Int J Pharm Bio Sci 2015 Jan.; 6(1.): (B) 519 - 527

Research Article **Nutritional Entomology**

International Journal of Pharma and Bio Sciences

ISSN 0975-6299

INSECTS FOR HUMAN DIET FROM KOLHAPUR REGION, INDIA

T. V. SATHE

Department of Zoology, Shivaji University, Kolhapur 416 004, (M.S.), India.

ABSTRACT

In near future, there would be tremendous scarcity of sources of animal proteins and protein food requirement will be the top priority. The insects can solve the problem of protein food requirement of humans as most suitable food since insect diet increase the food convertibility and caloric and nutritive values. Simultaneously, it reduces the risk of cholesterol and heart fail. As human diet insects contain very rich proteins, fats, carbohydrates, minerals, amino acids, vitamins and fibers. Therefore, diversity, distribution, suitability as human food, cooking methods and applications of 18 species of edible insects from Kolhapur region, India have been reported.

KEYWORDS: **Diversity, nutritive insects, human diet, cooking, Application, Kolhapur, India.**

T. V. SATHE
Department of Zoology, Shivaji University, Kolhapur 416 004, (M.S.), India.

*Corresponding author

INTRODUCTION

In near future the sources of human diet in the form of animal proteins will decrease at large extent due to limited animal populations and increased human population. Vegetarian diet would not fulfill the requirement of non-vegetarians. Reduction in edible animal population in recent years has increased tremendous pressure on the food management strategies. In 1950-51, 160 heads of animals per hectare which was reduced to 143 during 1990-91 and in recent years it is still reduced. The reduction in edible animal population has relation with the economic, environmental and health losses There are certain institutes those are actively engaged in finding out safe and nontoxic food insects, analyze their nutritive values and publicize them, warn people against poisonous insects and less nutritive insects. Therefore, attempts have been made to find out alternatives for loss of animal proteins and edible animals. To meet the need of increasing human population more animals are to be reared by providing suitable food and space to them or increasing more forest areas. Review of literature indicates that Arnold *et al*.,[1], Bennet [2], Bukken[4], Cherry[5], DeFoliart[6,7], Finke[8,9], Gorham[10], Logan[11], Ramos[13], Ramos *et al*.,[14], Rumpold & Schluter [15], Shrivastava[22], Taylor [23], Trehernez [24], Vane-Write[25], Womeni *et al.,*[26] and Xiaoming *et al.,*[27], etc. investigated the insects for human diet.

MATERIALS AND METHODS

Kolhapur district of Maharashtra, India is situated between 15^o to 17^o North latitude and 73^o to 74^o East longitude acquiring 1,46,575 hectares land and uneven rainfall ranging between 700 mm to 6000 mm. Much part of the Western Ghats, the 18 hot spots of the world also scattered in Kolhapur district. Therefore, Kolhapur district contain several water bodies and is a very rich source of biodiversity. Shirol, Kolhapur, Gargoti, Ajra, Radhanagari and Gaganbawada tahsils were selected for survey of edible insects. The survey was conducted at 15 days interval at every spots during 2013-2014. The nutritional insects have been collected and identified morphologically and nutritionally in the laboratory /fields consulting appropriate literature [3, 12, 16, 17, 18, 19, 20, 21]. Cooking methods and the applications of insects are also given in the paper.

RESULTS

A total of 18 species of edible insects have been identified from Kolhapur region, Western Maharashtra, India. Their occurrence and distribution is recorded in table-1 and their features, cooking methods and applications are given below.

1. Paddy grasshopper Hieroglyphus banian Fab. (Orthoptera : Acrididae)

Adults are about 50 mm in body length with greenish yellow colour and with 3 black lines on pronotum. Yellowish greenish nymphs are with reddish brown spots. Both are edible after removal of wings and legs and alimentary canal. These are either boiled or fried with oil, spices and salt and dish is prepared. The grasshoppers can also be eaten as fresh without cooking. Tribals and foreigners eat grasshoppers.

2. Hooded grasshopper Teratodes monticolis Grey (Orthoptera : Acrididae)

Adults are greenish and about 50-58 mm long, pronotum modified like hood which extend above the head of front side and back side near about the centre of tegmina. Mostly found in Western Ghats and forest environment. The insect dish is prepared as above. Tribals or foreigners use grasshopper dish.

3. Caterpillars

a) Bombyx mori L. (Lepidoptera : Bombycidae)

Caterpillars are larval stages of mulberry silk moth *B. mori* (Fig. 1). The full grown whitish caterpillars measure about 7 cm to 8 cm in body length. They are with 3 thoracic and 5 pairs of abdominal legs. Within 24 hour they vacate the alimentary canal. Therefore, there is no necessity of removal of alimentary canal for cooking. The larvae are either boiled with water and cooked or fried with oil, spices and salt. Omelets are also made out of them. The

larvae have a mild taste. Some people, starved caterpillars for 24 hour, are preferred even live for eating purpose in India. Tribal population as well as foreigners visiting India have their demand for silk worm diet. Dark coloured and hairy caterpillars are not preferred for human diet due to the presence of pigmentation and formic acid in their hair respectively. Faint coloured and whitish caterpillars (Fig. 2) are safety from the view point of health care.

b) Galleria mellonella Linnaeus

Larvae prepared in hot vegetable oil are very palatable like potato chips and corn putts or corn flakes.

4. Pupae of moths (Fig. 3)

Pupae of silkworms like *B. mori* and tasar silkworm, of early stage or before darkening are safety as human diet. The obtect type of pupae is broader at anterior end and pointed at posterior with clear segmentation. Pupae cooked by frying them with oil, spices and salt or they are boiled with water and cooked with butter/oil, spices and salt. The cocoons are nutty and highly nutritive. Chinese prepared silkworm diet for space researchers because of its high nutritional value. Pupae of Lepidopteran borers (fig- 2) are also found useful for human diet. Indian tribals and several countries prefer insect pupal diet.

5. Termites : Macrotermes spp. and Microtermes spp. (Isoptera : Termitidae)

Macrotermes gilvus (Hagen) : The workers of this species are relatively larger sized than other genera. They construct dome shaped mound with 3.5 height from above the ground level. These social insects show polymorphism, caste system and division of labour; termite digest cellulose.

Microtermes spp.: These are smaller than *Macrotermes* spp. *M. obesi* is widely scattered in South Asia including India and associated with crops such as bajra, maize, wheat, mulberry, sugarcane, groundnut and many vegetables found from June to September. The workers and queen (Fig. 4) of both, above mentioned species are fried with oil, spices and salt and eaten by humans in Asia. Winged reproductives (Fig. 5) was collected at the time of swarming. The queen may be cooked by boiling and further with oil, spices and salt. Termites diet help for building immunity in humans. Wings are removed, in fact, they get shed in 30-45 minutes after swarming. They are fried and dish is prepared. Termites may be eaten fresh (live). They may be stored after sun drying or smoking. *Macrotermes* spp. have about 45.00%, 36.00%, 6.5% and 550 fats, proteins, Ash and calories / 100g respectively while, *Microtermes* spp. 45%, 40%, 6.5% and 650 fats, proteins, Ash and calories / 100g respectively.

6. Weevils : (Coleoptera : Curculionidae)

Rhynchophorus ferrugineus Oliver Adult is reddish-brown, cylindrical and with snout as a extension of the head. Its life stages are found on coconut plant, larvae feed on plant tissues and are comma shaped. The legs and wings are removed before cooking. The weevils are boiled and mixed with spices, chili and salt and/or fried in oil. Other large sized weevils of light colour are also eaten. Indian tribals Africans, Thai, Chinese etc. eat weevils.

7. Rhinoceros beetle and white grubs : (Coleoptera : Scaraebaiedae)

The larvae or white grubs of *Rhinoceros oryctes* Linnaeus are mashed and fried in oil with chili, salt and spices and insect dish is prepared. The white grubs of *Holotrichia consanguinea* Blanchard, *Leucopholis lepidophora* Blanchard (Fig. 6) are also welcome as human diet. They are cooked as weevils. Indian tribals and western and eastern countries eat white grubs.

8. Wasps : (Hymenoptera : Vespidae)

Vespa spp. : Wasps have petiolate abdomen and transparent wings. The larvae (grubs) and early stage pupae are collected from the nests of wasps. They are fried in oil with salt and spices and dish is prepared. The larvae of Vespa contain very rich proteins.

9. Honey bees (Hymenoptera: Apidae)

The larvae and early stage pupae of *Apis dorsata, Apis indica, Apis florea* and *Apis mellifera* are collected from honey comb and fried in oil and mixed with spices and salt for preparation of bee dish for humans. The pupae and grubs are also cooked with salt by

boiling in water. This food is prepared by Indian tribals and several other countries.

10. Large red ants Atta sp. (Hymenoptera : Formicidae)

The grubs or pupae are cooked as above and used as human diet. This diet is also useful for increasing immunity in humans. The diets of wasps, bees and ants (Fig. 7) are preferred by many tribal populations in India and in several other countries.

Oecophylla smaragdina is having pungent flavour, it is fried for dish.

11. Crikets (Orthoptera : Gryllidae)

Acheta domesticus T. & C.: The wings and legs of *A. domesticus* are removed and remaining body is fried in oil and cooked with salt and spices. The cricket dishes are very famous by various names in various countries which refer to "cricket Hot Pie", "Fishin crickets", 'Crickets Mushroom", etc.

12. Scorpion bug (Hemiptera : Belostomidae)

Belostoma indica (Fig. 8):

This aquatic insect looks like scorpion which is brownish black. Fore legs are predaceous, hind legs used for swimming, post tibia is flattened and antenna is 4 segmented. Wings, legs and antennae are either removed or kept as it is and either boiled/ fried in cooking.

13. ***Dineutes indicus*** is another aquatic insect with short antennae, eye divided and post legs with paddles. This insect is broiled/ boiled and cooked or smoked or fried with salt and pepper.

Table – 1
Occurrence of nutritional insects in Kolhapur region

Sr. No.	Species	Shirol (750 mm)	Kolhapur (1050 mm)	Gargoti (1375 mm)	Ajra (2000 mm)	Radhanagari (2500 mm)	Gaganbawada (6000 mm)
1.	*H. banian*	+	+	+	+	+	+
2.	*I. monticolis*	-	+	+	+	+	+
3.	*B. mori*	+	+	_	+	-	-
4.	*G. mellonella*	+	+	-	-	-	-
5.	*Macrotermes* spp.	+	+	+	+	+	-
6.	*Microtermes* spp.	+	+	+	+	+	-
7.	*R. ferrugineus*	+	+	+	+	+	+
8.	*R. oryctes*	+	+	+	+	+	+
9.	*L. lepidophora*	+	+	+	+	+	-
10.	*H. consanguinea*	+	+	+	+	+	+
11.	*Vespa* sp.	+	+	+	+	+	-
12,	Bees	+	+	+	+	+	+
13.	*Atta* sp.	-	-	-	+	+	+
14.	*A. domesticus*	+	+	+	+	+	+
15.	*B. indica*	-	+	+	+	+	+

(Figures in Parentheses shows rainfall in millimeter)

Figure 1
B. mori larvae

Figure 2
Stem borer caterpillar C. partellus

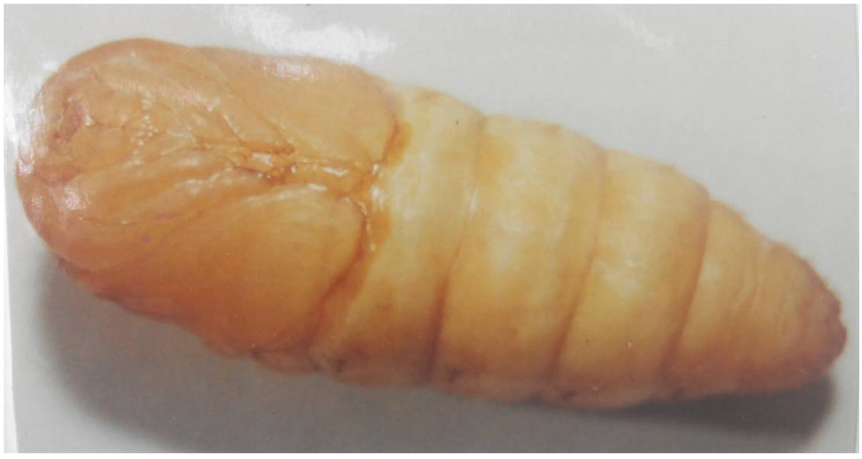

Figure 3
B. mori Pupa

Figure 4
Termite queen

Figure 5
Termite winged reproductive form

Figure6: *L. lepidophora*

Figure7: Red ant

Figure8: *B.indica*

DISCUSSION

According to Shrivastava[22] insect diet is advantageous to humans since it has high caloric and rich nutritive values containing proteins, amino acids, fats, minerals and vitamins and better food convertibility. Insect diet reduces cholesterol risk and insect pest populations and very suitable food for space travelers. Shrivastava[22] reported that entomophagy generated work and income for urban population similar to that of sericulture, apiculture, lac-culture, poultry and pisciculture in several countries. The escambole in Mexico and tequila-flavoured lollipop was marketed in USA while, in Korea, *Popillia japonica* was bought by individual @ 10 cents to keep them in their homes to attract the edible species *Popillia fermoralis* through pheromones. In Egypt, about 70,000 pounds of the honey-dew called "Mana" were sold every year. Similarly, in Zambia "Mumpa" caterpillars were the best source of survival of some people through their sale. About 140 kg of caterpillars were collected per week in this country by a single person. Like wise, in North Africa, desert locusts were collected in large quantities (200-900 kg) for sale. Taylor[23] provided a long list of edible insects from America. Honey bee *A. mellifera* larvae and pupae, Cricket *A. domesticus* nymphs and wax moth *G. mellonella* larvae were most palatable. Larvae and pupae of *A. mellifera* shallow-fried in butter and deep fried in vegetable oil were eulogistically tasty as walnuts, pork-cracklings, sunflower seeds and rice-crispies. Deep fat fried, butter fried and baked preparations were highly rated while smoked, pickled and branded ones were less preferred. Pupal preparations went very well with cocktails. Fried bees were found to be appetizing whose flavour was described half-way between pork cracklings and wild honey. Canned young bees were cost more $ 1.00 an ounce (28 gm). Similarly, a preparation called "Fishin crickets" was sold for about $ 14 per pound (45 gm) in USA. In the near future, the need of proteins will not be fulfilled by available protein sources of animals. Hence, entomophagy seems to be the only alternative which is easily and freely available in the nature and therefore, insect dish must be popularized amongst the people[2,3].

Traditional insect diets in many parts of the world were highly nutritious and specially rich in proteins and thus represented potential food and protein source. A compilation of 236 nutrient compositions in addition to amino acid spectra and fatty acid compositions as well as mineral and vitamin contents of various edible insects as derived from literature was given and the risks and benefits of entomophagy were discussed[15]. Although the data were subject to a large variation, it could be requirements for humans, were high in MUFA and/or PUFA, and rich in several micronutrients such as copper, iron, magnesium, manganese, phosphorus, selenium and zinc as well as riboflavin, pantothenic acid, biotin and in some cases folic acid. Liabilities of entomophagy included the possible content of allergenic and toxic substances as well as antinutrients and the presence of pathogens. However, more data are required for thorough assessment of the nutritional potential of edible insects and proper processing and decomtamination methods have to be developed to ensure food safety[15]. The nutritional values of edible insects tested were highly variable due to the wide variety of species[8,9]. Even within the same group of edible insect species, values were different depending on the metamorphic stages of the insect, and their habitat and diet. Like most foods, preparation and processing methods applied before consumption were also influenced nutritional composition. A few scattered studies analyzed the nutritional values of edible insects[8,9,13]. Rumpold and Schtuter[15] compiled nutrient compositions for 236 edible insects, many edible insects provided satisfactory amount of energy and protein, amino acid requirements for humans, were high in monounsatured and/or polyunsaturated fatty acids and were rich in micronutrients such as copper, iron, magnesium, biotin and folic acid. Ramos *et al*.[14] analyzed 78 insect species from Oaxaca State, Mexico and determined that caloric content was 293.762 kilocalories (kcal) per 100 g of dry matter. The energy content in kcal / 100g fresh weight were 1272, 94, 120 and 535 in *O. smaragdina, B. mori, Gryllus bimaculatus* and *Macrotermes subhyalinus* respectively. Xiaoming *et al*.[27] evaluated the protein content of 100 species from a number

of insect orders. According to them the range of proteins per cent were 23-66, 14-68, 42-74, 13-77 and 23-65 in Coleoptera, Lepidoptera, Hemiptera, Hymenoptera and Orthoptera respectively. In some insect species amino acids were very well represented[5]. Several caterpillars of the Saturniidae family, palm weevil larvae and aquatic insects have amino acid scored for lysine higher than 100mg amino acid per 100g crude protein. Fat is most energy dense macronutrient in food which contains triglycerides. Womeni *et al*.[26] investigated the content and composition of oils extracted from several insects. Their oils were rich in polyunsatured fatty acids and frequently contained the essential linoleic and α -linolenic acids. In termite *Macrotermes* sp. and saturniid caterpillar palmitic and oleic acid were in 30% & 8% and 48% & 9% respectively. Minerals play an important role in biological processes. Most edible insects boast equal or higher iron contents than beef[4]. The beef showed an iron content of 6 mg per 100 g of dry weight and the mopane caterpillar showed 31-77 mg per 100 g while, iron content of *Locusta migratoria* ranged from 8 and 20 mg per 100 g of dry weight which was dependant on diet. Zinc deficiency in children and maternity women has been corrected by insect diet[4]. In general, most insects are good source of zinc. Vitamins are present in most the insects which are essential for stimulating metabolic processes and enhancing immune system functions. In insects thiamine ranged from 0.1 mg to 4 mg per 100 g of dry matter and riboflavin from 0.11 to 8.9 mg per 100 mg[4]. Vitamin B_{12} was 0.47 mg per 100 g in *Tenebrio molitor* larvae and 5.4 µg per 100 g in adults and 8.7 µg per 100 g in nymphs in *A. domesticus.* Similarly, Vitamin E at 9.65 per 100 g was found in *B. mori* larvae. The insects also contain fibre in the chitin as insoluble content which ranged from 2.7 mg to 49.8 mg per kg fresh and 11.6 mg to 137.2 mg per kg for dry matter[4]. In general, the above findings clearly indicate that when prawns, fishes, chicken, goats and several other animals are welcome as human diet then why not insects?

ACKNOWLEDGEMENT

Author is thankful to Shivaji University, Kolhapur for providing facilities to this work.

REFERENCES

1. Arnold, V., Joost V.I., Harmke, K., Esther, M., Afton H., Giulia Muir & Paul, V.. Edible insects - Future Prospects for food and feed security. FAO, Rome, 2013, pp. 67-80.
2. Bennett, G. Eating matters : Why we eat, what we eat? Heinemann kings wood, London,1988 , pp. 224.
3. Bhoje, P.M., Kurne S.H., A.S. Desai and T. V. Sathe. Diversity of ants (Hymenoptera : Formicidae) of Amba Reserve Forest of Western Ghats, Maharashtra. *Global J. Res. Analysis* 2014, 317: 284-287.
4. Bukken, S.G.F. Insects in the human diet : nutritional aspects. In: M.G. Paoletti (ed). Ecological implications of minilivestock; role of rodents, frogs, snails and insects for sustainable development,. New Hampshire, Science Publisher, 2005, pp. 545-577.
5. Cherry, R.H.. Use of insects by Australian Aboringines. *Bull. Ent. Soc. Am*, 1991, 37: 9-13.
6. De Foliart, G.R.. The human use of insects as food and as animal feed. *Bull. Ent. Soc. Am,* 1989, 35: 22-35.
7. De Foliart, G.R.. Insects as human food. *Crop protection*, 1992, 11, 395-399.
8. Finke, M.D. Complete nutrient composition of economically raised invertebrates used as food for insectivores. *Zoo Biology*, 2002, 21(3): 269-285.
9. Finke, M.D. Estimate of chitin in row whole insects. *Zoo Biology,* 2007, 26: 105-115.
10. Gorham, J.R. The significance for human health of insects in food. *Ann. Rev. Entomol*, 1979, 24: 209-224.

11. Logan, J.W.M. Termites (Isoptera), A pest or resource for small farmers in Africa. *Trop. Sci*., 1992, 32: 71-79.
12. Metcalf, C.L. and Flint, W.P. Destructive and useful insects - Their habits and control. Tata McGraw Hill, New Delhi, 1962.
13. Ramos E.L. The importance of edible insects in the nutrition and people of the rural areas of Mexico. *Ecology of Food and Nutrition*, 1997, 36: 3.
14. Ramos E.L., Pino J.M., Prado, E.E., Perez M.A., Otero J.L. and de Guevara, O.L. Nutritional value of edible insects from the State of Oaxaca, Mexico. *Journal of Food consumption and Analysis*, 1997, 10: 142-157.
15. Rumpold, B.A. and Schluter, O.K. Nutritional composition and safety aspects of edible insects. *Mol. Nutr. Food Res.,* 2013, 57(5): 802-823. (DOI 10.1002/mufr. 201200735).
16. Sathe T.V. Sericultural crop protection. Asawari Publ., Osmanabad, 1998, pp. 1-120.
17. Sathe T.V. and M.R. Awate. Crikets and household pests Daya Publ. House, New Delhi, 2009, pp-1-171.
18. Sathe T.V. & A.R. Bhusnar. Grasshopper diversity and control. Astral Int. Nat. Pvt. Ltd., New Delhi, 2013, pp. 1-263.
19. Sathe T.V. and T.M. Chougale. Biodiversity of termites (Order : Isoptera) from Western Ghats of Sindhudurg district, Maharashtra. *Anim. Ecol. & Reproduction,* 2008, 5(4): 38-53.
20. Sathe T.V. & A.D. Jadhav. Sericulture and pest management. Daya Publ. House, New Delhi, 2001, pp. 1-197.
21. Sathe T.V. and P.V. Khairmode. Diversity of Weevils (Coleoptera : Curcullonidae) from Kolhapur district. *J. Nat. Con*., 2013, 25(1 & 2): 111-115.
22. Shrivastava, K.P. A text book of applied Entomology Vol. II, Kalyani Publ., New Delhi, 1993, pp. 487.
23. Taylor, R.L. Butterflies in my stomach : insects in human nutrition. Santa USA, wood brige Press Publishing Co, 1975.
24. Trehernez J. Review of the book, Why not eat insects? *Nature*, 1988, 336: 316-317.
25. Vane-Write, R.L. Why not eat insects? *Bull. Ent. Res.,* 1991, 1: 1-4.
26. Womeni, H.M., Linder, M., Tiencheu B., Mbiapo F.T., Villeneuve P., Fanni J. and Parmentier, M. Oils of insects and larvae consumed in Africa : Potential sources of polyunsaturated fatty acids. OLC-*Oleagineux, Corps Gras Lipides,* 2009, 16(4): 230-235.
27. Xiaoming, C., Ying, F., Hong Z. and Zhiyong C. Review of nutritive value of edible insects. In: P.B. Durst, D.V. Johnson, R.L. Leslie, & K. Shono (eds). Forest insects as food : humans bite back, proceeding of a workshop on Asia-Pacific resources and their potential for development. Bangkok. FAO Regional Office for Asia and Pacific, 2010.