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THE FOOD INSECTS NEWSLETTER

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CHOLESTEROL AND INSECTS

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The diet of humans living in industrialized nations is frequently high in lipids, such as fat and cholesterol. Unfortunately, an increase in serum cholesterol levels seems to increase the risk of a person developing coronary heart disease(1). More than a million Americans have heart attacks each year and more than one-half die as a result. Therefore the National Institutes of Health has recommended that one way individuals can reduce their risk of illness is to make changes in their diet (2).

With the amount of publicity that this recommendation has received, almost everyone knows of ways to reduce their dietary intake of cholesterol. Surveys indicate that health-conscious Americans are, indeed, trimming fat from meat, replacing red meat with poultry and fish, eating fewer eggs and using skim milk in their diet (2). The sales of natural products, such as oat bran, which apparently enhances the excretion of cholesterol, are booming. With all of this current interest in nutrition, it is certainly worthwhile to explore the sterol biochemistry of other lesser known food items, such as insects, and to evaluate their possibilities as low-cholesterol food additives.

Interestingly, most eucaryotic organisms require sterol, or sterol-like molecules, as structural components of their membranes (3). These molecules apparently interdigitate with the tails of the phospholipid molecules in the lipid bilayer and so help regulate the fluidity of the membrane. For example, the major sterol in many animal membranes is cholesterol (Figure 1, page 5) which has a double bond at carbon 5 and no alkyl group at carbon 24 (i.e., it is a Δ5-24-desalkylsterol). Plants and fungi also contain sterols but they tend to synthesize and utilize ones that have a methyl or ethyl group on the side chain at carbon 24, and have a double bond at carbon 5, or 7, or at both 5 and 7 (i.e., they are Δ5-Δ7-, or Δ5,7-24-alkylsterols).

The differences in the structure of the sterols in these different organisms helps to explain why a diet high in plant products is healthier than a diet high in animal products. Fortunately, humans can neither absorb nor metabolize 24-alkylsterols to cholesterol (3). Therefore, the plant sterols in corn oil pass harmlessly through the human digestive tract whereas the cholesterol in butter is absorbed and can contribute to the endogenous pools of cholesterol. (The human liver synthesizes cholesterol *de novo* in order to ensure that there are adequate amounts for cell membrane biosynthesis as well as to serve as precursors for bile salts and hormones, such as estrogen and testosterone.)

What about insects as a part of the human diet? Since they are animals, do their tissues also contain cholesterol? Insects are very interesting, in that they too need sterols for the biosynethesis of membranes and as precursors to hormones (.e.g., the ecdysteroids), but they are unable to synthesize them *de novo.* (4). Therefore, they must obtain these molecules exogenously, from their diet or from symbionts. Those insects that feed on animal products (e.g., the hide beetle, *Demestes vulpinus [5])* can easily obtain cholesterol from their diet and so

Directory finally going to the printer--hurry if you want to be included. hurry if you want to be included.

The long-promised Directory is scheduled to go to the printer on June 15th. Listees are those who have returned an Address Form from *Newsletter* Vol. II, Nos. 2 or 3, checking "yes' for Directory listing--about 110 individuals so far. Additional entries can be included if received before June 15th (form on page 7). The Directory will be mailed in late June to those listed in it, to 1989 and 1990 Sustaining Patrons, and to libraries. Others may obtain a copy for $4.00 postpaid.

usually utilize this sterol directly in their tissues. In contrast, those that feed on plants or fungi consume 24-alkylsterols and so must absorb and either use these sterols directly in their tissues or metabolize them to more utilizable ones. It appears that many insects (e.g., the tobacco hornworm, *Manduca sexta* [4] and the house cricket, *Acheta domesticus [6]*) contain the enzymes for the dealkylation of delta 5-24-alkylsterols and so convert such sterols to cholesterol. Therefore, like other animals, insects are approximately 0. 1% sterol (i.e., 1 mg sterol/g tissue).

Does this mean that the consumption of insects must entail the ingestion of unwanted dietary cholesterol as well? Not necessarily. Since there are probably well over one million different species of insects, it is not surprising to learn that there are some that are unable (or do not expend the energy) to convert delta 5-alkylsterols to cholesterol. Such species include the honey

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A PROGRAM PROFILE: HONEY ANTS AND AUSTRALIAN ABORIGINES

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Honey ants are unusual insects because certain workers called repletes have enlarged gasters to store nectar brought to them by workers foraging on plants. Although there are several genera of honey ants in the world which have independently evolved this adaptation, the largest repletes occur in species in

a picnic with a purpose: an opportunity for an Aboriginal mother to teach her children about the land and their ancestral way of life.

Honey ants also play a prominent role in the Aboriginal concept of Dreamtime, an epoch long ago when their totemic ancestors created all people, creatures and topographical features. Each plant and animal has a "Dreaming"--the story of its creation and importance. Aborigines born near the site of a mythological event are descendants of that Dreamtime ancestor the arid lands of North America *(Myrmecocystus* spp.) and central *Australia (Camponotus inflatus).* These repletes have a gaster about the size of a grape and hang suspended in dome-shaped chambers in the nest.

Having studied the biology of the honey ant, *Myrmecocystus mexicanus*, in Colorado and Arizona since the early 1970's I was aware of historical accounts of its use as a sweet delicacy by the Indians of the American southwest and Mexico. Some accounts even mention medicinal uses and a fermented drink made from the ants used in religious ceremonies of the Aztecs and Toltecs. The 'honey' in repletes tastes like cane molasses and analyses confirm it is sweet and nutritious, containing glucose, fructose and varying amounts of protein.

More recently I became intrigued by accounts of the present day use of honey ants by Aborigines in the Australian Outback. In 1984 1 first saw the black honey ant, *Camponotus inflatus*, while camping with an Aboriginal family near Alice Springs. They showed me how they dig and eat these insects and collect them as treats for friends in town.

In 1987 I led three EARTHWATCH expeditions to Alice Springs and Uluru National Park (Ayers Rock) to study the biology and use of honey ants by Aborigines. Since this ant occurs in country occupied by several tribal groups there are a variety of aboriginal terms for it. "Yerrampe," the Aranda name is common. Aboriginal women at Uluru National Park call repletes "Tjala." This ant nests in mulga *(Acacia aneura)* groves and feeds on nectaries at the base of the needlelike leaves (phyllodes). It is also reported to feed on flowers and lerp, a red scale on mulga, that exudes nectar.

It is usually senior Aboriginal women who locate and dig honey ants. Aborigines expend much time and effort digging. We found 27 excavation pits in one hectare at the Hamilton Downs Cattle Station outside Alice Springs. Women use digging sticks, shovels and pitis (curved wooden dishes) to expose the replete chambers. Most excavations are partial and last less than an hour. This practice probably spares the queen and most workers, thus preserving the nest and the species. Although repletes are reportedly used on occasion to sweeten dough ("damper") or to make a drink, Aborigines primarily eat them one-by-one by biting off their swollen abdomens. Since sugar and other modern sweets are widely available, honey ant digging is now and related to all plants and animals associated with it. The honey ant is the sacred totem for some Aboriginal clans. These honey-ant people have rituals, songs, art and initiations associated with the insects. Abstract honeyant designs have been depicted for years in ground mosaics, cave paintings, body paintings and on churingas (sacred ceremonial slabs of stone or wood). Today they are painted on canvas and printed on postcards and T-shirts sold to tourists. Thus, honey ants have had and continue to play an important role in the diet, culture and livelihood of Aboriginal people.

Dr. Conway has published articles and photographs on honey ants in entomological journals and in popular publications, such as *Ranger Rick, National Geographic World, National Wildlife, Science Digest, World Book Encyclopedia, New Scientist* (London), *Huisgenoot* (S. Africa), *Your Big Backyard, Highlights for Children, Learning Magazine*, and *Science and Children. Geo*, Australasia's geographical magazine, recently purchased an article for publication in 1990. He has exhibited photographs at the Cincinnati Zoo's World of Insects, the Everhart Museum, the Illinois State Museum, Tulsa Zoological Park and the Garden of the Gods Visitor Center. His work was filmed by the TV show "That's Incredible" and more recently by the BBC for a National Geographic Explorer program on ants.

Recipe: Crispy Cajun Crickets

Tired of the same old snack food? Perk up your next party with Crispy Cajun Crickets. Roasted crickets are a tasty and unique addition to any social occasion, with a crunchy-tangy flavor all their own. To prepare, place 1 cup of healthy Cajun Crickets into a large, clean, and airy container (add a pinch of oatmeal for food). After 1 day, remove sick crickets and freeze the remainder. Wash frozen crickets in tap water, spread on cookie sheet, and roast in oven at lowest setting. When crickets become crunchy, sprinkle them with butter sauce and serve. Prepare butter sauce by adding salt, garlic, paprika, chili, or tabasco sauce to melted butter. -- Mmmm - Good.

(Reprinted from the *Cajun Cricket Monthly* Vol. 1, No. 6, July 1989, to whom it was submitted by *Newletter re*aders, Dr. Douglas Whitman and by S. Sakaluk, Illinois State University, Department of Biological Sciences. Cajun crickets are of course specially pampered house crickets, *Acheta domesticus*, the "cricket on the hearth" of English literature. The *Cajun Cricket Monthly is* the house organ of Fluker's Cricket Farm, P.O. Box 378, Baton Rouge, LA 70821. As Fluker's is happy to endorse their crickets for human consumption, we are happy to pass along their toll-free number. Call 1-800-735-8537.

MONOGRAPH

Insects as food: aboriginal entomophagy in the Great Basin. Mark Q. Sutton. Ballena Press *AnthropologicalPapers No. 33*, 115 pp., 1988. Ballena Press, Publishers Services, P.O. Box 2510, Novato, CA 94948. Price $17.95, paper.

This is a major contribution to our knowledge about entomophagy among early cultures in western North America. From an entomological standpoint its unique value lies in the use of ecological information in an attempt to determine which species of insects were most likely used inasmuch as early ethnological accounts rarely give many clues. Data on the use of insects in aboriginal cultures are primarily of two types, ethnographic and archaeological (pp. 5-10). Ethnographic data are derived from direct observations by anthropologists, observations by non-anthropologists (e.g., ethnohistoric accounts), memory culture, continuation of practices into the present, and inferences from ethnographic data from neighboring groups. Dr. Sutton points out pitfalls relative to the gathering and interpretation of each kind, and the introductory chapter provides some excellent insights as to why the importance of insect consumption in aboriginal societies has been under-reported and underestimated.

Unfortunately, few of the observers were trained in anthropology, and fewer yet in the natural sciences. Observers from European cultural backgrounds were often biased in their necessary for an understanding of the system as a whole and of its interactions with other systems." Many components, including insects, are poorly known. Anthropologists often consider that insects are "famine food or backup resources, usually taken on an individual encounter basis," yet, Sutton states (p. 3): "While it is probably true that insects were taken individually during the course of other activities, the overall procurement of insects appears to have been systematic and not confined to chance." The author concludes that, "insects were commonly and extensively used and that they played an important part in fulfilling the nutritive requirements of the Great Basin Indians."

Following the introduction, chapters are based on specific groups of insects as follows: 2) Grasshoppers and locusts, 3) Crickets, 4) Caterpillars, 5) Flies, 6) Cicadas, 7) Mesquite beetles, 8) Ants, 9) Bees and yellow jackets, 10) Honeydew, 11) Other insects, and 12) Summary and discussion. References cited include ethnological, archaeological and entomological papers totaling about 258. Each chapter is divided into sections: 1) Description and ecology. 2) Ethnographic data, 3) Archaeological data, and 4) Discussion.

Sutton concludes that grasshoppers and locusts were widely used throughout the Great Basin and were a very important resource. An example of the use of ecological data is to reinforce, on the basis of their abundance, earlier reports of the use of several species of *Melanoplus* and of *Schistocerca* observations of insect consumption or disregarded it entirely. In addition, as insects were usually processed and fragmented, they often could not be recognized by ethnographers, and so were not recorded. As a result, it is probable that a much greater number and variety of insects were utilized by the Indians of the Basin than has been reported. In addition, misidentifications appear to have been frequent, e.g., the term "locust' used interchangeably for grasshoppers, crickets and cicadas. This affects conclusions as to seasonality, technology employed, and caloric return, and thus can lead to an underestimation of the importance of insects in the aboriginal diet and a corresponding overestimation of the importance of other dietary components.

Relative to archaeological data, poor preservation and inadequate field and laboratory methods result in a paucity of data. The author discusses reasons for this, and why even coprolite analysis is not as fruitful as might be expected.

As far as known, insects never comprised the staple in any economy, but they were often critical resources that were more than an occasional addition to the diet. The author notes that Great Basin investigators are now beginning to study resources in view of their seasonal availability, nutritional content, and search and processing time, but the usually cursory treatment of insect consumption by anthropologists leads to this statement (p. 2): "From an ecological standpoint, an understanding of, or at least a delination of, all parts of an economic system is

shoshone. The Mormon cricket, *Anabrus simplex* (actually a wingless tettigoniid grasshopper), was also a resource of major importance and was probably used by virtually every group in the Basin. The author cites historical accounts of the plague proportions of this insect, frequently lasting for years on end, notes the organized manner by which they were harvested (involving large numbers of people), and concludes that it provided huge returns for the labor invested. Ethnographic accounts of groups (men, women and children) spending days and considerable labor in the harvest preparation certainly suggest that crickets were not an ephemeral resource taken on an "encounter basis." The crickets probably constituted a formal part of the seasonal round, and the author states, "Hundreds of thousands of pounds of very high quality food for a few days of labor would have been a wise investment, especially since the resulting food was storable." Several species of true crickets *(Gryllidae)* are also common in the Basin and probably were used as well although none have been mentioned by specific identity in the ethnographic literature.

The use of caterpillars as food has been widely reported throughout the Great Basin, but the specific identity is known only of two species of moths, the pandora moth, *Coloradia pandora* (Family Satuurniidae), and the white-lined sphinx

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moth, *Hyles lineata* (Sphingidae). The food use of the pandora moth is well-documented in California and much is known about its ecology. Populations in Arizona have been estimated as high as 100,000 adults per hectare. The caterpillars were known as *piagi*, *Pe-ag'-gah* (big fat ones, good to eat) and similar spellings, depending on the tribe, and they were widely traded. Sutton quotes from a 1928 paper by Miller and Hutchinson: the Monos [Northfork Mono?], lured by the tempting collecting grounds, had crossed the range [the Sierra Nevada] and gathered caterpillars from areas that were considered exclusive worming grounds of another tribe (e.g., Miwok or Yokut]. This caused a serious break in diplomatic relations between the two tribes and very nearly resulted in a great Pe-ag'gie war.

Several investigators have concluded that the pandora moth provided a significantly greater nutrient return for effort expended than did plant resources.

In the Diptera, Sutton summarizes the numerous references to the use of the shore fly, *Hydropyrus hians* (pupae), and suggests that other shore flies were probably also used, particularly *Ephydra gracilis*, which coexists with *H. hians* in the Great Salt Lake and elsewhere. The presence of two sizes are mentioned in one early ethnographic reference, and *E. gracilis* is much smaller than *H. hians*. Although the larvae of *H. hians* were frequently mentioned in the early literature as the stage consumed, Sutton uses biological information to establish that it was primarily the pupae that were consumed. The larvae are generally attached to the bottom of the lake, while it is the pupae that wash up to the shore. The use of shore flies was probably widespread. They were traded, and some groups traveled fairly long distances to obtain them. They were available in great quantities and were apparently storable enough to serve as a winter staple.

Although there are no specific ethnographic records of the use of crane fly larvae by Great Basin groups, crane fly remains comprised 25% of a human coprolite found in east-central California. *Holorusia rubiginosa*, a large species with larvae from 30 to 55 mm in length, *Tipula simplex, T. derbyi, and mplex, T. derbyi, and* T. *quaylii*, all mentioned earlier by Essig, are among the species available. As the larvae appear in the winter months, January through March, they may have formed an important food source during what are considered lean months.

Sutton notes that cicada consumption may be underrepresented

species that are sometimes common in the Great Basin include the bloody cicada (*Okanagana cruentifera*), the bella cicada (O. *bella)*, the orchard cicada *(Platypedia areolata)*, and possibly *P. lutea*. The largest of these is *0. cruentifera*, which measures about 32 mm in length. There are numerous reports of the use of cicadas by groups in the Great Basin. Fowler identified a cicada used by the Northern Paiute at Pyramid Lake as probably *0. bella*. Ebeling reported a cicada gathered in large numbers from the saltbush *(Atriplex)* and eaten roasted by the Cahuilla *as Diceroprocta apache*. After emerging from the ground and molting it takes about a day before the adults are ready to fly. This is a vulnerable stage for easy harvest Sutton concludes that cicadas were a minor resource because they didn't occur each year and rarely occurred in large concentrations.

Bruchid beetles constituted an "automatic inclusion of animal protein in processed mesquite." Larvae, pupae and adults of the two major genera of Bruchidae in western North America, *Algarobius* and *Neltumius*, infest both the seeds and pods of the honey mesquite *(Prosopis grandulosa)* and screwbean *(P. pubescens)*. There are as many as three generations per year and as many as 80% of the pods may be infested during the latter part of the season. The pods are harvested from early to late summer and either eaten raw or stored for later use. Fine grinding incorporates the insects into the flour, but coarse grinding permits the insects to increase to a "living mass" as so graphically described in earlier reports quoted by Sutton. The insects were accepted as an agreeable ingredient of the flour by the Indians, who made no effort to remove them.

Sutton concludes that consumption of at least several genera of ants was widespread in the Great Basin. Larvae, pupae and adults were used; references to "ant eggs" most likely refer to larvae and/or pupae. Ants were easily stored and undoubtedly formed an important portion of the winter diet of some groups. They also had medicinal and ritual uses which Sutton describes. Genera and species which, from ecological considerations, were probably of importance as food in the Basin included the red harvester ants, *Pogonomyrmex occidentalis, P. owyheei, P. desertorum, and P. californicus*, the former two of which are much larger than the latter two. Other ants endemic to the Basin include the red ant, *Formica rufa*, carpenter ants, *Camponotus* spp., and the American black ant, *Lasius niger.* The honey ant, *Myrmecocystus mexicanus* var. *horti-deorum*, occurs throughout the Basin and may have been used as food. In going through the ethnographic accounts, Sutton in some cases speculates on the specific identity of the ants that may have been used by a tribe in a particular region.

Bee and yellowjacket larvae/pupae were fairly widely used in in the literature because of the confusion in terminology in which cicadas are often called "locusts." Although specific species have not been identified in the ethnographic record, the Basin, but they appear to be a minor resource that was gathered incidental to other activities. Honey also was a minor resource because the native species of bees do not produce appreciable quantities. Bees mentioned, among others, as in-

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bee, *Apis mellifera* (7). The latter insect has avoided the necessity of producing 24-desalkylsterols in order to biosynthesize ecdysteroids. It simply uses makisterone A (an alkylated ecdysteroid) as its molting hormone!

In addition, studies in my laboratory have shown that replacing the Δ5-sterols in the diet of the corn earworm, *Heliothis zea* with delta 7-, delta 5,7-, or delta O-sterols results in an insect that contains little, if any, cholesterol (8,9). This lepidopteran dealkylates the new dietary sterols but does not hydrogenate the double bonds or introduce new ones. The structures of the resulting tissue sterols render them unabsorbable by the normal human digestive tract. Therefore, if one was interested in producing insects, such as A. *domesticus*, with a low cholesterol level, one might try feeding them, for example, a diet rich in alfalfa sterols (i.e., Δ7-sterols). Perhaps they, like *H. zea* (10), would utilize the Δ7-sterols predominately in their tissues. The alfalfa weevil, *Hypera postica,* which is a pest of alfalfa, uses Δ7-sterols and routinely lacks cholesterol in its tissues (10). Other insects, which naturally feed on diets that contain sterols other than Δ5-sterols, and do not contain cholesterol in their tissues, include the fly, *Drosophila pachea* (11), and the leaf-cutting ant, *Atta cephalotes isthmicola (12).*

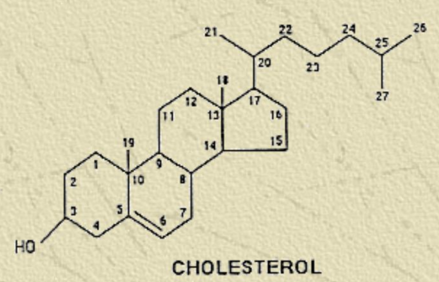

Figure 1:

In conclusion, the inability of insects to synthesize their own sterols forces them to be dependent upon exogenous sterols in order to complete their growth and development. This unusual sterol requirement of insects means that the sterol composition of their tissues may change when they feed on different diets. Thus, insect species whose tissues are low in cholesterol, either naturally or due to special feeding, may be an especially useful addition to the human diet.

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"Good" versus "Bad" Cholesterol

Sometimes the terms "good" versus "bad" cholesterol appear in the lay literature and can be confusing to persons attempting to regulate the cholesterol level of their diet. Just what is the difference between "good" and "bad" cholesterol? Interestingly, these adjectives don't refer to different structural forms of cholesterol. Instead, they are simple terms used to describe the ways in which this molecule can be transported in the human circulatory system.

Cholesterol is a lipid and, just as oil and water don't mix, neither does cholesterol and blood. Therefore, in order for cholesterol to move from one part of the body to another (e.g., from the digestive tract to fat tissue), without precipitating out of solution and causing blockage of the blood vessels, it has to bind to an amphipathic (i.e., detergent-like) molecule that can shield it from the aqueous medium and so transport it through the blood stream. Lipoproteins, such as HDL and LDL, are the molecules that transport cholesterol (and other lipids) through the circulatory system of humans.

Although hypercholesterolemia can occur with the elevation of any lipoprotein class, elevation of LDL levels increases the risk of coronary heart disease whereas elevation of HDL levels reduces the risk. Therefore, persons with a high level of "bad" cholesterol (i.e., LDL) should attempt to reduce the concentration of these lipoproteins in their blood.

Insects also have lipoproteins that transport their sterols through their body (see accompanying article). However, since they have an open circulatory system, they don't have to worry about heart attacks! Humans don't have to avoid consuming "bad' vertebrate, or invertebrate, lipoproteins in their diet since such molecules are digested in the intestinal tract. K.S.R.

LETTERS........

This cat is more than a mouser.

Dr. R.N. Sharma, Head of Entomology of the National Chemical Laboratory (Council of Scientific & Industrial Research), Pune, India, writes, in part:

"Some time ago, a cat had taken up residence in a store-cum-insectary in our laboratory. The preponderant majority of lady scientists and assistants permitted the cat to maintain her abode in an obscure dark, blind corner beneath piles of the breakfasts. She was, in fact, caught in the act several times and has since, I strongly suspect, been allowed to have these gourmet sessions with nary a demur by anyone."

Processed insects in China

Luo Ke of Beijing Agricultural University writes, in part: "Currently I am conducting a small project on the evaluation of the protein quality of the migratory locust and rice locust usual forgotten laboratory junk, provided she did not go on rampages - which she didn't. And eliminate mice she did, so acquiring a reluctant kind of pseudo-scientific justification for being allowed to stay on by more grumpier staff. Recently, we noticed that truant *Spodoptera litura* larvae (IV succulents) from a mother colony of the insect were simply not littering the floor, as they used to during peaks of high abundance, notwithstanding the usual wire net and muslin guards. It was soon discovered that our residence feline had turned insectivorous, apparently relishing the IV sl late night dinners and early morning

(Locusta migratoria menilensis Megen and *Oxya chinensis* Thunberg) when fed as the high protein source in rat diets, as well as the analysis of their nutritional contents of protein, vitamins, minerals and lipids. According to our investigation, the two locust species are widely used as food in China. The latter has been canned for sale in some town markets in recent years. In addition, we also found that several other insects such as cicada are canned for sale in the markets. In the near future, I also hope to work on using insects as poultry feed."

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habiting the Basin include the *Xylocopidae* carpenter bees, which are largely solitary. Among the common species in the Basin are *Xylocopa opifex and X. californica.* Bumblebees *(Apidae)* occur in large colonies, with the western bumblebee, *Bombus occidentafis,* the most common species in the western United States. Several other species of *Bombus* are also common. The most common yellowjacket in the Basin is *Vespula pennnsylvanica,* with V. *diabolica* also common.

Honeydew, the crystallized excretion of insects such as aphids and whiteflies, was probably widely used in the Great Basin, but Sutton considers it a minor resource. The mealy plum aphis, *Hyalopterus pruni*, is the insect most commonly identified with honeydew.

Sutton reports (via personal communication from Nancy Peterson Walter) that the Owens Valley and Mono Lake Paiute roasted June beetles (possibly *Phyllophaga fusca)* as late as 1981 (p. 79). These insects may have been used by other groups as well, but there are no other specific data. Woodboring beetles (Cerambycidae) are common throughout the Great Basin (p. 80) and their grubs may have been commonly used as food although ethnographic data are almost nonexistent. The larvae of some species are available during the winter.

Coprolite evidence exists for the use of termites *(Reticulitermes tibialis)* and water beetles of the genus *Cybister* (p. 81). Sutton notes that insect remains are frequently encountered during flotation analysis of soil samples from features and hearths in archaeological sites, but they are generally not identified because they are considered unimportant.

Sutton concludes (pp. 83-86) that crickets, grasshoppers, shore flies, caterpillars, and ants were the most significant insect resources and they were utilized by almost every Great Basin group. Other insects, including bees, yellowjackets, aphids, mesquite beetles, June beetles, and stoneflies were also eaten but in lesser quantity. Sutton disagrees with the view that insects were mostly obtained on an "encounter' basis, stating that, "die ethnohistoric and ethnographic data indicate that considerable planning, travel, and effort was often involved in insect procurement," and insect resources were fully integrated into aboriginal economic systems. Cost/benefit ratios for collecting most insect resources have not been determined, but studies have shown high return rates for Mormon crickets and grasshoppers. Although fresh insects were available primarily from April to October, many accounts specify that insect foods were stored for later use, often in large quantities. According to Sutton, "Stored insects,. combined with stored plant products (with which insects were often mixed) may have formed a balanced diet providing for a comfortable winter."

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Coprolites could yield much more information than has been the case to date. "The recovery of archaeological evidence of insect use suffers most from indifference, disinterest, or ignorance on the part of archaeologists who are not attuned to the recovery of such data." Flotation samples must be given special attention and new data recovery techniques must be employed.

Sutton's conclusion is that " insects probably constituted a major rather than a minor resource in the Great Basin .... Anthropologists should continue to seek elucidation of the use of insect foods, both ethnographically and archaeologically, and should consider insect foods important resources that were fully integrated into the various economies of the aboriginal Great Basin."

This ecological approach is of particular value in trying to elucidate the situation that formerly existed in North America. Here, one can no longer go into the countryside and determine the species used by direct observation, as can still be done in parts of Mexico, Africa, Asia and South America. The point made by Dr. Sutton that if the role of insects in North American aboriginal economies is underestimated, the role of other components is therefore overestimated and we lack an accurate understanding of the systems as a whole, is of particular interest. It has wide implications. If it is true for North America, it is probably equally true for Africa, Asia, and elsewhere inasmuch as most of the early information was furnished by Europeans. The under-reporting of insect use may be an excellent example of history distorted by being seen only through the eyes of those who wrote it.

Finally, the author is to be commended for consistently including the specific pages when citing books. Nothing is quite so wastefully time-consuming for readers who wish to consult an original source that has been cited as having to wade through hundreds of pages to find it.

GRD

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CORRECTION

In the article, "The Identity of Grasshoppers Used as Food by Native American Tribes," in the November 1989 Newsletter, a reference was made to "huge wingless *Boopedon* females." It should have read "huge wingless *Brachystola* females."