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LITTERFALL PRODUCTION IN A PRIMARY MANGROVE, *Rhizophora apiculata* FOREST IN SOUTHERN THAILAND

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บทคัดย่อ

ผลผลิตซากพืชในป่าโกงกางใบเล็กดั้งเดิม ดำเนินการศึกษาที่เกาะตูหรา อำเภอกันตัง จังหวัดตรัง โดยทำการศึกษาระหว่างเดือนกุมภาพันธ์ 2533 ถึงเดือนมกราคม 2536 ผลผลิตซากพืชรวมเฉลี่ย 1,376 กรัม/ม^2/ปี แยกเป็นซากพืชส่วนใบ 68% ส่วนสืบต่อพันธุ์ 20% ส่วนเนื้อไม้ 11% และส่วนอื่นๆ 1% รูปแบบการร่วงหล่นของซากพืชส่วนใบจะร่วงหล่นสูงสุดในฤดูแล้ง กลางฤดูฝน และปลายฤดูฝน และซากพืชส่วนใบมีปริมาณต่ำสุดในเดือนพฤษภาคม หรือมิถุนายน ซากพืชส่วนเนื้อไม้ และส่วนสืบต่อพันธุ์ มีปริมาณสูงสุดในช่วงกลางฤดูฝน

ปริมาณความเข้มข้นของไนโตรเจนในซากพืชส่วนใบที่เกาะตูหราจะมีปริมาณสูงกว่า ส่วนความเข้มข้นของฟอสฟอรัสจะต่ำกว่าซากพืชส่วนใบของป่าชายเลนอื่นๆ ในภาคใต้ฝั่งตะวันตกของประเทศไทย และฝั่งตะวันตกของคาบสมุทรมาเลเซีย

ABSTRACT

Litterfall production and nutrient concentration of litterfall in a primary mangrove forest which mainly composed of *Rhizophora apiculata* Bl. was investigated in Tura Island, (7°21'30"N, 99°30'32" E), Trang Province, southern Thailand, for 3 years. Average total annual litterfall was 1,376 g/m^2/y. Leaves, reproductive structure, and wood constituted 68, 20 and 11% of the total litterfall, respectively. Leaf litterfall patern appeared to be trimodal with the peaks in dry season, mid and late rainy season, and lowest fall in May/June. Reproductive materials and wood litterfall exhibited unimodal patterns with peak in mid rainy season. Nitrogen concentration of leaf litterfall in Tura Island was higher while phosphorus was slightly lower than those reported from other mangrove forests located along the west coast of the Malay peninsula.

INTRODUCTION

Mangrove forests are considered to be a highly productive ecosystem which not only have high rate of primary productivity, but also supply organic matters to form detrital-base for marine food web (Lugo & Snedaker, 1974; Snedaker, 1978; Boto & Bunt, 1981). Litterfall amount is a useful index of mangrove productivity since it is a major fraction of mangrove net productivity which supports aquatic organism (Bunt & Boto, 1979).

Several studies have been estimate litterfall production of mangrove forests in different parts

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amount is a useful index of mangrove productivity since it is a major fraction of mangrove net productivity which supports aquatic organism (Bunt & Boto, 1979).

Several studies have been estimate litterfall production of mangrove forests in different parts of the world (Woodroffe, 1982; Sasekumar & Loi, 1983; Woodroffe & Moss, 1984; Leach & Burgin, 1985; Saifullah *et al.*, 1989; Amarasinghe & Balasubramaniam, 1992). In Thailand, there were some studies on mangrove litterfall production, but all of the studies were on young plantations or poor mangrove forests where the tree heights were ranging from 3 to 11 meters (Christensen, 1978; Aksornkoae *et al.*, 1991; Angsupanich & Aksornkoae, 1994). At the present, matured primary mangrove forests in Thailand left only a few. Most of them found in the islands in Andamann Sea, which a few remain in the west coast of the southern peninsula of Thailand. The present investigation aims to determine the production of total litterfall and its components over a period of three years in the primary mangrove forest which mainly composed of *Rhizophora apiculata* Bl. and to comparing to the other mangrove forests especially where they are along the west coast of the Malay peninsula.

STUDY SITE

Tura Island (7°21'30" N, 99°30'32" E), a small island of an area about 13.5 ha is situated 6.5 km from the mouth of Trang River, Kantang District, Trang Province (Figure 1). The mangrove soil is muddy, flooded in average 22.7 days per month. The island is mainly dominated by *Rhizophora apiculata*, while some other species e.g. *R. mucronata* Poir are found along river fringe, *Avicennia alba* Bl. and *A. officinalis* Linn. at the shoal with a few relic of *Avicennia* spp. inside the island. A few individuals of *Sonneratia alba* Smith, *Bruguiera cylindrica* Bl. and *B. parviflora* Wight & Arn. ex Griff. are observed. *R. apiculata* forms a stand with closed and continuous canopy of 25-30 m high.

During the period of study, the average annual mean temperature of the study site was 28.3°C and the average annual maximum and minimum was 33.4°C and 23.2°C (Figure 2). The average annual precipitation was 1,943 mm. The meteorological data were obtained from the weather station in Trang Province 25 km northeast of Tura Island.

METHODS

Twenty-five of 1x1 m traps were placed in a 1 ha (100x100m) permanent plot where located in the southern part of the island. Each trap was 20 m apart. The trap was made of wooden rim held about 3 m above the ground by four wooden legs and 1 mm mesh nylon bag, with a hole in the bottom closed with a string. The bottom of the trap was about 2 m above the ground, beyond the reach of high tide. To collect litterfall, we opened the bottom and removed the litterfall from below.

Litterfall was collected twice a month, on the mid and the end of the month, from February 1990 to January 1993. Materials from each trap were sorted into (i) leaves (ii) wood (twig, fine branch with diameter less than 2.5 cm and bark), (iii) reproductive materials (flower buds, flowers, fruits and propagules) and (iv) unclassified (insects, grass and amorphous materials), dried at 80° C for 72 hours and weighed.

For nutrient analysis, sub-samples of the litterfall were ground then re-dried at 105° C and wet-digested in a mixed acids (H_2SO_4-$NaSO_4$-Se, 1000:100:1). Nitrogen was determined by the Kjeldahl method, phosphorus by the vanadomolybdate yellow color. Potassium was determined by flame photometer. Calcium and magnesium were determined by an atomic absorption.

RESULTS

Litterfall

The three-year mean total litterfall was 1,376 g/m^2/y (Table1). Leaf litterfall constituted the largest component, accounting for 68% of the total litterfall. Reproductive materials, wood, and unclassified was 20%, 11%, and 1% of the total litterfall, respectively.

The annual cycles of litterfall showed in Figure 3. The total litterfall and leaf litterfall were fluctuated. However, leaf litterfall in 1990 and 1992 tended to show a distinct increase in dry season (January/ February/March), mid rainy season (July/August) and late rainy season (November/December). The temporal variation of the 1991 leaf litterfall was more fluctuated . The lowest rate of leaf litterfall prevailed in May/June.

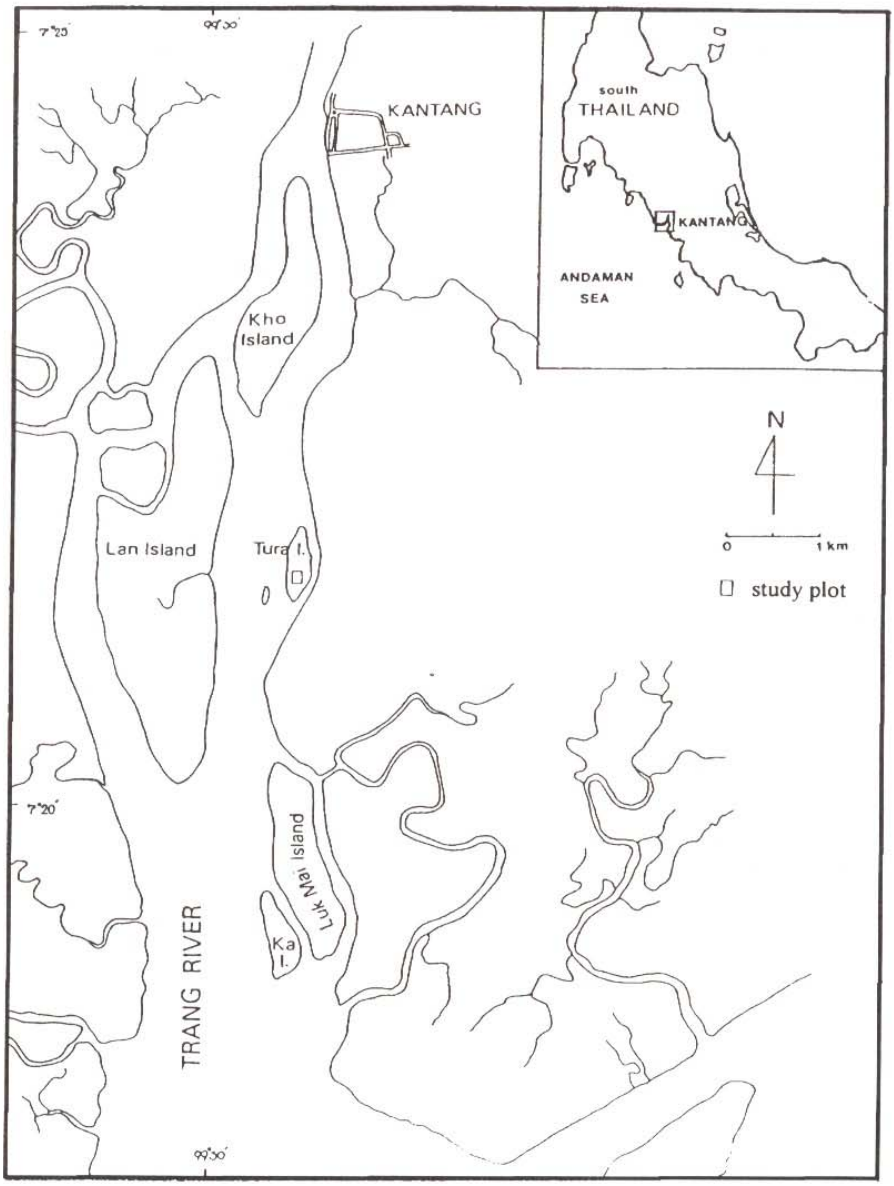

Figure 1. Map showing location of study area

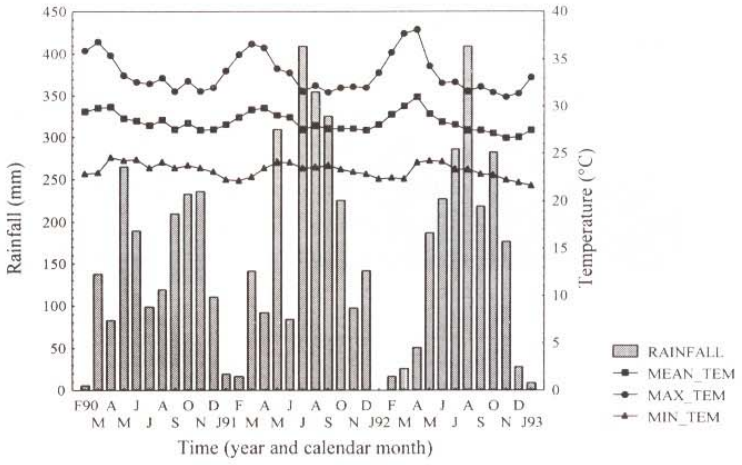

Figure 2. Distribution of mean monthly, mean monthly maximum and mean monthly minimum temperature (^{O}C) and of rainfall (mm) in Trang Province from February 1990 to January 1993

Table 1. Mean annual contribution of each component of total litterfall in *Rhizophora apiculata* forest at Tura Island in unit of g/m^2/y (n=25)

Year	Component				
	Leaves	Wood	Reproductive materials	Unclassified	Total
Feb. 1990-Jan. 1991	881.5	183.6	220.8	21.3	1,307.3
Feb. 1991-Jan. 1992	913.4	133.4	248.9	18.3	1,314.1
Feb. 1992-Jan. 1993	1,000.5	143.4	348.0	15.7	1,507.6
Mean	931.8	153.5	272.6	18.4	1,376.3

Unlike leaf litterfall, reproductive materials and wood litterfall exhibited unimodal patterns. Reproductive materials in 1991 and 1992 showed peak in June. The ripen periods of the *Rhizophora apiculata* propagules in Trang Province usually found from April to July. From this study may reflected that the fallen of ripen propagules peak in June. The maximum wood litterfall in 1991 and 1992 occurred in mid rainy season (August), while the 1990 wood litterfall peaked in October.

Neither mean monthly leaf litterfall nor total litterfall were correlated with mean monthly temperature and monthly total rainfall over the study period. Wood component was correlated with monthly rainfall which accounted for only 25% of the variation in litterfall over a period of three years (r^2 = 0.25, $P<0.05$, n = 36). Only 11% of reproductive materials can be attributed to the inference of mean monthly temperature (r^2 = 0.11, $P<0.05$, n = 36).

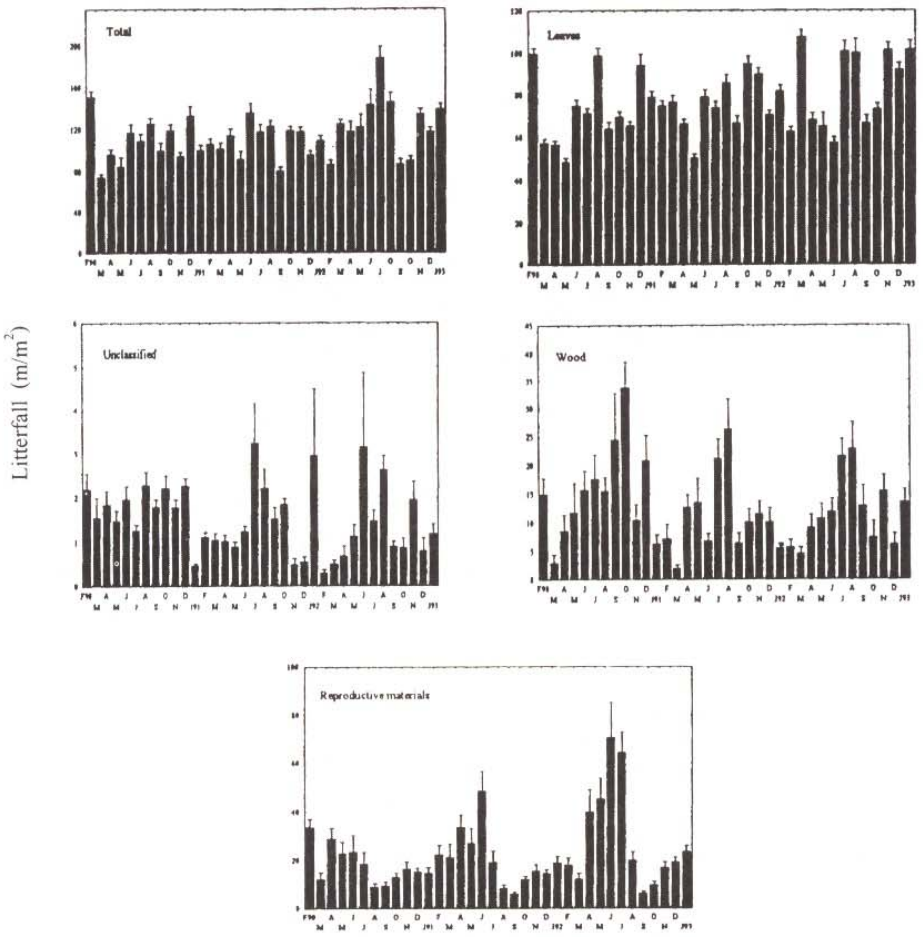

Figure 3. Temporal distribution of total litterfall and the fall of each component in *Rhizophora apiculata* stand at Tura Island from February 1990 to January 1993. Bars indicate one-side of standard error of the mean

Nutrients in Litterfall

The percentage of nitrogen and phosphorus content in leaf litterfall were 0.80 and 0.038, and in reproductive materials were 1.03 and 0.108. Nutrient concentration in the litterfall component was shown in Table2. Nutrient content of litterfall component calculated from mean annual litterfall of each component, and then sum for total nutrient content of total litterfall. Nitrogen, phosphorus, potassium, calcium and magnesium contents of total litterfall were 116, 7, 146, 146 and 71 kg/ha/y, respectively (Table3).

Table 2. Mean nutrient concentration (% dry weight) ± SE of litterfall in *Rhizophora apiculata* forest at Tura Island, Trang Province, n=4 except unclassified which n=1

Component	N	P	K	Ca	Mg
Leaves	0.80±0.05	0.038±0.005	1.16±0.08	1.06±0.03	0.62±0.08
Wood	0.78±0.02	0.052±0.004	0.45±0.01	2.19±0.05	0.28±0.01
Reproductive materials	1.03±0.09	0.108±0.011	1.08±0.03	0.46±0.05	0.29±0.03
Unclassified	1.06	0.078	0.81	0.85	0.28

Table 3. Nutrient content (kg/ha/y) of total litterfall and its components in *Rhizophora apiculata* forest at Tura Island, Trang Province

Component	N	P	K	Ca	Mg
Leaves	74.54	3.59	107.76	98.42	58.21
Wood	12.02	0.80	6.96	22.58	4.30
Reproductive materials	28.02	2.94	29.40	12.44	7.93
Unclassified	1.94	0.14	1.50	1.56	0.50
Total	116.52	7.47	145.62	146.00	70.59

DISCUSSION

The Tura Island site is a relatively productive mangrove forest comparing to several studies which mostly litterfall ranged from 365-1,000 g/m^2/y (Goulter & Allaway, 1979; Duke *et al.*, 1981; Clough & Attiwill, 1982; Woodroffe, 1982; Saifullah *et al.*, 1989; Amarasinghe & Balasubramaniam, 1992). Total litterfall in this study is more comparable to those in peninsular Malaysia (1,401 - 1,576 g/m^2/y) (Sasekumar & Loi, 1983) and Papua New Guinea (1,430 g/m^2/y) (Leach & Burgin, 1985). Only one higher litterfall production has been recorded was from Hinchinbrook Island, Australia, 2,810 g/m^2/y (Bunt, 1978, cited in Leach & Burgin, 1985). Although rate of litterfall from this study was similar to those of peninsular Malaysia and Papua New Guinea but the forest structure were quite different. Average canopy height in the mangrove forests in Papua New Guinea and peninsular Malaysia were 10-15 m, while forest in this study was 25-30 m high. It is evident that the taller and greater canopy area forest was not always be more productive than the short and smaller canopy forest.

Comparing to the other sites in mainland South East Asian mangrove forests, rate of litterfall in Tura Island was similar to the *R. apiculata* forest at Kuala Selangor, peninsular Malaysia, 3°15′ N, (Sasekumar & Loi, 1983) and was twice of those in southern Thailand at Phang-nga Bay (*Rhizophora* forest), 8°20′ N, (Angsupanich & Aksornkoae, 1994) and in mixed mangrove forest at Ranong, 9°50′ N, (Aksornkoae *et al.*, 1991). Since all sites located along the west coast of the Malay peninsula, the difference on litterfall production in the same region indicated that mangrove productivity was probably influence by soil nutrient condition (Boto & Wellington, 1983, cited in Sasekumar & Loi, 1983) and/or forest structure and species composition.

Non-leaf litterfall in this study constitute a significant input to the mangrove soil. Although these components take a longer time to decompose and remineralize, but it may be an important nutrients source during the less leaf litterfall period. Its important should be considered.

Seasonal trend of litterfall in *R. apiculata* forest were pronounced in many studies. Leach & Burgin (1985) found one peak of leaf fall annually in wet season, while dry season peak was found by Angsupanich & Aksornkoae (1994). Duke *et al.* (1984) showed trimodal with peak in November, February, and July to August. From this study, peak of leaf litterfall in 1990 and 1992 were almost exactly to those of Duke *et al.* (1984). Peak of reproductive materials during wet season in present study is similar to other areas (Williams *et al.* 1981; Leach & Burgin, 1985). No report on seasonality of mangrove wood litterfall have found.

Nitrogen concentration of leaf litterfall in this study (0.80%) was higher than those of the other sites along the west coast of the Malay peninsula, 0.44 - 0.67% (Ong *et al.*, 1982; Aksornkoae *et al.*, 1991; Angsupanich & Aksornkoae, 1994) and in Australia, 0.49% (Bunt, 1982). While phosphorus concentration of leaf litterfall (0.038%) in Tura Island was slightly lower than those in the Malay peninsula (0.04 -0.05%), but similar to phosphorus concentration in *R. apiculata* leaf litterfall in Australia (0.036%) (Bunt, 1982). For wood litterfall, all nutrient elements in this study was higher than the said sites, except calcium which slightly lower than those in peninsular Malaysia. The higher nutrients concentration in litterfall in this study was probably reflected the soil fertility in Tura Island.

Nitrogen content (117 kg/ha/y) in primary *R. apiculata* forest was similar to those in peninsular Malaysia (calculated from Ong *et al.*, 1982; and Sasekumar & Loi, 1983) and was 2.5 and 4 times greater than Ranong (Aksonkoae *et al.*, 1991) and Phang-nga Bay (Angsupanich & Aksornkoae, 1994), respectively. Phosphorus content in litterfall at Tura Island was also greater than those at Ranong and Phang-nga Bay 2 and 3 times, respectively.

Around the study area, mangrove forests along Trang River are in good condition, including an amount of old *R. apiculata* plantation, aged over 20 years. These forest plantation structure is similar to the study plot, their rate of litterfall should be more or less similar to those of the primary *R. apiculata* forest. All or part of litter from mangroves near the river mouth may be washed into the coastal ecosystem to form a nutrient source for shallow marine ecosystem. While litter in the upper part of river and inner mangrove, litter accumulates and decomposes in situ. The great amount of annual litterfall with high nutrient concentration will influence the available detritus and nutrient supply to the consumers in the mangrove in Trang River and in the coastal ecosystem. These probably an important factor to cause the rich of aquatic animals in Trang River and the shallow marine ecosystem of Trang Province.

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