

ENTOMOPHAGY AS BIO-PROSPECTING

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Abstract: *Entomophagy is using insects as human food. Insect as food play an important role in new insect focus. Ants, bees, termites, caterpillars, water bugs, beetle larvae, flies, crickets, katydids, cicadas, and dragonfly naiads are among a long list of edible insects that provide for the people of Asia, Australia, Africa, South America, the Middle East, and the Far East. Insects represent an important food source for a wide variety of other animal species. By weight termites, grasshoppers, caterpillars, weevils, houseflies, and spiders are better sources of protein than beef, chicken, pork or lamb. The nutritional and economic value of edible insects is often neglected and we should further encourage their collection and commercialization, given the benefits to the environment and human health. It is an interesting concept, managing pest insects by developing them into a sought after delicacy.*

Keywords: *Insectivory, Entomophagy, Traditional knowledge, Insect bio prospecting.*

Introduction:

Bioprospecting is the collecting and cribbling of biological samples (plants, animals, microorganisms) and the collecting of indigenous knowledge to help in discovering genetic or biochemical resources. Bioprospecting is intended for economic purposes (e.g., new drugs, crops, industrial products). Many insects contributed on a regular basis to the Indian diet. Ants, bees, termites, caterpillars, water bugs, beetle larvae, flies, crickets, katydids, cicadas, and dragonfly nymphs are among a long list of edible insects that provide nutrition for the people of Asia,

Australia, Africa, South America, the Middle East, and the Far East. Humans eat over 1,000 insect species worldwide. Edible insect harvest was a part of the annual rounds of food procurement. Not all insects are edible. Some insects are toxic and may create allergy problems. Some insects such as the mormon cricket, grass hoppers and pandora moth caterpillars yielded a very high energy return for the energy expended in their harvest, often much higher than return rates from seeds or other plant food resources. When dried, the insects were storable for use as winter food. It is agreed that edible insects might help feed the world.

Methodology

Insects were collected from respected habitat and made into solution by adding water. Here for protein extraction we have used Bradford spectroscopic method.

Bradford spectroscopic method- Prepare a series of standards diluted with 0.15 M NaCl to final concentrations of 0 (blank = No NaCl), 250, 500, 750 and 1500 µg/mL. Also prepare serial dilutions of the unknown sample to be measured. Add 100 µL of each of the above to a separate test tube (or spectrophotometer tube if using a Spectronic 20).

Add 5.0 mL of Coomassie Blue to each tube and mix by vortex, or inversion. Adjust the spectrophotometer to a wavelength of 595 nm, using the tube which contains no protein (blank). Wait 5 minutes and read each of the standards and each of the samples at 595 nm wavelength. Plot the absorbance of the standards vs. their concentration. Compute the extinction coefficient and calculate the concentrations of the unknown samples.

Insects as food

Insects represent an important food source for a wide variety of other animal species. Freshwater game fish such as trout, bass, and bream feed extensively on aquatic insects like mayflies, stoneflies, or hellgrammites. Artificial "flies" used by anglers are often made to resemble a fish's natural prey. Many toads, frogs, turtles, snakes, and lizards also consume insects as a major part of their diet. *Insectivory* is common among land dwelling birds. The lives of many bird species depend on a plentiful supply of insects. Purple martins, barn swallows, vireos, warblers, flickers, whippoorwills, and swifts, for example, survive almost exclusively on insects. Other birds (such as egrets, quail, geese, plovers, snipes, and bluebirds) have a more varied diet, but they still derive a large percentage of their total nutrition from insects. There are even some insectivorous mammals: shrews, moles, bats, armadillos, and anteaters. When other food is scarce, even foxes, raccoons, skunks, and bears will turn to insects as a source of food.

Human food

Food insects play an important role in the new "insect focus". The thought of eating insects may very unsettling to most people in this day and age. However, in many cultures, insects and other arthropods have been eaten as a staple and/or as a delicacy. Insects were undoubtedly an important source of nutrition for early human ancestors. Currently, many universities study this process, using the term *Micro-livestock* to categorize the insects that can be eaten. In some parts of the world, insects used for human food are termed as *Entomophagy*. Insects have played an important part in the history of human nutrition in Africa, Asia and Latin America. They were an equally important resource for the Indians of western North America, who likes other indigenous groups, expended much organization and effort in harvesting them. These areas have developed specific recipes for certain regional insects and include the eating of insects as part of their daily diet. Hundreds of species have been used as human food. Some of the more important groups include grasshoppers, caterpillars, beetle grubs and (sometimes) adults, winged termites (some of which are very large in the tropics), bee, wasp and ant brood (larvae and pupae) as well as winged ants, cicadas, and a variety of aquatic insects. Ordinarily, insects are not used as emergency food to ward off starvation, but are included as a planned part of the diet throughout the year or when seasonally available. Among the numerous examples that could be cited, the *Yukpa* people of Colombia and Venezuela prefer

certain of their traditional insect foods to fresh meat, as do the *Pedi* of South Africa. When *mopanie* caterpillars (*Gonimbrasia belina* Westwood) were in season, the sale of beef was seriously affected.

In general, insects provide a high source of protein and are relatively inexpensive to purchase in many developing countries as compared to meat products. Typically, the insects that are most popular to eat are those that can be gathered quickly and in large amounts. Taste is also a factor in selecting insects, as many can be eaten either raw or cooked, while others are used as ingredients to produce other food items, such as being used as an additive to flour. Other cultures around the world have made insects a main ingredient in their diets, providing an excellent source of protein. Insects are an inexpensive substitute for meat in many developing countries. Their nutritional value is equal to if not better than our traditional meat choices. According to the Entomological Society of America, by weight, termites, grasshoppers, caterpillars, weevils, houseflies and spiders are better sources of protein than beef, chicken, pork or lamb. Also, insects are low in cholesterol and low in fat. These insect parts make some food products more nutritious. According to one study, 80% of the world's population eats insects intentionally and 100% eat them unintentionally. Nutritionally, insects are high in protein, fat (and thus energy) and many of the important vitamins and minerals. They have served as traditional foods in most cultures of non-European origin and have played an important role in the history of human nutrition not only in western North America, but also in Africa, Asia and Latin America.

High nutritional value

The insects are also believed to have a higher proportion of protein and fat than beef and fish with a high energy value. Depending on the species, caterpillars are rich in minerals such as potassium, calcium, magnesium, zinc, phosphorus and iron, as well as various vitamins. Research shows that 100 gm of insects provide more than 100% of the daily requirements of the respective minerals and vitamins. Due to their high nutritional value, in some regions, flour made from caterpillars is mixed to prepare pulp given to children to counter malnutrition (Tables 1&2). For those who feel weak and anemic, termites are particularly high in iron while red ants are rich in bone building calcium.

Insects as human food

Tribal people of Phek, Dimapur and Kohima districts of Nagaland, eat grasshoppers, cricket, red ant, and larvae of mulberry silkworms. They also eat green colour larvae available in gold mohar in the month of March-April. Grasshoppers are easily available in the month of August and September in the local market nearby Dimapur and Kohima. Roasting are frequently used methods of cooking, after removing the wings and legs of grasshoppers and crickets. Grasshoppers are usually collected after the harvest of paddy, especially at night. The wings and stomach of the insect are removed, washed with clean water and then tried in vegetable oil with the ingredients like ginger, garlic, chilly, salt, onion, fermented bamboo shoot, etc. Water is usually not added and it is cooked dry. It can be collected from field and also can be purchased from market. Some people are allergic to grasshopper. Almost all the people in the village have followed this practice since time immemorial. Tribal People of Kandhamal, Koraput, Sundergarh, Keonjhar and Mayurbhanj

Table 1 — Nutritive value of different insects

Insect	Protein (g m)	Fat (g m)	Carbohydrate (g m)	Calcium (mg)	Iron (mg)
Giant water beetle	19.8	8.3	2.1	43.5	13.6
Red ant	13.9	3.5	2.9	47.8	5.7
Silk worm pupae	9.6	5.6	2.3	41.7	1.8
Meal worms	20.27	12.72	N/A	13.3	N/A
Wax worms	15.50	22.19	N/A	28.3	N/A
Super worms	17.41	17.89	N/A	12.4	N/A
Fly larvae	15.58	7.81	N/A	87.4	N/A
Dung beetle	17.2	4.3	2.0	30.9	7.7
Cricket	21.32	6.01	5.1	75.8	9.5
Small grasshopper	20.6	6.1	3.9	35.2	5.0
Large grasshopper	14.3	3.3	2.2	27.5	3.0
June beetle	13.4	1.4	2.9	22.6	6.0
Caterpillar	6.7	N/A	N/A	N/A	13.1
Termite	14.2	N/A	N/A	N/A	35.5
Weevil	6.7	N/A	N/A	N/A	13.1

N/A = Not Analyzed; Source: *The Food Insects Newslett*, 1996, 9 (2)

Table 2 — Nutritional content of edible insects and other animals

Name of edible insects and other animals	Based on a 100 gm serving					
	Energy (Kcal)	Protein (gm)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)
Termite (<i>Macrotermes subhyalinus</i>)	613	14.2	0.75	0.13	1.15	0.95
Caterpillar (<i>Usata terpsichore</i>)	370	28.2	35.5	3.67	1.91	5.2
Weevil (<i>Rhynchophorus</i>)	562	6.7	13.1	3.02	2.24	7.8

<i>phoenicis</i>)						
Beef (<i>Lean ground</i>)	219	27.4	3.5	0.09	0.23	6.0
Fish (<i>Broiled cod</i>)	170	28.5	1.0	0.08	0.11	3.0

Source: Ohio State University *Extension Fact Sheet Entomology* (1991)

districts of Orissa, eat red ant, and termite. Roasting are frequently used methods of cooking. They eat roasted insects as snacks or with rice. Termites were collected at the time of swarming, while red ants were collected as and when required from the plants where nest of ant were found. The villagers of Pithra village of Simdega district of Jharkhand as an ethnic food eat eggs of *Demta*, a red ant found on the trees. These ants fold the leaf of tree and reside inside. They lay eggs also in the curled leaf. These eggs are collected from the trees and fried with salt, chilly, spices and mustard oil and taken as food.

The Mono Indians derive a fruitful source of subsistence from small fly *Hydropyrus hians* pupae. By drying them in the sun and mixing them with acorns, berries, grass-seeds, and other articles of food gathered up in the mountains, they make a conglomerate called *cuchaba*, which they use as a kind of bread. It is very nutritious and not at all unpalatable. The worms are also eaten in their natural condition. It is considered a delicacy to fry them in their own grease. The Mormon cricket, *Anabrus simplex*, was another important insect food of the Indians, all over the West. Crickets were used to make bread that was very dark in colour. They were dried, ground on the same mill used to grind pine nuts or grass seed, making fine flour that will keep a long time, if kept dry. The crickets make the bread good, the same as sugar used by the white woman in her cakes. In several localities, pandora moth caterpillars *Coloradia pandora* are still harvested by elderly *paiute*, called *piuga* by the Indians. They sometimes occurred in great numbers and were collected in trenches dug around the bases of Jeffery pine trees. They were eaten after roasting, by mixing them with hot sand. *Piuga* is regarded by the *paiute* as a tasty, nutritious food that is especially good for sick people, much like our chicken soup. An ant of genus *Formica*, with a full load of sweet honeydew in its crop tastes extremely acidic. The pupae on the other hand, do not have this acid flavour and are, quite tasty. The best time to go pupae collecting is one hour after the sun has hit the mound in the morning. The pupae can be collected just under the surface of the mound at this time.

In Mexico, an ant (*Atta cephalotes*), is consumed in the rainy season, when there is wing females, these ants have 42% of protein. In the Mexican states of Oaxaca, Guerrero, Morelos and Veracruz, the people frequently cook a *salsa*, which has as main condiment crushed *jumiles* stinkbugs. These bugs have an aromatic and deep flavor like a mint or cinnamon. Also these bugs are eaten lives with the traditional *tacos*. Certain kinds of ant pupae, known as *escamoles*, are found on the menu in the finest restaurants. They are served fried with butter, or fried with onions and garlic. The famous Mexican caviar or *ahuahutle*, is composed of the eggs of several species of aquatic Hemiptera; these have formed the basis for aquatic farming in Mexico for centuries. In Mexico, grasshoppers are a popular food source especially when fried prior to eating. Near the Ecuador's capital, Quito, there is a small town called, Cotacollao where people cook the white beetles *Cyclocephala*. They cook it with some pork meat and some vegetables. Some people in the Amazonian region eat the Cerambycid's larvae and Cicadas. There are some kinds of ants edible here. One is the lemon ant, that most of the people eat alive. Another delicious ant is the *Hormiga Culona*, a big ant that is eaten fried. In Australia, *Oecophylla* are eaten as bush food. Australia is the home to many large colonies of termites, some of which have termites as long as three inches in length, Australians favour these insects and prefer to fry them prior to eating. One species of ant *Melophorus inflatus*, has an abdomen that distends with honey. The abdomen can be broken off and savored to pacify the urge to sweets. The Australian aborigines also ate the witchety grub, a moth larva that is reputed to taste like almonds.

In parts of Africa, ants, termites, beetle grubs, caterpillars, many species of moths, a few species of butterflies and grasshoppers are eaten. Moth larvae are collected and roasted, and may often be bought in the markets. Some insects such as termites are eaten raw soon after catching, while grasshoppers, caterpillars, and young beetles are fried and ants are eaten either raw or ground-up into a paste. Locusts are typically boiled and salted prior to eating. They are a particularly important source of nutrition (protein, fat, vitamins and minerals) in Africa. In one country alone, Congo (Kinshaza) (formerly Zaire), more than 30 species are harvested. Some caterpillars are sold not only in the local village markets, but are shipped by the tons from one country to another. There are even processing plants where caterpillars are canned in Botswana and South Africa. In the rural countryside, they are usually dried in the sun before being sold in the market. The larvae of Mopone Emperor Moth have turned to the status of *Cash crop* with an annual production of 2,000 tonnes in Southern Africa. Termites are most widely used as food in Africa. They are highly attracted to lights, even candlelight, and that is one way they are captured for use as food. The wings are broken off, and, fried. The queens are considered a special treat and are often reserved for children or grandparents. In Irian Java (Indonesia), the *Ekagi* people regularly eat large species of Cicada. Edible insects, like caterpillars and grubs, are important sources of protein. Caterpillars are an important food intake for many in central Africa. Edible insects from forests are an important source of protein, and unlike those from agricultural land, they are free of pesticides. Most people in tropical Africa, who are no longer dependent on wild foods, collect insects for food. The habit is especially well developed among the cultivators of the forest region whose normal diet is deficient in protein. The species utilized are those that are locally or seasonally abundant. Examples are locusts and termites, which at times can be extremely abundant. The larger species of termites *Macrotermes bellicosus*, *M. falciger*, and *M. subhyalinus*, are much favoured as food, in many areas of East Africa. Lake fly *Chaoborus* adults are used for making cakes and eaten as an important source of protein in Uganda. Honeybee larvae are also collected as food in Uganda. In eastern Uganda, winged termites are induced to emerge by beating the nearby ground with sticks. Drumming was observed to induce termite emergence near Namwnda in Bulmogi county of Busoga. The termites are eaten raw or lightly fried in their own fat. The locust species that are specially injurious to crops in tropical Africa (presumably including Uganda) are esteemed as food by many people. The species are the migratory locust, *Locusta migratoria*; the red locust, *Cyrtacanthacris septemfasciata*; and the desert locust, *Schistocerca gregaria*. They are usually fried but maybe pounded up and added to sauces. They resemble shrimps in flavour. *Brachytrupes membranaceus*, a large, fat cricket which is destructive to root crops, is regarded as a particular delicacy and is collected by digging them up from their burrows in the ground. Gryllotalpidae (mole crickets) *Gryllotalpa africana* Palisot, adult is kept for its chirping and as food.

All over Asia, the giant water bug gathered by farmers at night near water sources is roasted whole and eaten as a delicacy. The giant water bug roasted and eaten whole is a favourite food in Asia. It is easily collected around lights at night around bodies of water. In the Philippines, many insects including ants, beetles, crickets, grasshoppers, katydids, locusts, and larvae from the dragonfly are fried or boiled prior to eating. They can be fried, broiled or sauteed with vegetables. Workers in Chinese silk factories, after boiling the silk moth cocoons to remove the silk for further processing, take the pupae for dinner. Columbian citizens enjoy eating a variety of insects such as termites, palm grubs and ants. Ants are ground up and used as a spread on breads. Insects are often cooked prior to eating or are used as ingredients in recipes. It is ant's larvae and/or pupae that are usually eaten. Roasted leafcutter ant abdomens are sold, instead of popcorn, in movie theaters in Colombia, South America. In some cultures, bee nests are collected as much for their bee grubs as for the honey. They are considered a great delicacy. Larvae, pupae and/or adults of many beetles are used as food. Obviously, people would not eat adult beetles whole. The hard parts (wings, legs and head) are removed during preparation for cooking. Walking sticks and leaf insects are used as food in a few places in Asia and in Papua New Guinea. Sago grubs, the larvae of a wood-boring beetle, are considered a delicacy in Papua New Guinea. The islanders boil the larvae or roast them over an open fire to serve as a main meal. Other edible insects eaten in this country include larvae of moths, wasps, butterflies, dragonflies, beetles, adult grasshoppers, cicadas, stick insects, moths and crickets. Meanwhile, in Korea, fried locusts are popular as a food source.

In the United States, certain native American tribes commonly ate insects. Specifically, in the western United States, pupae of the fly known as *Ephvdrarians* were eaten. This food was called, *Koo-tsabe*. Typically, ants, crickets, mealworms, and grasshoppers are most commonly used for food although certain people enjoy eating insect larvae, especially from moths and yellow jackets. The most popular way to eat insects in the United States, however, is to deep fry pieces of them prior to serving. There's a tribe in the Andes of South America, which collects species of dryopoid beetles, dries them, grinds them up, and uses them as a spicy additive for food flavouring. Cicadas are used widely as human food. The nymphs of some species, known as *periodical cicadas*, spend up to 17 yrs underground, where they feed on roots. After 17 yrs they emerge from the soil, climb up a tree trunk or fence post and molt to the adult stage. Periodical cicadas (a complex of six species in the United States) occur as *broods*, which appear above ground only once every several years in any one locality. That is when they are collected as food. They are delicious when fried or roasted to a golden brown. They are eaten regularly in many other countries, especially in Asia, and some are very large. Grasshoppers and crickets and their relatives have played an important role in the history of human nutrition. Roasting and sautéing are frequently used methods of cooking, after first removing the wings and legs. Seasonings such as onion, garlic, cayenne, chili peppers or soy sauce may be added. Candied grasshoppers, known as *inago*, are a favorite cocktail snack in Japan. Bee or wasps *brood* (larvae/ pupae) are also eaten. Canned wasps, wings and all are sold in Japan. In ancient Rome, oak grubs were a delicacy and were purposely fattened on flour.

Economic implications

Thai rural communities like many in Asia and South America know that eating insects provide a valuable source of protein, minerals and vitamins as well as a tasty snack. Crickets and grasshoppers or locusts are a seasonal delicacy while the giant water beetles known as *mangdana* are used in salads. Using the latest canning and pasteurization techniques Insect Inter, has made it possible to ship them worldwide. The insects are fried to make crunchy snacks that go so well with a cold beer. In Mexico, grasshoppers and other edible insects are sold by the pound in village markets and are fried before being eaten. Many are old in cans as fried grasshoppers, chocolate covered ants, etc. Fried grasshoppers are also canned commercially and sold in supermarkets and local grocery stores. High in protein and low in fat, they may be fried or ground into meal and mixed with flour to make tortillas. Tortillas are served with red and white agave worms in many Mexico city restaurants. One species in Asia, the *giant waterbug*, is now exported from Thailand to Asian foodshops in the United States. In the United States, on the menu of some restaurants are interesting dishes such as stir-fried mealworms and caterpillar crunch (a combination of trail mix and fried caterpillars). Ants, crickets, grasshoppers and mealworms are the most common insects used for cooking. *Mopane* (the caterpillars of a moth species) are a huge industry in numerous African countries. Many tons of the caterpillars are harvested, processed, and sold in markets or by the truckload. In addition to raising your own food-insect supply or catching from the wild, there are numerous stores in various American cities that sell frozen insects from Thailand and other countries in SE Asia. There are already cricket farms in America, which raise these and other insects for the pet trade. They turn out tons of insects per week. Ethiopian tribes preserved bugs in salt, as did the Algerians who sold them in their markets.

There is a considerable trade in termites in some areas and that sun-dried termites are found at the right season in the local markets in many East African towns and villages. They are some times transported long distances to markets. The Baganda, who live around the northern shore of Lake Victoria in Uganda use termites and fried grasshoppers as snacks between the main meals. In many Bantu speaking parts of the country, boiled and dried termites are on sale in the markets at some seasons of the year. Cochineal consists of dried bodies of the female insect of *Dactylopius coccus* found in central and South America. The insects are hand picked and dried and about 100,000 to 150,000 insects yield 1kg of raw cochineal. Total World Production is 150–180 tones/year. Peru is the biggest producer accounting for 90%. Cochineal is primarily used as a food colouring and for cosmetics. Large scale production of cochineal emerged especially in Guatemala. Cochineal was already used as a colour by the Aztec and Maya peoples of Central and North America. Cochineal was a commodity of much value, even comparable to gold. Gallnuts of commerce produced on various sp. of oaks and other trees by certain Eurasian Cynipid wasps. It is also called Aleppo, Mecca, Chinese or Turkey galls. Best grades containing more than 50% tannic acid come from Iran, Turkey and Syria. Used in making dyes and medicine. Insect larvae of various kinds are also commonly used as fishing bait. Processed insects for sale as cocktail snacks, etc., are apparently no longer imported into the United States. Several processed insects are commercially available in Japan. The most widely eaten is *inago* (the grasshopper, *Oxya velox* F.), which is preserved by boiling in soysauce. This product appears as a luxury item in supermarkets throughout the country, including Tokyo. There is currently an effort to incorporate several insects that were important in aboriginal diets into the Australian cuisine. In Canada, attempts are under way to apply industrial methods to the production of insects as food. Commercially grown insects available to fanciers (from bait and pet food stores) in the USA and Europe include the cricket, *Acheta domesticus*, the mealworm, *Tenebrio molitor* L. (a beetle grub), and the greater waxmoth larva, *Galleria mellonella* (L.). More than 80 recipes based on these insects and honeybee pupae (*Apis mellifera*) are included in the tastefully executed cookbook.

Source of income

The collection of edible insects is also a good source of income, especially for women, as they require little capital input if gathered by hand. Insects are widely offered in local village markets, while some of the preferred species, such as the Sapelli caterpillars reach urban markets and restaurants. Tran's border trade in edible insects is significant not only within central African countries, but also with Sudan and Nigeria. On a smaller scale, they are even exported to France and Belgium, two countries that according to the study import about 5 tonnes and 3 tonnes, respectively of a dried caterpillar species annually from the Democratic Republic of Congo.

Food defect action levels

The Department of Health and Human Services has set a standard called the Food Defect Action Levels, which are set on the basis of no hazard to health. These levels are set because it is not possible, and never has been possible, to grow in open fields, harvest and process crops that are totally free of natural defects. Defect action levels do not represent an average of the defects that occur in any of the food categories (averages are much lower). They are the limit at or above which FDA will take legal action against the product and remove it from the market. US Food and Drug Administration (FDA) allows a percentage of bugs and/or bug parts in most of our foods. This happens because the FDA recognizes two facts: that those bug parts will do us no harm; and that food manufacturers could not possibly ensure that there are no bug parts at all in our food products.

Conclusion

Scientific validation of bioprospecting has assumed greater significance. Insects have long been a significant dietary factor in many regions of the world and we should further encourage their collection and commercialization, given the benefits to the environment and human health. It is an interesting concept, managing pest insects by developing them into a sought after delicacy. Edible insects are a nutritious source of food therefore; it must be taken into consideration for a world in which human nutrition has been a huge problem. If insects become more widely accepted as a respectable food item, the economic implications are obvious. They would form a whole new class of foods made to order for low-input small-business and small-farm production. 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. And also entomophagy will substitute meat and beef with high nutrition. It is a high time that scientists recognize this fact and begins to build on it.

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