EFFECT OF DIETARY PROTEIN ON HONEY BEE POLLEN FORAGING BEHAVIOR

PROVIDENCE COLLEGE

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Background

Bees obtain nutrients from flowers. Pollen provides proteins and fats; nectar provides carbohydrates. Pollen is important for providing essential amino acids which honey bees must obtain from their diet for proper development. Commercial honey bee colonies, however, pollinate monocultures, which contain one crop type thus, one unbalanced nutritional resource (Table 1). We examined how a lack of protein diversity affects honey bee pollen foraging behavior. Bees were raised on three diet treatments: no manipulation, all 10 essential amino acids (EAAs, i.e., protein building-blocks), or only 6/10 EAAs. Bee-collected pollen was trapped upon return to the hive and nutritional content was analyzed. We predict that bees raised on a diet lacking EAAs will compensate by foraging for pollen higher in nitrogen.

Table 1. Essential amino acids in honey bee diet broken down into minimum percent content required of the amino acid, how much is found in sunflower pollen and almond pollen

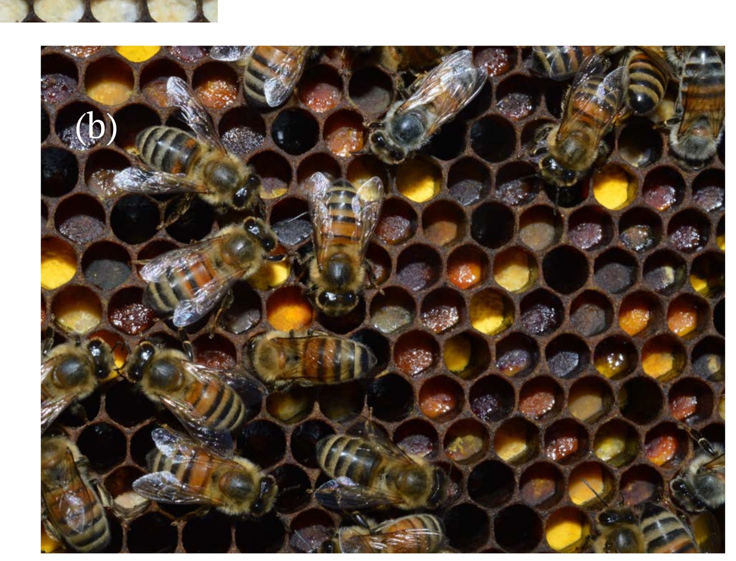
Honey bee EAAs (DeGroot, 1953)	Minimum % required by the honey bee (DeGroot, 1953)	% in bee collected sunflower pollen (Nicolson and Human, 2012)	% in bee collected almond pollen (Standifer, et al., 1980)
Arginine*	3.0	4.2	1.2
Histidine*	1.5	5.7	0.5
Isoleucine*	4.0	3.9	1.2
Leucine*	4.5	6.3	1.9
Lysine	3.0	6.3	2.9
Methionine*	1.5	0.3	0.5
Phenylalanine	2.5	3.9	1.2
Threonine	3.0	4.4	1.0
Tryptophan	1.0	0.2	0.0
Valine*	4.0	4.3	1.6

*amino acids in dandelion pollen (Auclair and Jamieson, 1948; Loper and Cohen, 1987)

Methods

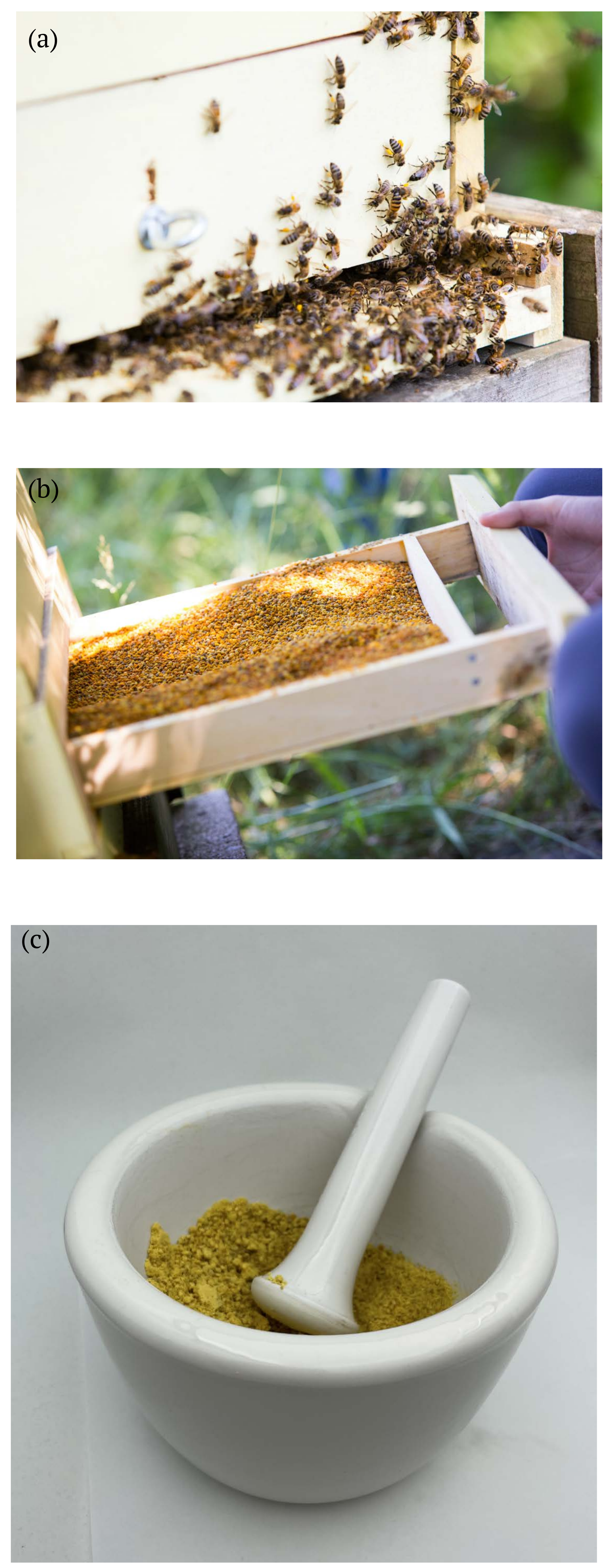
For the different diet treatments, semi-synthetic powder diets were created to mimic natural pollen diets with different ratios of amino acids present (Figure 1). In 2017, these diets were then placed in the field in a drawn frame and hives were checked on a weekly basis. Pollen samples were then collected for further analysis and stored appropriately (Figure 2). In 2021, the samples were homogenized with a mortar and pestle. Using Providence College's elemental analyzer (Elementar), the samples from treated hives were combusted to determine the percent carbon and nitrogen present along with ratio of carbon to nitrogen. Data was collected using 18 samples per diet treatment. These data were then analyzed using R to perform a Welch two-sample t-test.

Figure 1. (a) Honey bees on a frame with the semi-synthetic diet. (b) Honey bees on a frame with naturally collected and stored pollen. All photos: Rachael E. Bonoan

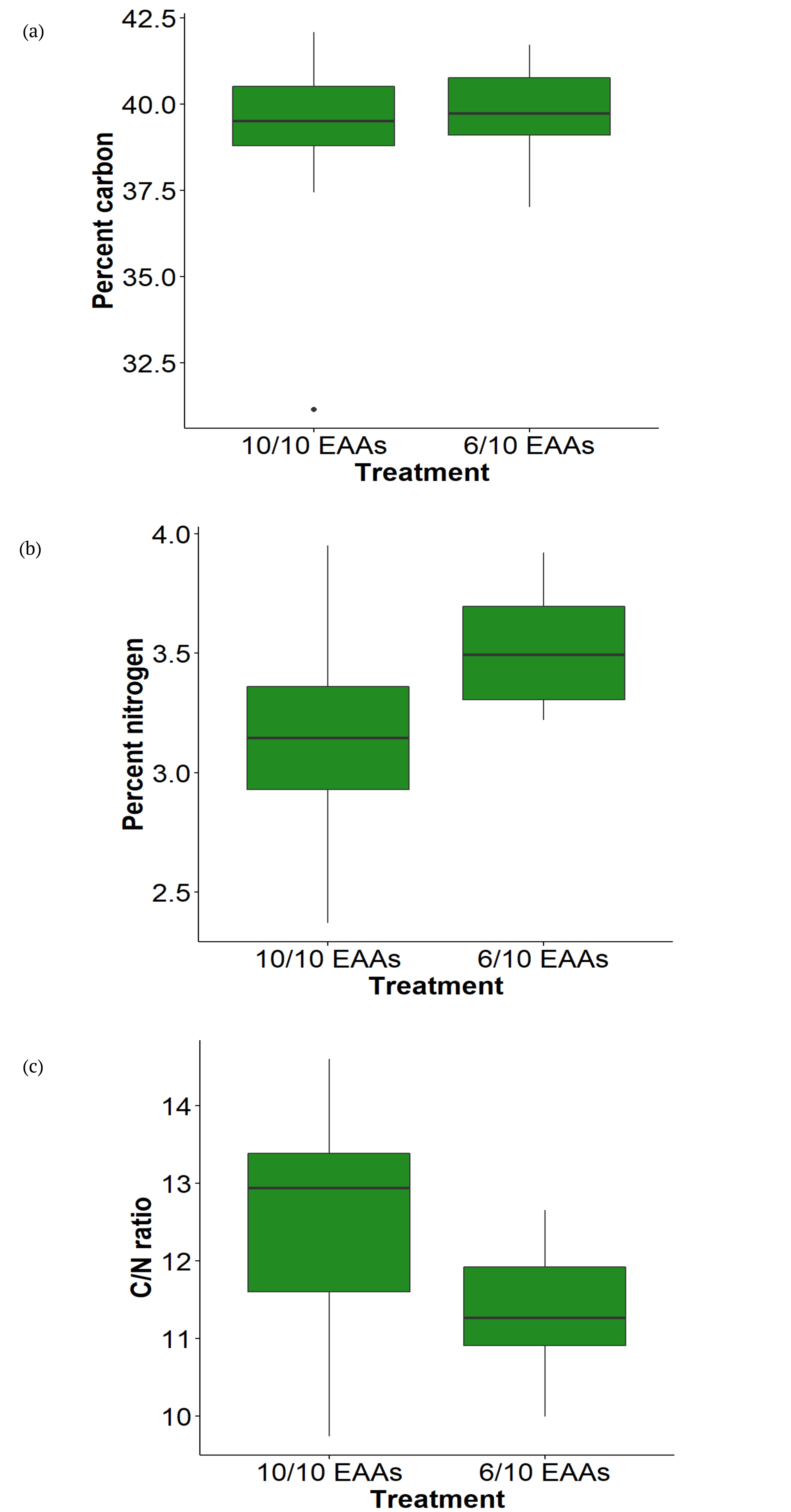


Results

Our results show a much higher amount of nitrogen brought back to the hives raised on 6/10 EAAs compared to 10/10 EAAs. Bees brought pollen with similar amounts of carbon back to the hive, no matter the diet treatment (t-test, $t = -0.72$, $df = 27.76$, $p = 0.48$) (Figure 3a). Bees raised on 6/10 EAAs brought pollen with significantly more nitrogen back to the hive than those raised on 10/10 EAAs (t-test, $t = -2.81$, $df = 25.65$, $p = 0.01$) (Figure 3b). Similarly, bees raised on 6/10 EAAs brought back pollen with a significantly higher ratio of carbon to nitrogen (t-test, $t = 2.81$, $df = 24.26$, $p = 0.01$) (Figure 3c).



Figures 2. (a) Bees returning to a hive with a pollen trap. (b) Bee collected pollen trapped upon entry to the hive. (c) Homogenized pollen in a mortar and pestle.



Figures 3. (a) Percent carbon in 10/10 EAAs and 6/10 EAAs treatments. (b) Percent nitrogen in 10/10 EAAs and 6/10 EAAs treatments. (c) Carbon to nitrogen ratio in 10/10 EAAs and 6/10 EAAs treatments.

Conclusion

These data support our hypothesis that bees will forage for pollen with a higher nitrogen content to compensate for the essential amino acids lacking in the 6/10 EAAs diet . Future research could investigate what specific amino acids honey bees are bringing back to the hive. Honey bees, like bumble bees, are generalist foragers so what can be learned from the honey bee nutritional data can be applied to bumble bees as well.

Photo: Susan E. Ellis

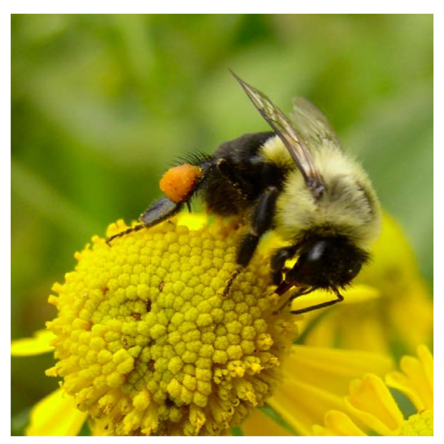


Photo: Beatriz Moisset

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