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**ECOLOGICAL STUDY  
ON ACROSTICHUM AUREUM  
OF MANGROVE FOREST  
IN SAMUT PRAKAN PROVINCE**

SUDAVON YODSNAHA



A THESIS SUBMITTED IN PARTIAL FULFILMENT OF  
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Thesis  
entitled

**ECOLOGICAL STUDY ON ACROSTICHUM AUREUM  
OF MANGROVE FOREST IN SAMUT PRAKAN PROVINCE**

*Sudavon Yodsanaha*  
Sudavon Yodsanaha  
Candidate

*Manas Watanasak*  
Manas Watanasak, Ph. D.  
Major Advisor

*Sanit Aksornkoae*  
Sanit Aksornkoae, Ph. D.  
Co-advisor

*V. Srivanobhas*  
Vithya Srivanobhas Ph.D.  
Co-advisor

*M. Chulasamaya*  
Monthree Chulasamaya, M.D., Ph.D  
Dean  
Faculty of Graduate Studies

*Laddawan Thongnop*  
Laddawan Thongnop, M.Sc.  
Chairman  
Master of Science Program in  
Technology of Environmental Management  
Faculty of Environment and Resource Studies

Thesis  
entitled

**ECOLOGICAL STUDY ON *ACROSTICHUM AUREUM*  
OF MANGROVE FOREST IN SAMUT PRAKAN PROVINCE**

was submitted to the Faculty of Graduate Studies, Mahidol University for the  
degree of Master of Science (Technology of Environmental Management)

on

May 15 , 1995.

*Sudavon yodsaha*  
.....

Sudavon Yodsaha

Candidate

*Manas Watanasak*  
.....

Manas Watanasak, Ph. D.

Chairman

*Sanit Aksornkoae*  
.....

Sanit Aksornkoae, Ph. D.

Member

*V. Srimanobhas*  
.....

Vithya Srimanobhas Ph.D.

Member

*M. Chulasamaya*  
.....  
*Monthree*

Monthree Chulasamaya, M.D., Ph.D

Dean

Faculty of Graduate Studies

*Debhanom Muangman*  
.....

Debhanom Muangman, M.D., Ph.D

Dean

Faculty of Environment and Resource Studies

## **BIOGRAPHY**

<b>NAME</b>	Sudavon Yodsnaha
<b>DATE OF BIRTH</b>	April 8, 1958
<b>PLACE OF BIRTH</b>	Bangkok, Thailand
<b>INSTITUTIONS' ATTENDED</b>	B.Sc. (Biology) Ramkhumhang University, 1985-1989 M.Sc. (Technology of Environmental Management) Mahidol University, 1991-1995



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Sudavon Yodsnaha

ชื่อวิทยานิพนธ์	การศึกษานิเวศวิทยาปรงทะเลในป่าชายเลน
ผู้วิจัย	จังหวัดสมุทรปราการ
ปริญญา	สุดาวลัย ยอดเสนาหา
	วิทยาศาสตร์มหาบัณฑิต
	(เทคโนโลยีการบริหารสิ่งแวดล้อม)
คณะกรรมการควบคุมวิทยานิพนธ์	มนัส วัฒนาศักดิ์ Ph. D.
	สนิท อักษรแก้ว Ph. D.
	วิทยา ศรีมโนภาษ Ph. D.
วันที่สำเร็จการศึกษา	15 พฤษภาคม พ.ศ. 2538

## บทคัดย่อ

ป่าชายเลนของจังหวัดสมุทรปราการปกคลุมเป็นแนวแคบ ๆ ตั้งแต่บ้านคลองแสนสุขอำเภอเมือง จนถึงบ้านคลองด่าน อำเภอคลองด่าน การลดลงของพื้นที่ป่าชายเลนมีสาเหตุเนื่องมาจากการทำฟาร์มกุ้ง การขยายตัวของชุมชน และการตั้งโรงงานอุตสาหกรรม

พันธุ์ไม้สำคัญที่พบในป่าชายเลนได้แก่ แสม ซึ่งจะพบได้ทั่วไปตามแนวชายทะเล ส่วนพันธุ์ไม้ชนิดอื่น ๆ จะพบเห็นกระจัดกระจายอยู่บ้างได้แก่ โกงกาง ลำพู ลำแพน ปอทะเล โพทะเล เหงือกปลาหมอ และจาก เป็นต้น

ปรงทะเลเป็นพืชป่าชายเลนสำคัญอีกประเภทหนึ่ง ที่ขึ้นในเขตใกล้ป่าบกและพบตลอดตามแนวชายทะเล ปรงทะเลจะมีความหนาแน่นมากในเขตของปรงทะเลและจะพบหนาแน่นมากที่บ้านบางเมฆขาว ซึ่งจะมีความหนาแน่น 47 ต้นต่อ 400 ตารางเมตร และบริเวณนี้มีค่าของความเค็ม 25 ส่วนในพันส่วน ความชื้นร้อยละ 30 สารอินทรีย์ร้อยละ 14 และเป็นดินเหนียวร้อยละ 52 ซึ่งจะเจริญเติบโตและพัฒนาได้ดีมากกว่าปรงทะเลที่อาศัยอยู่ในเขตอื่น และจุดศึกษาอื่น ปัจจัยสิ่งแวดล้อมที่ปรงทะเลมีการเจริญและพัฒนาได้ จะมีช่วงของค่าความเค็มอยู่ระหว่าง 21-29 ส่วนในพันส่วน ค่าของสารอินทรีย์ประมาณร้อยละ 10-20 และดินเป็นดินเหนียว

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การอนุรักษ์ และการขยายพันธุ์ของปรงทะเล



Thesis Title	Ecological Study on <i>Acrostichum aureum</i> of Mangrove Forest in Samut Prakan Province
Name	Sudavon Yodsnaha
Degree	Master of Science (Technology of Environmental Management)
Thesis Supervisory Committee	Manas Watanasak, Ph.D. Sanit Aksornkoae, Ph.D. Vitaya Srimanopas, Ph. D.
Date of Graduation	15 May B.E. 2538(1995)

## ABSTRACT

Mangrove forest of Samut Prakan Province remains in a small strip between Sukhumvit Road and shoreline from Ban Khlong Saen Suk to Ban Khlong Dan. Mangrove area has been decreasing continuously due to expansion of shrimp farms, urbanisation and industrial development.

The important mangrove species found are *Avicennia*, *Rhizophora*, *Sonneratia*, *Hibiscus*, *Thespesia*, *Acanthus*, and *Nypa*. *Avicennia* covers a large area along the coastal line.

*A. aureum* is an important species which dominates typically in inland area and so-called "A. aureum zone". The *A. aureum* zone, *A. aureum* distributes densely at Ban Bang Mek Klua (47 stems/400 m<sup>2</sup>) where the environmental factors are: salinity 25 ppt, moisture content 30%, organic matter 14%, and 52% clay.

The experiments on *A. aureum* regeneration both in the field and pot show different result depending on environmental factors including soil, water and sunlight.

Finally, this basic knowledge and information on the "Ecology of *A. aureum* Samut Prakan Province" will be useful for ecological study, mangrove forest plantation and management, and *A. aureum*'s conservation and propagation.

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# CHAPTER I

## INTRODUCTION

### 1.1 INTRODUCTION

Mangrove is a salt tolerant forest ecosystem of the tropical and subtropical inter tidal regions of the world. It is complex and fragile ecosystem composed of many varieties of plants and various kinds of marine animal. Mangroves vary from place to place upon geographic conditions, soil and water properties, topographic and climate condition. In Thailand, mangroves generally grow on lagoons, seashores, estuaries, and at the high tide along the tidal part of river around the East coast and West Coast of the Gulf of Thailand and the Andaman Sea. Mangrove forest is composed of many species and it is normally the species of *Rhizophora* associated with other trees and shrubs. Distribution of mangrove species can be divided into three main groups. Firstly, *Rhizophora*, *Avicennia* and *Bruquieria* species generally grow and occupy the tidal area and muddy soil condition. Secondly, *Xylocarpus*, *Lumnizera*, *Excoecaria* and *Acanthus* grow in relatively high tidal areas. Lastly, *A. aureum* occupies mainly the upper most of tidal level (Thamrongsiri, 1984).

In the Gulf of Thailand, mangrove forests occupy the areas in several provinces such as Trad, Chantaburi, Rayong, Choburi, Samut Prakan, Samut Songkarm, Samut Sakorn and Phetchaburi. Mangrove forest of Samut Prakan Province was estimated in 1986 approximately 1,040 hectares or 6,500 rais (Office of National Environmental Board, 1988). From the survey during 1990 to 1992, the mangrove forest of Samut Prakan covers a small area of coastal area from the Choa Praya river mouth to Amphoe Khlong Dan. The area of mangrove forest has mainly been converted to shrimp farms, rural development, industrial complex and private mangrove plantation (Forest Department of Samut Prakan, 1991).

*A. aureum* is one of the most important species associated in mangrove forest that occupies the wide range both in the brackish and fresh water habitats. *A. aureum* plays a very important role in mangrove ecosystem. It has widely distributed throughout the mangroves especially where the mangroves were cleared or disturbed. *A. aureum* also obstructs the natural mangrove forest regeneration (Aksornkoae, 1989) and a major problem in

commercially reforestation of mangrove species especially *Rhizophora* (Sukardjo, 1987). Therefore, *A. aureum* has been treated as a weed species in mangrove plantation (Aksornkoae, 1989)

## 1.2 PROBLEM OF STUDY

Mangrove forest in Thailand is about 168,682.56 hectares (1,054,266 rais), with the best-developed in the west coast of the peninsula and the east and west coast of Gulf of Thailand. During 1961 to 1979, the total area of 0.62 million rais of mangrove forests were converted by human activities and the destruction rate was high (Office of National Environmental Board, 1988). In 1976, the National Workshop on Ecosystem of mangrove resources and the Marine Biological Centre reported the important uses of mangrove and its significant depletion. The report recommended that the National Resource Council should act as the core body to establish a National Committee on mangrove resource management. In 1977, the cabinet approved the proposal concerning management, utilisation, conservation and research activities on the mangrove ecosystem (Smitinand, 1979).

The mangrove replanting project (Royal Forestry Department) reported that the *A. aureum* successfully germinated in the young shelter-wood areas. *A. aureum* successfully grow in the harvested or destroyed mangrove forests. It has been treated as a weed species in the cutting and new plantation areas (Sriphaeng, 1979 and West, 1992). The *A. aureum* has been quite difficult to get eliminate by using the aerial spraying of herbicides (Drew, 1976). Because major parts of the *A. aureum* are protected from herbicides such as mucus on leaf and sheath cover on root (Sriphaeng, 1979). Presently, *A. aureum* can be eliminated by cutting and burning. It is recommended that in the management of mangrove plantations after harvesting, the areas should be immediately replanted in order to prevent the invasion of *A. aureum* (Sriphaeng, 1979). Although *A. aureum* is a problem for mangrove plantation and management but it plays an important role in natural balance of the ecosystem. In addition, this fern can be used for cattle feeding. Some places, it can be used for roofing (Walsh, 1992).

Thus the study on "Ecological Study on *Acrostichum aureum* of Mangrove Forest in Samut Prakan Province" is considerably important on ecology and mangrove management; and should be carried out.

This study will emphasise on the environmental factors of study area, particularly salinity and soil texture, and the distribution of *A. aureum*. The information can be used in management planning of mangroves inhibit *A. aureum* in replanting, guide line information of *A. aureum* for ecological formation and management practices, *A. aureum* propagation.

### 1.3 OBJECTIVE

1.3.1 To study on some environmental factors in the areas where *A. aureum* grows in mangrove forest.

1.3.2 To study the relationships between the distribution and abundance of *A. aureum* and physical factors, such as soil texture, organic matter and salinity.

1.3.3 To provide fundamental knowledge for management and conservation of mangrove forest.

### 1.4 SCOPE OF STUDY

1.4.1 The studied area is located in Samut Prakan coastal region, lies about 30 kilometres from Ban Khlong Saen Suk, Amphoe Muang to Ban Khlong Dan, Amphoe Khlong Dan, Samut Prakan province. The area shows mangrove forest covers rather continuously on the southern side of Sukhumvit Road.

1.4.2 The distribution and abundance of *A. aureum* in different species zonations particularly in *Rhizophora* zone, *Avicennia* zone and mixed forest zone are investigated on Ban Bang Mek Kloa, and the *A. aureum* abundance is carried out at four stations of Samut Prakan coasts (Fig. 1).

1.4.3 The studied period ranges one year during January 1993 to January 1994.

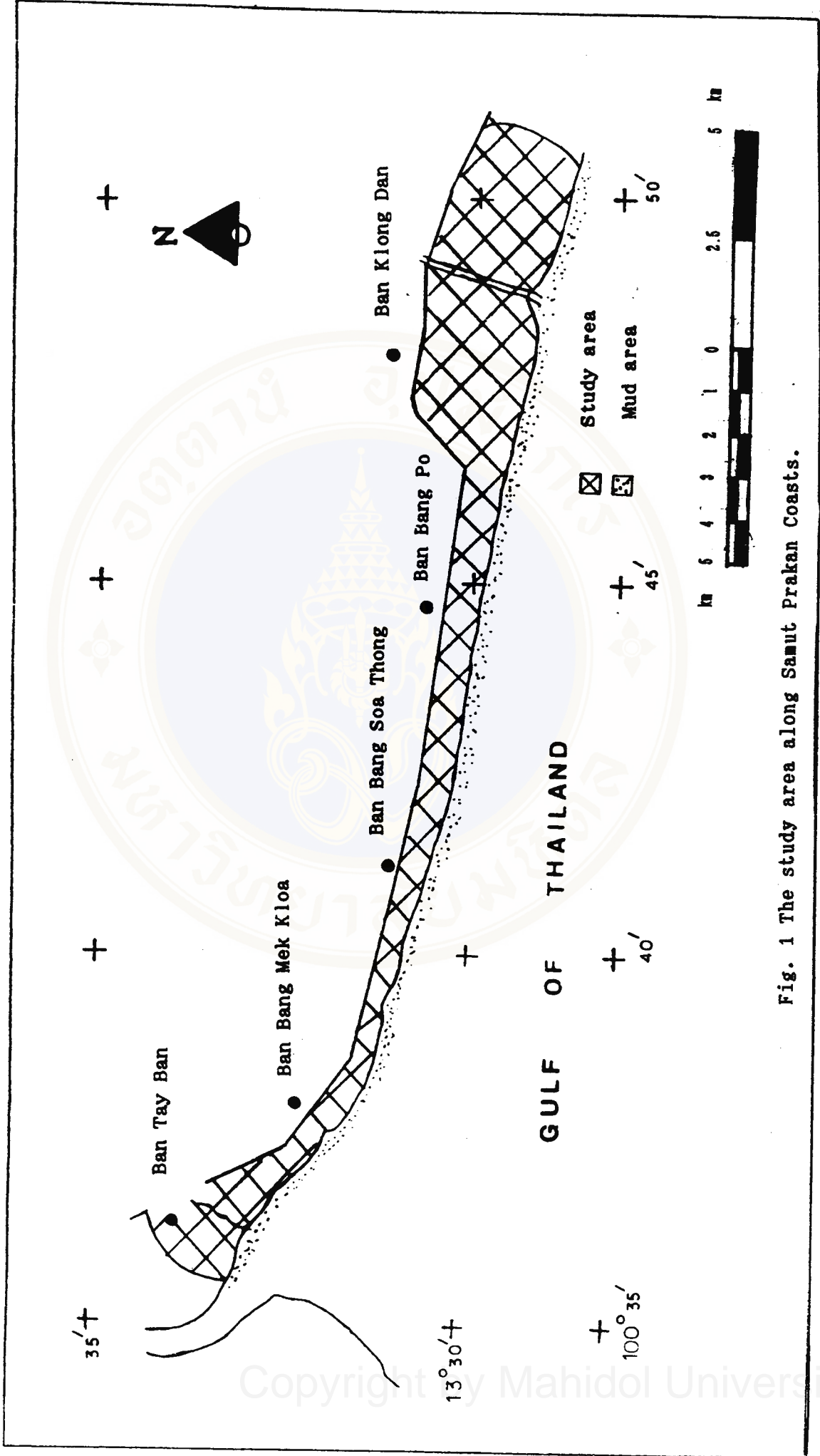


Fig. 1 The study area along Samut Prakan Coasts.

## 1.5 EXPECTED RESULTS

1.5.1 The knowledge of environmental factors obtained from this investigation may be used as an indicative factor for suitable environment of *A. aureum*.

1.5.2 This investigation will provide knowledge and understanding on ecology of *A. aureum* such as salt tolerant, soil texture, leaf canopy for mangrove plantation and management.



# CHAPTER II

## LITERATURE REVIEWS

### 2.1 THE GENERAL BACKGROUND OF THE STUDIED AREA

#### 2.1.1 Location of the studied area

The studied area is located on the upper part of the Gulf of Thailand along Samut Prakan coast from Ban Khlong Sean Suk (Amphoe Muang) to Ban Klong Dan (Amphoe Khlong Dan). It lies between latitudes  $13^{\circ}29'$  N and  $13^{\circ}35'$  N, and between longitudes  $100^{\circ}35'$  E and  $100^{\circ}50'$  E (Yenmanas et al., 1976). The area is approximately 477.28 hectares or 2,983 rais (Forest Department of Samut Prakan, 1991).

#### 2.1.2 Geographical condition

The studied area is active tidal flat. It mainly composes of recently fine-grained sediments. Most of the area is the low-lying topography of which ranging from 1 meter in elevation above sea level (Khearuenromne, 1991).

#### 2.1.3 Mangrove forest

The existing mangrove forest occurs in small areas along the Samut Prakan coast (Forestry Department of Samut Prakan Province, 1991). For a number of years, no license for charcoal production has been issued. Most of the mangrove forest in this area has been changed into shrimp farms, industrial complex and residential development areas. Yet the mangrove forest yield environmental benefits for fishery habitats, aesthetic values, and prevention of coastal soil erosion (Thammapraset, 1993).

#### 2.1.4 Climate

Climate (Table 1) in this area is classified as "tropical savannah". Average annual temperature is  $28^{\circ}\text{C}$  with little differences between the coldest and hottest months. Average annual rainfall is 1448.8 mm (the Bang Po Mai station). Average annual humidity is 73 % (Bangkok metropolis station).

Table 1. Climatic data of the studied area.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
<b>1992 TEMPERATURE</b>													
mean max.	28.3	29.1	29.9	31.5	32.1	31.6	30.5	30.4	30.5	29.5	29.0	29.0	30.1
mean min.	23.8	25.5	27.3	28.9	28.6	27.1	26.7	26.9	26.6	24.8	24.2	24.2	26.3
<b>1993 TEMPERATURE</b>													
mean max.	31.1	30.0	30.7	31.8	32.2	33.2	32.3	31.4	31.9	32.1	33.6	32.3	33.6
mean min.	24.5	24.9	26.5	27.7	27.6	28.0	28.0	26.3	25.8	25.7	26.0	23.2	26.2
<b>RAINFALL</b>													
1992	20.0	10.3	0.0	0.0	93.8	172.8	361.7	89.6	216.5	448.0	1.5	8.0	1422.2
1993	-	-	169.0	78.5	193.7	110.4	59.9	244.0	364.5	216.8	0.0	-	-
MEAN	20.0	10.3	84.5	39.5	143.8	141.6	210.8	166.8	290.5	332.4	0.8	8.0	1448.8
<b>HUMIDITY</b>													
1992	70	73	72	68	70	74	76	77	77	79	65	66	72
1993	70	70	76	73	75	73	72	79	81	79	69	63	73
MEAN	70	72	74	71	73	74	74	78	79	79	67	65	73

Source: Climatology Division, 1994.

### 2.1.5 Soil

Mangrove forest soil of the studied area has been classified as the Samut Prakan Series which characterises as alluvial and saline soil, thick sediments and flat surface. In summer, salt covers on the surface. Soil texture is loam to loamy clay (Yenmanas et al., 1976).

## 2.2 GENERAL BACKGROUND OF *A. AUREUM*

### 2.2.1 Plant taxonomy (Smitinand, 1976 and Sanuel, 1987)

KINGDOM:	Plant
DIVISION:	Pteridophyta
CLASS:	Filicopsida
ORDER:	Filicales
FAMILY:	Pteridaceae
GENUS:	<i>Acrostichum</i>
SPECIES:	<i>Acrostichum aureum</i>

### 2.2.2 Plant anatomy

#### 1). Stem

The rhizome is thick, horizontal branched, decumbent-ascending to erect or column and scaly on the rhizome (Jessen, 1965; Sriphaeng, 1979). A life duration of any part of horizontal rhizome is relatively short, for the rhizome continues to elongate at the growing tip and die at the end (Transeau, 1953; Brandwien, 1972). Stipe is about 1 m long, bearing on the upper part small spine like remaining of reduced glandular pinnae (Smitinand, 1976).

## 2). Leaf

Fronds are imparipinnate more than 1 m long. The frond is composed of lateral sterile pinnae at the apex, entire at cartilaginous margin, up to 30-50 cm long, 4-8 cm broad, and fertile pinnae only on the upper part, smaller in size (Smitinand, 1976; Varayoth, 1989).

## 3). Root

A root is like spongy, less branched. They are originated adventitiously at the node and along the internodes of the rhizome (Jessen, 1965; Muhlberg, 1982).

## 4). Spore

Sporangia is borne over the surface on and between the veins, interspersed with short, capitate paraphyses, exindusiate, the spore shape is tetrahedral-globose to nearly globose, and chromosome number:  $n=30$ ;  $2n=60$  (Tryon and Tryon, 1982b). The sporangia is, the cells of the sporangial jacket divide by anticlinal division and the products increase in size, as do the cells stalk. At maturity the sporangium is a slightly flattened ellipsoid. As the spore is mature, they become invested with brown-black wall, and exposing them to the air for propagation (Varayoth, 1985).

## 5). Life cycle

The ferns have alternation of generation in a life cycle (Fig. 2). The reproduction of fern gametophytes consist of a prothallus that produces gametangia and sex cells. The prothallus is bisexual, the antheridia mature before the archegonia (Jessen, 1965). A fertilisation phase water is necessary for sexual reproduction because the sperm through a film of water to the egg cases where they fertilise the egg (Varayoth, 1985). The alternation phase in the life cycle of fern, the sporophyte phase is partially dependent upon it as a source of food, when the spores fall upon the soil (Traseau, 1953).

## 2.3 ECOLOGY

*A. aureum* can grow in brackish or salt water condition. It also found on sea cliffs, and grow well in slightly shade (Tryon and Tryon, 1982a) and if it becomes so dense the natural regeneration of light-demanding mangrove seedlings is quite difficult. This feature commonly occurs elsewhere in the world (Chapman, 1976). In Thailand, *A. aureum* is common in mangrove swamps and tidal forest (Smitinand, 1989), open salt marsh and nearby

inland site (Aksornkoae, 1979). It can also be a weed in *Rhizophora* plantation (Aksornkoae, 1989). *A. aureum* can also grow on the acidic soil (West, 1991).

## 2.4 DISTRIBUTION

*A. aureum*, a pan tropic fern, is commonly found in natural mangrove forest ecosystem (Drew, 1976). Where the mangrove is felled or destroyed, *A. aureum* will take place, and becomes so dense (Chapman, 1976). *A. aureum* is thickest within the transitional zone and colonises of cut over or disturbed areas in mangrove (West, 1992). *A. aureum* is a common fern of mangrove around the Gulf of Thailand (Longe, 1968). Fig. 3 shows the distribution of *A. aureum* in mangrove of the Gulf of Thailand as follows.

Central:	Bangkok, Samut Prakan
South-Eastern:	Chachoengsao (Bangpakong), Phetchaburi (Sam Roi Yot), Prachuap Khiri Khan (Khlong Wan, Bang Saphan)
Peninsular:	Surat Thani (Khun Thale), Satun (Ko Tarutao), Trang (Kantang), Pattani (Smitinand, 1989).

## 2.5 THE ECOLOGICAL AND ECONOMICAL IMPORTANCE OF *A. AUREUM*

### 2.5.1 The usefulness

1). Pteridophytes are link in the food chain of most terrestrial organisms since they are the major primary producers on land. They also supply for most organisms against both environmental extremes and predation by other organisms (Seagel et al., 1984).

2). A part of body of *A. aureum* can be used by human for food especially young leaf but the use is specific in some area (Sriphaeng, 1989). In Malaysia, it can be litter for cattle (Walsh, 1992).

3). Economic value. Dry leaf of *A. aureum*, and colour dye can be used for decoration in Japan (Sriphaeng, 1989). The leaf can be used for roofing for homes in Malaysia (Walsh, 1992).

### 2.5.2 The problem from *A. aureum*

1). In cleared mangrove forest, *A. aureum* grows very well and other mangrove species are quite difficult to grow in *A. aureum* community (Aksornkoae, 1989). This situation

may reduce species biodiversity in mangrove forest. The *A. aureum* is commonly over grow in mangrove plantation and inhibit other replanting species (Ruksakeaw, 1989). Extensive infestation of *A. aureum* is a reduce in the regeneration of commercial mangrove species such as *Rhizophora apiculata* and *Bruguiera gymnorrhiza* seedlings (Sukardjo, 1987)

2). Elimination of *A. aureum* from the plantation areas is not practically simple. It can only be eliminated by cutting then dry and burn which is the most successful method (Drew, 1976).

## 2.6 ENVIRONMENTAL FACTORS

### 2.6.1 Soil

Mangrove soil are basically alluvial in nature and mainly consists of silt and clay particles. It has a low oxygen and high in salt content (Vijarnsorn, 1992). Mangrove soil is formed by the accumulation of sediments derived from coastal or river bank erosion or eroded soil from higher areas transported down along rivers and canals. It may originate from the sedimentation of material's particulate (Aksornkoe, 1993). *A. aureum* is also distributed in wet brackish soil (Chapman, 1992)

### 2.6.2 Salinity

Mangrove species distribute in different saline concentration zone (Clinton, 1981). General ferns have been able to adjust their physiology to the condition prevailing in saline habitats. These are adapted the range of salinity tolerated (between 10-30 ppt) varies somewhat with species which indicate by their presence different degree of salinity and so permit the invasion of different adapt species (Fitter, 1981). The plant of stand as well as that around the periphery of inland salt basins often exhibits a remarkably definite sequence of zone (Daubenmire, 1974).

### 2.6.3 Organic matter

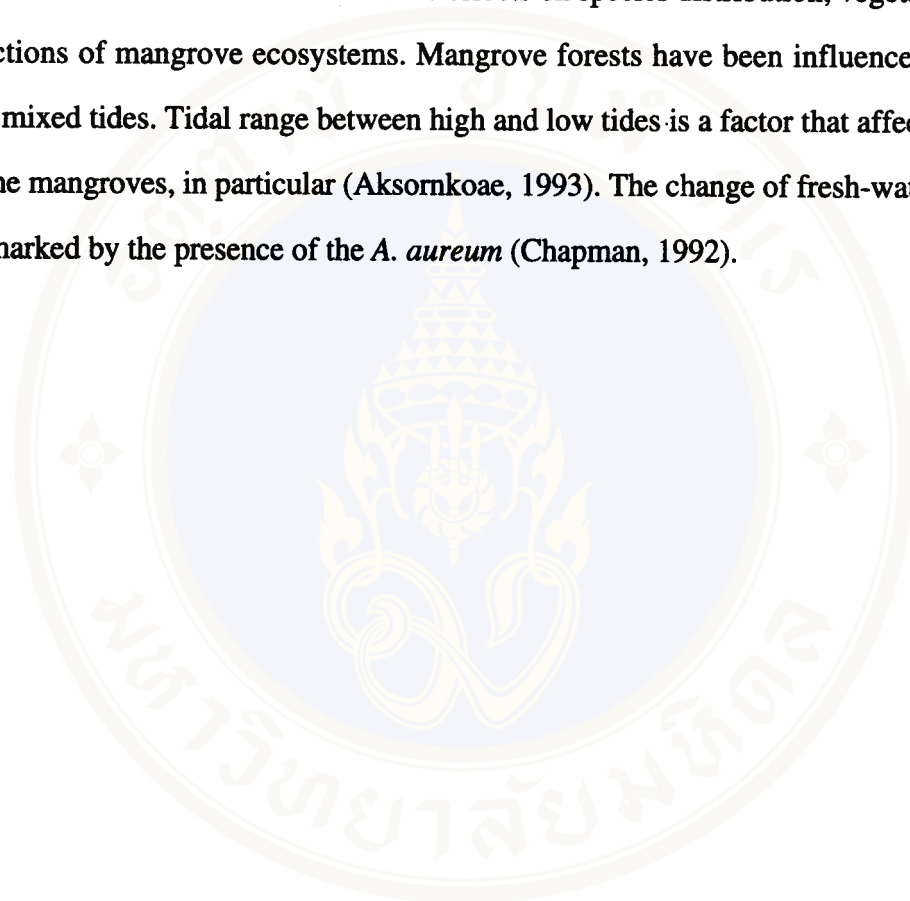
The organic matter is one of the most important properties in soil. Soil organic matter usually originates from plant remains and originally containing all nutrients needed for plant growth. Organic matter influences on soil structure especially the physical condition (Brady, 1984). In mangrove, organic matter is derived from dead organisms and excreta. The other allochthonous particulate is from river runoff, upland and coastal erosion (Aksornkoe, 1993).

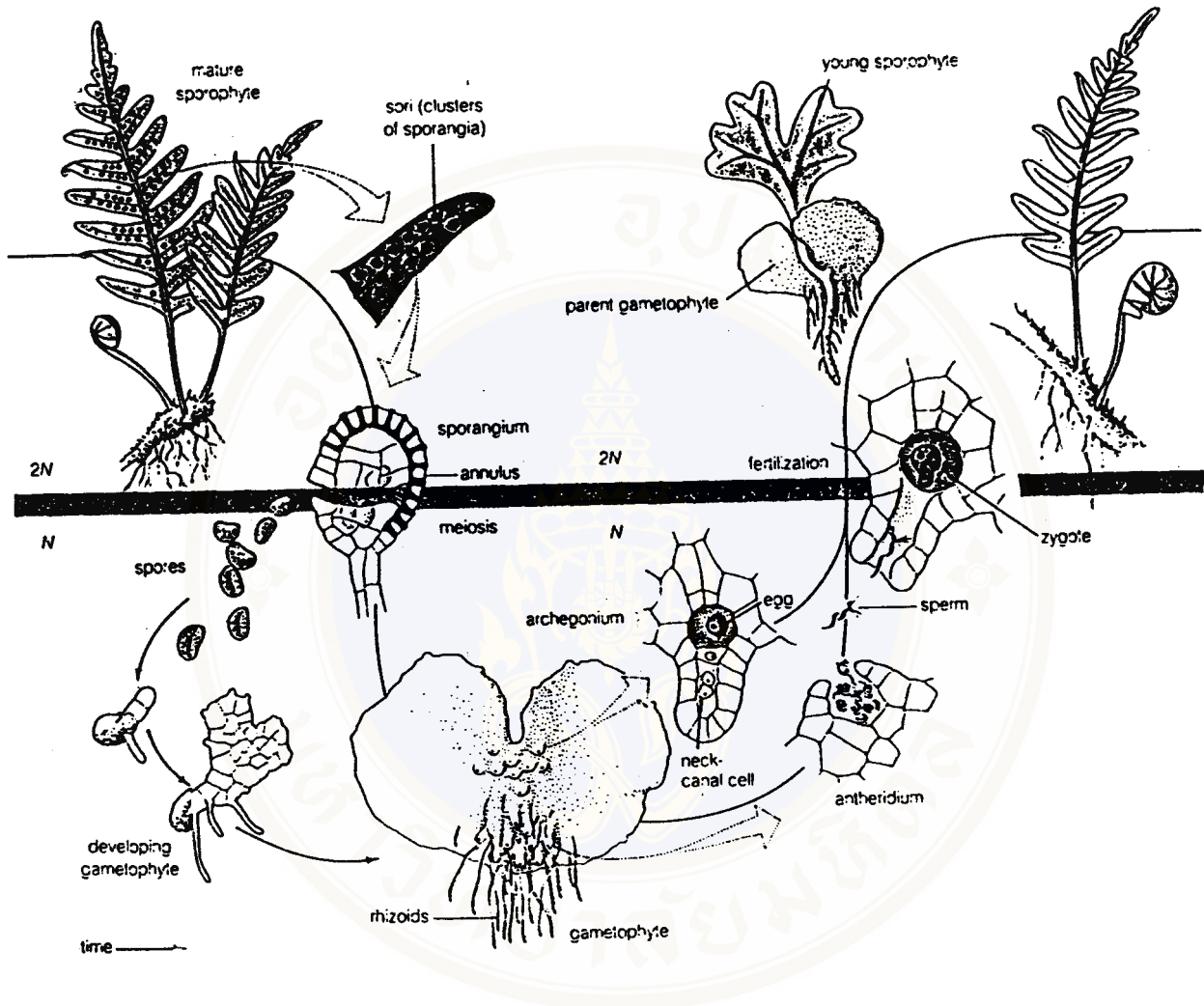
#### 2.6.4 Light

Generally, mangrove plants are long-day plants and require high intensity of full sunlight. It is variations of light intensity in different areas. Some mangrove species can be grow in shade and unshade (Aksornkoae, 1993). The *A. aureum* grows well in lightly shade (Tryon and Tryon, 1982b).

#### 2.6.5 Tides

Tidal inundation has the effects on species distribution, vegetation structure and functions of mangrove ecosystems. Mangrove forests have been influenced by diurnal tides and mixed tides. Tidal range between high and low tides is a factor that affects the root system of the mangroves, in particular (Aksornkoae, 1993). The change of fresh-water conditions may be marked by the presence of the *A. aureum* (Chapman, 1992).





**Fig. 2 Life cycle of Pteridophytes.**

**SOURCE: Greulack (1976).**

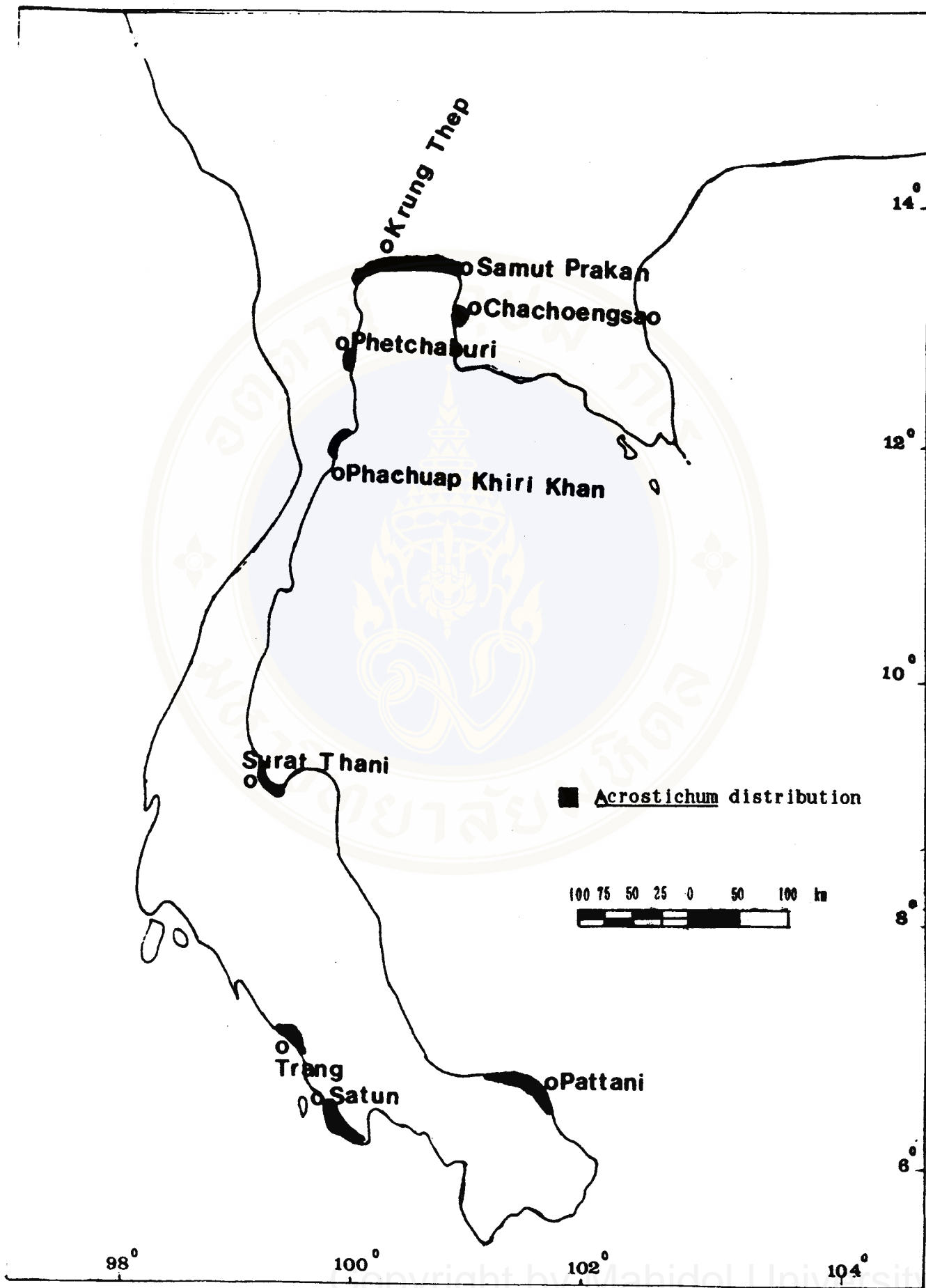


Fig. 3 *Acrostichum* distribution in the manrove forest around the Gulf of Thailand.

# CHAPTER III

## MATERIAL AND METHODS

### 3.1 FIELD WORK.

#### 3.1.1 Field survey

Map is a useful tool for this study particularly at the scale of 1:50,000 for detailed forest study. The boundaries of existing vegetation and their units were identified.

Field survey were divided into two areas. Firstly, the distribution of *A. aureum* and other mangrove species at Ban Bang Mek Kloa. Transect lines were drawn North-East direction across the area between Sukhumvit Road and the sea. The sampling plots of 20x20 m<sup>2</sup> were investigated diversity and density of mangrove species especially *A. aureum* along the transect.

Secondly, distribution of *A. aureum* along the coastline in four experimental study areas between Ban Khlong Sean Suk to Ban Khlong Dan. The sampling plots were the same size as mentioned.

#### 3.1.2 Study on regeneration of *A. aureum*.

*A. aureum* regeneration was studied by using single-stock population. The stock plant was collected in January 1993, and planted in plot of 10x10 m<sup>2</sup>. The plot was the same and continuously monitored. The experiment is performed using cutting with rhizome removal, taken from stock material in January 1993 to January 1994. *A. aureum* samples were collected from study site (Fig. 4).

The distribution of spores and their regeneration might have included from both natural distribution and plant removal during the experiment.

#### 3.1.3 Analysis of samples.

Four sampling areas were located at Samut Prakan Coast with approximately 30 kilometres from Ban Khlong Saen Suk to Ban Khlong Dan (Fig. 5). Four experimental studies were:

Station 1 Ban Khlong Saen Suk

Station 2 Ban Bang Mek Klao

Station 3 Ban Hua Lamplu Lai

Station 4 Ban Khlong Dan

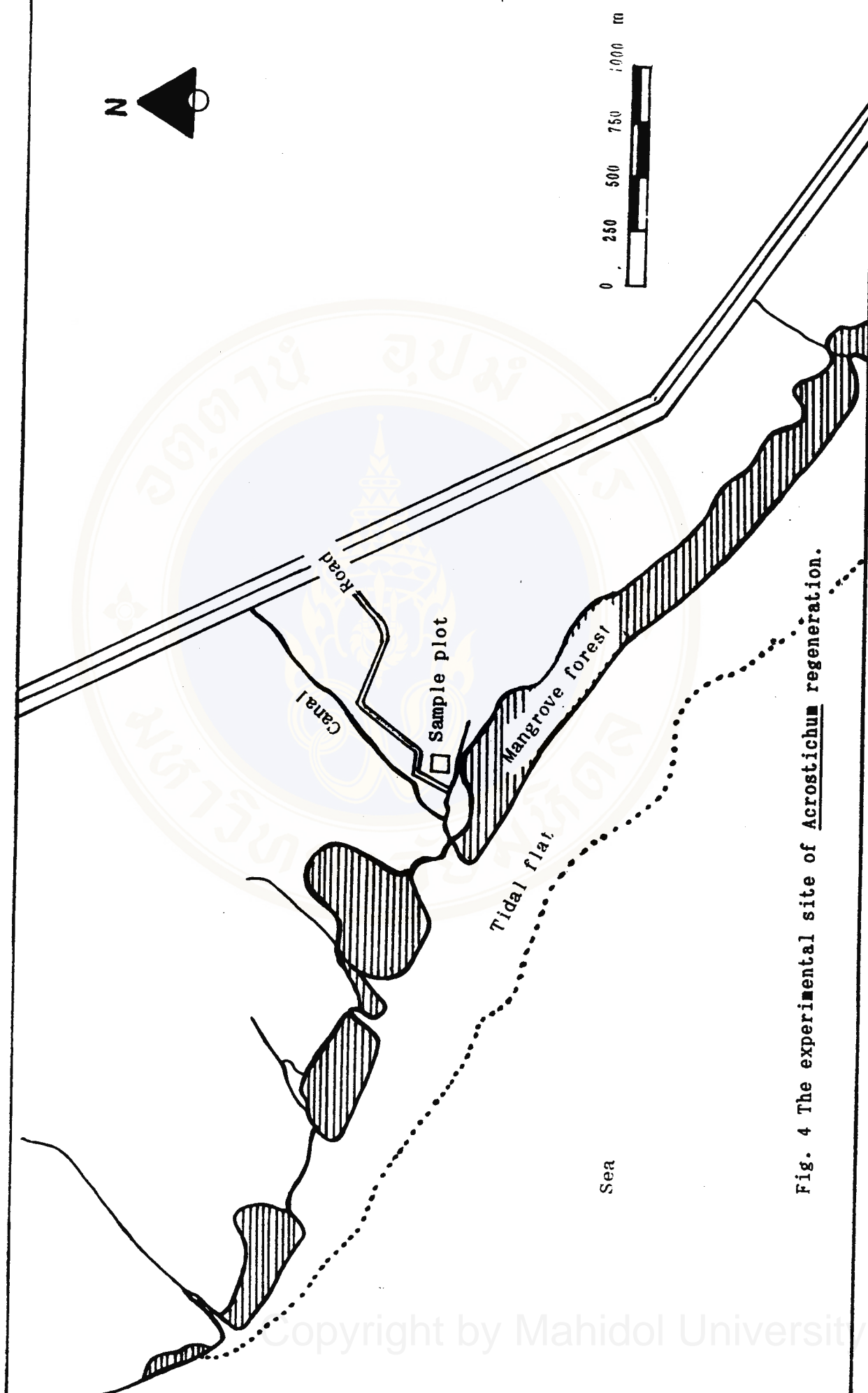


Fig. 4 The experimental site of Acrostichum regeneration.

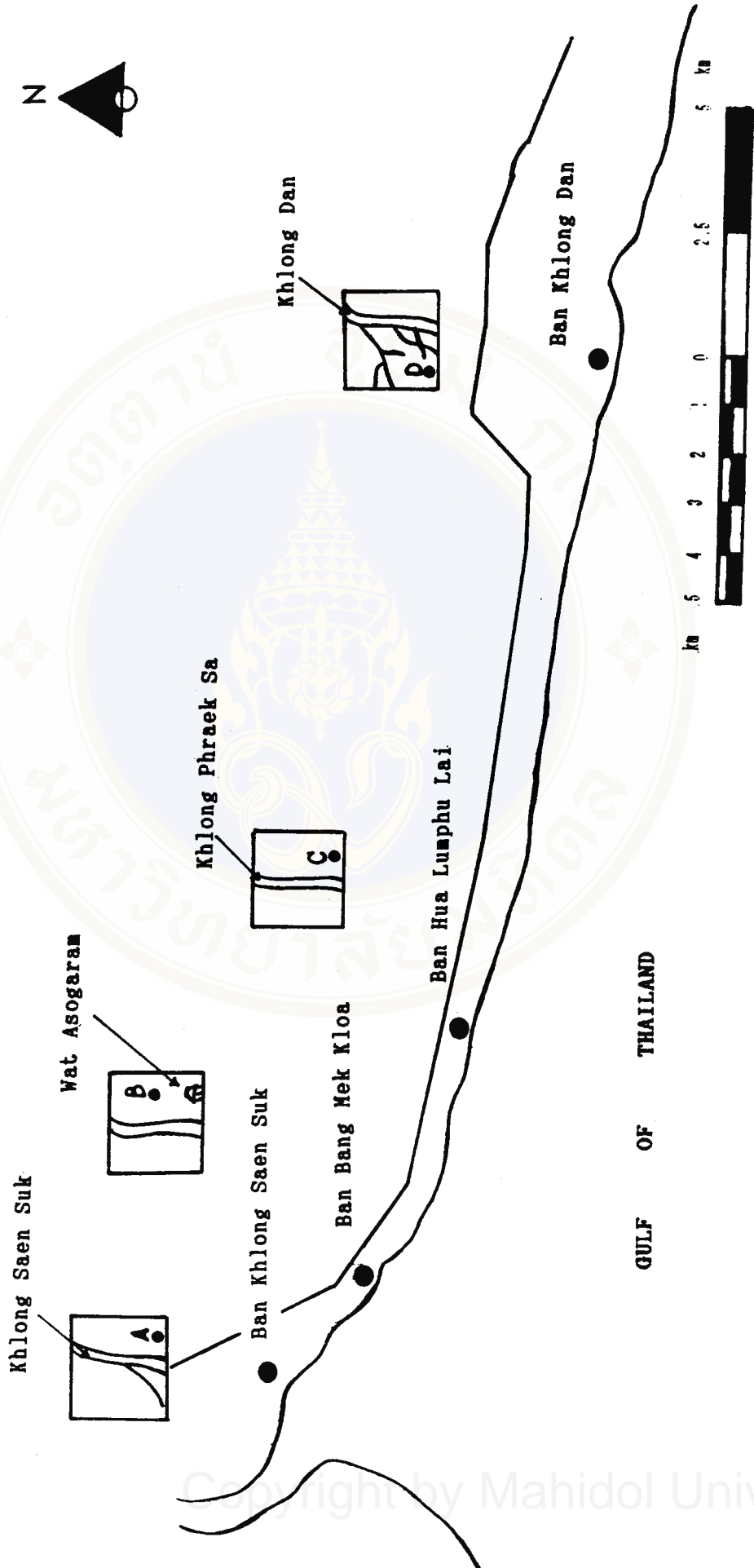


Fig. 5 Experimental stations of sample analysis.

## 3.2 LABORATORY STUDY.

### 3.2.1 Soil texture

Particle-sizes were determined by Pipette method. Soil texture was identified by using textural triangle (Fig. 6). Pipette method can be described as follows:

#### 1) Reagents

- Hydrogen peroxide ( $H_2O_2$ ), 30 to 35 %.
- Sodium hexametaphosphate ( $(NaPO_3)_6$ ). Dissolve 35.7 grams of  $(NaPO_3)_6$  and 7.94 grams of  $Na_2CO_3$  per litre of water.

- Demineralized water.

#### 2) Procedure

Removing organic matter. Place about 10 gm air-dry soil containing no particles larger than 2 mm in a tare beaker. Add about 50 ml of demineralized water, add 5 ml of  $H_2O_2$ , heat for about 30 minutes to remove any excess  $H_2O_2$ .

Filter the suspension through a short Pasteur Chamber-lain filter of " F " fineness, washings. Dry the sample overnight in an oven at  $105^\circ C$ . Use the weight of the oven dry for calculating percentages of the various fractions.

Separating sand from silt and clay. Wash the dispersed sample with water on a 300-mesh sieve. Silt and clay pass through the sieve into a one-litre cylinder.

#### 3) Calculation

Pipette fractions:

Percentage of pipette fractions =  $(A-B)KD$

where:

A = weight (gm) of pipette fraction

B = weight correction for dispersing agent (gm)

K = 1,000 / ml. in pipette

D = 100 / gm of  $H_2O_2$  treated oven dry total sample

The  $< 20 \mu$  fraction minus  $< 2 \mu$  fraction equals to silt.

Sand fractions:

Percentage of sieved fractions = weight (gm) of fraction on sieve times D.

Coarse silt fraction =  $100 - \% \text{ sand} - \% \text{ clay } (< 20 \mu) \dots\dots$  (Fig. 6).

### 3.2.2 Organic matter

Organic matter can be calculated from organic carbon content in soil and it is measured by titration with  $\text{Cr}_2\text{O}_7^{2-}$ .

#### *Walkley-Black Method with Measurement of Organic Carbon*

##### 1) Reagents

- Potassium dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ ), 1 N: Dissolve 49.04 gm of potassium dichromate (reagent grade) in distilled water and dilute the solution to a volume of 1,000 ml.

- Conc. Sulphuric acid ( $\text{H}_2\text{SO}_4$ ). If  $\text{Cl}^-$  is present in the soil, add  $\text{Ag}_2\text{SO}_4$  to the acid at the rate of 15 gm per litre.

- Conc. Orthophosphoric acid ( $\text{H}_2\text{PO}_4$ ).

- *o*-phenanthroline-ferrous complex, 0.025 M: Dissolve 14.85 gm of *o*-phenanthroline monohydrate and 6.95 gm of  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  in water and dilute the solution to a volume of 1,000 ml.

- Barium diphenylamine sulfonate: Prepare 0.16 % aqueous solution.

- Ferrous sulphate ( $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ) solution, 0.5 N: Dissolve 140 gm of reagent-grade  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  in water, add 15 ml of concentrated  $\text{H}_2\text{SO}_4$ , cool the solution and dilute it to a volume of 1,000 ml. Standardise this reagent daily by titration it against 10 ml of  $\text{K}_2\text{Cr}_2\text{O}_7$  as directed below.

##### 2) Procedure

Grind the soil to pass a 0.5 mm sieve, avoiding iron or steel mortars. Transfer a weighed sample, containing 10 to 25 mg of organic-C, but not in excess of 10 gm of soil, into a 500-ml wide-mouth Erlenmeyer flask. Add 10 ml of 1N  $\text{K}_2\text{Cr}_2\text{O}_7$ , and swirl the flask gently to disperse the soil in the solution. Then rapidly add 20 ml of concentrated  $\text{H}_2\text{SO}_4$ , directing the stream into the suspension. Immediately swirl the flask gently until soil and reagents are mixed, then more vigorously for a total of 1 minute. Allow the flask to stand on a sheet of asbestos for about 30 minutes. Then add 200 ml of water to the flask, and filter the suspension if experience shows that the end point of the titration cannot otherwise be clearly discerned. Add 3 to 4 drops of *o*-phenanthroline indicator, and titrate the solution with 0.5 N  $\text{FeSO}_4$ . As the end point is approached, the solution takes on a greenish cast and changes to dark green. At this

point, add the ferrous sulphate drop by drop until the colour changes sharply from blue to red. Make a blank determination in the same manner, but without soil, to standardise the  $\text{Cr}_2\text{O}_7^{2-}$ . Repeat the determination with less soil if more than 75 % of dichromate is reduced.

### 3) Calculation

Calculate the results according to the following formula, using a correction factor  $f = 1.74$ :

$$\% \text{ Organic-C} = \frac{(\text{Miliequivalents } \text{K}_2\text{Cr}_2\text{O}_7 - \text{miliequivalents } \text{FeSO}_4) \times 0.003 \times 100 \times (f)}{\text{Grams water-free soil}}$$

### 3.2.3 Salinity.

#### 1) Reagents

- Silver nitrate ( $\text{AgNO}_3$ ) 0.1595 N: Dilute 27.096 gm of  $\text{AgNO}_3$  in distilled water 1 litre and packing in dark bottom.

- Potassium chromate indicator ( $\text{K}_2\text{CrO}_4$ ): Dilute 5.0 gm of  $\text{K}_2\text{CrO}_4$  in distilled water 100 ml.

#### 2) Procedure

Using volume sample, containing 10 ml of saline water, into a 250 wide-mouth Erlenmeyer flask. Add Potassium chromate indicator 5 drops and swirl the flask gently to disperse the solution, and titrate the solution with 0.1595 N  $\text{AgNO}_3$ . As the end point is approached, the solution takes on a yellow cast and then change to red. Make a blank determination in the same manner, but without saline water, to standardise the 0.1595 N  $\text{AgNO}_3$ , and record volume of 0.1595 N  $\text{AgNO}_3$  solution for calculation.

#### 3) Calculation

$$\text{Salinity (ppt)} = \text{A volume of 0.1595 N } \text{AgNO}_3 \text{ (ml) from titration}$$

### 3.2.4 Soil moisture

A method of expressing soil moisture percentage is in terms of wet weight percentage or the kilograms of water associated with 1 kg off dry soil. The weight of the wet soil is an unsatisfactory basis for calculation since it changes with every moisture fluctuation.

$$\% \text{ Soil moisture} = \frac{(\text{Wet soil}) - (\text{Dry soil})}{(\text{Dry soil})} \times 100$$

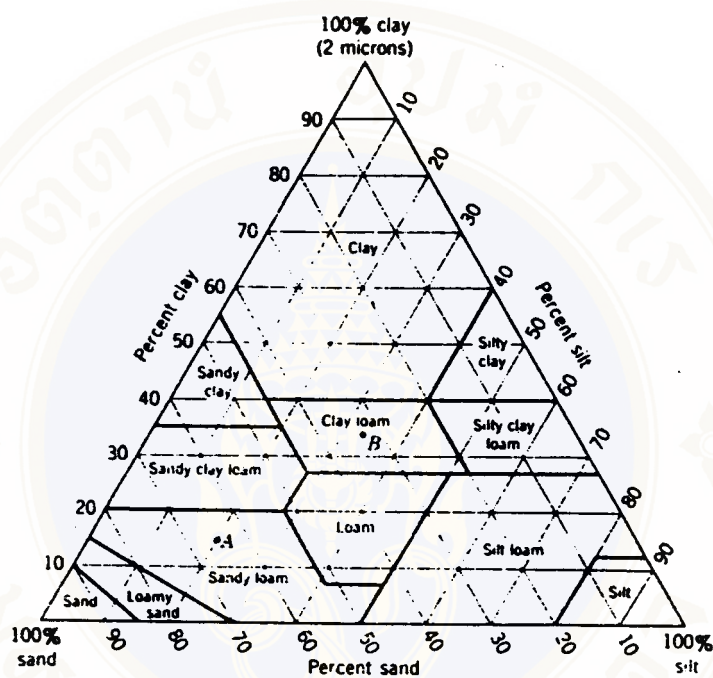


Fig. 6 The textural triangle shows the limits of sand, silt and clay contents of the various texture classes.

SOURCE: Soil survey laboratory staff (1992).

## CHAPTER IV

### RESULTS AND DISCUSSION

#### 4.1 CHARACTERISTICS OF STUDY AREA.

The location of study area was observed during the field investigations that mangrove forest in this area covers a narrow strip from Ban Khlong Saen Suk near the Chao Phraya River to Ban Khlong Dan. The mangrove forest has been mainly utilised for shrimp farming. Other uses of mangrove forest are housing and industrial developments. The reduction of mangrove forest have been caused by human activities (Thammapraset, 1993). Existing mangrove forest both natural and plantation is not treated as forest reserve and not responsible by the Royal Forestry Department (Fig. 7-9).

The mangrove trees in the studied area can be found at the Ban Khlong Saen Suk to Ban Khlong Dan. From the coastline to the inland sites, mangrove communities have been zoned as following: *Rhizophora*, *Avicennia*, mixed forest, and *A. aureum* zones. *A. aureum* grows densely and well developed in the *A. aureum* zone but distributes sparsely in the other zones. Mangrove zonation at Ban Bang Mek Klua is shown in Fig. 10. There are about 17 remaining species in Samut Prakan coastal area (Table 2).

Table 2. Mangrove species found in the studied area.

Scientific name	Family
<i>Acanthus ebracteatus</i>	Acanthaceae
<i>Acanthus ilicifolius</i>	Acanthaceae
<i>Acrotichum aureum</i>	Pteridaceae
<i>Avicennia alba</i>	Verbenaceae
<i>Caesalpinia nuga</i>	Caesalpiniadae
<i>Cerbera odollan</i>	Apocynaceae
<i>Clerodendrum inerme</i>	Verbenaceae
<i>Cyperus sp.</i>	Cyperaceae
<i>Deris tri-foliata</i>	Leguminosea
<i>Hibiscus tiliaceus</i>	Malvaceae
<i>Nypa fruticans</i>	Palmae
<i>Rhizophora mucronata</i>	Rhizophoraceae
<i>Rhizophora apiculata</i>	Rhizophoraceae
<i>Sonneratia casaularis</i>	Sonneratiaceae
<i>Sonneratia ovata</i>	Sonneratiaceae
<i>Sueda maritima</i>	Chenopodiaceae
<i>Thespesia populnea</i>	Meliaceae

Ban Khlong Sean Suk is located at the mouth of Chao Praya River. The mangrove species in this area is dominated by *Avicennia*. Other species are shown in Table 8.

Ban Bang Mek Kloa is covered by extensive mangrove species. The *Rhizophora* occupies small area while *Avicennia* species covers a larger area mixed with many species such as *Rhizophora*, *Sonneratai*, *Hibiscus* species, ...etc. (Table 8). The *A. aureum* is dominated at the inland sites. This region has many mangrove species more than other studied sites (Fig. 9).

Ban Hua Lamplu Lai consists of a few mangrove species due to cutting of mangrove for shrimp farms and other purposes (Fig. 7-9).

Mangrove forest at Ban Khlong Dan is used for commercial benefits especially the *Rhizophora* used for firewood. Table 8 shows mangrove species, sizes of tree and soil conditions at various studied sites.

## 4.2 ENVIRONMENTAL FACTORS.

### 4.3.1 Soil textures in four stations.

Table 3 indicates that most soil texture found in the studied is clay. Only at Ban Hua Lamplu Lai, soil texture is silty clay loam.

Table 3. Analysis of soil sample from mangrove forests in four stations at Samut Prakan Coasts. Soil depths are between 0-20 cm.

Stations	Soil properties			
	Sand (%)	Silt (%)	Clay (%)	Texture
Ban Khlong Saen Suk	1.66	30.64	67.70	Clay
Ban Bang Mek Kloa	22.68	25.30	52.02	Clay
Ban Hua Lamplu Lai	54.49	19.36	26.15	Silty Clay Loam
Ban Khlong Dan	0.96	24.34	74.70	Clay

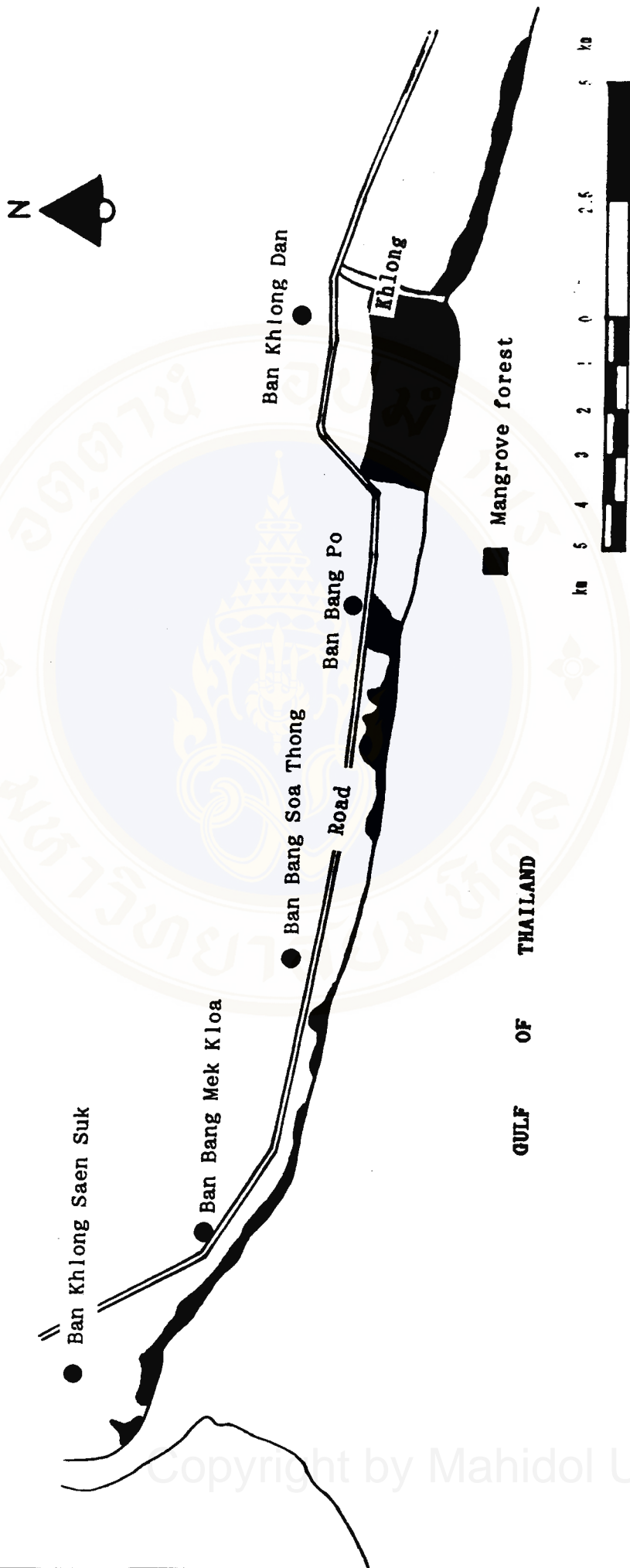


Fig. 7 Mangrove forests at various study area along Samut Prakan Coast.

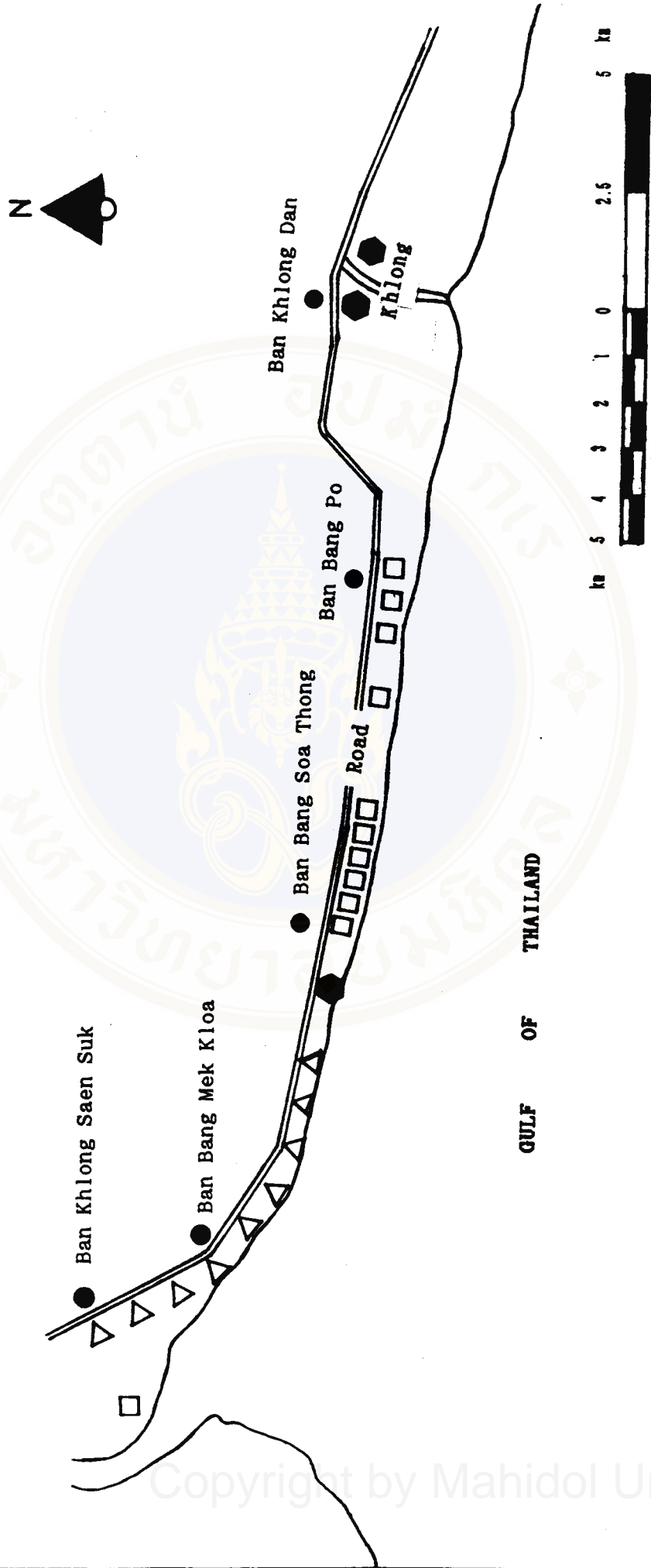


Fig. 8 Used mangrove forest for different purposes along Samut Prakan

Coasts: ● Community    △ Industrial    □ Shrimp farm.

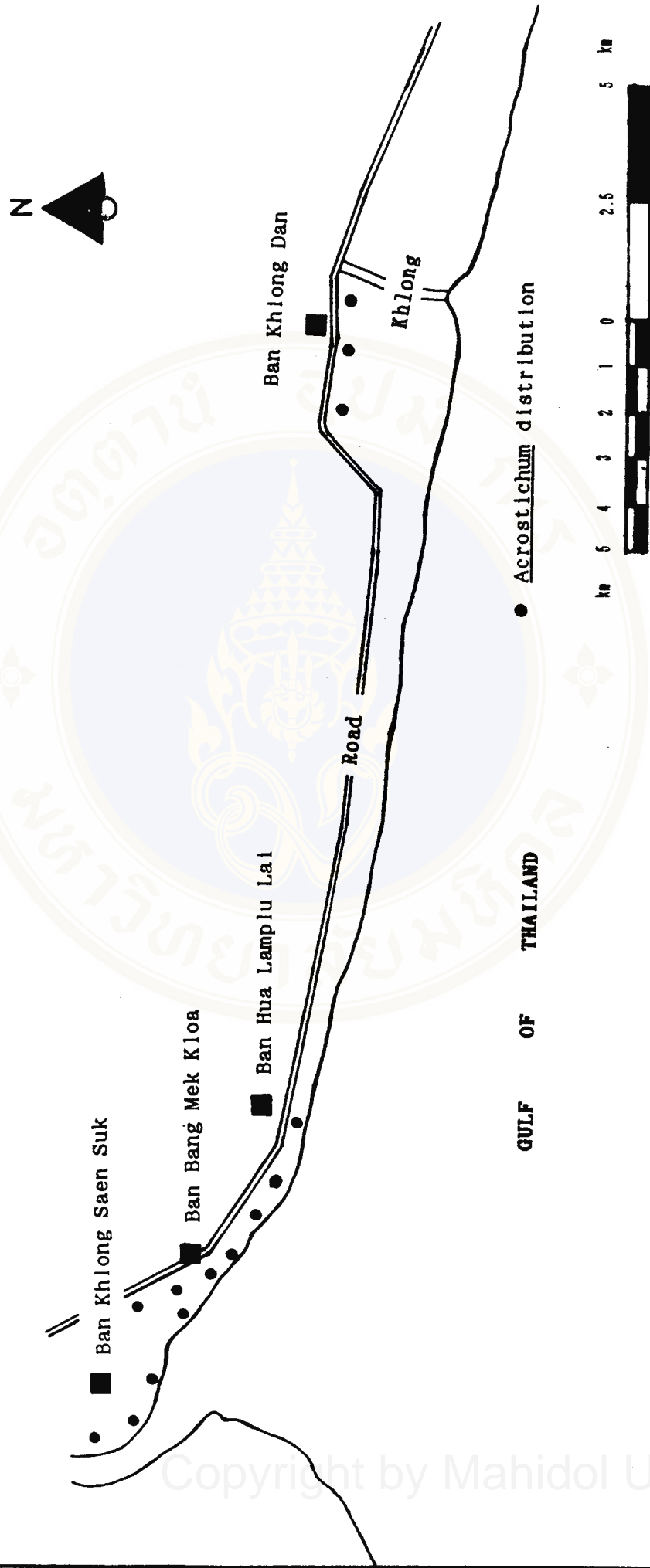


Fig. 9 Distribution of *Acrostichum* along Samut Prakan Coasts.

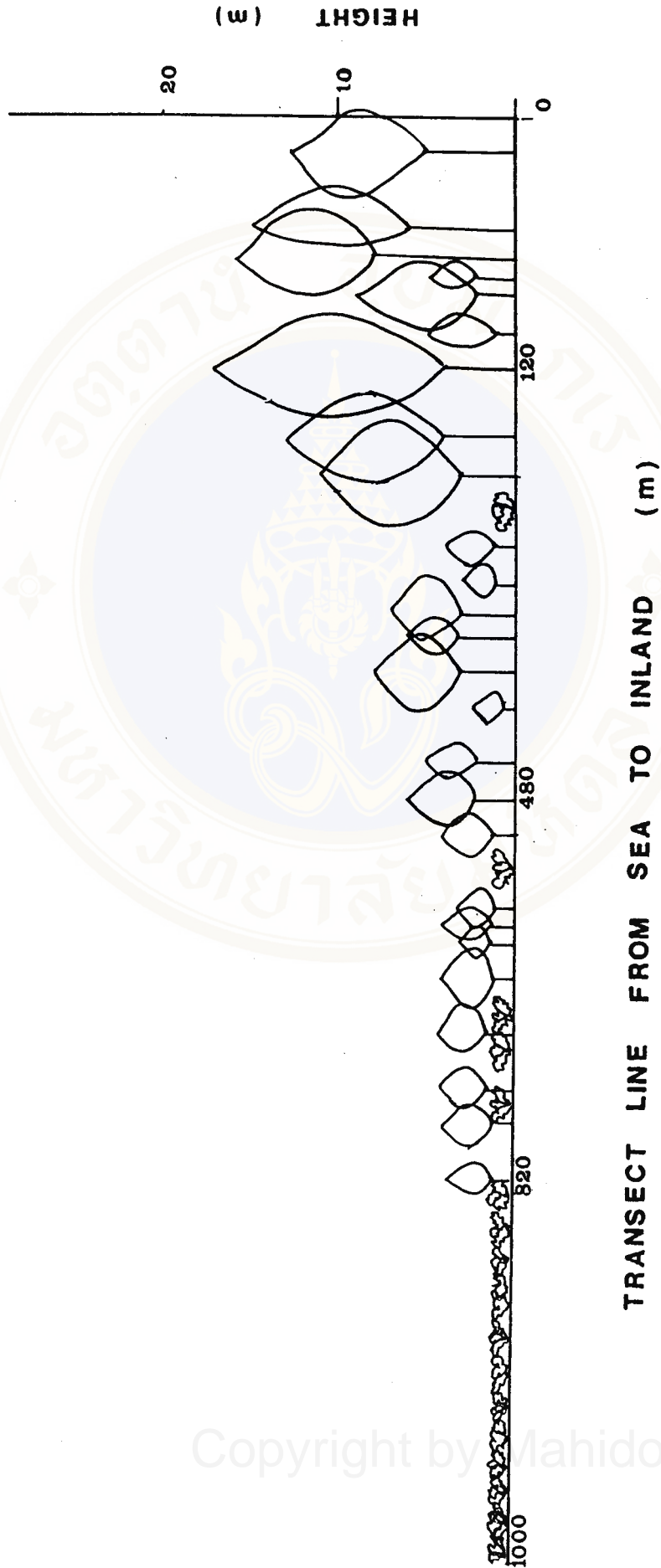


Fig. 10 Sketch of the dominant species found at Samut Prakan Coasts:  
0-120 Rhizophora; 120-480 Avicennia; 480-820 Mixed forest; 820-1000 Acrostichum

#### 4.3.2 Salinity, soil moisture, and organic matter in four stations.

Table 4 and Fig. 18-20 show the relationship between the environmental factors and density of *A. aureum* distribution. It can be seen that environmental factors are different at Ban Khlong Saen Suk to Ban Khlong Dan. Salinity varies from 21.86 to 29.40 ppt. Soil moistures shows differently from place to place with the values ranging between 17.5 to 32.5%. Organic matters are slightly different among the four study sites ranging from 10.8 to 18.8% .

Table 4. Density of *A. aureum* distribution on different factors in four stations of studied area at Samut Prakan Coast.

Stations	Salinity (ppt)	Soil moisture (%)	Soil texture (%clay)	Organic matter (%)	<i>A. aureum</i> density (stems/400 m <sup>2</sup> )
Ban Khlong Sean Suk	21.86	32.5	67.70	18.84	15.0
Ban Bang Mek Kloa	25.66	30.5	52.02	14.42	47.0
Ban Hua Lamplu Lai	29.40	17.5	26.15	10.89	8.0
Ban Khlong Dan	26.60	24.2	74.70	15.51	2.0

### 4.3 SPECIES DISTRIBUTION

The density of mangrove is higher in the Ban Bang Mek Kloa than other study sites. The number of species diversity is low in Ban Hua Lamplu Lai and Ban Khlong Dan due to high salinity. The *A. aureum* density seem to be high at area where the salinity is low. The *A. aureum* density is higher in Ban Bang Mek Kloa than Ban Khlong Dan (Table 4). According to zonation it was found that *A. aureum* cover a very large area on inland site with the average value of *A. aureum* average 47.6 stem per 400 m<sup>2</sup>. At *Rhizophora* zone and other zones, on the other hand, average density of *A. aureum* are only 0.3, 4.3, 30.0 and 14.3 stems per 400 m<sup>2</sup> respectively (Table 5-7). *A. aureum* is found both in the wet and dry zones. *Avicennia* species can be found throughout the coastal line. *Rhizophora* is only found in Ban Bang Mek Kloa and Ban Khlong Dan (Table 8). Comparative study of *A. aureum* and other mangrove canopies, it was found that *A. aureum* distribution was depending on light intensity (Fig. 11-17).



Fig. 11 Acrostichum distribution in Avicennia canopy.



Fig. 12 Acrostichum distribution in Mixed Avicennia and Sonneratia canopy.



Fig. 13 Acrostichum distribution in mixed forest.



Fig. 14 shows density of Acrostichum in Acrostichum zone.

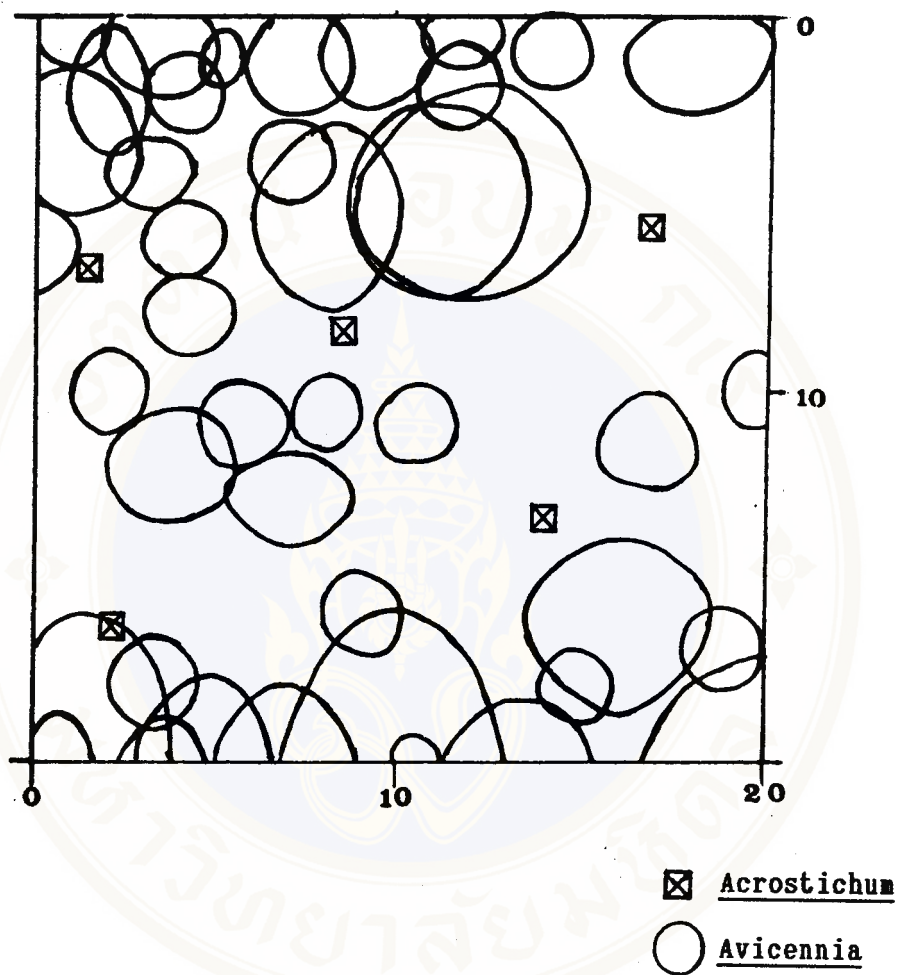


Fig. 15 Sketch of the Acrostichum distribution in Avicennia canopy in 20x20 m plot.

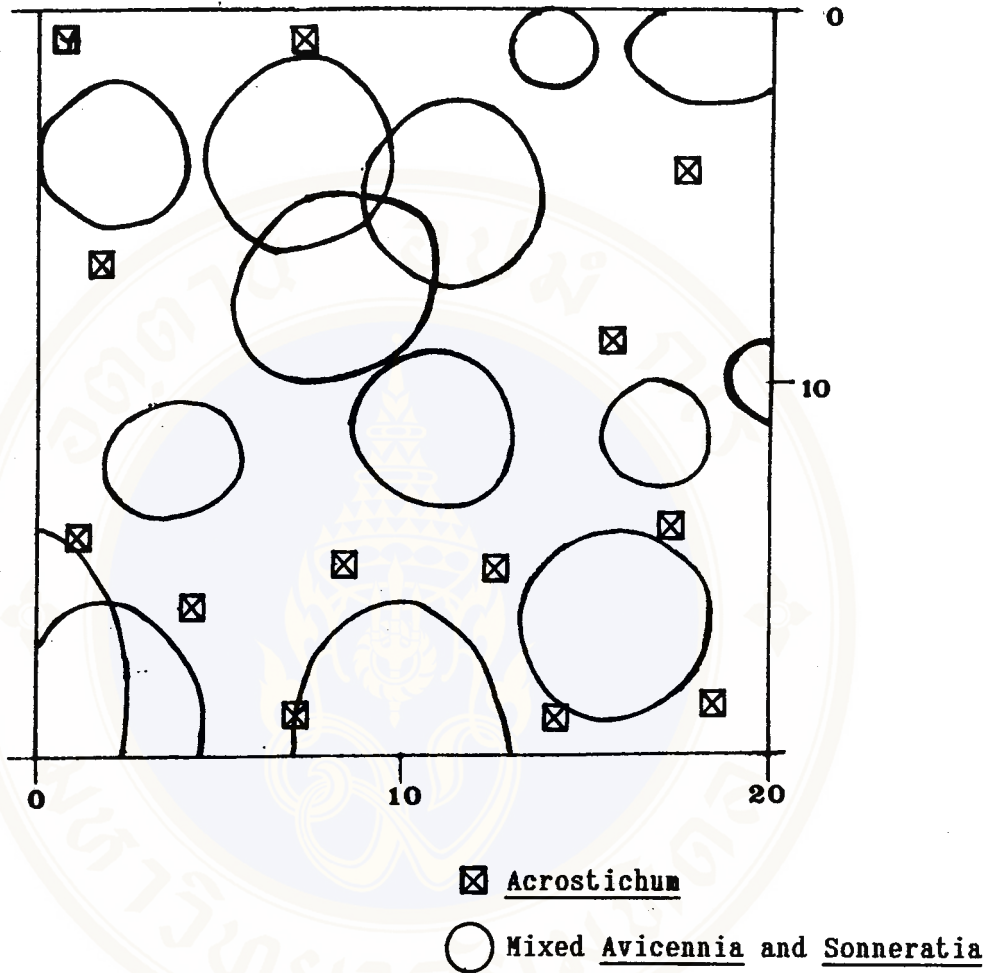


Fig. 16 Sketch of the Acrostichum distribution in mixed Avicennia and Sonneratia canopy in 20x20 m plot.

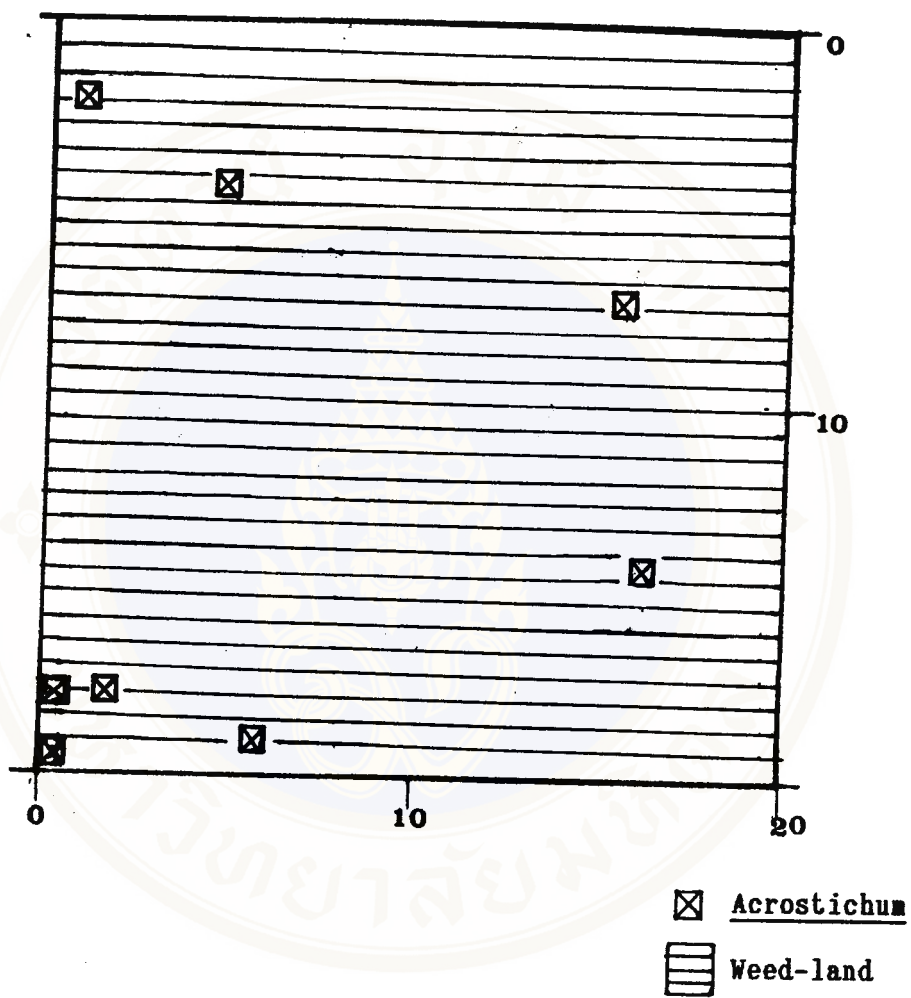


Fig. 17 Sketch of Acrostichum disstribution in Weed-land 20x20 m plot.



Table 5. Density of *A. aureum* in different areas and some factors at Ban Bang Mek Kloa.

Station	Salinity (ppt)	Soil moisture (%)	Soil texture (%clay)	Organic matter (%)	<i>A. aureum</i> density (stems/400 m <sup>2</sup> )
Sea (Open area)	23.86	33.5	70.00	26.26	0.0
<i>Rhizophora</i>	23.66	32.5	61.25	25.90	0.3
<i>Rhizophora</i> and <i>Avicenia</i>	21.62	32.2	14.97	3.17	1.6
<i>Avicenia</i>	21.50	30.5	47.66	10.89	4.3
Mixed forest	21.60	29.4	57.89	18.49	30.0
<i>Acrostichum</i>	21.81	28.2	60.36	18.84	47.6
Inland	-	14.7	52.24	20.03	14.3

Table 6. Analytical results of mangrove soil from different zones at Ban Bang Mek Kloa. Samples of at the 0-20 cm depth were collected.

Zones	Soil texture			
	Sand (%)	Silt (%)	Clay (%)	Texture
Sea (open area)	12.15	18.35	70.00	Clay
<i>Rhizophora</i>	6.23	32.52	61.25	Clay
<i>Rhizophora</i> and <i>Avicennia</i>	66.76	18.27	14.97	Silty Loam
<i>Avicennia</i>	12.39	39.95	47.66	Silty Clay
Mixed forest	6.21	35.90	57.89	Clay
<i>A. aureum</i>	11.61	28.03	60.36	Clay
Inland	14.94	32.82	52.24	Clay

Table 7. Density of *A. aureum* per 400 m<sup>2</sup> at Ban Bang Mek Kloa.

Sample Plot No.	Zonations					
	<i>Rhizophora</i>	<i>Rhizophora</i> and <i>Avicennia</i>	<i>Avicennia</i>	Mixed forest	<i>Acrostichum</i>	Weed
1	0	1	4	32	48	12
2	0	3	6	28	50	15
3	1	1	3	30	45	16
Average	0.3	1.6	4.3	30.0	47.6	14.3

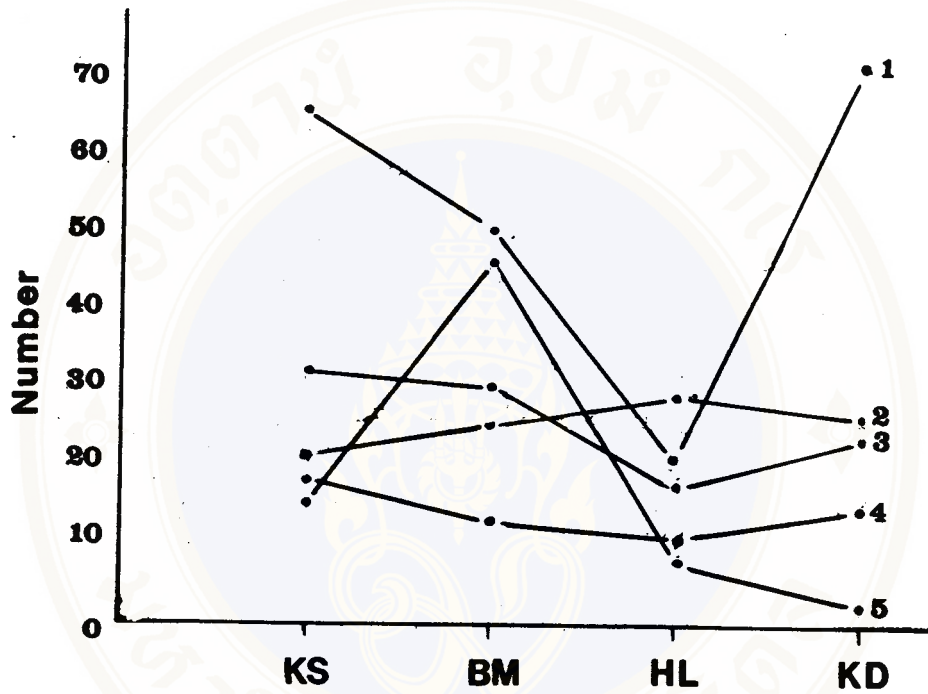


Fig. 18 Correlation between Acrostichum and environmental factors on Samut Prakan Coasts: KS = Ban Khlong Sean Suk, BM = Ban Bang Mek Klua, HL = Ban Hua Lamplu Lai, KD = Ban Khlong Dan; 1 = Soil texture (% clay), 2 = Salinity (ppt), 3 = Soil moisture (%), 4 = Organic matter (%), 5 = Acrostichum density (stem/400 m.<sup>2</sup>).

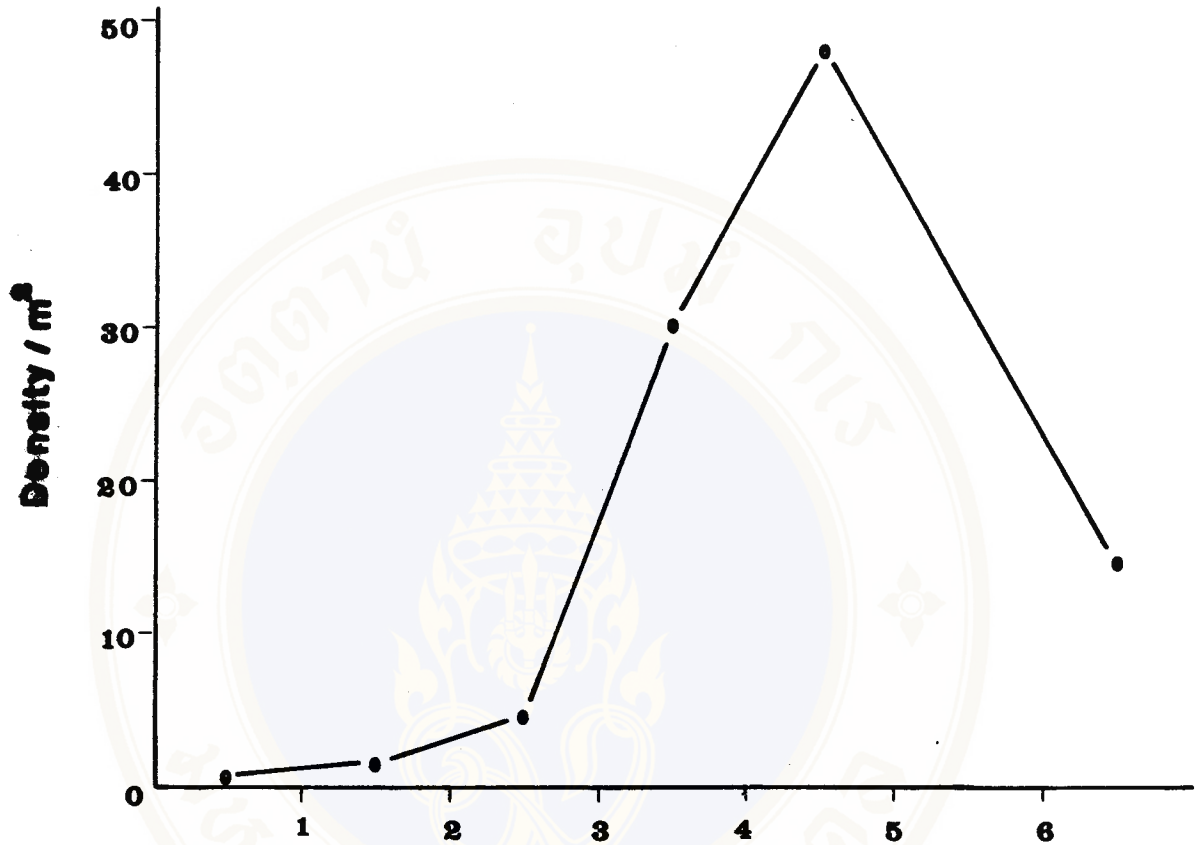


Fig. 19 Density of Acrostichum distribution in different zone:  
0-1 Rhizophora, 1-2 Rhizophora and Avicennia, 2-3 Avicennia, 3-4  
Mixed forest, 4-5 Acrostichum, 5-6 Weed.

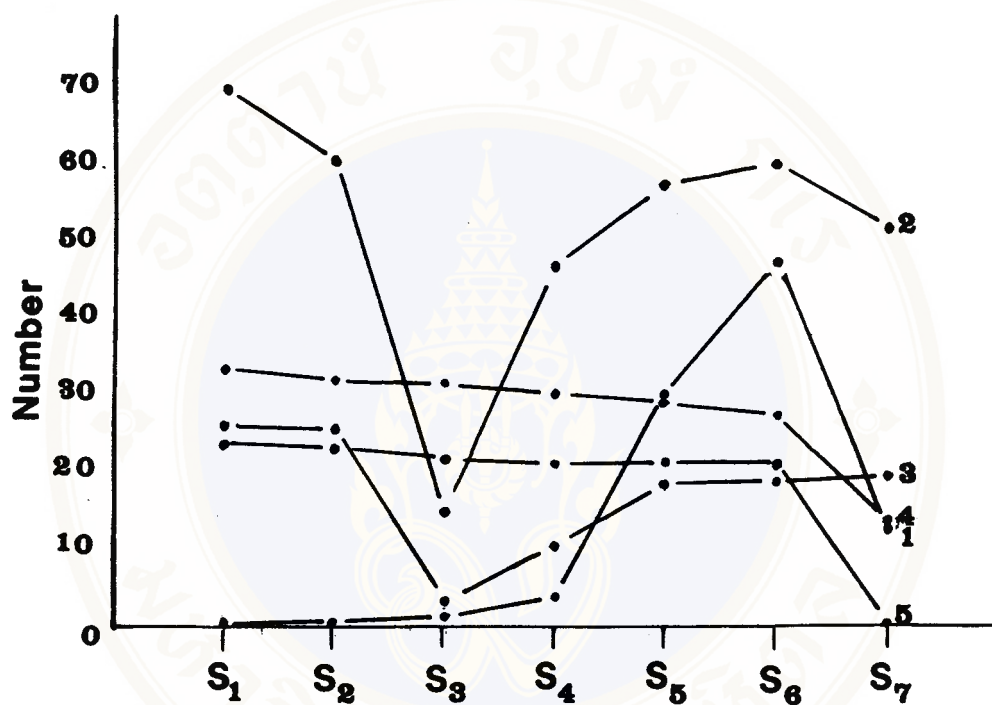


Fig. 20 Relationships between Acrostichum and environmental factors on Ban Bang Mek Kloa:

S<sub>1</sub> = Open area, S<sub>2</sub> = Rhizophora, S<sub>3</sub> = Rhizophora and Avicennia,  
 S<sub>4</sub> = Avicennia, S<sub>5</sub> = Mixed forest, S<sub>6</sub> = Acrostichum, S<sub>7</sub> = Inland;  
 1 = Acrostichum density (stem/400 m.<sup>2</sup>), 2 = Soil texture (% clay),  
 3 = Organic matter (%), 4 = Soil moisture(%), 5= Salinity (ppt).

Table 8. Mangrove species, size of trees and soil condition at various studied sites.

Species	Size of plant (Height, m)	Soil	Location
<i>Rhizophora mucronata</i>	8-15	Clay	Ban Bang Mek Klua Ban Khlung Dan (do)
<i>R. apiculata</i>	8-15	Clay	Ban Bang Mek Klua Ban Khlung Dan (do)
<i>Avicennia alba</i>	5-10	Silty Clay	All regions
<i>Sonneratia caseolaris</i>	5-8	Clay	Ban Bang Mek Klua
<i>S. ovata</i>	5-8	Clay	Ban Bang Mek Klua
<i>Hibiscus tiliceus</i>	3-7	Clay	Ban Bang Mek Klua
<i>Thespesia populnea</i>	3-7	Clay	Ban Bang Mek Klua
<i>Nypa fruticans</i>	3-5	Clay	Ban Khlung Saen Suk, Ban Bang Mek Klua, Ban Khlung Dan
<i>Cerbera odollan</i>	3-4	Silty Clay Loam/ Silty Clay	All regions
<i>Caesalpinia nuga</i>	2-3	Silty Clay Loam/ Silty Clay	Ban Bang Mek Klua
<i>Clerodendrum inerme</i>	1-2	Clay	All regions
<i>A. aureum</i>	1	Clay	Ban Khlung Saen Suk to Ban Hua Lamplu Lai, Ban Khlung Dan
<i>Deris tri-foliata</i>	0.8-1	Clay	Ban Bang Mek Klua
<i>Acanthus ebracteatus</i>	0.5-0.8	Clay	Ban Khlung Saen Suk to Ban Hua Lamplu Lai, Ban Khlung Dan
<i>A. ilicifolius</i>	0.5-0.8	Clay	Ban Khlung Saen Suk to Ban Hua Lamplu Lai, Ban Khlung Dan
<i>Cyperus sp.</i>	0.3	Clay	All regions
<i>Sueda maritima</i>	0.1-0.15	Silty Clay Loam/ Silty Clay	All regions

#### 4.4 PLANT REGENERATION IN THE FIELD

Plant regeneration was observed in the study site after clear cutting of mangrove during January 1993 to June 1994 (Table 9-10). During the first ten months no algae or plant seedling was observed. Algae firstly occurred in the eleventh month. The thirteenth month, occurrence of the first *Avicennia* seedling was found. Seven *Avicennia* seedlings were found in the fifteenth month. Until the eighteenth month, only seven *Avicennia* seedlings were found in comparatively higher growth. Some environmental factors such as soil texture, organic matter

and moisture were observed and slightly changes were found after eighteen months observation (Table 9).

Table 9. Soil properties before cleared-cutting of *A. aureum* and month after (in one year).

Samples	Soil properties					
	Sand (%)	Silt (%)	Clay (%)	Organic matter (%)	Moisture (%)	Texture
Pre-cut	0.52	30.77	68.71	19.29	30.5	Clay
18 months	0.73	41.50	57.77	10.30	30.0	Clay

Table 10. Plant succession from the clear-cut plot during January 1993 to June 1994.

Month	Plant Succession
1	No plant succession was observed.
2	No plant succession was observed.
3	No plant succession was observed.
4	No plant succession was observed.
5	No plant succession was observed.
6	No plant succession was observed.
7	No plant succession was observed.
8	No plant succession was observed.
9	No plant succession was observed.
10	No plant succession was observed.
11	Algae was firstly observed.
12	Algae yielded more colonies and densely developed.
13	One young <i>Avicennia</i> was found.
14	Three <i>Avicennia</i> was found.
15	Seven <i>Avicennia</i> was found.
16	Seven <i>Avicennia</i> was found with higher growth.
17	Seven <i>Avicennia</i> was found with higher growth.
18	Seven <i>Avicennia</i> was found with higher growth.

#### 4.5 REGENERATION IN CULTURE

*A. aureum* can grow in soil culture. The culture is wet soil and less sunlight (wet soil by watering once a day and less sunlight by covered with other tree's canopies). After culture, *A. aureum* grow from spore in 3<sup>th</sup> month until 12<sup>th</sup> month (Table 11). In 3<sup>th</sup> month, a prothallus becomes young plant and to mature plant ( Fig. 21 and 22) in one year period (mature means plant can produce spore).

Table 11. Growth rate of *A. aureum* in cultivation.

Months	1	2	3	4	5	6	7	8	9	10	11	12
Plant height (cm)	0	0	0.5	2	5	10	20	35	50	60	65	70

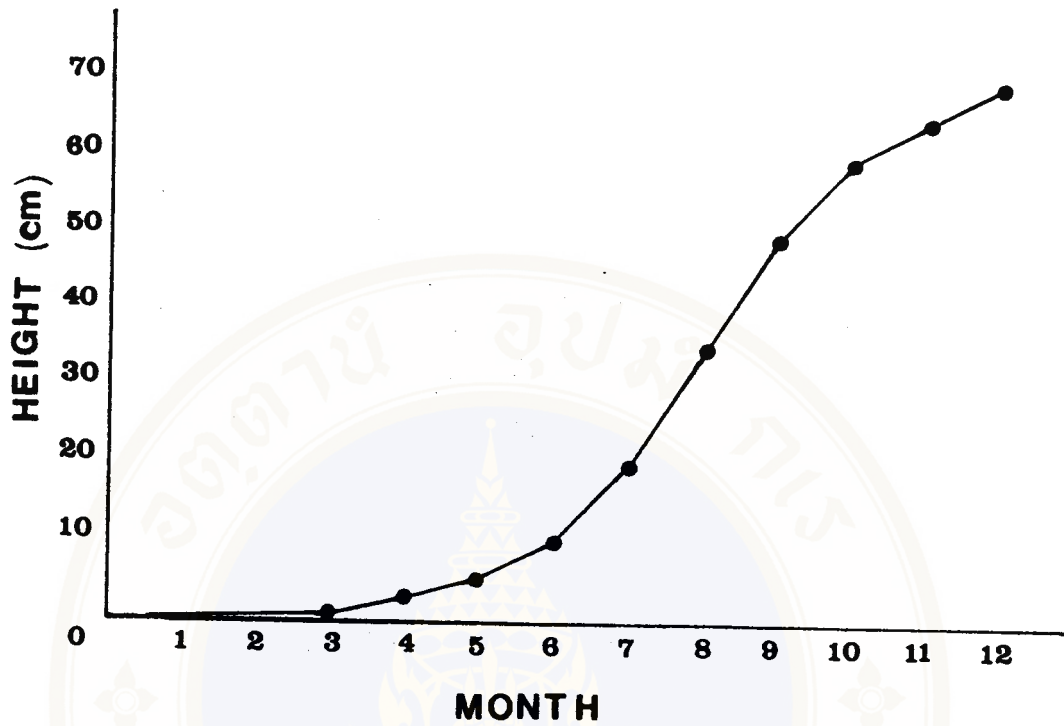


Fig. 21 Total height of Acrostichum in one year.

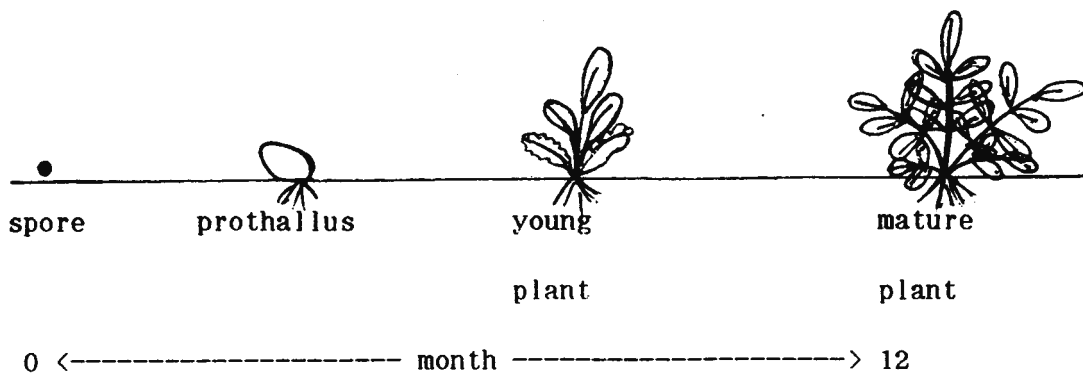


Fig. 22 Development of Acrostichum species.

# CHAPTER V

## CONCLUSION AND RECOMMENDATIONS

### 5.1 CONCLUSION

#### 5.1.1 Characteristics of the studied area

Studied area is located on the Samut Prakan coastline. The mangrove forest covers a small strip from Ban Khlong Saen Suk, East of Chao Phraya River to Ban Khlong Dan in Amphoe Khlong Dan. The mangrove forest extends about 2 kilometres from shoreline inward. According to the field observation, the mangrove forest in this area has been decreased at the rate alarming especially conversion to shrimp farms. Other changes are housing and industrial developments. Most of the mangrove forest is not treated as forest reserve and not responsible by the Royal Forestry Department. The important mangrove species found in this area is *Avicennia* which covers large area along the coastal line, other mangrove species sparsely found such as *Rhizophora*, *Sonneratia*, *Hibiscus*, *Thespesia*, *Acanthus*, and *Nypa*. At Ban Bang Mek Klua contains mangrove forest with various species composition. *A. aureum* fern is found throughout the study area along the Samut Prakan coastline.

#### 5.1.2 Environmental factors as related to the occurrence of *A. aureum*

The environmental factors related to plant communities of the studied area vary along with distance from coast line. The *A. aureum* species can grow throughout the studied area and suitable conditions for its development can be found at salinity ranging between 21 to 23 ppt. clay texture, and about 15% of organic matter.

#### 5.1.3 Succession and regeneration.

From the experiment on plant regeneration and succession after clear cut, the *Avicennia* was firstly found in 12 months but within 18 months the *A. aureum* did not appear in this experimental plot. It can be concluded that *Avicennia* is the most likely to be a dominant species in cleared cutting area.

#### 5.1.4 The *A. aureum* growth

In experiment of the *A. aureum* growth on culture, it was found that the *A. aureum* grow approximately 70 cm in height in the first year.

## 5.2 RECOMMENDATIONS

Recommendations from the study on “Ecological Study on *Acrostichum aureum* of Mangrove Forest in Samut Prakan Province” are as followings:

### 5.2.1. Management of mangrove plantation

Prior to mangrove plantation, it is recommended that the *A. aureum* should be clearly cut. This would reduce the natural competition between young seedlings and this fern.

### 5.2.2 Research

The investigation of *A. aureum* was not observed within 18 months after clear cut and suggests that further investigation on environmental factors may inhibit *A. aureum* germination such as light, soil, or others should be carried out.

### 5.2.3 Preservation

Although *A. aureum* is a problem in mangrove plantation, due to its competition with mangrove seedling. In the future *A. aureum* may be used for human, other organisms and ecological purposes. Therefore, *A. aureum* should be preserved for human use rather than to eliminate them.

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# APPENDIX

## GLOSSARY

- Acid soil:** a type of zonal soil in which soluble line has been leached from the surface layers due to persistent heavy rains and so it is acidic with low rate of decomposition of organic matter. Adventitious : the condition of organs that arise in places where they are not usually found.
- Aerenchyma:** parenchymatous tissue in which large air spaces develop separated by partition walls.
- Alternate:** describing arrangement of leaves on stem in which leave arise simply at node.
- Anatomy:** study of structure and distribution of tissue along with the study of their component cells inside the body of an organisms.
- Apical:** describing structure having a small broad point at the apex.
- Cambium:** lateral meristem present in vacular plants exhibiting secondary growth, present in stem mostly between xylem and phloem tissue, formed at other positions also, normally cuts off secondary phloem cells towards periphery and secondary xylem cells towards centre, both by periclinal divisions but sometime may also cut off cells other than these type.
- Chromosome:** thread-like structure having genetic material of organism made up of chromatin, becomes visible under light microscope prior to nuclear division due to condensation of chromatin.
- Cortex:** the tissue between epidermis and pericycle, endodermis being its innermost boundary in the stem and root.
- Dichotomous:** description system of branching where each division forms two equal parts from the branching structure as in many lower plants, branching of thallus or branching of stem.
- Endodermis:** a layer of cells at the boundary layer of cortex and stele, outer to pericycle, regarded as the innermost layer of cortex, distinct in all roots, pteridophytes and in certain dicotyledonous stems.
- Epidermis:** outermost layer of cells in organs of primary plant body, usually single layered but sometimes many layer differentiated from protoderm, replaced by periderm in old roots and stems with secondary growth.
- Fertile:** the ability to produce offspring.

<b>Fronde:</b>	describing a large leaf or leaf-like structure.
<b>Germination:</b>	physiological and physical change in a reproductive body such as spore, pollen, gemma, seed, zygote, etc, immediately prior to and including first visible indications of growth.
<b>Internode:</b>	a part of stem that lies between two adjacent nodes.
<b>Lamina:</b>	usually flattened structure that is thin and photosynthesis portion of the leaf.
<b>Morphology:</b>	science that deals with the study of external shape, size and structure of an organism.
<b>Node:</b>	point on the stem from where one or more leaves arise.
<b>Section:</b>	a rank in taxonomic hierarchy above the rank of series but subordinate to genus.
<b>Species:</b>	fundamental unit of study in taxonomy denoting a particular interbreeding group of organism.
<b>Sporangia:</b>	the structure in which spores are produced.
<b>Spore:</b>	unicellular asexual reproductive unit that may be formed by sporophytic generation following meiosis and therefore have half the number of chromosomes of sporophytes.
<b>Sporophyte:</b>	individual, usually of diploid phase of life cycle, that is formed from the fusion product of two gametes by mitosis throughout and reproduces by spore which germinate to form gametophyte in haploid phase of life-cycle.
<b>Soil structure:</b>	the shape and arrangement of large soil aggregates in the soil.
<b>Soil texture :</b>	the roughness of soil on the basis of relative proportions of different sized mineral particle in it
<b>Sterile:</b>	unable to produce off spring.
<b>Succession:</b>	successive replacement of communities by each other resulting in successive changes in the composition of vegetation seen during stabilisation of an area from extreme conditions.
<b>Swamp:</b>	fill or cover something with too much liquid.
<b>Tidal:</b>	rise and fall of the sea that happens twice a day.
<b>Tissue:</b>	a group or layer of similarly specialised cells which together perform certain special functions.

- Transect:** the line drawn across an area along with quantitative study of population characteristics is made in the vegetation of the area.
- Transverse:** extending from side to side.
- Weed:** any plant growing at the place where it is not wanted.
- Xylem:** a type of vascular tissue which serve mainly to translocate and solutes.

