ECOLOGICAL STUDIES OF MANGROVE FORESTS IN SOUTHERN THAILAND

——LEAF DYNAMICS OF SEVERAL KEY SPECIES——

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The population dynamic analysis of the leaf numbers through repetitive measurement was worked out at a natural mangrove forest in Ban Hatsaikhao, Ranong, southern Thailand. The field research was initiated in November 1982 and subsequent observations were carried out until December 1983.

MATERIAL AND METHOD

In November and December 1982, 34 individuals of 5 tree species (*Bruguiera cylindrica, B. gymnorrhiza, Rhizophora apiculata, R. mucronata, Sonneratia alba*) were selected. The initial size of sample trees ranged from 15.6 to 237 cm in tree height and 0.12 to 3.73 cm in diameter at ground level (mean 126 cm, 1.83 cm). 14 individuals of sample trees died or destroyed by December 1983 due to illicit felling of giant trees. On every branch of the sample

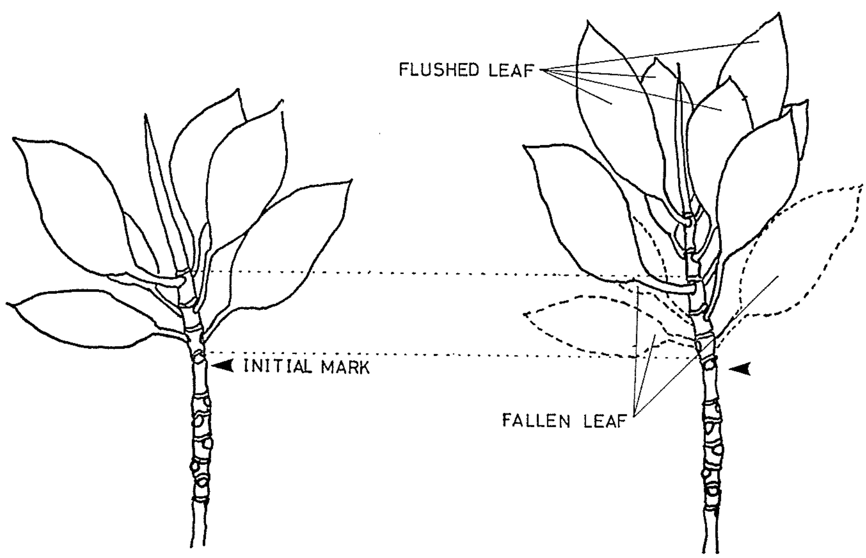

Fig. 1 The illustration of a branch at first (left side) and following (right side) observations.

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trees just below the lowest leaf, a mark with white paint was made (initial marking (Fig. 1)). The number of leaves (Ln), the number of nodes with living leaves (Nn) and the total number of nodes above initial marking point (NTn) were counted. The number of leaves newly flushed and the number of leaves fallen were calculated by the following equations. All the species observed in the present study have the opposite leafing.

$$LNn\text{-}1,\ n=(NTn-NTn\text{-}1)\times 2 \cdots\cdots (1)$$

$$LFn\text{-}1,\ n=Ln\text{-}1+LNn\text{-}1,\ n-Ln \cdots\cdots (2)$$

where, n stands for the nth occasion of observation,

n-1 for the (n-1)th occasion of observation,

L for the number of leaves standing at each observation,

LNn-1, n for the number of new leaves expanded in each period concerned,

LFn-1, n for the number of leaves fallen in each period concerned,

NT for the total number of nodes above initial marking point at each observation.

The date of observation and the interval between the two successive observations (figures expressed in parentheses) are as follows;

initial mark: Nov. 24, 25, 1982 (92 days) or Dec. 23, (63 days),

the second observation: Feb. 24, 1983 (62 days),

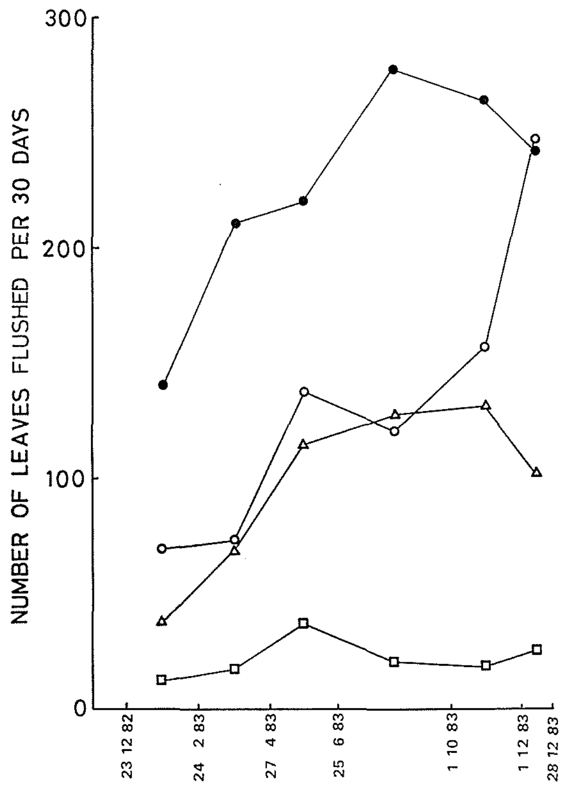

Fig. 2 The cumulative number of leaves flushed per 30 days in each period concerned by tree species.
●; *R. apiculata* ○; *R. mucronata*
△; *B. cylindrica* □; *B. gymnorrhiza*

the third: Apr. 27 (59 days), the fourth: Jun. 25, (98 days),
the fifth: Oct. 1 (61 days), the sixth: Dec. 1 (27 days),
the seventh: Dec. 28

At the final observation only 20 sample trees were successfully completed their leaf counting. The data of only 20 trees completed thus were used for the analysis as discussed bellow.

RESULTS AND DISCUSSIONS

Tab. 1 shows the numbers of standing leaves, Ln, of flushed leaves, LNn-1, n and of fallen leaves, LFn-1, n at the respective time of observations. In 16 sample trees out of 20, total number of leaves standing greatly increased, while that of Tree No. 27, 28, 29 and 30 of *R. apiculata,* which locate under the closed canopy, remained relatively constant through the year.

The cumulative numbers of leaves flushed and fallen by species are illustrated in Fig. 2 and Fig. 3. LNn-1, n and LFn-1, n were converted into the figures per 30 days for standardization of the same interval of time in these figures. Generally speaking in the latter half of the observation period the leaf numbers flushed and fallen were observed in higher level. There seems the trend to show a remarkable seasonal variation of leaf flush and fall throughout the year. However, the period which marked higher level of leaf flush and fall is not fixed

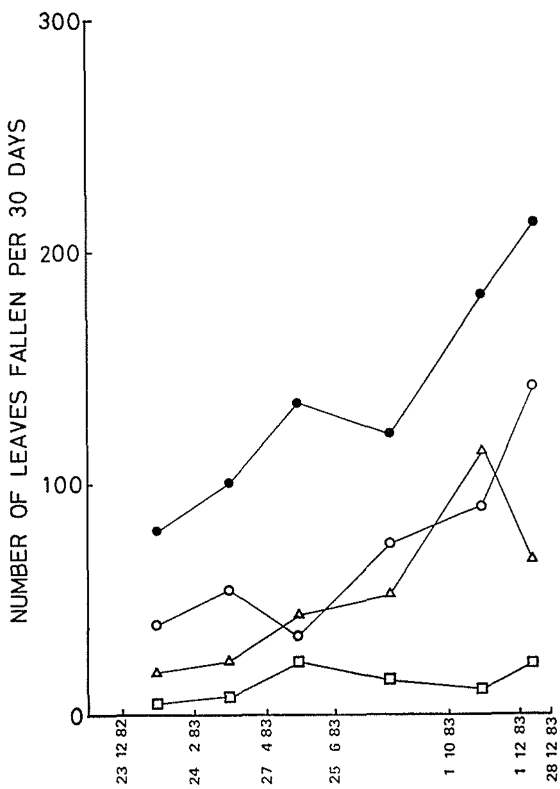

Fig. 3 The cumulative number of leaves fallen per 30 days in each period concerned by tree species.
●; *R. apiculata* ○; *R. mucronata*
△; *B. cylindrica* □; *B. gymnorrhiza*

by species. *R. apiculata* and *B. cylindrica* mark high level of leaf flush at 5 th and 6 th observation, while *R. mucronata* shows its peak at 7 th and 4 th observation and *B. gymnorrhiza* at 4 th observation. Leaf fall is the highest at 7 th observation in *R. apiculata* and *R. mucronata* and is also relatively high at 4 th and 3 rd observation respectively. *B. cylindrica* shows its peak of leaf fall at 6 th observation and *B. gymnorrhiza* at 4 th and 7 th observation.

The number of leaves standing at each observation is expressed as following equation derived from eq. (2).

$$Ln = Ln\text{-}1 + (LNn\text{-}1,\ n - LFn\text{-}1,\ n)$$

Seasonal variation of standing leaf number is thus results of those of number of leaves flushed and fallen followed by the change of leaf age structure. Assuming that leaf falls in accordance with the order of emergence, age structure chart as expressed in Fig. 4 on TNO-20 can be given. Solid line expresses the change of standing leaf number and space between two adjacent broken lines expresses leaves flushed during each period concerned (C1-C6). C1 (leaves flushed during 1 st period) and C2 shed their leaves during 5 th period and average leaf longevities are 297 days and 241 days respectively. Therefore at the 7 th observation this sample tree consists of C3, C4, C5 and C6. Fig. 5 shows another example of the age structure chart of TNO-30. A part of the leaves which were standing at the initial observation still remains at the 7 th observation in this individual. The proportion of C1, C3 and C6 is very little because few leaves flushed during each period. Leaf age structure thus depends on seasonal variation of leaf flush and fall.

Cumulative number of leaf flush and fall per year from Dec., 1982 to Dec., 1983 and the rate of those compared with the initial leaf number of each sample tree are shown in the last 4 columns of tab. 1. Cumulative number of leaf flush and fall a year of each sample trees are from 0.6 to 4.4 times and 0.6 to 2.1 times as large as the initial leaf number respectively.

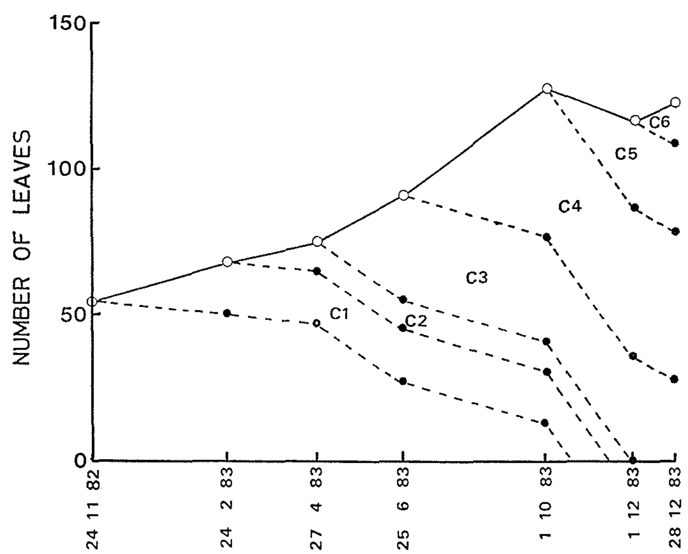

Fig. 4 The age structure chart of TNO-20. ○; the number of leaves standing at each observation, C1-C6 expresses leaves flushed during each period concerned.

Tab. 1 The number of standing leaves, flushed leaves and fallen leaves of each sample tree at the respective time of observation. Ln; number of leaves standing at nth observation LNn-1, n; the number of leaves flushed in each period concerned LFn-1, n; the number of leaves fallen in each period concerned *; Initial measurement was made at Dec. 23, 1982 (others at Nov. 24, 25). LN1,7 and rLN1,7 expresses cumulative number of leaves flushed per year from Dec. 23, 1982 and the rate of that compared with the initial leaf number in Dec. 23. LF1,7 and rLF1,7 expresses cumulative number of leaves fallen a year and the rate of that compared with the initial leaf number in Dec. 23.

TNO	SPP	L1	LN1,2	LF1,2	L2	LN2,3	LF2,3	L3	LN3,4	LF3,4	L4	LN4,5	LF4,5	L5	LN5,6	LF5,6	L6	LN6,7	LF6,7	L7	LN1,7	rLN1,7	LF1,7	rLF1,7
16	B.c	403	88	48	443	116	33	524	170	58	639	348	144	845	228	177	898	74	49	926	982	2.4	478	1.1
20	B.c	54	18	4	68	10	3	75	36	20	91	48	14	128	30	41	117	14	8	123	149	2.6	85	1.5
22	B.c	24*	4	2	26	14	12	28	18	7	39	20	12	49	8	14	43	4	3	44	67	2.8	47	1.2
s.	total		110	54	537	140	48	627	224	85	769	416	170	1,022	266	232	1,058	92	60	1,093	1,198	2.4	611	1.2
3	B.g.	33	6	5	34	10	5	39	22	11	50	26	14	62	6	1	68	6	4	70	73	2.2	37	1.1
21	B.g.	122*	20	6	136	26	11	153	50	34	169	38	34	173	30	21	182	16	17	181	178	1.5	119	1.0
s.	total		26	11	170	36	16	192	72	45	219	64	48	235	36	22	250	22	21	251	251	1.6	156	1.0
1	R.a.	90	66	16	140	50	17	173	52	28	197	136	47	288	82	37	334	30	18	346	390	3.7	153	1.4
2	R.a.	85	24	21	88	18	20	86	24	20	90	78	16	154	46	21	179	16	8	187	195	2.3	96	1.1
7	R.a.	121	22	42	101	38	15	123	58	26	155	64	17	202	46	37	211	20	10	221	238	2.1	133	1.2
12	R.a.	342	132	73	401	132	66	467	138	65	542	280	144	682	158	94	748	66	77	739	852	2.4	479	1.3
13	R.a.	76	76	15	137	72	36	173	64	44	193	124	40	278	74	51	301	22	18	304	402	4.2	196	2.1
14	R.a.	25	20	6	39	16	12	43	14	7	50	44	10	84	18	17	85	10	3	92	114	3.9	52	1.8
15	R.a.	115	90	23	182	46	18	210	60	32	238	98	75	263	72	50	287	38	29	296	371	2.7	213	1.6
27	R.a.	41*	0	6	35	6	10	31	2	1	32	14	11	35	2	6	31	0	0	31	24	0.6	34	0.8
28	R.a.	105*	0	13	92	22	5	109	12	10	111	30	11	130	18	25	123	2	10	115	83	0.8	73	0.7
29	R.a.	94*	0	8	86	16	4	100	6	19	87	20	11	97	8	10	95	12	7	100	61	0.6	55	0.6
30	R.a.	80*	0	4	76	20	3	94	2	13	83	20	11	93	12	20	85	2	11	76	55	0.7	59	0.7
s.	total		430	227	1,377	436	206	1,609	432	265	1,778	908	393	2,306	536	368	2,479	218	191	2,507	2,786	2.2	1,544	1.2
4	R.m.	338	180	99	419	110	90	439	200	48	596	272	191	680	250	134	798	168	99	868	1,108	3.0	611	1.7
8	R.m.	54	20	12	62	26	12	76	52	6	126	80	44	162	52	34	180	32	17	195	252	4.4	115	2.0
9	R.m.	9	2	2	9	4	2	11	8	4	15	14	1	28	4	8	24	8	3	29	38	4.2	19	2.1
10	R.m.	32	8	7	33	10	8	35	10	8	37	24	5	56	12	8	60	14	9	65	75	2.3	42	1.3
s.	total	433	210	120	523	150	112	561	270	66	774	390	241	926	318	184	1,062	222	128	1,157	1,473	3.2	787	1.7
TOTAL		2,243	776	412	2,607	762	382	2,989	998	461	3,540	1,778	852	4,489	1,156	806	4,849	554	400	5,008	5,708	2.4	3,098	1.3

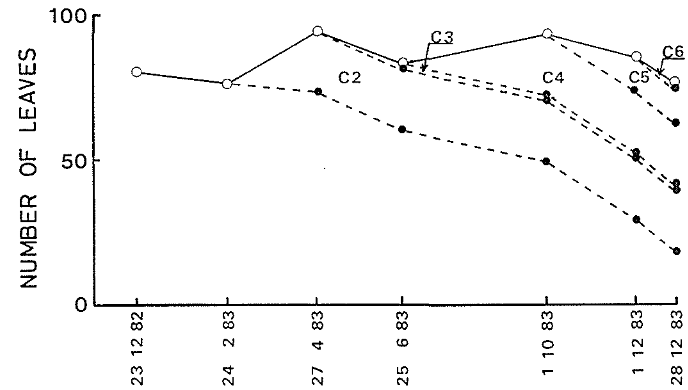

Fig. 5 The age structure chart of TNO-30. ○; the number of leaves standing at each observation, C2–C6 expresses leaves flushed during each period concerned.

The leaf numbers of TNO 27–30 which grow under closed canopy are rather constant as was mensioned before and the rate rate of cumulative number of leaf flush and fall a year also show comparatively constant value of 0.6 to 0.8. Average leaf longevity of these trees, which is given by the average number of standing leaves devided by number of leaves flushed a year, is estimated as about 1.5 yrs. In case of the other trees the rate of cumulative number of leaf flush and fall range from 1.5 to 4.4 and from 1.0 to 2.1 respectively.

Gill and Tomlinson (1971) studied on the growth of saplings of *Rhizophora mangle* (0.5–4 m tall) in South Florida and found leaf age was the order of 6–12 months in general and high productivity of leaves and great leaf fall in warm and humid summer. They also suggested that average leaf longevity varied according to the time of initiation and vigor of the shoot. Christensen and Wium-Andersen (1977) examined the phenology of *R. apiculata* on Phuket Island, southern Thailand and found bimodal seasonal variation of leaf production correlate with the period of beginning and end of the rainy season and no distinct seasonal variation of leaf fall the gave the estimate of average longevity of the leaves to be 17–18 months.

Leaf flush and fall of the observation of the present study did not show such a clear seasonal change as Gill and Tomlinson (1971) and Christensen and Wium-Andersen (1977) mentioned. Number of leaves flushed and fallen of each tree greatly varied seasonally but patterns of the variation were different by individuals and by tree species. It is probable that the number of leaves flushed and fallen, seasonal pattern of leaf flush and fall and leaf longevity by the each period of flush are affected by tree species, tree size and environmental factors.

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