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THE FOOD INSECTS NEWSLETTER

MARCH 1994   VOLUME VII, NO. 1

Ed.: This is the second in a series of invited articles on potential hazards that could be posed by *indiscriminate* consumption of insects. It is hoped that space in the July *Newsletter* will permit a followup interview with Dr. Blum and also with Dr. Berenbaum, author of the first paper. The third paper in the series, on insects as allergens, is tentatively scheduled for the November 1994 *Newsletter*.

The Limits of Entomophagy: A Discretionary Gourmand in a World of Toxic Insects

Murray S. Blum, Ph.D.
Laboratory of Chemical Ecology
Department of Entomology
University of Georgia
Athens, Georgia 30602 USA

A large variety of insect species can provide the basis for an epicurean repast that can be truly an olfactory delight as well as gustatorily piquant. In a word insects can constitute absolutely delicious fare, the seasoned entomophage experiencing the joys of an endless series of appetizing encounters with selected arthropods whose palatabilities provide the basis for a most highly pleasurable gastronomy. The entomophagous propensities of many peoples, combined with the fulsome number of insect species available for consumption, guarantees that these multifarious arthropods will frequently constitute an invertebrate cui sine par excellence. However, as delectable as some species are, it is important to recognize that entomophagy has its safe limits as a consequence of the presence of a diversity of insect species that contain powerful pharmacological agents that are known vertebrate toxins. Furthermore, it is very likely that a host of unrecognized toxic species may be encountered as possible food items. In short, the insect gourmet must be eminently assiduous in the selection of food. In order to illuminate the topic of insect nonfood items, the following explication is presented to emphasize that ingestion of the wrong species of insect may not be a matter to be taken lightly, unless one has an ironclad gastrointestinal tract and the constitution of *Bufo morinus!*

Before addressing the question of the toxicity of ingested insects to man, it seems desirable to consider several points that are relevant in analyzing the potential hazards of entomophagy. Hopefully, in so doing it will become evident that the terminological exactitude required to accurately describe the possible consequences of insect eating by humans is not always readily apparent.

Insect vs. Plant Natural Products This review will only deal with compounds that are synthesized within the body of the insect. Compounds that are sequestered by the insect from plants, the allelochemicals, were discussed in the last issue of the *Newsletter* by another reviewer and will not be treated here. Thus, insects and selected examples of their own natural products will be regarded as potentially toxic effronteries when ingested, and this study of the toxic effects of compounds of natural origin will be referred to as toxinology.

The State of Toxinological Data for Insect Natural Products Our knowledge of the toxic effects of insect natural products is far from complete. Hundreds of insect-derived compounds have been identified in the last four decades (Blum 198 1), but it would be no exaggeration to state that virtually nothing is known about their toxinology *vis-a-vis* humans. Indeed, it seems evident that detailed toxinological data for insect natural products, with few exceptions, are only available for compounds that are of obvious public health significance (e.g., vesicants). A host of insect-derived compounds, many of which are unique substances, have never been evaluated as toxic agents. When one considers the millions of insect species, many of which are generating natural products, the task of undertaking toxinological studies on these arthropods is truly daunting, but nevertheless very exciting.

Distasteful vs. Toxic Insects Although a multitude of insect species are distasteful or repellent, they will not be included in this review of toxic species. For example, the μ,b-unsaturated aldehydes produced by pentatomids and other hemipterans may be eminently distasteful, but there is no persuasive evidence that these odoriferous compounds are very toxic to vertebrates. The same can be said for 4-methyl-3-heptanone, a characteristic exocrine compound synthesized by reduviids and hymenopterans. Distasteful compounds usually result in their producers being rejected at the oral level or before (e.g., repellent spray), and enteric toxicity does not generally appear to be of great significance.

Acute vs. Chronic Toxicity Toxicity is a relative phenomenon, reflecting among other things, both the dosage of a candidate compound and the temporal period subsequent to its ingestion. For toxic insects, available data are for all intent and purpose, acute. Chronic toxicity is essentially unrecognized, as is the case for delayed toxicity, a phenomenon of major importance in the area of toxicology (Gilmanetal. 1980).As far as the literature is concerned, rapid reactions to the ingestion of toxic insects were a *sine qua non* if the toxicity of the enteric challenge was to be described in detail. If delayed toxicity results, or if intoxication follows the ingestion of insects over a prolonged period, it is not unlikely that the victims of this pernicious entomophagy will receive no recognition for their gastronomic suffering.

Exocrine vs. Nonexocrine Natural Products When a human ingests a toxic insect, the adverse effects of the toxins may be first experienced when the products of an exocrine gland are secreted as

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More About Cutworm Moths and Grizzly Bears

In the November 1992 *Newsletter* we reported, based on a short article in *Newsweek* that cutworm moths had been observed to be an important food of grizzly bears, now staging somewhat of a comeback in the northern Rocky Mountains. The study mentioned In *Newsweek* was in the Absaroka Mountains east of Yellowstone National Park in Wyoming. The specific identity of the moth or moths involved was not known, or at least not mentioned in the article.

Now, as the result of yet another small world story, we have learned the identity of the moth and a little about its biology. My wife and I were returning from the Portland, Oregon area last summer when, during a stop at the airport in Minneapolis for a connecting flight to Madison, we ran into Professor Bob Ruff, Department of Wildlife Ecology at the University of Wisconsin. When we boarded the flight to Madison, as good luck would have it, Bob and I had seats across the aisle from each other. He was

mid-August collections averaged 18% protein and 35.4% fat. Bear use of moth aggregation sites lasted at least from July 12 to September 3 in 1992, and 67% of bear activity on the talus slopes was directed toward moth feeding. All bears were grizzlies, no black bears were observed. Several species of birds also fed on the moths.

The moth has an interesting life cycle. It undergoes its development in the Great Plains where the eggs, about 2000 per female, are laid in the soil in the fall. The larva, which has a total of seven instars, is in the first or second instar when it enters diapause. It resumes feeding in the spring on plants such as alfalfa or small grains. The larval period varies depending on temperature and location but may be as long as 25-32 days in Kansas and 43-63 days in Montana. Pupation is in underground cells. The adult moths emerge in early summer and migrate westward into the Rocky Mountains where they congregate above timberline. The moths occupy the interstitia of talus slopes during the day and feed nocturnally, nectar sources being alpine and subalpine flowers. The return migration to the plains occurs in late returning from bear country in Wyoming, so I mentioned the grizzly-cutworm connection. He had seen a report or two on it and said he would send over some information -- which turned out to be an article in the *International Bear News* by Don White, Jr. (Department of Biology, Montana State University, Bozeman, M'I) and Katherine Kendall (National Park Service, Glacier National Park, West Glacier, MT).

In the spring of 1992, they initiated a three-year study on bear feeding ecology at moth aggregation sites in Glacier National Park. Nine moth aggregation sites were identified in the alpine regions of the Park. All of the moths collected at two of the study sites proved to be *Euxoa auxiliaris* Grote (Lepidoptera: Noctuidae). Moths collected in mid-July 1992 averaged 24.4% protein and 34.4% fat;

summer or early fall.

White and Kendall mention several areas in the Rocky Mountains of Wyoming and Montana where grizzlies are known to feed on cutworm moths and other alpine insect aggregations. In the Mission Mountains, grizzlies feed not only on *E. auxiliaris*, but also on ladybird beetles *(Coccinella* and *Hippodamia* spp.*)*.

White, D.; Kendall, K. 1993. Grizzly bears and army cutworm moths in the alpine of Glacier National Park, Montana. *Internat. Bear News 2(3):2-3.*

New Entomology Textbook Devotes Space to Entomophagy

Gullan, P.J.; Cranston, P.S. *The Insects: An Outline of Entomology.* Chapman & Hall, United Kingdom (In press).

Dr. Penny Gullan, The Australian National University, sent a manuscript copy of a section titled, "Insects as human food: entomophagy," which will be part of the first chapter of this new general entomology textbook. It is an excellent short discussion of the subject (6 manuscript pages). We quote below two paragraphs that focus on implications and challenges for the future:

"Large scale harvest or mass production of insects for human consumption brings some practical problems. The small size of most insects presents difficulties in collection or rearing and in processing for sale. Development of culture techniques also is necessary to overcome the unpredictability of many wild populations. However, the encouragement of entomophagy in many rural societies, particularly those with a history of insect use, may help diversify peoples' diets. By incorporating mass harvesting of pest insects into control programs, the use of pesticides can be reduced. Furthermore, cultivating insects for protein should be less environmentally damaging than cattle ranching, which devastates forests and native grasslands. Insect farming is compatible with low input, sustainable agriculture and most insects have a high food conversion efficiency compared with conventional meat animals. Perhaps the bugburger, cricketburger or beeburger will become acceptable alternatives to the well-known American hamburger....

"Clearly insects can form part of the nutritional base of people and their domesticated animals. Further research is needed and a database with accurate identifications is required to handle biological information. We must know which species we are dealing with in order to make use of information gathered elsewhere on the same or related insects. Data on the nutritional value, seasonal occurrence, host plants or other dietary needs, and rearing or collecting methods must be collated for all actual or potential food insects. Opportunities for insect food enterprises are numerous, given the immense diversity of insects."

Letters
They're olins -- not sandwiches!

Dr. Sophie D. Coe, New Haven, Connecticut, sets the historical record straight:

Herrera y Tordesillas, A., Historia General de los Hechos de los Castellanos, Emprenta Royal, Madrid, 160 1. Decada IV, Book IX, p.236, 1531.

"They eat lice, spiders, 'cigarrones', snakes, ants, toads, lizards, scorpions, toasted caterpillars, mosquito empanadas and 'vascosidades.' Olin, an Indian of Mexico, was seen by many to take a very large live yellow scorpion, and removing the stinger on the tail, which is where the sting comes from, put it between two pieces of wheat bread, like a 'toffezno', and pressing it down well ate it with the scorpion, enjoying it very much, and while some thought he would die from eating it it did him no harm."

Dr. Coe concludes: "Seeing as this was at least two centuries the rules of precedence we should be eating olins, not sandwiches."

Further proof, if needed, that we aren't error-free

From Joseph Evans, Grand Coulee, Washington, after reading about our change in policy in the last *Newsletter* and checking his mailing label:

"My CM designation notes a non contribution to your great newsletter. Cognizant of my initial defraying of suggested $5.00 when requesting your newsletter I underwent head, thoracic and abdomenable constrictions. However, herewith a contribution of $10.00 to help perpetuate your great program. "

Ed.: Any other readers who may have experienced those same symptoms, should write the editor for a prescription.

Adding to the growing dialogue on palm weevils
Dr. Jun Mitsuhashi, Tokyo University of Agriculture and Technology, and author of *Edible Insects of the World,* wrote in part:

"I understand that many people are interested in palm weevils, because articles on this insect have appeared frequently in the Newsletter. I am also Various species of palm trees. Besides palm trees, it is said that sugar cane, aloe, apple and some other plants will be alternate hosts. I am rearing the adults and larvae of this species on apples. The adults can oviposit their eggs into apiece of apple. The hatched larvae can grow on apples. Now my larvae are in the full grown state. The infested apple was often liquefied. In the liquid I saw many yeasts. I assume that the yeast may play an important role in nutrition of the weevils. I hope soon they will become pupae. I have also attempted to rear this insect on an artificial diet. Contrary to my expectation, I found that formulation of synthetic diet for this weevil was quite difficult. They ate neither potatoes nor sweet potatoes. A synthetic diet consisting of sugar, potato starch, yeast, cellulose powder, and coconut flake was refused by the adults and the larvae. Modifications of this diet all failed to grow the larvae. I am afraid that apples are too expensive as diet for mass production of this weevil. Now, I am analysing the ") nutritive value of this larva. When I finish these experiments, I may send you a report.

Delicious tacos
From Angela Corelis of Puerto Vallarta, Mexico, in part:

"In reading the *Gran Libro de Coaina Mexicana* by Alicia Gironella de'Angeli and Jorge de'Angeli, under Maguey (the Tequila Cactus) I found how to prepare *meocuiles* -- the maguey worm. They are collected between the months of April and August; they are found in the roots and are put in sacks made of mixiotes (haven't found for sure what these are, but sounds like they are young maguey leaves -- also used for tamale coverings). The *meocuiles* are rinsed, dried, then toasted on a comal (a grill - not open) or fried with a little oil until golden. Mix guacamole and *meocuile* worms to make delicious tacos."

Ed.: The insect is the larva of a skipper butterfly, *Aegiale.* Ms. Corelis mentioned four more insects that are apparently included in the book.

The Chinese hepialid caterpillar identified

Remember the article in the last *Newsletter* about the fungus/ caterpillar potion that purportedly allows Chinese distance runners to pick'em up and lay'em down faster than anybody else on earth? Entomology professor Karl Espelie, University of Georgia, responded with the following information:

"I enjoyed the story about the hepialid caterpillars in your November 93 one of those people, and this year visited Papua New Guinea to look at the habit of native people to eat palm weevils. So, I may provide some information you are requesting. The weevil I saw and collected was *Rhynchophorus ferugineus.* It attacks

issue. I talked about the coverage given these insects in my "insect appreciation" course last fall when the story came out in the papers. I asked a Chinese graduate student who works in our department about these insects. She wrote to a colleague at Nanjing University who said that the fungus is *Cordyceps sinensis* and the insect is *Hepialus armoricanus* Oberthur. The infected insects are eaten to cure asthma, cough and impotence."

TV Company seeks stories about food insects

A Natural History Filming Company in England is looking for food stories about insect-eating for a new series challenging people's attitudes towards animals that are usually found frightening or unpleasant. We would like to hear of any specialty restaurants or chefs who serve insects and other invertebrates, and of people who have adopted them in their diet. Also fo interest are events featuring food insects and any particularly unusual stories about them.

Please contact: Jan Castle, Zebra Films, The Production House, 147a St. Michael's Hill, Bristol, BS2 8DB, England. FAX (44 272) 736866. TEL: (44272) 706026

Some Recent Articles in Professional Journals

Fasoranti, J.O.; Ajiboye, D.O. 1993. Some edible insects of Kwara State, Nigeria. *Amer. Entomologist* 39(2):113-116, 6 figs. Department of Biological Sciences, University of Ilorin, Ilorin, Kwara State, Nigeria.

According to the authors, taboos - religious and other- are important among factors influencing entomophagy in West Africa. The taboos are believed to run generally along ethnic lines, and the authors set out therefore to investigate beliefs militating against entomophagy among the four major tribes in Kwara State, the Yoruba, Ibira, Nupe and Baruba. Seven species of insects are generally acceptable within these four dominant tribes. A questionnaire was sent to all local government areas of Kwara State and followed up by personal interviews to clarify questions that arose from responses to these questionnaires.

Macrotermes natalensis (termite): The winged reproductives, which are strongly attracted to light sources, are eaten by all age groups but are collected mainly by the women and children. Termites are. sold in the markets when catches are large, while small collections are consumed at home. They are fried or roasted. The queen termite is considered a delicacy for adults only, but can be obtained only when a termitarium is destroyed.

Brachytrupes membranaceus (cricket): These insects live in tunnels which are easily detected. They turn a golden color when roasted. Members of the Ire clan of the Yoruba tribe do not eat crickets for reasons discussed by the authors.

Cyrtacanthacris aeruginosus unicolor and *Zonocerus vatiegatus* (grasshoppers): these are prepared in a manner similar to that for crickets and are consumed by all age groups of all tribes. Grasshoppers are plentiful only periodically and were not observed being sold in the markets.

Cirinaforda (moth larva): Popularly known as Kanni, this is perhaps the most important and widely marketed edible insect in Kwara State. The larvae are starved for a day or two to eliminate the gut contents, then boiled for 2 hours, then sun-dried on mats. Most tribes in Kwara State do not eat dried larvae of other insects, but Kanni is an essential ingredient in a vegetable soup, considered a delicacy, which also includes onion, melon, tomatoes, pepper oil, and salt to taste. In the market, the dried larvae sold forNI9.50/kg (N1.00= US 300) compared with the 1986 price of N9.00/kg for beef.

Rhynchophorus phoenicis (palm weevil larva): Palm trees under stress for any reason and fallen palms serve as breeding sites and can support hundreds of larvae. Mature larvae are huge, measuring about 10.5 cm long and 5.5 cm wide. Collected larvae are washed and fried; condiments added include onion, pepper and a little salt. "Most people who were interviewed believe that this insect is very delicious."

Oryctes boas (scarabaeid beetle larva): Breeding sites such as dunghills and refuse of various kinds are searched for by all age groups, but more frequently by the women and children in the course of their other duties. The larvae are even larger than palm weevil larvae. After preparation, they are washed thoroughly and fried. Acceptability of this insect is decreased because of the "dirty" nature of the breeding sites, but it is still popular among most insect eaters.

The authors conclude that entomophagy should be promoted through education and that edible insects can help substantially in reducing the protein deficiency problem that exists in Kwara state. They stress that only the development of artificial breeding methods, rather than relying on harvesting from natural populations, would ensure an abundant and continuous supply.

The authors discuss several taboos, but relative to termite queens they state: "Children are forbidden to eat the queens for several reasons, not all of which have to do directly with safety to health. Children form a large proportion of the farm hands, and the elders believe that if the young ones are allowed to eat the queens they will cherish the insects and spend so much of their time searching for them, that productivity in the fields will be reduced." From similar reasoning, children are discouraged from eating palm weevil larvae: "As the larvae taste so good, the young ones are likely to become preoccupied with felling palm trees to provide more breeding sites and a bumper harvest of larvae. Indiscriminate felling of trees would deprive the community of primary palm products such as palm oil, palm kernals, and palm wine."

Cherry, R.H. 199 1. Use of insects by Australian Aborigines. Amer. *Entomologist* 37(l): 8-13. Everglades Research and Education Center, University of Florida, Belle Glade FL 33430.

The author discusses insects as part of Aborigine cultural beliefs and their use as food and medicine. While most entomologists have ready access to ESA's American Entomologist, many of our readers do not, so we quote a large part of four paragraphs: "An interesting example of the mass harvesting of edible insects is the moth feasts that occurred in the Bogong mountains of New South Wales. The Bogong moth, *Agrotis injiisa* (Boisduval), aestivated in large numbers every year on rock shelters of these mountains. From November to January, hundreds of Aborigines from different tribes would gather for huge feasts on these adult moths. Rock crevices were covered with layers of these moths, which were collected by dislodging and then collecting the moths from the cave or crevice floor. Moths were then cooked in sand and stirred in hot ashes, which singed off the wings and legs. Moths were then sifted in a net to remove their heads. In this state, they were generally eaten, although sometimes they were ground into a paste and made into cakes. As a food, the Bogong moth was rich in fat ....

"Common (1970) states that the larva of *Xyleutes leucomochla* Turn. is the true witchety grub of the Aborigines. Witchety grubs (larvae) are found in the roots of Acacia bushes, commonly known as the witchety bush in central Australia. These grubs were the most important insect food of the desert and were a much valued staple in

the diet of the Aborigines - especially women and children. Men also loved the grubs, but would seldom dig them. The grubs were collected by digging up the roots and chopping them to obtain the grubs within. The grubs can be

live below the federal poverty level; "With little money and no access to major grocery chains, many families cannot buy the kind of food that supports an adequate diet...... We quote from two paragraphs in the report:

eaten raw or can be cooked in ashes. Cooking causes the grubs to swell and their skins to stiffen. Cooked witchety grubs frequently have been likened in taste to almonds (Isaacs 1987). The larvae are rich in calories, protein, and fat. Ten large grubs are sufficient to provide the daily needs of an adult (Australian National Commission of UNESCO 1973).

"... honeypot ants were a highly valued food that provided a source of sugar for the Aborigines of central Australia. Workers of the honeypot ants *(Melophorus bagoti* Lubbock and *Camponotus* spp.*)* gather honeydew from scale insects and psyllids, and feed it to other workers, which become mere nectar storage vessels with greatly enlarged abdomens. These helpless replete ants, which regurgitate some of their nectar when solicited by other workers, are kept safe in deep underground galleries (Norris 1970). The ants were obtained by scraping the surface of the ground to find the vertical shaft of the nest that led down to horizontal chambers where the honeypot ants were located. Vertical shafts may be dug down to almost two meters (Mountford 1976).

"Another popular source of sugar in the Aborigine's diet was the honeybag (hive) of stingless native bees *(Trigona* spp.). To locate the honeybag, the Aborigines caught a bee feeding on pollen, and after attaching to it a leaf or petal by means of sticky juices of certain plants, let it go. The bee would fly straight to the hive and the item it was carrying not only would make it easy to see, but also would result in its flight being lower and slower, thus, it was easily followed by the hunter (Massola 1971). Also, when looking for honey, Aborigines watched for small, black lizards, which often lived in honey trees and fed upon the bees as they returned to the hive. To obtain the honeybag, a tree could be cut down or, if the tree were large, a hole could be cut in the tree under the hive. A stick could then be poked into the hive and stirred about until the honey ran down the stick into a bark basket (Roughsey 1971). When the honey was extracted from the hive, it usually was mixed up with honeycomb, bees, immature bees, and eggs. The Aborigines put the lot into their mouths and spat out the inedible parts (Crawford 1968)."

Cherry notes that the Aborigine population, estimated at more than 300,000 before 1770, is now down to about 160,000 and that about two-thirds of them now live in cities and have adopted suburban lifestyles. This article was reprinted in *Pest Control Technology*, February 1992. For more on the Bogong moth, see November 1992 *Newsletter.* For more on Australian honey ants, see the March 1990 *Newsletter.*

Ikeda, J.; Dugan, S.; Feldman, N.; Mitchell, R. 1993. Native Americans in California surveyed on diets, nutrition needs. *Calif. Agric.* 47(3):8-10.

Some 500 descendants of the Miwok-speaking Native Americans live in Mariposa County, the county where Yosemite National Park is located. Joanne Ikeda *et al* (1993) report that 50% of the families

"Some families augmented their food supply in traditional ways: 47% gathered wild berries, nuts, mushrooms and other plants; 67% said their grandparents and parents traditionally used wild plants as foods, and 8 1 % said this knowledge had been passed on to them by their elders ... [22% gardened, 26% fished**,** 14% hunted].... Many Miwok recalled foods their grandparents ate that they do not eat: insects such as pine tree worms, Monarch butterfly larvae [Ed.: questionable] and grasshoppers; animals like squirrel, Mono Lake shrimp, quail, deer, rabbit, bear and hedge hog; and plant foods such as acorn mush, pine nuts, wild vegetables and berries. Some of these foods, particularly the insects, are not considered food by the dominant culture. This may have influenced these native Americans to abandon them as food sources."

(Ed.: Thanks to David Strange, MD, Petaluma, California, for calling attention to this recent study. Earlier studies of the Miwok had also reported the use of insect foods.

Directory Supplement Mailed in March

The original Directory was published and distributed in February, 1992. It listed the names of 409 Newsletter subscribers (all of those who requested inclusion), 280 in the United States and 129 from other countries, along with their addresses, telephone; Telex and Fax numbers, and relevant interests. The 1994 Supplement updates information, corrects errors in the 1992 listings, and adds new names. The two together provide currently accurate information on 581 subscribers, 413 in the U.S. and 168 from elsewhere.

Those listed in the original Directory were sent a copy of the Supplement. Those listed for the first time in the Supplement were sent copies of both the Supplement and the original Directory. Others may obtain postpaid copies: 1992 Directory $4.00; 1994 Supplement, $2.00; both $5.00.

Damerow, Gail. 1993 (August). Wax worm fritters (and other edible delights). *Bee Culture* 121 (8):448-449.

Stating that "Beekeepers have ready access to two of the tastiest edibles, " this article focuses on the greater wax moth larva and bee brood, reprinting a recipe for wax worm fritters by Sharon Elliot, head chef New York Parties (this recipe was also printed in the July *1992 Newsletter).*

Entomophagy Limits (from page one)

a consequence of traumatic stimulation of the arthropod selected as a food item. In general, the natural products synthesized by arthropods are externalized from glands and in a sense constitute the first line of chemical defense. Furthermore, some species synthesize compounds that are often unique animal natural products but these compounds are not discharged from exocrine glands but rather, fortify the blood and of course the whole body. As a consequence, the toxic effects of these products may not be realized until the insect is injured and the toxin-laden blood comes into contact with the predator's tissues.

However, while these nonexocrine compounds are not discharged from specific glands, in some species they may nevertheless be externalized by autohemmorhage from weakened cuticular areas such as the legs, thorax, orelytra. For example, hemolymph fortified with pharmacologically active natural products is characteristically elaborated by reflex bleeding in the case of species of adult Meloidae (Carrel and Eisner 1974) and Lampyridae (Blum and Sannasi 1974). Indeed, the discharge of toxic blood by reflex bleeding appears to be far more characteristic of beetles than species of any other order.

It is imperative that the insect gourmand learn to recognize both phanerotoxic and cryptotoxic species in order to avoid a traumatic assault on both the palate and the intestine. Cryptotoxic species produce toxic nonexocrine secretions as previously described, but in some cases the active compound(s) may be localized in a single structure rather than fortifying the blood. For example, females of the meloid *Lyua vesicatoria* localize cantharidin in the ovaries and eggs (Sierra et al. 1976), their cryptotoxicity becoming devastatingly evident when their reproductive poison gland, reservoir, venom duct, and a device for injecting the venom. Venomous secretions are produced by species in the orders Hymenoptera, Hemiptera, and Lepidoptera, and their secretions are delivered by either retractile stings, piercing mouth parts, or urticating setae. These obviously venomous insects are refer-red to as *phanerotoxic* species and contrast to *cryptotoxic* species whose toxicity is not manifested until the insect is ingested. Often the toxins produced by phanerotoxic species are only active by injection and these venomous compounds are inactivated in the gastrointestinal tract. However, as will be described in the next section, ingestion of some phanerotoxic insects could constitute a lot more than just a bad gustatory experience.

Oral Vulnerability vs. Gastrointestinal Detoxicative Defense The larvae of many lepidopterans possess urticating spicule hairs which are powerful vesicants; similar reactions are caused by the spine hairs of larvae of moths in several families (Kawamoto and Kumada 1984). In addition to these vesicatory hairs, the larvae of some saturniid species produce powerful fibrinolytic proteinases that have been implicated in a hemorrhagic syndrome in humans (Amarant et al. 199 1). For the most part, the active compounds are believed to be proteins that should be readily inactivated in the gastrointestinal tract. Despite enteric detoxication of these vesicatory toxins, a modicum of caution is recommended in order to ensure that disasterous larval revenge does not occur.

Although the toxic compounds present in larval urticating hairs are in all probability proteinaceous constituents that can be facilely hydrolyzed (detoxified) in the intestine, major oral injuries can occur before the ingested larva becomes an intestinal victim. In short, the oral cavity is probably very susceptible to the pernicious effects of these lepidopterous toxins. The entomophage may also be vulnerable to the impaling of spines system is exposed to the sensitive oral and enteric tissues of a naive predator. On the other hand, a phanerotoxic species possesses an apparatus for synthesizing, storing, and injecting the venomous products. Phanerotoxic species may not be readily evident, as is the case for the larvae of many satumiid species which possess clusters of venom-filled spines that are rendered invisible by being enveloped by dense hairs. Obviously the poison apparatuses of bees, wasps, and ants are so conspicuously phanerotoxic--and distasteful--as to require little comment.

Vesicants vs. Internal Toxicity For the entomophage, it is of great importance to be able to discriminate against toxic insect species before they become gastrointestinal disasters, the victim possibly subjected to exaggerated waves of reverse peristalsis, or worse. Fortunately, a multitude of decidedly toxic insects advertise, as external vesicants, the adverse pharmacological effects of their natural products and they are clearly marked as species that should be immediately rejected as food items. This is particularly true for lepidopterous larvae in a variety of families (Kawamoto and Kumacla 1984) and adult beetles in several families. In short, the well-developed vesicatory properties of diverse insects often translate into considerable internal toxicity for a variety of toxinological reasons that will be discussed subsequently.

Phanerotoxic vs. Cryptotoxic Species A large variety of insect species posses a true venom apparatus that generally includes a in the esophagous and elsewhere in the oral region, which could result in a real toxic overload. It is advisable to know your larval lepidopteran (Blake and Wagner 1987) before ingesting it.

When an Ingested Insect's Biochemical Constituents Become Toxins by Augmenting the Concentration of the Same Compounds in the Host When a human predator ingests an insect with which it shares a pharmacologically active agent, this compound can constitute a true toxin if applied in a toxic dose under *Coca* conditions (Vogt 1970). For example, high concentrations of histamine, a known algogen, are characteristic of hymenopterous venoms and several biogenic amines have been identified in the venoms of wasps and honey bees (Owen 197 1). The richest source of acetylcholine in the animal kingdom is the venom *of Vespa crabro* (Bhoola *et al* 1961), raising the question of what effect on an entomophage would result if a concentrated intrusion of this neurotransmitter was introduced into the gastrointestinal tract. In short, insect-derived compounds may constitute cryptic toxins whose roles as dangerous physiological agents are not easily recognized because these biochemicals are identical to agents utilized by the host in relatively low concentrations. "Too much of anything, however, especially biogenic amines, is not necessarily a good thing."

SEE ENTOMOPHAGY LIMITS, P. 7

Paiute youths eating burgers and fries instead of ant pudding, laments a tribal elder.

Paiute-Shoshone tribal members are considering whether to let the government store its radioactive nuclear waste on their reservation, creating badly needed jobs and economic growth, according to a story in *The Sunday Oregonian* of June 27, 1993. The reservation is in a remote area at the Oregon-Nevada border. Ernestine Coble, 46, tribal council chairwoman, who was quoted at length, believes that the old values are slipping away and she would like to save the ones that remain. For instance, her grandmother would say, "Well, we're going to have ant pudding. You'd better get ready. We're going to have to leave when the sun comes up."

Eight-year-old Ernestine's job was to put on warm clothing and to carry an empty coffee can. They would hike around the res (short for reservation). Her grandmother would spot a mound, lift the top like an old straw hat, and scoop out balls of cold-numbed ants. They were put into the coffee can and cooked on the old wood stove. Ernestine said that the ant pudding was not her favorite food, but it was a tradition and an anchor to a world of power and solidarity.

The editor mentions this story for two reasons, first, I had not heard the term, "ant pudding" before, although ants and their pupae were widely eaten by Indian tribes in the West, and secondly, it reveals that the older generation of Paiutes in Oregon were still eating their insect foods as recently as 1955 (age 46 minus age 8 = 38 years ago).

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Anabolic Steroids and Corticosteroids from Beetles--And a Lot More. Coleopterans are preeminent in the biosynthesis of steroids other than ecdysteroids, and for the entomophage it is best to exercise considerable restraint before ingesting these insects. For example, about 20 steroids have been identified as prothoracic gland products of species in the family Dytiscidae (Schildknect 1970), and many of these compounds are either identical to vertebrate steroids or constitute unique triterpenes that are closely related to these hormones. Indeed, since dytiscid species in only seven genera have been subjected to analytical scrutiny (Blum 198 1), it is very likely that a host of steroidal surprises will be forthcoming when species in other genera are analyzed. However, it is already evident that the dytiscid prothoracic glands rival the endocrine glands of vertebrates in biosynthesizing steroids with powerful physiological activity, for everything from fish to mammals. Let the eclectic entomophage beware of dytiscids and other coleopterans as well!

Anabolic steroids have been identified as exocrine products of *Ilybius fenestratus* and these include testosterone and 1,2-dehydrotestosterone (Schildknect 1970). In addition, this secretion contains estrone and 17B-estradiol. Conceivably, prolonged ingestion or sucking this beetle could result in a real anabolic effect characterized by nitrogen retention and skeletal muscle enlargement (Gilman *et al* 1980). Although prolonged ingestion of dytiscid steroids may result in the entomophage possessing a body similar to that of Hercules, there may be untoward effects that militate against this means of achieving the perfect physique. Younger males could experience serious disturbances of growth and sexual and osseous development.

Edema, jaundice, and hepatic carcinoma can result from prolonged ingestion of anabolic steroids; azoospermia and impotence may also be the consequence of a long-term beetle diet containing these hormones. For female entomophages, the danger of masculization is very real as a consequence of a diet of dytiscids fortified with these androgens (Gilman *et al* 1980). Women may experience a deepening of the voice, develop body hair, and suddenly show a tendency toward baldness, probably too great a price to pay for the epicurean delight of dytiscids!

For vertebrates, steroids such as testosterone may constitute considerably more than anabolic stimulators. When toads *(Bufo* and *Pelobates* spp.) ingested adults of two dytiscid species in the genus *Ilybius*, the beetles, often alive, were rapidly regurgitated, enveloped by a bloody slime (Schildknecht *et al.* 1967). The prothoracic gland secretion of *Ilybius* species is dominated by testosterone and contains 1,2-dehydrotestosterone as well. The protective role of anabolic steroids for vertebrates is also demonstrated by the fact that testosterone is a powerful stupaficient for goldfish, causing rapid paralysis of the carp. These steroids have been presumably evolved to act as deterrents for fish and amphibians, two of the potentially major groups of predators for these water beetles.

In addition to anabolic steroids, dytiscids generate a large variety of steroids, some of which are identical to well known vertebrate corticosteroids whereas others are novel triterpenes (Schildknecht 1970). For example, about 0.4 mg of cortexone, the major steroid in the secretion of the beetle *Dytiscus marginalis*, is present in the prothoracic glands of an adult (Schildknecht *et aL* 1966). This corresponds to the amount of steroid that can be extracted from I 000 ox suprarenal glands and suggests that these corficosteroids may constitute powerful deterrents for selected vertebrates. Mineral cortical steroids such as cortexone are capable of destabilizing the sodium-potassium balance, and it is significant that pike and trout are rapidly narcotized by *Dytiscus* secretion or by cortexone, just as they are by testosterone (Schildknecht *et al* 1966).

It is important to recognize that corticosteroids exhibit a potpourri of toxic effects that are observed either after withdrawal of the steroids or as a consequence of continued use of these compounds (Gilman et al. 1980). Acute adrenal insufficiency can result from too rapid withdrawal of corticosteroids, whereas prolonged dytiscid tasting or ingestion could result in pituitary-adrenal suppression, increased susceptibility to infection, peptic ulceration, myopathy, and behavioral disturbances. Although dytiscids may be delicious, it would seem advisable to avoid them as prey items.

Steroids are produced by beetles in other families, and even though pharmacological data are lacking, it would seem desirable to discriminate against them as food items. The cardiac glycosides pro-

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duced by chrysomelids (Pasteels and Daloze 1977) and the steroidal pyrones synthesized by lampyrids (Eisner *et al*. 1978), should serve to warn the entomophage that ingestion of these coleopterans may be hazardous to her health.

A final word of dytiscid caution seems advisable for resolute entomophagous predators. The steroidally fortified secretions of all species of Dytiscidae that have been analyzed consist of mixtures that may contain at least seven compounds. It is not unlikely that interactive pharmacological effects may result from these mixtures, the steroids of which may be present in inordinately high concentration. Conceivably, vertebrate predators that ingest dytiscids may experience considerably greater toxicity than would be anticipated based on the activity of individual steroids. Feeding deterrency studies have almost invariably emphasized tests with single compounds, in spite of the fact that mixtures are, almost without exception, a defensive *sine qua non*. So beware of mixtures--they can hurt you!

A Cyanogenic Menu for Entomophagous Rejection A wellknown member of the snapper family, *Lutjianus argentimaculatus*, employs the same strategy as an archerfish in order to obtain food. This mangrove snapper ejects ajet of water from its mouth which is aimed at a variety of animals that are on the leaves overhanging the stream in which L *argentimaculatus* is found. While the archerfish technique for securing prey is admirable, it is not without life threatening hazards. Sometimes the aqueous "bullet" launched by the mangrove snapper dislodges the millipede *Polyconoceras allosus***,** a cyanogenic species. Ingestion of this polydesmoid diplopod results in an almost instantaneous death for the snapper (Johannes 1981). Cyanide-producing arthropods may be more than repellent for a predator--they may be deadly!

Although hydrogen cyanide combines and inhibits a variety of mammalian enzymes (e.g., carbonic anhydrase, succinate dehydrogenase), the great toxicity of this compound primarily reflects its great affinity for ferric iron in cytochrome oxidase, the last enzyme in the cytochrome system (Curry 1992). The binding of cyanide to cytochrome oxidase stops electron transport with a consequent fall in oxygen consumption and ATP production, a thoroughly perilous state of affairs. The known distribution of cyanogenic animals is limited to species in three arthropodous classes--Chilopoda, Diplopoda, and Insecta (Duffey 198 1). In the Insecta, cyanide-producing species have only been detected in selected taxa in the orders Lepidoptera (Jones *et al*. 1962) and Coleoptera (Moore 1967; Blum *et al*. 1981). Larvae of the moth *Zygaena trifolii* are very unusual in sequestering the same cyanogens from their host plant that they synthesize *de novo* (Nahrstedt and Davis 1986). Cyanogenic lepidopterans (all stages) are also found in the Nymphalidae and Heliconidae, usually in species that are very aposematic or involved in mimicry complexes (Nahrstedt and Davis 198 1). Although many of these species develop on plants that are fortified with toxic natural products (e.g., pyrrolizidine alkaloids), these lepidopterans do not sequester these compounds but rather biosynthesize cyanogens (Brown and Francini 1990).

Cyanogenic beetles have not been encountered frequently, having only been detected in species in the families Chrysomelidae and Cicindellidae. It would appear that the cyanogenic chrysomelids in the genera *Chrysophtharta and Paropsis* (Moore 1967) are exceptional in producing defensive allomones that are atypical for members of this family. The production of cyanide by adults of the tiger beetle *Megacephala virginica (Blum et al*. 1981) may also be regarded as unusual since no members of the closely related family Carabidae have been demonstrated to produce cyanogenic allomones.

Should the adventurous entomophage eat these aposematic lepidopterans and beetles? The levels of cyanide produced by individual insects should hardly constitute a real toxinological hazard, but in the absence of good information about cyanogenic insects being eminently benign, discretion would seem to be the best part of epicurean valor. It is worth recognizing the possibility that the defensive arsenals of these sundry arthropods may contain more than cyanide, and they do!

Beetles for Sniffing--And a Lot More The aromatic hydrocarbon toluene is widely used as a solvent for products such as varnishes and glues. This compound is a central nervous system depressant and confusion, weakness, and fatigue can result from exposure to low concentrations (Gilman *et al*. 1980). The CNS effects of solvents such as toluene are responsible for the practice of "glue sniffing" and demonstrate its considerable pharmacological activity when administered in the vapor phase. Beetles in selected genera constitute real toluene factories, and as a consequence could be regarded as potential subjects for the practice of "beetle sniffing"!

Longhorn beetles in the genera *Stenocentrus and Syllitus* produce toluene-dominated secretions in their mandibular glands and, in addition, the phenolic constituent o-cresol (Moore and Brown 197 1). These defensive secretions, which constitute the only known sources of toluene in the Arthropoda, should probably be "off limits" for either "beetle sniffing" or ingestion. Sniffing the secerambycids could result in the well-recognized toxic effects resulting from exposure to low levels of toluene. These include ocular and respiratory irritation, dizziness, and decrement in motor performance (Sullivan and Van Ert 1992). Major acute and chronic effects have also been reported after exposure to toluene. Cresols have also been reported to cause significant public health effects such as dermal injury and in some cases central nervous system, kidney, and liver injury (Geehr and Salluzzo 1992). All and all, these longhorn beetles can hardly be recommended for either sniffing or ingesting.

Vesicatory and Aposematic Staphylinids are not for Eating There are times when determined entomophagy must yield to insects that fairly scream their dangerous unpalatability. This is certainly the case for the warningly colored beetles in the genus *Paederus, the* members of which contain a powerful vesicant that is detected when the beetles are crushed. The major vesicant produced by these staphylinids is pederin, a novel amide that is the most complex nonproteinaceous compound identified in insects (Pavan 1975). The

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wide range of pharmacological activities possessed by pederin marks it as a compound to be avoided at all costs.

Pederin is a powerful inhibitor of protein synthesis and mitosis as well (Pavan 1975). The vesicatory properties of this amide produce pronounced cutaneous sores and ocular lesions (Pavan 1963) which, when combined with its inordinately high toxicity, mark it as a defensive compound par excellence. Curiously, pederin, in very low concentrations, has the remarkable ability to promote the healing of dermal lesions such as bed sores (Pavan 1975). However, when it comes to *Paederus*, "let the gourmet beware"!

Ants Producing Necrotoxic Alkaloids are to be Avoided--At all Costs In

If the entomophage chooses to ignore the toxic trials and tribulations of bluegills feeding on dialkylpiperidine-fortified fire ants, she/he should not forget what happened to Socrates when he was introduced to a related nitrogen heterocycle. A word to the wise-alkaloid--should be sufficient.

Of Necrosis, Edema, Enteritis, and Lepidopterous Larvae Human entomophages who have been fortunate enough to sample outstanding insect delicacies rank selected insect larvae as some of the world's great taste sensations. Succulent scarab larvae would delight even the most fastidious gourmet, and a large variety of lepidopterous larvae would render any meal a special occasion. This is particularly the case for the Paiute Indians who consider the pandora moth, *Coloradia Pandora lindseyi*, an extremely delicious food source (Blake and Wagner 1987). However, the Paiutes might be shocked to learn that the saturniid that they covet had relatives that are truly capable of causing major pathological reactions. For the entomophage, immature lepidopterans must not be considered as the New World the biomass generated by colonies of some species of the fire ants *Solenopsis (Solenopsis)* may approximate 250,000 workers, but this potential food resource is too dangerous to consider even as an occasional feast enjoyed by the most n-tithradatic entomophage. In short, the venomous chemical arsenals possessed by the aggressive fire ant workers constitute powerful tissue toxins, which, when combined with their pronounced algogenicity, render them eminently unsuited for ingestion.

The poison gland secretions of fire ants are dominated by alkaloids that are related to coniine, the hemlock-derived compound that was responsible for the death of Socrates. The nitrogen heterocycles produced in the venoms of fire ants are 2,6-dialkylpiperidines (MacConnell *et al.* 197 1), novel alkaloids that are characteristic of *Solenopsis (Solenopsis) spp .(*MacConnell *et al*, 1976). The cytotoxicity of these compounds is demonstrated by their abilities to produce rapid necrosis after injection into the human derma (Caro *et* al, 1957). Sterile pustules at the sting sites characterize the reactions of human beings to encounters with the typically aggressive workers, all of which seem determined to inject a venomous "cocktail" into the source of the disturbance. Since these alkaloids, after ingestion, are probably considerably more stable than venom derived proteins, they may be capable of manifesting real toxicity in the gastrointestinal tract. Indeed, there is considerable evidence that piscine predators feed on fire ants at their own peril.

Mortality of bluegill sunfish *(Lepomis macrochirus)* has been reported in ponds after these fish had fed upon masses of fire ant workers that floated from mounds during conditions of flooding (Green and Hutchins 1960). Several grams of workers were reported to be in the stomachs of the dead sunfish. Although feeding ants under field conditions did not result in extensive mortality of these bluegills, introduction of macerated fire ants by gavage or directly into the aquarium water produced immediate intoxication and rapid death. Furthermore, it has been suggested that fire ant workers may kill bluegills by extensively stinging the stomach lining, thus inducing intoxication even before the ants are transported to the intestine (Ferguson 1962). Although these studies were undertaken with fire ant workers, it has been reported that female alates of *S. richteri* can kill sunfishes or frequently cause temporary intoxication (Crance 1965).

appropriate snacks until it is established that "the skin (cuticle) fits the bones" in terms of their suitability as food items.

Irritative lepidopterans have been identified in at least 13 families and for the most part these constitute species of adult and larval moths (Kawamota and Kumada 1984). Pathological conditions resulting from human encounters with lepidopterans has been termed lepidopterism and may result in pronounced dermatitis, severe algogenic reactions, and allergenicity. For example, in Japan about 200,000 people experienced severe dermatitis after contact with the Oriental tussock moth *Euproctis subflava* (Asahina and Ogata 1956); *E. similis* is reported to have caused dermatitis in at least 500,000 people in the city of Shanghai, China (DeLong 1981). This type of dermatitis is frequently characterized by pruritus, swelling, erythema, pain, and in some cases necrosis. However, the poison-bearing spines of some lepidopterous larvae can cause histopathological reactions of great severity that in some cases are life threatening.

The hairs of caterpillars have been reported to cause ophthalmic and respiratory injuries, and the dedicated entomophage will do well to note that ingestion of larvae in the genera *Thaumetapoea and Hemileuca* by humans caused intense stomatitis or enteritis (Pesce and Delgado 197 1). Allergenicity which is manifested by dermatitis may characterize the reaction to a variety of caterpillar hairs. Most frequently vasodilation and edema mark the site of the skin lesion (Kawamoto and Kumada 1984) but in the case of saturniid larvae in the genus *Lonomia,* reactions are so severe as to sometimes require hospitalization (Fraiha Neto *et al.* 1985). For example, contact with larvae of *L achelous* can result in severe hematomas accompanied by extensive hemorrhaging. Recently, the biochemistry of the *Ionomia* toxins and their pharmacology have been elucidated as the first example of the structural determination of compounds in caterpillar venoms.

Fibrinolytic substances found in the saliva and hemolymph of *L. achelous* have been associated with serious hemorrhagic reactions of individuals that have had dermal contact with larvae of this

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saturniid (Archoa-Pinango and Layrisse 1969). The plasma of patients possesses potent fibrinolytic activity which persists for about a month; fibrinogen levels are reduced considerably for a prolonged period of time (Arocha-Pinango *et aL* 1988). Two proteinases are responsible for the fibrinolytic activity of L *achelous* larvae, and these compounds degrade all three chains of fibrin in a pattern indistinguishable from that of trypsin (Amarantetal. 1991). The enzymes, apparent isozymes, termed achelase I and achelase H, utilized chromogenic peptides (e.g., kallikrein) as substrates whereas serine proteinases (e.g., thrombin) were not hydrolyzed. The presence of the classic triad (histidine-41, apartate 86, and serine 189) suggests that the achelases may be serine proteinases.

It is not unlikely that, as is the case for the *Ionomia* fibrinolytic proteinases, larval toxins are generally proteinaceous constituents. Consequently, larvaphilic entomophages may be encouraged to sample immature lepidopterans, feeling that proteinaceous toxins may be readily degraded in the gastrointestinal tract. While this may or may not be true, events preceding enteric introduction of the larvae may constitute a histopathological disaster. Dermal contact may result in severe pharmacological reactions, but the worst may be yet to come! Once a larva is placed in the mouth, contact with the oral mucosa may produce rapid dermatitis and tissue swelling as the initial steps in a hierarchy of severe pathological events. All things considered, more than a scintilla of caution should be exercised before taking gastronomic liberties with insect larvae.

The Beetle of Aphrodite and the Marquis de Sade: Tale of a Pernicious Anhydride Named Cantharidin It may come as a surprise to realize that 2000 years ago Hippocrates used an insect natural product to treat a pathological condition (dropsy) and more recently this compound was recommended for the treatment of venereal diseases, strangury, and bladder and kidney infections (Howell and Ford 1985). Cantharidin, a potent vesicant produced by species in the family Meloidae, has also been recommended as a counter-irritant for painful conditions such as pleurisy and sciatica. However, it is its long-standing reputation as an aphrodisiac unfortunately for his victims, the Spanish fly caused devastating pathological conditions. Cantharidin's aphrodisiacal reputation is probably associated with its ability, in minute quantities, to cause bladder and kidney irritation, an aching of the pelvis, and the painful voiding of urine with a sensation of burning. These pelvic discomforts were believed to arouse the female and to inflame in her a desire for sexual intercourse (Howell and Ford 1985). Nothing could be further from the truth!

For the male, the action of cantharidin is similarly pernicious, and may involve additional painful discomforts. Prolonged and painful erections can result from cantharidin ingestion but this priapism can hardly arouse a man to passionate demonstrations. Indeed, such dolorous erections may result from the second-hand ingestion of cantharidin as resulted with French troops about 140 years ago. Vizien (1861) recognized that the urethritise experienced by French troops in Algeria was in reality cantharidian cystitis resulting from the soldiers eating flesh from frogs ("la chair des grenouilles") that had feasted on meloids. Vizien (I 850) was very qualified to recognize this pathology having specialized in the fevers of Algeria. Vezien (1861) emphasized that the short-term condition was not serious and that the soldiers differed greatly in their sensitivity to cantharidin. Similarly, Meynier (1893) encountered cantharidian cystitis in Zouaves and chasseurs who had eaten frogs legs in Algeria and as was the case with Vizien (I 86 1), the relationship between meloids, frogs, and humans was inescapable. Erections notwithstanding, the general weakness and lassitude of the soldiers rendered them eminently incapable of any sexual fantasies. Fortunately, as emphasized by Meynier (I 893), the triad of blister beetle, frog, and man appears to be rare.

If the extreme oral toxicity of cantharidin is not enough, it has long been recognized that this compound can penetrate unbroken skin with toxic, if not fatal, results (Howell and Ford 1985). In the event of a laceration, cantharidin can be internalized very rapidly. Recently, Eisner *et al.* (1990) demonstrated that frogs sequestered cantharidin after administration of blister beetles or pure compound. Levels of stored cantharidin diminished quite rapidly.

Conclusions

that has led to the utilization of cantharidin as a sexual stimulant. Unfortunately, fatal and near-fatal poisonings have resulted from the use of cantharidin as an aphrodisiac, and in some cases this corrosive compound has been used as a poison per se (Howell and Ford 1985). This compound is an unusual corrosive in not acting immediately, but it more than makes up for its toxic delay by devastatingly corroding the linings of the tongue, palate, and throat. Probably this insect natural product, first prepared from the European meloid *Lytta vesicatoria*, has been served to more people than any other arthropod-derived compound. For the entomophage, this anhydride and insect, variously termed Spanish fly and blister beetle, have such a frighteningly checkered history that ingestion of meloids can only be considered as an act of the worst pathological masochism!

The Marquis de Sade was beheaded in absentia for nearly killing two prostitutes by giving them aniseed sweets laced with cantharidin. The alleged aphrodisiacal properties of this compound made it an ideal agent for promoting the licentious activities of de Sade, but

A vast number of insect species are available for immediate consumption or for subsequent gourmet cooking with everything that implies ("bon appetite"!). The knowledgeable entomophage can experience an infinite variety of delightful taste experiences, provided that she or he exercises a modicum of recognitive awareness. As I have endeavored to emphasize, when it comes to eating, not all insects are equal for the human entomophage. Species that are well protected from vertebrate predators should probably be avoided, and this would certainly be the case for aposematic species. The gourmand's life can await you, however, if you select your insects with the same care that you select your sauces. On the other hand, if you are the 'devil may care' type, then it will not prove surprising if your gustatory experience results in "mal appetit!"

SEE REFERENCES, P. 11

References Cited (Entomophagy Limits)

Amarant, T., Burkhart, W., Levine, H., Arocha-Pinango, C.L., Parikh, I. 1991. Isolation and complete amino acid sequence of two fibrinolytic proteinases from the toxic saturnid caterpillar *Lonomia achelous*. *Bio Chem. Biophys. Acta* 1079:214-221.

Arocha-Pinango, C.L., Layrisse, M. 1969. Fibrinolysis produced by contact with caterpillar. *Lancet* 1:810-812.

Arocha-Pinango, C.L., De Bosch, N.B., Nouel, A.L., Torres, A., Perales, J., Alonso, M.E., De Rodriguez, S., Carvajal, Z.A., Ojeda, A., Tasayco, M.I., and Chitty, '*. 1988. Fibrinolitic and procoagulant agents from a Satumidae moth caterpillar. In: *Hemostasis and Animal Venoms.* Vol. 7 (H. Pirkle, F.S. Markland, eds.), 223-240. New York: Marcel Dekker.

Asahina, S., Ogata, K. 1956. Records of the outbreak of the Far Easten urticating moth, *Euproctis flava*, in Japan. *Japan J. Sanit. Zool.* 7:104106.

Bhoola, K.D., Calle, J.D., Schachter, M. 1961. Identification of acetylcholine, 5-hydroxytryptamine, histamine and a new kinin in hornet venom *(Vespa crabro)*. *J. Physiol.* (Lond.) 159:167-182.

Blake, E.A., Wagner, M.R. 1987. Collection and consumption of pandora moth, *Coloradia pandora lindseyi (*Lepidoptera*:* Saturniidae), larvae by Owens Valley and Mono Lake Paiutes. *Bull. ESA* 1987:23-27.

Blum,M.S. 1981. *Chemical Defenses of Arthropods.* New York, Academic Press, 562 pp.

Blum, M.S., Sannasi, A. 1974. Reflex bleeding in the lampyrid *Photinus pyralis:* defensive function. *J. Insect Physiol. 20:451-460.*

Blum, M.S.' Jones, T.H., House, G.J., Tschinkel, W.R. 1981. Defensive secretions of tiger beetles: Cyanogenetic basis. *Comp. Biochem. Physiol. 69B:903-904.*

Brown, K.S., Francini, R.B. Evolutionary strategies of chemical defense in aposematic butterflies: cyanogenesis in Asteraceae-feeding American Acraeinae. *Chemoecology 1:52-56.*

Caro, R., Derbes, V.J., Jung, R. 1957. Skin responses to the sting of the imported fire ant *(S. saevissinta)*. *A.M.A. Arch. Derm.* 75:475-488.

Carrel, J.E., Eisner, T. 1974. Cantharidin: potent feeding deterrent to insects. *Science* 183:755-757.

Crance,J.H. 1965. Fish kills in Alabama ponds after swarms of the imported fire ant. *Prog. Fish Cult.* 27:91-94.

Curry, S.C. 1992. Hydrogen cyanide and inorganic cyanide salts. In: *Hazardous Materials Toxicology (J.G. Sullivan; G.R. Krieger, eds.)*, pp. 698-710. Baltimore: Williams and Wilkins.

De Long, S. 1981. Mulberry tussock moth dermatitis. A study of an epidemic of unknown origin. *J. Epidemiol. Community Health 35:1-4.*

Duffey, S.S. 1981. Cyanide and arthropods. In: *Cyanide in Biology* (B. Vennesland, E.E. Conn, C.J. Knowles, J. Westley, F. Wissing, eds.), pp. 385-414. New York: Academic Pres.

Eisner, T., Wiemer, D.F., Haynes, L.W., Meinwaid, J. 1978. Lucibufagins: defensive steroids from the fireflies *Photinus ignitus and P. marginellus. Proc. Nati. Acad. Sci.* USA 75: 905-908.

Eisner, T., Conner, J., Carrel, J.E., McCormick, J.P., Slagle, A.J., Gans, C., O'Reilly, J.C. 1990. Systemic retention of ingested cantharidin by frogs. *Chemoecology 1:57-62.*

Ferguson, D.E. 1962. Fish feeding on imported fire ants. *J. Wildlife Mgmt.* 26:206-208.

Fraiha Neto, I., Amaral, I.M., Ballarini, A.E., Din, L.B., Costa, L.B., Leao, R.N.Q. 1985. *E Lonomia achelous* (Cramer) o "tapiru de saringueira" agente do acidente hemoffagico por contato corn larvas de mariposa no Territorio Federal do Amapa (Lepidoptera, Satumiidae). *XXI Congr. Soc. Brasil Trop. Med.* 1985:5.

Geehr, E.C., Salluzo, R.F. 1992. Dermal injuries and bums from

Gilman A.G., Goodman, L.S., Gilman, A. 1980. *The Pharmacological Basis of Therapeutics.* 6th Edition. New York: Macmillan Publ. Co.

Green, H.B., Hutchins, R.E. 1960. Laboratory study of toxicity of imported fire ants to gluegill fish. *J. Econ Ent.* 53:1137-1138.

Howell, M., Ford, P. 1985. *The Beetle of Aphrodite and Other Medical Mysteries*. New York: Random House.

Johannes, R.E. 1981. *Words of the Lagoon.* Berkeley: Univ. California Press.

Jones, D.A., Parsons, J., Rothschild, M. 1962. Release of hydrocyanic acid from crushed tissues of all stages in the life cycle of all stages of Zygaeninae (Lepidoptera). Nature 193:52-53.

Kawamoto, F., Kumada, N. 1984. Biology and venoms of Lepidoptera. In: *Insect Poisons, Allergens, and Other Invertebrate Venoms* (A. T. Tu, ed.). pp. 291-330. New York: Marcel Dekker.

MacConnell, J.G., Blum, M.S., Fales, H.M. 1971. The chemistry of fire ant venom. *Tetrahedron* 26: 1129-1139.

MacConnell, J.G., Blum, M.S., Buren, W.F., Williams, R.N., Fales, H.M. 1976. Fire ant venoms: Chemotaxonomic correlations with alkaloidal compositions. *Toxicon* 14:69-79.

Meynier,J. 1893.Empoisonnement par la chair de grenouilles infectees par des insectes du genre *Mylabris* de la famille des meloides. *Arch. Medicine Pharm. Militaires* 22: 53-56.

Moore, B.P. 1967. Hydrogen cyanide in the defensive secretions of larval Paropsini (Coleoptera: Chrysomelidae). J. Aust. Ent. Soc. 6:36-38.

Moore, B.P., Brown, W.V. 197 1. Chemical defence in longhorn beetles of the genera *Stenocentrus and Syllitus* (Coleoptera: Cerambycidae). J. *Aust. Ent. Soc.* 10:230-232.

Nahrstedt, A., Davis, R.H. 1986. Uptake of linamarin and lotaustralin from their food plantby larvae of *Zygaena trifolii. Phytochem.* 25:2299-2302. Owen, M.D. 197 1. Insect venoms: Identification of dopamine and noradrenaline in wasp and bee stings. *Experientia* 27:544-546.

Pasteels, J.M., Daloze, D. 1977. Cardiac glycosides in the defensive secretion of chrysomelid beetles: Evidence for their production by the insects. *Science* 197:70-72.

Pavan, M. 1975. Sunto delle attuali conoscenze sulla pederina. *Publ. Istituto Ent. Agraria Univ.* Pavia 1: 1-35.

Pesce, H., Delgado, A. 197 1. Poisoning from adult moths and caterpillars. In: *Venomous Animals and Their Venoms*, Vol. 3, Venomous Invertebrates (W. Bucherl, E.E. Buckley, Eds.). pp, 119-156. New York: Academic Press.

Schildknecht, H. 1970. The defensive chemistry of land and water beetles. *Angew. Chem. Intern. Edit.* 9:1-9.

Schildknecht, H., Siewerdt, R., Maschwitz, U. 1966. A vertebrate hormone as defensive substance of the water beetle *(Dytiscus nzarginalis). Angew. Chem. Intem. Edit.* 5:421-422.

Schildknecht, H., Birringer, H., Maschwitz, U. 1967. Testosterone as protective agent of the water beetle *Ilybius. Angew. Chem. Intern. Edit.* 6:588-559.

Sierra, J.R., Woggon, W.D., Schmid, H. 1976. Transfer of cantharidin during copulation from the adult male to the female *Lytta vesicatoria* ('Spanish flies'). *Experientia* 32:142-144.

Sullivan, J.B., Van Ert, M. 1992. Alkylbenzene solvents and aromatic compounds. In: *Hazardous Materials Toxicology* (J.H. Sullivan, G.R. Krieger, eds.). pp. 1086-1104. Baltimore: Williams and Wilkins.

Vezien, M. 1850. Les fievres de Algerie. These pour le Doctorat en Medecine. Faculte de Medecine de Paris. No. 64:1-39. Vezien, M. 1861. Note sur la cystite cantharidienne causee par l'ingestion de grenouilles qui se sont nourries de coleopteres vesicants. *Recueil de Medicine Chirurgie Pharmacie Militaire* 4:457-460.

hazardous materials. In *Hazardous Materials Toxicology* (J.B. Sullivan, G.R. Krieger, Eds.) pp. 415-424. Baltimore: Williams and Wilkins.

Vogt, W. 1970. What is a toxin? *Toxicon* 8:251.

Three little books that are different:

Critter Cuisine, Photography by Al Clayton, Text and Styling by Mary Ann Clayton, 1992, viii + 54 pp., Longstreet Press, Inc., 2140 Newmarket Parkway, Suite 118, Marietta, GA 30067, $15.95. ***Dreadful Delicacies***, 1993, viii + 50 pp. Other data same as for *Critter Cuisine.*

Maybe the best way to describe these two books would be to have the author, Mary Ann Clayton, explain the rationale behind them as she did in a letter to the Editor: "Please find enclosed copies of *Critter Cuisine and Dreadful Delicacies*. My husband and I produced these two books as spoofs of what I call "gourmet mania", an affliction that is quite widespread in the U.S. We hope the books will encourage people to really examine what they eat and why they eat it. Your interest and research in entomophagyis an inspiration to this cause. Although we did not choose to include actual recipes in these books we intended them to get the message across that our own particular prejudices can deprive us of some very intriguing gastronomic. adventures and that readers will be encouraged to broaden their culinary repertoires."

The book jacket for *Critter Cuisine* provides another bit of insight of value to cooks everywhere: "Designed both to celebrate our gastronomic diversities and test our eating preferences, *Critter Cuisine* solves a perennial question: What can I serve that I've never served before?" If you can't guess what that might be, how about mouse kabobs (using whole mice)? Beautifully photographed, as are the other 20 offerings. Only one uses insects - beetle salad (with intact Japanese beetles). In *Dreadful Delicacies,* however, 10 of the 19 offerings are insects, plus two others of earthworms.

Conversations with Bugs, A Journal with Words and Drawings by Gwynn Popovac, 1993, pages unnumbered, Pomegranate Artbooks, Box 6099, Rohnert Park, CA 94927,$17.95 plus $3.95 for shipping and handling.

This little book has nothing to do with insects as food, but I will borrow a paragraph from my letter to Ms. Popovac to describe it: "Thanks very much for sending me a copy of your 'blank journal," *Conservations with Bugs.* The paintings of insects 'set in decorative shrines' are just beautiful. You may be an amateur entomologist, but you obviously are not an amateur artist. And I can't say how impressed I am with the inspirational way in which you have combined the two."

Thomas Eisner offered this: "A Gem! For insect lovers, and for those in need of discovering insects...." So far, the Chicago Art Institute and the Smithsonian have it in their shops, and the Xerces Society and the Entomological Society of America are printing notices and reviews.