The Effects of Changing Temperature in Drosophila melanogaster

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Abstract: To determine whether the changing temperature will have impact on fruit flies' behavior. Method: place the fruit fly into a small container, which has a baseboard that the temperature is changeable. The computer will record the flies' movement route. Result: with the temperature rise up, the fruit fly became more and more active, spend more and more time moving. Conclusion: the temperature can influence fruit flies' behavior, and it is a positive relationship.

1. Introduction

Drosophila melanogaster, also known as the fruit fly, is a common insect in people's daily life. But the role it plays in laboratory is much more important [1] [2] [3]. It is one of the most crucial animal models in biological study [4] [5] [6]. In the early twenty century, scientists established the field of genetics based on this insect. Due to its clear genetic background and simple experimental operation, it occupies a significant position in many fields such as genetics, developmental biology, biochemistry and molecular biology. As the genetic study keep progress, it enriched some basic concepts and theories we know today, and it will play more important part in the future.

2. Animal' s instinct of survive

When detecting some danger, animals often have instinct to react, normally they run away from the danger. Now the study have already proven that certain nerve system in animal's brain is strongly relates to animal's runaway behavior. It controls animal's behavior. When animals sense the danger, their nerve system will have an impact on their behavior and assist them to run away. The following study and experiment is based on this mechanism, we used the rising temperature as the potential threat to the fruit flies, as the fruit fly cannot stand the high temperature, to see whether fruit fly will react differently according to to different temperature.

3. Material

3.1 Fruit fly (Drosophila melanogaster)

The breed of fruit fly include wild CantonS breed and mutate rut2080 breed. These experimental fruit flies are all strictly raised [7], they are raised in a glass bottle, the upper open bottleneck is covered with a soft plunger, and the bottom is filled with their food, the mixture of water, corn meal, starch, agar, sugar, and yeast. Inside the bottle, the temperature was also precisely maintained at about 25℃, and the humidity is about 60%. The bottle has 12 hours exposed to the light and 12 hours in the dark in a day. All of these fruit flies are 3 to 6 age in days, and the gender is not mattered in this experiment.

3.2 Heatbox Experimental Device

The fruit fly motion platform is based on a semiconductor refrigeration sheet that connect to water-cooled heat dissipation device, and it is so called Heatbox [8]. Each platform is divided by a frame in the middle. The divided area is used as one fly's activity area, so one platform can have two fruit flies. There are transparent glass sheet above the platform, which is used to prevent the fly from escaping. Moreover, the infrared HD camera above the motion platform will constantly track the location of fruit

fly inside the platform, and send these information to the lab software. All the experimental devices are covered by trestle and black cloth to exclude the interference caused by outside factors. The infrared illuminant inside the cover will provide appropriate light source. The fruit fly motion platform is showed in picture Figure 1.

Figure 1. The fruit fly motion platform.

3.3 Control Models

In this experiment, Digital-mode conversion units, relay switch units, temperature sensors and power supplies were used to precisely control the temperature. Using a customed program to control the device temperature, so that the device can automatically input the positive current or negative current, in order to control the rise or fall of the temperature, and make the temperature inside the platform ideally.

4. Method

4.1 Experiment 1

There were six fruit fly motion platform and each can contain two fruit flies. The bottom of these platforms are devices which the temperature can be adjusted. The experiment is, placing one fruit fly in each platform. After these are all set, turn on the computer, change the temperature of the platform, observe the flies' condition, the HD camera will record the flies' status, which includes the flies' velocity, movement, turn angle, and distance moved. Seven different temperatures were used to test fruit flies: 20℃, 25℃, 30 ℃, 35℃, 37℃, 38.5℃ and 40℃. 25℃, which is the normal temperature in their habitats, was used as the standard temperature, it is the closest to the temperature in their living environment. Fruit flies' behavior under each temperature mentioned above will be recorded and compared. Each test lasted for ten minutes, and each group will be tested two to three times.

4.2 Experiment 2

Second experiment was based on the previous one, which is put one group of fruit flies into the platform and change the temperature to 20℃, 10 minutes later, raise the temperature to 30℃ and last for another 10 minutes, then compare this new group with the regular group that under 30℃ directly.

Statistical Analysis Method:

Line chart and Bar chart, record fruit flies' distance moved, velocity, movement, and turn angle, as shown below.

5. Result

5.1 Experiment 1

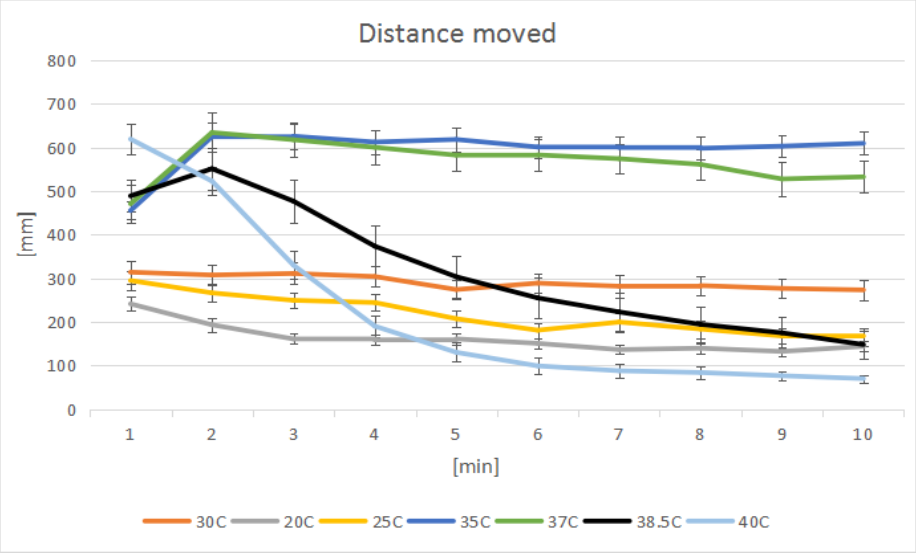

Figure 2. Date of distance moved in experiment 1.

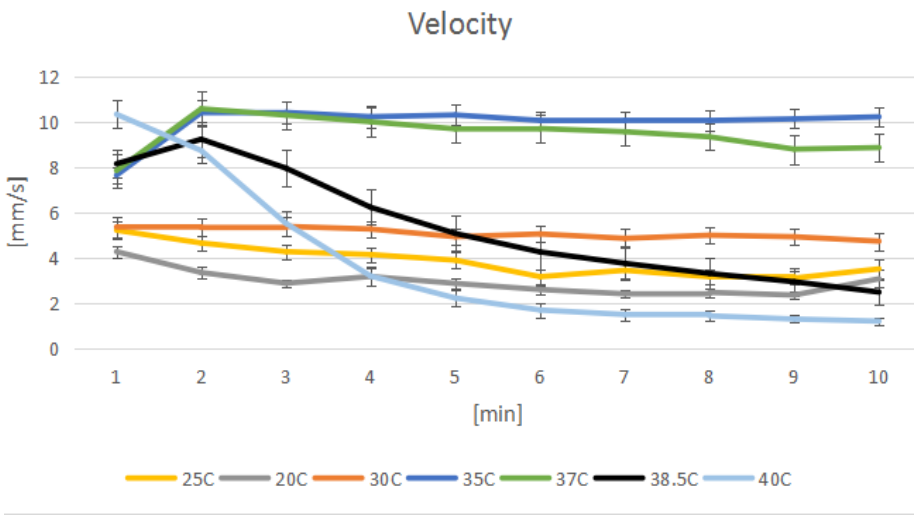

Figure 3. Date of velecity in experiment 1.

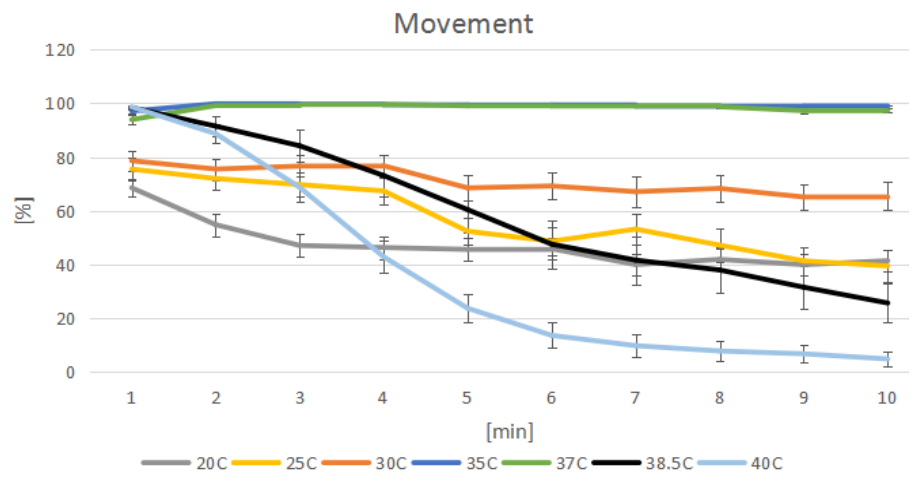

Figure 4. Date of movement in experiment 1.

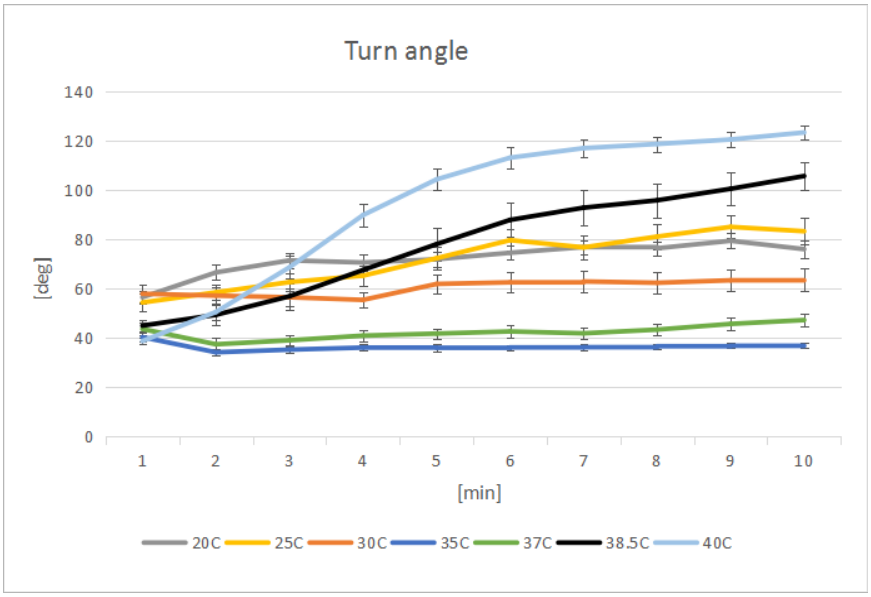

Figure 5. Date of turn angle in experiment 1.

The results showned in Figure2-5 showed evident differences in fruit flies' behavior among different temperatures. The velocity, movement, and distance moved parts showed similar story. Flies under 20℃ behaved the least active. They moved not only slowest but also ran the least path, with most of them nearly stayed in one place without moving after around 5 minutes. Until the record was over, we moved off the sheet and recovered the temperature to 25℃, they started to move again, just like they wake up from sleep. The group under 25℃ showed regular behavior, the fruit flies' movement, velocity, and distance moved all decreased steadily after the first minute began, they may be tired and stay still after moving for a while. Compare to the 25℃, the group under 30℃ moved more actively, their distance moved, movement, and velocity almost stay unchanged in 10 minutes, which means that they spend more time moving than the group under 25℃ did. These results clearly illustrated that, the temperature and fruit flies' behavior do have positive relation, the higher the temperature is, and the more active the fruit fly behaves.

When observing the group under 35℃, 37℃, 38.5℃, and 40℃, here comes the more interesting part. When temperature rose to 35℃, the fruit flies behaved "crazily", their distance moved and velocity increased drastically in first 2 minutes and remained highest among all other groups, with their movement reached nearly 100%, which means that they spent nearly every minutes moving and rarely stop. The group under 40℃ was the most active in the first minute, but soon decreased dramatically, most of them were just could not handle this high temperature and died, only few of them survived. In order to find out what temperature the fruit fly move the most intensely, the temperature of 37.5℃ and 38℃ are used to do more experiments. As the result showed, the group under 38.5℃ moved intensely in the beginning, just behind the group under 40℃. And their movement increased for 1 minutes then decreased just as the group under 40℃, most of them did not survive. However, the group under 37℃ acted nearly similar to the group under 35℃, with the fruit flies acted more intensely at the first minute yet less actively in the rest of time. So the temperature which fruit fly act the most extremely should be somewhere between 35℃ and 37℃.

About the turn angle part, in general, told a different story. This result was just the opposite to the results of velocity, movement, and distance moved. Beside the temperature of 40℃ and 38.5℃, which most of the flies died during experiments, the lower the temperature, the bigger the angle these flies turned. One possible reason is that when temperature raised up, these flies' movements also increased, and they tended to fly curly routes, instead of straight ones, which means that they might turn more sharp angles, so the angle tend to be small.

5.2 Experiment 2

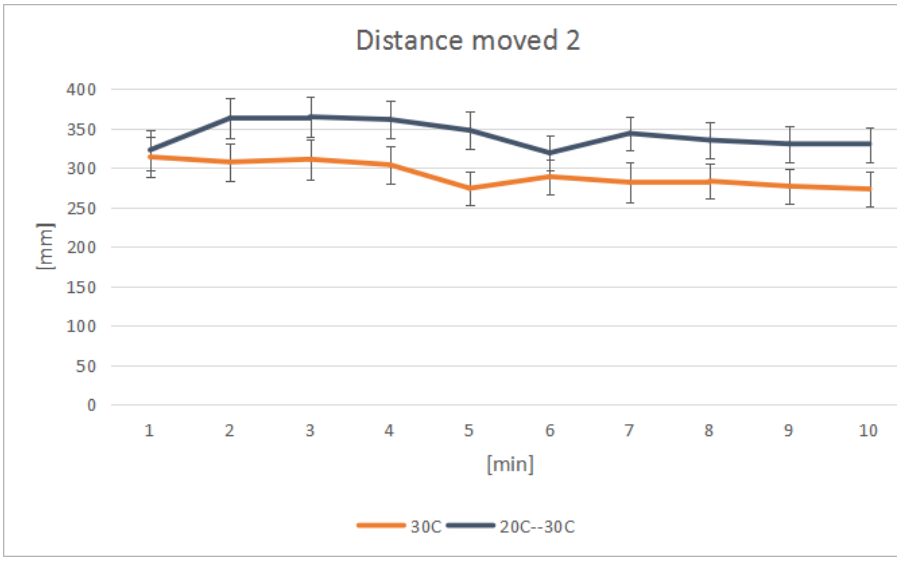

Figure 6. Date of distance moved in experiment 2.

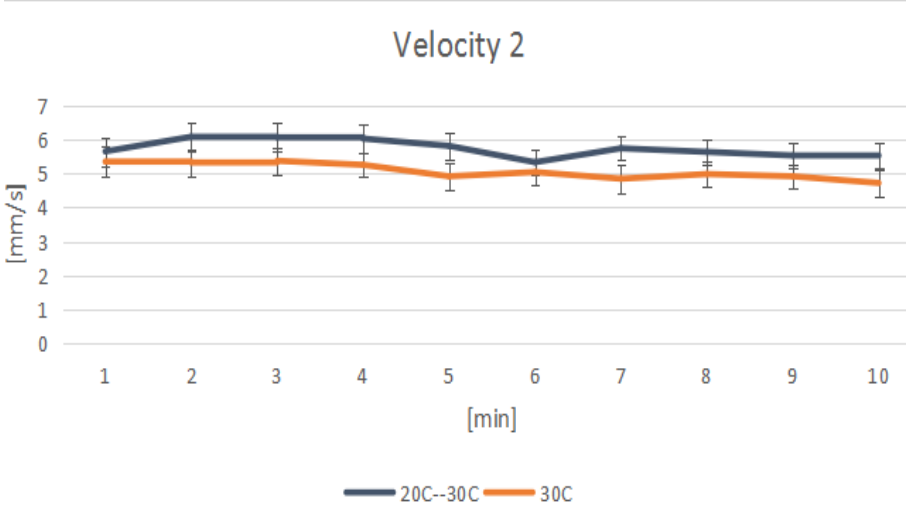

Figure 7. Date of velocity in experiment 2.

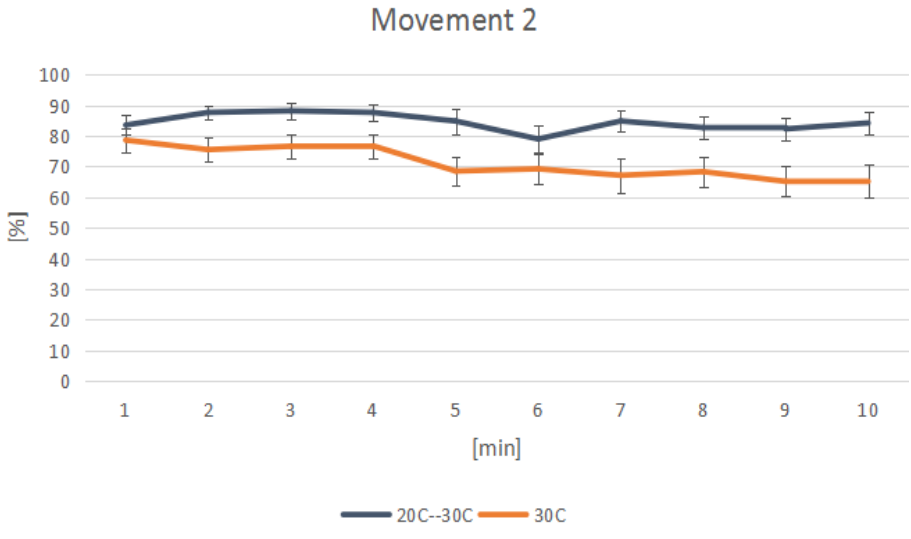

Figure 8. Date of movement in experiment 2.

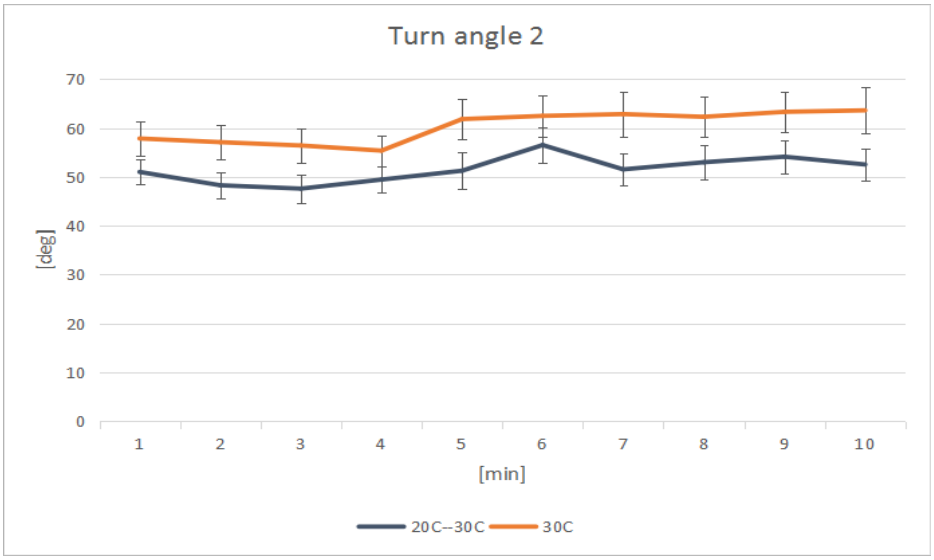

Figure 9. Date of turn angle in experiment 2.

The result showned in Figure6-9 was also fascinating. The new group even act more actively, with higher velocity, movement, distance moved, and lower turn angle after experience the low temperature of 20℃ compared to the regular group under 30℃ directly. So, why would this happen?

One possible reason is that when doing regular experiment, the initiate temperature was 25℃, the regular temperature, during the process of placing flies into the containers, then the temperature raised up to 30℃. However, in this new experiment, although the same setting work before the experiment initiate was done, these flies had been through under 20℃ for 10 minutes. 20℃ was the temperature that relatively low compare to 25℃, so they might felt even "hotter" when the temperature went up to 30℃, and moved more intensely compared to the regular group under 30℃.

6. Discussion

Animals' escape mechanism is a complicated instinct. It is led by a specific nerve system inside animals' brains. We used this as base to our experiment. During the experiment, we used different temperature, involve 20℃, 25℃, 30℃, 35℃, 37℃, 38.5℃, and 40℃ to test the fruit flies' reaction, and used multiple devices like HD camera and Heatbox device to operate the experiment and record fruit flies' motion path. Based on these information and experiments above, the conclusion was that fruit flies' behavior can actually be influenced by the temperature, and it is a positive correlation. With the temperature became higher, they moved more often, reacted more intensely. Although they have simple brains and body structure, their escape mechanism is advanced, more advanced than once believed.

7. Outlook

The Heatbox device was also used in many other scientific study such as fruit flies' learned helplessness experiment. Researchers used this device to raised up temperature as the punishment towards the fruit flies when they entered the punish area. Our experiment was also based on this advanced instrument. However, although we now know that the temperature have a positive correlation with the fruit flies' behavior, many questions are still unsolved. Specifically, under what exact temperature does the fruit fly act the most intense? And when flies in containers under 20℃, were they just sleeping or lowering their metabolism, slow down their movement on purpose? These questions need more experiment in the future to solve. We believe that with the Heatbox device, and with the features of fruit fly: relative simple nerve system and easy experimental operation, we can deepen our understanding of insect's behavior and escape mechanism.

8. Conclusion

This experiment used different temperature and devices to examine the effect of temperature on fruit flies' behavior. The results showed that they will react differently under different temperature. With the temperature became higher, they spent more time running around, turning sharp angles. What is more, in the second experiment, we found that the new group reacted more intensely than the regular group, probably because they sensed relatively higher temperature after staying in platform under 20℃ compared to the regular group. All these result promote our understanding of fruit fly. The Heatbox device will be used in the future to do more experiment and prove more theory about fruit fly.

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