

BEHAVIORAL PERSPECTIVES ON COCKROACH BAIT AVERSION

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Abstract Bait aversion is a behavioral avoidance phenomenon, whereupon some naturally and/or artificially (e.g. toxic baits) selected *Blattella germanica* genotypes become less responsive to or completely avoid certain phagostimulatory food ingredients. Cases of avoidance behaviors, including associative learning, in vertebrates and invertebrates are reviewed to provide insights and stimulate discussions on how the German cockroach may have developed its olfactory and gustatory means to discriminate these food components.

Key Words Behavioral avoidance, bait aversion, olfactory, gustatory. *Blattella germanica*

The resurgence of bait aversion has once again tainted the successful long history of using non-repellent toxic baits in German cockroach, *Blattella germanica* (L.), management programs, and has directly affected business services of professional pest management companies in the United States (Harbison et al., 2003). While the first documented bait aversion by Silverman and Bieman (1993) demonstrated that a single major gene, which controlled glucose aversion, was the fundamental cause in the T-164 *B. germanica* genotype, the underlying mechanism of the most recent bait aversion is yet to be established. Wang et al. (2004) reported that the Cincy strain of *B. germanica* showed feeding aversion to several mono- and disaccharides, including glucose, fructose, sucrose and maltose, which are phagostimulants to the non-aversive J-wax laboratory strain. This may in part explain some of the evolving mechanisms related to bait aversion under investigations.

Bait aversion is a behavioral avoidance phenomenon. It can be viewed as a diminished, averted or completely halted feeding process where a behavioral avoidance must occur either in the olfactory or in the gustatory system, or in both sensory systems. Under this assumption, it is necessary to determine first where exactly the avoidance behavior may originate. Bait aversion in *B. germanica* has been quantitatively measured by a comparative consumption ratio, or feeding index. This is based on carefully designed experiments in which paired bait formulations or individual ingredient(s) are tested against a blank background media, usually agar (Silverman and Bieman, 1993; Silverman and Ross, 1994). Without considering olfactory factors, the feeding index is probably an accurate measurement of the gustatory response. However, if aversion occurs in receptors or signaling pathway of the olfactory system, the feeding index can be a confounding measurement of responses. Hence, new experimental techniques and methodologies will help advance our knowledge considerably.

Avoidance behavior is modulated by learned as well as the innate factors. It is known that human and animal infants at perinatal stage, prior to any food-intake experience, were found to respond differentially to sweet and bitter tastes, these behavioral displays can be seen as innate and probably even inherited competencies of the nervous system (Steiner 1997). Glucose aversion in *B. germanica* was also confirmed as an inherited autosomal incompletely dominant trait rather than being learned (Silverman and Bieman, 1993; Silverman and Ross, 1994).

Learned avoidance behavior has been studied extensively in vertebrates, especially conditioned learning behaviors in rodents (Gustavson and Gustavson, 1982; Grill, 1985). Pavlovian conditioning is a widely used technique that pairs a neutral conditional stimulus (CS) with a biologically significant unconditional stimulus (UCS). When an UCS elicits an unconditional response (UCR) in rats, the CS eventually becomes associated with the UCS as a result of CS-UCS pairings. The acquisition of this association is called conditional response (CR). Once this association is established, such CR may be elicited and generalized by novel stimuli. There has been no documented evidence that such a CR generalization may occur or relevant to the bait aversion in *B. germanica*. But it may explain why the multiple sugar aversion found in the Cincy strain (Wang et al., 2004), in the absence of the genetic basis as illustrated for glucose aversion (Ross and Silverman, 1995).

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