Seasonality of Mineral Preferences in Honey Bees

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Background

Nutrition shapes all living organisms, and yet there are few studies that take into account the complexity of nutrition at the ecological level.[1] Nutrition is not as simple as balancing energy intake with energy output; many organisms require a certain balance of complex resources such as carbohydrates, proteins, lipids, vitamins, and minerals.[2] While nutrition is often studied with a focus on macronutrients (i.e. carbohydrates and protein), micronutrients are just as physiologically important.[3,4]

This study examines the nutritional ecology of a specific honey bee behavior: honey bees prefer dirty water over clean water (Fig 1). Since a bee's main floral diet only contains trace amounts of essential vitamins and minerals,[5] **I hypothesize that to obtain a well-rounded diet, honey bees selectively forage in soil and water for minerals the colony may lack.** Butterflies,[6,7] ants,[8,9] and solitary bees[10] exhibit a similar behavior. I predict that compared to deionized water, honey bees will prefer mineralized water. As honey bees live in temperate regions and the hive is a dynamic environment, I also predict that mineral preferences will vary with forage changes across seasons, and with hive health parameters.

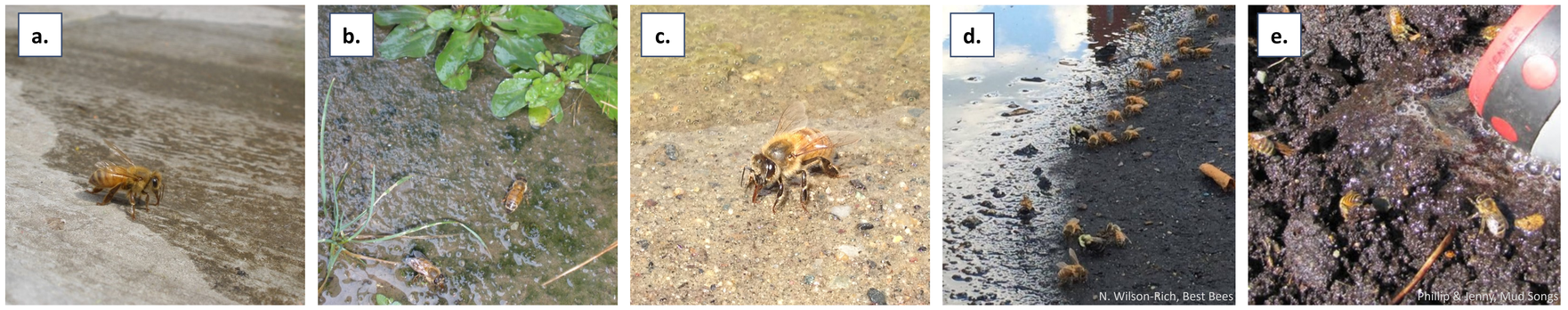

Fig 1. Honey bees drinking dirty water in (a-c) Medford and (d) South Boston, MA, and (e) Newfoundland.

Methods

Preference assays (Fig 2) were set up using 8 different solutions (Table 1). Overall mineral preferences were determined by measuring volume change of each solution after 5 - 7 hours of foraging. Assays were run during Fall and Summer. To determine hive-specific preferences, hives were marked with a unique colored powder and the number of visits each hive (n=8) made to each solution (Fig 3) was counted. Hive health was tracked by estimating the adult population and capped brood area (amount of oldest brood) of each hive 3 times per week.

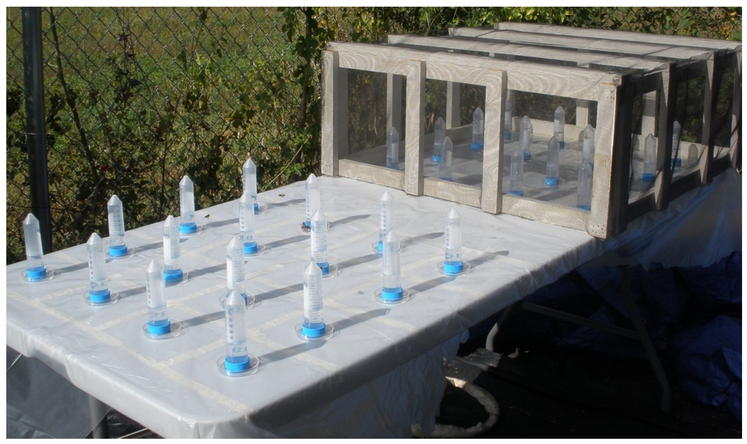

Fig 2. Preference assay set up.

Table 1. Solutions tested.

Micronutrient	Solution
	Deionized Water
	Sucrose
Sodium	NaCl (1%)
Potassium	KCl (1%)
Magnesium	$MgCl_2$ (1%)
Calcium	$CaCl_2$ (1%)
Nitrogen	NH_4Cl (1 %)
Phosphorous	KH_2PO_4 (1%)

Fig 3. Mass-marked honey bees at the preference assay.

Results: Mineral Preferences

Season did not have a significant effect on mineral preferences (Fig 5a) however, bees do tend to drink more water in the summer than in the fall (Fig 5a). Thus, relative to deionized water, there is a seasonality of mineral preferences for **K, Ca, N, and P** (Fig 5b). No matter the season, bees have a strong preference for **Na** compared to water.

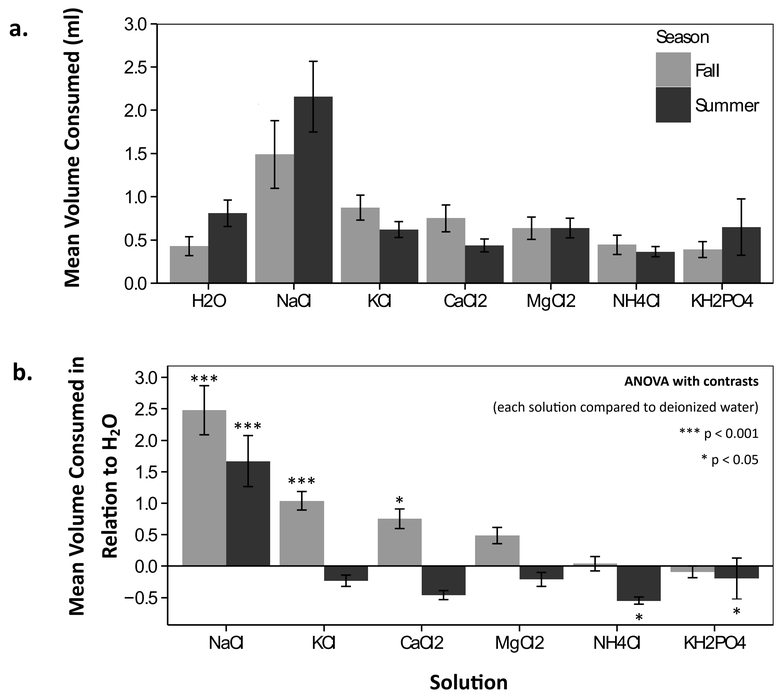

Fig 5. (a) Mean volume change of each mineral solution. (b) Mean volume change of each mineral solution in relation to that of deionized water (0.0).

Results: Hive Health

The number of visits to each solution significantly differed between individual hives. Also, the number of visits significantly correlated with hive health parameters (Fig 6). Data were collected from 8 observation hives; Fig 6 shows a representative **healthy** and **unhealthy hive**.

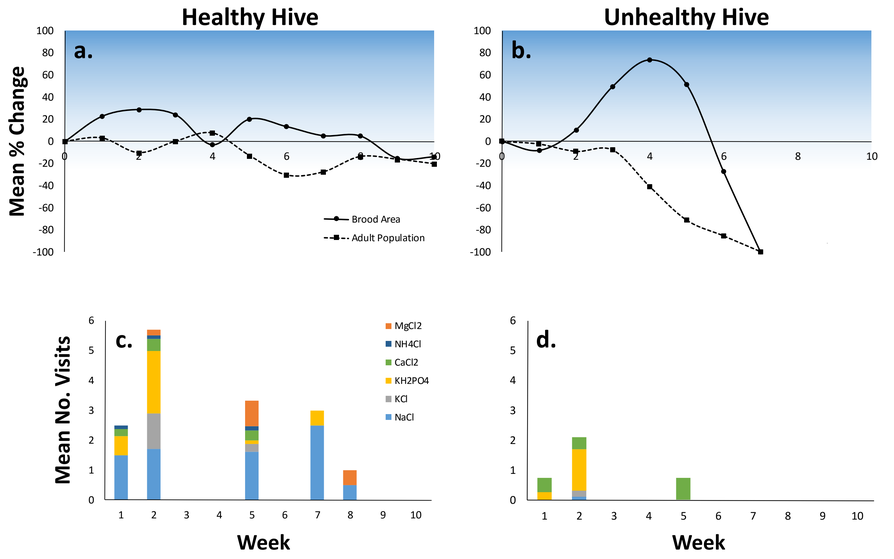

Fig 6. Mean percent change per week relative to baseline hive health parameters of a (a) healthy and (b) unhealthy hive. Mean number of visits per week to each solution of a (c) healthy and (d) unhealthy hive.

Conclusions

Although there was not a seasonality of mineral preferences overall, there is a seasonality of the proportion of K, Ca, N, and P consumed compared to deionized water. K and Ca are two of the most prevalent minerals found in bee-collected pollen. Furthermore, the levels at which these minerals are found in pollen varies with season; there are higher levels in the summer and lower levels in the fall. Pollen is also a good source of N however, there are less floral resources in the fall than in the summer. **Thus, honey bees are likely switching their mineral preferences based on the floral landscape.** Also, mineral preferences do correlate with internal hive dynamics. These data will allow for better understanding of nutrition throughout the year for managed honey bee hives as well as wild pollinator populations.

Acknowledgements

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