Team 4
School name: Diocesan Girls' School

Group members:
F4 Katrina Chau
F4 Eden Chua
F4 Jimsyn Jia
F4 Allie Poon
F4 Pallas Wan

Topic: Ants

1. Abstract

Fig.1 Image of carpenter ant

Carpenter ants, also known as sugar ants, are a large group of ants under the genus *Camponotus*. They are commonly found in forested parts of the world, and Hong Kong is not an exception.

In our project, we are investigating whether some visible abiotic factors, such as the colour of the path, the colour of the destination and the light intensity, will affect the ants' decision when choosing their paths or places of stay.

We conducted three experiments which involved observing the carpenter ants' movement within several regions with fixed physiological parameters, and determining the proportion of ants found in each region. Each region in the respective experimental setups vary in colour of the path, the colour of the destination, and the light intensity of the entire region. From our experimental results, it can be seen that ants show a preference for yellow when choosing their path or place of stay, but this tendency cannot be explained by light intensity. A follow-up experiment proves that ants prefer dark places to bright places, thus leading us to the conclusion that ants show a liking for yellow not because it is light in colour.

2.Introduction

2.1 Introduction on research topic

In Hong Kong, it is never hard to find ants, given how many there are around us. In fact, Hong Kong has more than 170 species of ants. We have always been taught how ants form systematic units in the ecosystem, but as we grow we realize that ants are not just little insects who carry out their assigned tasks. It seemed that even if ants are so commonly found, we do not really understand them and how they react to changes as they move.

As they take other factors into consideration as well when they move around, we designed experiments to investigate on the effect of different environmental changes on their choice of paths. This would allow see how these little insects would react to these changes according to their preference. At the same time, this could give us a clearer glimpse about their usual practices in their own habitats.

We decided to conduct experiments on the effect of colour on ants' path choosing process, the effect of colour on ants' final destination choosing process, and the effect of light intensity of ants' decision on place of stay.

For the first and second experiment, as ants have a high adaptability to their living environment, (they can build formicariums practically everywhere), we wonder what colour of environment do they generally prefer, or what colour are they most comfortable with. This could tell us more about the abundant colours in their habitat, which is very useful for us to understand more about their daily routine.

The third experiment was stemmed from our questions of what do these ants' habitats generally look like, and whether they show a preference for a particular colour due to their preference for a specific degree of light intensity. To our general understanding, ants live in colonies and underground, but we also see ants scurrying in broad daylight, so we wonder if ants have a preference for light or darkness.This also links to the location of their formicariums, and how they look like on the inside.

2.2 Objectives

1. To investigate the effect of colour on ants' path choosing process
2. To investigate the effect of the colour of the destination on the ants' choice of paths/ motion
3. To investigate the effect of light intensity on ants' decision on place of stay

2.3 Background information of Camponotus spp.

2.3.1 Taxonomy

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Hymenoptera
Family	Formicidae
Subfamily	Formicinae
Tribe	Camponotini
Genus	Camponotus

2.3.2 Habitation

Carpenter ants, are large ants indigenous to many forested parts of the world. Due to their high adaptability, they nest in dead trees and in rotting logs and stumps, also living and foraging in the soil. They prefer wood that is moist and rotting, as wet or rotting wood is soft enough to allow carpenter ants to hollow it out to create living space and produce a colony. This was also observed in our field observation, as we found ants in moist, dead branches.

2.3.3 Structural characteristics

Carpenters ants are commonly black, ranging in hues from red to yellow . They are considered large ants, some even reaching a length of 25 mm.

Like most ants, they have a segmented body divided into head, thorax and abdomen. The head includes a set of large mandibles that open horizontally like scissors and a pair of antennae that take an elbow shape. Six legs attach to the thorax, and a narrow petiole separates the thorax from the abdomen. A carpenter ant's petiole has one node, which makes the area between the thorax and abdomen look like a small notch.

2.3.4 Feeding

Carpenter ants are foragers. When worker ants find food sources, they communicate information to the rest of the ants by using biochemical pheromones to mark the shortest path that can be taken from the nest to the food source. When a significant number of workers follow this trail, a foraging trail is established and the rest of the ants would be very likely to follow. The ants would stop travelling to the food source when the food source is depleted. We find this feeding habit useful for our experiment, since their system of foraging for food may allow us to observe their motion more easily and in a more systematic way.

This was observed in our field observation when an ant discovered a food source and many ants soon arrived. We also saw that the ants were very active and would go long distances to find food.

3. Experiment

Venue: school laboratory

3.1 Experiment 1

Objective:

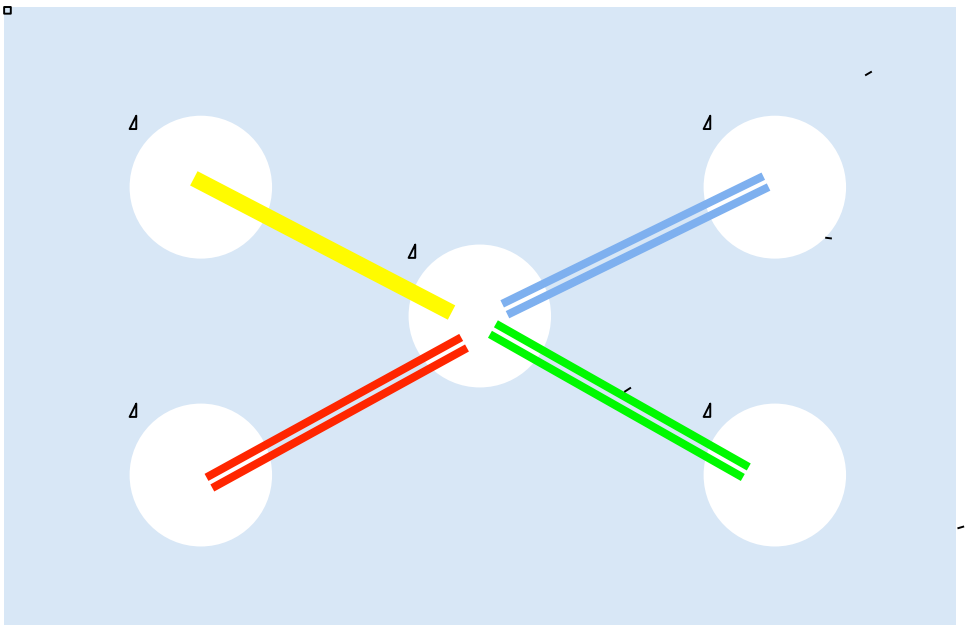
To investigate the effect of the colour of paths on the ants' choice of path/ motion

Design of experiment:

A tub of water with several platforms was set up. A central platform (i.e. a small lidded container) was linked to the four side platforms by different coloured chopsticks as bridges respectively. The side platforms were be glazed with honey. Ants were be put on the central platform, and they were be allowed to move from one platform to another via the bridges in between. The relative number of ants found on each platform and its respective bridge will be measured and determined.

Apparatus:

Small containers with lids x5
Plastic tank x1
Tap water
Anti-escaping powder
Honey
Dropper
Forceps
Coloured chopsticks x4 (red, yellow, green and blue)



Set-up:

Procedure:

1. The edges of the plastic tank were smeared with anti-escaping powder (calcium carbonate).
2. The plastic tank was filled with water.
3. The plastic containers were filled with water to allow them to stay in a fixed position. Four containers were put at each of the four corners of the tank, with one placed at the centre of the tank. The top of the containers were kept above the water surface.
4. A pair of coloured wooden chopsticks was placed between the central container and each of the four other corner containers.
5. The same amount of honey was drizzled onto the top of the four containers at the corners.
6. 15-20 ants were transferred to the central platform and their motion was observed for around 15 minutes. The relative number of ants found on each bottle and its respective bridge was counted.
7. Steps 1-5 were repeated for 2 more times, and different ants were used for each trial.

Results:

Colour of chopsticks/ Percentage of ants	Red	Yellow	Green	Blue
Trial 1	20%	40%	10%	30%

Trial 2	35%	35%	20%	10%
Trial 3	30%	40%	10%	20%

Ants generally show a greater preference for yellow when choosing their paths, as reflected by the greater proportion of ants which choose to move across the yellow coloured chopstick as compared to the other coloured chopsticks.

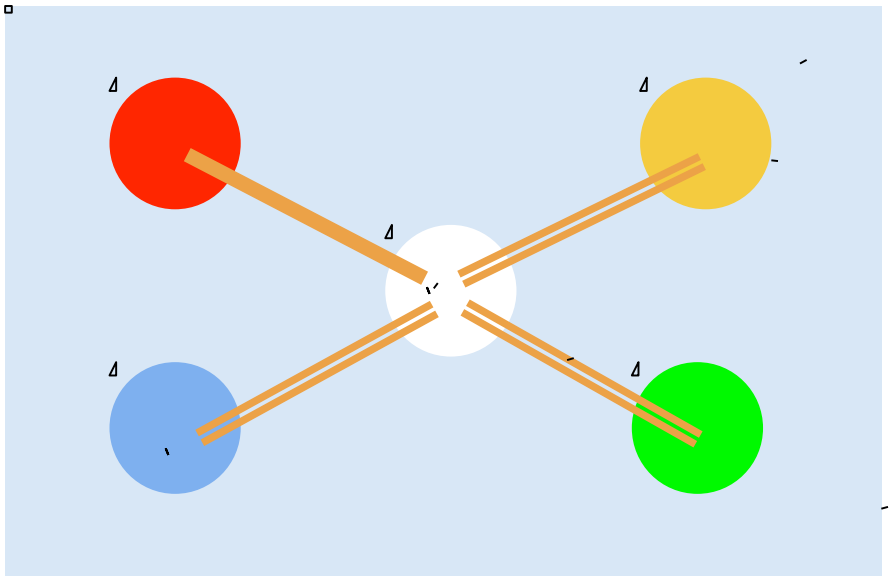
3.2 Experiment 2

Objective:
To investigate the effect of the colour of the destination on the ants' choice of paths/ motion

Design of experiment:
A tub of water with several platforms was set up. A central platform (i.e. a small lidded container) was linked to the four side platforms by chopsticks of the same colour as bridges respectively. Coloured paper of different colours and glazed with honey were put on each of the side platforms. Ants were be put on the central platform, and they were allowed to move from one platform to another via the bridges in between. The relative number of ants found on each platform will be determined.

Apparatus:
Plastic container x5
Plastic tank x1
Tap water
Anti-escaping powder
Honey
Dropper
Forceps
Wooden chopsticks (plain) x4
Coloured paper (red, yellow, green and blue)

Set-up:



Water

Plastic container with coloured paper and honey

Chopsticks

Tank

Procedure:

1. The edges of the plastic tank were smeared with anti-escaping powder (calcium carbonate).
2. The plastic tank was filled with water.
3. The plastic containers were filled with water to allow them to stay in a fixed position. Four containers were put at each of the four corners of the tank, with one placed at the centre of the tank. The top of the containers were kept above the water surface.
4. Pieces of coloured paper (red, yellow, green and blue) were cut out and placed onto the plastic containers at the four corners
5. A pair of plain wooden chopsticks was placed between the central container and each of the containers at the four corners.
6. The same amount of honey was drizzled onto the top of the four containers at the corners.
7. 15-20 ants were transferred to the central platform and their motion was observed for around 15 minutes. The relative number of ants found on each bottle and its respective bridge was counted.
8. Steps 1-7 were repeated for 2 more times

Results:

Colour of paper/ Percentage of ants	Red	Yellow	Green	Blue
Trial 1	30%	40%	20%	10%

Trial 2	20%	35%	35%	10%
Trial 3	20%	40%	30%	10%

Ants generally show a greater preference for yellow as the colour of their destination, as reflected by a greater proportion of ants found at the yellow coloured paper.

Analysis for experiments 1 and 2:
For both experiments, we noticed that the ants preferred the colour yellow. We initially thought that it was because the colour yellow was more eye-catching, but this is not a convincing prediction because ants do not rely on their sight that much, when compared to others senses such as sense of smell.

We investigated around the carpenter ants' habitat, and realized that one source of their food is honeydew, secreted by oleander aphids which are bright yellow in colour. This might be a possible explanation as to their preference of the color yellow. Ants may link the color to the honeydew-secreting aphids, thus they are willing to seek the color out. However, this is just an estimation of their reaction.

Another possible reason we have hypothesized is that yellow is a lighter colour when compared with green, pink and blue, which may imply that the ants have a preference for light intensity. If this is true, the fact that ants prefer lighter paths reflects that ants prefer a brighter environment.

Both possible reasons, albeit different, stem from the ants' basic needs for survival and their preference has far-reaching implications.

We also noticed that ants preferred the color blue least in all three trials of the second experiment, which is a very consistent result. This may be due to the similarity of the tank, water and colored paper as they were all blue. Due to their poor eyesight, the ants may have had difficulty discerning the presence of the honey on the blue paper as compared to the honey on colored paper of other colors.

However, in the first experiment, while ants did not show a clear preference for the color blue, some ants still chose blue colored chopsticks. This may be because wooden chopsticks have a smell, thus ants are able to discern the presence of the chopsticks, which they can cross to get to food.

3.3 Experiment 3

This experiment is a follow-up experiment of the above colour tests, to see if the preference for the colour yellow is because of the ants' preference to light.

Objective:

To investigate the effect of the light intensity on the ants' choice of paths/ motion.

Design of experiment:

A piece of aluminium foil will be stuck in the middle of the plastic tank using tape, leaving 2 cm at the bottom in order to let ants pass through. The ants will be put randomly into the tank, and some time are allowed for the ants to disperse evenly throughout the tank. Afterwards, the lights of the room will be switched off, and a table lamp will be shone at half of the tank only, as the tin foil blocks the light from going into the other half. (ie. In the diagram below, the right side of the tank is bright, while the left side is dark) The relative number of ants in each portion will be counted.

Apparatus:

Plastic tank x1
Anti-escaping powder
Table lamp x1
Aluminium foil
Tape

Set-up:

Procedure:

1. The edges of the plastic tank were smeared with anti-escaping powder.
2. A piece of aluminium foil was folded into 4 layers.
3. Tape was used to stick the aluminum foil in the middle of the tank, so that the tank was divided into two equal portions. A gap between the aluminium foil and the bottom of the tank was left so that the ants would be able to pass through the gap.
4. The table lamp was turned on, and the position of the lamp was adjusted so that the light is shining at half of the tank only.
5. 10 ants were placed on the area without light, and 10 other ants were placed on the area with light.
6. The lights in the room were switched off.
7. A timer was used to time for 5 minutes, during which the ants were allowed to move to the area they prefer.
8. The lights in the room were switched on and the table lamp was switched off.
9. The ants on each side of the tank was observed and counted.
10. The ants were removed from the tank.
11. The lamp was put on the other side so that its light is shining in the other portion of the tank only.
12. Steps 4-11 were repeated. (trial 2)
13. Steps 4-11 were repeated. (trial 3)

Results:

The ants prefer the dark to the light.

	Number of ants in each area	
	Area with light	Area without light
Trial 1	0	20
Trial 2	7	13
Trial 3	3	17

Analysis:

This experiment disproves our previous hypothesis about the ants choosing yellow over the other three available colours because of preference of lighter environments. The results coincide with our field observations about their habitat, as the ant colonies we found were all in dark corners.

The ants' preference for the dark imply that they do not rely on their eyesight most of the time, and thus rely on other senses to find food and move around, which also explains their choice of

habitat. The results show their dependency on senses other than sight. In a roundabout way, the reason the ants prefer the dark may be because of the similarity to their usual habitat. They are more familiar with the dark due to time spent in their habitat, and may associate it with their nest.

The ants' general avoidance of the bright areas may also imply that the ants associate the light with objects threatening their survival, such as the presence of other organisms.

4. Field investigation

Venue: Aberdeen Country Park (Barbecue Area)

To find out where the ants' habitats are, we spread honey on leaves and stones to attract ants. From background research we found out that sweet food would be a major lure for the ants to come out, so this would be a viable method to find out where the ants are living. From our experiments we observed that the ants in general respond to the attraction of honey, so we decided to use it as a test to see where the ants would live.

However, because of the cold weather, the ants are less active than usual, so we were not able to locate many ants. Even if we managed to attract them out for observation, the number of ants that came out in the end was very little. Yet at the same time, because their were quite a lot of people who came to barbeque, the savoury smell of food also helped attract the ants to come out from their habitats.

This observation that honey is an effective lure for ants also explains their preference for yellow in experiments 1 and 2. Other than making them think of yellow aphids and their honeydew, the honey that we used were pale yellow as well, which might be the reason why the ants prefer the colour yellow.

We initially thought that the ants either lived in soil or near the bushes or trees. However, when we tried using leaves or directly adding honey into soil, we found out that no ants would come out despite the proximity to barbeque sites. We were only able to locate ants on a circular stone bench surrounding a tree, which apparently is a much darker and damper area than underground. With the help of more honey, more ants came out to take in the honey, and we even managed to locate another type of ant. Hence, we believe there may be an ant colony under the tree/ in the stone bench, as the ants came out from the cracks in the stone bench.

This observation explained why the ants in our third experiment preferred the dark over the light. This is because they live in the stone crack, where no light is present. Also, after research we found out that ants' habitats usually are filled with curved alleyways and narrow passages, which makes the stone crack even more fitting as their habitat. Hence, we understood the experimental results of experiment 3.

Another interesting observation is that ants seem to have a way of communicating with each other. We found out that when one ant locates the honey, it goes back into the crack, and

afterwards more ants came out from the crack to eat the honey. Presumably, the first ant went in to tell other ants, and so afterwards more ants came out.

5.Discussion

5.1 Limitations

5.1.1 Small sample size

We only used about 15-20 ants in each set-up, so the sample size for each set-up is quite small. It is hence difficult to be sure if the behaviour of this group of ants can represent the general behaviour of carpenter ants in Hong Kong.

However, due to the cold weather the number of carpenter ants we could capture were limited, so we were limited to this small sample size to experiment upon. Efforts to overcome this that we made was to increase the number of trials we conducted, in order to increase the accuracy of the experimental results.

5.1.2 Limited variations in colour

In the experiment on colour preference, the only colours we used were red, yellow, green and blue, which are the elementary colours in nature. Though so, as the options for the ants to choose were limited to these four, which might have affected the choice of the ants as the colour they prefer was not in the list.

However, as similar experiments have not been found in our research, we did not have a general idea of what colours ants would prefer. We also thought that too many colours would complicate the experiment and make the results even harder to deduce, so we only experimented with these four elementary colours. This might have affected the accuracy of the experiment.

5.1.3 Different species of ants we might have collected

Although we researched about where carpenter ants would be located and collected the samples there as well, we could not be sure if these carpenter ants belong to the same species. We could only identify them as carpenter ants because of their obvious node between their thorax and abdomen, and also the ring of hair around their abdomen. However, we could not ensure if they belong to the same species or the same colony, which would affect their reaction to environmental changes. This would make the accuracy of the experiment limited.

5.1.4 Difficulty in keeping track of the number of ants in each region

The ants, as observed in the first and second experiments, are tentative in their choices of their paths. They tend to leave a platform after feeding and go to another platform, and their place of stay alternates repeatedly. This phenomenon lowers the accuracy of our experiment, since we cannot determine the actual number of ants on each platform. We could only make take note of the observations at regular time intervals, and estimate the relative number of ants choosing a particular colour based on the overall proportion of ants found on each respective platform. We made the assumption that, with the greater the proportion of ants found on a platform, the more

ants are attracted towards the colour of that particular region, which may not necessarily be the case. It is also observed that some active ants repeatedly travel between different regions, and we may have overestimated or underestimated the number of ants visiting particular coloured regions.

5.2 Sources of errors

5.2.1 The ants' disinterest in honey

The unexpected thing we noticed in this experiment is how the ants were actually not that interested in honey. Initially when we decided to use honey, it was to incentivise the ants to move towards the honey and hence for us to observe their movement. However, during the experiment we realized that the ants were not that attracted by the honey. Rather, at times, they remained on the central platform and hesitated whether to go to the honey or not. One possible reason was that they did not know that there was honey on the four platforms at the corners, while it was also likely that they were too scared to show an interest in food.

5.2.2 Different hues and shades of the same colour available

The ants may have had a preference for a particular shade of a colour, instead of that colour in general. We have neglected this possibility and have just drawn a conclusion that the ants show a preference for yellow, simply because they show a tendency to move towards a particular shade of yellow. However, there is a chance that the ants may be attracted to different colours due to their colour intensity, rather than a specific colour.

5.3 Improvements

5.3.1 Experiment with more different colours and hues

As stated above, the variations in colours and shades are extremely limited, which may reduce the accuracy of our experiment. We can improve by experimenting with more different colours, such as brown, black, orange and purple. Also, we can experiment with more shades of colours, so as to determine whether ants show a preference for a particular degree of colour intensity, rather than a particular colour in general.

5.3.2 Increase the sample size

5.3.3 Dyeing the honey into different colours using food colouring

5.4 Conclusion

Ants prefer yellow-coloured objects, which may be due to the colour of their food source -- honeydew. They prefer the dark rather than light, which implies they rely on senses other than sight, and have a darker habitat.

6. Bibliography

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