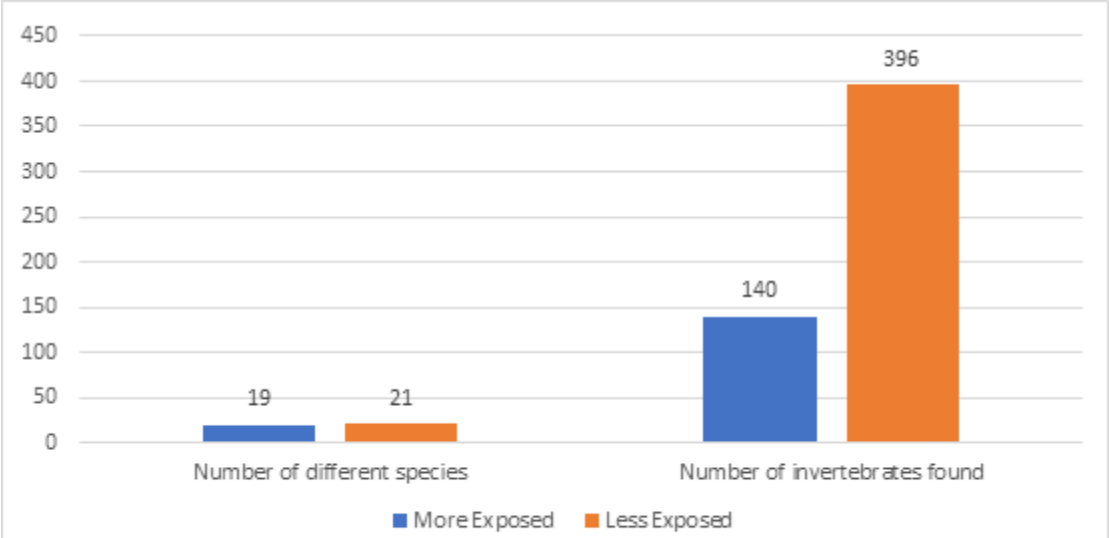
Afternoon	1	1
Evening	0	0

Afternoon	0	1
Evening	0	0

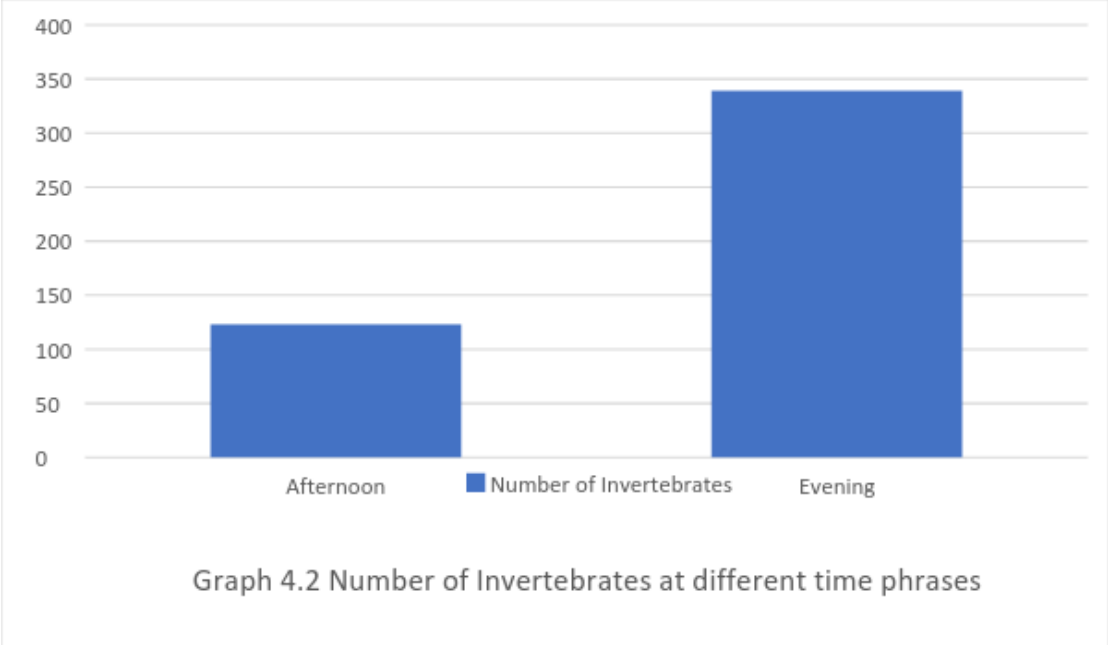
Unknown invertebrates

	More exposed	Less exposed
Morning	1	0
Afternoon	0	1
Evening	51	3

Table 4.2 Invertebrates counts



Graph 4.1 Population of invertebrates



	More exposed			Less exposed		
	Sample 1	Sample 2	Average	Sample 3	Sample 4	Average
Conductivity (Before) (mS/m)	15	18	16.5	16	15	15.5
Conductivity (After) (mS/m)	34	58	46	84	66	75
pH (Before)	7.9	8.1	8	7.8	7.8	7.8
pH (After)	7.2	7.1	7.15	7	6.8	6.9

Table 4.3 Difference in conductivity and pH in the two sites

	More exposed			Less exposed		
	Sample 1	Sample 2	Average	Sample 3	Sample 4	Average
% Change of Conductivity (%)	+126.67	+222.22	+174.44	+425	+340	+382.5

Table 4.4 Percentage Change of Conductivity in the two sites

	Invertebrate present	No Invertebrate
Conductivity (Before) (mS/m)	15	15
Conductivity (After) (mS/m)	25	26
pH (Before)	6.5	6.3
pH (After)	6.6	6.5

Table 4.5 Difference in conductivity and pH with the presence and absence of invertebrates

5. Discussion

5.1 Difference in invertebrate population in different light intensities

From graph 4.1, it was observed that less exposed area has a larger total amount of population of invertebrates(396) than more exposed area(140).Also, population amount of invertebrates found is the largest when it is in the evening(339) than afternoon(136). As only one datum is collected in morning, it is not reliable in making comparison. But the amount of invertebrates found at that time is the lowest (22) in both areas. This observation shows that lower light intensity will increase the population of observed invertebrates. It is an expected result because some of the invertebrates are nocturnal organisms, which is active when there is low light intensity. Moreover, most of the common invertebrates will live in dark and wet environment, for example, earthworm or booklice, they tend to live away from light. Thus, we believe that it is normal that there is more invertebrates in places and time with lower light intensity.

Other than difference in population, we also discovered that the total number of different species observed in less exposed areas (21) is slightly higher than that in more exposed areas (19). It may due to the less disturbed nature in the less exposed area. Since the human disturbance in the area is minimal, it may favour more types of species to stay.

Of all the invertebrates identified, ant is the most common species found in the habitats regardless of the light intensities. The highly socialised living style of ant may explain the abundance in population. There may be large colonies present in the habitat.

5.2 Soil fertility in different light intensities

According to table 4.3, it was found that in less exposed area, the change conductivity is greater in less exposed area. On average, in more exposed area, the increase is 29.5mS/m(174%), while in less exposed area, the increase is 59.5mS/m(383%). As mentioned before, soil's conductivity can show the soil fertility. Thus, we can conclude that soil fertility is relatively higher when the light intensity decrease.

Such difference may be caused by the difference in invertebrate population. It is known that some bacteria helps the growth of invertebrates, creating a mutualistic relationship. For example, *Verminephrobacter* lives in excretory organs of earthworms. Earthworms benefit from the bacteria activity by having a higher reproductive success while *Verminephrobacter* gets shelter and food from the earthworm. . (Peter Funch (GenØk, 2017) Some invertebrates like nematodes also feeds on microorganisms. Usually, when there is more invertebrates, there are more microorganisms, and microorganisms facilitates decomposition. Hence, the soil fertility may be higher where there is more invertebrates.

On the other hand, we observed that there is more water condensed on the surface of the box which contained the soil from less exposed area, showing that there is more moisture. This is more favourable for the growth of bacteria and fungi, whose life heavily depends on water. The less exposed area has more moisture may be a result of the less heat energy received and lower temperature, causing lower evaporation rate.

5.3. Limitations and errors

5.3.1 Short experimental time

Decomposition of plant litter mostly takes a long period of time (i.e 2-3 years) (Heneghan et al., 1999) In this investigation, we were unable to obtain a significant change decomposition rate within a short period of time. There was not enough time for them to decompose completely and observe a significant effect of invertebrates on the decomposition rate. Therefore, it was hard to make comparison of the result with little changes.

5.3.2 Sampling condition

Due to rainy days in March and April, replication work was not able to be carried out and so we cannot observe the changes in decomposition rate within the same area on different time period to ensure the reliability of the decomposition rate. Since the data collected was under different weather condition, we could not eliminate the effect of different weather condition (i.e. temperature and air pressure) on the decomposition rate and the activity of invertebrates' movement. Therefore, effect of other abiotic factors, other than the factor under investigation (light intensity), was not assessed.

5.3.3 Sampling of invertebrate method

In the investigation of the effect of population of invertebrates on the decomposition rate, we had observed that there were flying invertebrates and fast-moving organism which we were not able to take photo or collect it for further investigation. Their roles in decomposition were not assessed as most of them escaped very quickly and difficult to take a closer look. This limits our ability to identify and record invertebrate community that under investigation.

5.3.4 Existence of bacteria

As mentioned in the introduction, bacteria take up tmain role as decomposers. They may contribute to the decomposition process. We were not able to eliminate bacteria due to a limitation in laboratory apparatus. The role of bacteria is neglected which we cannot ensure the fertility is affected by light intensity and invertebrates only.

5.3.5 Conductivity as an indicator of soil fertility

Conductivity is the measurement of amount of soluble salt in a sample. We chose conductivity as the indicator for soil fertility because ions are produced while decomposition, so salt content will be increased upon decomposition. However, it is an indirect measure of soil fertility and we can just say that soil conductivity is proportional to the soil fertility.

5.3.6 Error in measurements

The error of the electronic balance is 0.005%, which is quite accurate. The reading

of conductivity meter and pH meter has an error of 4%.

5.4 Further studies

Although we were planning to investigate the population of invertebrates on the decomposition rate, due to limited time as mentioned above, we were not able to do replications. Still, we observed that wherever there was no invertebrates present in the sampling area, the soil fertility of the particular sampling area was recorded to be higher by measuring the conductivity and pH. From Table.4.5, the one without invertebrates recorded a higher increase in conductivity in both conductivity and pH value comparing to the one with invertebrates. The increase in conductivity of samples collected from more exposed and less exposed areas are +11 and +0.2 respectively. In our investigation, we could not directly conclude the relationship between the two but we predicted that there could be some effect of invertebrates on decomposition rate.

6. Conclusion

1. The Species richness and number of invertebrates is higher in areas with a lower light intensity.
2. Soil fertility is higher at places with lower light intensity

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