Litter Production of Mangrove Forests at the Gesashi River

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Abstract

Mangrove releases the nutrient as litter to the nearshore. Litter is an important source of organic detritus, which supports detrital marine food webs. The importance of mangrove in timber production, nursery and hatchery for fish, crustacea and molluscs and coastal protection from erosion is well appreciated. Mangrove is also important for the ability to control nutrient and sediment fluxes in the nearshore waters. Litterfall rate in the Gesashi mangrove forests is seasonal. It is generally low in winter and high from spring to summer. Total weight of litterfall was 1190 gm^{-2} yr^{-1} or 11.9 t ha^{-1} yr^{-1} in the mixed mangrove forests.

Introduction

Mangrove is consisted of trees or bushes which grow between the level of high tide and low tide. It ranges all around the oceans of the tropics, but it grows only in the sheltered shores. It penetrates into the estuaries of rivers where salt water penetrates. The mangrove forests, or tidal forests, are one of the major ecosystems of the biosphere. About 60-70% of the tropical coasts are covered by this ecosystem. They are one of the most productive ecosystems in the world in terms of gross primary productivity and litter production (Twilley, et al., 1986). Odum (1971) describes mangrove ecosystems as interface or open system because of their flow through pathways for transporting matters. According to Miyawaki (1986), mangrove in Japan is at northern limit of their distribution in the Indo-Pacific region. It occurs as fragmental outliners, typically with a few species. Six mangrove communities have been recognized. They are *Avicennia marina, Sonneratio alba, Kandelia candel, Rhizophora stylosa, Bruguiera gymnorrhiza* and *Lumnitzera racemosa.* The mangrove forests in the Ryukyu Islands occur in the sheltered shores of deltas along the side river estuaries, and in the creeks which are abundant with time grained sediment (silt and clay) in the upper part of the intertidal zone.

Study Area

Study sites were selected at the estuary of the Gesashi River in Higashi village,

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northeastern part of Okinawa Island. It is situated at 128°7'30" E and 26°36' N (Fig. 1). The mangrove has developed in the river mouth. Stands of the mangrove *Bruguiera gymnorrhiza* (L) Lamk. and *Rhizophora stylosa* Griff are dominant along the both sides of the river mouth. *Rhizophora stylosa* Griff forms pure stands in many places and is clearly the dominant species. *Kandelia candel* (L) Druce forms pure stands, but it is less represented than *Bruguiera gymnorrhiza* (L) Lamk. Coastal northeastern part of Okinawa is warm temperate, with an annual temperature at 26.6℃ (the coldest mean in January was 16.4℃ and the warmest in July was 28.8 ℃). Rainfall was seasonal with annual value 1395.5 mm (the lowest mean in December was 36.5 mm and highest in March 201.5 mm). Annual mean wind speed was 3.6 m s^{-1} (the maximum wind speed was 28.2 m s^{-1} in September). The data of the monthly rainfall, wind speed, and temperature in the Gesashi catchment from May 1993 to April 1994 was provided by the Nago Meteorological Service.

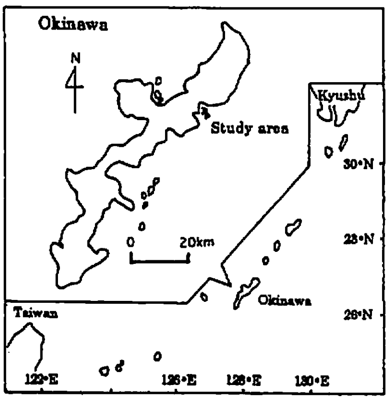

Fig.1. Map of Okinawa Island showing the study area.

Material and Method

Litterfall was determined at four permanent sites (M1, M2, M3, and M4) which were representative samples of the mangrove forests. M1 was a *Kandelia candel* (L) Druce and *R. stylosa* Griff community. M2 was a *B. gymnorrhiza* (L) Lamk. community. M3 formed the bulk of stand mixture of *B. gymnorrhiza* (L) Lamk. and *R. stylosa* Griff community. M4 was a mixed *Kandelia candel* with terrestrial community. Selection of the sites was determined by dominant species. In order to estimate litterfall rate, two sets of rectangular traps were set in the mangrove area. 14 traps were set in total. Seven of them had surface area 0.204m^2 and other seven traps had 0.144m^2. Rain water passed through 1mm mesh size of nylon screen attached to the traps (Brown, 1984). The litter traps were positioned above the high tide level. All litterfalls which were accumulating in the traps were collected from each trap at monthly intervals from May 1993 to April 1994. The materials were separated into leaves, fruits, branches, stipules, flowers, and others. All of the materials were further sorted according to species. Before weighing, the sorted materials were dried at 65℃ for 48 hours.

Results and Discussion

A substantial portion of mangrove products returns to the environment in the form of litterfall. Litterfall is an important source of organic detritus, which supports important detrital marine food webs (Odum, 1971). It is a direct food source to various herbivory crustacean and molluscs. Table 1 and figure 2 show the monthly dry weight of litterfall in the Gesashi mangrove forests. Litterfall rate is seasonal, generally being low in winter and high from spring to summer. The total dry weight of mixed mangrove forests was 1190.28 g m^{-2} yr^{-2} or 11.9 t ha^{-1} yr^{-1}. It was consisted of 563.07 g m^{-2} (47.3%) from mangrove leaves, 115.97 g m^{-2} (9.73%) from terrestrial leaves, twigs 179.77 g m^{-2} (15.10%), fruits 122.11 g m^{-2} (10.30%), others 103.18 g m^{-2} (8.66%), stipules 70.10 g m^{-2} (5.88%), and flowers 35.41 g m^{-2} (2.79%).

Table 1. Monthly total litterfall (g m^{-2}).

Month	M.leaves	T.leaves	Twigs	Fruits	Flowers	Stipules	Others	Total	%
May	73.10	18.20	18.50	68.53	5.53	4.48	6.27	194.18	16.30
Jun.	44.90	12.80	3.69	8.37	1.07	14.40	8.69	94.00	7.89
Jul.	68.70	19.60	29.70	0.29	1.28	11.30	23.20	154.00	12.90
Aug.	71.20	9.64	32.80	6.78	5.68	12.00	14.80	152.60	12.80
Sep.	90.70	26.90	76.90	27.00	6.68	6.64	26.10	261.00	21.90
Oct.	16.60	8.21	1.26	0.00	7.27	5.20	7.79	46.40	3.89
Nov.	13.60	7.44	0.52	0.00	1.43	4.39	4.21	31.60	2.65
Dec.	9.98	1.91	1.12	0.00	1.78	2.64	3.74	21.20	1.78
Jan.	7.49	0.63	4.48	0.00	1.62	2.44	1.02	17.70	1.49
Feb.	27.00	1.55	7.43	1.09	1.79	1.64	1.02	41.70	3.50
March	65.20	1.23	0.95	1.36	0.00	1.35	2.03	71.00	6.04
April	74.60	7.86	2.42	9.12	1.28	3.62	3.96	104.90	8.80
Total	563.07	115.97	179.77	122.11	35.41	70.10	103.18	1190.28	
%	47.30	9.73	15.10	10.30	2.79	5.88	8.66		100.00

Table 1 shows that the total value of mangrove leaf was higher than that of terrestrial leaf. However, the response to environmental conditions was similar in all of them, since all tend to shed higher litter during summer than during winter. Although data was not presented, low value of leaf litter of *K. candel* was observed in June. It may be attributed to the change from high shedding rates to high leafing rate. This was further exemplified by the less of stipules in this period. The others contained shell of Sesarminid crab after molting. Others also contained some feces of crab and material unidentified. Figure 2b shows others were higher in July and September. Molting time for Sesarminid crab is may be July (personal observe) and in September many materials unidentified came during typhoon.

Figure 2 shows that leaf litterfall was a dominant component of litterfall throughout the year. The high value in May was attributable to the fall of mature propagules of *K. candel.* The highest value in September coincided with heavy typhoons which not only caused severe leaf fall, but also caused branches and twigs break off. Okinawa Island is located in a typhoon zone. Therefore, the typhoon attacks during the period of the experiment was not accidental events, and should be recognized as a environmental factor with unique effects on the character of forests. The effect of the typhoon during the period of the experiment (September), which made the amount of litte fall remarkably high in these months is interesting. The influence of typhoon in litterfall rates in Ohura Bay was also discussed by Hardiwinoto, *et al.* (1989).

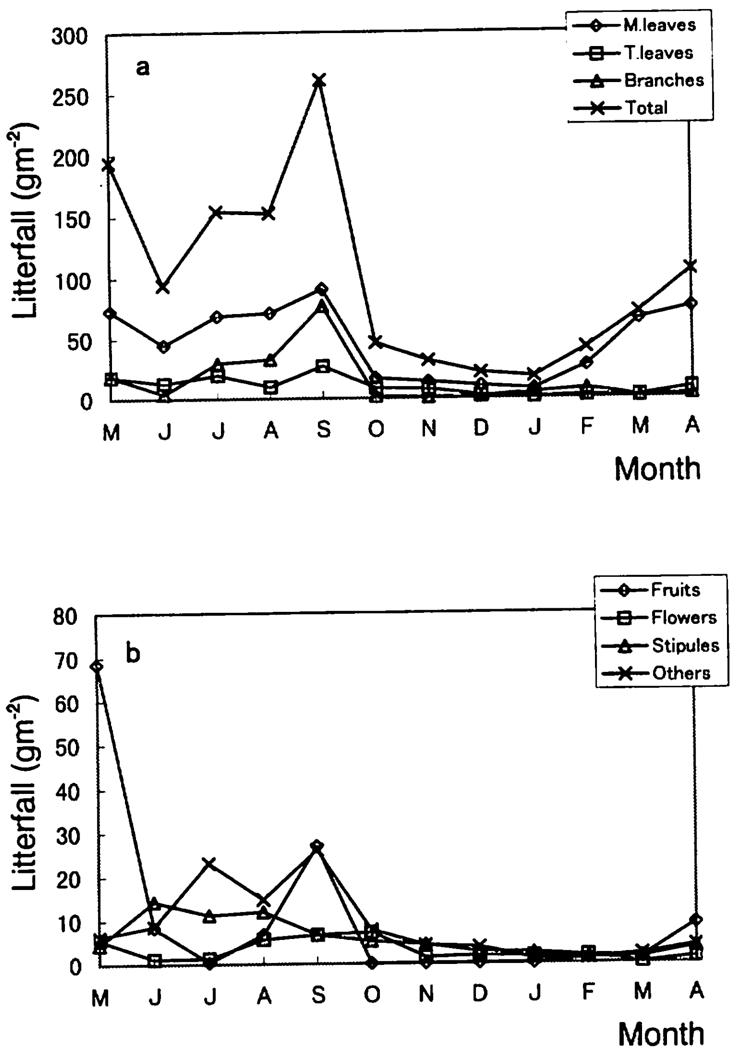

Fig.2. Seasonal variation of monthly litterfall.

The litterfall rate was the lowest during the winter (January), increased in warmer months (spring) from April to May and decreased again in the coming summer (June). It increased progressively and reached the large peak in September. The peak of litterfall in May was caused by leaf and fruits. That time is also seasonal for fruits of *Kandelia candel*. At that time the peak was caused by branches which not only made dead branches fall but also made living ones break. A general trend of litterfall peak to occur during high wind speed and heavy rainy season (Figure 3 and 4), has been reported in a number of mangrove studies (Twilley. *et al.*, 1986; Day Jr. et al., 1988; Amarasinghe and Balasubramaniam, 1992 and Mmochi, 1993). Leaf production was found to be continuous throughout the study period, which suggests that the environmental conditions are favorable for leaf emergence all year round and the stress does not appear to limit the leaf production. This trend was also shown by stipules fall. The similar results have been reported by Wium-Andersen and Christensen (1978), and Steinke and Charles (1984).

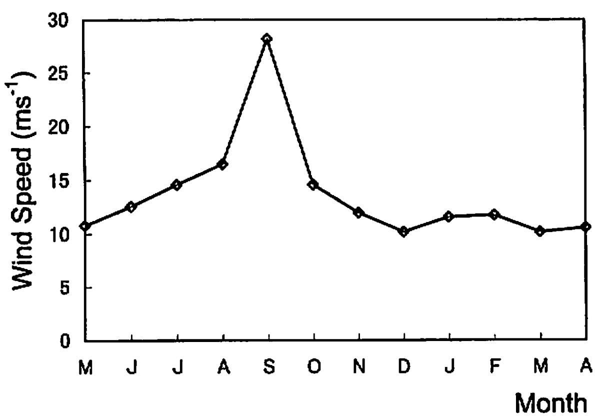

Fig.3. The maximum wind speed from May 1993 to April 1994 in Nago.

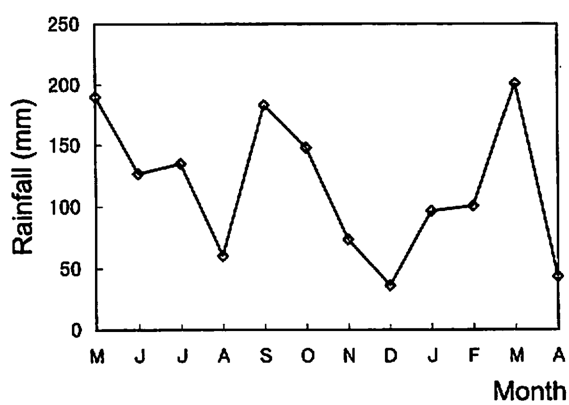

Fig.4. Monthly rainfall from May 1993 to April 1994 in Nago.

The total annual litterfall was 11.9 t ha^{-1} yr^{-1}. Twilley. *et al.* (1986) reported that the total annual litterfall of mixed mangrove forest of *Avicennia germinans, Rhizophora mangle* and *Laguncularia racemosa* in South Florida was 8.68 t ha^{-1} yr^{-1} (in Fort Myers) and 7.51 t ha^{-1} yr^{-1} (at Rookery Bay). Steinke and Charles (1984) reported the total annual litterfall of mangrove forest in the Mgeni estuary was 8.61 t ha^{-1} yr^{-1}. Kishimoto. *et al.* (1987) reported that the litterfall of mangrove stands on Iriomote Island (Japan), was 7.5 and 8.8 t ha^{-1} yr^{-1} in *Rhizophora stylosa* and *Bruguiera gymnorrhiza* community, respectively. The annual litterfall across broad geographic boundaries are reported as 7 to 12 t dry weight ha^{-1} yr^{-1} (Duke. *et al.*, 1981; Twilley. *et al.*, 1986; Hardiwinoto. *et al.*, 1989; Lee, 1990; Gong and Ong, 1990; Mall, *et al.*, 1991 and Mmochi, 1993). In general, comparing with subtropical results, the mean annual litterfall at the Gesashi mangrove forests 11.9 t ha^{-1} yr^{-1} was higher.

Conclusion

Litterfall was collected from May, 1993 to April, 1994 in the mangrove forests at the Gesashi River, Higashi village, Okinawa Island, Japan. The following conclusions are got from this study: 1) *Kandelia candel* (L) Druce, *Bruguiera gymnorrhiza* (L) Lamk. and *Rhizophora stylosa* Griff were dominant in the mangrove forests at Gesashi. 2) The peak of litterfall appeared in April and May. It was caused by seasonal mangrove fruits and leaves. The peak of litterfall also appeared in September when the typhoon attacked, but it was lower than in April and May. 3) Leaf production was found to be continuous throughout the study period. 4) The annual litterfall was 11.9 t ha^{-1} yr^{-1}.

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