BIOMEDICAL SCIENCE JOURNAL FOR TEENS

MAY 2017

Can microbes make fruit flies stronger?

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Abstract

Have you ever thought of yourself as an ecosystem? Or even, a planet, hosting trillions of inhabitants! If not, get used to the fact that you are one! Each and every one of us provides a home for millions of *microbes* that live inside our body, and on our skin. Some of these tiny creatures just use us as their living space, without affecting us. Some do us harm. Many, however, benefit us immensely. They help us digest food and fight off diseases, and might even be important in keeping our brains healthy. The community of microbes in our body is called our *microbiome*.

Humans are not unique in having microbiomes! Insects - like fruit flies - also host microbial communities. We examined the microbiomes of different fruit fly *populations* originating from six different places across Europe. We showed that their microbiomes were different, even though all flies had eaten the same food over the past four years. We also examined the effect of microbes on fruit fly resistance to parasite attack. In some populations we found evidence for this, but for other populations we did not find a clear connection.

Introduction

Microbiomes – the communities of tiny little organisms (*microbes*, such as bacteria and fungi) that inhabit the body of any living creature - are a hot topic in science these days. That is because scientists keep discovering how important those "body-mates" are for our health and well-being.

Usually, when people hear the word *microbe*, they think of germs – an unfriendly term used for nasty bacteria that make us (or other animals and plants) sick. But the vast majority of microbes are beneficial, living inside (or outside of) other living bodies, forming different types of communities. These microbes (or communities) help their host digest food, provide protection against diseases and have many other important functions.

Insects like the well-studied *model organism* fruit fly *Drosophila melanogaster* (Fig. 1), also have a microbiome. Their microbial communities are far less complex than the ones in larger animals. This makes them much easier to study, and allows scientist to address important questions about the nature and origin of these tiny but important microorganisms. (It also helps that fruit flies are themselves pretty small, very easy to rear in the lab, and reproduce really quickly).

Figure 1: The common fruit fly (*Drosophila melanogaster*) is one of scientists' favourite model organisms. Do you know why?

In our study, we set out to answer these questions about the fruit fly microbiome:

Do flies from different geographical locations harbor a different microbiome? How much overlap is there in the types of microbes that different fruit flies carry? And what factors determine the microbiome of fruit flies? (The food they eat, their place of origin or maybe the genetic makeup of the fruit fly itself?)

Do these microbes help or hinder fighting off parasites that attack the fruit fly larvae (babies) (Fig. 2)?

We predicted that:

1. All fly populations would have a very similar microbiome if the food they eat is the main factor that determines the bacterial communities. If the place of origin or genetic makeup is (also) important, we expect differences between them.

2. Larvae with the original healthy microbiome will be better in surviving parasite attacks than larvae treated with *antibiotics* (which changed their microbiome).

In science, we call these predictions *hypotheses* (plural from *hypothesis*).

Figure 2:
The parasitic wasp (*Asobara tabida*) has a merciless method to attack the fruit fly. Do you know how?

Methods

To answer these questions and test our hypotheses, we collected fruit flies from six different locations all over Europe (Germany, the Netherlands, Scotland, and France). We then brought them into the lab where we fed them the same food for four years (a total of 50 generations, so a very long time for fruit flies).

Afterwards, we tested whether the bacterial communities were different between fruit fly populations. We wanted to see if their microbiomes overlapped or differed.

To analyse if the microbes help the fruit flies fight off parasite attacks, we divided each of the six fruit fly lab populations into two groups (a treatment and a control group). We then gave antibiotics (which will kill many microbes) to all fruit flies in the treatment groups, but not the control groups.

Finally, we exposed fruit flies' larvae from both groups to parasitic wasps. These wasps normally lay eggs into the baby fruit fly and then the wasp larva eats the poor fly larvae from the inside. Attacked fruit fly larvae can either die or resist the attack by encasing the wasp eggs in a hard shell.

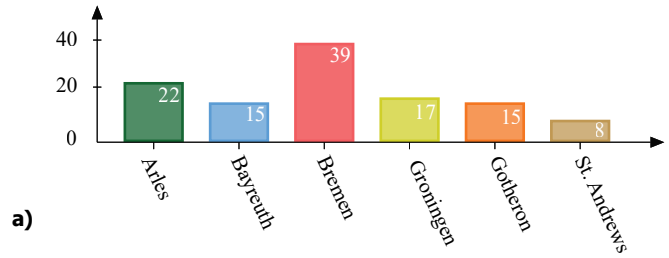
Results

We found that the microbiomes of all our six study populations were different from each other. There were between 8 and 42 different types of microbes (bacteria) living in each fly but not much overlap between microbiomes (Fig. 3).

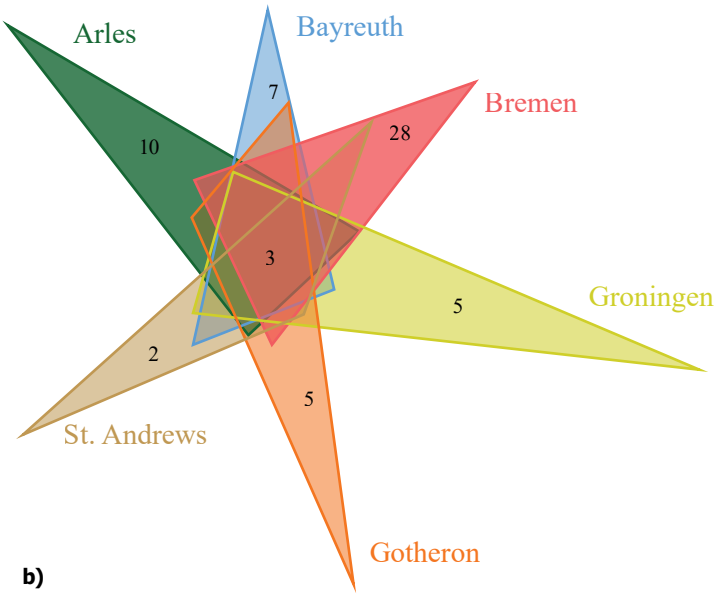
It turned out that the treatment with antibiotics did not kill all the microbes living in the fruit flies, but selectively killed some of them. This resulted in changes in the 'original' microbiomes: we found different types of bacteria in the group treated with antibiotic and the control groups.

Our antibiotic treatment showed no direct connection between the microbiome of fruit flies and their resistance to the wasp attacks. The population from Scotland was more resistant with the original microbes present (without antibiotics), but the other populations did not fare better or worse against the wasps before or after the antibiotic treatment.

Please, see Figure 3 on Page 3



a)



b)

Figure 3:
Our results:
a) The barplot shows the number of different types of bacteria per fruit fly population. The name of the population is where in Europe we got them from.

b) A Venn diagram between the six fruit fly populations. It shows the different types of microbes in the microbiome of each.

The overlapping parts in the center represents the number of microbial types that are shared among the different fruit fly groups. (*How many were there?*) The non-overlapping parts represent types of microbes which are unique to each single group.

Discussion

Our results clearly show that the microbiome of fruit flies differs between geographically separated populations of fruit flies, regardless of diet. We do not know if this is due to genetic differences between the fruit flies, or due to their different places of origin. It is interesting, however, that over the four years in the lab eating the same food their microbiomes did not become more similar.

As we saw, the antibiotics did not kill off all the microbes in the fruit flies, but rather changed the type of species they hosted. The flies' response to parasites probably depends on the exact type of microbes present within a microbiome (because each microbe interact with the insect's immune system differently). Therefore, it is not surprising that different microbes can have quite different effects on parasite resistance.

Conclusion

We are still uncovering how important microbes are for health, growth, digestion and other body functions, both in ourselves, other animals, plants and insects. We still need to know more on what each microbe does, and how they act together in the microbiome, or which microbes are important for functions like fighting off parasites.

So there is still a lot to figure out in future studies. But let's not underestimate that despite their tiny sizes, microbes are of enormous importance, not only for fruit flies, but also for our own bodies and health.

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Glossary of Key Terms

Microbes – are organisms that are so small that you have to use a microscope to look at them. (Sometimes they are so small that millions of them can fit in the eye of a needle). They can either consist of a single cell, or several cells. They are bacteria, archaea, fungi or other tiny organisms.

Microbiome – the ecological community of microorganisms that live in and on animal or human bodies. These microorganisms can either be beneficial for their host (*symbiotic*), without positive or negative consequences (called *commensal*), or harm their host (which means they are *pathogenic*).

Population – a group of organisms who live together or close by.

Model organism – is a species that has been widely studied, usually because it is easy to maintain and breed in a laboratory. Scientific discoveries in model organisms can often tell us a lot about the workings of many other organisms, too. Some common model organisms, besides fruit flies, are mice, zebra fish, the bacteria *Escherichia coli* etc.

Antibiotic – a chemical substance that kills bacteria.

Hypothesis – a prediction scientists make (usually based on observation or previous scientific knowledge) which can be tested.

Parasite – is an organism that lives in or on other organisms (the host), and benefits at the expense of the host. Parasites don't usually kill their host (or not right away at least, as predators do), because it is in their self-interest to keep the host alive to keep exploiting it. For instance, a tapeworm is a human parasite. For the fruit flies in our study, we specifically looked at a parasitic wasp that lays their egg into the fruit fly larvae. The wasp then develops inside the fruit fly larva, slowly eating away at it from the inside.

Check your understanding

1. The insect we used our study, the fruit fly (*Drosophila melanogaster*) is a model organism. What does this mean? And how does this make our study easier?

2. What functions could the microbiome have in fruit flies? What about in humans?

3. For our parasite resistance experiment, we split our fruit fly populations into "treatment" and "control" group. Why do you think did we choose to have the control group that we did not do anything to? Wouldn't it have been easier to just use one group for the experiment?

4. Which statement do you think is true for the human microbiome:
   a) We have many more human cells than non-human microbial cells in our body
   b) We have about the same amount of non-human microbial cells in our body as human cells
   c) We have many more non-human microbial cells in our body than human cells.

5. Are all microbes in our body (or that of insects) beneficial to us or their other hosts?