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Traditional insect bioprospecting – As human food and medicine

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The wisdom that indigenous people have regarding bioprospecting is embedded in their belief system and their culture. Food insects play an important role in the new insect focus. 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. 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 traditional healers use Insects as medicine. Chemicals produced by insects against self defense can be used for antibacterial and anticancer drugs. 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 bioprospecting

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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[1,2]. 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[3]. 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[4]. It is agreed that edible insects might help feed the world[5].

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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 be

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[6]. 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[7]**.** When *mopanie* caterpillars (*Gonimbrasia belina* Westwood) were in season, the sale of beef was seriously affected[8].

In general, insects provide a high source of protein and area 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[9].

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[10]**.** Tribal People of Kandhamal, Koraput , Sundergarh , Keonjhar and Mayurbhanj

Table 1 — Nutritive value of different insects

Insect	Protein (gm)	Fat (gm)	Carbohydrate (gm)	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 *(Macrotermes subhyanlinus)*	613	14.2	0.75	0.13	1.15	0.95
Caterpillar *(Usata terpsichore)*	370	28.2	35.5	3.67	1.91	5.2
Weevil *(Rhynchophorus phoenicis)*	562	6.7	13.1	3.02	2.24	7.8
Beef *(Lean ground)*	219	27.4	3.5	0.09	0.23	6.0
Fish *(Broiled cod)*	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[11]**.** 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[12]**.**

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[13]. 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[14]. 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[15]. 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[16].

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[17]. Near the Ecuador's capital, Quito, there is a small town called, Cotocollao 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 Cerambicid'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[18]. 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[19].

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[20]. 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[21]. 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[22]. 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 may be 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[23].

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[24]. 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[24]. Workers in Chinese silk factories, after boiling the silk moth cocoons to remove the silk for further processing, take the pupae for dinner[24]. 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[24]. 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[24].

In the United States, certain native American tribes commonly ate insects. Specifically, in the western United States, pupae of the fly known as *Ephydra hians* 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[25]. 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[26]. 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[27]. 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 know 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[28]. In Mexico, grasshoppers and other edible insects are sold by the pound in village markets and are fried before being eaten. Many are sold 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[29]. One species in Asia, the *giant water bug*, is now exported from Thailand to Asian food shops in the United States[30]. 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[24]. *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[31]. 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[24]. Ethiopian tribes preserved bugs in salt, as did the Algerians who sold them in their markets[24].

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[24]. 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[32]. Gallnuts of commerce produced on various sp. of oaks and other trees by certain Eurasion Cynipid wasps. It is also called Allepo, 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[33]. Insect larvae of various kinds are also commonly used as fishing bait[34]. 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 soy sauce. 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[35].

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[35]. 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.

Insects as medicine

The increasing infestation of Jatropha Leaf Miner *Stomphosistis thraustica* in Jatropha is although a

bad news for the Jatropha growers but it is good news for the traditional healers utilizing the insect particularly the green coloured larva. Traditional healers using this insect as medicinal insect are aware of its presence since decades, in Chhattisgarh. The larvae collected just before the pupation is considered best for the preparation of medicine. After the collection of larvae, it is dried in shade and after drying; it is converted into dry powder and kept for future use. The traditional healers use this powder internally as galactgoggue. The powder is given internally with lukewarm water in order to increase the flow of milk in lactating women. Many healers use the decoction of powder to get more promising effects. The traditional healers of Southern Chhattisgarh use the larvae in treatment of common fever. For the preparation of medicine, they dry the larvae in moonlight and convert it into powder. This powder is taken internally in combination with other herbs mainly *Kalmegh* (*Andrographis paniculata*)[36]. A common practice in North Gujarat is to feed animals, which fail to come into heat with two or three grasshoppers along with *chapatti* (bread) or fodder. It is believed that animal comes into heat within 15 days after this treatment. Single treatment cycle is enough to get the desired result. The grasshopper is locally called *titighodo*. It is generally found during rainy season on cactus (*Euphorbia* sp) and *akada (Calotropis* sp). It has yellow and greenish stripes on the body[37]. Natives of Sambar Village of Chhattisgarh use common agricultural pest *Kambal Keeda* (*Diacrisia oblique*) in case of dog bite. The patients are advised to eat freshly laid minute eggs in order to reduce the effect of dog bite. It is also applied externally in affected parts. It is promising treatment and since generations, they are using it successfully. *Bhavri Keeda*, an aquatic insect, used in other villages of Bagbahera region, in treatment of dog bite[38]. Lumbermen in early Maine ate carpenter ants, supposedly to prevent scurvy[39]. Fly larvae (maggots) were formerly used to treat wounds to prevent or stop gangrene, as they would only consume dead flesh. This treatment is finding modern usage in some hospitals[40]. Chemicals produced by insects against self defense can be used for antibacterial and anticancer drugs. Pierisin, a protein purified from pupa of cabbage butterfly, *Pieris rapae* exhibit cytotoxic effects against human gasteris cancer. Extract of body fluids of other cabbage butterflies, *P. brassicae* and *P. napi* also contains Pierisin[41]. Butterflies produce antibacterial proteins including cecropins, defensins and lysozymes. Cercopin has also been reported to be cytotoxic against mammalian lymphoma and leukemia cells. Butterflies may be a good source of novel bioactive materials such as anti-bacterial, anticancer drug. In India 1,501 species of butterflies are found, has a tremendous potential in butterfly bioprospecting[42].

In Zaire insect have been used for the treatment of various diseases in human beings successfully. Trembling red ant locally known as L.NKAAM used for the treatment of Muyeem (bronchitis). Because of the sticky saliva of the ants, the solution helps the patient recover his normal respiration. The entire ants are used. The healer places the ants in a bowl made of forest leaves; he mixes it with sweet and clear water and gives it to the patient to drink. Duration of treatment is up to one week. These insects also have a common name meaning "child-birth aid" because of the sting they leave on the body of the woman who is in the height of childbirth[43]. Grasshopper locally known as MPAYLAAR in Zaire used for the treatment of violent headaches. The healer crushes the dry grasshoppers and ashes; mixes the ashes of the grasshopper with a little organic salt; makes incisions on the nape and front of the patient and then applies the solution on the incisions. This stings a lot and the patient must sleep a lot. Duration of treatment is at least 3 days[43]. Worker wasp locally known as *Ngankoy* in Zaire strengthens a weak infant. The healer takes the nest of the wasp, crushes it in a glass of water, and has the infant drink it. Also, she rubs it into the skin over the body of the infant. The nest of the worker wasp has a substance, which gives life strength to the weak[43]. Cockroach locally known as *Kembaar* in Zaire cures scabies / mange caused by the animal cockroach. The entire animal is used. Cockroaches are burn, ashes are mixed with palm oil and after each bath it is rubbed on the body until the scabies is cured[43]. Praying mantis locally known as *Kayakua* in Zaire are used for the treatment of epilepsy. The entire animal is used. The healer places the whole mantis in a pot with boiled aromatic leaves, washes the entire body of the patient with this and has him drink it. Duration of treatment: one week[43]. Builder/worker caterpillar locally known as Kenbul Mpiak in Zaire, cures haemorrhage during childbirth or during pregnancy. The healer crushes the nest and the caterpillar, and also crushes the red earth, called

largile nkol. He makes a mix and makes the woman drink it to cure the haemorrhage[43].

Termite locally known as *N'zo Musien* in Zaire used to cure internal haemorrhage. The nest of the termite is used. The specialist removes the bark of the *Muton* (a tree which gives red bark). He puts these in a broken pot and mixes them with the nest of termites. He has the patient drink a little of this solution and places it on the composition. It also heals hemorrhage from a wound. The healer mixes the nest of termites with wild leaves[43]. Glowworm locally known as *Nkwazeb* in Zaire are used for chasing the spirits/boogey-men from an infant when he's having nightmares. The healer takes several glowworms, mixes them with ashes from the cooking fire where the infant resides. He has the victim drink a small quantity, which he has put in a glass of water. The mother rubs this same mixture on the forehead, head, ears and nape of the infant. The ashes signify the invisibility of the infant[43]. Bee, locally known as *Ngobo* in Zaire cures stuttering. The healer places several bees in a *calabasse* (gourd-bowl) of palm wine. He pours a glass of wine, which contains several bees and has the stuttered drink it[43]. Domestic cricket, locally known as *Mpayenzo* in Zaire cures stuttering. The healer takes the domestic cricket and has the stuttered eat it. After eating it he puts his tongue on the opening of a casserole dish. The healer and several assistants insult and mock the patient so that he can definitely abandon stuttering[43]. Butterfly, locally known as *Kenguapob* in Zaire heals illnesses of the ears. The nymph-larvae-worm stage in his cocoon is used. The healer puts the nymph and his cocoon in a cone made with wild leaves. She puts in the aromatic plant *Losaal Nzian (aile de Dieu;* wings of God), adds the cocoon, a hot coal with fire, and blows the smoldering smoke on the ears of the patient. When the heat has touched the ears, the illness will be cured[43]. The fattest caterpillar that hides in the leaves locally known as *Nkukab* in Zaire is used for the treatment of elephantiasis of the arms[43]. Tse-tse fly, locally known as *Kebty* in Zaire is used to avoid the sleeping sickness after having been bitten by the tse-tse fly. Tse-tse fly is crushed and rubbed on the skin, and making an incision is also applied there[43]. Aquatic bee locally known as *Ngundumugun* and *Kender Maza* in Zaire are used to cure exaggerated menstruation. The healer, after fishing for this insect, places it in a pot with a piece of clothing from the woman who's menstruating. He bums these to make ashes. She gives the cinders to the patient who applies them in her reproductive part each time after bathing[43].

Soldier termites locally known as *Mbwiidi* in Zaire are used to revive someone who's fallen into a syncope/blackout/fainting fit. The whole animal is used. The specialist takes the soldier termites and puts them in a container, into which he's already put the sap of tobacco leaves/tobacco juice. The live insects are absorbed into this substance. He places them on the body of the patient, when the termites bite the patient, he will wake up and quickly regain consciousness. The tobacco juice used here signifies the remedy, the substance that will bring the patient to full consciousness. The soldier termites are used like an injection/shot in the arm[43]. Salivating insects, locally known as *Bentiey* in Zaire are used to stop exaggerated salivation. The specialist takes the insects and prepares them by cooking them with the meat of the gourd called *Ntambien*. Very hot, the patient eats the solution. After one week of this meal, the person will no longer salivate excessively[43]. Water bug also called the lion bug locally known as *Kenzi&Nziie* in Zaire is used in insanity, craziness. The patient eats the insects mixed with mud from the same river to calm insanity[43]. Lion-ant, locally known as *Munkuuk* in Zaire is used to relieve and cure a high fever. The lion ant is made to bite the patient[43]. Farmers of Sonarhi and Terhi villages of Banda district of Uttar Pradesh give insects hosted on *babool* tree to their cattle and buffaloes to eat, for getting them into heat. The insect seems to contain excellent type of hormone, which might induce heat in the animals[43,44]. Soil collected from termite hill is made into a paste with warm water and applied to the wounds of sheep and goats for 2 to 3 days for healing of the wounds Makarbilli village of Nawapada district in Orissa[45].

Conclusion

Scientific validation of traditional wisdom in bioprospecting has assumed greater significance. Insects have long been a significant dietary factor and remedies for illnesses 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. It is a high time that scientists recognize this fact and begins to build on it.

References

1 Bodenheimer FS, *Insects as Human Food*, (W Junk, The Hague), 1951, 352.

2 Sutton MQ, Insects as food: aboriginal entomophagy in the Great Basin, Ballena Press Anthropol, Paper No 33, (Ballena Press, Menlo Park, California), 1988, 115.

3 Ivie GW, HoIt DL & Ivey MD, Natural toxic ants in human foods: psoralens in raw and cooked parsnip root, *Science,* 213 (1981) 910.

4 Triplehorn Charles A & Norman F Johnson, *Introduction to the Study of Insects*, 7th edition, (Thomas Brooks/Cole), ISBN 0030968356, 2005,643.

5 Holt Vincent M, Why Not Eat Insects? (EW Classey Ltd, Hampton, Middlesex), 1967, 9.

6 Arnett RH, *American Insects: A Handbook of the Insects of America North of Mexico,* edited by Florence, (Van Nostrand Reinhold, Kentucky), 1985, 465.

7 Ruddle K, The human use of insects: examples from the Yukpa, *Biotropica*, 5 (1973) 94-101.

8 Quin PJ, *Foods and Feeding Habits of the Pedi,* (Witwatersrand Univ Press, Johannesburg), 1959, 428.

9 Ramos Elorduy J, Insects: a sustainable source of food?, edited by MG Paoletti, SG F Bukkens, Special Issue: Mini livestock, *Ecol Food Nutr,* 36 (2-4) (1997) 247-276.

10 Jishing Aloli, *Inventory of indigenous Technical Knowledge in Agriculture,* Document *2,* edited by Das P, Das SK, Mishra A, Arya HPS, Bujarbaruah KM, Singh RP, Verma LR, Subba Reddy G, Geetha Rani, Gupta HS, Kavia ZD & Ray DP, (Mission Unit, Division of Agricultural Extension, Indian Council of Agricultural Research, New Delhi, Published by Director, DIPA, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi), 2003, 623.

11 Verma LR, *Inventory of indigenous Technical Knowledge in Agriculture,* Document *2,* edited by Das P, Das SK, Mishra A, Arya HPS, Bujarbaruah KM, Singh RP, Verma LR, Subba Reddy G, Geetha Rani, Gupta HS, Kavia ZD & Ray DP, (Mission Unit, Division of Agricultural Extension, Indian Council of Agricultural Research, New Delhi, Published by Director, DIPA, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi), 2003, 542.

12 Pradhan Matu, *Inventory of indigenous Technical Knowledge in Agriculture,* Document *2,* edited by Das P, Das SK, Mishra A, Arya HPS, Bujarbaruah KM, Singh RP, Verma LR, Subba Reddy G, Geetha Rani, Gupta HS, Kavia ZD & Ray DP, (Mission Unit, Division of Agricultural Extension, Indian Council of Agricultural Research, New Delhi, Published by Director, DIPA, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi), 2003,625.

13 Gene De Foliart, Some insect foods of the American Indians: and how the early whites reacted to them, *Food Insects Newslett,* 7 (3) (1994) 1-2 &10-11.

14 Gottfredson P, From the Gottfredson Family History, Ms on file, Utah State Hist Soc, Salt Lake City, *J Perter Gottfredson*, 1874, 15-16.

15 Blake EA & Wagner MR, Collection and consumption of *pandora* moth, *Coloradia pandora lindseyi* (Lepidoptera: Saturniidae) larvae by Owens Valley and Mono Lake Paiutes, *Bull Entomol Soc Am,* 33 (1987) 23-27.

16 Essig EO, The value of insects to the California Indians, *Sci Mthly,* 38,1934, 181-186.

17 Ritter KS, Cholesterol and insects, *Food Insects Newslett*, 3 (1) (1990) 5.

18 Dufour DL, Insects as food, A case study from the northwest Amazon, *Am Anthropologist*, 89 (1987) 383-397.

19 Cherry RH, Use of insects by Australian Aborigines, *Am Entomologist*, 37 (1991) 13.

20 Scholtz CH & Holm E, *Insects of Southern Africa,* (Butterworths, Durban), 1985, 534.

21 Osmaston HA, The termite and its uses for food, *Uganda J* (Kampala), 15 (1951) 83.

22 Owen DF, Man's Environmental Predicament, An introduction to human ecology in tropical Africa, (Oxford Univ Press, London), 1973, 136.

23 Fladung EB, Insects as Food, *Maryland Acad Sci Bull*, Oct, 1924, 8.

24 Anonymous, Ohio State University, *Extension Fact Sheet Entomology,* 1991, Kenny Road, Columbus, OH 43210-1000 Insects as Human Food (Micro-livestock) HYG-2160-96 edited by,William F, Lyon (http:// ohioline.osu.edu/ hyg-fact/ 2000/ 2160.html).

25 Triplehorn Charles A & Norman F Johnson, *Introduction to the Study of Insects*, 7th edition, (Thomas Brooks,Cole) ISBN 0030968356, 2005,643.

26 Website: biology.clc.uc.edu/ steincarter/ cicadas.htmand http:// www.foodinsects.com/ edible%20species.htm

27 Pemberton RW & Yamasaki T, Insects: Old food in new Japan, *Am Entomologist,* 41 (1995) 229.

28 Website: http://www.thaitastes.com/index.php.

29 Sahagun FB de, Original Codex, 1557, Biblioteca Nacional de Mexico, Mexico, DF* (Introduction).

30 Pemberton RW, The use of the Thai giant waterbug, *Lethocerus indicus* (Hemiptera: Belostomatidae) as human food in California, *Pan-Pacif Entomol*, 64 (1988) 81-82.

31 Dreyer JJo & Wehmeyer AS, On the nutritive value of mopanie worms, *South Afr J Sci,* 78 (1982) 33-35.

32 Website: http://www.food-info.net/uk/colour/cochineal.htm.

33 Website: http://www.itmonline.org/arts/gallnuts.htm.

34 Website: http:// www. hobbyandlifestyle.com/ fishing-bait.html.

35 Fasoranti JO & Ajiboye DO, Some edible insects of Kwara State, Nigeria, *Am Entomologist,* 39 (2) (1993) 116.

36 Website:http://botanical.com/site/column_poudhia/publish/journal.cgi?folder=journal&next=800.

37 Patel SN & Patel IK, Inducing animal into heat feeding grasshoppers, *Honey bee,* 6 (3) (1995) 14.

38 Website:http://botanical.com/site/column_poudhia/83_mites.html.

39 Website: http://www.slshrimp.com/Data/Facts.html
40 Website:http://www.riverdeep.net/current/2002/03/030402_bugmedicine.jhtml
41 Website: http:// sciencelinks.jp/ j-east/ journal/ S/ G0184A/ 2003.php
42 Website: http://lib.bioinfo.pl/meid:186381
43 Tango Muyay, *Les Insectes CommeAliments de LHomme*, Published in 1981, reviewed in *Food Insects Newslett*, 7 (3) (1994) 3-4.
44 Singh Sanjay K, *Inventory of Indigenous Technical Knowledge in Agriculture,* Document *2,* edited by Das P, Das SK, Mishra A, Arya HPS, Bujarbaruah KM, Singh RP, Verma LR, Subba Reddy G, Geetha Rani, Gupta HS, Kavia ZD & Ray DP, (Mission Unit, Division of Agricultural Extension, Indian Council of Agricultural Research, New Delhi, Published by Director, DIPA, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi), 2003, 324.
45 Behera Bhanumati, *Inventory of indigenous Technical Knowledge in Agriculture,* Document *2,* edited by Das P, Das SK, Mishra A, Arya HPS, Bujarbaruah KM, Singh RP, Verma LR, Subba Reddy G, Geetha Rani, Gupta HS, Kavia ZD & Ray DP, (Mission Unit, Division of Agricultural Extension, Indian Council of Agricultural Research, New Delhi, Published by Director, DIPA, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi), 2003, 405.