



Should everyone feed their bees spirulina?

Do you eat spirulina as a nutritional supplement? If not, there's a good chance you've eaten fish, eggs, chicken or beef that was fed spirulina. Why? Because spirulina (i.e., the microalga *Arthrospira platensis*) is packed with nutrients and relatively easy and cheap to produce.

So, if spirulina is so great, why isn't it used as a nutritional supplement for honey bees? Beekeepers of-

ten complain that pollen substitutes aren't as nutritious as real pollen. Is spirulina more nutritious than existing pollen substitutes, which are made from soy, yeast, egg, wheat or lentils? And what happens when bees eat spirulina? Does it actually lead to healthier bees? These are the topics for our thirty-second "Notes from the Lab," where we highlight "Nutritional and prebiotic efficacy of

the microalga *Arthrospira platensis* (spirulina) in honey bees," written by Vincent Ricigliano and Michael Simone-Finstrom and published in *Apidologie* [2020].

For their study, Ricigliano and Simone-Finstrom first compared the types of nutrients that are found in dry spirulina powder (commercially sourced), fresh spirulina (grown fresh in the lab), a common pollen substitute (commercially sourced), and real polyfloral pollen (collected using pollen traps at a USDA ARS apiary in Baton Rouge and immediately frozen). The authors analyzed the amino acid content of each diet (amino acids are the building blocks of proteins) and the lipid profile of spirulina (i.e., all the different types of lipids and sterols).

Next, small cages of newly-emerged workers (50 bees/cage) were used to test how well honey bees consumed the dry or fresh spirulina compared to pollen substitute or real pollen. In addition, the authors tested how the bees responded to each diet via several health metrics. Specifically, to see if they gained weight (and what type of weight they gained), Ricigliano and Simone-Finstrom measured thorax weight, head protein and fat body mass after the bees had consumed the diets for 5 or 10 days.

To assess nutritional status, the authors measured vitellogenin expression and gut bacteria abundance. Vitellogenin is a lipoprotein produced in fat body cells that's often used as a biomarker of diet quality and nutritional status. Gut bacteria abundance

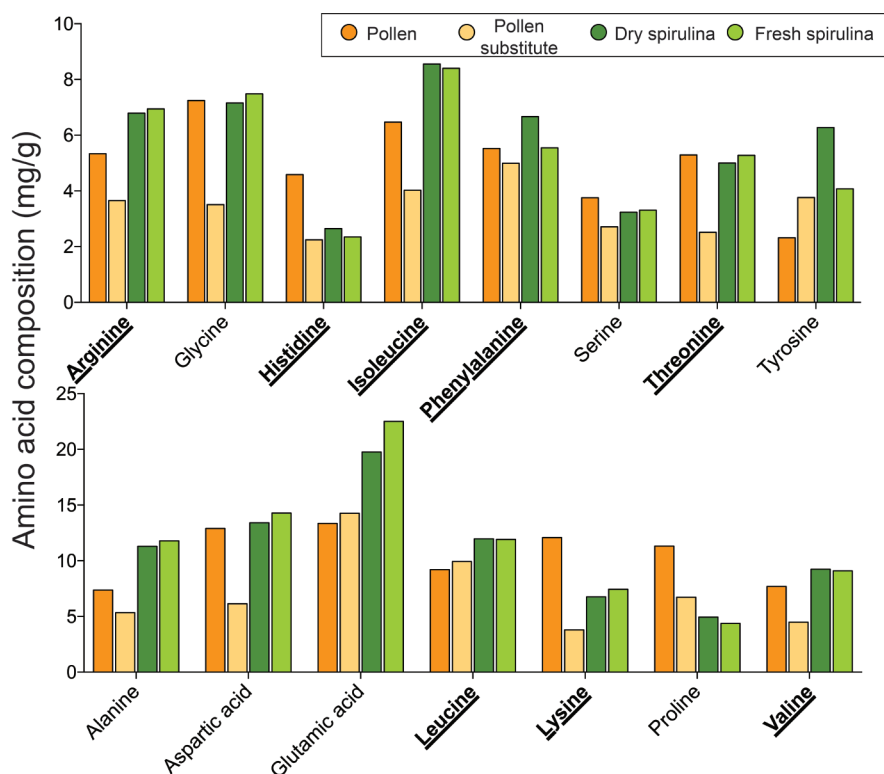


Fig. 1 Amino acid content of different protein sources: bee-collected pollen, pollen substitute, dry spirulina, and fresh spirulina. Essential amino acids are underlined in bold.

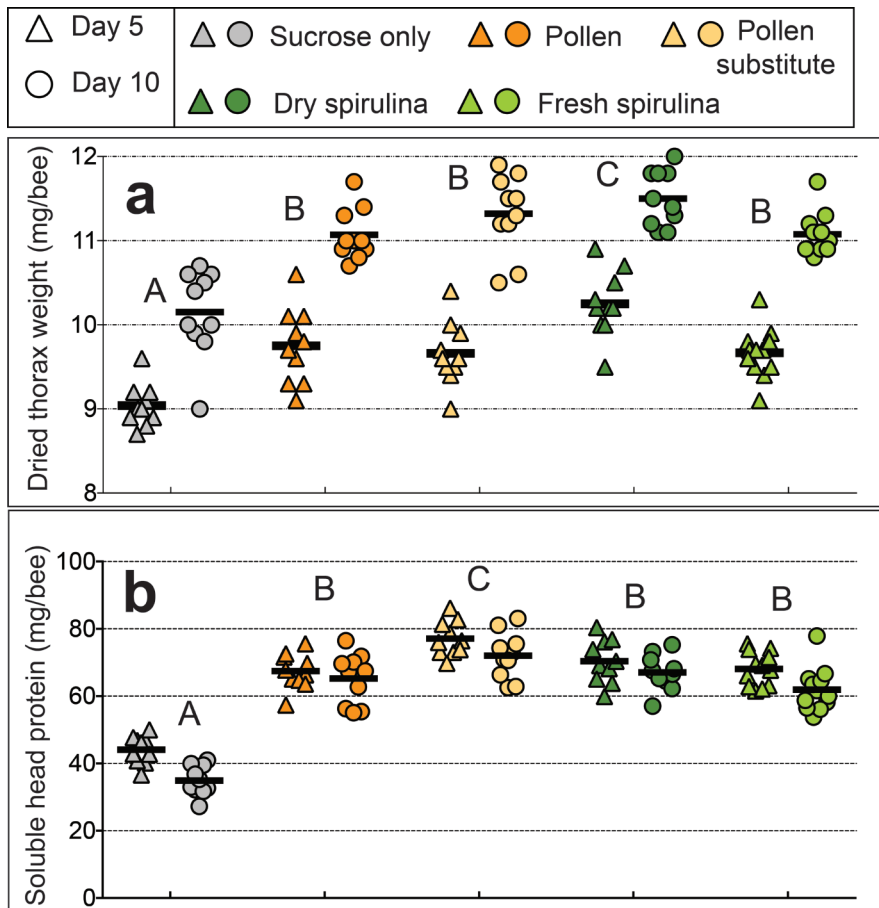
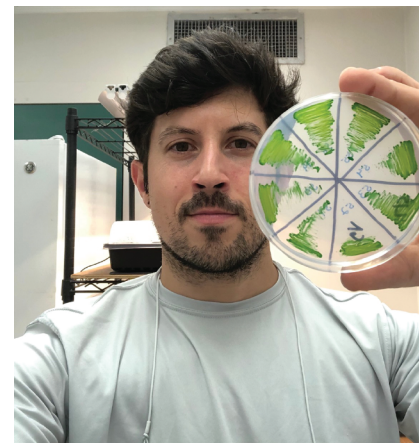


Fig. 2 Protein assimilation in bees fed different diets after 5 and 10 days. (a) Thorax weight as a proxy for flight muscle development. (b) Soluble head protein as a proxy for hypopharyngeal gland development. Each point represents an independent cage of worker bees, black horizontal lines indicate the mean. Different letters indicate statistically significant differences ($P < 0.05$).

was assessed to evaluate how spirulina may act as a “prebiotic” nutrient source (i.e., a nutrient source that could potentially promote beneficial gut microbiota in the bees). As we all know nowadays, a healthy gut microbiota is critical for all animals, including honey bees.

So, what did they find? Did the dry or fresh spirulina contain good

nutrients compared to the artificial pollen or real pollen? Yes and yes. In fact, as can be seen in Figure 1, both dry and fresh spirulina nearly always had higher amino acid concentrations compared to real pollen (compare the green bars to the orange bars in Figure 1). Interesting! This included all the essential amino acids (i.e., the amino acids that bees can’t make on



Vincent shows spirulina growing on a petri dish. “This is how I start larger cultures to grow up the ‘fresh spirulina’ diet that was fed to bees.”

their own and therefore must have in their diet) with the exception of histidine and lysine.

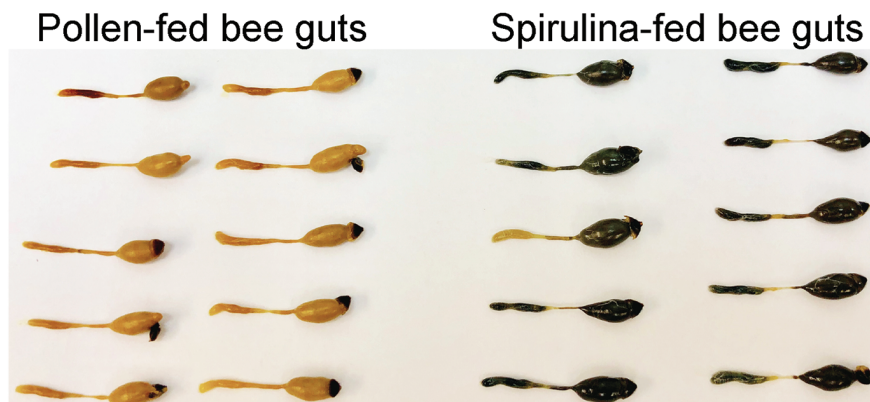
When compared to the pollen substitute, both dry and fresh spirulina always had higher amino acid concentrations (compare the green bars to the yellow bars in Figure 1). Finally, for those of you who are wary about growing your own spirulina, you’ll be happy to see there was very little difference in amino acids between the dry spirulina powder (i.e., spirulina that was bought at a store) and fresh spirulina (i.e., spirulina that was grown fresh in the lab).

What about consumption? Did the bees actually consume the spirulina?

Yes. And before you start thinking this is weird, remember that spirulina is a plant, and pollen comes from ... plants. Pollen is packed with proteins and lipids, and so is spirulina. So, perhaps it shouldn’t be surprising that bees will readily eat spirulina.

More specifically, in two different tests, the bees consumed almost as much spirulina as pollen substitute or real pollen. Not quite as much — about 10-25% less after 10 days compared to real pollen, and about 5-10% less after 10 days compared to pollen substitute. This slightly lower consumption of spirulina is actually quite interesting given the next results.

Did the bees gain weight when fed spirulina? Yes. Even though they ate 10-25% less spirulina compared to real pollen, the bees gained just as much weight (dried thorax weight shown in Figure 2, panel a) and had just as much protein in their heads (soluble head protein content shown in Figure 2, panel b) compared to bees that consumed fresh pollen.



Vincent removed 10 bee guts per cage to show that consumption of diets in a cage is relatively uniform among bees in a single cage.

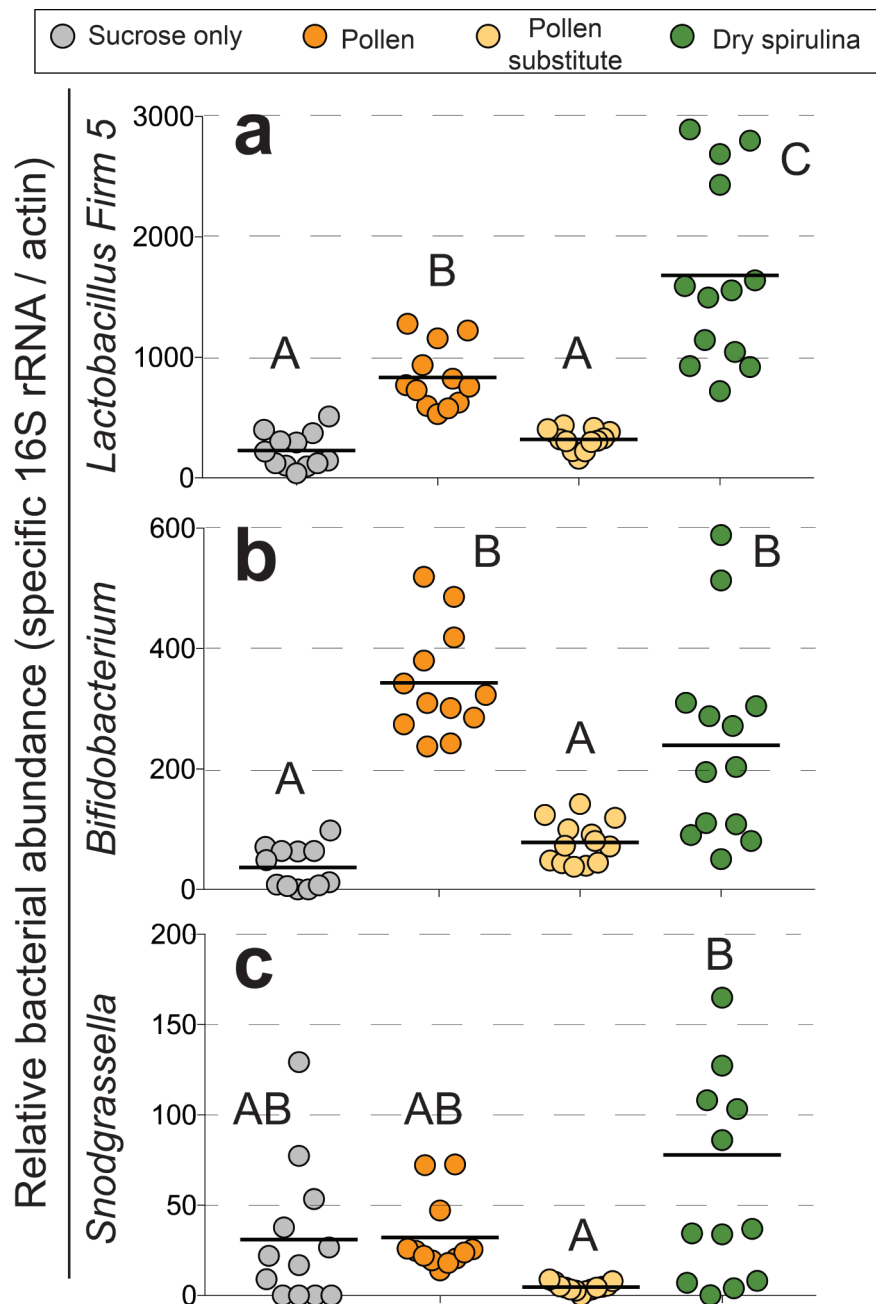


Fig. 3 Relative core gut bacteria abundance in bees fed different diets at day 10. Each point represents an independent cage, black horizontal lines indicate the mean. Different letters indicate statistically significant differences ($P < 0.05$).

Compared to the pollen substitute, bees that consumed spirulina gained about as much weight (Figure 2, panel a) and had slightly lower levels of protein in their heads (Figure 2, panel b). Finally, fat body mass after 10 days was similar between bees fed spirulina vs. fresh pollen, and slightly higher in bees fed spirulina vs. pollen substitute.

OK, this seems really promising. But how healthy were the bees? Ricigliano and Simone-Finstrom assessed two measures of nutritional status and health. First, they found that vitellogenin expression was

equivalent or higher in bees that consumed spirulina vs. fresh pollen, and either slightly higher or slightly lower (depending on which vitellogenin gene was expressed) in bees that consumed spirulina vs. pollen substitute. This indicates that nutritional status of the bees that consumed spirulina was very good.

Second, when the authors looked at bacterial abundance in the guts of the bees fed different diets, they found that bees that consumed spirulina had “good” gut bacteria that were as abundant as, or slightly more abundant than in bees fed fresh pol-



Bees consume fresh spirulina in the hive.

len (compare the green dots to the orange dots in Figure 3). However, bees fed pollen substitute had very little “good” bacteria — between ~60-90% less than bees fed spirulina (compare the green dots to the yellow dots in Figure 3).

This result comparing gut bacteria in spirulina-fed vs. pollen-substitute-fed bees is especially important since we’re starting to realize just how critical it is for honey bees to have a healthy gut microbiota. While pollen substitute doesn’t foster this healthy microbiota, spirulina does. Thus, compared to a popular existing pollen substitute, the nutrients in spirulina not only promote bee growth, they also act as a “prebiotic” that fosters healthy gut microbes and overall bee health. That is very promising for beekeepers who need (or want) to feed their bees but don’t want to compromise the health of their bees via poor nutrition.

Until next time, bee well and do good work.

Scott McArt

REFERENCE:

Ricigliano, V. A. and M. Simone-Finstrom. 2020. Nutritional and prebiotic efficacy of the microalga *Arthrospira platensis* (spirulina) in honey bees. *Apidologie*. <https://doi.org/10.1007/s13592-020-00770-5>



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