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# The Ethnobotanical Study of an Edible Freshwater Red Alga, *Lemanea fluviatilis* (L.) C.Ag. from Manipur, India

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## Research


### Abstract

An ethnobotanical study of an edible fresh water red alga *Lemanea fluviatilis* (L.) C.Ag. was carried out in the Thoubal district of Manipur State, India. The alga locally known as **nungsham,** due to its hair like growth on stone, grows profusely in the rocky and shallow river beds of the Chakpi and Manipur rivers. In earlier reports, the alga was misidentified as *Lemanea australis*. Harvested by the women of the Meitei, Kuki and Kuki-Chin-Mizo communites, the sun dried alga is sold in the local market. The dried filaments are eaten with major meals. A total of 23 strategically selected informants have been interviewed through structured questionnaires to obtain indigenous knowledge about the alga and its uses. Detailed morphological and reproductive features are described to reveal the correct taxonomic status of the species. Some ethnopharmacological information is also incorporated.


### Introduction

Owing to high protein content and diverse amino-acid composition, the potential of algae as a source for food and nutrients is well recognized (Spoehr 1951, Tamiya 1959, Tamiya 1962). Despite being a primary producer in an aquatic food chain, very little is known about ethnobotanical uses of fresh water algae. Barring a few reports on spirulina (*Arthrospira* sp.), ethnobotanical studies are mostly confined to marine algae. The Kanembu tribe of the Republic of Chad uses spirulina as food in the form of **dihe** (dried bread) (Romero-Manilla *et al.* 2008). While conducting studies on fresh water algae of Manipur, a remotely located north-eastern state of India with rather high ethnic diversity (Ali & Das 2003), we came across a rare fresh water edible red algae (*Lemanea* sp.) used by the local people. Use of plants for preparation of commercial products including edibles and handicrafts are a characteristic feature of the Manipuri people in general. The population structure of Manipur is comprised of about 90% hill area tribal communities and 10% Meitei non-tribal communities. Of the 28 tribes, those belonging to the Kuki and Kuki-Chin-Mizo (consisting of four other sub-clans, the Hmar, Vaiphei, Thodou and Paite) clans are the predominant users of the red alga. All members of the communities speak the Kuki language. People of the Meitei community, another user of the alga, speak Manipuri, the official state language of Manipur State. These communities possess quite rich traditional knowledge (Singh 1996, Singh 1997, Singh *et al.* 1996, Singh & Sundriyal 2003, Singh *et al.* 2003, Sinha 1996). Due to poor sanitation, and a lack of medical and transport facilities these people are mostly dependent on traditional knowledge. The average number of patients served annually per medical center is 4213, with 954 patients per hospital bed and 2517 people per doctor (Jain *et al.* 2007). Medical facilities in remote areas are very limited, with most medical institutes and health care centers located in the state capi-


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tal, Imphal. The healers, locally called **Maiba** for males and **Maibi** for females, play a crucial role in village health care. More than 90% of the village people are dependent on such traditional healthcare systems (Jain *et al.* 2007). Many families in villages traditionally maintain a few medicinal herbs in their home garden, ponds, etc.

The genus *Lemanea* is comprised of fresh water red algae which occur in shallow rivers or streams and canals of cold environments (Thirb & Benson-Evans 1985, Kucera & Marvan 2004, Simic 2007). Known worldwide by 12 taxonomically accepted species, *Lemanea* growing in the Chakpi and Manipur rivers of Manipur State have been documented for their ethnobotanical uses (Deb *et al.* 1974, Jain *et al.* 2007, Ghosh 2000). Although several previous studies (Jain *et al.* 2007, Mao *et al.* 2009, Deb *et al.* 1974) have cited a species thought to be *Lemanea australis*, a careful scrutiny of detailed morphological characters of the alga in the present study led to the identification of this species as *Lemanea fluviatilis* (L.) C.Ag. It is pertinent to mention that *L. fluviatilis* growing in streams with swift currents have been reported from other parts of the world (Kucera & Marvan 2004, Simic 2007, Thirb & Benson-Evans 1985). Low water temperature, and the physical and chemical properties of river substrata (rocks) have been reported to influence distribution and colonization of *L. fluviatilis* (Thirb & Benson-Evans 1985).

The alga is locally known as **nungsham** (stone hair) in Manipur, the name being common to all the user communities in Manipur State. People of the Meitei and the tribal communites (*vide infra*) harvest, sell and use the species for its edible and ethnomedicinal values. Although the alga was abundant decades ago, it has become very rare recently due to indiscriminate exploitation and habitat degradation caused by rock and boulder removal for construction purposes. Even in Manipur, the alga is presently confined to the Chakpi river habitat of the Serou and Sugnu areas in Thobul district. The species is listed as a critically endangered taxa (Mao *et al.* 2009). In other parts of the world the species is recorded as critically endangered, threatened or vulnerable (Eloranata & Kwadrans 1996, Entisle 1989, Necchi *et al.* 1999, Pevalek 1996; Starmach 1977, Whitton 1975). The focus of the present paper is to provide the correct taxonomic identification of this species and describe its value as an edible and ethnomedicinal product based on a knowledgebase survey conducted in the Serou area, among some strategically selected people residing in user communities.

## Materials and Methods

### *Study site*

The alga and information on its uses by local inhabitants was obtained in the Serou area of Manipur. The species grows during winter (November to January) on the rocks under the swiftly flowing waters of the Chakpi and Manipur rivers in Nunglap, Likla, Nungmaijam and Yenanghousi, etc. in the district of Thoubal. The rivers are shallow (~ 0.5m depth) with rocky bottoms. The collection site is located at 790m altitude and lies between 23º43' to 24º45' N and between 93º45' to 94º15' E. The location of the study area is shown in Figure 1. The study site has a subtropical climate. In winter the temperature ranges from -2ºC to 16ºC and summer (May to September) the temperature ranges from 25 ºC to 36ºC. The average annual rainfall at the study sites is around 1435 mm.

### *Sample collection and taxonomy*

Fresh algal material (2 kg) was collected from the Chakpi river from the area of Serou to Sugnu (Thobul district) through the help of women harvesters at the sites (*vide infra*) during the harvesting season. As per traditional belief related to conservation threats, males are not supposed to harvest the alga. The collected material was carefully washed in the respective river water, transferred to ice packs, and brought to our laboratory. The fresh material was soaked in 0.1N NaOH and subjected to taxonomic studies and species characterizations. Morphology of the plant was studied carefully using an Olympus BX 40 microscope. Kumano (2002) was referred to for the identification. Packets of dried alga sold in the market were also procured, and after being soaked in water can be used for different studies.

### *Ethnobotanical data*

The ethnobotanical and related information on the alga was collected by a survey conducted through a semi-structured questionnaire (Appendix I). A total of 23 people (13 women and 10 men) ranging in age from 30 to 60 years were classified as harvesters (6 women belonging to the Meitei community or Kuki tribe communities), sellers (4 women belonging to the Meitei, Kuki or Kuki-Chin-Mizo communities), buyers (6 women belonging to the Meitei, Kuki or Kuki-Chin-Mizo communities) local healers (3 men all belonging to Meitei community) and local villagers (4 Meitei men) were included in the interviews and discussions, after obtaining prior informed consent. Culturally, linguistically, and religiously the Kuki tribe differ substantially from the Meitei community.

## Results

The habits and morphological characteristic of the alga are shown in Figure 2. In the Chakpi river, the alga grows in abundance on river-bed rocks (Figure 3-A) during mid winter. With the advent of pre-monsoon showers, the rocky substratum becomes free from the alga. The alga is greenish-black, with a fishy smell. Other algal species *viz. Euglena* sp. also possess a fishy smell, this therefore may not be an unique taxonomic character for this alga. The algal species is thread-like, branched, and ranged from 5-7 cm in length. Characteristically, thalli of the alga narrowed

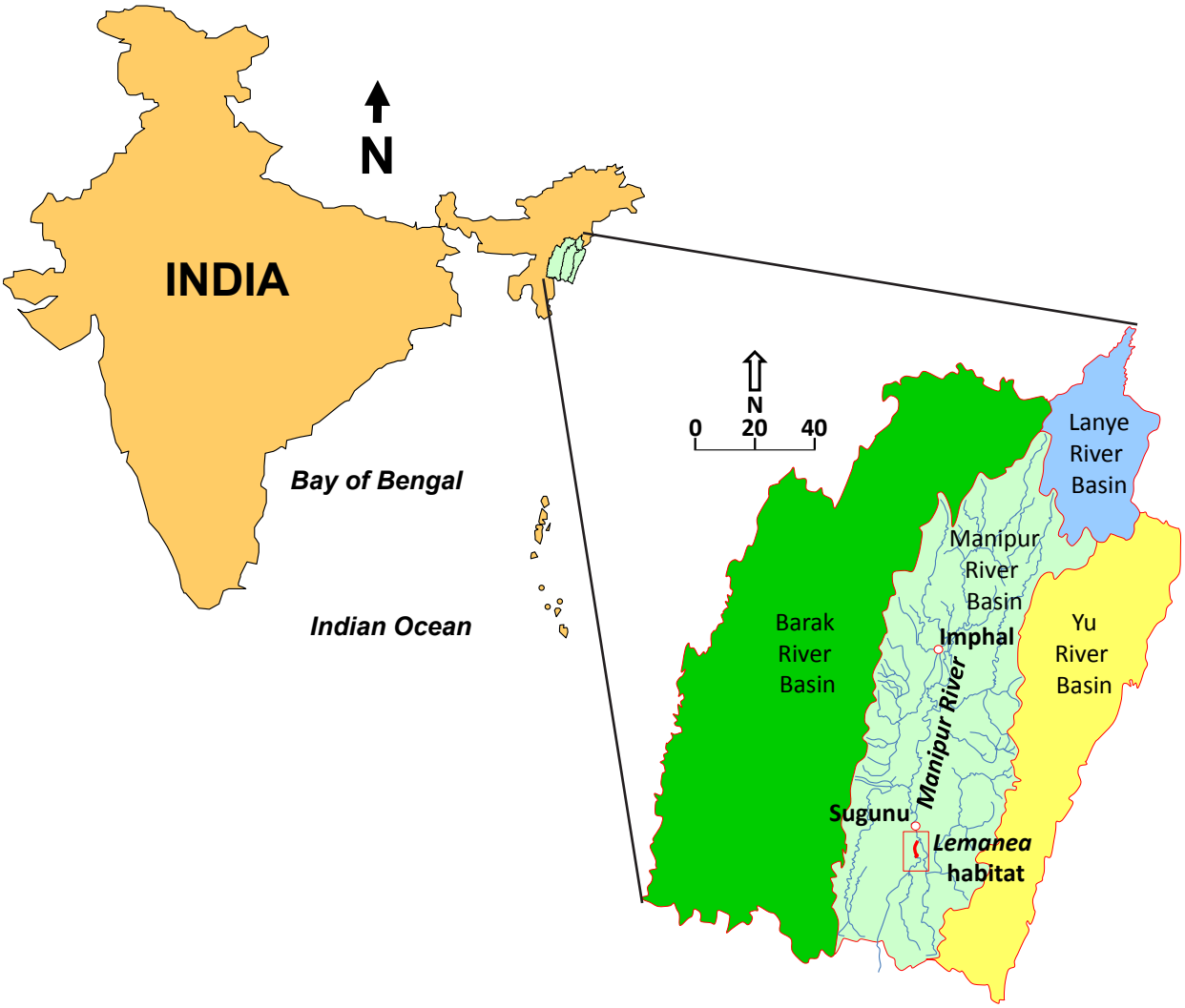


**Figure 1.** Study site in the Serou area of Manipur State, India, with the habitat of *Lemanea fluviatilis* (L.) C.Ag.

abruptly towards the base forming a thin cylindrical stalk. The branches were often fasciculate, arcuate, long, pedicelled and ≤ 4 in number. The axis and branches showed distinct nodes. Spermatangial papillae were 3-4 in number, mostly separated but sometimes partly confluent. The carpogonial branch was 3-4 celled with sessile trichogyne; gradually tapering towards the tip. The carpospores were ellipsoidal with gonimoblast filaments. In its morphology and reproductive feature, the alga resembles those of *L. fluviatilis* as described by Kumano (2002). Arrangement of spermatangial sori in patches and a ratio of ~ 1.2 of nodal to internodal diameter in the alga is the most distinctive characteristics of *L. fluviatilis* (Simic 2007). The dimensions of the thallus, cells and reproductive structures are summarized in Table 1. Earlier, the species has been misidentified as *Lemanea mamillosa* Kuetz. by Khan (1973) and *Lemanea australis* Atk. by Deb *et al.* (1974).

In typical *L. mamillosa*, the thalli turns yellow when dried (Kumano 2002) which was not observed in the present case. Besides other diagnostic features of *L. mamillosa* such as unstalked thalli, more branches gradually narrowing towards the base were not mentioned by Khan (1973). Later, Deb *et al.* (1974), Jain *et al.* (2007) and Mao *et al.* (2009) in their respective account continually indicated the alga from Manipur as *L. australis*. No illustrations or detail description of the alga were provided by these authors.

***Ethnobotanical Study***

The alga is sold by local people in dried form as a food product in the local markets of Sugnu and Serou (Figure 3-B). Women of the Meitei community are usually engaged in collection of the alga from different sites in the river bed. Figure 3-C shows the collection of alga from one of the six sites by Meitei women during the winter season. The freshly collected alga (2-3 kg) by each person in a day is sun dried for 2-3 days on dry cloths. The dried alga equivalent to 400-450 g dry weight is wrapped with paper and cut into 20 to 30 packets each weighing about 15g. These packets are sold in the market at a price of around INR 100- 150 (US $2-3) i.e., INR 7,000 / kg (US $140). The entire process from collection to selling is exclusively done only by women. The earnings of each person during this season reach around INR 10,000 (US $200). The income from selling the alga is only supplementary in nature and restricted to the harvest season. The harvest of alga by the local people depends on its availability and luxuriant growth in the river. Thus in the lean season income is often reduced to INR 3,000 (US $60). Based on periodic visits to the sites during 2008-2009, we conclude that the growth of the alga appears to be affected due to anthropogenic factors.

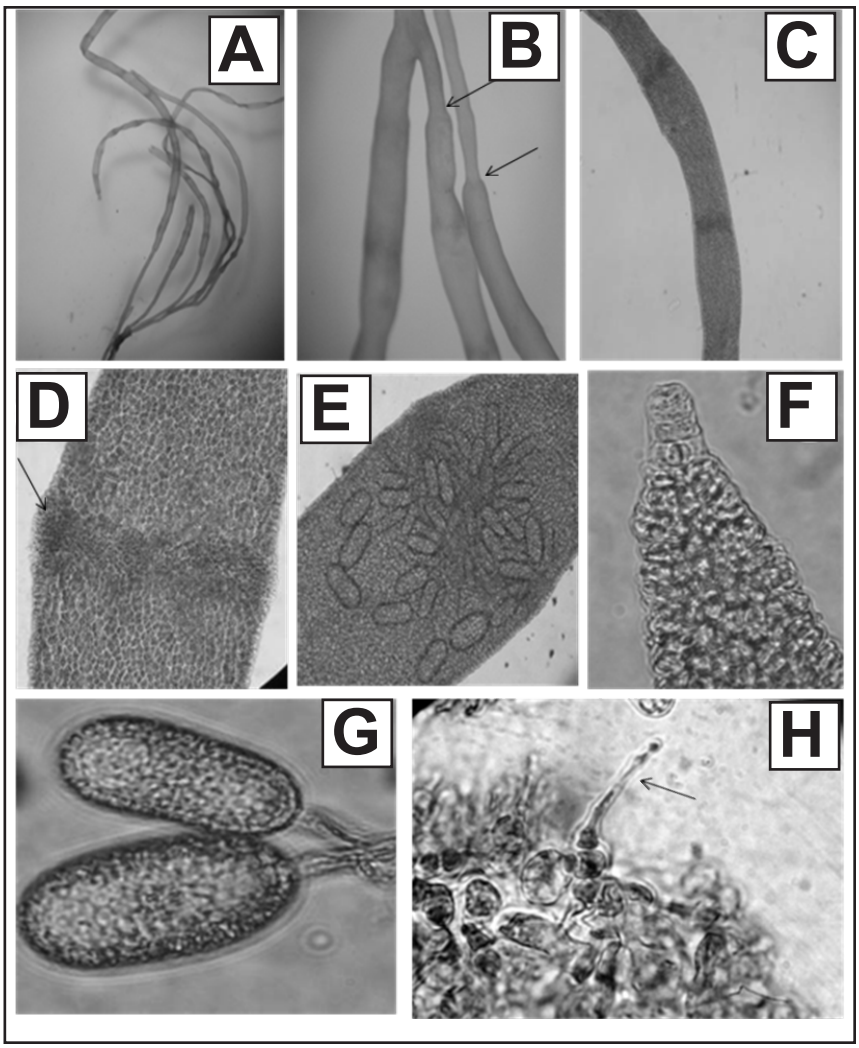


**Figure 2.** Habit and peculiarities of *Lemanea fluviatilis* (L.) C.Ag. in a Meitei community market, Manipur, India. **A**: Habit, **B**: Thalli abruptly narrowed branches towards the base, **C**: Nodes and internodes, **D**: Sori at node, **E**: Carposporangium, **F**: Apical cell, **G**: Long cylindrical carpospore, **H**: Carpogonial branch with sessile trichogyne having spermatia at tapering tip.

***Utilization of alga as food***

As the alga grows in the rivers for only few months, particularly in winter, the local people collect the alga from the river and sun dry it for use throughout the year. The people who visit the Serou market regularly belong to the Meitei, Kuki, and/or Kuki-Chin- Mizo communities. The sun dried algae are eaten regularly with major meals. It is cooked with vegetables primarily for its characteristic fishy smell. The dried filaments are also added to **Singju** (a local preparation) to make a Manipuri delicacy. These plants are conveniently served in chutney (a sour preparation) or as a vegetable in dried, fried or roasted form.

## Discussion

***Ethnopharmacological Uses***

Ethnopharmacological uses of this alga are as follows: (1) a boiled extract of fresh filaments is prescribed as an abortive measure particularly for removing placenta when it is obstructed during childbirth by the **Maiba** and **Maibi** in the Sugnu and Serou areas, (2) **Nungsham** is also used as an aphrodisiac, (3) it is given twice a day for about 10 days to relieve urinary trouble due to kidney stones, and (4) algal filaments are roasted in the fire and the aqueous filtrate is consumed to treat diabetes.


**Figure 3.** Habitat, collection and selling of the alga. **A**: *Lemanea fluviatilis* (L.) C.Ag. colonized in the river during peak of winter season. **B**: Tribal woman collecting the alga in the Chakpi river. **C**: Tribal women selling *L. fluviatilis* in a Meitei community market, Manipur, India.

***Nutritional value and future prospects***

Deb (1974) reported the present alga as *L. australis* and found the species to be rich in proteins and carbohydrates, suggesting its nutritional importance. Bhosale *et al.* (2010) studied *L. fluviatilis* from Manipur and determined the amino acid and fatty acid (FA) composition, silver content, total protein, lipids, and carbohydrates of the alga. The alga under study revealed low lipid content (2.4%) and proved to be a rich source of carbohydrates (55.8%). This alga contains about 24% protein. All essential amino acids were detected and the alga displayed uniquely high concentrations of aspartic acid (31.7%). The most abundant fatty acids were palmitic acid, docosadienoic acid, erucic acid and oleic acid. The total polyunsaturated fatty acid (PUFA) content obtained was 24.5% with the presence

**Table 1.** Morphometric features of *Lemanea fluviatilis* (L.) C.Ag. from Manipur State, India.

| Morphological Character | Dimensions |
|---|---|
| Plant length | 5-7 cm |
| Nodal diameter | 286-527 µm |
| Carpogonial branch number | 3-4 |
| Internodal | |
| -Height | 678-1583 µm |
| -Diameter | 226-407 µm |
| Carpogonium | |
| -Height | 6-7 µm |
| -Width | 5 µm |
| Trichogyne | |
| -Height | 64 µm |
| -Width | 3 µm |
| Spermatia | |
| -Diameter | 3 µm |
| -Length | 51-105 µm |
| Carpospore | |
| -Width | 13 µm |
| Whorl | |
| -Diameter | 256-346 µm |
| Basal Cell | |
| -Number | 2-3 |
| -Diameter | 8 µm |

of pharmaceutically important eicosapentaenoic acid (1%). Interestingly, the FA distribution in this alga showed high levels (90.3%) of long chain fatty acids (LCFA) and demonstrated a nutritionally ideal n-6/n-3 FA ratio (2:1). Presence of silver (9.31µg/g) has also been reported in this alga. Silver ions and silver compounds are known to exhibit antimicrobial, anti-disease properties (Russell & Hugo 1994). In Ayurveda, silver is known for its rejuvenating and anti-aging properties. The use of silver leaf to garnish food and sweets on auspicious occasions in India is a century-old tradition. Silver is highly edible, and practitioners of ancient Indian medicine claim it is good for health, particularly the heart (Kenneth 1970). Plants are known to be used as an indicator of economic deposits (Cannon 1971). Presence of silver as a trace element in the plant has been highlighted, necessitating a thorough survey of the region.

The alga has been in use among the Manipuri people since ancient times as food as well as for its ethnopharmacological utility. The indiscriminate harvesting of the alga and anthropogenic disturbances is believed to have caused gradual depletion of the algal population. The genus *Lemanea* is known to occur in India only from the state of Manipur; therefore it is essential to take conservation measures for its sustainable growth and utilization. However, no information is available on the life cycle of the alga and the physicochemical features of water in which the alga grows. It is also deemed necessary to undertake detailed studies on the pharmaceutical values of the alga, quality changes due to storage, as well as toxicological effects, if any.

***Acknowledgements***

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**Appendix 1.** Semi-structured questionnaire, used for data collection on the ethnobotanical and related information in community use and knowledge of *Lemanea fluviatilis* (L.) C.Ag.

**SEMI-STRUCTURED QUESTIONNAIRE**

Locality of the algal collection site:
Date:
Collection No.:
Scientific Name of the species collected:
Location of Interview:

1. Name of the respondent:
2. Age & sex:
3. Profession:
4. Distribution (rare or abundant stating reasons why):
5. Changes in abundance of the species for the last 10 yrs (more abundant/same/rare):
6. Habitat profile:
7. Diseases treated:
8. Methods of preparation of medicine (dosage):
9. Used singly or in combination with other plant parts etc.:
10. Amount collected per year:
11. Is it sold? (Quantity sold per day/month/year):
12. Who are the buyers? (Price/kg):
13. Condition of the plant sold (dry/fresh):
14. Brought to the market (daily/weekly/monthly):
15. Percentage of the people in the area doing the business:
16. Availability period:
17. Any side effects reported:
18. What kinds of traditional methods are being used for the processing after harvesting:
19. Any food value (mode of preparation):
20. Any other uses other than medicine:
21. Traditional beliefs associated with the harvest and use of alga: