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ON SOME EDIBLE AQUATIC FLORA AND FAUNA OF NORTHERN THAILAND–THEIR MORPHOLOGY, ECOLOGICAL DISTRIBUTION AND THEIR UTILIZAION

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Several kinds of aquatic microscopic plants both the Cryptogams and the Phanerogams are being utilized as food by the people of Northern and North-eastern Thailand. The plants are collected from natural waters and are considered in the past and at present more as a delicacy than as a source of nutritious food. As the availability of some of these plants is subjected to seasonal variations and ecological conditions of the habitat, together with the fact that they have to be collected and freshly consumed, few people has the chance to include them in the items of their diet; even though this eating habit is known to them. Hardly any body of water, where algae and other aquatic plants thrive, is devoid of animal life–especially insects' larvae. It is therefore unavoidable–when collecting aquatic plants that these animals are unintentionally and intentionally constitute part of the diet, or vice versa. There are enough of indications to believe that certain algae and most of the edible insects' larvae are of high nutritive value. There are many reasons why this habit has never achieved popularity throughout Thailand; these are, limited supply in natural waters, inaesthetical appearances, decreasing unpolluted habitat in which these organisms grow, availability of other food matter and finally fast changing of food habit, whereas edible freshwater algae and insects' larvae are mostly well known in the mountainous areas of Northern Thailand and the agricultural poor region of Northeastern Thailand.

As it is difficult to distinguish one kind of algae from another with the naked eyes, and, as many species (of algae) look very much alike; it does occur that different kinds of algae have been eaten in the assumption that they are of the same identity.

Also due to the fact that these inhabitants of flowing and stagnant water bodies are uilized by numerous small groups of people, the same food items are known under different names.

The author is convinced that there are a lot more edible algae and insects' larvae that can be and are being utilized by the people in Thailand, however, this article only concerns with the findings made in Northern Thailand dealing with some of the most well-known edible algae and insects' larvae; what they are, where to find them and how to utilize them as food.

Among the Phanerogams one very well known species, i.e. *Wolffia* sp. (Fig. 1) is presented. *Wolffia* or pigmy duck's meat belonging to the family Lemnaceae is known as Khai nam (Water egg) or Puem. The plant which is not bigger than one mieelimetre is considered the smallest of all the flowering plants, and has been very often mistaken as algae. Due to entrapped air in cell compartments the bright green thallus, which is devoid of roots, floats on the water surface. Reproduction (HAUSMAN 1936) is achieved by budding, thus this plant will form a more or less extensive mat that can cover the total surface area of small standing water areas such as stagnant pools, fish ponds or it can be concentrated on one side of a water body by wind action.

It is stated that under high light illumination the plants will manufacture starch, becomes heavier and will sink to the bottom of the pond. It will spend the time in the mud probably forming a kind of spore and will rise again when condition is "favourable" (HAUSMAN 1936). Very little is known about the mineral composition of the water where *Wolffia* grows, why at certain time a water body is covered with this minute plants and at another time it is devoid of *Wolffia*.

According to the people of Chiang Mai *Wolffia* does occur throughout the year in more or less abundance in natural stagnant waters, in rice fields and in khlongs (canals). As this plant has gained popularity in the diet of northern people and can be bought at the local morning market, many fish farmers and gardeners, who possess ponds or natural closed water areas, preferred to utilize the water body for the cultivation

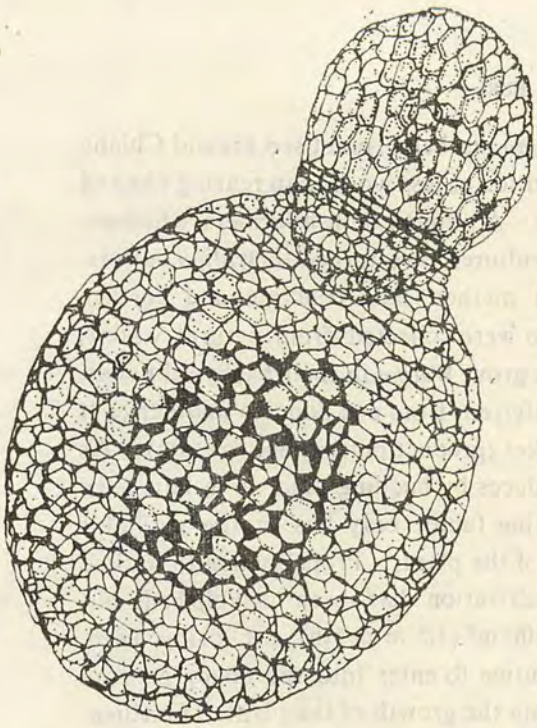

Fig. 1 : *Wolffia* sp. natural size one mm. Plant showing budding system.

Fig. 2 : *Nostoc* sp. A. Growth in natural size; B. Cross section of mucilage masses; C. Surface structure formed by numerous filaments; D. Filaments enlarge.

of *Wolffia*. In fact growing *Wolffia*, as being practised around Chiang Mai, demands practically no attention or less work than rearing fihs and brings in satisfactory side income. A number of fish farmers, who have been less successful with *Tilapia* culture, have turned to *Wolffia* culture. In this very extensive cultivation method both concrete and earthen ponds can be used. The inoculum were collected from natural waters, however, as more and more people grow *Wolffia* in their backyard ponds, the inoculum can be easily transferred from one pond to another or it can be bought fresh from the market (product putting out for sale). As mentioned above, *Wolffia* reproduces by budding thus it is harvested when there is demand. The limiting factor only lies in the available water surface and less in the age of the plant. Probably due to limited market no commercial scale cultivation has been established, but converted fish ponds of 400–600 m^2 (1,5 m depth) are being used. Except to prevent man made pollution to enter into the pond, no care has to be taken in order to promote the growth of the plant. Fertilization derives from rain, from surface run off and from decaying leaves. Concrete pond is said to yield better growth than earth pond. Once in a year usually during summer period the water is completely drained and filled with new well water or left alone allowing ground water to gradually seep in. (Water quality as measured from one concrete pond in winter; pond surface covered with *Wolffia* ready for harvesting are as followed : total N 54.36 mg/100ml, no NH_4, no P, Inorganic 7.73 mg/100 ml, total solid 23.1 mg/100 ml, Organic 15.3 mg/100 ml, suspended solid 4.47 mg/100 ml ɣ pH 5–5.5)

When harvesting the swimming plants are concentrated into one corner of the pond using floating bamboo poles. A filtering contraption (similiar to devices for collecting small shrimps and fish in shallow water) is made out of two layer of net size; the one on top is of bigger mesh size and serves as a pre-filter for unwanted floating materials such as leaves and part of branches, which are naturally among the *Wolffia* plants. The second filter is made of fine nylon net to hold back the plantlets, which have passed through the first filter. The product is then washed several times with clean water and put for sale on the morning market at the price of approximately 5 Baht

per kilo. As a production of 10 grams per m^2 per day can be achieved, a pond of 400 m^2 during favourable time can bring in an income of 20 Baht per day. (Naturally it is inevitable that *Wolffia* product contains a certain amount of insects larvae, frog eggs and others which is objected by some people).

In contrary the Cryptogams is presented by many kinds of fresh-water algae. Several works have been done on the edible fresh and brackish water algae. Probably the most well known are blue-green algae *Spirulina platensis* of Africa and Mexico. In the Far East and on the main land China the blue-green algae *Nostoc* seems to be dominating the scene.

SMITH (1933) stated for the first time that "Under the names of Dok hin (rock flower) and Kai Hin (rock egg) the people of the Chiengmai region in North Siam designate small dark green spheroidal plants which grow in abundance in clear, cool streams attached to the top, sides, and under-surfaces of stones and boulders. The plants when apparently full-grown are 10 to 15 mm. in diameter, and have a bladder-like form, a gelatinous consistency and rather thick walls that are complete except at the place of attachment to the stones". JOHNSTON (1970) believes that the blue-green alga species mentioned by SMITH (1933) can be referred to the species of *Stratonostoc verrucosum* (ELENKIN 1931).

The edible blue-green algae (Family Nostocaceae), which are known as Dok hin or Khai hin in North Thailand, belong to two genera : *Nostoc* (Fig. 2) and *Nostochopsis* (Fig. 3). The algae occupy very definite (limited) zone and can be found nearly exclusively in cold mountain streams. As one of the blue-green, *Nostoc* sp. is confined to swiftly flowing water, clinging to rock surface especially in the most torrential part of the stream such as the middle portion of the torrent or directly beneath riffles and waterfalls, whereas *Nostochopsis* sp. is found in less torrential part of the stream; it seems that SMITH's (1933) finding at the Mae Klang River is identical with *Nostochopsis* sp. and not *Nostoc* sp. Apart from the description of collecting locaton the size of the gelatinous masses (10–15 mm in diameter) also fits well with the

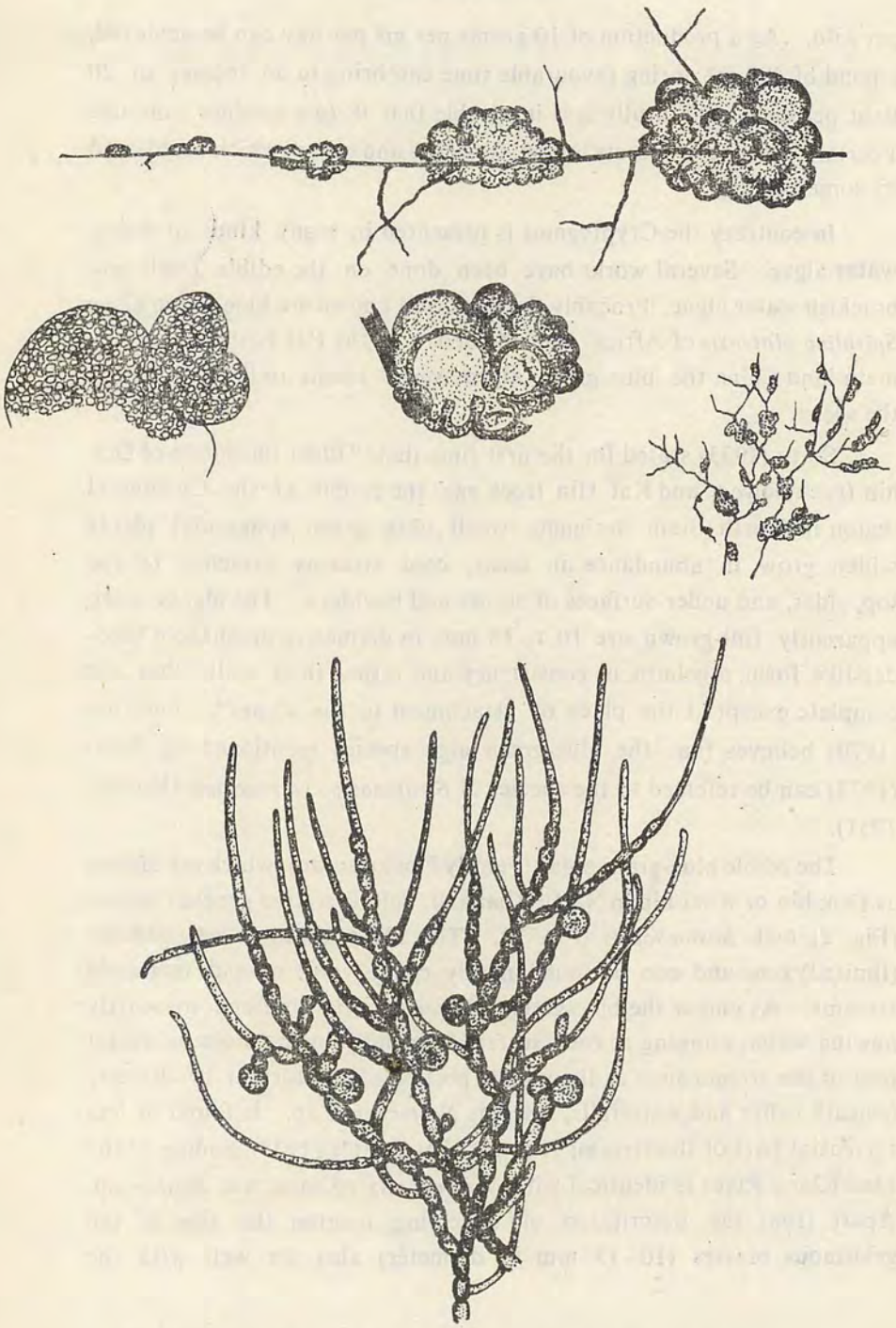

Fig. 3 : *Nostochopsis* sp. Filament enlarged showing heterocysts.

findings of the author. [SMITH's (1933) finding was made on February 8, 1932; the author's finding on February 7-15, 1977) Mae Klang Falls (Doi Inthanon].

Nostoc sp. has an undefined gelatinous masses, which are formed by innumerable contorted threads of rounded or oval cells that aggregate within a more or less firm surface of mucilage body covering the colony (FRITSCH 1965). In the big colony the threads are compactly entangled in globular mass forming tubercular growth. This greenish brown mass can reach the size of many centimetres in diameter. The colour of the gelatinous mass, the colour of the rock substrate on which the algae grow and the water splashing over it made it very inconspicious, and is not easily detected by inexperience eyes. In order to collect this mountain stream *Nostoc* which happens to grow directly in the falls, one would need some experiences in climbing on and clinging to the slippery rocks. Local villagers can quickly identify locality under the falls where *Nostoc* are abunant, they skillfully climb into the falls and scrape the plants from the rocks with their fingers, and put them into baskets attached to their waists.

Not restricted only within a narrow range of the stream like *Nostoc* there are little green gelatinous mass of blue-green algae, which is submersed attaching to rock surface in the stream side or in pools with slow water movement. Local people call this algae also Khai hin which has been identified as belonging to the genus *Nostochopsis*. Because of their small size (in cold mountain streams) villagers usually preferred to collect only *Nostoc*.

The outer appearance of both genera are very similiar. The compact aggregate of *Nostochopsis* is formed by radiately arranged trichomes which are confusely branched within the mucilage. Some of the branches are short and ended with a heterocyst. Hormogonia are formed from entire lateral branch (FRITSCH 1965; FOTT 1971). The dense filament tapering ends protude outwards forming the mantle of the plant nodules.

As Noctocaceae is usually described as a defined globular shape growing in slow moving water, in stagnant water, in rice fields or moist areas; it is assumed that the above *Nostoc* sp., which has a very undefinite shape of the colony, probably derive from the constant pounding of the water. (Differences in morphological character induced by environmental factors.)

According to local informations Khai hin or Dok hin only occurs in the dry season during winter months when water is cold, clear and at its lowest level in the stream. In the rainy season sand, silt or other solid matter deriving from soil erosion, carried along by the water, will act like sand paper scraping on the algae body and preventing growth. That there are reduction in growth with the increase in silt content in the water has been confirmed by observation in August 1977.

Exactly in the same habitat, where *Nostochopsis* grows, there are also a kind of green algae which forms gelatinous balls. Although its colour is pale green (whereas *Nostochopsis* more brownish) its outer appearance both in size and forms does not differ much from *Nostochopsis*. The green algae identified as belonging to the family Chaetophoraceae, *Chaetophora* sp. (Fig. 4) are quite common in the Mae Klang stream. Threads are held within a compact mucilagenous envelope forming globular structure. Filaments radiated outwards. Towards the end of the branches more dichotomous branching are formed. Branch ends are often prolonged into hairs (FRITSCH 1965; PRESCOTT 1970). It can be assumed that *Chaetophora* have always been collected together with other Nostocaceae and consequently unknowingly included in the algal diet.

Apart from the above mentioned algal species there are many other, which grow in the same habitat, attached to submerged rocks or vegetation forming also gelatinous tegument. However, due to their small size and scarcity it can be assumed that these algae are of no significance as food and thus also have not been mistaken as Khai hin or Dok hin; these are the blue-green *Aphanocapsa* sp. or *Heterogloea* sp. (Fig. 5) belonging to the division Chrysophyta. Both algal species have their cells more or less distributed throughout the mucilage. The tubercular yellowish green colonies can reach the size of 1 cm in diameter.

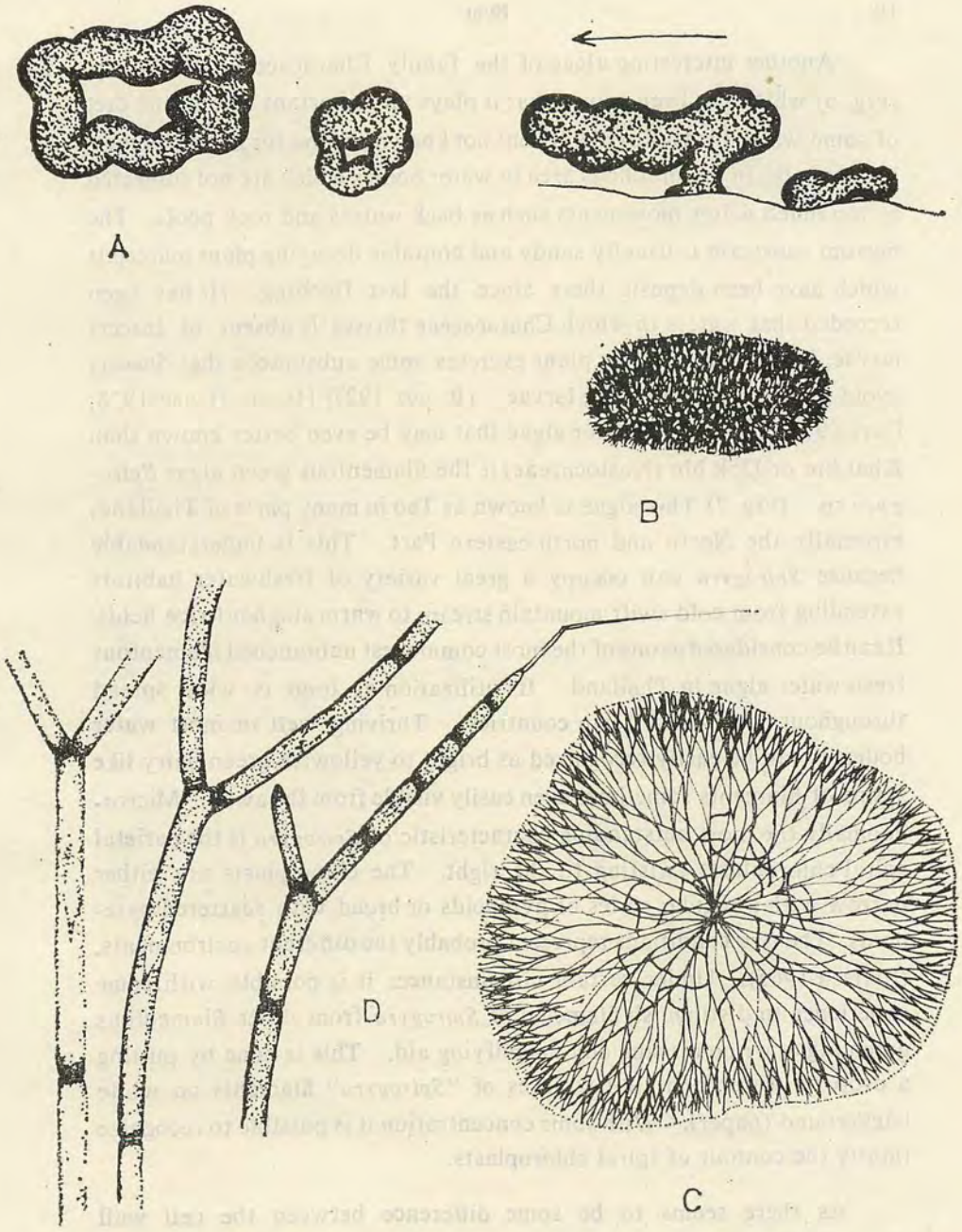

Fig. 4 : *Chaetophora* sp. A. Growth forms in running waters; B. Surface structure formed by filaments ending; C. Enlarged crossection (schematic); D. Dichotomous branch & branch ends.

Another interesting algae of the family Characaceae, *Nitella* sp. (Fig. 6) which has been known that it plays an important role in the diet of some water birds (FOTT 1971) but not known as food for human beings, is found also in mountainous area in water bodies which are not subjected to too much water movements such as back waters and rock pools. The bottom substrate is usually sandy and contains decaying plant materials which have been deposit there since the last flooding. (It has been recorded that waters in which Characaceae thrives is absent of insects larvae, indicating that this plant excretes some substances that insects avoid or that is toxic for the larvae. (BUIHOT 1927; HAMLIN-HARRIS 1928; FOTT 1971) Edible freshwater algae that may be even better known than Khai hin or Dok hin (Nostocaceae) is the filamentous green algae *Spirogyra* sp. (Fig. 7) This algae is known as Tao in many parts of Thailand, especially the North and north-eastern Part. This is understandable because *Spirogyra* can occupy a great variety of freshwater habitats extending from cold swift mountain stream to warm stagnant rice fields. It can be considered as one of the most commonest unbranched filamentous fresh water algae in Thailand. Its utilization as food is wide spread throughout South-East Asian countries. Thriving well in most water bodies it can be easily recognized as bright to yellowish green hairy like stains of filaments sometimes even easily visible from far away. Microscopically the most outstanding characteristic of *Spirogyra* is the parietal spiral chloroplasts twisting to the right. The chloroplasts are either narrow with a regular series of pyrenoids or broad with scattered pyrenoids. The two conditions represent probably the different environments. (FRITSCH 1965). Under certain circumstances it is possible with some experience to distinguish filaments of *Spirogyra* from other filamentous green algae without using any magnifying aid. This is done by putting a drop of water containing pieces of "*Spirogyra*" filaments on white background (paper). With some concentration it is possible to recognize faintly the contour of spiral chloroplasts.

As there seems to be some difference between the cell wall structure (fibre) of *Spirogyra* growing in cold water and of those growing in warm water, the algal filament that is used for consumption derives

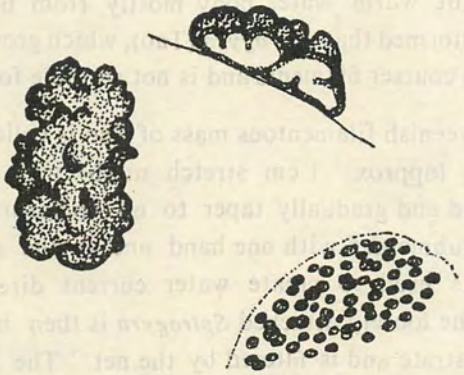

Fig. 5 : Blue-green & green algae forming gelatinous masses *Aphanocapsa* sp. and *Heterogloea* sp.

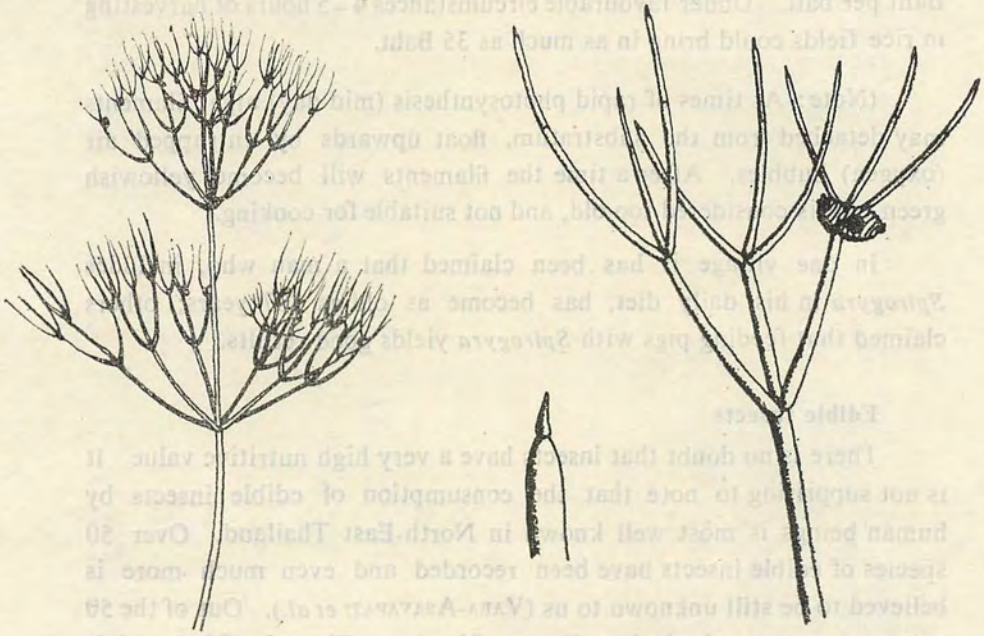

Fig. 6 : *Nitella* sp. Filament structure.

only from stagnant warm water body mostly from firiceelds. The author has been informed that *Spirogyra* (Tao), which grows in mountain streams, possesses courser filaments and is not suitable for cooking.

The slimy greenish filamentous mass of Tao is collected by using conical shape net (approx. 1 cm stretch mesh) with a fixed (stiff) opening on one end and gradually taper to an enclosure on the other end. The net is submerged with one hand and at the same time the other free hand is used to create water current directing into the collecting net. The loosely attached *Spirogyra* is then being ripped off from the mud substrate and is filtered by the net. The algal filaments are washed several times with clean water in order to get rid of mud or sand particles. This procedure also seperates insects' larvae which thrive on and in between the filaments. The cleaned filaments are then squeezed dry and formed into balls of the size of tennis ball weighing approximately 70 gramms and sold on the market at the price of .50 Baht per ball. Under favourable circumstances 4–5 hours of harvesting in rice fields could bring in as much as 35 Baht.

(Note: At times of rapid photosynthesis (mid day) algal filaments may detached from the substratum, float upwards by entrapped air (oxygen) bubbles. After a time the filaments will become yellowish green and is considered too old, and not suitable for cooking.

In one village it has been claimed that a man who, includes *Spirogyra* in his daily diet, has become as old as 107 years; others claimed that feeding pigs with *Spirogyra* yields good results.

Edible Insects

There is no doubt that insects have a very high nutritive value. It is not supprising to note that the consumption of edible insects by human beings is most well known in North-East Thailand. Over 50 species of edible insects have been recorded and even much more is believed to be still unknown to us (VARA-ASAVAPATI *et al.*). Out of the 50 species many are only the larval stage of insects. The animal in its adult stage is not consumed. Many of these larvae spend their time in aquatic environment browsing on sediments or algal coatings. Some occur in

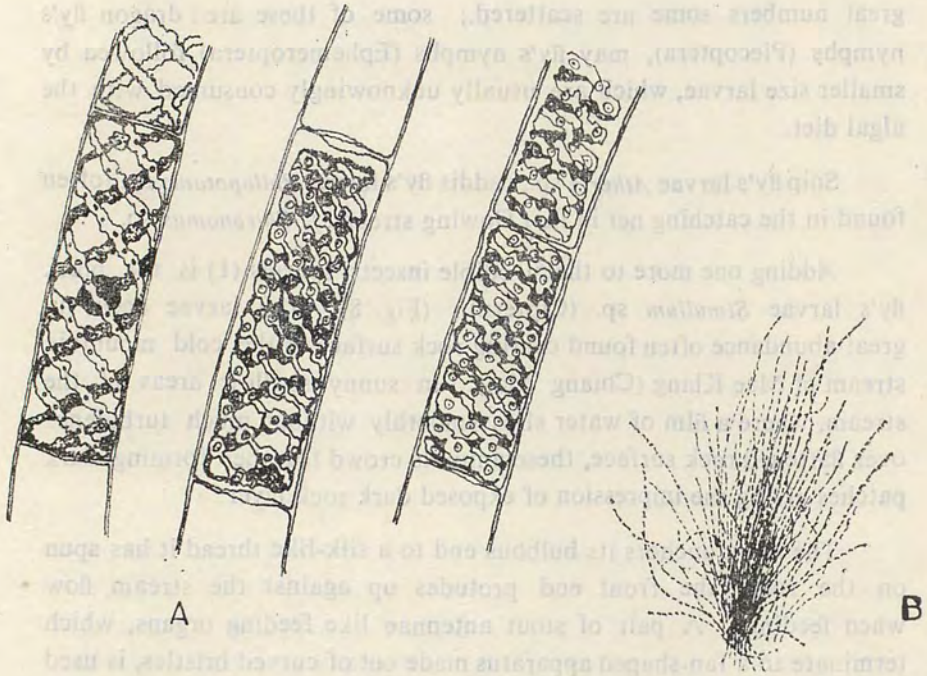

Fig. 7 : *Spirogyra* sp. showing : A. Different chloroplast formation; B. Filament masses.

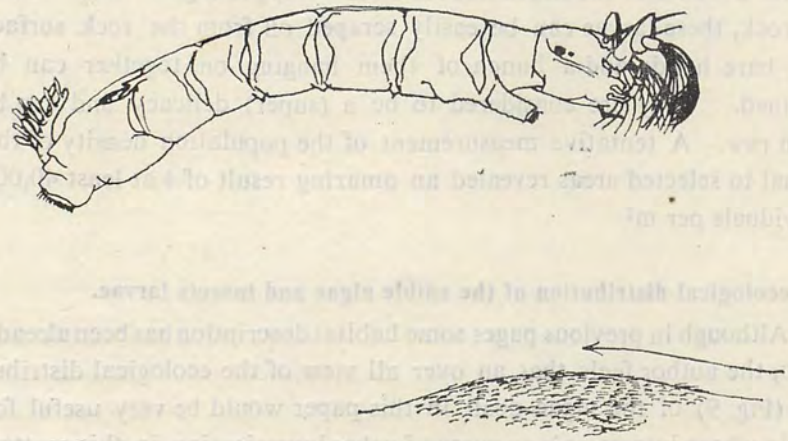

Fig. 8 : *Simulium* larvae population on submerged rocks (schematic).

great numbers some are scattered.; some of these are: dragon fly's nymphs (Plecoptera), may fly's nymphs (Ephemeroptera) followed by smaller size larvae, which are usually unknowingly consumed with the algal diet.

Snip fly's larvae *Atherix* sp., caddis fly's larvae *Philopotams* sp. (often found in the catching net in fast flowing streams), *Chironomus* sp.

Adding one more to the 50 edible insects species (1) is the black fly's larvae *Simulium* sp. (Ciptera). (Fig. 8). The larvae occur in great abundance often found coating rock surface in the cold mountain stream of Mae Klang (Chiang Mai). In sunny shallow areas of the stream, where a film of water slips smoothly without much turbulence over flattened rock surface, these animals crowd together forming dark patches giving the impression of exposed dark rock layer.

The larva anchors its bulbous end to a silk-like thread it has spun on the rock, the front end protudes up against the stream flow when feeding. A pair of stout antennae like feeding organs, which terminate in a fan-shaped apparatus made out of curved bristles, is used to filter out food particles (mostly diatoms) carried by the stream. The animal shows very high sensitivity towards light fluctuation and will contract its body swiftly if a sudden shadow is caused by body movements. Because of the silken line fastened the appendage of the larvae to the rock, these larvae can be easily scraped off from the rock surface with bare hands and a bunch of them hanging on together can be obtained. They are considered to be a (super) delicacy and can be eaten raw. A tentative measurement of the population density of this animal in selected areas revealed an amazing result of 4 at least 40,000 individuals per m^2

The ecological distribution of the edible algae and insects larvae.

Although in previous pages some habitat description has been already given, the author feels that an over all view of the ecological distribution (Fig. 9) of the algae dealt in this paper would be very useful for people whose intererest is to pursue further investigation in this matter; because without some luck and the help of local villagers it would be

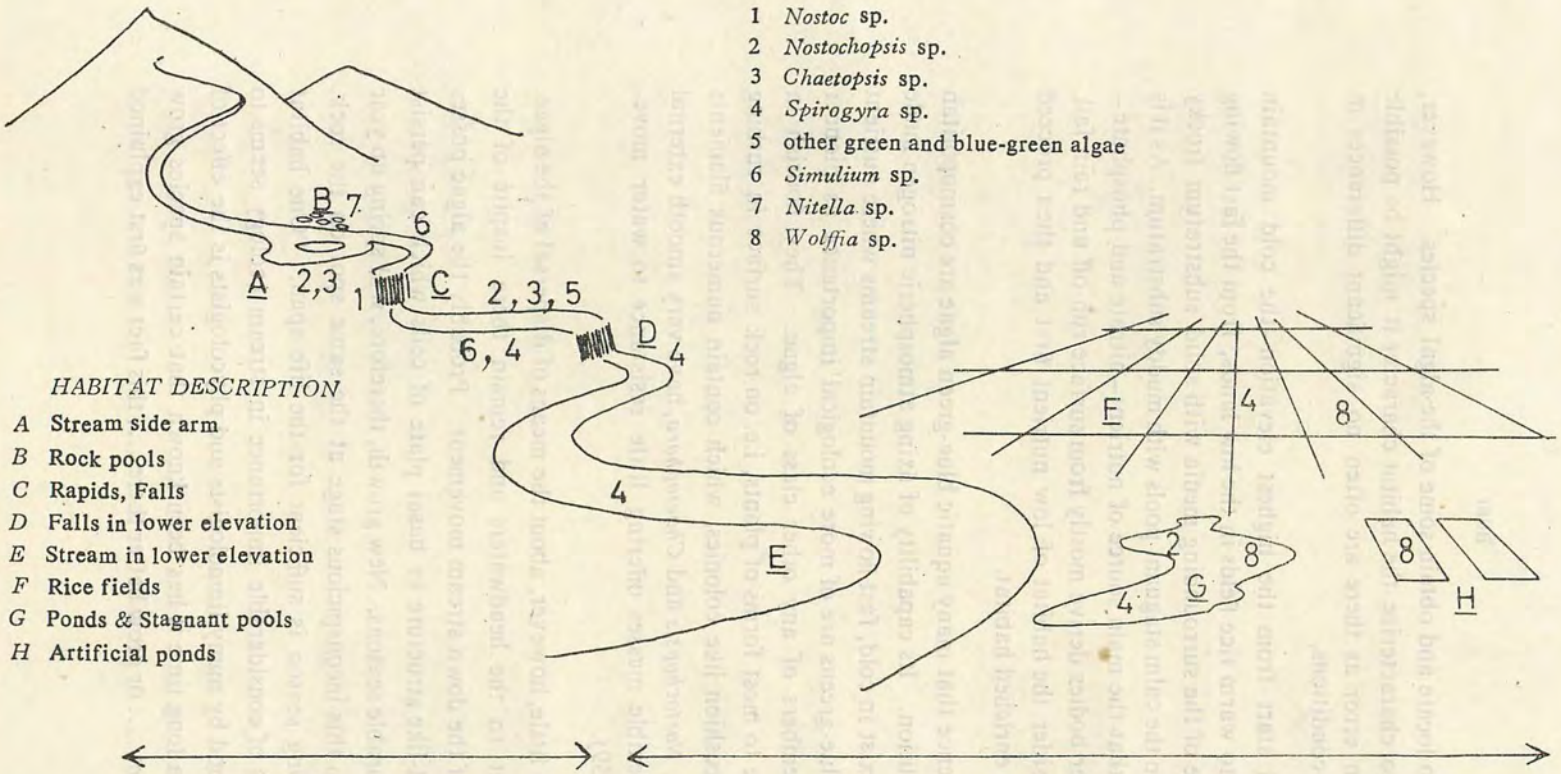

Fig. 9 : Ecological distribution chart for edible algae of North Thailand

very difficult to locate and obtain some of the algal species. However, in attempting to characterize the habitat character it might be possible that we are in error as there are often no significant differences in environmental conditions.

We will start from the highest elevation–the cold mountain stream–down to warm rice fields in the low lands, from the fast flowing unstable nature of the surrounding media with solid substratum (rocky underground) to the calm stagnant pools with muddy substratum. As it is generally true that the main source of nutrient–nitrate and phosphate–in natural water bodies derive mostly from surface run-off and rain fall, we would consider the habitat of low nutrient first and then proceed to the nutrient enriched habitat.

It is evidence that many aquatic blue-green algae are cosmopolitan in their distribution. Its capability of fixing atmospheric nitrogen made it possible to exist in cold, fast flowing mountain streams where nutrient is low. The blue-greens are of more ecological importance as pioneer forms than members of any other class of algae. They flourish in habitats hostile to most forms of plants, i.e. on rock surface in rushing waters. The cushion like colonies, which contain numerous filaments such as *Nostoc*, *Nostochopsis* and *Chaetophora*, have very smooth external surface and flexible masses offering little resistance to water movement (BLUM 1959).

We know little, however, about the means of dispersal of the algae. How they get to the headwaters and remain there inspite of the continuation of the down stream movement. Probably the algae posses a basal rhizoid-like structure or basal plate of cells which can persist during unfavourable seasons. New growth, therefore, will spring up year after year from this inconspicious stage at the same spot on the rock. A single growing season is sufficient for the life span. "One habitat factor which is of considerable importance in stream ecology seems to be misunderstood by many limnologists and phycologists is the effect of current. For a long time it has been known that certain species grow only in a current .... or grow better there .... this fact was first explained

by assuming that running water has a higher content of dissolved gases and a lower temperature than still water. .. there is now much evidence that these assumptions are incorrect... (BLUM 1959). Ruttner (1926) seems to have offered the first explanation, that in a rapid current there is a continuous exchange of water mass–new portion of nutrient–eventhough it is not absolutely but rather physiologically rich in nutrients. As already mentioned *Nostoc* sp. (Khai hin) is abundant only within a narrow range of the stream habitat. It thrives on rock substratum that is subjected to the most torrential current in fast flowing part of the mountain stream and in the falls itself. Findings have shown that luxuriant growth are found solely in Mae Klang stream (Falls). This mountain stream has its origin in Doi Intanon (2300 m) and other neighbouring mountains of over 1800 m (Water analysis : no NH_4, no N, no P, inorganic 4.3 mg/100 ml, total solid 6.64 mg/100 ml, organic matter 2.3 mg/100ml and suspended solid 0.9 mg/100ml). However, the Mae Sa Falls which has its headwater in Doi Khom Rong (1459 m) is at the same time seems to be devoid of this mountain stream *Nostoc* sp. This is also valid for many other mountain streams in North Thailand such as Mae Mao River originated from Doi Laem (1668 m) in Fang, Mae Ngan Noi (Fang) and mountain streams on Doi Pui (1685 m), Chiang Mai. This finding is supported by the fact that mountain stream Khai hin is practically unknown to local villagers in these areas excluding Mae Klang. Also it should be noted that *Nostoc* sp. is difficult to obtain because its growth is of seasonal periodicity.

Only few metres away from this fast flowing part of the stream (riffles and falls) in shallower water, where current along the side and bottom is slow or retarded by irregularities of the stream flow (side arm of stream or stream area with lower elevation differences), one would find instead of *Nostoc* sp. other gelatinous masses of *Nostochopsis* sp., *Chaetophora* sp. and other blue-green algae which occur only sparelingly. Among dense growth of macrophytes in stagnant rock pools or in stream area, where exchange of water is very slow, *Nitella* sp. or *Spirogyra* sp. could be found. On areas where a film of water continuously overflows flat rock surface *Simulium* larvae thrive forming large patches of dense black mats.

It is interesting to note that water falls in the low land has no distinctive algal communities but is rather similar to the slow moving streams. The vegetation is dominated by the filamentous *Spirogyra* which cover extensive areas– on rocks boulders, tree trunks and any solid substratum. This greenish hair–like appearance is found extensively in streams as long as solid substratum is offering for attachment, and decreases as the river beds and banks become more and more sandy and muddy; there will be relatively vacant spaces. Until again in stagnant pools and rice fields one would find *Spirogyra* loosely attached or floating in masses. These water areas comparing to the other mentioned habitat are quite rich in nutrient with total N of 81.5 mgN/100ml, inorganic 24.6mg/100ml, total solid 31.1 mg/100ml and organic 6.5mg/100ml.

Only *Wolffia* sp. shows clearly its preference for stagnant, warm habitat. It is found in large watershed in area that is less subjected to wind blow, in rice fields, pools, klongs and fish ponds.

Recipe for edible algae and Simulium larvae

Fried Wolffia with curry paste

Ingredients

dried chilli
shallot
galanga
lemon grass
garlic
shrimp paste
fish sauce
M S.G + Ribotide
kaffir lime

Prodecure

Pannel dried chilli, shallot, galanga, lemon grass garlic, shrimp paste all together and fried in hot oil. Add Wolffia, fish sauce, M.S.G. + Ribotide cook until done then add kaffir lime loaf.

Spirogyra and Wolffia salad

Ingredients

galanga
lemon grass
chilli (small)
pea-nut
dried fish or field crab
Spirogyra
fermented fish (Pla ra)

Procedure

Cut galanga, lemon grass, chilli to small pieces, ground peanut, boiled field crab or bake dried fish until done.

Combine all ingredients add Spirogyra and Wolffia, fermented fish and peanut.

Fried Spirogyra

Ingredients

garlic
vegetable oil
fish sauce

Procedure

Chopped garlic and fried in hot oil until light brown. Add Spirogyra and fish sauce.

Spirogyra soup with fish

Ingredients

fish or field crab
Spirogyra
garlic
vegetable oil
fish sauce

Procedure

Boiled water, add fish or field crab, and Spirogyra; cook until done, add fish sauce and chopped garlic (fried with hot oil).

Sour soup Nostoc

Ingredients

fish (cut small pieces)
fermented fish
beans
Nostoc, Nostochopsis
hot pepper
lemon grass (cut small pieces)
lime juice
kaffir lime

Procedure

Boiled water add fish, fermented fish, beans, lemon grass, Nostoc, and kaffir lime; then add fish sauce and lime juice and hot pepper.

Simulium sour soup

Ingredients

Simulium larvae
olive (cut small pieces)
dried pork skin (fried in hot oil)
green onion
fish sauce
hot pepper
M.S.G. + Rebotide
lime juice

Procedure

Boiled water add worms, dried pork skin, olive and green onion; cook until done, add fish sauce, lime juice hot pepper and M.S.G. + Rebotide.

This study has shown that the criteria for the utilization of some slimy masses found on rocks as food is greatly affected by the environmental condition it is found, its outer appearance, its texture and taste and finally its availability. In many instances algae and insects are not eaten because of hunger but solely because of its delicate taste.

Of all the edible plants and animals described in this paper only *Wolffia* seems to be suitable for cultivation. Although in North Thailand this is being very extensively done, cultivation of *Wolffia* is quite successful, however, in order to establish commercial scale production, further studies on the life history of the plant and its environmental requirements will be needed.

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