Entomophagy

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Entomophagy (/ˌɛntəˈmɒfədʒi/, from Greek ἔντομον *éntomon*, "insect", and φᾰ́γειν *phagein*, "to eat") is the human use of **insects as food**. The eggs, larvae, pupae, and adults of certain insects have been eaten by humans from prehistoric times to the present day.[1]

Deep-fried insects on sale at a food stall in Bangkok, Thailand

Human insect-eating is common to cultures in most parts of the world, including North, Central, and South America; and Africa, Asia, Australia, and New Zealand. Over 1,000 species of insects are known to be eaten in 80% of the world's nations.[2] The total number of ethnic groups recorded to practice entomophagy is around 3,000.[3] However, in some societies insect-eating is uncommon or even taboo.[4][5][6][7][8] Today insect eating is rare in the developed world, but insects remain a popular food in many regions of Latin America, Africa, Asia, and Oceania. Some companies are trying to introduce insects into Western diets.[9] FAO has registered some 1900 edible insect species and estimates there were in 2005 some 2 billion insect consumers worldwide. They also suggest entomophagy should be considered as a solution to environmental pollution.[10]

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Definition

Entomophagy is sometimes defined broadly to cover the eating of arthropods other than insects, including arachnids and myriapods.[11] Insects and arachnids eaten around the world include crickets, cicadas, grasshoppers, ants, various beetle grubs (such as mealworms), the larvae of the darkling beetle or rhinoceros beetle,[12] various species of caterpillar (such as bamboo worms, mopani worms, silkworms and waxworms), scorpions and tarantulas. There are over 1,900 known species of arthropods that are edible to humans.[13]


Mealworms presented in a bowl for human consumption

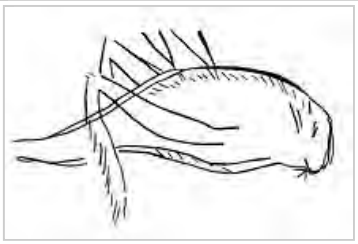
Recent assessments of the potential of large-scale entomophagy have led some experts to suggest entomophagy as a potential alternative protein source to animal livestock, citing possible benefits including greater efficiency, lower resource use, increased food security, and environmental and economic sustainability.[14][15][16][17]

In non-humans

Insects,[18] nematodes[19] and fungi[20] that obtain their nutrition from insects are sometimes termed entomophagous, especially in the context of biological control applications. These may also be more specifically classified into predators, parasites or parasitoids, while viruses, bacteria and fungi that grow on or inside insects may also be termed "entomopathogenic" (see also entomopathogenic fungi).

History

Before humans had tools to hunt or farm, insects may have represented an important part of their diet. Evidence has been found analyzing coprolites from caves in the US and Mexico. Coprolites in caves in the Ozark Mountains were found to contain ants, beetle larvae, lice, ticks, and mites.[22] Evidence suggests that evolutionary precursors of *Homo sapiens* were also entomophagous. Insectivory also features to various degrees amongst extant primates, such as marmosets and tamarins,[23] and some researchers suggest that the earliest primates were nocturnal, arboreal insectivores.[4] Similarly, most extant apes are insectivorous to some degree.[24][25][26]


Carving of Cave grasshopper on animal bone discovered in the Magdalenian grotto of Les Trois Frères indicates a possible link with food magic.[21]

Cave paintings in Altamira, north Spain, dated from about 30,000 to 9,000 BC, depict the collection of edible insects and wild bee nests, suggesting a possibly entomophagous society.[22] Cocoons of wild silkworm (*Theophilia religiosae*) were found in ruins in the Shanxi province of China, from 2,000 to 2,500 years BC. The cocoons were discovered with large holes, suggesting the pupae were eaten.[22] Many ancient entomophagy practices have changed little over time compared with other agricultural practices, leading to the development of modern traditional entomophagy.[22]

Uses

Entomophagy can be divided into two categories: insects used as a source of nutrients and insects as condiments.[27] Some insects are eaten as larvae or pupae, others as adults.


Lollipop with ants

Traditional cultures

There are a large number of cultures that embrace the eating of insects. The species include 235 butterflies and moths, 344 beetles, 313 ants, bees and wasps, 239 grasshoppers, crickets and cockroaches, 39 termites, and 20 dragonflies. Other commonly eaten insects are termites, cicadas and dragonflies.[28] Insects are known to be eaten in 80% of the world's nations.[2] The leafcutter ant *Atta laevigata* is traditionally eaten in some regions of Colombia and northeast Brazil. In southern Africa, the widespread moth *Gonimbrasia*

belina's large caterpillar, the *mopani* or *mopane worm*, is a source of food protein. In Australia, the witchetty grub is eaten by the indigenous population. The grubs of *Hypoderma tarandi*, a reindeer parasite, were part of the traditional diet of the Nunamiut people.[29]

Use of insects as an ingredient in traditional foodstuffs in places such as Hidalgo in Mexico has been on a large enough scale to cause their populations to decline.[30]

Western culture

Eating insects has not been adopted in the West, despite attempts to introduce insect based food in Western markets. The most likely early adopters of insects as a meat substitute in Western societies have been profiled as younger males with a weak attachment to meat, who are open to trying novel foods and interested in the environmental impact of their food choice.[31]

Market introduction of insects foods is usually done by small companies, often startups. A few companies have introduced products made using insects, whole or processed into food products. Whole insects as snacks (Jimini's in France) or as novelties (HotLix lollipops in the US) are examples.

In France, the first online shop for edible insects and products with edible insects came online in 2009.[32] They have been offered edible insects from Thailand, Africa and Europe especially as appetizer, a ready-to-cook range but also home made candies and gluten-free protein bars with bugs. In 2011, Micronutris created the first French farm to raise insects. They grow mealworms and crickets in the South of France at Toulouse and craft fine products with them.[33] In 2013, edible insects ready to cook are back with the first recipe book in France, *Délicieux ! 60 recettes à base d'insectes*.[34] The first North American edible insect online marketplace opened in 2015; and distributes products from entomophagy companies from the US, Mexico, Europe and Thailand.[35]

Crickets

The most common insect integrated into food is the Cricket, usually dried and milled into a powder usually called cricket flour. There are now several companies in the US farming crickets or producing cricket flour, including Tiny Farms, All Things Bugs, Aspire. The flour is then used in protein bars, baked goods and other products.[36][37] In Canada, there is Entomo Farms (former Next Millennium Farms), dedicated to farming insects specifically for human consumption in North America and producing cricket flour.[38] The first company to use cricket powder was Chapul,[39] which launched a project on Kickstarter on 12 July 2012, to make a protein bar with the cricket powder[40] and followed up with a successful appearance on ABC's *Shark Tank*, partnering with Mark Cuban. Another startup is Exo, which successfully used Kickstarter in 2013 to fund an initial batch of protein bars made with cricket powder.[41] The bars are now available for sale online.[42] Another startup named Bugsolutely produces Cricket Pasta, a fusilli pasta made with 80% wheat flour and 20% cricket flour, made in Thailand for western markets.[43] Company in New Zealand 'Crawlers' were the first (est 2013) to start supplying a huge range of edible insects in New Zealand through their online store and through various restaurants.

Bee brood

Bee brood (pupae and larvae) although low in calcium, has been found to be high in protein and carbohydrate, and a useful source of phosphorus, magnesium, potassium, and trace minerals iron, zinc, copper, and selenium. In addition, while bee brood was high in fat, it contained no fat soluble vitamins (such as A, D, and E) but it was a good source of most of the water-soluble B-vitamins including choline as well as vitamin C. The fat was composed mostly of saturated and monounsaturated fatty acids with 2.0% being polyunsaturated fatty acids[44][45]

Restaurants

There are also restaurants that serve insects to the public on a regular basis. For example, two places in Vancouver, British Columbia, Canada, offer cricket-based items. Vij's Restaurant has parathas that are made from roasted crickets that are ground into a powder or meal.[46][47][48][49] Its sister restaurant, Rangoli Restaurant, offers pizza that was made by sprinkling whole roasted crickets on naan dough.[48][49][50][51][52]

Reality television

Entomophagy has been featured on some reality television shows, such as *Fear Factor*.[53] Barrington Hall, a former student cooperative at U.C. Berkeley held an annual insect banquet for many years until the co-op was closed down in 1990. The New York Entomological Society held a Centennial Banquet on Wednesday, 20 May 1992 at the Explorers Club in New York. The theme for the evening banquet was the use of insects as food. Appetizers and desserts featured insects in their preparations.[54][55] The Explorers Club itself holds an annual dinner at New York's Waldorf-Astoria Hotel featuring a wide array of unusual dishes including many featuring insects.[56] Theme park operator Six Flags Inc, based in New York, staged a contest as part of a promotion leading up to Halloween in which it also offered customers free entry or line-jumping advantages if they ate a live Madagascar hissing cockroach; the People for the Ethical Treatment of Animals (PETA) opposed the overall promotion. "Insects do not deserve to be eaten alive especially for a gratuitous marketing gimmick," PETA spokeswoman Jackie Vergerio told Reuters.[57][58]

Advantages

Food security

Insects as food and feed emerge as an especially relevant issue in the twenty-first century due to the rising cost of animal protein, food and feed insecurity, environmental pressures, population growth and increasing demand for protein among the middle classes.[59] At the 2013 International Conference on Forests for Food Security and Nutrition,[60] the Food and Agriculture Organization of the United Nations released a publication titled "Edible insects - Future prospects for food and feed security" describing the contribution of insects to food security.[59] It shows the many traditional and potential new uses of insects for direct human consumption and the opportunities for and constraints to farming them for food and feed. It examines the body of research on issues such as insect nutrition and food safety, the use of insects as animal feed, and the processing and preservation of insects and their products.

Minilivestock

The intentional cultivation of insects and edible arthropods for human food, referred to as minilivestock, is now emerging in animal husbandry as an ecologically sound concept. Several analyses have found entomophagy to be a more environmentally friendly alternative to traditional animal livestocking.[14][61]

Fried silk worm pupae sold by a street vendor in Jinan, China, one with a bite taken out of it

Edible insects have long been used by ethnic groups in Asia,[62][63][64][65][66][67] Africa, Mexico and South America as cheap and sustainable sources of protein, and the major role of entomophagy in human food security is well-documented.[16] Up to 2,086 species are eaten by 3,071 ethnic groups in 130 countries.[68] While more attention is needed to fully assess the potential of edible insects, they provide a natural source of essential carbohydrates, proteins, fats, minerals and vitamins and offer an opportunity to bridge the gap in protein consumption between poor and wealthy nations but also to lessen the Ecological footprint.[16] Many insects contain abundant stores of lysine, an amino acid deficient in the diets of many people who depend heavily on grain.[69] Some argue that the combination of increasing land use pressure, climate change, and food grain shortages due to the use of corn as a biofuel feedstock will cause serious challenges for attempts to meet future protein demand.[15]

In Thailand, two types of edible insects (cricket and palm weevil larvae) are commonly farmed in the north and south respectively.[70] Cricket-farming approaches throughout the northeast are similar and breeding techniques have not changed much since the technology was introduced 15 years ago. Small-scale cricket farming, involving a small number of breeding tanks, is rarely found today and most of the farms are medium- or large-scale enterprises. Community cooperatives of cricket farmers have been established to disseminate information on technical farming, marketing and business issues, particularly in northeastern and northern Thailand. Cricket farming has developed into a significant animal husbandry sector and is the main source of income for a number of farmers. In 2013, there are approximately 20 000 farms operating 217 529 rearing pens.[70] Total production over the last six years (1996-2011) has averaged around 7 500 tonnes per year.

In the Western world, agricultural technology companies such as Tiny Farms[71] have been founded with the aim of modernizing insect rearing techniques, permitting the scale and efficiency gains required for insects to displace other animal proteins in the human food supply. The first domestic insect farm, LIVIN Farms Hive, has recently been successfully Kickstarted and will allow for the production of 200-500g of mealworm per week, a step toward a more distributed domestic production system.

Therapeutic foods

In 2012, Dr. Aaron T. Dossey announced that his company, All Things Bugs, had been named a Grand Challenges Explorations winner by the Bill & Melinda Gates Foundation.[72] Grand Challenges Explorations provides funding to individuals with ideas for new approaches to public health and development. The research project is titled "Good Bugs: Sustainable Food for Malnutrition in Children".[72] Director of pediatric nutrition at the University of Alabama at Birmingham Frank Franklin has argued that since low calories and low protein are the main causes of death for approximately 5 million children annually, insect protein formulated into a ready-to-use therapeutic food similar to Nutriset's Plumpy'Nut could have potential as a relatively inexpensive solution to malnutrition.[73] In 2009, Dr. Vercruysse from Ghent University in Belgium has proposed that insect protein can be used to generate hydrolysates, exerting both ACE inhibitory and antioxidant activity, which might be incorporated as multifunctional ingredient into functional foods. Additionally, edible insects can provide a good source of unsaturated fats, thereby helping to reduce coronary disease.[3]

Indigenous cultivation

Edible insects can provide economic, nutritional, and ecological advantages to the indigenous populations that commonly raise them.[74] For instance, the mopane worm of South Africa provides a "flagship taxon" for the conservation of mopane woodlands. Some researchers have argued that edible insects provide a unique opportunity for insect conservation by combining issues of food security and forest conservation through a solution which includes appropriate habitat management and recognition of local traditional knowledge and enterprises.[74] However, senior FAO forestry officer Patrick Durst claims that "Among forest managers, there is very little knowledge or appreciation of the potential for managing and harvesting insects sustainably. On the other hand, traditional forest-dwellers and forest-dependent people often possess remarkable knowledge of the insects and their management."[75]

Similarly, Julieta Ramos-Elorduy has stated that rural populations, who primarily "search, gather, fix, commercialize and store this important natural resource", do not exterminate the species which are valuable to their lives and livelihoods.[68] According to the FAO, many experts see income opportunities for rural people involved in cultivation. However, adapting food technology and safety standards to insect-based foods would enhance these prospects by providing a clear legal foundation for insect-based foods.[75]

Pest harvesting

Some researchers have proposed entomophagy as a solution to policy incoherence created by traditional agriculture, by which conditions are created which favor a few insect species, which then multiply and are termed "pests".[15] In parts of Mexico, the grasshopper *Sphenarium purpurascens* is controlled by its capture and use as food. Such strategies allow decreased use of pesticide and create a source of income for farmers totaling nearly $3000 per family. Some argue that pesticide use is economically inefficient due to its destruction of insects which may contain up to 75 percent animal protein in order to save crops containing no more than 14 percent protein.[15]

Environmental benefits

The methods of matter assimilation and nutrient transport used by insects make insect cultivation a more efficient method of converting plant material into biomass than rearing traditional livestock. More than 10 times more plant material is needed to produce one kilogram of meat than one kilogram of insect biomass.[15] The spatial usage and water requirements are only a fraction of that required to produce the same mass of food with cattle farming. Production of 150g of grasshopper meat requires very little water, while cattle requires 3290 liters to produce the same amount of beef.[76] This indicates that lower natural resource use and ecosystem strain could be expected from insects at all levels of the supply chain.[15] Edible insects also display exponentially faster growth and breeding cycles than traditional livestock. An analysis of the carbon intensity of five edible insect species conducted at the University of Wageningen, Netherlands found that "the average daily gain (ADG) of the five insect species studied was 4.0-19.6 percent, the minimum value of this range being close to the 3.2% reported for pigs, whereas the maximum value was 6 times higher. Compared to cattle (0.3%), insect ADG values were much higher." Additionally, all insect species studied produced much lower amounts of ammonia than conventional livestock, though further research is needed to determine the long-term impact. The authors conclude that insects could serve as a more environmentally friendly source of dietary protein.[77]

Economic benefits

Insects generally have a higher food conversion efficiency than more traditional meats, measured as efficiency of conversion of ingested food, or ECI.[78] While many insects can have an energy input to protein output ratio of around 4:1, raised livestock has a ratio closer to 54:1.[79] This is partially due to the fact that feed first needs to be grown for most traditional livestock. Additionally endothermic (warm-blooded) vertebrates need to use a significantly greater amount of energy just to stay warm whereas ectothermic (cold blooded) plants or insects do not.[76] An index which can be used as a measure is the Efficiency of conversion of ingested food to body substance: for example, only 10% of ingested food is converted to body substance by beef cattle, versus 19–31% by silkworms and 44% by German cockroaches. Studies concerning the house cricket (*Acheta domesticus*) provide further evidence for the efficiency of insects as a food source. When reared at 30 °C or more and fed a diet of equal quality to the diet used to rear conventional livestock, crickets showed a food conversion twice as efficient as pigs and broiler chicks, four times that of sheep, and six times higher than steers (oxen) when losses in carcass trim and dressing percentage are counted.[22]

Insects reproduce at a faster rate than beef animals. A female cricket can lay from 1,200 to 1,500 eggs in three to four weeks, while for beef the ratio is four breeding animals for each market animal produced. This gives house crickets a true food conversion efficiency almost 20 times higher than beef.[22]

Mexican *chapulines*

Nutritional benefits

Insect protein contains a useful level of essential amino acids, comparable with protein from soybeans, though less than in casein (found in foods such as cheese).[80]

Impacts of animal agriculture

According to the United Nations Food and Agriculture Organization (FAO), animal agriculture makes a "very substantial contribution" to climate change, air pollution, land, soil and water degradation, land use concerns, deforestation and the reduction of biodiversity.[81] The high growth and intensity of animal agriculture has caused ecological damage worldwide; with meat production predicted to double from now to 2050, maintaining the status quo's environmental impact would demand a 50 percent reduction of impacts per unit of output. As the FAO states, animal livestock "emerges as one of the top two or three most significant contributors to the most serious environmental problems, at every scale from local to global."[81] Some researchers argue that establishing sustainable production systems will depend upon a large-scale replacement of traditional livestock with edible insects; such a shift would require a major change in Western perceptions of edible insects, pressure to conserve remaining habitats, and an economic push for food systems that incorporate insects into the supply chain.[17]

Greenhouse gas emission

In total, the emissions of the livestock sector account for 18 percent of total anthropogenic greenhouse gas emissions,[14] a greater share than the transportation sector.[81] Using the ratio between body growth realized and carbon production as an indicator of environmental impact, conventional agriculture practices entail substantial negative impacts as compared to entomophagy.[14] The University of Wageningen analysis found that the CO2 production per kilogram of mass gain for the five insect species studied was 39-129% that of pigs and 12-54% that of cattle. This finding corroborates existing literature on the higher feed conversion efficiency of insects as compared to mammalian livestock. For four of the five species studied, GHG emission was "much lower than documented for pigs when expressed per kg of mass gain and only around 1% of the GHG emission for ruminants."[14]

Land use

Animal livestock is the largest anthropogenic user of land.[81] 26 percent of the Earth's ice-free terrestrial surface is occupied by grazing, while feedcrop production amounts to 33 percent of total arable land. Livestock production accounts for 70 percent of all agricultural land and 30 percent of the planet's surface. According to the Food and Agriculture Organization, livestock activity such as overgrazing, erosion, and soil compaction, has been the primary cause of the degradation of 20 percent of the world's pastures and rangeland.[81] Animal livestock is responsible for 64 percent of man-made ammonia emissions, which contribute significantly to acid rain.[81] By extension, animal waste contributes to environmental pollution through nitrification and acidification of soil.[14]

Water pollution

According to the Food and Agriculture Organization, 64 percent of the world's population is expected to live in water-stressed basins by 2025. A reassessment of human usage and treatment of water resources will likely become necessary in order to meet growing population needs.[81] The FAO argues that the livestock sector is a major source of water pollution and loss of freshwater resources:

> The livestock sector [...] is probably the largest sectoral source of water pollution, contributing to eutrophication, "dead" zones in coastal areas, degradation of coral reefs, human health problems, emergence of antibiotic resistance and many others. The major sources of pollution are from animal wastes, antibiotics and hormones, chemicals from tanneries, fertilizers and pesticides used for feedcrops, and sediments from eroded pastures. Global figures are not available but in the United States, with the world's fourth largest land area, livestock are responsible for an estimated 55 percent of erosion and sediment, 37 percent of pesticide use, 50 percent of antibiotic use, and a third of the loads of nitrogen and phosphorus into freshwater resources. Livestock also affect the replenishment of freshwater by compacting soil, reducing infiltration, degrading the banks of watercourses, drying up floodplains and lowering water tables.[81] (brackets added)

Disadvantages

Spoilage

Spore forming bacteria can spoil both raw and cooked insect protein, threatening to cause food poisoning. While edible insects must be processed with care, simple methods are available to prevent spoilage. Boiling before refrigeration is recommended, with drying, acidification, or use in fermented foods also seeming promising.[82]

Toxicity

In general, many insects are herbivorous and less problematic than omnivores. Cooking is advisable in ideal circumstances since parasites of concern may be present. But pesticide use can make insects unsuitable for human consumption. Herbicides can accumulate in insects through bioaccumulation. For example, when locust outbreaks are treated by spraying, people can no longer eat them. This may pose a problem since edible plants have been consumed by the locusts themselves.[22]

In some cases, insects may be edible regardless of their toxicity. In the Carnia region of Italy, moths of the Zygaenidae family have been eaten by children despite their potential toxicity. The moths are known to produce hydrogen cyanide precursors in both larvae and adults. However, the crops of the adult moths contain cyanogenic chemicals in extremely low quantities along with high concentrations of sugar, making *Zygaena* a convenient supplementary source of sugar during the early summer. The moths are very common and easy to catch by hand, and the low cyanogenic content makes *Zygaena* a minimally risky seasonal delicacy.[83]

Cases of lead poisoning after consumption of chapulines were reported by the California Department of Health Services in November 2003.[84] Adverse allergic reactions are also a possible hazard.[85]

Cultural taboo

Within Western culture, entomophagy (barring some food dyes, such as carmine) is seen as taboo.[86] There are some exceptions. Casu marzu, for example, also called casu modde, casu cundhídu, or in Italian formaggio marcio, is a cheese made in Sardinia notable for being riddled with live insect larvae. Casu marzu means "rotten cheese" in Sardinian language and is known colloquially as maggot cheese. A scene in the Italian film *Mondo Cane* (1962) features an insect banquet for shock effect, and a scene from *Indiana Jones and the Temple of Doom* features insects as part of a similar banquet for shock factor. Western avoidance of entomophagy coexists with the consumption of other invertebrates such as mollusks and the insects' close arthropod relatives crustaceans, and is not based on taste or food value.[86]

Casu marzu is a traditional Sardinian sheep milk cheese that contains insect larvae.

Some schools of Islamic jurisprudence consider scorpions haram, but eating locusts as halal. Others prohibit all animals that creep, including insects.[87][88]

Within Judaism, most insects are not considered kosher, with the disputed exception of a few species of "kosher locust" which are accepted by certain communities.[89]

Public health nutritionist Alan Dangour has argued that large-scale entomophagy in Western culture faces "extremely large" barriers, which are "perhaps currently even likely to be insurmountable."[73] The anthropologist Marvin Harris has also suggested that the eating of insects is taboo in cultures that have other protein sources that require less work to obtain, such as poultry or cattle, though there are cultures which feature both animal husbandry and entomophagy. Examples can be found in Botswana, South Africa and Zimbabwe where strong cattle-raising traditions co-exist with entomophagy of insects like the mopane worm. In addition, people in cultures where entomophagy is common are not indiscriminate in their choice of insects, as Thai consumers of insects perceive edible insects not consumed within their culture in a similar way as Western consumers.[90]

Policy instruments

The Food and Agriculture Organization has displayed an interest in developing entomophagy on multiple occasions. In 2008, the FAO organized a conference to "discuss the potential for developing insects in the Asia and Pacific region.".[75] According to Durst, FAO efforts in entomophagy will focus on regions in which entomophagy has been historically accepted but has recently experienced a decline in popularity.

In 2011, the European Commission issued a request for reports on the current use of insects as food, with the promise that reports from each European Union member state would serve to inform legislative proposals for the new process for novel foods.[91] According to NPR, the European Union is investing more than 4 million dollars to research entomophagy as a human protein source.[92]

See also

- Ethnoentomology
- Feed conversion ratio
- Taboo food and drink
- The Food Defect Action Levels
- *Man Eating Bugs: The Art and Science of Eating Insects* (book)
- *The Eat-A-Bug Cookbook* (book)

References

1. "Entomophagy (Eating insects)". *Center for Invasive Species Research, University of California (Research)*. Retrieved 27 January 2014.
2. Damian Carrington. "Insects could be the key to meeting food needs of growing global population (https://www.theguardian.com/environment/2010/aug/01/insects-food-emissions)", *The Guardian* 1 August 2010. Retrieved 27 February 2011.
3. Ramos-Elorduy, Julieta; Menzel, Peter (1998). *Creepy crawly cuisine: the gourmet guide to edible insects*. Inner Traditions / Bear & Company. p. 44. ISBN 978-0-89281-747-4. Retrieved 23 April 2014.
4. Weiss, M.L. & Mann, A.E. (1985). *Human Biology and Behaviour: An Anthropological Perspective*. Boston: Little Brown & Co. ISBN 0-673-39013-6.
5. McElroy, A. & Townsend, P.K. (1989). *Medical Anthropology in Ecological Perspective*. Boulder, Colorado: Westview Press. ISBN 0-8133-0742-2.
6. Saggers, S. & Gray, D. (1991). *Aboriginal Health & Society: The Traditional and Contemporary Aboriginal Struggle for Better Health*. Sydney: Allen & Unwin. ISBN 1-86373-057-5.
7. Gordon, David George (1998). *The Eat-A-Bug Cookbook*. Berkeley, California: Ten Speed Press. ISBN 0-89815-977-6.
8. Wilson, Charles B. (2015). *All Cricket, No Bull...* Portland, Oregon: CreateSpace. ISBN 1503079643.
9. Thompson, Addie (7 July 2013). "Want To Help Solve The Global Food Crisis? Eat More Crickets". Forbes.
10. FAO:Insects to feed the world (http://www.fao.org/forestry/edibleinsects/en/)
11. "Insects Are Food". Insects Are Food. Archived from the original on 7 May 2012. Retrieved 26 September 2012.
12. *Global Steak - Demain nos enfants mangeront des criquets* (2010 French documentary)
13. Food & Agriculture Organization of the United Nations http://www.fao.org/forestry/edibleinsects/84627/en/
14. Oonincx, Dennis G. A. B.; Van Itterbeeck, Joost; Heetkamp, Marcel J. W.; Van Den Brand, Henry; Van Loon, Joop J. A.; Van Huis, Arnold (2010). Hansen, Immo A, ed. "An Exploration on Greenhouse Gas and Ammonia Production by Insect Species Suitable for Animal or Human Consumption". *PLoS ONE*. **5** (12): e14445. Bibcode:2010PLoSO...514445O. doi:10.1371/journal.pone.0014445. PMC 3012052. PMID 21206900.
15. Premalatha, M.; Abbasi, Tasneem; Abbasi, Tabassum; Abbasi, S.A. (2011). "Energy-efficient food production to reduce global warming and ecodegradation: The use of edible insects". *Renewable and Sustainable Energy Reviews*. **15** (9): 4357–4360. doi:10.1016/j.rser.2011.07.115.
16. Gahukar, R.T. (August 2011). "Entomophagy and human food security". *International Journal of Tropical Insect Science*. **31** (3): 129–144. doi:10.1017/S1742758411000257.
17. Yen, Alan (2009). "Edible Insects: Traditional Knowledge or Western Phobia?". *Entomological Researc h*. **39** (5): 289–298. doi:10.1111/j.1748-5967.2009.00239.x.

18. Clausen, Curtis Paul (1940). *Entomophagous insects*. OCLC 807191.
19. Poinar, G.O. (1986). "Entomophagous Nematodes". *Fortschritte der Zoologie*. **32**: 95–121.
20. Domnas, Aristotle J.; Warner, Steven A. (1991). "Biochemical Activities of Entomophagous Fungi". *Critical Reviews in Microbiology*. **18** (1): 1–13. doi:10.3109/10408419109113507. PMID 1854431.
21. Bodenheimer, F. S. (27 November 2013). *Insects as Human Food: A Chapter of the Ecology of Man*. Springer. p. 16. ISBN 978-94-017-6159-8. Retrieved 18 December 2015.
22. Capinera, John L. (2004). *Encyclopedia of Entomology*. Kluwer Academic Publishers. ISBN 0-7923-8670-1.
23. Jones, Steve; Martin, Robert; Pilbeam, David, eds. (1994). *The Cambridge Encyclopedia of Human Evolution*. Cambridge: Cambridge University Press. ISBN 0-521-32370-3.
24. Tutin, CE; Fernandez, M; Rogers, ME; Williamson, EA; McGrew, WC; Altmann, S. A.; Southgate, D. A. T.; Crowe, I.; Tutin, C. E. G.; Whiten, A.; Conklin, N. L.; Barrett, L. (1991). "Foraging profiles of sympatric lowland gorillas and chimpanzees in the Lopé Reserve, Gabon". *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*. **334** (1270): 179–85; discussion 185–6. doi:10.1098/rstb.1991.0107. PMID 1685576.
25. McGrew, W.C. (1992). *Chimpanzee Material Culture: Implications for Human Evolution*. Cambridge University Press. pp. 153–154. ISBN 0-521-42371-6.
26. Goodall, Jane (1986). *The Chimpanzees of Gombe: Patterns of Behavior*. The Belknap Press of Harvard Univ. Press. p. 248. ISBN 0-674-11649-6.
27. "Cooking with Insects: Are Bugs the Latest Culinary Trend?". Foodie Gossip. 22 July 2011. Retrieved 26 September 2012.
28. Ramos-Elorduy, Julieta; Menzel, Peter (1998). *Creepy crawly cuisine: the gourmet guide to edible insects*. Inner Traditions / Bear & Company. p. 150. ISBN 978-0-89281-747-4. Retrieved 2 April 2010.
29. Eric Loker, Bruce Hofkin et al. *Parasitology: A Conceptual Approach*. p. 229
30. Ramos-Elorduy, Julieta (2006). "Threatened edible insects in Hidalgo, Mexico and some measures to preserve them". *Journal of Ethnobiology and Ethnomedicine*. **2**: 51. doi:10.1186/1746-4269-2-51. PMC 1716161. PMID 17144918.
31. Verbeke, Wim (2015). "Profiling consumers who are ready to adopt insects as a meat substitute in a Western society". *Food Quality and Preference*. **39**: 147–155. doi:10.1016/j.foodqual.2014.07.008.
32. http://www.leparisien.fr/espace-premium/oise-60/grace-a-lui-mangez-des-insectes-a-l-apero-12-02-2014-3581751.php
33. http://www.lefigaro.fr/actualite-france/2013/05/17/01016-20130517ARTFIG00326-micronutris-veut-nous-faire-manger-des-insectes.php
34. Romain Fessard. *Délicieux ! 60 recettes à base d'insectes* (in French). Héliopoles.
35. http://www.EdibleInsects.com
36. All Things Bugs LLC. http://www.allthingsbugs.com/ All Things Bugs LLC. (http://www.allthingsbugs.com)
37. Griopro. http://www.cricketpowder.com/ Griopro. (http://www.cricketpowder.com)
38. Entomo Farms. http://www.entomofarms.com/ Entomo Farms. (http://www.entomofarms.com)
39. "Chapul - Home".
40. "Chapul - The World's First Cricket Bar".
41. "Exo: Protein Bars Made from Cricket powder". Kickstarter.
42. "Products". Exo Inc. Retrieved 4 June 2014.
43. "Americas: Company releases pasta made with cricket flour". *Food News International*. 21 March 2016. Retrieved 31 March 2016.
44. Mark D Fink (2007). "Nutrient Composition of Bee Brood and its Potential as Human Food". Taylor & Francis, Ecology Food and Nutrition.
45. Annette Bruun Jensen (2016). "Standard methods for Apis mellifera brood as human food". Taylor & Francis, Journal of Apicultural Research.
46. "Crickets, bugs, worms: It's what's for dinner!" (http://today.msnbc.msn.com/id/32127636/ns/today-food/t/crickets-bugs-worms-its-whats-dinner/#.T857esUt11E), *Today (NBC program)*, 24 July 2009.
47. "Vij's restaurant staff members Amarjeet Gill, Akiko Masutoni and Sarbjit Randhawa try the cricket paratha" (http://www.ottawacitizen.com/life/story.html?id=6412587), *Ottawa Citizen*, 17 June 2008.
48. "Kitchen nightmares: Rachel Herz unravels mystery of repulsion" (http://www.timescolonist.com/touch/life/Kitchen+nightmares+Rachel+Herz+unravels+mystery+repulsion/6411367/story.html?rel=802038), *Times Colonist*, 5 April 2012.
49. "Eating bugs fine in many cultures" (http://www.canada.com/story_print.html?id=7e4356aa-3e1c-4978-a72b-3f224c742488&sponsor=), *Vancouver Sun*, 28 June 2008.
50. "Meeru's crickets" (http://blogs.vancouversun.com/2011/10/24/rangoli-puts-insect-dish-on-menu/meerus-crickets-2/), *Vancouver Sun*, 24 October 2011.
51. "Researcher unravels our delight in the disgusting" (http://www.vancouversun.com/life/Researcher+unravels+delight+disgusting/6423508/story.html), *Vancouver Sun*, 7 April 2012.
52. "Cuisine to chirp about" (http://www.theglobeandmail.com/news/british-columbia/cuisine-to-chirp-about/article4200877/), *Globe and Mail*, 18 November 2011.
53. Mott, Maryann. Bugs as Food: Humans Bite Back. (http://news.nationalgeographic.com/news/2004/04/0416_040416_eatingcicadas.html) *National Geographic News.* 16 April 2004.
54. Newman, Judith. *What is fried and has six legs? Welcome to Insect Cuisine*. (http://www.nytimes.com/1992/05/20/garden/what-is-fried-and-has-six-legs-welcome-to-insect-cuisine.html?pagewanted=1) The New York Times. 20 May 1992. Accessed 2 April 2010.
55. "A short history of the society". New York Entomological Society. Retrieved 1 April 2010.
56. "Eating Maggots: The Explorers Club Dinner". Epicurious.com. Retrieved 1 April 2010.
57. Schiffrin, Anya (9 February 2009). "Cockroach Eating Contest at Six Flag Draws PETA Protest". Today.reuters.com. Retrieved 26 September 2012.
58. "Cockroach Eating Contest Bugs Animal Rights Activists:". Military-quotes.com. 12 October 2006. Retrieved 26 September 2012.
59. *Edible insects - Future prospects for food and feed security*. Rome: Food and Agriculture Organization of the United Nations. 2013. ISBN 978-92-5-107595-1.
60. International Conference on Forests for Food Security and Nutrition (http://www.fao.org/forestry/food-security/en/)

61. Paoletti, M.G. (2005). *Ecological implications of minilivestock: potential of insects, rodents, frogs, and snails*. Science Publishers. p. 648. ISBN 978-1-57808-339-8. Retrieved 7 May 2010.
62. Oudhia, P. "Traditional medicinal knowledge about green leafhopper, Nephotettix spp., in Chhattisgarh (India)." International Rice Research Notes 25.3 (2000).
63. Oudhia, P. "Traditional medicinal knowledge about pod borer Helicoverpa armigera in Chhattisgarh, India." International Chickpea and Pigeonpea Newsletter 8 (2001): 14-15.
64. Oudhia, P. "Traditional medicinal knowledge about common insects and mites in India." ECOLOGY ENVIRONMENT AND CONSERVATION 8 (2002): 339-340.
65. Oudhia, P. "Traditional medicinal knowledge about red ant Oecophylla smaragdina (Fab.)[Hymenoptera; Formicidae] in Chhattisgarh, India." Insect Environment 8.3 (2002): 114-115.
66. Oudhia P.(2002). Traditional medicinal knowledge about Fireflies, Photuris sp.(Coleoptera : Lampyridae)in Chhattisgarh (India).Insect Environment,Vol.8(1):25.
67. Oudhia P.(2000). Common housefly Musca nebulo Wiedemann (Diptera: Muscidae) as medicinal insect in Chhattisgarh. Insect Environment.6(1):36-37.
68. Ramos-Elorduy, Julieta (2009). "Anthropo-Entomophagy: Cultures, Evolution And Sustainability". *Entomological Research*. **39** (5): 271–288. doi:10.1111/j.1748-5967.2009.00238.x.
69. Gordon, David George (1998). *The Eat-A-Bug Cookbook*. Berkeley, California: Ten Speed Press. p. xiv. ISBN 0-89815-977-6.
70. *Six-legged Livestock: Edible insect farming, collection and marketing in Thailand* (PDF). Bangkok: Food and Agriculture Organization of the United Nations. 2013. ISBN 978-92-5-107578-4.
71. "Jiminy Cricket! Bugs could be next food craze". *New York Times*. 3 August 2014.
72. "Company Gets Grant To Develop Food Based On Insects to Fight Malnutrition". *Eurasia Review*. 12 May 2012. Retrieved 30 November 2012.
73. Parry, Wayne (22 February 2012). "Study: Eating bugs could reduce global warming". Christian Science Monitor. Retrieved 30 November 2012.
74. Yen, Alan (2009). "Entomophagy And Insect Conservation: Some Thoughts For Digestion". *Journal of Insect Conservation*. **13** (6): 667–670. doi:10.1007/s10841-008-9208-8.
75. "Beastly bugs or edible delicacies". *FAO Newsroom*. 19 February 2008. Retrieved 30 November 2012.
76. Walsh, Bryan (29 May 2008). "Eating Bugs". *Time*. Archived from the original on 26 September 2012.
77. Oonincx, Dennis G. A. B.; Van Itterbeeck, Joost; Heetkamp, Marcel J. W.; Van den Brand, Henry; Van Loon, Joop J. A.; Van Huis, Arnold (2010). "An Exploration on Greenhouse Gas and Ammonia Production by Insect Species Suitable for Animal or Human Consumption". *PLOS One*. **5**: e14445. doi:10.1371/journal.pone.0014445. PMC 3012052. PMID 21206900.
78. Gordon, D.G. (1998) p.xv
79. "U.S. could feed 800 million people with grain that livestock eat, Cornell ecologist advises animal scientists Future water and energy shortages predicted to change face of American agriculture". *Cornell Science News*. 7 August 1997.
80. Van Huis, Arnold (2015). "Edible insects contributing to food security?". *Agriculture & Food Security*. **4** (20). doi:10.1186/s40066-015-0041-5.
81. Henning Steinfeld; Pierre Gerber; Tom Wassenaar; Vincent Castel; Mauricio Rosales; Cees de Haan (2006). "Livestock's Long Shadow: Environmental issues and options". Food and Agriculture Organization of the United Nations. Retrieved 25 October 2012.
82. Klunder, H.C.; Wolkers-Rooijackers, J.; Korpela, J.M.; Nout, M.J.R. (2012). "Microbiological aspects of processing and storage of edible insects". *Food Control*. **26** (2): 628–631. doi:10.1016/j.foodcont.2012.02.013.
83. Zagrobelny, Mika; Dreon, Angelo Leandro; Gomiero, Tiziano; Marcazzan, Gian Luigi; Glaring, Mikkel Andreas; Møller, Birger Lindberg; Paoletti, Maurizio G (2009). "Toxic Moths: Source of a Truly Safe Delicacy". *Journal of Ethnobiology*. **29**: 64–76. doi:10.2993/0278-0771-29.1.64.
84. "State Health Department issues health warning on lead-contaminated chaplines (grasshoppers)". California Department of Health Services. 13 November 2003. Archived from the original on 1 January 2006. Retrieved 16 December 2006.
85. Phillips, Joel; Burkholder, Wendell (1995). "Allergies Related to Food Insect Production and Consumption". *Food Insect Allergies*. **8** (2).
86. Gullan, P. J.; Cranston, P.S. (1994). *The Insects: an Outline of Entomology*. Chapman and Hall. ISBN 1-4051-1113-5.
87. "Laws of Islam Concerning Food". Yomatari's Laws of Religion. 10 May 2011. Retrieved 26 September 2012.
88. "The Fiqh of Halal and Haram Animals". Shariahprogram.ca. Retrieved 1 August 2014.
89. Abramowitz, Jack. "Knee-High to a Grasshopper: The obligation to examine locusts for signs of being kosher". OU.org. Retrieved March 20, 2013.
90. Tan, Hui Shan Grace; Fischer, Arnout R.H.; Tinchan, Patcharaporn; Stieger, Markus; Steenbekkers, L. P. A.; van Trijp, Hans C. M. (2015). "Insects as food: Exploring cultural exposure and individual experience as determinants of acceptance". *Food Quality and Preference*. **42**: 78–89. doi:10.1016/j.foodqual.2015.01.013. Retrieved 16 February 2015.
91. Byrne, Jane (16 November 2011). "FSA flags up potential of purified insect protein". *Food Navigator*. Retrieved 30 November 2012.
92. Schultz, Teri (4 November 2012). "Time For A 'Bug Mac'? The Dutch Aim To Make Insects More Palatable". *National Public Radio*. Retrieved 30 November 2012.

Further reading

- Dossey, Aaron (2013). "Why Insects Should Be in Your Diet". *The Scientist*. **27**: 22–23.
- Dossey, Morales-Ramos and Rojas. *Insects as Sustainable Food Ingredients: Production, Processing and Food Applications*.
- Shockley and Dossey (2014). "Insects for Human Consumption". *Mass Production of Beneficial Organisms*: 617–652. doi:10.1016/B978-0-12-391453-8.00018-2.
- Calder, Daniel. *The Dietitian's Guide to Eating Bugs* 2013 ebook [1] (http://www.scribd.com/doc/160318509/The-Dietitian-s-Guide-to-Eating-Bugs)
- DeFoliart, Gene (1992). "Insects as Human Food". *Crop Protection*. **11** (5): 395–399. doi:10.1016/0261-2194(92)90020-6.

- Holt, Vincent. *Why Not Eat Insects?* 1885 Pamphlet Full text of the 1885 pamphlet *Why Not Eat Insects* by Vincent Holt, with French cuisine recipes (http://bugsandbeasts.com/whynoteatinsects/)
- Ichinose, Katsuya (9 February 1989). "More insect eating". *Nature*. **337** (6207): 513–514. Bibcode:1989Natur.337..513I. doi:10.1038/337513b0. PMID 2915701.
- Kantha, Sachi Sri. (24 November 1988). "Insect eating in Japan". *Nature*. **336** (6197): 316–317. Bibcode:1988Natur.336R.316K. doi:10.1038/336316b0.
- Taylor, Ronald L. (1975). *Butterflies in My Stomach, or, Insects in human nutrition*. John Gregory Tweed (illus.). Santa Barbara, California: Woodbridge Press. ISBN 978-0-912800-08-0.

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Wikimedia Commons has media related to ***Entomophagy***.

- "Bug Vivant LLC: Gastronomy on Six Legs: Edible insect recipes, information, nutrition, and much more".
- "Edible insects". *New Scientist*. **2595**: 56. 2007. doi:10.1016/s0262-4079(07)60691-5.
- DeFoliart, Gene R. (29 September 2002). "The Human Use of Insects as a Food Resource: A Bibliographic Account in Progress". University of Wisconsin–Madison. Archived from the original on 24 February 2007.
- Stewart, Jeff. "Understanding the Role of Insects in Foods and Foodways". Creepy Crawly Cooking.
- Frazier, Ian (1997). "It's Hard to Eat Just One". Outside. Archived from the original on 4 April 2005.
- Unger, Lana (20 January 1999). "Insect Snacks from Around the World". University of Kentucky.
- Toms, Rob; Thagwana, Mashudu (2003). "Eat your bugs - harvesting edible stink-bugs". Science in Africa. Archived from the original on 16 April 2011.
- Menzel, Peter; D'Aluisio, Faith (1998). *Man Eating Bugs: The Art and Science of Eating Insects*. Ten Speed Press. ISBN 1-58008-022-7.
- Nejame, Sam. "Man Bites Insect" (http://www.nytimes.com/2008/02/10/magazine/10wwln-essay-t.html?ref=magazine) *New York Times Sunday Magazine*. 10 February 2008.]
- Dicke, Marcel. "Why not eat insects? (http://www.tedxamsterdam.com/2009/video-marcel-dicke-why-not-eat-insects/)", *TEDxAmsterdam*. Retrieved 12 March 2011.
- Risk profile related to production and consumption of insects as food and feed (http://efsa.europa.eu/en/efsajournal/pub/4257) European Food Safety Authority 2015
- "Entomo Farms - Recipes by Entomo Chef Caryn: Delicious Recipes from Main Dishes to Deserts by your Entomo Chef and You".
- Edible insects: Future prospects for food and feed security (http://www.fao.org/docrep/018/i3253e/i3253e.pdf)

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