CHAPTER II

LITERATURE REVIEW

Classification

The genus Padina Adanson is the marine algae classified in:

Division Phaeophyta

Class Isogeneratae

Order Dictyotales

Family Dictyotaceae

Genus Padina (Lewin, 1962; Tilden, 1968)

Nomenclatural History

The name of the genus Padina came from the greek "pedinos", meaning flat, level or pertaining to a plain (Tilden, 1968); the plants are flat, leafy and commonly bear tufts of fan-shaped blades and fringed along the curved upper margin by reddish or brown, soft hair, this feature reminded the early naturalist of the feathers of the peacock, so commonly known as "Peacock's tail" algae. (Thivy 1945, Tilden, 1968).

Description of the Genus Padina Adanson 1763

Plants stalked, usually erect form a creeping laterally branched rhizome, which is well seen in juvenile stage

(Plate VIII, fig.1); several blades ultimately from the same stupose base (Taylor, 1945), plant attached to the substratum by means of branched rhizoids arising from a rhizomatous basal hold-fast (Misra, 1966), upper portion broadening towards the apices forming flatten, fan-shaped blade, more or less dichotomously branched or split into narrow segments; blade generally thin and pale brown or straw color sometimes dark brown, growing from a marginal row of initial cells producing two or more celled layers, commonly whitened by a thin deposit of lime which is aragonite (orthorhombic) form (Fritsch, 1965; Lewin, 1962) on one or both surfaces. Apical margin of the blade involute, hairs richly occurred all over the surface of thallus in concentric rows (Misra, 1966) forming the piliferous zones, so that the blade zonates by piliferous lines and glabrous zones between them, blade composes of a one-layered cortex on the upper surface or a cortex on either surface, and a medulla of 1 to several layers, a cortical layer consisting of rectangular, chromatophore-bearing cell, the medulla or central tissues consisting of somewhat elongated colorless cells (Tilden, 1968); blade are two-layered in the younger portion near to the apex, three to four or more layered in the lower portion (Misra, 1966). Sporophyte produces tetraspores which formed in globular or pyriform, unilocular sporangia grouped in indusiate or non-indusiate sori which occur alternately with piliferous zones in definite relation with them on upper

or both surfaces of blade (Misra, 1966; Thivy 1945); tetrasporangia thick-walled at first, becoming thin-walled when mature. Gametophytes dioecious or monoecious; antheridial and oögonial sori in unisexual plants usually band-like with similar relation to the piliferous zones as in the tetrasporophytes; antheridial sori narrower than the tetrasporangial sori, yellow or light brown in color, sometimes naked (Taylor, 1960), antheridia columnar-rectangular containing spermatozoides, which are released by dissolution of the outer and lateral walls when mature; oögonial sori indusiate, also narrower than the tetrasporangial, dark brown in color, oögonia club-shaped or cylindrical, the wall of mature oögonia is thicker than that of mature tetrasporangia; in bisexual plants antheridial and oögonial sori are in the same band of sori or in part separated in different glabrous zones (Thivy 1945). There is an evidence of a correlation between the tetrasporangia and sex organs development with spring tidal cycles (Chapman, 1964).

The Early Development of the Thallus

In Dictyotales the germination of the tetraspores shows certain difference in the individual genus. In most genera, however, the germinating spore first produces a multicellular oval body (Plate IX, fig. 1-a) well seen in Padina. One of the superficial cells of this nodule becomes protruded to form the apical cell of cylindrical shoot (Plate IX, fig. 1-b, c)

which later flattens at its apex and slowly passes over into the adult fan-shaped blade (Plate IV, figs. 1, 2). Other cells of the nodule subsequently grow out in the same manner, although some of the resulting shoots usually remain arrested; other surface-cells give rise to rhizoids. One of its superficial cells determined by the direction of the incident light, enlarges to form an apical cell which, however, only cut off a few segments before dividing longitudinal to form a number of initials. The cells of the nodule sometimes grow out into branched uniseriate threads attached to the substratum by rhizoids and growing by means of an apical cell; from this protonema or rhizome a number of fronds arise as lateral outgrowths. More usually, however, the outgrowing cell of the nodule directly develops into a mature plant. The young frond may retain one layer for a long time (Fritsch, 1965), but this rapidly gives place to a marginal meristem occupying the almost straight front edge (Plate VIII, fig. 2). Its cells are widest at right angles to the surface. Branching of blade is due to segmentation of special wedge-shaped initials.

The Life-Cycle (Fritsch, 1965)

The life-cycle of genus Padina is isomorphic alternation of generations between gametophyte or sexual and tetrasporophyte or asexual plants, which indicates by the distribution of the reproductive organs; as a general rule, zygotes give

rise to tetrasporophyte plants, and tetraspores generally give rise to equal numbers of male and female plants, differentiation of the two sexes occur at the reduction division. Although the two generations often occur simultaneously, there is an evidence of some seasonal succession (Reinke, 1878).

I. The asexual reproduction (Fritsch, 1965)

In Dictyotales, one of the characteristic features is the forming of tetrasporangia on the sporophyte plant. The sporangial arrangement in the different genera affords features of taxonomic importance (Plate XVII, fig. 1, Plate XXIII, fig. 1). They are spherical or pear-shaped; those of Padina are pear-shaped, grouped in band-like sori, or partly punctate and partly band-like sori; with or without indusia and occurring in definite relation to the piliferous lines, on one or both surfaces of the blade, indusia persistent or evanescent. Tetrasporangia occur by superficial outgrowths, which are separated from the parent cells by a transverse septum. The sporangia generally project well above the surface. During the enlargement of the sporangium the nucleus increases greatly in size. The first nuclear division, after the basal cell has been cut off, is meiotic and follows by one mitotic division. After this the cytoplasm surrounds the four nuclei to form the naked tetraspores (Plate IX, fig. 2) which are usually arranged crosswise in the sporangium when viewed from

above, although a tetrahedral grouping is not uncommon. The mature spores generally become rounded before liberation through the gelatinised apex of the tetrasporangium. Soon after the liberation, the motionless spore secretes a cellulose membrane and then develope directly into a new plant; in fact, germination sometimes occurs within the sporangium. The developing sporangia of a sorus gradually elevate the "cuticle" usually called indusium, which may persist for a period of time as a protective covering before bursting.

II. The sexual reproduction (Fritsch, 1955)

The oögonia and antheridia are usually borne on distinct individuals (Plate XVI, figs. 1, 2) although a few species, such as P. australis and P. pavonica are monoecious (Fritsch, 1965) (Plate XVI, figs. 1, 4, Plate XXII, fig. 1). Antheridial and oögonial sori in unisexual plants usually band-like, sometimes punctate, disposed with relation to piliferous lines as in the tetrasporangial plant; antheridial sori about as wide as the tetrasporangial, yellow to light-brown; antheridia columnar-rectangular, septate into numerous cubical cells, each containing a spermatozoid (Plate XII, figs. 1, 2; Plate XIII, fig. 1) when mature undergoing dissolution of

the outer and lateral walls, as well as of the dissepiments within; oögonial sori usually narrower than the tetrasporangial, dark brown, fanshaped in sections and enveloped by persistent indusia (Taylor, 1960) (Plate XI, fig. 1), oögonia club-shaped or cylindrical (Plate XI, fig. 2) opening by an apical pore, mature oögonium has a thicker wall then the mature tetrasporangium and half to two-third of their diameter; in monoecious gametophytes, the zones of oögonial sori are interupted by antheridial sori here and there, for P. australis the antheridial sori commonly occur in every fertile zone in radial pattern (Plate XVI, fig. 1).

Taxonomic Study

For identification of the species of Padina many characteristics are used, such as sorus distribution, number of cell layers, the indusium, piliferous zones and glabrous zones, sizes of the cortical cells, diameter of sporangia, length of antheridia and distribution of sexes, etc. as stated by Dr. F. Thivy in her paper "A revision of the genus Padina Adans" (Thivy, 1945).

i. Sorus distribution

The sori arise in definite positions with reference to the piliferous zones. In general the tetrasporangial, oögonial and antheridial sori agree in distribution, but since the sporangial plants are more commonly found, their arrangement is used in identifying the species. Three primary types of sorus distribution are recognized:

a) The bands of sori occur on both side of a piliferous zone of the upper surface. (There are piliferous zones on the lower surface, which alternate with those on the upper but they are not flanked by sori). The bands of sori in a species may vary in position from touching the piliferous zones to a little distant from them.

b) Bands of sori, 1-3 in number, arise alternately with glabrous zones. (The piliferous zones are alternately on the upper and lower surfaces and sori occur above the piliferous zones of the upper surface).

c) One to five bands of sori arise in each glabrous zone.

In richly fruiting plants, besides the typical tetrasporangial sori, small scattered sori may be present in abnormal positions, as on the lower surface of the blade, in the zones that are ordinarily sterile, or in the upper part of the zones that bear normal sori, yet the typical arrangement is recognizable.

ii. Number of cell layers

Species may differ in the number of cell layers developed in the lamina, which is definite or varies by a characteristic small or large difference. The stipe shows either the same number of cell layers as the basal region of the blade or a few more. The thickness of frond, in general, appears to be proportional to the number of cell layers and in some plants of a species, by greater rigidity or opacity, appear to be thicker than the others, it is caused by the walls becoming thicker and less translucent and also by the presence of denser pigmentation, but there is actually no appreciable increase in thickness.

iii. The indusium

The outer part of the external walls of the tetrasporangium either segregate or aggregate from an indusium over the sorus, which finally breaks into fragments, or

the external walls stretch as the sporangia enlarge and the sorus is non-indusiate.

a) Persistence: The indusium in some species, after opening is seen as a flap around the sorus. The markings of cell from the surface of which it has peeled off are clearly seen on the persistent indusium. It may be "conspicuous" (visible with a hand lens) or "inconspicuous" (required magnification with a compound microscope).

b) Evanescence: The indusium while opening breaks away completely. In surface view the broken edge may be seen or not. In order to detect it, low-power magnification is necessary, but some times it is overlapped by the sporangia and can be seen only in sections of the sorus.

The oögonial sorus always has a persistent indusium which can be seen in surface view with low-power magnification. In the antheridial sorus the cuticle seperates, to some extent, but the outer and lateral walls of the antheridium and the cuticle dissolved when the antheridium is mature.

iv. Piliferous zones and glabrous zones:

The lamina is transversely divided by the piliferous lines into glabrous zones which are either alternately broad and narrow, or equal in width. In some species the piliferous lines of the lower surface do not developed.

v. Size of cortical cells

The cortical cells in each species have a definite range in cell diameter and length, the thinner species has wider and longer cortical cells than the thicker. In species with small cortical cells, these cells are one half to about one twelfth shorter than the subcortical cells and mostly one half of the width. In species with large cortical cells, they are in part one half of the length and in part the same length as the subcortical cells and mostly equal in width.

vi. Diameter of sporangia

The mature sporangia of various species are more or less equal in diameter but certain species may be separated by the constantly larger diameter of the mature sporangia, this characteristic correlates with larger size of cortical cells.

vii. Length of antheridia

Some species differ in the length of antheridia and in the ratio of length of antheridium to subcortical cell.

viii. Distribution of sexes

Some species can be distinguished definitely only by this criterion. Most species have unisexual gametophytes except in Padina australis and P. pavonica, which have the bisexual gametophytes.

Phycological Work on Padina in Thailand

Although there are several plant collections in Thailand by several botanists since 1778 (Thiemmedth, 1968) but very few phycological works have been done. The first phycological study was made by G.V. Martens (Martens, 1866), whose collection was made at Java, Singapore, Siam (Thailand nowadays), Makao, Hong Kong, Philippines and Makassar from July 25, 1860 to April, 1862; among 13 species of algae collected from Simaharadscha (called "Sri Racha" nowadays), only Zonaria gymnospora (Kütz.) Vickers which is synonym to Padina gymnospora (Kütz.) Vickers, was recorded.

Another study was made in the year 1888 by Weber van Bosse, the result was published in the Siboga-Expedition (Weber van Bosse, 1913). In this report 5 species of Padina found in Thailand were recorded, they are Padina tetrastromatica Hauck, P. pavonia Lmx. (Syn. P. pavonica (Linn.) Thivy), P. Durvillaei Bory, P. commersonii Bory (syn. P. boryana Thivy) and P. australis Hauck.

During the time of 1899 - 1900, Johannes Schmidt collected 669 species of algae in addition to the flowering plants and cryptogams. These species were macroscopic and microscopic algae of the surrounding sea of Koh[1] Chang, an island off the east coast of the Gulf of Siam[2] (Schmidt, 1900 - 1916).

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1 Koh = Island

2 Gulf of Thailand now

Dr. Schmidt was the botanist of the Danish Scientific Expedition arrived in Siam in the latter half of December 1866. Schmidt's resultant collections included 521 species of flowering plants, 72 ferns, 61 mosses, 95 lichens, 95 fungi and 669 algae, 38 of which were described as new. Among these only one species of Padina was recorded; it was P. commersonii, the results were published, under the title "Flora of Koh Chang" in the Botanisk Tidsskrift (XXIV - XXXII (1901 - 1915)). The collections are in the Universities Botanical Museum, Copenhagen

On March 28, 1953 another collection was made by E. Yale Dawson, who make the collection in the vicinity of the northern-most rocky outcrop in the Gulf of Thailand near the resort village of Saen Soek (or Bang Saen). The results were published under the title "Notes on tropical Pacific marine algae" in the Bulletin, Sounthern California Academy of Sciences, vol 53. Among 23 species listed, there was only one species of Padina, that was P. tetrastromatica (Dawson, 1954).

In 1956 another study on marine algae was made by Lois Egerod (Egerod, 1971), the collection was made on October 25, from Koh Charn, an island 8 kilometers offshore from Khlong Wan Village near the Prachuap Fisheries Station, Prachuap Khiri Khan Province, on the South western side of the Gulf of Thailand, 13 species were reported but none of Padina was recorded.

From previous marine phycological studies of Thailand, 6 species of Padina were recorded, those are: Padina australis Hauck, P. boryana Thivy, P. Durvillaei Bory, P. gymnospora Kütz., P. pavonica (Linn.) Thivy and P. tetrastromatica Hauck.

The Reported Species from Other Research

In the unpublished thesis of Dr. Francesca Thivy, 1945, on "A revision of the genus Padina Adans", she reported 28 species of Padina, determining from the previous collected specimens from the orient and the shores of America and outlying islands which were available at the University of Michigan; those species are listed below:

Padina arborescens Holmes

P. australis Hauck

P. boryana n. sp.

P. caulescens n. sp.

P. concrescens n. sp.

P. crassa Yam.

P. crispata n. sp.

P. distromatica Hauck

P. dubia Hauck

P. Durvillaei Bory

P. fernandeziana Levring

P. Fraseri Grev.

P. gymnospora (Kütz.) Vickers

P. haitiensis n. sp.

P. japonica Yam.

P. Levringiana nom. nov.

P. mexicana Dawson

P. minor Yam.

P. Novae-Cambriae n. sp.

P. pavonica (L.) comb. nov.

P. perindusiata n. sp.

P. plumbea (Aresch.) Levring

P. Sanctae-Crusis Börg.

P. somalensis Hauck

P. sundica n. sp.

P. tetrastromatica Hauck

P. Tsengii n. sp.

P. Vickersiae Hoyt

Uses of Padina spp.

Padina spp. are used as a fertilizer in the Philippines (Rao, 1965). According to Zaneveld P. australis Hauck is one of the edible algae (Zanevald, 1955). In Indonesia it is sometimes eaten raw, or cooked with coconut milk, pickled or preserved by smoke-drying, frequently it is collected for preparing a gelatine-like sweetmeat. In Ceylon P. commersonii Bory (syn. P. boryana Thivy) and P. tetrastromatica Hauck are both consumed

either as salad vegetable or for making a gelatine-like sweetmeat. (Michanek, 1971; Rao, 1965).

P. australis Hauck contains iodine about 550 ppm. of dry weight and 7.86 mg. of vitamin C (as ascorbic acid) per 100 gm. of fresh weight which varies with the season (Rao, 1965).

In Thailand Padina spp. have never been utilized, though they are commonly found almost all year round along the coasts of the Gulf of Thailand.