# THE FOOD INSECTS NEWSLETTER

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Ed.: This is the first in a series of invited articles on potential hazards that could be posed by indiscriminate consumption of insects. The second, by Murray Blum of the University of Georgia, will appear in the March 1994 *Newsletter*. It is hoped that space in the March issue will also permit follow-up interviews with Dr. Berenbaum and Dr. Blum.

## Sequestered Plant Toxins and Insect Palatability

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Although etymologically entirely distinct from entomology, the phrase, "You are what you eat," has unusual applicability to the feeding behavior and physiology of herbivorous insects. Insects that eat plants, particularly plant foliage, consume enormous quantities of food relative to their size; a Japanese silkworm caterpillar, for example, must eat 40,000 times its own weight in mulberry leaves in order to complete its development. Thus, it's not altogether surprising that herbivorous insects often coopt plant chemical constituents, often with little or no structural change, for their own use. Ingested plant pigments are oftentimes responsible for insect body color, plant sterols form the structural basis for cholesterol and other insect sterols, and, in at least one case, plant phenolics can substitute for endogenous phenolics for use in sclerotizing cuticle.

Most conspicuous, however, is the tendency of herbivorous insects to expropriate plant secondary chemicals for defense against their own enemies. Plants produce an extraordinary variety of chemicals that have no known function in the primary physiological processes of plant life, such as photosynthesis or respiration. These so-called secondary compounds tend to have idiosyncratic distributions throughout the plant kingdom; structural types are often restricted to a single family, genus, or even species. These compounds generally possess biological activity and are thought to function as the mediators between plants and the living environment--they are the principal attractants for pollinators, dispersal agents, and other mutualists, and they are the major deterrents against herbivores, pathogens, and other enemies. Over evolutionary time, however, many species of herbivores have developed means of circumventing the deterrent, repellent, or toxic defenses of their host plants. Whereas some insects have evolved mechanisms for rapidly detoxifying and excreting the offending molecules, others have simply developed a systemic immunity. With this systemic immunity comes the ability

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## Insects and the Feeding of Zoo Animals

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The intrinsic value of exhibiting insects in zoological parks, evidenced by a full section of a recent edition of the *International Zoo Yearbook (1991)* dedicated to the husbandry of invertebrates, *is only* overshadowed by the use of insects as a feed source. Indeed, many species of amphibians and reptiles, and numerous birds and mammals are fed invertebrates either as a substantial part of, or as their entire diet. Furthermore, live or whole invertebrate prey are often used as preferred treats or food pan garnishes, valuable for animal management techniques including diet adaptation, medical dosing, or daily censusing of individuals.

A number of nutritional issues must be considered in evaluating the use of insects in feeding zoo animals; these become increasingly important when insects comprise the major portion or total diet for any species. Most published data on the nutritional value of insects has focused on proximate composition only--fat, protein, carbohydrate, and water, from which calorie (or energy) content can be calculated. Two other nutrient categories which deserve more attention, and will be specifically addressed here, include vitamins and minerals.

Fat. Crude fat content is quite variable in food insects, changing with reproductive state, season, life stage (age), or sex (Myers and Pedigo, 1977; Redford and Dorea. 1984; Mason *et al.*, 1990; Pennino *et al*, 1991).Fat contains twice the calories of other nutrient categories (9 kcal/g), is highly digestible, and provides a major energy source to insectivorous species. Additionally, fat yields almost 2 times more metabolic water when digested, thus may provide a significant water supply to insectivores. Published values of crude fat content range from 10% in honeybees *(Apis mellifera)* to 58% (dry matter basis) in waxmoth larvae *(Galleria mellonella)* and dragonfly nymphs (spp. unknown). In general, nymph, larval,

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## EDITOR'S CORNER

First, thanks to the many readers who responded to our call in the *July Newsletter* of "Help! Send money!" Many of the contributions were in the generous range of $15 to $25 or more (there were three of $50). The all-time record single donation to the *Newsletter*, by the way, was $ 1 00 by a Virginian in 1990 The downside is that most of those who responded have contributed before, while hundreds of others, some of whom have been on the mailing list for as long as three to six years, are not heard from. To be precise, only about 600 of the nearly 2700 currently on the mailing list have ever contributed financially to support of the *Newsletter.* Actually, voluntary contributions from one of every 4 1/2 probably isn't bad for a publication that is supposed to be "free, " but henceforth the *Newsletter* will need financial input from a larger proportion of its readers.

### A bit of historical perspective

*The Food Insects Newsletter* was initiated in July 1988 as part of an educational effort to make Americans and other Westerners more aware of per page for photocopying, and postage, run annual costs up to more than $7,000. What's free? Not much these days. Ask any academic. But so far, we don't have to pay our phone bill, and the Department of Entomology covers the first $280 of postage each year.

It should be understood that the *Newsletter* continues to be a strictly informal voluntary undertaking. Although contributors are asked to make checks payable to the Board of Regents, University of Wisconsin, the *Newsletter has* no formal standing in the department of Entomology nor elsewhere within the University of Wisconsin. Formal recognition would presumably be granted if applied for, but, frankly, already two years into retirement, the editor isn't looking for long term contracts.

### The new policy

The situation is this. The July *Newsletter* mailing and correspondence handled since that mailing exhausted all funds on hand at the time.

the fact that insects are traditional foods in most nonEuropean-derived cultures, that the insects play an important nutritional and economic role in those cultures, and that the well-known Western bias is counterproductive in meeting the world's food and environmental challenges. It was envisioned that the *Newsletter* might become a networking mechanism and communications link for researchers, educators and others, both here and abroad, who were, or might become, interested in this important subject. With re-education the goal, the *Newsletter* advertised itself as "free," while noting that it welcomed financial contributions to help cover costs.

Costs weren't much of a factor the first years when names on the mailing list numbered only a few hundred. Both costs and time demands began escalating as *Newsletter* circulation passed the 1000 mark, then 2000, and now approaches 3000. For example, the billing for the July 1993 *Newsletter* was $1,720 ($855 for printing $230 for U.S. bulk mailing, and $635 for overseas airmail postage). Multiplied by three, the annual bill for three mailings exceeds $5,000. During 1992 and 1993, these exploding costs resulting from expanding circulation have been partially underwritten by a grant of $1,700 from the LTW College of Agricultural and Life Sciences and a grant of $2,500 from the Agrecol Corporation.

Requests for information have also increased exponentially. The *Newsletter* responds to hundreds of requests per year from students and teachers (from elementary to university level); museums, zoos, nature and science centers; environmental and other public interest organizations; Peace Corps Volunteers and Third World agricultural managers, educators and researchers; and last but not least, mass media people and free lance writers who in turn produce magazine and newspaper articles, radio programs and TV documentaries. The informational packets sent usually consist mainly of several *Newsletters* and one or more article reprints. Although back issues are technically priced at $1.50 each, I would estimate that for each one sold, at least 10 are given away in these informational packets. Additional costs involved in responding to this and other correspondence, e.g., $5 per hour for typing (student hourlys), 5 cents

Contributions received since July will pay for the November *Newsletter,* but the cash drawer will then again be empty. Thus, stringent measures are necessary. Volume VII (1994) will be sent only to those who meet one of the following criteria:

1) Contributed at least $5 during 1993. Or. last contribution was in 1992, but contributions have totaled at least $ 10; for 1991--$15; for 1990--$20, and for 1989--$25.

2) The editor has been notified that making a contribution would pose a problem. (For example, it is difficult or impossible to send any out of some developing countries. Funds for purchasing resource materials can be tight at times for students, teachers, residents of countries with poor economies and sky-high inflation rates, or almost anybody at one time or another. Notify the editor.)

3) Public and institutional libraries and active Peace Corps Volunteers are exempt and will continue to receive the *Newsletter* at no cost.

Check your mailing label. The code in the upper right-hand corner has been revised to include a category "P". The first two numbers following the P designate the last year during which a contribution was received, the last two numbers show the total amount you have contributed, according to our records. For example, P9225 means that you contributed in 1992, and whatever the amount actually sent in 1992, your contributions have totaled $25. All formerly used code designations, such as CM, D, and those starting with an M are no longer relevant and mean only that, according to our records, you have never made a financial contribution in support of the *Newsletter.*

We regret that we are probably going to lose a few hundred, maybe a thousand subscribers, but we see no alternative. We assume that some we've never heard from, after originally requesting the *Newsletter,* found it not what they expected, but never notified the editor to discontinue it. We hope to hear, however, from those who, like the editor, simply never do anything today if it can possibly be put off until tomorrow. And remember, when you do contribute to *the Newsletter,* you are not only paying your own way but are participating in what has become, we believe, a productive educational endeavor that is producing significant results. Contributions are tax deductible.



**How 'bout this, sports fans?**

China's fantastic runners train on hepialid caterpillars!

In September at the 7thNational Games in Beijing, Wang Junxia of the Liaoning Province women's track team smashed the world 10,000 meters mark by 42 seconds! She smashed the 3000 meters record by 10 seconds. And four of her teammates also beat the 9 year-old previous record. Qu Junxia, another member of the team, broke the 1500 meters record by 2 seconds. All of this of course rocked the track world back on its heels, and, predictably, prompted suspicions that such stunning performances could be attributed to steroids or other performance-enhancing drugs. Which, predictably, angered the coach, Ma Zunren, who attributed his athletes' success not to drugs but to hard work and drinking large portions of an expensive potion made from the rare *dong chong xia cao* worm found on China's western high plateau.

Taken from accounts in the *New York Times* by Patrick Tyler (September 12) and William Rhoden (September 18), the worm (sometimes spelled as *dong qiong sya cao)* lives during the summer; when it dies in the winter it produces a thick fungus that herbalists say is rich in minerals. Peasants harvest the worms and sell them to herbal medicine markets. According to Grace Ho, a herbalist interviewed by Rhoden, the potion's power comes not exclusively from the worm or the fungus but from both being used in combination with other herbs. Ho said the properties contained in the fungus help to open the lungs, allow a greater oxygen capacity and increase endurance. A packet of about 20 worms costs $35. Each worm is about an inch and a half long and the fungus growth, resembling a stem protruding from the top of each carcass, adds about half an inch. The worm potion, which the Chinese have been drinking for hundreds of years, is sometimes used by men as an aphrodisiac.

The editor knows of only two technical papers that shed any light on the identity of the "worm"/fungus association. Hoffman (1947) reported that caterpillars of the Family Hepialidae (ghost moths and swifts) infected with furious of the genus *Cordyceps* are sent from Szechwan Province to other provinces in China as well as abroad. About a dozen of the infected caterpillars, each with a long strand of fungal growth, are tied into neat

is not new. Insects are widely used as food in parts of Africa, Asia and South America. Many are high in protein, vitamins and minerals." He closed his article by saying: "Perhaps American athletes, faced with the challenge of serious competition at home during the Atlanta Olympic Games in 1996, will consider altering their diets. They may find that it's better to eat worms than dust."

Reference

Hoffman, W.E. 1947. Insects as human food. *Proc. EntomoL Soc. Wash.* 49:233-237.

Thanks to Robert Boyle (Cold Spring, N.Y.) and Ralph Mistier(San Francisco, Calif.) for sending the Times articles. We hope that one of our Chinese readers will let us know more about this interesting combination, especially the specific identity of the caterpillar.

**"Escargots in Your Garden: Turn the tables on those annoying backyard pests."** By Gail Damerow, *Mother Earth News,* June/July 1993, pages 48-51.

Snails aren't insects, but as far as most Americans are concerned, they have the same image problem. So we call attention to this article because it could serve as a model for the kind of "How to from capture to cooking" articles that are needed from entomologists or others with first-hand experience if willing Americans are going to be allowed to indulge in wild insects. Ms. Damerow's article begins with the following two paragraphs: "After years of battling snails in my garden while cooking up escargots purchased at a premium from a local import shop, I finally got wise. As long as I was gathering garden snails, why not harvest them for dinner? One bite told me I was onto something: those fresh snails from my garden, though smaller, tasted far superior to the pricey escargots from cans.

"This revelation came to me back in the days when most folks didn't want to know that snails and escargots are one and the same. When I served garden snails to my friends, their invariable reaction was 'yuk!' But when those same friends thought they were eating escargots from France, I got rave reviews."

bundles of uniform size. They are made into a broth, with both the larvae and the broth being consumed. They are considered both a delicacy and as tonic food, and are expensive, only the middle classes and the well-to-do being able to afford them. Hoffman states that, "I have sampled this material myself and found it quite tasty, but since I felt fine both before and after doing so, I cannot testify as to its efficacy. " Hoffman observed an instance in which hospitalization was necessary for three individuals who ate a large quantity of cicada nymphs infected with *Coryceps*.

A translated excerpt that I have from a Chinese journal (author and date unknown) gives the identity of the "Chinese caterpillar fungus" *as Cordyceps sinensis*. It is "cooked with chick; Yunnan, Sichuan, and Tibet; high mountains."

It was pleasing to note that Rhoden paused in the middle of his *Times* article to say: "The concept of deriving nutrition from eating insects

The author then follows with detailed instructions on how to lure the snails to a collecting spot (their "passion for bran"); how to house them (a bait pail or a 5-gallon food grade bucket makes a "dandy snail farm"); where to house them (out of the sun, where temperatures fall between 550 and 75'F.); why you allow them a I 0-day clean sing period (you have no idea of what they have been munching on that could taste unpleasant to you or be toxic); what to feed them (plain lettuce is fine); how to water them ("For pre-marinated molluscs, take a tip from the Romans and fill the jar with wine instead of water"); withholding food for three days to allow clearance of the digestive tract; how to de-slime (with salt water and vinegar). The remaining instructions are for gourmet-style preparation and dining.

Ms. Damerow added a side-box section titled "A Word on Insect Cuisine" in which she mentioned *The Food Insects Newsletter*. Within a month, the editor received more than 50 requests for the *Newsletter*. Come on, entomologists. America is waiting!



**Letters ...**

**The New York Bug Banquet revisited**

**From Dr. Durland Fish,** New York Medical College, and former president of the New York Entomological Society: Lou Sorkin is re-staging the Bug Banquet for Japanese TV. They are setting up a table at the Explorers Club and re-creating the dishes complete with Thai water bugs and Australian Kurrajong grubs, all at their expense. They will be using CNN and other **TV** tapes to fill in the crowd scenes. I will be out of town for the event. Just as well. There can never be an equal to the real thing.

**Americans (and others) abroad sample a variety of insect delicacies**

**From Ms. Ilze Balodis,** Machias, Maine, in part: We were in San Cristobal in Chiapas, Mexico. During most of July and some in June, roasted ants were available in the market. They were called ants by the sellers and were rather large (at least 1/2 inch). In any case, they were yummy.

**From Dr. Janice Swab,** Raleigh, North Carolina, in part: We ate termites in Zambia, instead of popcorn -- fried in their own oil.

**From Colin McQueen,** Lismore, NSW Australia, in part: In a recent issue you referred to the sago grub. Enclosed is a slide of bunches of sago grubs, skewered on small sticks, cooked in coconut milk**,** and on sale in a PNG [Papua New Guinea] provincial market for ... (about US 22 cents) for six *(Rhynchophorus ferrugineas* var. *papuana).*

I have eaten these grubs and they are very tasty indeed, tho the head a bit crunchy. The bodies are a smooth texture, but I find it difficult to describe the taste. Suffice to say that I would eat them regularly, but they are not generally available in Port Moresby where I'm living at present (perhaps not daily, but certainly once a week if they were available).

... Commercial/semi-commercial production of sago grubs would be threatened by wild pigs -- perhaps trapping wild pigs attracted to the sago grubs could be a by-product of sago grub farming!

**Protein-fortified guava juice?**

**From Charles Marden Fitch,** Mamaroneck, New York: Your newsletter *The Food Insects Newsletter* is fascinating. Here's a question or idea for an article. I've noticed that most ripe Guavas *(Psidiuni)* are food/home to small larvae, white about 1/4 inch size. What insect produces these? I seem to remember reading that a fly pollinates the guava flower and lays eggs in the fruit. Have studies been done to show the protein contribution made by these larvae (maggots?) when ripe guavas are used as human food? Guava juice**,** so popular in the tropics, must always contain this protein supplement.

Ed.: Anyone know the specific identity of this insect?

**Edible wilds soon to include more than botanical foraging**

**From Faith Thayer,** Hitchcock Center for the Environment (525 South Pleasant St., Amherst, Mass. 01002), in part: Thank you so much for the current issue, and back issues of *The Food Insects Newsletter* and your interest and encouragement in our program. My summer position is as an "Interpreter Naturalist " at a state forest. I work on a campground with families who have come from all over the country to camp in the Berkshire Mountains. I plan to incorporate entomophagy into my programs this summer along with harvesting of insects in fields and forests around the campground. Foraging for edible wilds usually means botanical foraging to most people. It will be very interesting to get feedback on a new look at edible wilds.

*Ed. The Newsletter* hears frequently from nature centers, and the editor has had a bit of discussion along the above lines with Deborah Duchon, editor of the delightful newsletter *The Wild Foods Forum* (4 Carlisle Way, NE, Atlanta, Georgia 30308). But as we've said before, more input is needed from entomologists on where and how to look for the edible insect species. Deborah heads her letters section, "Letters to the Editor (who loves to hear from you)." Same here.

**And more from, or about students**

**From Tiffany Reed,** McConnelsville, Ohio, dated October 3: 1 am a seventh grader from Morgan County, Ohio. I would like to work on a science fair project about eatable bugs that will be due in December. I received a few copies of *The Food Insects Newsletter* from our County Extension Office. I have not been able to obtain any other information. I was wondering if you would be willing to send

***Entertaining* with Insects**

Newer readers of the *Newsletter* continue to ask, "Where can I find recipes?" The answer of course is *Entertaining with Insects* which contains about 85 of them. Published originally in 1976 and long out-of-print, it was reprinted last year and can be obtained from:

Salutek Publishing Co.
5375 Crescent Drive
Yorba Linda CA 92687

If you want your book autographed by the senior author, so indicate in your order. Better hurry. You don't want to wait until this book is again out-of-print.

**Price per copy:** $14.95 (Discounts are available for purchases of more than 12 copies. California residents add sales tax (State and, if any, local and transit).)

**Shipping and handling per book:** U.S. $4.05; Foreign $9.05, (Add $ 1.00 for each additional book. Publisher pays for shipping and handling on orders of 12 or more books.)

**Method of payment:** U.S.: Money order (delivery within 7 days). Check (allow 6 weeks for delivery). Credit card purchases are not accepted. Foreign orders: International Money Order in U.S. dollars.

me some information and suggestions for this project and any ideas for a hypothesis and possible experiments would be helpful and very much appreciated.

**From Jennie Morris,** Beavercreek, Ohio, dated October 3: 1 am an honors student working on my science project. My project deals with insects as a food source. I need references for this project. I would like to order a copy of *Food Insects Newsletter.* Is this possible, or do I need to buy a year's subscription? I am also definitely interested in back issues and their cost. Do you have any additional information you could send me (such as bibliographies or other sources). Please send this information as soon as possible...

**From Therese Fish,** Dale, Texas, dated September 16: Love your *Newsletter* -- we're all hooked .... My husband's boss's son used our copies to research his project for his school's science fair, and won second place with his chunky earthworm cookies (the worms were left in large pieces so everyone would know they were really in there). I believe he was beat out by a nuclear reactor, or something like that.

**From Dr. Roger Akre,** Department of Entomology, Washington State University, Pullman, dated October I 1: We had a bug feed last month -- about 20 students -- very successful. African bee pupae and wax moths are a favorite.

**In Burkina Faso -- the guerba caterpillar and the sheanut tree From Cynthia Bertelsen** of Purdue University IPIA, West Lafayette, Indiana: I am a nutritionist currently posted in Africa, in Burkina Faso, where I am engaged in a series of studies on the food and medical plants used by the Mossi tribe. One of the foods eaten is a caterpillar called the *guerba* in Moore; it seems to frequent the sheanut tree. This has sparked my interest in insects as food and then, lo, I saw your newsletter mentioned in the Nov.-Dec. 1992 issue of *Eating Well*.

Ed.: Anyone out there with a clue as to the scientific identity of this insect?

**Two letters from Peace Corps Volunteers in Ivory Coast**

**From Ms. Nicole Lacoste**, whose service as a health education volunteer will soon be ending. Thank you very much for providing me with a subscription to *The Food Insects Newsletter* during the past year of my Peace Corps service here in Cote d'lvoire. Your publication has always been one of the highlights of checking my mailbox since your newsletter continuously contains interesting articles on insect consumption and its application in our world today….I will be leaving Cote d'Ivoire at the end of November and ask if it is at all possible for me to maintain my name on your mailing list but now at my permanent stateside address ....

**And from Ms. Eve Beeler,** who is director of a workshop for the physically handicapped. Though there is not a direct link between the subject of food insects and my work, your newsletter interests me personally because through the urgings of my Ivoirienne husband well for the use of insects and other arthropods such as scorpion as medical food. Scorpion often appears now in the dishes of many restaurants including our university restaurant. In Shanghai there has opened a restaurant of food insects, which is sponsored by the Shanghai Institute of Entomology and Jinjiang Restaurant. Two kinds of drugs have appeared in the market recently, which are made of extract from moths and able to improve the sex of man, according to the report by the producers, Jilin Research Institute of Plant Protection and Shenyang Agricultural University.

Ed.: Does anyone have comparative data on the aphrodisiacal qualities of arthropods versus rhino horn? It would be great if we could promote greater demand for the former and reduced demand for the latter.

**More about palm weevil larvae**

**Dr. Ed Dresner,** Vernon, Connecticut, who sampled fried crickets and win-ed ants at a street-side restaurant in Chiang Mai, Thailand, during a recent trip to India and SE Asia, wrote in part: Re palm weevil larvae: after looking at many coconut "trunks," I believe that mass production has a much better chance of success with Sa-o Palm which has a core which can easily be removed and used as media. Fruit fly *(trypetid)* larvae are mass reared on carrot media, not fruit; eggs are collected from a fruit oviposition attractant. I wonder if palm weevil larvae can be reared on a sweet potato or cassava type media with or without palm flavoring; oviposition would still depend on a palm attractant.

Ed.: Can anyone provide information on alternate hosts (other than the various species of palms) of the larvae? *Rhynchophorus ferrugineous* (the major Asian species) can be reared on sugarcane stem diet or on artificial diet according to reports by Rahalkar *et al.* (I 972, 1978, 1985) and Rananavare *et al.* (I 975), but the editor has not seen the originals of any of these papers. According to Kaishoven and Van der Laan (198 *1, Pests of Crops in Indonesia*, Jakarta, pp. 487-9 1), the larvae can develop in the refuse (ampas) formed during the processing of sago. Chandavimol (1973) mass reared large numbers of another species, *R. vulneratus*, in central Thailand bv feedin- adults and larvae on fresh coconut (this paper also not seen by the editor). According to Hagley (I 965, *Ann. Entomol*. Soc-. *Am.* 58: 22-28), oviposition by *R. pallnarum* (the major species in the Western Hemisphere) occurred not only in all palms, but in sugar cane and in some fruit and root crops, but nothing is said about larval development.



**Toxins/Palatability** (from page one)

to tolerate large amounts of erstwhile toxins in their own bodies. Insects who store, or sequester, such toxic substances in their bodies acquire the same deterrent or repellent properties possessed by the plants that they consume. Thus, insects gain protection from species that would likely otherwise consume them--including humans.

Sequestration of plant secondary chemicals for defensive purposes has been documented in at least six orders of insects. The phenomenon is not restricted to herbivorous insects -- in a few cases, carnivores sequester the toxins sequestered by their herbivorous prey. These exceptional cases include both predators (e.g., *Chrysopa carnea)* and parasitoids *(Zenilla adamsoni*, a tachinid parasitoid of *Danaus plexippus).* The secondary compounds involved represent a broad range of biosynthetically distinct structural types and include alkaloids, aristolochic acids, cardiac glycosides (cardenolides), cyanogenic glycosides, cucurbitacins, iridoid glycosides, mustard oil glycosides (glucosinolates), and phenolic glycosides. The phenomenon of sequestration may be widespread among insects because it is a relatively energy-efficient means of self-defense. Insects have a tendency to retain relatively fat-soluble materials in any case because their bodies have a high fat/water ratio, because the gut (where uptake usually occurs) represents a major percentage of the overall surface area and body weight, and because they process such large amounts of part per billion by humans (Ferguson and Metcalf 1985). Other sequestered compounds induce immediate, often violent, physiological reactions in would-be consumers. Cardiac glycosides, for example, induce, among other symptoms, visual disturbances, heartbeat irregularities (hence "cardiac"), and emesis (vomiting) in vertebrates that consume foliage of Asclepiadaceae, Apocynaccae, and other plants producing cardiac glycosides. This same ran-c of symptoms is induced in vertebrates ingesting insects sequestering cardiac glycosides. Even invertebrate predators such as the praying mantis *Tenodera aridifolia* regurgitate after ingesting even a few bites of cardiac glycoside-containing prey; coccinellids that ingest *Aphisiterii*, an Asclepiadaceae-feeding aphid that sequesters cardiac glycosides, during their development show severe niorphological abnormalities in the adult stage. Aristolochic acids are sequestered from aristolochiaccous host plants by many species of troidine swallowtails; these same plants, when ingested by vertebrates (including humans) can induce symptoms ranging from abdominal distension, nausea, vomiting, itching, and "frequent expulsion of flatulence" (Millspaugh 1974). Intense bitterness, visual disturbance, dizziness, hallucinations, and vomiting are, for most predators (with the possible exception of thrill-seeking humans), sufficiently unpleasant experiences that the offensive morsel, and all other potential morsels that even remotely resemble the offensive morsel, are scrupulously avoided by the predator in the future.

For distasteful species, then, there is a premium on being instantly and unmistakably recognizable. Not surprisingly, the vast majority of distasteful materials on a daily basis. Instead of expending metabolic energy to biosynthezize defensive compounds *de novo,* insects can exploit to their own advantage the energy investments plants have made in secondary metabolism. In many cases, particularly those in which insects sequester plant compounds in essentially unmetabolized form, there appears to be no detectable metabolic expenditure required to take up and store the compounds from the host plant. The large milkweed bug, *Oticopeltus fasciatus,* for example, sequesters cardiac glycosides from its asclepiadaceous host plants by a physico-chemical process that appears to involve no energy investment on the part of the bug (Duffey *et al.*, 1978).

Even when sequestered compounds are metabolized derivatives of host plant constituents, there may be energy savings over *de novo* biosynthesis. That many of these questered compounds are glycosides is probably no coincidence. The presence of a sugar moiety in a sequestered compound means that an insect can gain a nutritional benefit at the same time it gains a defensive advantage. In the case *of Chrysomela confluens,* a cottonwood leaf beetle, the glucose molecule liberated from salicin, a phenolic glycoside present in cottonwood foliage, during its processing more than compensates for any costs involved in sequestering the phenolic aglycone salicylaldehyde, which is stored in paired dorsal defense -lands oil the thorax and abdomen (Kearsley and Whitham 1992).

By sequestering plant toxins with little or no structural modification, insects acquire the same toxic properties as their host plants. In some cases, the sequestered compounds confer intense distastefulness. Cucurbitacins, for example, sequestered from host plants in the Cucurbitaccae by the southern corn rootworm *Diabrotica utidecimpuctata* and the striped cucumber beetle *Acaymma vittata* are so bitter that they can be detected at concentrations as low as one

insects are aposematic, or brightly colored. Because prey that are defenseless and hence perfectly palatable can't afford to be detected, bright colors and conspicuous behavior (such as leisurely flight) are generally indicative of chemical protection. In nature, chemically protected species in a variety of taxa have converged upon a few universal visual signals: aposematic species are frequently black, red, yellow, orange, or marked with various combinations of black, red, yellow, and orange. Tile universality of this signaling system is evidenced along highways and roadsides, where stop signs are red, warning signs are yellow and black, and hazard signs are orange and black. To sonic extent, the universal signalling system breaks down for humans, who have leaned to tamper with the natural color of the thin-s then, consume and who thus have grown accustomed to ingesting foods of every imaginable color courtesy of coal tar derivatives and other synthetic food colorants. Cryptic coloration, particularly in packaging, would put competing products at a significant disadvantage in attracting the notice of a shopper. Spicy foods (e.g. cans of chili) as well almost any food intended for children tend to stand out as examples of foods and packaging designed to attract attention.

Even in nature, however, bright colors are not a completely reliable indicator of distastefulness for the discrimination entomophage. Insects that resemble toxic species which themselves are not too toxic nonetheless can benefit from that resemblance if their potential predators generalize their avoidance behavior after an unpleasant experience. Hence, toxic species are often found in the company of completely palatable mimics that bear an uncanny resemblance to

**SEE TOXINS/PALATABILITY, P. 8**



**Table 1. Insects known to sequester hostplant toxins ***

| Insect | Hostplant | Toxin |
|---|---|---|
| **HOMOPTERA** (aphids, scales, etc.) | | |
| Family Aphididae | | |
| *Acyrtosiphon nipponicus* | Rubiaceae | Iridoid glycosides |
| *Aphis craccivora* | Leguminosae | Alkaloid |
| *A. cytisorum* | Leguminosae | Alkaloid |
| *A. genistae* | Leguminosae | Alkaloid |
| *A. nerii* | Asclepiadaceae, Apocynaceae | Cardenolides |
| *Macrosiphum albifrons* | Leguminosae | Alkaloid |
| Family Diaspididae | | |
| *Lepidosaphes ulmi* | Leguminosae | Alkaloids |
| *Aspidiotus nerii* | Apocynaceae | Cardenolides |
| Family Margarodidae | | |
| *Icerya purchasi* | Leguminosae | Alkaloids |
| **HEMIPTERA** (true bugs) | | |
| Family Lygaeidae | | |
| *Caenocoris nerii* | Asclepiadaceae | Cardenolides |
| *Lygaeus kalmii* | Asclepiadaceae | Cardenolides |
| *Oncopeltus fasciatus* | Asclepiadaceae | Cardenolides |
| *O. sandarachatus* | Asclepiadaceae | Cardenolides |
| *Spilostethus pandurus* | Asclepiadaceae | Cardenolides |
| Family Pentatomidae | | |
| *Murgantia histronica* | Cruciferae | Glucosinolates? |
| **ORTHOPTERA** (grasshoppers, etc.) | | |
| *Poekilocerus bufonius* | Asclepiadaceae | Cardenolides |
| *Romalea guttata* | Many plants (e.g., onion) | Sulfur compounds |
| *Zonocerus variegatus* | Leguminosae | Pyrrolizidine alkaloids |
| *Z. elegans* | Cannabinaceae | Cannabinoids |
| **COLEOPTERA** (beetles, weevils) | | |
| Family Cerambycidae | | |
| *Tetraopes tetraophthalmus* | Asclepiadaceae | Cardenolides |
| *T. femoratus* | Asclepiadaceae | Cardenolides |
| *T. basilis* | Asclepiadaceae | Cardenolides |
| Family Chrysomelidae | | |
| *Acalymma vittata* | Cucurbitaceae | Cucurbitacins |
| *Chrysochus cobaltinus* | Asclepiadaceae | Cardenolides |
| *Chrysomela confluens* | Salicaceae | Phenolic glycosides |
| *Chrysolina brunsvicensis* | Guttiferae | Quinones |
| *Diabrotica balteata* | Cucurbitaceae | Cucurbitacins |
| *D. undecimpunctata* | Cucurbitaceae | Cucurbitacins |
| *Phratora vitellinae* | Salicaceae | Phenolic glyc |
| **LEPIDOPTERA** (butterflies, moths) | | |
| Family Arctiidae | | |
| *Amphicallia bellatrix* | Leguminosae | Pyrrolizidine alkaloids |
| *Arctia caja* | Asclepiadaceae | Cardenolides |
| | Compositae | Pyrrolizidine alkaloids |
| | Scrophulariaceae | Cardenolides |
| *Argina cribraria* | Leguminose | Pyrrolizidine alkaloids |
| **LEPIDOPTERA** (butterflies, moths)(continued) | | |
| *Creatonotos* spp. | Leguminosae | Pyrrolizidine alkaloids |
| *Seirarctia echo* | Cycadaceae | Cyanogenic glycosides |
| *Tyria jacobaeae* | Compositae | Pyrrolizidine alkaloids |
| *Utetheisa bella* | Leguminosae | Pyrrolizidine alkaloids |
| *U. pulchelloides* | Leguminosae | Pyrrolizidine alkaloids |
| Family Ctenuchidae | | |
| *Syntomeida epilais* | Apocynaceae | Cardenolides |
| Family Danaidae | | |
| *Danaus gilippus* | Asclepiadaceae | Cardenolides |
| *D. plexippus* | Asclepiadaceae | Cardenolides |
| *Euploea core* | Asclepiadaceae | Cardenolides |
| Family Geometridae | | |
| *Meris alticola* | Scrophulariaceae | Iridoids |
| *M. paradoxa* | Scrophulariaceae | Iridoids |
| *Neoterpes graefiaria* | Scrophulariaceae | Iridoids |
| Family Lymantriidae | | |
| *Eloria noyesi* | Erythroxylaceae | Alkaloids |
| Family Nymphalidae | | |
| *Euphydryas anicia* | Scrophulariaceae | Iridoids |
| *E. cynthia* | Plantaginaceae | Iridoids |
| *E. editha* | Plantaginaceae | Iridoids |
| *E. phaeton* | Plantaginaceae | Iridoids |
| *Hypolimnas bolina* | Convolvulaceae | ?? |
| *Poladryas minuta* | Scrophulariaceae | Iridoids |
| Family Noctuidae | | |
| *Lepolys* spp. | Scrophulariaceae | Iridoid glycosides |
| *Xanthopastis timais* | Moraceae | Alkaloids |
| Family Papilionidae | | |
| *Battus philenor* | Aristolochiaceae | Aristolochic acid |
| *B. polydamus* | Aristolochiaceae | Aristolochic acid |
| *Ornithoptera priamus* | Aristolochiaceae | Aristolochic acid |
| *Pachliopiera aristolochiae* | Aristolochiaceae | Aristolochic acid |
| *Papilio antimachus* | Unknown | Cardenolides |
| *Zerynthia polyxena* | Aristolochiaceae | Aristolochic acid |
| Family Pieridae | | |
| *Catopsilia pomona* | Leguminosae | Alkaloids |
| *Pieris brassicae* | Cruciferae | Allylisothio-cyanate |
| Family Pterophoridae | | |
| *Platyptilia pica* | Scrophulariaceae | Iridoids alkaloids |

* See page 9 for common names of plant families in Table 1

 

**Toxins/Palatability** (from page six)

them. This particular arrangement, with a toxic model and a palatable mimic, is called Batesian mimicry, in honor of H.W. Bates, a nineteenth century English naturalist who first described the phenomenon. Thus, on milkweed plants, of the many aposematic species found feeding on milkweed plants, only a few actually contain cardiac glycosides. While the orange and black patterned large milkweed bug, and the red and black milkweed longhorn beetle *Tetraopes tetraophthalmus* are loaded with cardiac glycosides, the orange-and-black patterned milkweed leaf beetle *Labidomera clivicollis*, despite its conspicuous coloration, contains no appreciable amounts of cardiac glycosides in its body.

Distinguishing model from mimic is no mean feat and is complicated by the fact that under certain circumstances toxic species resemble each other, in a form of mimicry known as Muellerian mimicry. The presumed benefit of Muellerian mimicry is that aposematic species derive a common advantage if predators in a given area have to learn to recognize only a limited number of warning patterns. What was widely regarded as a classic example of Batesian mimicry has recently proved otherwise. The monarch butterfly, *Danaus plexippus*, sequesters cardiac glycosides from its asclepiadaceous host plants as a caterpillar and is toxic and emetic (depending on cardiac glycoside concentrations) as an adult as a result. The viceroy, *Limenitis archippus*, bears an extremely close resemblance to the monarch but, because of its habit of consuming willows, poplars, and other presumable inoffensive salicaceous plants as a caterpillar, it was always assumed to be a Batesian, or palatable, mimic of the monarch (a viceroy being, in fact, a "representative of the king")> Recent studies, though have demonstrated that the viceroy itself is unpalatable -- in some cases more so than the monarch -- and thus is a Muellerian mimic. The chemical basis for the distastefulness of the viceroy has not yet been eludicated.

For people who would like to increase their dietary intake of insects without risking vomiting, visual disturbance, or worse, it pays to know where your potential meal last dined. In general, in terms of sequestered plant toxins, predaceous insects are far less likely to contain them than are herbivorous insects--but these predators often produce their own defensive venoms, toxins, and the like. Oligophagous insects (those with a very restricted range of host plants) tend to sequester host plant toxins in greater frequency than do polyphagous species that feed on a broad range of host plants. This may be the case for two reasons; first, oligophages, having been closely associated with a particular class of toxins over evolutionary time, are more likely to have evolved tolerance to the limited range of chemicals that they encounter in their hosts, and second, by consuming only a single type of plant over the course of a lifetime they are likely to be exposed to larger amounts of particular types of chemicals. There are no guarantees, however. The arctiid caterpillar *Arctia caja* not only has a broad diet, it also has the ability to sequester different types of compounds from different hostplants -- cardenolides from asclepiads, pyrrolizidine alkaloids from composites, and in the laboratory, cannabinoids from *Canitabis*. There are insect families in which sequestration is certainly more widespread than in most. These include the seed bugs (Lygaeidae--Hemiptera), aphids and scales (Aphididae and Coccoidea-Homoptera), leaf beetles (Chrysomelidae--Coleoptera), and a host of caterpillars in the Papilionidae, Nymphalidae, Arctiidae, and Pieridae (Lepidoptera).

Another complication to selecting a nontoxic insect meal is the fact that, because plants vary widely in the chemical composition of their tissues, insects that eat plants and sequester plant compounds also show tremendous variability in their toxin content. Thus, in some parts of the country, e.g. in the northern parts of North America where *Asclepias silriaca* and other species low in cardenolides predominate, monarch butterflies contain virtually no cardenolides and in other places, such as in southern parts of the range where different *Asclepias* species contain much higher cardenolide levels, the butterflies can contain upward of 3.5 milligrams per gram dry weight of butterfly. The age and condition of the butterfly can also affect cardenolide content; monarchs that have completed the long and arduous migratory flight from northern North America to overwintering sites in Mexico often have very little cardenolide remaining in their bodies by the time they arrive for the lon- winter haul (Malcolm and Brower 1989).

Table 1 (page 7) provides a fairly comprehensive list of species known to sequester hostplant toxins. Essentially all of the species on the list are aposematically colored, so if there is a guideline to follow in searching for inoffensive insects for culinary purposes it is to avoid anything that makes itself conspicuous. Only at iny fraction of the 300,000 or so herbivorous species of insects, however, have been carefully scrutinized for their palatability characteristics; it may well be that aposematic insects are more likely to be investigated for their sequestering potential. As well, the predominance of certain plant families in the list may reflect the tendency of investigators to concentrate on familiar systems; that an extraordinary variety of insects, including butte,-flies, beetles, aphids, and lygaeid bugs, sequester cardenolides from asclepiadaceous plants may simply reflect the fact that the phenomenon of sequestration of herbivorous insects was first demonstrated in *Dallaus plexipplis*, a cardenolide--sequestering associate of asclepiadaceous plants, rather than any unique attributes of cardenolides or Asclepiadaccae. Because hostplants vary in their toxin content, and because at least some conspicuous insects are palatable mimics, there is no way to know with any certainty the extent to which aposematism is a reliable indicator of good taste.

Which brings up yet another point. Humans have come to value toxic plants in small doses for their psychotropic or bracing properties; most spices, ingested in large amounts, are toxic, hallucinogenic,or worse (e.g., myristicin, a principal constituent of nutmeg, is hallucinogenic at high dosages). It may well be that people can utilize insects that sequester hostplant toxins in the same way--as flavoring agents, stimulants, or even as narcotics. *Eloria noyesi*, a lymantriid caterpillar restricted to feeding on the foliage of *Erythroxylon coca*, the coca plant, contains detectable qualititites of cocaine in its body; females may contain as much as 53 nanograms in their bodies. While possession of cocaine is illegal in most

**SEE TOXINS/PALATABILITY, P. 9**



***Cultural Entomology Digest,*** edited by Dexter Sear, P.O. Box 1797, Kailua, Hawaii 96734. Volume 1, Issue 1, containing 20 pages, was mailed in June 1993.

Who is it for? *"[The Digest]* is a biannual publication distributed freely to anyone interested in the multitudes of insect references within human culture. The publication serves as a discussion forum and reference source for academic, environmental, and anthropological special interest groups as well as the general public."

What is cultural entomology? "Cultural entomology studies the reasons, beliefs, and symbolism behind the inclusion of insects within all facets of the humanities. Insects have and do play an important role in the arts, philosophy, psychology, and religions of almost every culture; therefore, a holistic study of this diverse wealth of references provides much insight into our current attitudes towards insects and nature in general." Cultural entomology became established as a recognized field of study following the 17th International Congress of Entomology in Hamburg in 1984. The editor credits the late Dr. Charles Hogue of the Los Angeles County Museum of Natural History as monumental in his organization and research into cultural entomology and in motivating a wide interest in the subject. Hogue's definitive work was "Cultural Entomology" published in the 1987 *Annual Review of Entomology,*, Vol. 32, pp. 181-199, which is reprinted in this first issue of the *Digest*. Some of' the other articles in this first issue are also reprinted. The next issue, planned for January 1994, will focus on cultural references to beetles.

The design, format and content of this first issue are attractive. Although "free," the *Cultural Entomology Digest* will depend for its survival on financial contributions from its readers.

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**Toxins/Palatability** (from page eight)

countries, possession of caterpillars is not and may make these toxic

Butterfly *Euphydryas cynthia* (Lepidoptera: Nymphalidae). *Phytochemistry* 26:103-106.

sequesterers highly sought after rather than scrupulously avoided. By the same token, while bitter compounds are avoided by the general populace, some people are rather fond of them--to the extent that "bitters", alcohol solutions of various potent herbs, are used as condiments and flavoring agents. It remains a distinct possibility, then, that aposematic and potentially toxic insects might well take their place among the brightly colored candy bars, cans of chili, and other more familiar foods that attract the eye as well as test the palate.

Ed.: The common names of plant families listed in Table 1:

Apocynaceae (dogbane family) Cycadaceae (cycad) Aristolochiaceae (birthwort) Erythroxylaceae (coca) Asclepiadaceae (milkweed) Leguminosae (legume) Cannabinaceae (hemp) Plantaginaceae (plantain) Compositae (composite) Buriceae (madder) Convolvulaceae (convolvulus) Salicaceae (willow) Cruciferae (mustard) Scrophulariaceae (figwort) Cucurbitaceae (gourd)

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**Insects/Zoo Animals** (from page one)

and alate stages (in the case of termites and ants) have a higher fat content than other life stages of the same species. This fact may be nutritionally relevant for animal species which consume immature compared to adult sizes (for example pinhead crickets compared to adults), but has not been investigated in detail.

Protein. The value of insects as an economic source of high-quality protein is well known (Martin *et al*., 1976; DeFoliart *et al*., 1982, Redford and Dorea, 1984). A fraction of the nitrogen in many insects used in zoo feeding programs is, however, chemically bound within the chitinous exoskeleton and may be unavailable to animals consuming them. In our laboratory, we assayed bound versus total nitrogen in common food insects, and found that approximately 93% of total nitrogen was unbound, thus theoretically available to enzymatic degradation, levels that were similar to those found by Finke *et al* (1989). Just as with humans, insects provide a significant protein source for insectivores, with values ranging from 34% (waxmoth larvae) to 80% of dry matter in cockroaches, dragonfly nymphs, and gypsy moths.

requirements of this nutrient. Trials are underway with Dr. Gary Ferguson and others at Texas Christian University, to examine vitamin A requirements of chameleons fed only crickets; theoretical calculations of low requirements have been determined (Annis, 1993).

Measurements of the vitamin E content of insects used as food in zoos showed that five species obtained from commercial suppliers contained 10to5O m-/k µ-tocopherol (dry basis), while three wild caught species had concentrations ranging from 49 to 179 mg/kg. Walking sticks recently analyzed in our laboratory contained >200 mg/kg vitamin E activity, likely due to the leafy diet *(Ficits spp.)* which fills their gut (dark green plants are a good source of vitamin E). Dietary concentrations of vitamin E have a significant effect on subsequent vitamin E content of prey insects; it is possible to increase mealworm and cricket vitamin E body concentration through diet supplementation (Penninoetal., 1991). Duno beetles collected in the Ngorongoro Crater in Tanzania contained about 150 mg/kg atocopherol, and are reported to be the primary food source for jackals during lactation periods. Dr. Patricia Moehl man, of Yale University and NYZS/The Wildlife Conservation Society, is currently sampling different species of dung beetles, collected during different seasons, and attempting to evaluate contributions to jackal nutrition and reproduction.

Carbohydrate. In general, insects contain little simple carbohydrate such as sugars or starch, but may have a substantial (around 20% of dry matter) complex carbohydrate component in the form of chitin, which is a nitrogen-containing polysaccharide. Insectivores possessing chitinases (enzymes to break down chitin) may obtain energy from digestion of the exoskeleton (up to 20% digestibility values of chitin have been reported in small mammals; Allen and Oftedal, 1989). For animals not exhibiting chitinase activity, the dilution of high fat and high protein insect diets with indigestible "fiber" may be important to gut function by affecting passage, fecal bulk, or absorption of other nutrients. Specific examples of this effect in the zoo community can be found by the addition of chitin (15%of dry matter) to diets fed to ant- and termite-eating specialists, with dramatically improved stool quality (firmness) an immediate observation.

Vitamins. Very few data can be found on the vitamin content of insects used as food. Recent studies (Penninoetal., 1991) found vitamin A levels ranging from unmeasurable in crickets and Tenebrio larvae to a high of 3000 IU (International Units)/kg dry matter in honeybees. No differences were apparent between commercially supplied (n=6species) or wild-caught (n=3) insect species. Although vitamin A requirements of insectivores have not been specifically determined, requirements established for wildlife and domestic species ran-e from 3000 to 15,000 IU/kg dry matter. Insects in general appear to be a poor source of pre-formed vitamin A, but it is possible that pigments in the exoskeleton of insects may provide vitamin A activity (Brush, 1990). Many animal species have the physiological ability to convert carotenoid pigments (primarily P-carotene) to active vitamin A. Carotenoid levels in food insects are currently under investigation through collaborative studies with Dr. Harold Furr at the University of Connecticut. Additionally, due to the relatively low levels of vitamin A measured, in insects, we hypothesize that strict insectivores may, in fact, have low dietary

A final fat-soluble vitamin, vitamin K, has not been measured in prey insects. There is, however, inferential evidence that termites may be a good source of this nutrient through microbial synthesis in the gut cavity of the termites. Termite-eating specialists held in zoos (and fed substitute diets) often suffer from vitamin K deficiencies if diets are not supplemented. Analysis of natural foods of ant- and termite-eaters may provide useful guidelines for proper levels of K supplementation.

Minerals. The ash content of insects, as found in many tables of nutrient composition, contains an entire suite of inorganic constituents. Much of the existing literature on mineral content of insects has focused on imbalances of calcium (Ca) to phosphorus (P) ratios in crickets or mealworms, along with subsequent health problems associated with calcium deficiency in species fed solely on these food items (Allenetal., 1993).Supplementation of the diet fed to prey insect species has been shown to increase Ca content, and high-Ca cricket diets are available commercially. A simple mixture consisting of approximately 20% (by weight) powdered calcium carbonate, and 80% nutritionally-complete chick mash, with a final Ca content of 8% (dry matter) appears suitable for feeding crickets and *Tenebrio* larvae 2 days before they are fed out. Additionally, insects should be coated in calcium carbonate immediately prior to feeding to insectivores (if coated more than 30 minutes prior to feeding, crickets may have opportunity to remove the Ca supplement through grooming).

Although studies of selected mineral (Cu, Zn, Ca, Na, K) requirements for raising crickets (McFarlane, 1991), and the mineral composition (Fe, Ca, M-, Na, K) of June beetles have been reported (Keeler and Studier, 1992),the mineral content of insects in general has not been

**SEE INSECT/ZOO ANIMALS, P. 11**

### Recent Magazine Articles

*Focus: The world in perspective*, July 1993, published in London. Writer Janet Fricker begins an article (pages 68-70) titled "Why don't you eat insects?" by saying: "When I casually mentioned I was planning a visit to a restaurant serving insects, people looked aghast. But the reality of The Insect Club, a restaurant and nightclub in Washington DC, destroyed all my preconceptions. The food was delicious and I was won over to this new concept in nutrition."

Fricker then discusses a wide range of relevant aspects of the subject, including the adverse effect of Western bias on cultures that have traditionally used insects; nutritional value, naming specifically a number of the nutrients supplied by insects; food conversion efficiency of insects and their high reproductive capacity; opportunities for cutting pesticide use because many important food insects are also important crop pests; economic opportunities for small farmers in developing countries; health benefits derivable from chitin; possible hazards from eating certain kinds of insects; and the potential of insects and problems associated with their possible use as food in space. The article is colorfully illustrated, and another good example of the high quality journalism which edible insects are now getting from Western writers.

**The Last Hunt: On the trail with Paraguay's forest people.** By Stephen Homer, *Nature Conservancy*, November/ December 1992, pp. 24-29.

The first 3 1/2 paragraphs of this article are quoted below:
Juancito squatted over the split palm trunk, eyeing the fat white palm grubs that wiggled in the rotten wood's red fibers. He grabbed one between thumb and forefinger and popped it in his mouth like a canape. Slashing open more of the trunk with his axe revealed dozens of the wiggling larvae, which he proceeded to gobble up.

It's been a long time since I've eaten *buju* [the palm grub] - my body was craving it," said Juancito, a Paraguayan Ache (pronounced "ahchay") Indian. "There are not many old palm trees near our village."

Insect larvae were once among the staple foods of the Ache, who roamed the forests of eastern Paraguay. But since these people were forced from their native lands in the seventies, palm grubs have become a prized delicacy. The Ache now live in a number of small villages on cleared land, where they struggle to make the difficult transition from hunting-and-gathering to small cash-crop agriculture.

In an effort to help the Ache preserve their traditions, and to protect one of the last remaining untouched strands of forest wilderness in the country, The Nature Conservancy and its Paraguayan partner, The Moises Bertoni Foundation, have helped establish the new Mbaracayu nature reserve in eastern Paraguay.

**Insects/Zoo Animals** (from page ten)

summarized, nor have researchers concentrated on the links between diet, substrate, mineral interactions, and subsequent whole body composition for other mineral nutrients apart from Ca and P. This area is one which deserves much further attention, particularly as we strive to characterize and optimize diets for wildlife species.

Ed.: We thank Dr. Diernfeld for accepting our invitation to prepare this article for the *Newsletter.*

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### The Montreal Insectarium to again offer insect treats

From Marjolaine Giroux, November 13th: As you know, in February 1994, l'Insectarium de Montreal will present the exhibition CROQUE INSECTES. Acrain, we will offer edible insects to the public. Also, because the event was so popular last year, we decided to enlarge the exhibition so that the public may have more information about entomophagy.

Ed.: For more information about dates and details, write to Marjolaine Giroux, Montreal Insectarium, 4581 Sherbrooke Street E, Montreal, Quebec, HIX 2B2, Canada.

### Australian Entomologists Grub Out

Another successful entomological gourmet event recently came to our attention, thanks to Dr. Penny Gullan of the Australian National University in Canberra. The Annual Dinner of the Entomological Society of New South Wales was held on November 7, 1992 at the Ku-ring-gai Wildflower Garden in Sydney. The entree: Witchety grubs were planned, but unavailable, so large roasted cerambycid larvae, close in size and taste to Witchety, were substituted and "they were delicious" according to the Society's Circular #424. Bogonli moth (Noctuidae, descaled) pate served on cheese biscuits was "quite nice." Vic Cherikoff, the well-known bush tucker specialist, supplied the insect and herbal part of the menu alone, with expert advice on how to prepare it. Cherikoff also presented a short talk on edible bush insects, accompanied by a series of color slides. Digesting part of the Australian insect fauna proved to be "both an interesting culinary experience and unorthodox entomological education for most people present."

### *The* Newsletter goes to 82 countries

The July 1993 mailing of the *Newsletter* totaled 2418 copies, with 1903 going to U.S. addresses. Canada ranked second with 171. Nigeria ranked first among African countries with 29. India topped Asia with 18, closely followed by Thailand at 17 and the Peoples' Republic of China at 16. Colombia topped Latin America with S. The United Kingdom led Europe with 35. The top 10 states were California 276, Wisconsin 159, New York 144, Florida 72, Pennsylvania 72, Illinois 70, Massachusetts 69, Washington 68, Texas 65, and Ohio 59.