CHAPTER 3

THE USE OF INSECTS AS FOOD IN MEXICO

Taxonomic Inventory
Taxa and life stages consumed

Coleoptera

Buprestidae (metallic woodborers)
Chalcophora sp., larva

Cerambycidae (long-horned beetles)
Aplagiognathus spinosus Newman, larva, pupa
Aplagiognathus sp., larva
Arophalus afin *rusticus* Linn., larva, pupa
Callipogon barbatus Fabr., larva, pupa, adult
Lagocheirus rogersi Bates, larva, pupa, adult
Stenodontes cer. *maxillosus* Drury, larva, pupa
Trichoderes pini Chevr., larva, pupa

Chrysomelidae (leaf beetles)
Leptinotarsa decemlineata Say, larva

Cicindelidae (tiger beetles)
Cicindela curvata Chevr., larva
Cicindela roseiventris Chevr., larva

Curculionidae (snout beetles, weevils)
Metamasius spinolae Vaurie, larva, pupa
Rhynchophorus palmarum Linn., larva, pupa
Scyphophorus acupunctatus Gyllenhal, larva, pupa

Dytiscidae (predaceous diving beetles)
Cybister explanatus Leconte, larva, pupa, adult

Histeridae (hister beetles)
Homolepta sp., larva

Hydrophilidae (water scavenger beetles)
Tropisternus tinctis Sharpe, larva, pupa, adult

Passalidae (bess beetles)
Oleus reinator Trequi, larva, pupa
Passalus af. p*unctiger* Lep. & Serv., larva, pupa

Scarabaeidae (scarab beetles)
Melolontha sp., larva
Phyllophaga rubella (author?), larva
Phyllophaga spp., larvae, pupae
Strategus sp., larva
Xyloryctes spp., larvae, pupae

Tenebrionidae (darkling beetles)
Tenebrio molitor Linn., larva, pupa

Family uncertain
Paxillus leachi M. & Y.,larva
Rhantus sp., adult

Diptera

Ephydridae (shore flies)
Hydropyrus (= Ephydra) hians Say, larva, pupa, adult
Mossilus (= Gymnopa) tibialis Cresson, larva

Muscidae (filth flies)
Musca domestica Linn., larva, pupa

Stratiomyidae (soldier flies)
Stratiomyid spp., larvae

Syrphidae (flower flies)
Copestylum haaggii J., larva

Hemiptera

Belostomatidae (giant water bugs)
Abedus ovatus Stal., nymph, adult
Abedus sp., nymph, adult
Belostoma sp., nymph, adult
Lethocerus sp., nymph, adult

Coreidae (leaf-footed bugs)
Acanthocephala luctuosa S., nymph, adult
Pachilis gigas B., nymph, adult

Corixidae and Notonectidae
Corixidae (water boatmen)
Corisella edulis J., nymph, adult
Corisella (= Corixa) mercenaria Say, egg, nymph, adult
Corisella texcocana Jacz., egg, nymph, adult
Krizousacorixa (= Kirzousacorixa; = Ahauhtlea) azteca, egg, nymph, adult
Krizousacorixa femorata Guerin-Meneville, egg, nymph, adult
Notonectidae (backswimmers)
Notonecta unifasciata Guerin-Meneville, egg, nymph, adult

Naucoridae (creeping water bugs)
Naucorid sp./spp., nymphs, adults

Pentatomidae (stink bugs)
Edessa conspersa Stal., nymph, adult
Edessa mexicana Stal., nymph, adult
Edessa petersii Stal., nymph, adult
Euchistus crenator Stal., nymph, adult
Euchistus lineatus Walk., nymph, adult
Euchistus strennus Distant (= *zopilotensis* Distant), nymph, adult
Euchistus (= Atizies) sufultus Smith, nymph, adult
Euchistus (= Atizies) taxcoensis Ancona, nymph, adult
Pharylpia fasciata (author?), nymph, adult

Family uncertain
Brachymona arcane tenebrosa M., nymph, adult

Homoptera

Aphididae (aphids)
Aphid honeydew

Cicadidae (cicadas)

Proarna sp., adult
Tibicen puinosa S., adult

Membracidae (treehoppers)
Hoplophorion (= Metcalfiella) monograma Germar, nymph, adult
Umbonia reclinata Germar, nymph, adult
Umbonia sp., nymph, adult

Hymenoptera

Apidae (honey bees, bumble bees)
Apis mellifera Linn., egg, larva, pupa
Bombus diligens (author?), adult
*Bombus formosus (*author?), adult
Bombus medius (author?), adult
Lestrimelita limao Sm., egg, larva, pupa
Melipona beeckei Bennet, egg, larva, pupa
Melipona fasciata querreroensis Schw., egg, larva, pupa
Partamona sp., egg, larva, pupa
Scaptotrigona mexicana G., egg, larva, pupa
Trigona jaty Fabr., egg, larva, pupa
Trigona nigra nigra Cress, egg, larva, pupa
Trigona sp., egg, larva, pupa

Diprionidae (conifer sawflies)
Neodiprion guilletei (author?), prepupa

Formicidae (ants)
Atta cephalotes Latr., adult reproductive
Atta mexicana Bourmeir, adult
Liometopum apiculatum Mayr., egg, larva, pupa
Liometopum occidentale var. *luctuosum* W., egg, larva, pupa
Myrmecosystus (= Formica) melliger Llava (= *melligera)*, adult
Myrmecosystus mexicanus W., adult
Pogonomyrmex sp., larva, pupa

Sphecidae (sphecids or mud daubers)
Ammophila sp., immature stages

Vespidae (wasps, hornets)
Amnophila sp., immature stages
Brachygastra azteca (Sauss.), immatures
Brachygastra (= Nectarinia) lecheguana (Latr.), immatures
Brachygastra mellifica (Say), immatures
Mischocyttarus sp., immatures
Parachartegus apicalis (Fabr.), immatures
Polistes canadensis (Linn.), immatures
Polistes instabilis (Sauss.), larva, pupa, adult
Polistes major Palisot de Beauvois., egg, larva, pupa
Polistes sp., egg, larva, pupa
Polybia diguetana du Buysson, immatures
Polybia occidentalis bohemani Holmgren, immatures

Polybia occidentalis nigratella du Buysson, immatures
Polybia parvulina Richards, immatures
Polybia spp., eggs, larvae, pupae
Vespula squamosa Drury, immatures

Xylocopidae (carpenter bees)
Xylocopa sp., larval food

Isoptera

Miscellaneous termites
Scientific name(s) unreported

Lepidoptera

Cossidae (carpenter moths, leopard moths)
Comadia (= Xyleutes; = Cossus) redtenbachi Hamm., larva

Geometridae (measuringworms)
Synopsia mexicanaria Walk., larva

Hepialidae (ghost moths, swifts)
Phassus sp., larva
Phassus trajesa Linn., larva
Phassus triangularis E., larva

Megathymidae (giant skippers)
Aegiale (= Acentrocneme) hesperiaris Kirby, larva

Noctuidae (noctuids)
Ascalapha (= Erebus) odorata Linn., larva
Heliothis zea Boddie, larva
Spodoptera frugiperda J.E. Smith, larva

Pieridae (whites, sulphurs)
Catasticta teutila Doubleday, larva
Eucheira socialis Westwood, larva, pupa

Psychidae (bagworm moths)
Bagworm tea

Pyralidae (snout moths, grass moths)
Laniifera cyclades Druce, larva

Saturniidae (giant silk moths)
Arsenura armida Cramer, larva
Hylesia frigida Hubner, larva
Hylesia sp., larva
Latebraria amphipyroides Guenee, larva

Sphingidae (hawk-moths, sphinx moths)
Hyles lineata (author?), larva

Family uncertain
Scientific name(s) unreported

Megaloptera

Corydalidae (dobsonflies, fishflies)
Scientific name(s) unreported

Odonata

Aeschnidae (darners)
Anax sp., nymph, adult

Orthoptera

Acrididae (short-horned grasshoppers)
Arphia fallax Sauss., nymph, adult
Boopedon flaviventris Bruner, nymph, adult
Boopedon sp. af. *flaviventris* Bruner, nymph, adult
Encoptlophus herbaceous Sauss., nymph, adult
Melanoplus femurrubrum DeGeer, nymph, adult
Melanoplus mexicanus Sauss., nymph, adult
Melanoplus sp., nymph, adult
Ochrotettix cer. *salinus* Burm., nymph, adult
Osmilia flavolineata DeGeer, nymph, adult
Plectrotettra nobilis Walk., nymph, adult
Schistocerca paranensis Burm., nymph, adult
Schistocerca sp., nymph, adult
Spharagemon aequale Say, nymph, adult
Sphenarium histrio Gerst., nymph, adult
Sphenarium magnum Marquez, nymph, adult
Sphenarium purpurascens Charp., nymph, adult
Sphenarium spp., nymphs, adults
Trimerotropis sp., nymph, adult
Tropinotus mexicanus Brunner, nymph, adult

Blattidae (cockroaches)
Medicinal use

Gryllidae (crickets)
Scientific name(s) unreported

Gryllotalpidae (mole crickets)
Scientific name(s) unreported

Romaleidae (lubber grasshoppers)
Romalea colorata S., nymph, adult
Romalea sp., nymph, adult
Taeniopoda sp., nymph, adult

Tettigoniidae (long-horned grasshoppers)
Microcentrum sp., nymph, adult

Trichoptera

Hydropsychidae (net-spinning caddiceflies)
Leptonema sp., larva

In her book on insects as a future source of protein (1982a), **Dr**. **Julieta Ramos-Elorduy de Conconi** states that, "Mexico can be described as a country where there is so much hunger that the country doesn't feel it." In some areas of the State of Oaxaco and in some arid regions of the country, insects are the only significant source of protein. The author presents in tabular form a list of 71 species of insects that are consumed in Mexico, listing them by order and family and giving the developmental stage(s) that are eaten and the geographical location [state(s)] where eaten.

Analyses of samples from Mexico have revealed a crude protein content (dry weight) between 31% and 72% in most species. Most amino acids (including lysine) surpass FAO standards, but in keeping with generally-obtained results from elsewhere, most insects are low in methionine and tryptophan. The author notes the need for more data on bioavailability, particularly when insects are used in conjunction with other common foods in the rural diet.

Conconi proposes that the "industrialization" of insects (the establishment of small industries in the countryside for the mass-culture of insects as food) would work both to the benefit of rural economies and better nutrition in the country as a whole. Relative to their exploitable attributes, it is pointed out that insects are the dominant animal group on earth, they are adapted to a wide variety of ecological conditions, and many have high reproductive capacity and short life cycles. Relative to their acceptability as food, a survey taken in the Federal District (Mexico City) revealed that 75% of the population is aware that there are edible insects in Mexico, 93% considered "industrialization" a viable project, 39% responded that they would use the resulting products, 29% that they would use them once in awhile, and 19% that they would try them only as a curiosity.

Conconi demonstrates that edible insects are prominant in the rural markets, but in addition several species command high prices in Mexico City and other urban areas where they are purchased by people of various economic levels and are sold as delicacies in the finest restaurants. The author mentions that in 1981, the demand for "escamoles" (immature stages of the ant, *Liometopum apiculatum*) was so great that the price per kilogram went up to 1,000 pesos (more than U.S. $2 at the then-prevailing exchange rate). "In Tlaxcoapan . . . . they are sold in restaurants like El Prendes, Las Meninas, Delmonicos, and Bellinghaussen, where 2 tacos with 50 grams of ants costs 300 pesos. They are served fried or with black butter, but the best way is fried with onions and garlic."

The recorded history of edible insect use in Mexico goes back hundreds of years. The work of the great Spanish writer, **Sahagun** (**1557**; vide **Curran 1937, 1951**), reveals that the Aztecs knew a great deal about natural history, including the insects that are edible. As extracted from Curran's summary, the Indians ate honey from bees' and wasps' nests whenever they could find them, and the larvae and pupae were frequently eaten along with the honey. The Indians greatly relished the honey of the "honey ant," termed *mequazcatl*, and consumed the ant along with the honey. The corn ear worm was eaten with relish, along with the corn. All grasshoppers were considered edible and formed an important part of the diet during seasons when they were abundant. Curran reproduced a number of early native drawings taken from Sahagun's work, including the maguey caterpillar and several others that the Aztecs relished as food. Sahagun (1557 [1946]; vide Massieu et al 1958) also mentioned that the Indians ate the aquatic insects (Hemiptera) known as *axayacatl* after drying them in sunlight.

In their English translation of **Clavigero's (1786)** "History of Lower California," **Lake and Gray** (**1937**) note that it describes experiences in the 1750's and they cite two references showing, first, the diversity of animal foods used by the Indians of northwestern Mexico and, secondly, the consequences of giving up insects as part of the diet. From Report of the Smithsonian Institution, 1864 (Lake and Gray, p. 93 footnote): "There seem to have been few animals which the Indian did not eat. Father Baegert states that they lived chiefly on dogs and cats, horses and mules, mice and rats, lizards and snakes, grasshoppers and crickets, owls and bats, green caterpillars, 'an abominable white worm of length and thickness of the thumb,' and other insects and small animals." A second footnote (p. 93) states:

> Under the instruction of the missionary the Indian was induced to give up the eating of many kinds of insects and worms, and to eat beef. From an economic point of view this was a mistake of the missionaries. The Mission Indians required an enormous amount of beef. It was not uncommon to have an Indian consume in a day from fifteen to twenty pounds of beef. Cattle stealing became a favorite pastime of the Indians, and at first it was difficult to increase the number of cattle at a Mission. Father Baegert wrote that 'for eight years I kept, ranging at large, from four to five hundred head of cattle, and sometimes as many goats and sheep, until the constant robberies of my own and the neighboring missions compelled me to give up cattle breeding. . . . The Indian

> never learned to eat pork nor to drink milk, and so he always demanded a generous supply of beef. . . (University of California Publications in American Archeology and Ethnology, Vol. VIII, Part I, p. 13).

In a paper useful for comparative nutrient values, although no insects are included, **Cravioto et al (1945)** analyzed the major fruit and vegetable foods of Mexico for carotene, thiamine, riboflavin, niacin, ascorbic acid, calcium, phosphorus, iron, nitrogen, ash and total solids content. **Massieu et al** (**1950**) analyzed the tyrosine in several foods of high protein content: commercial samples of "zeina" and wheat gluten; "axayacatl" (nymphs and adults of the aquatic hemipteran genera *Krizousacorixa, Notonecta* and *Corisella*); "ahuahutle" (eggs of *Krizousacorixa* and *Corisella*); "maguey worms" or "meocuiles" (*Acentrocneme [Aegiale =] hesperiaris)*; "jumiles" (hemipterans of the genera *Atizies, Edessa* and *Euchistus [Euschistus* =]); "acociles" (small crustaceans, *Cambarus moctezumi*); and "charales" (small freshwater fish, *Chirostoma jordani*). The crustacean and the fish are used as food in many regions of Mexico, while the use of the insects is limited to certain groups of the Mexican population. A very high tyrosine content was found in the "ahuahutle," nearly twice the amount found in "zeina" and more than twice the amount in the other materials tested.

Cravioto et al (1951) analyzed several hundred Mexican foods for their nutritional value. Results obtained from insects (ahuautle, axayacatl, gusanos de maguey, and jumiles) are shown in Mexico Table 1 (see Cravioto et al p. 153). Also extracted from the lengthy table of Cravioto et al and included in Table 1 are data on "acocile," a crustacean, and "charales," a small fish (these data are discussed below under Massieu et al (1958)).

Barrera and Bassols (**1953**) mention (vide Ramos-Elorduy and Pino 1989) that lepidopteran larvae, ahuahutle (Corixidae), and honey ants (Formicidae) were used as food by the Aztecs. Larvae of large cerambycid beetles (Cerambycidae) were eaten in the Ferreria Region of the State of Hidalgo, and caterpillars which grow in cactus (Pyralidae: *Laniifera cyclades* Druce according to Ramos-Elorduy and Pino) were eaten in Yucatan.

Grimaldo et al (1957), pointing out the lack of information on cystine and tyrosine in previous amino acid studies on Mexican foods, reported the results of their analyses for these two amino acids. Included are data on ahuahutle, axayacatl, chapulines (grasshoppers), and jumiles (Mexico Table 2; see Grimaldo et al Table II, p. 6). The authors discuss their results in relation to whole milk protein, considered an appropriate standard for promoting growth and nitrogen retention. For comparisons, tyrosine values in the proteins of ahuahutle and axayacatl are borrowed from the previous study by Massieu et al (1950). Ahuahutle, with cystine at 4.64% of total protein, was the highest in this amino acid of the 58 foods that were analyzed, 34 of vegetable origin and 24 of animal origin. "Requeson," a product obtained from milk, was, at 4.48%, the only other sampled food that was close. The other insects were much lower than whole egg protein in cystine. Ahuahutle, at 11.10%, was much higher in tyrosine (as a percentage of total protein) than were any of the other sampled foods. The other insects were also higher than egg protein (Table 2) and higher than most other foods in tyrosine.

Massieu et al (1958) conducted amino acid analyses on six primitive Mexican foods, four insects, a crustacean, and a small fish (Mexico Table 3; see Massieu et al Table 2, p. 213). Of ahuahutle, known also as "aguaucle" or "Mexican caviar," they state that several dishes which are typically Mexican are prepared with it today: "Usually it is eaten after it is mixed with eggs and fried; it is sometimes mixed into other popular foodstuffs. It tastes much like shrimp." Jumiles "are eaten raw, fried, or roasted and ground, by several groups of the rural population, especially in tropical and subtropical regions." Gusanos de maguey or "meocuiles" today are eaten after they have been fried in lard or in their own fat and rolled in 'tortillas.' They are consumed by a number of people, especially those living on the high plateaus in Mexico where the *Agave* plant (maguey) is cultivated for the 'pulque' industry. The flavor of meocuiles is very much valued and in Mexico City they are considered delicacies." Other foods discussed are "Acociles," small Crustacea belonging to the genus *Cambarus*, specifically *C. moctezumi* which live in Lake Xochimilco near Mexico City, and "charales," small fish (in this case *Chirostoma jordani*) which are common in the fresh water lakes near Mexico City and elsewhere. These crustaceans and fish, especially the latter, "are quite popular among groups in Mexico which have been considered to consume inadequate amounts of amino acids in the diet."

The amino acid analyses of Massieu et al revealed that none of the insects are as high as the fish or crustacean in lysine, but axayacatl and jumiles contained a high level of tryptophan and ahuahutle was the richest in arginine and tyrosine (Mexico Table 3). Massieu et al also compare the nutrient composition of the six foods using the data of Cravioto et al (1951) (see Mexico Table 1).

Ahuahutle, axayacatl, jumiles, and the fish were high in protein based on the conversion factor of N x 6.25. The jumiles and gusanos de maguey were rich in fat (ether extract), although the fat of the former included fats used to prepare them for market. Axayacatl was high in calcium although not nearly as high as the fish and crustaceans. Ahuahutle and axayacatl were among the samples high in phosphorus but the calcium-phosphorus ratio was very low in ahuahutle. Axayacatl was especially rich in iron, while the gusanos de maguey were relatively low compared to the other foods. All of the foods were rich in niacin, especially ahuahutle and

axayacatl, and these plus jumiles and the crustacean were high in riboflavin. Massieu et al conclude: "These primitive foods can contribute much toward the nutrition of those who consume them."

Massieu et al (**1959**) describe the systematic program of studies conducted by the National Institute of Nutrition over the past 15 years on the composition of Mexican foods. The studies have included foods used frequently in the diets of precolombian Mexicans, and the authors suggest that some of these products "are potentially important, especially those of animal origin, because they could complement the drastic protein deficiency often observed in some sectors of the Mexican population." Studies are needed, the authors say, to determine ways in which the use of some of these foods, which include insects, could be made more widespread and available in Mexican diets.

Samples of the 190 foods included in the present study were obtained in local markets. Among the insects studied (Mexico Table 4), the authors noted the high protein and niacin content of "chapulin" (*Sphenarium* grasshoppers), and the protein, riboflavin and niacin of jumiles. "Tismitches" (Table 4; see Massieu et al, 1959, Table VIII, p. 64) apparently is a mixture of insect larvae, crustaceans and fish collected in areas like Tlacotalpan; the composition was not uniform, possibly because of seasonal changes in the proportions of the organisms collected. The dried product had a high vitamin content.

MacNeish (1958) is cited by **Callen** (**1963**) as finding grasshopper wings and legs in two of 11 coprolites from Mexico. Callen examined coprolites supplied by MacNeish from two caves of the Sierra Madre in southwestern Tamaulipas, Mexico, and found parts of grasshoppers, beetles, bees, ants, wasps and termites. The material examined covered eight cultural phases spanning 7000 to 400 BC, but the author does not specify which phase(s) contained insects.

Conconi (**1974**) points out that insects are the dominant animal group and have great reproductive potential, therefore, they are a natural resource that offers new food alternatives (vide Conconi and Burgess 1977). In the 1970's, Conconi and colleagues at the National Autonomous University in Mexico City initiated an extensive research program on the nutritional value of Mexican insects.

Conconi and Bourges (1977) cited several recent studies noting the poor nutrition that occurs in the arid and semiarid zones that make up a large part of Mexico, and stated that this makes it obligatory to search for new food alternatives that enrich the basic diet and fit within traditional Mexican food habits. They list 52 species of insects known to be consumed in Mexico, many of which have not been previously recorded as food. Species are listed according to insect order and family, and information is given for each species on the life stage(s) consumed and the geographic area (state) where consumed. The authors also present a world list of insects recorded as food (369 species), most of which, however, are, as stated by the authors, drawn from Bodenheimer (1951).

The six species studied were all high in crude protein (dry weight basis), ranging from 58.3% to 71.0% (Mexico Table 5; see authors' Table 1). Except for methionine and tryptophan, and in the case of *Atizies taxcoensis*, lysine, amino acids exceeded F.A.O. (1957) recommended daily allowances (mg/16 mg/N). Thus, these insects are, in general, of intermediate protein quality. Studies are needed to determine their value as blended with other foods which are common in the rural Mexican diet. Conconi and Bourges emphasize that, except for the grasshopper, *Sphenarium histrio*, none of the species included in their study compete with man for food. Furthermore, four of the species, *Atizies taxcoensis* (jumiles), *Cossus (Xyleutes =) redtenbachi* (pink caterpillar), *Corisella mercenaria* (axayacatl), and juvenile stages of the ant, *Liometopum apiculatum* (escamoles), are endemic in arid zones, thus enhancing their importance as a food source.

In addition to the data in Table 5, Conconi and Bourges conducted a proximate analysis on *C. mercenaria*, one of the "axayacatl" group, with the following results (dry weight basis): protein 68.74%, fat 11.13%, ash 5.53%, and carbohydrate 12.60%.

Conconi and Pino (1979) conducted a study in eight counties of the high, semiarid Mezquital Valley (State of Hidalgo) which has long been considered one of the areas of poorest nutrition in Mexico. The soil is poor in organic matter and minerals and the alkalinity high enough to inhibit cultivation. Average calorie consumption in Hidalgo State is only 2,064 per day per person, and there is high infant mortality because of malnutrition. Malnutrition in the Mezquital Valley is even more severe with an average calorie consumption of less than 1,774 per day per person. The diet is based on corn, beans, chilies, quelite and a ration of pulque (liquor from the maguey), and consumption of products of animal origin (such as meat, eggs and milk) "is very rare." Insects of one kind or another are commonly eaten daily, however, and the authors obtained proximate analyses on 13 species and on five plants which serve as hosts for seven of them (Mexico Table 6; see authors' Tables II, III and IV).

It is readily seen by the data that the insects are many times higher in protein and fat than are the plants upon which they feed (Table 6). Protein ranges as high as 69.05% in the adult weevil, *Metamasius spinolae*, compared to 5.21% in nopal, the cactus upon which it feeds. Fat ranges as high as 58.55% in the larva of *Aegiale hesperiaris* compared to 3.60% in the maguey plant. The insects are all much lower in crude fiber. Conconi and Pino make the interesting suggestion that some plants that are widespread and characteristic of arid regions, but

of limited food value, such as mezquite, madrono, and some cacti, could be used for cultivation of their associated insects, thus producing more protein of animal quality.

In this first of a series of published abstracts by J.R.E. de Conconi and colleagues, **Conconi and Pino** (**1980a**) report that they have conducted proximate analyses on several species of edible insects: larvae of *Phyllophaga rubella* (Coleoptera); larvae, pupae and adults of *Ephydra [Hydropyrus =] hians* (Diptera); larvae of *Erebus [Ascalapha =] odoratus [odorata =]* (Lepidoptera), preserved in salt; and *Abedus ovatus* and *Leptocerus* sp. (Hemiptera). These insects ranged from 35% to 85% crude protein on a dry weight basis. Administration of the juvenile hormone analogue, Altocid ZR 515, to *Locusta migratoria* by sprinkling on the insects or on their food produced no significant difference in their nutritive value. **Conconi and Pino** (**1980b**) report preliminarily on the digestibility of insect proteins (see Conconi et al 1981a for the full report). **Conconi et al** (**1981c**) provide preliminary data on the protein quality of three edible species, *Pachilis gigas, Euschistus strennus,* and *Ephydra [Hydropyrus =] hians* (see Conconi et al 1982a for the full report).

Conconi et al (1981a) determined the protein digestibility of nine insect foods (Mexico Table 7; see authors' Table 4). The data show, by column, respectively, protein as a percentage of dry matter, digestible protein as a percentage of dry matter, and the percentage of the protein that is digestible, using methods and criteria described by the authors. As shown, the percentage of the protein that is digestible ranged from 77.86% to 98.93% in the different species or species groupings. The authors discuss these results in relation to the daily intake of proteins that are considered adequate by various experts on nutrition, noting that Mexican nutritionists consider 25 grams per day per person to be, at best, minimal (this level of intake is well below FAO and U.S. standards).

Conconi et al (1982a) present data on 11 species, including new data on amino acid content of six species (Mexico Table 8; see authors' Table 4). The most notable feature of this report is the high methionine/cysteine values found, for all six species exceeding FAO-OMS standards. The authors report protein chemical values, based on the 1973 FAO guidelines, for 10 species as follows (authors' Table 5): *Sphenarium histrio* 60%; *S. purpurascens* 65%; *Atizies taxcoensis* 10%; *Pachilis gigas* 58%; *Euschistus strennus* 56%; *Cossus [Xyleutes =] redtenbachi* 60%; *Hydropyrus hians* 42%; *Musca domestica* 58%; *Atta mexicana* 60%; *Liometopum apiculatum* immature reproductives 80%, immature workers 51%.

Conconi et al (**1983b**) report amino acid analyses on several species not previously analyzed, i.e., the grasshoppers *Boopedon flaviventris* and *Melanoplus mexicanus*; the homopteran *Hoplophora monograma*; the bee *Trigona* sp.; the caterpillar *Hylesia frigida,* from the madrono tree; and the grub of the weevil, *Scyphophorus acupunctatus* from the maguey. The authors do not give the tabularized data in this abstract, but state that all of the insects analyzed meet FAO (1973) quidelines for all of the essential amino acids except tryptophan. The chemical value of *H. monograma* was 96%, which is excellent and the highest value found in any insect yet studied. The chemical value for the weevil, *S. acupunctatus*, was also high, 81%. **Conconi et al** (**1983c**) conducted analyses of sodium, potassium and lithium in 28 species from different localities in Mexico. None of the samples contained lithium, and no relationship was observed between classification (order to which the insect belongs) and the quantity of sodium or potassium found.

Conconi (**1982b**) presents in condensed form various points made in her book (Conconi 1982a). **Conconi et al** (**1983d**) discuss the past use of insects as food by different ethnic groups in Mexico. According to the authors, 38 species were included, but, in this abstract only 21 are mentioned and specific ethnic groups are not identified. **Robles et al** (**1983**) report that 28 edible species were found to be used in a region in the southeastern part of the Federal District. Lepidoptera predominated. Most of the insects were collected and consumed locally, with only a few such as the escamole ants, ahuautle and axayacatl entering commerce. **Eerde** (**1980/1981**) provides a popular account of insects as food, based on the work of Conconi and colleagues.

Conconi (1984) re-emphasizes many of the points made in her earlier works (1982a,b), pointing out that the Mexican diet is based on corn, beans and chili, and that 24 of the 32 states are regarded as having inadequate nutrition (too few calories and too little protein). In the States of Hidalgo, Oaxaca, Chiapas and Puebla, insects supply a large part of the animal protein consumed by the inhabitants, and some species such as grasshoppers, caterpillars, stink bugs, wasps and ants are "commercialized" by the local people. Generally, the insects are eaten roasted or fried, "or they are boiled and then fried with onions and chilies and eaten in tacos." Flavor varies from insect to insect: "For example, the white maguey worm tastes like crackles, grasshoppers generally assume the taste of the condiment with which they are cooked, such as chili piquin or lemon in garlic; 'escamoles' taste like nuts fried in butter, 'cuecla' larvae preserved in salt taste like herring, etc." Insect dishes found in restaurants in Mexico, the United States and France include such as "escamoles in black butter," "chapulines in garlic," and "chinicuiles in curry." The author concludes that:

> We don't know how much it would cost to cultivate insects as food; however, we believe that because of their high protein content, high digestibility, variety in food diets, high conversion efficiency, and great reproductive potential associated with a short life cycle, the useful biomass

obtained would be significant when compared to other products which are used to obtain protein. That is why insects should be taken into consideration as a food alternative for a world in which human nutrition has been a huge problem.

Conconi et al (1984a) listed 101 species of insects that had been found up to that time to be used as food in Mexico (the number of species known to be used has since then increased to more than 200 [Conconi, pers. comm. 1986]). The authors summarize data (largely incorporated in a later paper [see Table 9]) on crude protein content of 68 species, protein ranging as high as 81.7% on a dry weight basis. "Chemical values" are reported for 10 additional species as follows: in the Hymenoptera, *Brachygastra azteca* 70%, *B. mellifica* 70%, *Parachartegus apicalis* 50%, *Polybia parvulina* 70%, *Trigona* sp. 58%, and *Vespula squamosa* 70%; in the Lepidoptera, *Hylesia frigida* 45%; in the Orthoptera, *Boopedon flaviventris* 56%, *Melanoplus mexicanus* 56%, and *Sphenarium* spp. 56%. These chemical scores are based on amino acid profiles in comparison to FAO/OMS (1973) guidelines, but insofar as this reviewer is aware, the authors have never described precisely how they calculate their chemical scores. Finally, the authors list 86 vernacular names for the edible stages of various species; these are listed under the appropriate groups in this chapter.

Insects may be added to Mexico's tortillas according to a United Press International article, datelined Mexico City (*San Francisco Chronicle*, February 17, 1988) by **Eda Chavez**. Nutrition specialists are investigating enriching basic foodstuffs with high-protein substances from insects such as crickets, flies, "worms" or termites. Pedro Valle, dietary researcher at the National Autonomous University of Mexico, is quoted: "The tortilla is one of the basic dietary elements among Mexican families because of its low cost, but it also has a low protein content." He added that the incidence of malnutrition could be effectively lowered by adding animal protein. Dr. Julieta Ramos-Elorduy, an entomologist at the university, noted that 40% of Mexicans suffer from malnutrition. "And this will continue as the buying power of the average Mexican decreases daily." Many peasants, especially among Indian communities, exist on tortillas, black beans and hot chile peppers. They almost never eat meat or vegetables. "Insects ensure a reliable alternative protein source and would reduce the possibility of Mexico being a hungry nation in the future, " Elorduy said. Javier Cordoba, researcher at the Institute of Agronomic Research, noting that dietary customs may make whole insects repulsive, says, "But just by using insect flour, we can convert any type of snack into a product with high protein value." Dr. Hector Burges, at the Institute of Nutrition, mentioned a wide range of insect flavors resembling almonds, pine nuts, apples, a hot highly seasoned flavor, and fried pork rinds.

Carolyn Dunlap (pers. comm. **1987**) reported that during two years as a Peace Corps Volunteer in Mexico (1984 to 1986), she saw grasshoppers and "gusanos" sold in the markets. They were also on the menu as delicacies in Mexico City and surrounding areas, and in Veracruz, Acapulco and Oaxaca.

From their own extensive field work and from historical documents, **Ramos-Elorduy and Pino (1989)** describe how insects contributed to the diet of Mexicans in the past, before the Spanish Conquest. Of the 247 species known by the authors to be consumed in Mexico, 70 species are treated in this book. Some of Sahagun's accounts from the early 16th Century are quoted and some of his drawings are duplicated in order to establish the antiquity of use of many species. Some insects such as escamole ants and ahuahutle (eggs of aquatic Hemiptera), were held in such high esteem that they were used to pay taxes to the Emperor Montezuma.

The book is divided into Prolog, Preface, Introduction, Chapters 1-4, Appendices and Bibliography. In Chapter 1 (pp. 9-45), the early use of the various species is documented. Species discussed include 1 from the Order Odonata (dragonflies), 7 species from Order Orthoptera (grasshoppers), 1 from Anoplura (lice), 13 from Hemiptera (true bugs), 17 from Coleoptera (beetles), 9 from Lepidoptera (caterpillars), 2 from Diptera (true flies), and 20 from Hymenoptera (bees, ants, wasps). Many common or vernacular names are identified, for example a total of 11 for the leafcutter ants, *Atta cephalotes* and *A. mexicana.*

In Chapter 2 (pp. 47-56), nutritional value of insects is discussed. Most, if not all of the data (5 tables) are drawn from previously published work by these authors and their colleagues. It should be noted that work published prior to the late 1980s by the senior author was under her then-married name, de Conconi. The insects highest in protein content are the grasshoppers, with the five species analyzed ranging from 70.9% to 77.6% on a dry weight basis, and the wasps, six of seven species analyzed ranging from 61.4% to 72.0%. Protein digestibility in nine species examined ranged from 77.9% to 98.9%. From amino acid data on 18 species, the insects generally surpassed 1973 FAO values except most were low in tryptophan. Insects comprising the ahuahutle and axayacatl (aquatic Hemiptera) were low in methionine/cysteine, but rich in tryptophan.

In Chapter 3 (pp.57-65), the authors present a figure (representative for south-central Mexico) showing the seasonal distribution of edible insect consumption by month for 63 species. Elevational (climate) and and vegetational differences variously modify these distribution patterns in other parts of the country. Of the species discussed, 58.6% are most abundant during the summer and fall (rainy season), while 29.2% are more abundant in spring (dry season). About 12% are found also during the winter (dry).

In Chapter 4 (pp. 67-75), the authors present a map showing the distribution of 23 ethnic groups in central

and southern Mexico and discuss consumption of edible insects by the different groups. Which insects are consumed by which ethnic groups appears to be determined largely by which insects are abundant in a given ethnic territory. Some widely distributed insects are consumed by all ethnic groups. The early manuscripts consulted by the authors give little clue to differences in insect foods of different groups. The authors suggest that, although "mestizos" (Pima-Nahua ethnic group) are found all over Mexico and have probably had the highest consumption of edible insects, it may be less common now because of acculturation than in groups which have had less exposure to "roads, radio, television and tourism, and the distribution of processed foods by the multinational companies." These poorer groups have tended to "preserve their culture and vivid memories of their ancestors' lifestyle." The authors suggest that because of the large territory they occupy in south and central Mexico, the Zapotecos, Mixtecos, Otomies and Nahuas are the ethnic groups with the highest consumption of edible insects.

Much information on collecting, preparation and marketing of the edible species is provided in the Appendix (pp. 79-93), which consists of 40 black and white photographs and accompanying legends. As the authors point out (p.75), insects should not be considered "unconventional food"; they have been eaten extensively in the past, and they continue to be consumed today. They conclude by saying that insects "could become the 'good Samaritans' in our fight for survival." Additional information provided in the book is included under the appropriate insect groups in this chapter.

Ramos-Elorduy (**1990**) reports that her research group, to date, has recorded 247 species of insects used as food in Mexico. She notes that some two-thirds of the country lies in arid zones, and notes the heavy pressure placed by the demographic explosion on land use and the resource base. She discusses nutritional value of the insects, the fact that many are storable when collected in quantity, their economic role, and asks, "if so many people eat insects and in large numbers and wide variety, why do they often continue to suffer from hunger and malnutrition." The answer is complex, involving economic, social, geographic and other factors, but basically, "we can say that it is because edible insects are not consumed in sufficiently large quantities, probably due, in turn, to the fact that these species are gathered in the wild." Ramos-Elorduy concludes her revealing analysis, saying:

> Insects have long been a significant dietary factor in the poorer regions of the world, and it is high time that scientists recognize this fact and begin to build on it, rather than discouraging or ignoring the practice. The merits of insects as human foods should be addressed by nutrition scientists, with entomologists supplying basic data on the insects' identities and on their mass production.

Ramos-Elorduy and Pino (**1990**) used data from proximate analyses (Mexico Table 9; see authors' Table I) to calculate the energy values (authors' Table II) of 94 of the insect species used as food in Mexico. Caloric values ranged (dry weight basis) from 2827 kcal/kg (1000 g) to 7769 kcal/kg. Caloric values were generally higher for immature stages (eggs, larvae, pupae) than for adult insects. Excluding pork, which is very high in fat, soybeans at 4660 kcal/kg was the highest ranking non-insect Mexican food, plant or animal. Maize (corn) had a caloric value of 3700 kcal/kg. Of the 94 insect species analyzed, 50% had a higher caloric value than soybeans, 87% were higher than corn; 63% were higher than beef, 70% were higher than fish, lentiles and beans, and 95% were higher than wheat, rye or teosintle.

The five highest Lepidoptera (caterpillars) (of 16 species examined) averaged 6594 kcal/kg; the five highest Coleoptera (beetle grubs) (of 17 species examined) averaged 5964 kcal/kg; the five highest Hemiptera (mixed nymphs and adults) (of 14 species examined) averaged 5646 kcal/kg; the five highest Hymenoptera (of 24 species examined) all were ants (samples varied from adults to mixtures of immatures) and averaged 5361 kcal/kg; while the five highest Orthoptera (grasshopper nymphs and adults) (of 20 species examined) averaged 4168 kcal/kg. Thus, Mexican insects constitute a rich source of energy.

The economic role of edible insects, especially their importance for impoverished farmers, was portrayed in an article (datelined Actopan, Mexico) by **Mark Smith** in the *Houston Chronicle* (July 4, 1991); the title was "Mexican gourmets pay big for rich taste of ant eggs. Odd delicacy provides both food and income."

> For *campesinos*, or poor farm workers, like Aviles Hidalgo, 29, who live in the state of Hidalgo some 120 miles north of Mexico [City], *escamoles* (ehs-cah-MOH-lehs) are a source of pocket money. In a country where the unemployment rate may range higher than 30 percent, money is scarce. Aviles Hidalgo, like many of his neighbors, lives in a one-room, 35-foot-by-15 foot, dirt-floor, cinder block house at the rocky base of the Cero Alto and Puerta de la Cruz mountains. They eke out a meager living. But despite rocky land, little income and a few goats, chickens and cattle, Aviles Hidalgo said he has been blessed with a rich supply of agave desert plants, known in Mexico as the *maguey* (mah-GAY).

'If I moved to Mexico (City) and lost my job, I wouldn't be able to eat,' Aviles Hidalgo said, sitting next to his wife while baby chicks roamed below, picking at scraps on the home's dirt floor. 'At least on my farm, I'll always be able to eat. Also, where else would I be able to find such a delicacy like *escamole*,' he added with a smile. Aviles Hidalgo said the thick, leathery, gray-green *maguey* has a diverse array of uses. Juices from the heart of the *maguey* are distilled into *pulque* (POOL-keh), an alcoholic drink related to mescal and tequila. Along the *maguey*'s roots are often colonies of ants, serving as a source of *escamoles*. From February through spring, Aviles Hidalgo, like many of his neighbors, weaves along cactus-lined, winding trails and through rocky ravines in search of the *maguey* and the treasured *escamoles* below. Using a crowbar, *campesinos* dig below the *maguey* into ant colonies. Then they carefully scoop out the eggs with their bare hands and dump them into duffel bags that they shake to remove any lingering ants.

Also, inside the *maguey*, *campesinos* carve out two types of butterfly larvae [actually, one is a moth larva], or *gusanos* (goo-SAH-nohs), which are also sold and served as delicacies in Mexican restaurants. White *gusanos*, which are abundant in June and October, are carefully removed from the *maguey* with a hook by grabbing the worms' heads. *Campesinos* sell the *escamoles* and *gusanos* to distributors in a Pachuca market some 20 miles away for a handful of dollars. The distributor then sells the *escamoles* and *gusanos* to restaurants that charge as much as $25 per plate. The food is served fried or roasted in butter, chili or garlic sauce. [At the Fonda Don Chon restaurant in Mexico City's historic district], the plates range in cost from $20 for a load of 500 to 1000 *escamoles*, to $6 for a plate of 200 to 300 *jumilies*. Across town, the Riscal Restaurant serves 30 to 40 orders each of *escamoles* and *gusanos* every day.

Various preparations of escamoles and Agave larvae are the house specialties of the Restaurant La Cava del Leon (see *The Food Insects Newsletter* 8(2): 9, 1995 [personal comm. from Dr. Carlos Blanco, Ciudad Obregon, Sonora, to G.R. DeFoliart]). Interestingly, at 40.00 "new pesos" (at the time, 6 new pesos = US $1) the insect dishes are substantially more expensive than meats, poultry and other items on the menu. Dr. Blanco commented that these prices don't seem too expensive in US currency, but the minimum wage in Mexico is low. Professor **J. Mitsuhashi** (**1996**) who visited the restaurant in August 1995 reported that prices of the insect dishes had increased (in less than one year) to 63.00 pesos.

Mexican insect cuisine and other pre-Columbian food has received much attention in U.S. newspapers and magazines in the past several years. The November 1991 issue of *The Food Insects Newsletter* (4(3): 8-9, 11) published a sampling of magazine articles including one from *American Way* (American Airlines), one from *Sports Illustrated* and two from *Natural History*, both of the latter by food author Raymond Sokolov. The restaurant Don Chon's in Mexico City has been the recipient of a particularly great amount of publicity, not only for the quality of its creations but its prices of $20 to $30 per plate.

Coleoptera

Beetles and weevils of at least 10 families and more than 25 species are consumed in Mexico. It is mainly the larvae that are eaten, but some pupae and adults also.

Buprestidae (metallic woodborers)
Calcophora sp., larva

For proximate analyses and caloric content, see Mexico Table 9.

Cerambycidae (long-horned beetles)
Aplagiognathus spinosus Newman, larva, pupa
Aplagiognathus sp., larva
Arophalus afin *rusticus* Linn., larva, pupa
Callipogon barbatus Fabr., larva, pupa, adult
Lagocheirus rogersi Bates, larva, pupa, adult
Stenodontes cer. *maxillosus* Drury, larva, pupa
Trichoderes pini Chevr., larva, pupa

The first report of cerambycid larvae by scientific name was that of **Simmonds** (**1885**: 353) who mentioned that the natives of Mexico make the larva of the beetle *Trichoderes pini* a part of their fare. The larvae of this family are known as *gusanos de los palos*, or "worms of the wood." *A. spinosus* is also called

gusanos de elite podrido. Cerambycid larvae are very high in fat, ranging from 34.3% to 56.1% on a dry weight basis, and in energy from 4739 to 6530 kcal/1000 g (Mexico Table 9).

Ramos-Elorduy and Pino (**1989**) have treated several aspects of edible cerambycids in Mexico (pp. 21, 58, 71, 83-84). *A. spinosus*, *A. rusticus*, *L. rogersi* and *T. pini* occur in the temperate and cold zones, while *C. barbatus* and *S. maxillosus* are found in the lower tropical humid areas (p. 71). Most of the species are consumed the year-round with peak consumption during the summer months, but *A. rusticus* is consumed in large quantities from June through November. The very large larvae of *Aplagiognathus spinosus* are eaten roasted, in tacos and have a flavor similar to pork rinds (p. 84). Because of its high fat content, it is frequently cut in half longitudinally and put into the pot as a source of fat (J.R.E. de Conconi, pers. comm. 1986). Ramos-Elorduy and Pino mention (p. 83) that *C. barbatus* is known as *ticoco* in Oaxaca, as *tumbas* in Chiapas, and as *cuautotolin* in Puebla. The larvae, adult bodies, or simply the adult abdomens are eaten roasted with salt in tacos. Larvae and adults of *L. rogersi* are eaten roasted.

See also Barrera and Bassols (1953) in the Introduction and Hunn (1977) under References Cited.

Chrysomelidae (leaf beetles)
Leptinotarsa decemlineata Say, larva

Larvae of this species are consumed in the state of Oaxaca (**Conconi et al 1984a**).

Cicindelidae (tiger beetles)
Cicindela curvata Chevr., larva
Cicindela roseiventris Chevr., larva

Theodorides (**1949**: 2) states that these two cicindelid beetles, soaked in water or alcohol, give Mexico a spicy and fragrant drink well-liked for its stimulating properties. They are called *escarabajos tigre*, or "tiger scarab" and, according to **Ramos-Elorduy and Pino** (**1989**), both occur in the temperate and cold zones (p. 71). Consumption of both species peaks in the summer, but *C. roseiventris* has a longer season (p. 58).

Curculionidae (snout beetles, weevils)
Metamasius spinolae Vaurie, larva, pupa
Rhynchophorus palmarum Linn., larva, pupa
Scyphophorus acupunctatus Gyllenhal, larva, pupa

Three species are reported (**Conconi et al 1984a**). Proximate analysis of *Metamasius spinolae* larvae (known as *picudo del nopal*), which feed in the nopal cactus, revealed a crude protein content of 69.05% and fat content of 7.44% (see Conconi and Pino 1979 above, and Table 6). Proximate analyses as well as energy values for *M. spinolae* and *S. acupunctatus* were reported by Conconi and Pino (1990) (Introduction and Table 9). **Conconi et al** (**1983b**) reported a high protein chemical value, 81%, for the larva of *Scyphophorus acupunctatus*, which breeds in the maguey, and is known as *picudodel maguey*. These larvae, according to **Ramos-Elorduy and Pino**(**1989**, p. 83), "taste like tender beans and are eaten roasted in tacos, or mixed with a sauce." They are high in the amino acid tryptophane and considered to be of nutritional importance. For proximate analyses and caloric content of *M. spinolae* and *S. acupunctatus* larvae, see Mexico Table 9. Vernacular names for *R. palmarum* are *gusano del coyal* and *gusano de la palma*.

See also Conconi and Pino (1979) in the Introduction.

Dytiscidae (predaceous diving beetles)
Cybister explanatus Leconte, larva, pupa, adult

Ramos-Elorduy and Pino (**1989**, pp. 18-19) cite earlier works regarding the use of *Cybister* (known as *atopinan* or *cucarachas de agua*) as food. They are eaten roasted with salt and in tacos. See also Smith (1807) under References Cited.

Histeridae (hister beetles)
Homolepta sp., larva

The larvae are consumed in Oaxaca (**Conconi et al 1984a**). For proximate analyses and caloric content, see Mexico Table 9.

Hydrophilidae (water scavenger beetles)

Tropisternus tinctis Sharpe, larva, pupa, adult

Ramos-Elorduy and Pino (**1989**, p. 22) reported the common name as *atelepitz.* See also Smith (1807) under References Cited.

Passalidae (bess beetles)
Oleus reinator Trequi, larva, pupa
Passalus af. *punctiger* Lep. & Serv., larva, pupa

The larvae of *0. reinator* are known as *ticoco* or *gusanos de los palos,* those of *P. punctiger* as *bechano* or *gusanos de los palos* (**Conconi et al 1984a).** For proximate analyses and caloric content of these species, see Mexico Table 9.

Scarabaeidae (scarab beetles)
Melolontha sp., larva
Phyllophaga rubella (author?), larva
Phyllophaga spp., larvae, pupae
Strategus sp., larva
Xyloryctes spp., larvae, pupae

Species of the genera *Phyllophaga* and *Xyloryctes* are found in the temperate zones and have a relatively short harvest season (**Ramos-Elorduy and Pino 1989**, pp. 58, 71). The vernacular name for *Xyloryctes* is *escarabajo rinoceronte,* the names for *Phyllophaga* spp. are *gusano del la tierra* and *gallina ciega*. For proximate analyses and caloric content of these two genera, see Mexico Table 9.
See also Hunn (1977) under References Cited.

Tenebrionidae (darkling beetles)
Tenebrio molitor Linn., larva, pupa

For proximate analyses and caloric content, see Mexico Table 9.

Family uncertain
Paxillus leachi M. & Y., larva
Rhantus sp., adult

For proximate analyses and caloric content, see Mexico Table 9. See also Callen (1963) in the Introduction.

Diptera

Larvae, and in some cases pupae or adults, of at least four species in three families have been reported.

Ephydridae (shore flies)
Hydropyrus (= Ephydra) hians Say, larva, pupa, adult
Mossilus (= Gymnopa) tibialis Cresson, larva

Amino acid content and a protein chemical value of 42% were reported for *Ephydra hians* by **Conconi et al** (see **1981c**, **1982a** above, and Table 8). For proximate analyses and caloric content, see Mexico Table 9. **Ramos-Elorduy and Pino** (**1989**, pp. 27-29) cite earlier authors in describing the historic use of *H. hians* in Mexico and provide the following common names: for larvae, *izcahuitli, escahuitli*, and *ocuiliztac*; for pupae, *poxi*; for adults, *amoitl* and *michpili*. Larvae are also called *gusano del agua* and adults *mosca del agua*. The authors quote from a 1959 book by F. Hernandez:

> The izcahuitli are a mass of small worms collected in nets in Mexican lakes and placed in big containers, which are sold in markets called 'tianguis' in Indian language. They are found in the markets and are black in color, smell like fresh eggs and [have] a consistency of pressed bread crumbs. They increase the milk of women breastfeeding, and some use them to make tortillas which they dry and save, even though they don't keep for a long time. When they are half-cooked, salt and pepper are added for flavor and don't cause harm.

The authors note that they are still collected in nets, made from plastic market sacks, then dried in the sun to make tamales. A fisherman told Ramos-Elorduy the larvae were also used to feed ducks.

Ramos-Elorduy and Pino state that *poxi* (the fly pupa) is commercialized on a small scale and exported to Germany for hormone extraction in the manufacture of cosmetics. The authors mention that *H. hians* is still plentiful in Lake Texcoco, but not as abundant as in the past. See also Smith (1807) under References Cited.

Muscidae (filth flies)
Musca domestica Linn., larva, pupa

Conconi et al (**1980**) report preliminary work on *Musca domestica*, used to recycle organic matter as a protein supplement for birds. In an abstract, **Conconi et al** (**1981b**) report that the *in vitro* digestibility of fly, *M. domestica*, dry matter is 42% and the percentage of protein digestible is 58%. The amino acid pattern and a protein chemical value of 58% were reported by **Conconi et al** (**1982a**; see above and Table 8). The larvae and pupae both are known as *gusano del queso* (**Conconi et al 1984a**). For proximate analyses and caloric content, see Mexico Table 9.

Stratiomyidae (soldier flies)

Larvae of undetermined species are known as *gusanos planos de maguey* (**Conconi et al 1984a**).

Syrphidae (flower flies)
Copestylum haaggii J., larva

Larvae of syrphid flies are known as *gusanos planos de maguey* (**Conconi et al 1984a**). For proximate analyses and caloric content of *C. haaggii*, see Mexico Table 9.

Hemiptera

At least 16 species in five families are consumed in Mexico. Eggs and/or nymphs and adults are eaten depending on the species.

Belostomatidae (giant water bugs)
Abedus ovatus Stal., nymph, adult
Abedus sp., nymph, adult
Belostoma sp., nymph, adult
Lethocerus sp., nymph, adult

The *Lethocerus* sp. reported by **Conconi and Bourges** (**1977**) may be synonymous with the *Belostoma* sp. reported by **Ramos-Elorduy and Pino** (**1989**, pp. 19-20). These insects are called *cucarachon de agua* or "water roaches." According to Ramos-Elorduy and Pino (1989, p. 81), people collect *A. ovatus*, which is the largest of the aquatic insects, and store them dry. They are ground and mixed with eggs to make a pie that is eaten with sauce. They are also eaten roasted with salt (p. 19). *Abedus* sp. is a smaller member of the genus (p. 20). For proximate analyses and caloric content of *A. ovatus*, see Mexico Table 9. See also Hunn (1977) and Smith (1807) under References Cited.

Coreidae (leaf-footed bugs)
Acanthocephala luctuosa S., nymph, adult
Pachilis gigas B., nymph, adult

Nymphs and adults of *Pachilis gigas* (known as *chamoes*) are consumed directly, or, when fed to laying hens they provide exactly the shade of orange that Mexicans like in their egg yolks (J.R.E. de Conconi, pers. comm. 1986). **Conconi and Pino** (**1979** and Table 6) reported a crude protein content of 65.4% and fat content of 19.4% for *P. gigas*, which feeds on the mezquite. **Conconi et al** (**1981c, 1982a**; see above and Table 8) conducted an amino acid analysis and reported a protein chemical value of 58%. **Ramos-Eloduy and Pino** (**1990**, and Table 9) reported proximate analysis and calorie content for both of these species.

Families Corixidae and Notonectidae
Corixidae (water boatmen)

Corisella edulis J., nymph, adult
Corisella (= Corixa) mercenaria Say, egg, nymph, adult
Corisella texcocana Jacz., egg, nymph, adult
Krizousacorixa (= Kirzousacorixa; = Ahauhtlea) azteca, egg, nymph, adult
Krizousacorixa femorata Guerin-Meneville, egg, nymph, adult
Notonectidae (backswimmers)
Notonecta unifasciata Guerin-Meneville, egg, nymph, adult

Ahuahutle, the famous "Mexican caviar," is composed of the eggs of five species of aquatic hemipterans, four species in the family Corixidae and one species in the Notonectidae. The adult bugs, known as *axayacatl*, are also eaten but considered less of a delicacy. These hemipterans formerly bred in tremendous numbers in the alkaline lakes of Mexico and were the basis of aquatic farming for centuries. The bugs and their eggs are harvested by what amounts to setting oviposition trap lines. Bundles of shore grass are tied together, weighted with a stone, and then distributed by canoe. After about three weeks, they are collected and brought ashore to dry in the sun. When dry, the bundles are shaken and the eggs fall off. Harvests are now much reduced because of lake pollution and land-filling, particularly around Mexico City as the city has expanded (J.R.E. de Conconi, pers. comm. 1986).

The food use of these hemipterans has been recorded back to the time of Sahagun. **Sahagun** (**1557** [**1946**]; vide Massieu et al 1958) mentioned that the Indians ate the aquatic insects (Hemiptera) known as "axayacatl" after drying them in sunlight.

Gage (**1721**, I: 144) states (translation): "During a certain time of the year the inhabitants collected with nets a lemon powder which accumulates on the waters of the Lake of Mexico, and which resembles meerschaum. This they collected in great piles and formed them into flat cakes in the shape of bricks. These bricks are not only sold in the market there, but in many distant towns as well. They ate them with as much appetite as if they were the best European cheese."

Mayer (**1844**: 218; vide Bodenheimer 1951: 297) stated:

> On the lake of Tescuco I saw some people occupied collecting the eggs of flies on herbs and from rags which are planted in long rows as traps for these insects. These eggs, called *agayacatl*, were a favoured food of the Indians long before the conquest. When they are cooked in pastry, they do not differ from the eggs of fishes, having the same flavour and appearance. They are rather a delicacy and I find that they also are found on the tables of the rich in the capital.

Kirkaldy (**1898**) summarized earlier literature and differences in the size, shape, surface structure, and manner of attachment of the ova of *Notonecta americana* and *Corixa mercenaria*. He notes that arrangements had recently been completed for importing to England both adult bugs and ova for use as food for insectivorous birds, game, fish, etc. He states: "Some idea of the enormous swarms of *C. mercenaria* may be gathered from the fact that it is being imported *by the ton!* and I have calculated, somewhat roughly, that each ton will contain little short of 250 millions of individuals!! As to the ova, they are beyond computation."

Kirkaldy cites Thomas Gage (1625) who mentioned cakes made of a "kind of froth" from the Mexican lakes (undoubtedly the aquatic Hemiptera known as "ahuahutle" or "axayacatl"), which had an extensive sale among the inhabitants, a custom which undoubtedly had descended from remote antiquity. Kirkaldy cites F.E. Guerin-Meneville (1857) who enumerated three species involved as food, *Corixa mercenaria* Say, and two which he considered as new, *Corixa femorata* and *Notonecta unifasciata* (which Kirkaldy considered synonymous with *N. americana* Fabr.). Also cited is Virlet d'Aoust (1858) who reviewed the previous literature and noted that the adult bugs of both genera leave the water at night for "love meetings" and other types of dispersion. As described by Kirkaldy, "They are captured with nets, dried, and (according to Virlet d'Aoust) sold as 'bird food' under the name 'moschitos,' although Clavigero states that the Mexicans eat them dried and dressed with saltpetre!" Apparently continuing to draw on Virlet d'Aoust's paper, Kirkaldy states:

> At the proper season bundles of rushes are placed in the lake shallows, and upon these the ova - named by the Mexicans 'Axayacatl' or 'waterface' - are deposited, gathered by the natives and made with meal into cakes; these are eaten au naturel or with green chilies! They are also cooked without further preparation, having then the appearance of fish roe, when they are called 'Ahuauhtli' or 'waterwheat'; they are said to have a delicate flavour and not to be disdained at fashionable tables, Virlet d'Aoust comparing it to Caviare.

Barber (**1928**) cites Thomas Say (1832) who, in describing *Corixa mercenaria* as a new species, remarks

that: "Passing through the market in the city of Mexico I obtained a few specimens from the quantity of at least a peck, exposed for sale by an Aztec woman. They are made use of as food."

China (**1931**; vide Bodenheimer 1951: 295) mentions *ahuatle* as a locally important food, as does **Portevin** (**1933**: 337; vide Bodenheimer, p. 296).

Ancona (**1933a**) conducted extensive studies on the ecology of the aquatic hemipteran species of which "ahuautle" is composed and described their collection and use as follows:

> The 'ahuautle' fishermen in Sochiaca, Chimalhuacan, and Texcoco, collect these insects in great quantities in the channels connected to the lagoon when the rainy season starts [April]. For this collection they use nets made of canvas measuring approximately 1 m (length) by 60 cm (width), which they submerge in the 'alpacle' nests. The insects are placed in baskets to dry in the sun. They are sold in the streets and markets of the city under the name, 'mosca for the birds.' Ground, they are used in small delicious pies. They are sold not only in Texcoco, but also in the markets of Chimalhuacan, Xochitenco, Sochiaca and Los Reyes, and also in Mexico City, especially at 'La Merced' and 'San Juan.' In May, June and July, the 'ahuautle' eggs (*Krizousacorixa azteca* Jacz., *Krizousacorixa femorata* Guer., *Corisella texcocana* Jacz., *Corisella mercenaria* Say) are often used by our people who fry them with eggs, which has a delicious taste similar to shrimp. Dried, they are kept in cupboards and kept as seasoning in preparing a typical dish from Nochebuena called 'revoltijo.' The common insects known as 'ahuautle' also include *Notonecta unifasciata* Guer., as well as their eggs. The population near Lake Texcoco has been collecting and exporting these eggs and insects to many places in England and Germany where they are used to feed fish in nurseries. According to information supplied by people in the business, 1 kg of eggs and insects costs 75 or 80 centavos at the markets in Texcoco, Chapingo, San Vicente and Los Reyes. During the off season it may reach $1 or $1.25 in the warehouses.

Ancona cited several early authors. Citing Francisco Hernandez (1649), the Aztec Indians used the term "axayacatl" or "axaxayactl" for "small lake flies which reproduce on the surface of water, and which are collected with nets from Mexican lakes during certain times of the year. The eggs ["ahauautle" or "aguaucle"] are so abundant that when ground they form a dough that is sold in markets, afterwards they are cooked by the Indians in potassium nitrate water, and wrapped in corn leaves in the form of a cone."

Clavijero (1780) is cited by Ancona as follows:

> . . . because of the isolation in which some tribes from near the lake live, and because of poor resources, they eat not only aquatic plants, but also amphibians from the lakes, and insects from the swamps such as 'atetepiz' and 'atopinan' and also the eggs of the 'axayacatl.' These, as well as other lime substances taken from the surface of the water, are dried in the sun and used to manufacture a type of food, similar in flavor to cheese, called 'tecuitlatl.'

Ancona cited Leon Coindet (1867) that, "The cooked eggs of the 'axayacatl' are known under the name of 'ahuautli' and are well-liked by Mexicans. The insects are sold on streets, and referred to by the native name of 'mosco for the birds.'"

Torre-Bueno (**1942**) called attention to the excellent study on "ahuautle" and the ecology of Lake Texcoco by Ancona (1933a), but questioned the accuracy of Ancona's enumeration of fewer than five nymphal instars, as with rare exceptions, five is the number observed in waterbugs.

Bachstez and Aragon (**1945**) provide good historical background on the use of "ahuauhtli." The authors point out that cattle, goats and sheep were unknown in Mexico prior to the conquest, and life was maintained mainly by vegetables, corn, fish and poultry, all of which were apparently abundant. A number of insects were considered delicacies, among which was the "Ahuauhtli of Texcoco," which consists of the eggs of *Krizousacorixa azteca* Jacz., *K. texcocana* Jacz. and *Corisella mercenaria* Say. Until World War II, the adult bugs, known as 'Axayacatl," were exported in carload quantities to Holland and from there to Germany where they were used in canary bird food. A Dutch company in Mexico City, until about 1938, purchased the bugs from the natives of Texcoco who brought them to the city in bags and received as much as one peso twenty-five per kilo, or the equivalent of about 16¢ U.S. per pound. The eggs are deposited at the beginning of the rainy season in tremendous numbers on the surface of the stagnant alkali waters of Lake Texcoco or on reeds growing in the lake. The eggs are collected and brought to market from June to October.

According to Bachstez and Aragon, Sahagun states that at the court of Emperor Moctezuma and the Aztec kings that preceded him prior to the tenth century, the "Ahuauhtli" were especially prepared during the ceremony dedicated to the god Xiuhtecutli. They were brought into Tenochtitlan by native runners from Texcoco

so that the emperor would have them fresh for breakfast. They were called "aguaucle" by the common people, meaning "seeds of the water."

Bachstez and Aragon cite several earlier authors for the information that the ahuauhtli were usually prepared with the eggs of fowl in the form of an omelette. The conquistadores called them "Mexican caviar," but did not particularly care for them. Bachstez and Aragon state that: "Today they may still be found on sale in the markets of the old town of Texcoco as well as at Los Reyes, a village bordering upon the lake, and at the La Merced and San Juan markets in Mexico City. Many of the typical Mexican restaurants serve them as a delicacy in much the same manner as they serve Maguey cactus worms. The flavor is quite similar to that of crab or caviar."

Bachstez and Aragon conducted the first chemical analysis of the ahuauhtli (eggs) and found, using air-dried material: water 9.3%; ash 6.5%, with calcium 0.33%, iron 0.20%; fat 5.7%; protein 77.0% and lecithin 17.4%. Hydrolysis of the protein gave principally histidine and arginine, and the authors suggest that the eggs should be investigated as an economical commercial source of these amino acids.

Bachstez and Deschamps (**1950**) mention that, based on descriptions of Old Mexico, "ahuautle" or "Mexican caviar" was probably a valuable food source long before the conquest of Mexico by Cortez. They are consumed "today" as a light dish which is prepared with eggs, the taste of which resembles that of caviar or clams. The eggs are deposited in Lake Texcoco in large numbers during the rainy season; the farmers of the area know these eggs and take them to market. A sample (containing 8.74% water) prepared for amino acid analysis contained 72.1% protein and yielded (as percent of total N): arginine 14.28%; cysteine 0.94%; histidine 7.52%; lysine 5.79%; proline-oxyproline 7.96%; other amino acids 52.2%; ammonium 6.72%.

Other studies on nutrient content of *ahuahutle* and *axayacatl* have been conducted by **Cravioto et al** (**1951**), **Grimaldo et al** (**1957**), **Massieu et al** (**1958**), **Conconi and Bourges** (**1977**, on *Corisella mercenaria* only), and **Conconi et al** (**1981a**) (see Introduction and Tables 1, 2, 3 and 7). *Ahuahutle* is high in the amino acids cystine, tyrosine and arginine, and the vitamins niacin and riboflavin. *Axayacatl* is high in tryptophan, iron, niacin and riboflavin. See also **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9 for proximate analyses and energy content.

Ramos-Elorduy and Pino (**1989**, pp. 15-17, 80-82) cite some of the authors cited above and some additional authors in their summary of the use of these insects in old Mexico. They note that *ahuahutle* is still harvested in the same way as in the past (although in reduced amounts because of reduced lake surface), still sold in many markets, eaten in tortillas with eggs and also in tamales, eaten daily in large restaurants in the capital, and still exported to Germany and Great Britain as fish and bird feed.

See also Barrera and Bassols (1953) and Curran (1937) in the Introduction, and Cowan (1865) under References Cited.

Naucoridae (creeping water bugs)

See Hunn (1977) under References Cited.

Pentatomidae (stink bugs)
Edessa conspersa Stal., nymph, adult
Edessa mexicana Stal., nymph, adult
Edessa petersii Stal., nymph, adult
Euchistus crenator Stal., nymph, adult
Euchistus lineatus Walk., nymph, adult
Euchistus strennus Distant (= *zopilotensis* Distant), nymph, adult
Euchistus (= Atizies) sufultus Smith, nymph, adult
Euchistus (= Atizies) taxcoensis Ancona, nymph, adult
Pharylpia fasciata (author?), nymph, adult

These insects are widely consumed and are collectively known as "jumiles," with one species, *Atizies taxcoensis*, being known as "jumiles de Taxco." Bugs from the city of Taxco are particularly famous. There is a "Day of the Stink Bug in November, and a temple in the Hill of the Stink Bug, near Taxco (**Conconi 1982a**: 92-93, 120).

The bugs are kept alive, usually mixed with leaves, in jars or baskets in the markets, and are sold in small packages of 10 bugs for 5 pesos. Or, they may be sold by the "hand full." The price varies according to season and abundance in the market. In some markets, a vendor waits on an average of 15 persons per hour, and income may be about 300 pesos per day. The bugs are eaten alive in tacos, or with chile sauce and rice adding a pleasant flavor. They may also be fried with onion, persil, garlic, "manzano chile" and lemon juice (J.R.E. de Conconi, pers. comm. 1986). As the bugs have a stink gland, they are roasted first in a metallic pot to eliminate the

secretions of the gland.

Ancona (**1932-1933**) states that the "jumiles," or stink bugs are used as seasoning in foods by Mexicans who are ignorant of the microbial flora and fauna which may, in many cases, contaminate the digestive tracts of insects (no specific examples are given, however). Material was studied from the states of Mexico, Guerrero, Veracruz, Oaxaca, Hidalgo and Morelos, and included *Euschistus crenator* Stal., *E. lineatus* Walk., *Edessa mexicana* Stal, *Atizies sufultus* Smith and *A. taxcoensis*, the latter being described as a new species in this paper. The two *Atizies* species were found only in the State of Guerrero. The "jumiles" are plentiful from November to February and disappear when the first rains arrive. They are found frequently in shrubs bordering maize plantations, living among the rocks and dried leaves and on the smaller branches of broad-leaved trees.

Ancona describes various orifices that externally lubricate the body of the "jumiles," and he states that the insects have an unpleasant odor that increases when they are touched. Their use as food is described as follows:

> Even though they have this strong odor, people eat them toasted, grinding them and eating with tomato 'salsa,' reporting a pleasant taste of sesame. They are also fried in their own oily secretion, or in olive oil and put into tortillas with lemon sauce and salt with a taste like fried potato peels, the manner in which it is most used by the people. In Taxco and other places of the State [Guerrero], as well as in the State of Morelos, poor people eat them raw, chewing the posterior part of their bellies, sucking their contents, believing that these insects cure dyspepsia, and skin problems.

Ancona (**1933b**) adds *Euschistus zopilotensis* Distant to the list of confirmed species known as "jumiles." The bugs appeared as first instars by the end of December and as adults by mid-January in the corn fields and pine woods around Cuautla and Amileingo. Ancona describes their use as follows:

> In the markets at these locations they are used as food seasoning, fried, ground with chili or pepper and as a powder added to food (preferably in rice soups) or are used whole in tomato 'salsa' and placed over hot tortillas. We also saw them fried and eaten with lemon and salt, as they are used in Taxco. Even though they have a bad odor, poor people eat them alive, chewing the lower part of their bellies and sucking their contents, because they believe that they are good medicine for rheumatism.

Ramos-Elorduy and Pino (**1989**, pp. 17-19, 82) added *P. fasciata* to the species reported as eaten and they indicate that many other species of pentatomids are eaten (translation): "Presently 'jumiles' (stink bugs) means virtually any edible Hemiptera from the families Pentatomidae and Coreidae, and the number of species grows to 23, with the State of Guerrero having 18 species, but all species are eaten the same way."

Studies on nutrient content of jumiles have been conducted by (see Introduction) **Cravioto et al** (**1951**), **Grimaldo et al** (**1957**), **Massieu et al** (**1958, 1959**), **Conconi and Bourges** (**1977**, *Atizies taxcoensis*), **Conconi et al** (**1981a**, *A. taxcoensis*) and **Conconi et al** (**l982a**, *Euschistus strennus*) (see also Tables l-5, 7 and 8). The jumiles are high in tryptophan, fat, niacin and riboflavin, but low (as shown for *A. taxcoensis*) in lysine. Protein chemical values of *Atizies taxcoensis* and *Euschistus strennus* were reported as l0% and 56%, respectively, by **Conconi et al** (**1982a**). See also **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Mexico Table 9 for proximate analyses and calorie content.

See also Conconi (1984) in the Introduction.

Family uncertain

Brachymona arcana tenebrosa M., nymph, adult

Ramos-Elorduy and Pino (**1990**) provide proximate analyses and caloric content of this species (Table 9).

Homoptera

Aphididae (aphids)

Regarding honeydew, **Clavigero** (**1786**; Lake and Gray translation 1937: 51) states:

> In some places near the dry stream beds, there grows a small, common reed grass, the thickness of the little finger or, when larger, the index finger. . . . This little reed is the only plant in California on which manna is seen. This is a very sweet and whitish substance called by the Cochimies

> *cadese*, which means 'cane juice.' And they gave this very name to sugar when they became acquainted with it and tasted it. From this it is seen that, although barbarians, they thought about the origin of manna better than did our ancient philosophers, who considered it dew. . . .

Constanso (**1911**) reported: "A multitude of Indians came to the camp [south of San Diego, California] with presents of seeds, acorns, and honeycombs formed on frames of cane [presumably aphid honeydew]. They were a very good-natured and affectionate people."

Cicadidae (cicadas)
Proarna sp., adult
Tibicen puinosa S., adult

Conconi and Pino (**1979**) conducted a proximate analysis of *Proarna* sp. adults, finding a crude protein and fat content of 72.0% and 4.4%, respectively (Table 6). **Ramos-Elorduy and Pino** (**1990**) provide proximate analyses and caloric content for both of the above species (Mexico Table 9). *Proarna* is called *chichara* (Conconi et al 1984a). See also Hunn (1977) under References Cited.

Membracidae (treehoppers)
Hoplophorion (= Metcalfiella) monograma Germar, nymph, adult
Umbonia reclinata Germar, nymph, adult
Umbonia sp., nymph, adult

Hoplophorion monograma, known as the "parakeet of the aguacate," feeds on this tree (*Persea mexicana*). They are eaten raw or roasted in tacos, and people say they taste like "aguacate" (**Conconi 1982a**: 121). They are abundant in the States of Mexico, Michoacan and Oaxaca. **Conconi et al** (**1983b**) conducted amino acid analysis of *H. monograma* and calculated a protein chemical value of 96%, which is excellent and the highest value yet reported for an insect. **Ramos-Elorduy and Pino** (**1990**) provide proximate analyses and caloric content of both of these species (Table 9). *H. monograma* is known as *periquito del aguacate* and *U. reclinata* as *torito* (**Conconi et al 1984a**).

Hymenoptera

More than 35 species of Hymenoptera in three families have been reported as food in Mexico.

Apidae (honey bees, bumble bees)
Apis mellifera Linn. egg, larva, pupa
Bombus diligens (author?), adult
Bombus formosus (author), adult
Bombus medius (author?), adult
Lestrimelita limao Sm., egg, larva, pupa
Melipona beeckei Bennet, egg, larva, pupa
Melipona fasciata querreroensis Schw., egg, larva, pupa
Partamona sp., egg, larva, pupa
Scaptotrigona mexicana G., egg, larva, pupa
Trigona jaty Fabr., egg, larva, pupa
Trigona nigra nigra Cress, egg, larva, pupa
Trigona sp., egg, larva, pupa

Common names are *abeja prieta* for *A. mellifera, abejorro* for the *Bombus* species, *abeja que no pica* or *abeja alazana* or *pipiioli* for *M. beeckei*, and *abeja sin aquijon* for *S. mexicana* and *Trigona* sp.

Kellogg (**1945**) described beekeeping in Mexican villages, mentioning that, although there are many modern hives and some large up-to-date apiaries, as much as two-thirds of the honey crop is produced in crude containers. No mention is made of bee brood (larva and pupa) consumption. The immature stages of at least seven species are now known to be consumed, including those of the domestic honeybee, *Apis mellifera*. Stingless bees of the genera *Melipona*, *Scaptotrigona* and *Trigona* are cultivated in small clay jars near the walls of houses and in small hollowed trunks placed to face east. Both the honey and the brood are utilized. **Conconi et al** (**1984a**) reported a protein chemical value of 58% for *Trigona* sp. **Ramos-Elorduy and Pino** (**1990**, Introduction and Table 9) provide data on proximate analyses and caloric content.

See Callen (1963) and Curran (1937) in the Introduction, and Pennington (1969) under References Cited.

Diprionidae (conifer sawflies)
Neodiprion guilletei (author?), prepupa

Ramos-Elorduy and Pino provide a proximate analysis of this species (Table 9).

Formicidae (ants)
Atta cephalotes Linn., adult reproductive
Atta mexicana Bourmeir, adult
Liometopum apiculatum Mayr., egg, larva, pupa
Liometopum occidentale var. *luctuosum* W., egg, larva, pupa
Myrmecosystus (= Formica) melliger Llava (= *melligera)*, adult
Myrmecosystus mexicanus W., adult
Pogonomyrmex sp., larva, pupa

Genus Atta. Two species are reported as food in Mexico, *A. cephalotes* and *A. mexicana*, known as "hormiga arriera ", "hormiga chicatana" or "noku." Only the winged adults are eaten, and, generally, the females are more flavorful than the males. They are often fried, and are especially enjoyed by children. According to **Conconi** (**1982a**: 129-130), the winged *A. mexicana* emerge from their nests for the mating flight early in the morning and, at Pochutla, Oaxaca, the people come to the mating sites after l am. They capture up to 20 liters of ants per person. At Pochutla and also in Huatusco, Veracruz and probably elsewhere, collecting these ants is a ritual among the people who get together to collect them at the beginning of the mating flights. Studies on nutrient content of *Atta* ants have been conducted by (see Introduction) **Conconi and Bourges** (**1977**), **Conconi and Pino** (**1979**), **Conconi et al** (**1981a**, **1982a**). The latter authors (1982a) calculated a protein chemical value of 60% for *A. mexicana*. See also **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9 for proximate analyses and caloric content.

Ramos-Elorduy and Pino (**1989**, pp. 35-37, 90) state that in Oaxaca up to 2 kg per person are collected, and this exerts a degree of control of these pests which defoliate fruit trees, as collection of the reproductives prevents establishment of new colonies. There is no established commerce in these ants, as there are no middlemen, but they are sold in local markets. In Veracruz, according to the authors, the ants are ground, refrigerated and eaten in tortillas with peanut cream. In Oaxaca they are prepared in sauces with chile and herbs and said to taste like crabs. Kunckell D'Herculais in 1882 is cited by the authors as saying that, with a little salt abdomens of *A. mexicana* loaded with eggs "was one of the most exquisite foods which the Indians ate."

Genus Liometopum. Conconi (1982a: 95) states (translation): "The 'escamole' ants, or 'maicitos' (small corn) as they are also called, have a very delicate flavor, as if they were nuts fried in butter. They are eaten fried, with eggs, in black butter or by themselves. They are also fried with onions, garlic, etc. Because of their flavor and the versatility of their use they are sought after and called 'delicious.'" The two species of *Liometopum*, *L. apiculatum* and *L. occidentale* var. *luctuosum* are found in different habitats, the former in dry or semi-dry areas such as in Hidalgo, and the latter in wooded areas such as in Michoacan. According to Dr. de Conconi (pers. comm 1986), digging out the underground nest (or trabecula) where the escamoles are found is very labor-intensive. According to Conconi (1982a: 130), the two species have slightly different flavors. As noted earlier (also on p. 130), there is a great demand for escamoles and they are sold in good restaurants. An economic survey revealed that the people collecting escamoles, known as "escamoleros," sometimes make more money than most rural persons do during the entire year. Although called "ant eggs," the escamoles are mainly pupae.

Ramos-Elorduy and Pino (**1989**: 31-34, 91) note that "escamoles" are eaten by all social classes in Mexico and that they are the most enjoyable and expensive edible insect in the markets. In 1983, they cost 4,800 pesos per kilo, but now (1988), the cost is 80,000 pesos and the demand is increasing. They are served in the best restaurants and are exported to the United States, Japan and elsewhere. In 1988, a Mexican company was exporting canned escamoles to Canada where they sold for $50 (Canadian dollars) per 30-gram can. In Hidalgo, the nests are private property and cared for well. After harvest of ants from the nest (2 or 3 times per year between February and June), the nest is covered with nopal, dried grass, fresh weeds, etc. in order to maintain an environment suitable for survival and regrowth of the colony. The *Liometopum* ant is considered such a special treat that it is the subject of songs, dances and festivities.

Studies on nutrient content of *Liometopum* have been conducted by (see Introduction) Conconi and Bourges (1977), Conconi and Pino (1979), and Conconi et al (1981a, 1982a) (see also Tables 5-8). Conconi et al (1982b) report preliminary studies on the life cycles of *Liometopum apiculatum* and *L. occidentale* var. *luctuosum*. Immature reproductives of the latter were found to contain 41.68% protein, and immature workers 48.26% (dry weight) or about the same as found previously for *L. apiculatum*. The immature workers were found

to be rich in lysine, methionine plus cysteine, and leucine, while immature reproductives were rich in threonine, valine, isoleucine, phenylalanine plus tyrosine, and tryptophan. See also **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9 for proximate analyses and caloric content.

Conconi et al (**1983a**) report preliminary results of a study on how colonies of *Liometopum apiculatum* are founded, and **Conconi et al** (**1984b**) report results of a study on the biology of *L. apiculatum.*

Packard (**1885**), citing information from a J.M. Carter, reported that the larva of an ant "living in oven-like hills" is eaten by the Otomite Indians. Ramos-Elorduy and Pino (1989, p. 32) suggest that the ant referred to was *Liometopum.*

Genus Myrmecosystus. Pablo de Llave (**1832**) is quoted by Wheeler (1908: 361) regarding the honey ant, *Formica melligera,* which the peasants call *busileras*:

> He assured me that the inhabitants of these nests are a species of small ant which does not make an earthen mound at the entrance of its dwelling, and that in following the excavations and removing the earth, one comes upon a kind of gallery from the ceiling of which the busileras hang suspended and huddled together, covering both the roof and the walls of the gallery. He told me also that the peasant women and children are well acquainted with these nests, that they seek them assiduously for the purpose of obtaining the honey and that when they are going to make a present of them, they take hold of them very cautiously, carefully remove the head and thorax and then place them in a dish; but if the insects are to be eaten as soon as found, the saccharine portion is sucked out and the remainder thrown away. The head and thorax are removed, I was told, to prevent the ants from injuring one another. . . .

Weatherill (**1854**) analyzed an alcohol-preserved sample of Mexican honey ants and found them to be "a nearly pure solution of the sugar, so-called, of fruits, which is in a state of hydration, isomeric with grape sugar, C12H14014, and differing from grape sugar in not crystallizing." He reported that the average quantity of honey per ant weighed 0.3942 grams or 8.2 times the weight of the body. Honey ants were discussed by **Langstroth and Leidy** (**1854**) on the occasion of Langstroth's presentation of specimens from Matarnoras to the Philadelphia Academy of Natural Sciences. They were described as living globular repositories analagous to the honey combs of bees.

Simmonds (**1885**: 369) mentions that the translucid abdomens of the ant, *Myrmecocystus melligerus [M. melliger* =], which contain a syrupy fluid, are eagerly sucked by the children and commonly employed in cases of earache. The ants are fastened to square pieces of paper and are sold by the dozens. **Bodenheimer** (**1951**: 300) cites Brygoo (1946) who in turn cites an earlier, undated source that 1,000 honeypots are required to yield one liter of honey.

"Honey pot" ants, *M. melliger* and *M. mexicanus*, are still a sweet treat in Mexico today. They are held by the front end and the abdomen is bitten off. They come in different flavors, varying with the color of the abdomen: if brown, they are called "coca cola" ants; if yellow-orange, "butter" ants; or if yellow, "vinegar" ants (J.R.E.. de Conconi, pers. comm. 1986). **Conconi and Pino** (**1979**) conducted a proximate analysis of *M. melliger*. **Ramos-Elorduy and Pino** (**1990**) provide data on proximate analysis and caloric content.

Conway (**1994**) presents information on the biology and ecology of *M. mexicanus* summarized under the following subject headings: honey ant habitat, nest density, population size, reproductives and nuptial activity, guests and parasites, repletes, nest architecture, circadian and seasonal activity, food sources, intraspecific and interspecific competition, and predators.

Also see Cowan (1865) under References.

Genus uncertain

According to **Felger and Moser** (**1985**), the Seri had names for at least eight kinds of ants, but they were not utilized.

Relative to Formicidae, see also Barrera and Bassols (1953), Callen (1963), Conconi (1984) and Smith (1991) in the Introduction, and Pennington (1969) under References Cited.

Sphecidae (sphecids or mud daubers)
Ammophila sp., immature stages

Recorded by **Conconi et al (1982c)** as eaten in Mexico.

Vespidae (wasps, hornets)

Brachygastra azteca (Sauss.), immatures
Brachygastra (= Nectarinia) lecheguana (Latr.), immatures
Brachygastra mellifica (Say), immatures
Mischocyttarus sp., immatures
Parachartegus apicalis (Fabr.), immatures
Polistes canadensis (Linn.), immatures
Polistes instabilis (Sauss.), larva, pupa, adult
Polistes major Palisot de Beauvois., egg, larva, pupa
Polistes sp., egg, larva, pupa
Polybia diguetana du Buysson, immatures
Polybia occidentalis bohemani Holmgren, immatures
Polybia occidentalis nigratella du Buysson, immatures
Polybia parvulina Richards, immatures
Polybia spp., eggs, larvae, pupae
Vespula squamosa Drury, immatures

Conconi et al (**1982c**) reported that 12 species of wasps have been recorded as eaten in Mexico (vernacular names as given by Conconi et al [1984a]): *Nectarinia lecheguana, Polybia occidentalis bohemani ("avispa rayada"), P. o. nigratella ("avispa huevo de toro"), P. parvulina ("avispa negra"), Brachygastra azteca ("avispa cola amarilla"), B. mellifica ("avispas, panal de castilla"), Polistes instabilis ("avispa guittarilla," pupae), P. canadensis, Parachartegus apicalis ("avispa ala blanca"), Vespula squamosa ("avispa panal de tierra"),* and *Mischocyttarus* sp. (*"avispa negra con franjas")*. In general, it is the immature stages that are eaten, occasionally with the nests, but in the case of *Polistes* the adults are also eaten. Protein content ranged from 52.84% to 74.51% (dry basis). Of the amino acids, only tryptophan was somewhat below F.A.O. (1973) guidelines. Chemical scores ranged from 51% to 73%, *Polybia parvulina* being the highest. **Conconi et al** (**1984a**) also reported protein chemical scores, as follows: *Brachygastra azteca* 70%, *B. mellifica* 70%, *Parachartegus apicalis* 50%, *Polybia parvulina* 70%, and *Vespula squamosa* 70%. See also **Ramos-Elorduy and Pino** (**1990**) for data on proximate analyses and caloric content.

The total vespids now known to be eaten is at least 14 species. Combs with wasp brood are sold in the markets (**Conconi 1982a**: 131, and pers. comm. 1986). The nests are collected in nature when there is just a little foundation comb, brought in and hung on the roofs of farm homes until they reach a large size. This is, in a way, primitive cultivation. Other methods of collection are also used. To collect the comb of *Brachygastra mellifica*, people throw rocks to make the adult wasps leave, then by using a long, hooked stick, the nest is pulled down (p. 133). To collect the nests of *Vespula squamosa*, a fire is built to drive off the adult wasps. Then the young and the honey can be collected without being stung (p. 135). Among the largest combs with edible brood are those of *Polybia occidentalis bohemani*, which may become one meter in width (p. 137). Wasp brood, with a little pepper, either fried or roasted, has the flavor of almonds or walnuts (Conconi, pers. comm. 1986). For the honey-producing wasps (*Polistes* spp. don't produce honey), the honey comb is taken home, cut like a cake and roasted before eating (**Ramos-Elorduy and Pino 1989**, pp. 44-45, 92-93).

Clavigero (**1786**: Lake and Gray translation 1937: 59) mentions larvae of an unidentified species of wasp: "Those of the third class are smaller, light, and armed with a severe sting, which causes inflammation and much pain. Although they do not make honey, they make nests hanging from the rocks, but in those places which are sheltered from the rains. The Californians are very fond of these little worms, and many times they risk the danger of falling when climbing over the crags to get them from the nests."

Paper wasp (*Polistes*) nests, *saaij*, were crushed and brewed as a tea taken by Seri women to prevent conception (**Felger and Moser 1985**).

U T'an Yik'el Kab is a Spanish-language newsletter published in Yucatan and devoted to preservation and promotion of traditional Mayan techniques for keeping honey-making social insects, with emphasis on stingless bees of the genus *Melipona*. **Starr** (**1992**) furnishes a translation of a recipe by Ada Mex de Canché and Manuelita May which appeared in issue no. 5 (February 1992):

> Wasps of the genus *Brachygastra* (Vespidae: Polistinae) are quite common in our area. They build large, round nests of a carton-like material. These wasps are valued by local people for their honey, which is tasty and aromatic, although rather strong. The larvae are roasted in a pan and then mixed with sour orange juice and hot red peppers. Finally, they are made into little tacos, ready for eating.

See also Callen (1963), Curran (1937) and Conconi (1984) in the Introduction, and Pennington (1969) under References Cited.

Xylocopidae (carpenter bees)

Felger and Moser mention that the Seri highly esteemed *Copni yamaax* or "carpenter-bee its wine," the sweet "beebread" (pollen plus nectar) made by the carpenter bee (*Xylocopa*). It was described as being like cream, not honey, and the people ate a lot of it during the time of year when the bee was putting this food in the hole for its larvae.

Isoptera

See Callen (1963, termites in human coprolites) in the Introduction.

Lepidoptera

Cossidae (carpenter moths, leopard moths)
Comadia (= Xyleutes; = Cossus) redtenbachi Hamm., larva

The pink worm of the maguey, *Xyleutes redtenbachi*, also called the red agave worm or *"gusano rojo de maguey,"* is the larva used in tequila bottles. It is sold in the market, placed in a string forming a necklace. It is also used, raw or cooked, to season sauces (**Conconi l982a**: 92).

Ancona (**1931**), in the first of his papers on the biology of insects used as food in Mexico, reports encountering, on an excursion to the State of Oaxaca, vast numbers of the pink caterpillar that feeds in the maguey cactus, and which are known locally as "small worms of the salt." In areas of Oaxaca, the caterpillars invade 5% to 15% of the magueys, but rarely do they reach plague proportions. The eggs are laid in groups which are easily seen, and plants can be protected by gathering the eggs during the early months of the year. According to Ancona, people encourage their protection and development by placing the eggs in "cubas" of magueys set aside for their production.

In addition to their use in bottles of mezcali, in Oaxaca these larvae are eaten fried in butter or their own fat, eaten in tortillas, cooked in rice soup or in tomato sauce, roasted and ground with salt and red chile (**Ramos-Elorduy and Pino 1989**: 25-26). In Hidalgo, they are displayed in large baskets in the markets (p. 87) and may be eaten alive, but normally they are roasted or fried with salt and eaten in tacos. The authors cite P.M. Alvarado and P.E. Escamilla (1982) that a plant may have 15 to 30 larvae and people know that yellow-tipped leaves contain larvae. The authors state that larvae move out of their plant sites when it rains and are easily collected.

Studies on nutrient content of *C. redtenbachi* have been conducted by **Conconi and Bourges (1977), Conconi and Pino (1979) and Conconi et al (1981a, 1982a**) (see Introduction and Tables 5-7). The latter authors (1982a) reported a protein chemical value of 60%. See also **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9 for proximate analysis and caloric content.

Geometridae (measuringworms)
Synopsia mexicanaria Walk., larva

This species (common name: *pescaditos*) was reported by **Conconi et al** (**1984a**). **Ramos-Elorduy and Pino** (**1990**) provided a proximate analysis and caloric content (Table 9).

Hepialidae (ghost moths, swifts)
Phassus sp., larva
Phassus trajesa Linn., larva
Phassus triangularis E., larva

Conconi (**1982a**: 125-126) notes that the larvae of a tree-infesting *Phassus* species, known as *"gusanillo,"* are appreciated for their size and flavor. Rural people know when the larva is ready to eat by the size of the knots in the wood. The larvae are also used as medicine for children's diarrhea. See **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9 for data on proximate analysis and caloric value.

Megathymidae (giant skippers)
Aegiale (= Acentrocneme) hesperiaris Kirby, larva

Alzate (**1795**; vide Ancona 1934) stated that maguey caterpillars "are so delicious that the gastronomers from Paris would rather eat them than oysters from Ostende or pigeon eggs from China." This insect, *Aegiale*

hesperiaris, also known as the "white agave worm" or *"gusano blanco de maguey,"* has been relished by the people of Mexico since before the days of Sahagun. It is now relatively scarce because of over-collecting (Conconi, pers. comm. 1986).

Ancona (**1934**) reported on the food uses and biology of the larva of the skipper butterfly, *Aegiale (Acentrocneme) hesperiaris* Kirby, popularly known as the "gusanitos del maguey" or "caterpillar of the maguey." The Indians in the States of Puebla and Hidalgo also call the caterpillars "meocuilines." Ancona describes their use as follows:

> Our people are accustomed to eating the maguey caterpillars fried in butter or fried in their own grease and wrapped in tortillas. They are a rich food with a pleasant flavor that can be compared to 'chicharron' . . . . The maguey caterpillars are also eaten roasted and as small pieces mixed with rice soup, or with 'jitornate salsa.' In the town of Los Reyes the caterpillars are eaten toasted and ground with salt and red chili with strong alcoholic beverages and slices of oranges. They are also used as a powder with many uses and are always among the supplies in the kitchen of the Mexican poor. In some places peasants eat these caterpillars alive to cure stomach problems and rheumatism, but this may contaminate people's digestive tracts by colibacillus.

Ancona cites a thesis by Elena Rojo in 1934 that, under certain conditions, people can become infected with the"bacillus typhus" as a result of ingesting maguey caterpillars [Note: To the writer's knowledge, there has been no confirmation of this].

In biological studies, Ancona found that third-instar larvae are present in March and April, fourth instars in May and June, and pre-pupae from July to September.

Bachstez and Aragon (**1942**) assert that "gusanos de maguey," the maguey caterpillars of *Acentrocneme hesperiaris* (Aztec: "meocuilin"), have been considered a delicacy in Mexico since before the days of Cortez. For eating, they are fried in their own grease, and in some places are eaten raw as a medicine for digestive troubles. They are collected in the early spring and brought to market in small packages made from the thin covering of the maguey leaf. The authors analyzed the glycerides of the larval oil, finding the following: glycerides of linoleic acid (4.3%), oleic acid (60.1%), palmitic acid (30.0%), and stearic acid (3.6%). The unsaponifiable matter amounted to 2.0%.

Hodge (**1949**) notes that the Zapotec Indians in Oaxaca offer fried or toasted "caterpillar pretzels" (actually the larvae of the skipper butterfly, *Aegiale hesperiaris*) as an appetizer to accompany the drinking of alcoholic mescal. Locally, they are called "gusanitos del maguey" meaning "little agave caterpillars." They are found throughout the semiarid districts of Mexico, infesting the fleshy leaves of several species of maguey (Agave spp.), which is the source of pulque, mescal and tequila. Hodge says:

> Instead of attempting the chemical eradication of these pests, the Indians long ago hit upon a better solution: they eat them. So popular are they that they may be found in most native Mexican food markets and are even canned for the grocery store trade. Like the writer, many a tourist has tried these *gusanitos* and has found them tasty and as appetizing as pretzels. For ease in handling they are threaded into bunches and are individually salted when eaten.

In Oaxaca, the larvae are placed in a string and a person can collect up to 300 larvae (there may be up to a dozen larvae per leaf) (**Ramos-Elorduy and Pino 1989**, pp. 23-24). They are processed and canned and exported to various countries such as the United States, Canada, France and Japan where they are sold as gourmet food (pp. 85-86). Ramos-Elorduy and Pino give additional vernacular names and cite several earlier authors concerning the high demand for these larvae by people of all social classes in Mexico, and their sale for high prices in the best restaurants in Mexico City.

Angela Corelis (**1994**) translates instructions from the *Gran Libro de Coaina Mexicana* by Alicia Gironella de'Angeli and Jorge de'Angeli on how to prepare *meocuiles*, or maguey larvae. The larvae are found in the roots and are put into sacks made of mixiotes (probably young maguey leaves - also used for tamale coverings). "The *meocuiles* are rinsed, dried, then toasted on a comal (a grill - not open) or fried with a little oil until golden. Mix guacamole and *meocuile* worms to make delicious tacos."

Additional studies on nutrient content have been conducted (see Introduction) by Cravioto et al (1951), Grimaldo et al (1957), Massieu et al (1958), and Conconi and Pino (1979) (Tables 1, 3 and 6). The larvae are especially high in fat content. See, in addition, **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9 for proximate analysis and caloric content.

See also Conconi (1984), Conconi and Pino (1979), Curran (1937), Dunlap (1987) and Smith (1991) in the Introduction.

Noctuidae (noctuids)
Ascalapha (= Erebus) odorata Linn., larva
Heliothis zea Boddie, larva
Spodoptera frugiperda J.E. Smith, larva

Conconi and Pino (**1979, 1980a**) conducted proximate analyses on the larvae of *Heliothis zea*, the corn earworm (Table 6), and *Erebus odorata*. See also **Ramos-Elorduy and Pino** (**1990**) for proximate analyses and caloric content.

Packard (**1885**) mentioned a caterpillar, about 5 cm long, and apparently a noctuid, living in the thick leaves of the maguey or century plant that is eaten either raw or cooked by Mexican Indians. It was not found in March, but is often abundant in July. Although Packard called it a "noctuid," it may have actually been the megathymid, *A. hesperiaris*. **Hunn** (**1977**) mentions an insect that may be the larva of *Thysania agrippina* (see Hunn under References Cited).

The corn worms, *H. zea* and *S. frugiperda*, are known as *cinocuili* (**Ramos-Elorduy and Pino 1989**: 28, 88) and, roasted or fried, they taste like cooked corn. The farmers generally eat them as the ears of corn (where they develop) are collected, but, sometimes, because of the high demand for maguey worms, these larvae are sold as smaller "tender" worms of the maguey. The larvae of *A. odorata*, known as *cuecla*, taste like anchovies (p. 29); they are preserved by allowing a day for the digestive tract to be emptied, then cooked in salt water and dried in the sun.

See also Curran (1937) in the Introduction.

Pieridae (whites, sulphurs)
Catasticta teutila Doubleday, larva
Eucheira socialis Westwood, larva, pupa

The larva of the butterfly, *Eucheria [sic] socialis*, known as "worm of the madrono" or *"gusano del madroño,"* is eaten throughout Mexico (**Conconi 1982a**: 123-125). Rural people "cultivate" the caterpillars, which live in groups in silken pockets which they weave. At night, the larvae leave the pockets to feed on madrono leaves. To harvest the larvae, the silken pockets are collected. The larvae are fried before being eaten. In Hidalgo, the larvae are known as the "green worm from Huasteca." Studies on nutrient content have been conducted by **Conconi and Pino** (**1979**), **Conconi et al** (**1981a**) and **Ramos-Elorduy and Pino** (**1990**) (Tables 6, 7 and 9).

Farmers are familiar with the biology of *E. socialis* (**Ramos-Elorduy and Pino 1989**: 26-27, 87-88). The larvae in each silken pocket, 300-400 larvae per pocket, are of one sex, so farmers leave 3 or 4 pockets in the madrono trees to ensure the next harvest. Trees may average about 5 pockets, and a farmer may thus harvest about 500 pockets. The larvae and the pupae are eaten roasted, with salt and in tacos. These authors cite C.R. Beutelspacher (1984) that this species is known as "guenchuis" in the State of Michoacan.

Kevan and Bye (**1991**) describe the life history of *E. socialis* and cite earlier references to use of the larvae and especially the pupae as food by various peoples in Mexico. They confirm by observation its use as food by the Tarahumara. The larvae are called *nowiki*, the pupae *iwiki*; the *iwiki* are preferred as food and are boiled or slightly roasted. They are also ground with maize and eaten with atol (boiled maize chowder) or esquiate (a cold maize porridge). The pupae are fatty and said to promote healthy teeth, but over-consumption causes vomiting and headaches. *Nowiki* are prepared by boiling and stripping to remove the setae, but they are considered inferior. The silken tents which the larvae inhabit are known as bolsas. Each bolsa may contain up to 600 larvae and there may be 20 bolsas on a single tree. Larvae inhabit the bolsas from July to April, pupation occurs within the bolsa and duration of the pupal stage is 25-30 days. The authors note that old bolsas have occasionally been found tied to madrone branches, suggesting attempts at husbandry.

In a report on papers presented at the annual meeting of the Society of Ethnobiology in Washington, D.C., **Cowen** (**1992**) reports further discussion by Bye and Kevan of research on *E. socialis* in northwest Mexico. The pupae, or *iwiki*, are collected and roasted by the Tarahumara Indians who sometimes mix them with corn gruel. This serves as a nutritional supplement as late spring is traditionally a time of food shortage between the end of the dry season and the beginning of the main agricultural cycle. Snacking on *iwiki* now appears limited to the elders of the Tarahumara tribe as the butterfly is threatened by lumbering of its pine-oak habitat. Bye and Kevan found evidence, however, that some tribe members now practice animal husbandry, taking silken bags from madrone trees that contain many of them (as many as 20 bags per tree), and retying them with leather straps on trees that lack them. This may promote repopulation of the butterfly. Redistribution of cocoons has been observed only in localities where people eat the pupae. As noted above, Tarahumara who eat large numbers of pupae sometimes vomit or develop headaches. As madrone leaves contain glycosides, chemicals that can affect the heart and are poisonous to humans, Bye and Kevan point to the need for determining whether they are

partially neutralized by the larvae or pupae and whether cooking the pupae may detoxify them.
See also Pennington (1969) under References Cited.

Psychidae (bagworm moths)

Bagworm cases containing the female moth were boiled by the Seri and the tea drunk to "make one thin" (**Felger and Moser 1985**). The bagworm was called *cacaojc* .

Pyralidae (snout moths, grass moths)
Laniifera cyclades Druce, larva

Larvae of *Laniifera cyclades*, known as "worm of the nopal cactus" or *"gusano sel nopal,"* are eaten fried or in tacos. Its flavor is similar to french fries and is delicious (**Conconi 1982a**: 122). **Conconi et al** (**1984a**) reported a crude protein content of 45.8%; for data on protein digestibility, see **Conconi et al** (**1981a**, Table 7); for data on proximate analysis and caloric content, see **Ramos-Elorduy and Pino** (**1990**, Table 9). The larvae are found during a 4-month period, February-May, and there are 20-30 larvae per leaf (**Ramos-Elorduy and Pino 1989**: 27). See also Barrera and Bassols (1953) in the Introduction.

Saturniidae (giant silk moths)
Arsenura armida Cramer, larva
Hylesia frigida Hubner, larva
Hylesia sp., larva
Latebraria amphipyroides Guenee, larva

Conconi et al (**1984a**) reported a crude protein content of 41.9% and a protein chemical value of 45% for the larva of *Hylesia frigida* (called *"mariposadel madroño*"). The larvae of *A. armida* and *L. amphipyroides* are known as *cuecla* or *cuetla* (**Ramos-Elorduy and Pino 1989**: 28-29, 89), and Del Barco is cited that, "The Indians love this food because it is nutritious and has a buttery and smooth taste." The authors state that children sometimes eat the larvae alive "since they have a sweet flavor." They are sold in the markets of Oaxaca, Veracruz, Puebla and Tlaxcala. For proximate analyses and caloric content of all three species, see **Ramos-Elorduy and Pino** (**1990**) in the Introduction and Table 9.

Sphingidae (hawk-moths, sphinx moths)
Hyles lineata (author?), larva

Felger and Moser (**1985**: 39-40, 113, 350) reported that, like the Papago, the Seri of northwestern Mexico gathered and ate the caterpillars (*hehe icam*) or "plant's live thing") of the white-lined sphinx moth, *Hyles lineata*, which feeds more often on *hamip caacol* than on other plants. According to the authors: "The head was twisted off, the viscera stripped out with the fingers, and the "skin" (actually mostly muscle or meat) cooked in oil in pottery vessels . The cooked caterpillars were often dried and stored in covered vessels.
The only other report of sphingid larvae being eaten in Mexico is by Hunn (1977; see under References Cited).

Family uncertain

Clavigero (**1786**; Lake and Gray translation 1937: 59) mentioned two caterpillars:

> These poor Indians find sustenance likewise from two kinds of grayish worms, which are long and as thick as the little finger and which are found on certain plants after the rains. In order to eat them, they catch them one by one by the head with their two fingers, and with the other two they continue pressing them from the head as far as the other extremity, in order to empty their digestive system. Afterward they roast them and make a long string of those which they wish to keep for further use.

Caterpillars are mentioned as a food of the Paipai, a Yuman-speaking people who live about 80 miles east-southeast of Ensenada, Baja, California (**Joel 1976**).

Megaloptera

Corydalidae (dobsonflies, fishflies)

See "water bug" complex under Hunn (1977) in References Cited).

Odonata

Aeschnidae (darners)
Anax sp., nymph , adult

Conconi and Bourges (**1977**) reported that the nymph of a species of *Anax* (family Aeschnidae) is eaten. The Aeschnidae are part of the superfamily Anisoptera. **Hunn** (**1977**) reported that both dragonfly larvae (Anisoptera) and damsel fly larvae (superfamily Zygoptera) are consumed in the central highlands of Chiapas. See **Ramos-Eloduy and Pino** (**1990**) in the Introduction and Table 9 for proximate analysis and caloric content of *Anax*.

Orthoptera

Acrididae (short-horned grasshoppers)
Arphia fallax Sauss., nymph, adult
Boopedon flaviventris Bruner, nymph, adult
Boopedon sp. af. *flaviventris* Bruner, nymph, adult
Encoptolophus herbaceous Sauss., nymph, adult
Melanoplus femurrubrum DeGeer, nymph, adult
Me1anoplus mexicanus Sauss., nymph, adult
Melanoplus sp., nymph, adult
Ochrotettix cer. *salinus* Burm., nymph, adult
Osmilia flavolineata DeGeer, nymph, adult
Plectrotettra nobilis Walk., nymph, adult
Schistocerca paranensis Burm., nymph, adult
Schistocerca sp., nymph, adult
Spharagemon aequale Say, nymph, adult
Sphenarium histrio Gerst., nymph, adult
Sphenarium magnum Marquez, nymph, adult
Sphenarium purpurascens Charp., nymph, adult
Sphenarium spp., nymphs, adults
Trimerotropis sp., nymph, adult
Tropinotus mexicanus Brunner, nymph, adult

About 20 species of grasshoppers and locusts are known as food in Mexico. They are sold widely in the village markets, species of the genus *Sphenarium* being particularly important (de Conconi, pers. comm. 1986). As sold, they have frequently been mixed with onion, garlic and chili powder, then boiled (during which they turn to a pinkish-brown color) and dried in the sun or fried. According to **Conconi** (**l984**), grasshoppers generally assume the taste of the condiment with which they are cooked, such as chili piquin or lemon in garlic. Nets are often used to collect them.

Steininger and Van de Velde (1935) [1971 reprint: 11] report that in San Pablo, a typical Zapotecan Indian village in southwestern Mexico, toasted grasshoppers are an article of diet:

> [Collecting] is generally done by the women who go out at dusk and pick them from the grass and the bushes and place them in a little jar which they have brought for the purpose. The grasshoppers are kept in these jars over night, during which time they purge themselves of their acrid black juice. The following morning they are either fried in lard or toasted with lemon juice and salt. Connoisseurs claim that, when properly prepared, grasshoppers are quite succulent.

Felger and Moser (**l985**) cite an earlier reference indicating that the Seri ate grasshoppers and they note that the name of two small shrubs in the mallow family, *Caatc ipapl* (*Abutilon incanum* and *Horsfordia alata)*, means "what grasshoppers are strung with," and likewise indicates that grasshoppers were eaten.

Clavigero (**1786**; Lake and Wade translation 1937: 63) described great locust flights and said (p. 65):

> Formerly the Californians were accustomed to eat roasted and pulverized locusts frequently, after

they had removed the contents of the stomach. The good advice of the missionaries and the experience acquired in 1722, in which a great epidemic attacked the Indians because they ate so many locusts, diverted them, for the most part, from such food. Nevertheless, some continued to eat them, since they were not averse to taking advantage of what was so abundant when other foods are so scarce.

Studies on nutrient content have been conducted by (see Introduction) Grimaldo et al (1957) (Table 2), Massieu et al (1959) (Table 4), Conconi and Bourges (1977) on *Sphenarium histrio* (Table 5), **Conconi and Pino** (**1979**) on *Trimerotropis* sp. (Table 6), **Conconi et al** {**1981a**) on *S. histrio* (Table 7), and **Conconi et al** (**1982a**) on *Sphenarium purpuracens* (Table 8). Massieu et al noted the high protein and niacin content of grasshoppers (*Sphenarium*) compared to other foods. Conconi et al (1982a) reported protein chemical values of 60% and 65%, respectively for *S. histrio* and *S. purpurascens*, and **Conconi et al** (**1984a**) reported chemical values of 56% each for *Boopedon flaviventris, Melanoplus mexicanus* and *Sphenarium* spp. **Ramos-Elorduy and Pino** (**1990**) reported proximate analyses and caloric values for 12 species (Introduction and Table 9).

Ramos-Elorduy and Pino (**1989**: 1-13, 79-80) review parts of the Florentino Manuscript pertaining to grasshoppers (known as "chapulines") and locusts ("langostas"), and state that 27 species are now recorded as eaten in Mexico (although the authors do not list them). They note that 1 kilogram of grasshoppers costs 12,000 pesos in Oaxaca and 18,000 pesos in Mexico City. Ten grams cost about 1,200 pesos, and they are eaten in tacos. Special nets are used for commercial collecting. To avoid a bitter taste, they are held for a day to allow clearing of the digestive tract, then placed in boiling water, then sun-dried.

Long (**1993**) described a trip by the U.S. Department of Agriculture's Gary Cunningham who was invited to Mexico to recommend new pest management approaches which might help quell grasshopper swarms centered in the Yucatan Peninsula and to the west in the states of Tlaxcala and Puebla, and described as of "epidemic proportions." The highly toxic insecticide, methyl parathion, most of it applied by backpack sprayers, had been the Mexican government's method of choice in combatting the outbreaks, but the government was also studying alternatives including harvesting the insects as a food source. While Cunningham was in Puebla, an extension specialist from Mexico City was demonstrating grasshopper recipes learned from natives in the nearby State of Oaxaca. Cunningham purchased a pound of freshly prepared *Sphenarium* grasshoppers in a Puebla market for 4,000 pesos, or about US $1.25. The recipe was simple and "complimented the insect's hearty flavor." It is mentioned that the natives gather grasshoppers in a sweep net and place them in water for 24 hours. After they are drained, they are placed in boiling water for about 30 minutes, adding salt and garlic. Corn husks are added "to give them a darker, more delicious color."

See also Callen (1963), Clavijero (1786), Conconi (1984), Curran (1937) and Dunlap (1987) in the Introduction, and Hunn (1977) under References Cited.

Blattidae (cockroaches)

See Hunn (1977, medicinal use by Tzeltal-speaking Indians) under References Cited.

Gryllidae (crickets)

See Clavijero (1786) in the Introduction.

Gryllotalpidae (mole crickets)

Hunn (**1977**) reported that mole crickets are eaten in the central highlands of Chiapas.

Romaleidae (lubber grasshoppers)
Romalea colorata S., nymph, adult
Romalea sp., nymph, adult
Taeniopoda sp., nymph, adult

"Locusts" called "colaca-chapoli" mentioned in the Florentino Manuscript probably belong to the genus *Taeniopoda* according to **Ramos-Elorduy and Pino** (**1989**: 13). See also Hunn (1977, *Taeniopoda* not eaten by Tzeltal-speaking Indians) under References Cited. Data on proximate analyses and caloric content were reported by **Ramos-Elorduy and Pino** (**1990**, Introduction and Table 9).

Tettigoniidae (long-horned grasshoppers)
Microcentrum sp., nymph, adult

One of the grasshoppers (called "Cacatecuilichtli") mentioned in the Florentino Manuscript as edible is probably *Microcentrum* sp. (**Ramos-Elorduy and Pino 1989**: 13-14). See also Hunn (1977) under References Cited.

Trichoptera

Hydropsychidae (net-spinning caddiceflies)
Leptonema sp., larva

Miscellaneous Insects

Gage (**1721**: 144) stated (translation): "In the Indian markets, they sold, among other things, 'long worms.'"

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Bachstez, M.; Aragón, A. 1945. Notes on Mexican drugs, plants, and foods. III. Ahuauhtli; the Mexican caviar. *J. Am. Pharm. Assoc., Sc. Ed.*, 34:170-172. (Corixidae)

Bachstez, M.; Deschamps, I. 1950. Notas sobre-drogas, plantas y alimentos mexicanos. XI. Distribucion de los aminoácidos en proteínas de huevos de insectos (ahuautle). *Ciencia* X (3-4): 81-83. (Corixidae)

Barber, H.S. 1928. Thomas Say's unrecorded journey in Mexico. *Entomol. News* 39: 15-20. (Corixidae)

Barrera, A.; Bassols, I. 1953. Un ensayo sobre los conocimientos entomologicos en el Mexico antiguo. *Mem. del Congr. Cient. Mex. UNAM* VII: 85-98.* (Introduction)

Bodenheimer, F.S. 1951. Insects as Human Food. The Hague: W. Junk, 352 pp. (A source of several references)

Callen, E.O. 1963. Diet as revealed by coprolites. *In* Science in Archaeology (D. Brothwell, E. Higgs, eds.), pp. 186-194. Great Britain: Thames and Hudson. (Introduction)

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Clavigero, Francisco Javier. 1786. See under Lake and Gray (1937).

Clavijero, Francisco Javier. 1780. Storia Antica del Messico. I, II. Bologne.* (Introduction; see Clavigero 1986 above)

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Conconi, J.R.E. de; Pino, J.M.; González, O. 1981a. Digestibilidad in vitro de algunos insectos comestibles en Mexico. *Folia Entomol. Mex.* 49: 141-154. (Introduction and Table 7)

Conconi, J.R.E. de; Pino Moreno, J.M.; Machain Castel de Oro, V. A. 1981b. Digestibilidad total y proteinas de las pupas de *Musca domestica*. *Folia Entomol. Mex.* 48: 101 (Abstr.). (Muscidae)

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Conconi, J.R.E. de. 1982a. Los insectos como fuente de proteinas en el futuro. Edit. Limusa, 142 pp. (Introduction)

Conconi, J.R.E. de. 1982b. Los insectos comestibles de México presente y futuro. *Rev. Tecnol. Aliment. (Mex.)* 17(6): 19-22. (Introduction)

Conconi, J.R.E. de; Bourges, H.; Pino Moreno, J. 1982a. Valor nutritivo y calidad de la proteina de algunos insectos comestibles de Mexico. *Folia Entomol. Mex.* 53: 118. (Introduction and Table 8)

Conconi, J.R.E. de; Delage-Darchen, B.; Bourges, H.; Pino Moreno, J.M. 1982b. Life cycle of *Liometopum apiculatum* and *Liometopum occidentale* var. *luctuosum* (Hymenoptera: Formicidae) with reference to their nutritive value as food in worker and reproductive casts. Proc. 9th Congr. Internat. Union Study Social Insects, Boulder, Colo., 2nd Suppl., p. 1 (Abstr.). (Formicidae)

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Conconi, J.R.E. de; Pino Moreno, J.M.; Bourges, H. 1983b. Valor nutritivo y calidad de la proteina de algunos insectes comestibles de Mexico. XVIII Congr. Nac. Entomol. Resumenes, pp. 134-135 (Abstr.). (Introduction)

Conconi, J.R.E. de; Pérez G., R.M.; Pino Moreno, J.M.; Muñoz, J.L. 1983c. Deteccion de minerales en

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Constanso, M. 1911. Diary of M. Constanso. The Portola Expedition of 1769-1770. *Publ. Acad. Pacific Coast Hist.* 2(2): 28-29. (Aphididae)

Conway, J.R. 1994. Honey ants. *Amer. Entomologist* 40(4): 229-234. (Hymenoptera)

Corelis, Angela. 1994. [Letters] *Food Insects Newslet.* 7(1): 3. (Megathymidae)

Cowan, F. 1865. Curious Facts in the History of Insects; Including Spiders and Scorpions. Philadelphia: J.B. Lippincott & Co., pp. 160, 275-277.

Cowan cites (pp. 275-277) and quotes from numerous earlier authors on the harvest and food use of the "hautle" (or Mexican caviar)(Corixidae, Notonectidae). Cowan also cites (p. 160) Smith's *Nature and Art* regarding a singular species of ant, which carries on its abdomen "a little bagful of a sweet substance, of which the children are very fond: the Mexicans suppose this to be a kind of honey collected by the insect; but Clavigero thinks it rather its eggs." (Formicidae).

Cowen, R. 1992. Butterflies in their stomachs. *Sci. News* 141: . (Pieridae)

Cravioto, R.O.; Lockhart, E.E.; Anderson, R.K.; Miranda, F. deP.; Harris, R.S. 1945. Composition of typical Mexican foods. *J. Nutrition* 29: 317-323. (Introduction)

Cravioto, R.O.; Massieu H. G.; Guzman G. J.; Calvo de la Torre, J. 1951. Composicion de alimentos mexicanos. *Ciencia,* Mexico, D.F., 11(56): 129-155. (Introduction and Mexico Table 1)

Curran, C.H. 1937. Insect lore of the Aztecs. *Nat. Hist.* (N.Y.) 39: l96-203. (Introduction)

Curran, C.H. 1951. Insects in Your Life. New York: Sheridan House, pp. 278, 281, 284. (Introduction)

Eerde, E. 1980/1981. Butterflies in your stomach? R&D Mexico, Dec. 1980/Jan. 1981, pp. 6-8. (Introduction)

Felger, R.S.; Moser, M.B. 1985. People of the Desert and Sea. Ethnobotany of the Seri Indians. Tucson, Ariz.: Univ. Ariz. Press, pp. 39-40, 113, 350. (Xylocopidae, Formicidae, Vespidae, Psychidae, Sphingidae, Acrididae)

Gage, T. 1721. Nouvelle Relation contenent les Voyages de Thomas Gage dans la Nouvelle Espagne.... 2 vols. Amsterdam, I, p. 144. (Corixidae, Miscellaneous Insects)

Grimaldo, R.; Suarez Soto, M. de L. Luz; Massieu, G.; Cravioto, R.O. 1957. Continedo en cistina y tirosina de algunos alimentos mexicanos. *An. Inst. Biol. Univ. Nac. Auton. Mex.* 28: 1-10. (Introduction and Mexico Table 2)

Hodge, W.H. 1949. Letters: Insects as food. *Nat. Hist.* (N.Y.), Nov., p. 385. (Megathymidae)

Hunn, E.S. 1977. Tzeltal Folk Zoology. The Classification of Discontinuities in Nature. New York: Academic

Press, pp. 254-306.

Hunn defines hundreds of terms applied to insects by the Tzeltal-speaking Indians of Tenejapa in the central highlands of Chiapas. Many are considered edible, others not edible. The "taxonomic" precision is amazing; the original work should be consulted for the Tzeltal terms. Groups containing edible species are as follows:

"Water bug" complex (pp. 254-255): Aquatic larvae of the orders Odonata, Neuroptera, and Diptera and nymphs and adults of aquatic Hemiptera and Coleoptera comprise the complex. According to Hunn, none of the included taxa are considered inedible, and several are the object of collecting trips during the low-water season. Damselfly larvae (superfamily Zygoptera) and dragonfly larvae (superfamily Anisoptera) are collected as food, the latter by turning stones at the water's edge. Hellgrammites (larval Corydalidae) are collected, and are common beneath streamside stones. Nymphs and adults of giant water bugs (Belostomatidae) and creeping water bugs (Naucoridae) are also collected as food by searching under streamside stones.

Ant complex (pp. 259-263): [Don't have pp. 262-263, which includes *Atta* ants, and should be checked before completing this section.]

Butterfly-moth complex (pp. 280-288): Baked cicadas are fed to children who talk too much in order to cure them of this trait; Hunn says this use is sympathetic, the insect and the child both making loud and incessant noise.

Grasshopper complex (pp. 288-294): This corresponds closely to the order Orthoptera, most of the included categories being clearly defined and scientifically relevant. Only the cockroaches are excluded. The cultural significance of this group as food and to a lesser extent as pests may explain the detail in classification. Wingless nymphal stages of several taxa are recognized as such. Small, medium and large short-horned grasshoppers (Acrididae), including the spur-throated grasshoppers (Cyrtacanthacridinae) are edible. The lubber grasshoppers (Acrididae: Romaleinae: *Taeniopoda)* are fairly common in season but are not eaten. Meadow grasshoppers (Tettigoniidae: Copiphorinae), brush and round-headed katydids (Phaeneropterinae), and camel crickets (Decticinae) are all considered edible. Praying mantids and walking sticks are not eaten, but mole crickets (Gryllotalpidae) are captured and eaten.

Cockroach complex (pp. 294-295): Cockroaches (Blattidae) are not normally eaten, but *Blatella germanica* and *Pseudomops* sp. are roasted, ground to powder, and drunk with water as a cure for "whooping cough." Insecticides are now usually used for roach control, rather than formerly used methods.

Beetle-bug complex (pp. 295-299): Rhinoceros beetles (Scarabaeidae: Dynastinae) are considered edible, while dung beetles (Scarabaeinae), because of their association with dung, are not considered edible. They are not to be killed, however, because their scavenging role is considered essential. June beetles (Melolonthinae) and shining leaf beetles (Rutelinae) are considered edible, as are long-horned beetles (Cerambycidae: Prioninae).

Weevil complex (pp. 299-303): Antlion larvae (Neuroptera: Myrmeleontidae) are included in this complex, and, although not eaten, women desiring larger breasts collect these and induce them to bite their nipples. This is to insure that in a few years their breasts will enlarge and be similar to the round abdomens of these larvae. An insect considered edible is the "true tree critter," a large (7.5 cm) larva with yellow bands (which may prove to be the larva of the giant noctuid moth, *Thysania agrippina*, according to Hunn). It is found on a variety of trees. The larvae are found by searching for the hole made when a larva enters the wood. A machete is used to cut through to the larva. Other wood-boring larvae are edible if white, inedible if black. Large white grubs (scarab beetle larvae), which damage the roots of cultivated plants are considered inedible; "If eaten, they make a fierce man stupid."

Caterpillar complex (pp. 303-306): This includes lepidopterous larvae except the wood-boring types and also includes a few fly larvae. The classification of larval Lepidoptera is much more detailed than that of adult Lepidoptera, mainly because of their pest importance. Only one type (*tsac*'), the large larvae of a sphinx moth, is eaten, but it is considered a delicacy. Trips to lower areas to the north are required to collect the larvae. They are large, dark, hairless, swarming caterpillars which protrude a hornlike osmaterium when disturbed.

Joel, Judith. 1976. Some Paipai accounts of food gathering. *J. Calif. Anthropol.* 3(1): 59-71. (Lepidoptera: Family uncertain)

Kellog, C.R. 1945. Beekeeping in Mexican villages. *Am. Bee J.* 85(10): 356-357. (Apidae)

Kevan, P.G.; Bye, R.A. 1991. The natural history, sociobiology, and ethnology of *Eucheira socialis* Westwood (Lepidoptera: Pieridae), a unique and little-known butterfly from Mexico. *The Entomologist* 110(4): 146-165. (Pieridae)

Kirkaldy, G.W. 1898. An economic use for waterbugs. *Ent. Month. Mag.* 2nd Ser., IX (Vol. XXXIV): 173-175. (Corixidae)

Kunckell de Herculais. 1885-1886. Observaciones acerca de la hormiga cae de miel *Myrmecocystus melliger* Wesmael. *La Naturaleza* Vol. VII, pp. 1-14. (Formicidae) [Awaiting translation from Spanish.]

Lake, S.E.; Gray, A.A. 1937. The History of [Lower] California by Don Francisco Javier Clavigero, S.J. Transl. from the Italian and edited. Stanford University, Calif.: Stanford Univ. Press, 413 pp. (Introduction).

Langstroth; Leidy. 1854. [No title.] *Proc. Acad. Nat. Sci. Philadelphia* 6: 71-72. (Formicidae)

Llave, P. de. 1832. Registro Trimestre o Collection de Memorias de Historia. Literatura, Ciencias y Artes, Mexico.* (Formicidae)

Long, K. 1993. Locust and grasshopper populations plague Mexico. *Inside APHIS* 13(3): 10-11. (Acrididae)

Massieu, H.G.; Trigo, M; Cravioto, R.O.; Calvo de la T., J. 1950. Sobre la applicación del Metodo de Thomas a la dosificación de tirosina en algunos alimentos Mexicanos. *Ciencia e Investigación (Argentina)* 6: 424-428. (Introduction)

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Massieu, G.H.; Cravioto, R.O.; Guzmán, J.; Olivera, H. 1959. Contribucion adicional al estudio de la composicion de alimentos mexicanos. *Ciencia Mex.* XIX (4-5): 53-66. (Introduction)

Mayer, Brantz. 1844. Mexico as it was and as it is. New York, p. 218.* (Hemiptera: Corixidae)

Mitsuhashi, J. 1996. [Letters) *Food Insects Newslet.* 9(2): 10. (Introduction)

Packard, A.S. 1885. Edible Mexican insects. *Am. Nat.* 19: 893. (Formicidae, Noctuidae)

Pennington, C.W. 1969. The Tepehuan of Chihuahua. Their Material Culture. Salt Lake City: Univ. Utah Press, 413 pp. (pp. 143, 309-310)

The author reports studies on the Tepehuan of southern Chihuahua during the 1960's. Insect foods included an ant (p. 143): "The *davurai*, or *daburi*, is a yellow insect that builds an underground nest in the *monte*. The nest is opened with a stick, and smoke is used to drive away the larger insects. Smaller ones are removed from the hive and toasted on coals. The *davurai* is sought throughout the year." Also: "Upland and canyon Tepehuan esteem a grub (*kakeduni*) taken from a cocoon that is found on *Arbutus arizonica, A. glandulosa,* and *A. xalapensis*; this grub is added to the corn dish *yorika*." Honey from honey bees (including wild *Apis mellifera*), bumble bees (*Bombus formosus*), and a wasp (*Polybia diguetana*) is collected by the Tepehuan, but no mention is made regarding consumption of the bee brood. Pennington states (p. 309) that, "Not one Tepehuan would admit ever to have eaten a fly, locust, grasshopper, corn worm, tadpole, toad, or lizard - all of which are certainly not ignored as food by the Tarahumar," their immediate neighbors to the north.

Portevin, G. 1933. Les Insectes Comestibles. La Terre et la Vie. 1933: 336-340.* (Corixidae)

Ramos-Elorduy, J.; Pino M., J.M. 1989. Los insectos comestibles en el Mexico antiguo. Mexico, D.F.: A.G.T. Editor, S.A., 108 pp. (Introduction and many orders and families)

Ramos-Elorduy, J. 1990. Edible insects: barbarism or solution to the hunger problem? *In:* Ethnobiology:

Implications and Applications (D.A. Posey and W.L. Overal, organizers). *Proc. 1st Internat. Congr. Ethnobiol. (Belém, 1988)*. Belém: Museu Paraense Emílio Goeldi, 2 vols. (Introduction)

Ramos-Elorduy, J.; Pino M., J.M. 1990. Caloric content of some edible insects of Mexico. *Rev. Soc. Quim. Mex.* 34(2): 56-68. (Introduction and Table 9)

Robles, A.F.; Conconi, J.R.E. de; Pino Moreno, J.M.; Sandoval Castro, M.E. 1983. Deteccion de insectos comestibles en Milpa Alta, D.F. Congr. Nac. Entomol. Resumenes p. 151 (Abstr.). (Introduction)

Sahagun, F.B. de. 1557. "Original Codex (1557)." Biblioteca Nacional de Mexico, Mexico, D.F.* (Introduction)

Sahagun, F.B. de. 1946. Historial general de las cosas de la Nueva Espana. Ed. Nueva Espana, Mexico, Tomo II.* (Introduction)

Simmonds, P.L. 1885. The Animal Food Resources of Different Nations. London: E. and F.N. Spon, pp. 353, 369. (Cerambycidae, Formicidae)

Smith T. 1807. Wonders of Nature and Art. 12 vol. Philadelphia, XII, pp. 197-198.*

Smith (vide Bodenheimer 1951: 293-294) discussed as follows several insects eaten by the ancient Mexicans:

> The *Atelepitz* [Hydrophilidae], a marsh beetle, resembling in shape and size the flying beetles, having four feet, and covered with a hard shell. The *Atopinan* [Dytiscidae] is a marsh grasshopper of a dark colour and great size, 15 cm long and 5 cm broad (!). The *Ahuihuilla* [Belostomatidae] is a worm inhabiting the lakes of Mexico, 10 cm long, thick as a goose quill, tawny above and white below; it stings with a tail, which is hard and poisonous. The *Ocuiliztac* [Ephydridae] is a black marsh worm which becomes white on being roasted.

Starr, C.K. 1992. [Published communication] *Food Insects Newslet.* 5(3): 5. (Vespidae)

Steininger, G.R.; Van de Velde, P. 1935 [1971 reprint]. Three Dollars a Year. Detroit: Blaine Ethridge--Books, p. 11. (Acrididae)

Theodorides, J. 1949. Les Coleopteres comestibles. Natur. Belge 30: 126-137. (Cicindelidae)

Torre-Bueno, J.R. de la. 1942. A bibliographic note on aquatic Hemiptera used as food in Mexico. *Bull. Brooklyn Entomol. Soc.* 37(5): 168-169. (Corixidae)

Wetherill, C.M. 1854. Chemical investigation of the Mexican honey ant. *Proc. Acad. Nat. Sci. Philadelphia* 6: 111-113. (Formicidae)

Wheeler, W.M. 1908. Honey ants, with a revision of the American Myrmecocysti. *Bull. Am. Mus. Nat. Hist.* 24: 345-397. (Formicidae)

Chapter 3 of The Human Use of Insects as a Food Resource: A Bibliographic Account in Progress, by Gene R. DeFoliart, posted on website July, 2002.

Added References

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Ramos-Elorduy, J. 1997. Insects: a sustainable source of food? In M.G. Paoletti, S.G.F. Bukkens (Eds.), *Special Issue: Minilivestock. Ecol. Food Nutr.* 36(2-4): 247-276.

The Food Insects Newsletter 10(1): 5-6 (1997) lists 19 references, dated from 1990 to 1997, authored or co-authored by J. Ramos-Elorduy. None of these are included above under our References Cited.

Items Needing Attention

Pp. 2, 19. To what families of Coleoptera do *Paxillus* and *Rhantus* belong?
Pp. 3, 26. To what family of Hemiptera does *Brachymona* belong?
Pp. 28, 46. Kunckell D'Hercules (1885-1886), vol. VII, pp. 1-14 , awaiting translation
P. 40. *Leptonema* sp. is reported in which reference?
P. 44. Cowen, R. (1992), pagination?
P. 45. Hunn (1977), copy of pages 262-263 of Ant complex needed.