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Carpenter Ant-Microbe Interactions: A Focus on Yeast Associates

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Abstract

The yeast microorganisms associated with *Camponotus vicinus* are discussed. Experiments where worker ants and larvae were fed holidic or nutrient deficient diets and then exposed to the yeast, *Debaryomyces polymorphus* showed that pupal weight was sometimes positively affected by exposure to *D. polymorphus*. It is speculated that the yeast may aid in more efficient assimilation of nutrients when fed nutrient-deficient diets, particularly diets lacking sterols.

Introduction

The carpenter ant *Camponotus vincinus* (Mayr) is widespread pest of wood in service particularly in the Pacific Northwest where it is common (Mankowski and Morrell, 2000). Workers possess a buccal filter or infrabuccal pocket limiting the ability of large food particles to enter the midgut (Eisner and Happ 1962). The yeast *Debaryomyces polymorphus* (Kloecker) has been found in the infrabuccal pocket as well as in the nests of *C. vincinus* (Mankowski and Morrell 2004). The nutritional contribution associated with this yeast to the diet of *C. vicinus* is unknown. Ba *et al*. (1995, 2000) found yeasts associated with colonies of the fire ant *Solenopsis invicta* (Buren) appeared to contribute to overall colony health producing exogenous sterols the ants themselves could not generate. In beetles, yeast-like endosymbionts present in the digestive systems supply nutrients and necessary metabolic compounds for larval development

(Pant and Dang 1972). Other insects use yeasts to aid in the synthesis of nutrients absent in their diets such as B complex vitamins and sterols (Dadd 1985).

We examined the potential contribution of the yeast *D. polymorphus* to the nutrition of *C. vicinus* using component deletion of a holidic artificial diet developed in a previous study (Mankowski and Morrell 2014).

Materials & Methods

The effects of adding live *D. polymorphus* to diets was assessed by feeding the ants a basal diet containing all dietary components and diets deficient in particular components. Four diets were tested: A basal (complete) diet, the basal diet minus B vitamins, the basal diet minus B vitamins and cholesterol, and sugar water only. Ants and larvae were fed these diets only and a second set fed these same diets augmented with live *D. polymorphus* cultures.

Sixteen groups of *C. vicinus* consisting of 8 workers and 15 second to third instar larvae were fed the aforementioned diets for a 12 week period (Mankowski and Morrell, 2014). Half of the replicates were exposed to yeast cultures using a suspension of *D. polymorphus* grown in 125 ml of vitamin free media (Barnett et al. 1990) and filtered through a 0.22µ filter paper. Yeast cells were removed from the filter paper and added to 20 ml of sterile water. The yeast suspension was applied topically to the worker ants and larvae in 100 µl aliquots so that the workers would ingest the yeasts as they groomed themselves and larvae. Larval development was monitored for the 12 week period and pupae were removed as they developed and incubated at 25° C until the cuticle of the ant inside darkened. When this occurred the ant was physically removed from the pupal case and its weight were recorded.

Results and Discussion

Pupal weights for ants and larvae fed four diets and the same diets plus live yeast cultures are shown in Figure 1. Pupal weights were highest for ants fed the complete basal diet only. This same diet plus exposure to yeast resulted in slightly lower pupal weights. All other diets resulted in lower pupal weight compared to the basal diet only. Ants fed diets lacking both B vitamins and cholesterol, but exposed to live yeast, had heavier pupae than those not exposed to yeast and fed the same diet.

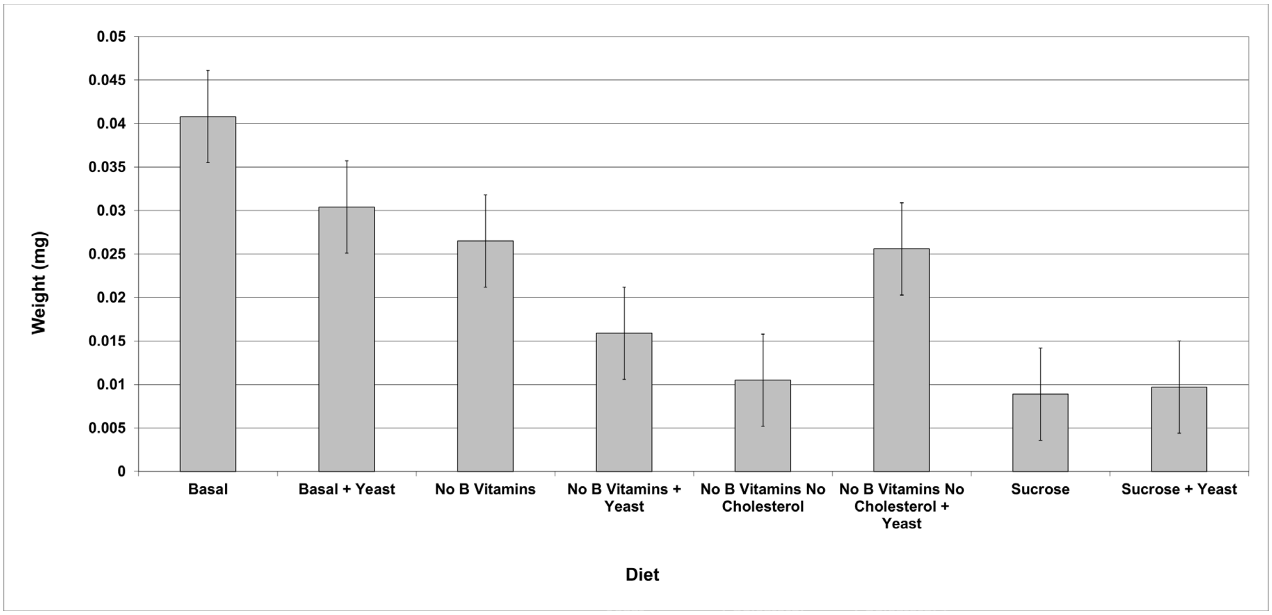

Figure 1. Average pupal weight of 2nd and 3rd instar *C. vicinus* larvae fed four diets and the same four diets augmented with live *D. polymorphus* after 12 weeks.

Exposure of *C. vicinus* larvae to various diets and the same diets augmented with live *D. polymorphus* affected pupal weights particularly those fed diets lacking both B vitamins and cholesterol and exposed to live yeast. Interestingly, brood exposed to a diet lacking all B vitamins and exposed to live yeast did not react similarly indicating that the yeast may supply sterol compounds that aid in pupal development. Unlike vertebrates, which biosynthesize sterols directly from acetate, insects have no way of synthesizing sterol compounds and must obtain them from their diet or microbial symbionts (Friend and Dadd, 1982). In insects, sterols are necessary for molting to occur and are necessary for proper development and growth (Schneiderman and Gilbert 1964). Although the yeast may have helped the brood in the treatments minus cholesterol and B vitamins, ants fed sugar water only and sugar water with yeast did not differ. Sucrose treatments also lacked B vitamins and cholesterol, but there was little or no difference between the ants exposed and those not exposed to yeast. Ba et al. (1995) measured sterol levels in fire ants and concluded that fire ants may obtain ergosterol from associated midgut yeasts. Maurer et al. (1992) examined sterols associated with leaf-cutting ants and found that the ants obtained sterols from their fungal symbiont. Smith (1944) found that carpenter ant colonies reared smaller brood on diets without yeast extract, indicating that yeast or something produced by yeast was beneficial to brood development.

The presence of *D. polymorphus* may have affected larval development of *C. vicinus* by producing nutrients or enzymes that facilitated larval digestion. Although we have only tested this for *D. polymorphus*, a more complex microbial community is probably involved in associations between carpenter ant nutrition and the infrabuccal pocket.

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