Anaphylaxis to the Ingestion and Inhalation of Tenebrio Molitor (Mealworm) and Zophobas Morio (Superworm)

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Anaphylaxis to the Ingestion and Inhalation of Tenebrio Molitor (Mealworm) and Zophobas Morio (Superworm)

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ABSTRACT

It has been well documented, worldwide, that inhalation and/or contact with airborne particulate insect products has resulted in sensitivity to insect proteins and is manifested by such common entities as dermatitis, conjunctivitis, rhinitis, and asthma. However, the deliberate ingestion of a variety of insects (undertaken to prove their edibility and nutrient value) resulted in subsequent sensitization of some individuals. Such an outcome has not previously been reported in the literature. The objective was to document the anaphylactic reaction to the purposeful ingestion of mealworm in an individual known to be sensitized to the inhalation of beetle larvae. We used the occasion of the Centennial Celebration of The New York Entomological Society to expose members and guests of the Society to the ingestion of various insects. The subjects of the study consisted of: 1) Three members who were adversely affected; 2) One individual with Baker's asthma; and 3) A number of controls with no known hypersensitivity to insect products. The investigation was undertaken by food challenges, inhalation challenges, skin testing to the individual insect allergens, a) Tenebrio molitor (TM), b) Zophobas morio (ZM), c) Blattella germanica (BG), skin testing to common indoors and outdoor allergens, and direct bind ELISA and ELISA inhibition. One individual manifesting hypersensitivity both by ingestion and inhalation to mealworm was identified. This sensitivity was documented clinically as well as by objective testing. (Allergy and Asthma Proc 17:215–219, 1996)

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As early as 1929, Parlato in the first "Journal of Allergy" documented allergic manifestations caused by the inhalation of insect emanations.[1,2] In 1941, Sheldon and Johnston reported the inhalation hypersensitivity to beetles (order Coleoptera).[3] This was followed by other reports further documenting upper and lower respiratory allergies to the yellow mealworm, Tenebrio molitor (Figure 1).[4,5]

Insects have been and still are an important source of human nutrition. In prehistoric times and currently in Africa, Australia, Asia, South America, and among the Indians in Western America, insects have been an important source of protein in the diet. (Most dramatically, Captain Scott O'Grady survived on ants after the recent downing of his

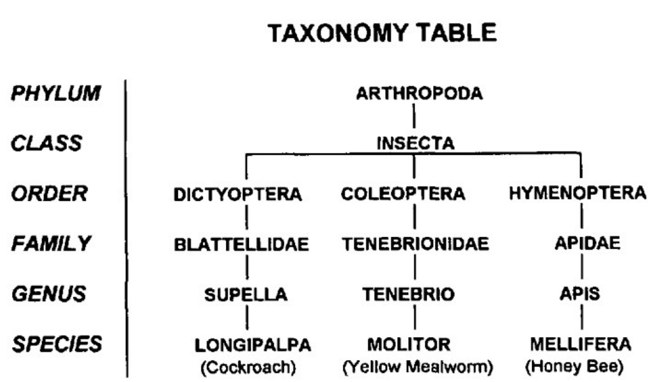

Figure 1. Partial taxonomy of the arthropod phylum.

Menu

At the Bar

Assorted Crudites with
Peppery Delight Mealworm Dip

Butlered Hors d'oeuvres
Plain, Wax work and Meal worm
Avocado California
Rolls with Tamari Dipping Sauce
Wild Mushrooms in Mealworm Flour Pastry
Cricket and Vegetable Tempura
Mealworm Balls in Zesty Tomato Sauce
Mini Fontina Bruschetta with
Mealworm Ganoush
Wax Worm Fritters with Plum Sauce
Roasted Australian Kurrajong Grubs
Sauteed Thai Water Bugs
Thai Water Bug and Mango Dip

Buffet Dinner

Chicken Normandy with Calvados Sauce
Rice Pilaf
Roast Beef with Gravy
Roast Potatoes
Mediterranean Pasta
Melange of Vegetable Ragu
Mesclun Salad with Balsamic Vinegar
Assorted Seasoned and Cricket Breads
with Butter

Dessert

Lemon Squares
Chocolate Cricket Torte
Mini Cannoli
Peach Clafouti
Assorted Insect Sugar Cookies
Coffee and Tea Service

***Figure 2.** Menu: Unique 100th anniversary dinner.*

plane in Bosnia.) The ingested insects are primarily grasshoppers, cicadas, caterpillars and adult moths, grubs and adult beetles, wasps, bees, larvae and pupae of ants, winged ants, and a variety of aquatic insects.

In the Western world, gastrointestinal exposure to insect allergens usually occurs from insect debris found on tomatoes, ketchup, tomato juice, dried fruit, pickles, wine, chocolate, cereals, nuts, grains, flour, cornmeal, and oatmeal.[6] It is therefore predictable that ingestion sensitivity as well as inhalant hypersensitivity follows.[7,8]

***Figure 3.** Plate 2: hors d'ouvres.*

On May 20, 1995, The New York Entomological Society celebrated its 100th Anniversary with a very unique dinner in the splendor of the Explorers Club in New York City.[9] The menu (Fig. 2) featured insect hors d'ouvres, bread, and desserts (Figs. 3, 4, 5). The probands (1, 2, 3) at this unusual dinner were individuals who are regularly exposed to Superworm (Zophobas morio [ZM]), mealworm (Tenebrio molitor [TM]), and German Cockroach (Blatella germanica [BG]). All of these probands were known, by past history, to react to the airborne particulates of these insects, their symptoms being bronchospasm, conjunctivitis, and rhinitis.

***Figure 4.** Plate 3: bread.*

Figure 5. Plate 4: desserts.

One week prior to dinner at a preliminary taste testing, one diner (1) experienced significant symptoms, including generalized urticaria, diarrhea and pruritis of throat, tongue, and palms of hands. These symptoms occurred within 30 minutes after the ingestion of cooked mealworms, crickets, waxworms, and stonefly nymphs (he also had wine). During the next 24 hours, he continued to experience intermittent diarrhea, pruritis of palms of hands, and urticaria on the abdomen and on the dorsum of the feet. He responded to treatment with antihistamines.

METHODS

All patients signed an agreement to participate in the clinical investigation.

The three diners as well as four controls and one patient with Baker's asthma were prick tested to ZM, TM, and GC, GC containing 1.72 mg protein/cc. (Greer); TM 1.07 mg protein/cc (Greer) and ZM 1.36 mg protein/cc (Greer). They were also tested by the intradermal route using Greer extracts of grass, weed, trees, dust, mite, cat, dog, and feathers at 1:1000 w/v dilution with appropriate controls. A skin test was considered positive if there was a wheal at least 3 mm greater than the saline control. They all had ventilatory function testing before and 15 minutes after inhalation challenge to particulate debris of TM, and all had blood drawn for direct bind ELISA and ELISA inhibition experiments. Diner 1 received oral challenge to crickets, waxworms, nonTenebrio larvae, and belostomatid bugs, as well as to the wine he had previously ingested.

ELISA and ELISA inhibitions were carried out as follows: Allergen extracts from TM, ZM, and GC were prepared by homogenizing the whole insects with 20 volumes 0.1 M ammonium bicarbonate in a Waring blender. The homogenate was clarified by centrifugation and dialyzed exhaustively against distilled water at 4 °C. The dialyzed extract was filtered through a sterilizing 0.2 μ membrane filter and lyophilized. The lyophilized extract was reconstituted with 50% glycerosaline before use. The protein content was determined by the Bradford method, using bovine serum albumin as the reference.

Serum was collected from the diners exposed to ZM and TM (via ingestion), cockroach-allergic individuals and nonallergic controls. Direct bind ELISAs were conducted as follows: ELISA plate wells (Corning) were coated using 40 ug/cc TM, ZM, and GC extracts in carbonate coating buffer pH 9.6. The allergosorbent was coated with a 1:10 dilution of each serum for 4 hours. The plate wells were washed with PBS-Tween three times and IgE bound was detected by sequential incubations in biotinylated anti-human IgE (Diagnostic Products Corp., Los Angeles, CA), alkaline phosphatase labeled avidin (Zymed, San Francisco, CA) and p-nitrophenyl phosphate substrate (Sigma, St. Louis, MO). The absorbance at 405 nm was measured 60 minutes after addition of substrate. ELISA inhibitions were performed as above for direct bind ELISAs, with the exception that varying concentrations of the insect extracts were added with the serum sample (1:10 final dilution) to inhibit the binding of IgE antibodies to the allergosorbent. The percent inhibition was calculated using the formula $(Ao - Ai/Ao) \times 100$, where Ao is the absorbance measured in the absence of inhibitor, and Ai is the absorbance in the presence of inhibitor.

RESULTS

Ingestion challenge by Diner 1 to crickets, waxworms, non-Tenebrio larvae, and belostomatid bugs as well as wine was negative. Rechallenge to ZM and TM was not done. Prick testing to ZM, TM, and GC was positive in all three diners (1, 2, 3), positive in one control (4), who had no history of overt exposure to ZM, TM, and GC and positive to TM and GC in another control who had no overt exposure to ZM, TM, and GC. Number 5, who has Baker's asthma, was negative to TM, ZM, and GC (see Table I). Intradermal testing to common indoor and outdoor allergens was positive to most allergens tested (see Table II). All diners and controls had normal ventilatory function testing that did not

TABLE I

Skin Testing: Prick

Patient	Mealworm	Superworm	German Cockroach
* 1	Pos	Pos	Pos
* 2	Pos	Pos	Pos
* 3	Pos	Pos	Pos
4	Pos	Pos	Pos
+ 5	Neg	Neg	Neg
6	Neg	Neg	Neg
7	Pos	Neg	Pos

** Probands.*

+ Baker's Asthma

Mealworm = 1.07 MG Protein/cc; Superworm = 1.36 MG Protein/cc; German Cockroach = 1.72 MG Protein/cc.

TABLE II								
Skin Testing: Intradermal 1/1000								
Pt	Grass	Weed	Trees	Dust	Mite	Cat	Dog	Feathers
* 1	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Neg
* 2	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos
* 3	Neg	Neg	Pos	Pos	Pos	Pos	Pos	Neg
4	Pos	Pos	Pos	Pos	Pos	Pos	Neg	Neg
+ 5	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos
6	Neg	Pos	Neg	Pos	Pos	Neg	Neg	Pos
7	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos

** Probands.*
+ Baker's Asthma.

TABLE III			
Direct Bind ELISA Results			
Patient	Mealworm	Super Worm	German Cockroach
* 1	0.649	0.960	0.155
* 2	0.365	0.046	Not tested
* 3	0.152	0.130	0.055
4	0.072	0.026	0.018
+ 5	0.073	0.036	0.055
6	0.056	0.036	0.020
7	0.096	0.048	0.081

** Probands.*
+ Baker's Asthma.

change significantly in the probands, when they were challenged by inhalation to particulate airborne debris of TM. Inhalation exposure was carried out with Mealworm using Jack Pepy's technique of transferring the allergen from one tray to another.

Direct bind ELISA showed significant IgE binding to all three insect allergosorbents in "1" and to Mealworms (TM) and Superworm (ZM) in "3", and to Mealworm (TM) in "5." Controls 6, 4, and 7 were negative, as was 5, who has Baker's asthma (see Table III). The ELISA inhibition dose response curves (Fig. 6) revealed that 1) The cockroach extract was a potent inhibitor of the mealworm ELISA using "1" sera; and 2) The worm extracts were potent inhibitors of the cockroach ELISA using "1" sera.

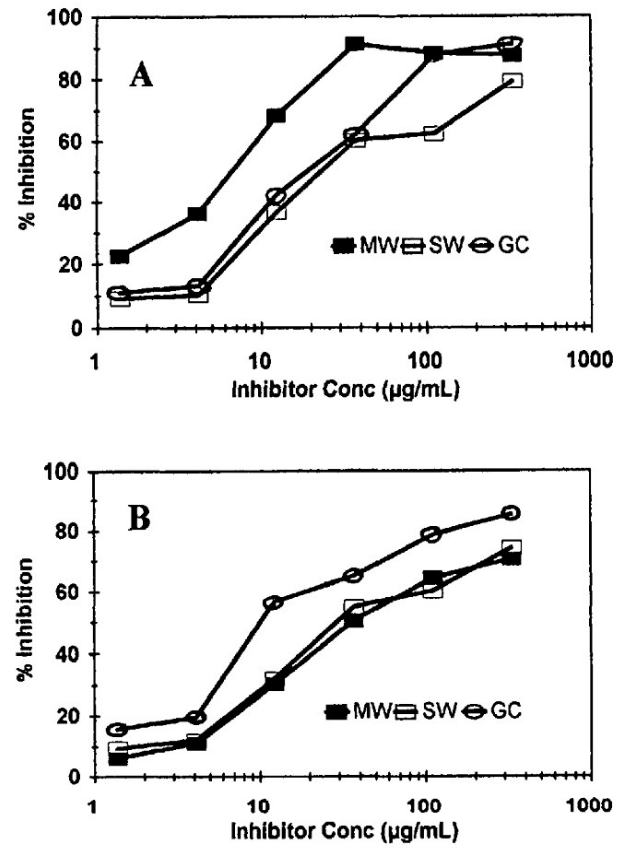

Figure 6. ELISA inhibitions utilizing mealworm (A) or German cockroach (B) allergosorbents and serum from subject 1, which contains IgE antibodies directed toward both mealworm and German cockroach. The insect extracts derived from mealworm (TM), superworm (ZM), and German cockroach (GC) extracts were potent inhibitors in both systems suggesting allergenic cross-reactivity.

DISCUSSION

We have presented a case of anaphylaxis in a patient who is both hypersensitive to the inhalation and ingestion of mealworm and superworm, a phenomenon not previously reported. In addition, we have studied one patient with Baker's asthma who had no skin test or serological evidence of mealworm or superworm sensitivity, contrary to the report submitted by abstract last year,[10] undoubtedly illustrating the fact that a variety of insects and grain proteins may be the responsible antigen. The cockroach sensitivity detected in "1" sera may have been due to cross-reacting IgE antibodies induced by exposure to larvae and will be the subject for a future study in progress.

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