

พลวัตและการเติบโตของแทลลัสไลเคนในระบบนิเวศป่าเขตร้อน ณ อุทยานแห่งชาติเขาใหญ่

Dynamic and growth of lichen thalli in tropical ecosystems at Khao Yai National Park

บังอร วรรณลัก^{1,*}, เวชศาสตร์ พลเยี่ยม, กัญจรี บุญประกอบ

Bungon Wannalux^{*}, Wetchasart Polyiam, Kansri Boonpragob

Department of Biology, Faculty of Science, Ramkhamhaeng University, Huamark, Bangkok, Bangkok 10240, Thailand

*e-mail: wannalux.ru.th@gmail.com

บทคัดย่อ: การติดตามการเปลี่ยนแปลงของแทลลัสและการเติบโตของไลเคนในเขตร้อน ในป่าดิบเขา ป่าดิบชื้น และป่าเต็งรัง ณ อุทยานแห่งชาติเขาใหญ่ จำนวนทั้งหมด 598 ตัวอย่าง แบ่งเป็น ครัสโตส 280 ตัวอย่าง และ โฟลิโอส 318 ตัวอย่าง ระหว่าง เดือน มีนาคม 2547 - พฤษภาคม 2552 พบว่า มีแทลลัสไลเคนเหลือรอด ร้อยละ 78 โดยมีลักษณะการเหลือรอดต่างกันในส่วนที่ต่างกันคือ แทลลัสสมบูรณ์ร้อยละ 17 แทลลัสตายบางส่วนและเติบโตต่อร้อยละ 41 แทลลัสที่ตายบางส่วนและไม่เติบโตต่อ ร้อยละ 20 และแทลลัสตายอย่างสมบูรณ์ร้อยละ 22 การเติบโตของไลเคนครัสโตสมีอัตราเฉลี่ย 2.52 มม./ปี (n= 175) และโฟลิโอส 3.85 มม./ปี (n= 165) อัตราการเติบโตสัมพัทธ์ของครัสโตสไลเคน 0.64-2.12 มม./มม./ปี. โดยมีค่าสูงเมื่อขนาดเส้นผ่านศูนย์กลางของแทลลัส 2-4 ซม. ส่วนโฟลิโอสมีค่า 3.66-6.04 มม./มม./ปี และมีค่าสูงเมื่อขนาดเส้นผ่านศูนย์กลางของแทลลัส 1-3 ซม. ทั้งนี้ครัสโตสและโฟลิโอส มีอัตราการเติบโตสัมพัทธ์ลดลงเมื่อขนาดเส้นผ่านศูนย์กลางแทลลัสมากกว่า 4 ซม.

Abstract: Changes and growth of lichen thalli in the LMF, TRF and DDF at KYNP were observed from 598 thalli during March 2004 – May 2009. They composed of 280 crustose and 318 foliose lichens. As much as 78% of the thalli remain, consisting of different stages and proportions of survivors. The complete thalli had 17 %, partially died and regenerated 41%, partially died without regenerated 20 % and died completely 22%. Crustose thalli had average growth rate 2.52 mm/yr (n=175), while foliose thalli had 3.85 mm/yr (n=165). Relative growth rates of the crustose thalli were 0.64-2.12 mm/mm/year, those of the foliose thalli were of 3.66-6.04 mm/mm/year. The crustose thalli had high RGR (log phase) when thallus was 2- 4 cm, and declined substantially to stationary phase when thallus grew beyond 4 cm. The foliose thalli showed log phase of thallus development until thalli attended diameters about 1-3 cm in most species, and then decline to stationary phase after thalli were larger than 4 cm.

Introduction: Information on lichen growth is important for understanding potential yield of biomass for utilization and conservation of different lichens in various ecosystems. It is also useful information for harvesting lichen at the maximum stage of thallus development. Growth of lichen is influence by environmental condition especially water availability, illumination and temperature, which differ among seasons and locations. Growth of lichens have been studied intensively in the temperate regions.¹ However, growth of tropical lichen is less known. Lichen grow very slow. In temperate region they can grow up to 27 and 0.04

mm/year for the foliose (*Peltegera*) and crustose (*Diploschistes scruposus*) respectively.^{2,3} However, lichens in tropical region growth rate varied, a large foliose lichen, *Parmotrema praesorediosum*, grow as much as 20.4 mm/year and a common crustose in the dry forest, *Laurera bengnelensis*, was recorded at 2.4 mm/year and the rainy season support highest growth rate and the small size of thallus have efficient in high relative growth rate.^{4,5} The objectives of this study were 1) to monitor general growth pattern of tropical lichens in different ecosystems 2) to measure and compare growth of various lichens and 3) to discover the fastest growth rate during thallus development for maximum utilization.

Methodology: This study was conducted at Khao Yai National Park during March 2004-May 2009 in the tropical rain forest (TRF), the lower montane forest (LMF) and the dry dipterocarp forest (DDF). A total of 598 thalli consisting of 280 crustose and 318 foliose lichens were selected from tree barks and rocks. The selected thalli had different sizes ranged from diameters 0.67 to 17.50 mm of the crustose thalli, and 0.25 to 14.50 mm of the foliose thalli. Thallus areas were measured during time intervals by drawing outlines on overlaying transplant sheets, and areas determined by using program AxioVision LE Rel.4.1 (Carl Zeiss). Growth rates were calculated by changing thallus diameters over time.³

Result, discussion and conclusion:

Dynamic of lichen thalli in natural habitats: After five years as many as 465 thalli or 78% of the total existed, however, in various conditions, whereas 22% disappeared completely. The crustose thalli had more proportion of survivors than those of the foliose thalli, accounting for 88% and 69% respectively (Table 1). Most of the crustose lichens survived in the warm wet TRF, accounting as much as 97%, whereas less than half of them survived in the hot-dry habitat of DDF. The foliose thalli had the highest survivors in the LMF accounting as much as 89%. About half of original foliose thalli survived in the DDF, which was the lowest proportion observed. It can be concluded that the warm-dry habitat of the DDF was unfavorable for prolonged existence of lichen thalli. The remaining thalli can be categorized into four statuses (Figure 1) as follow: 1) Completed thalli, of which the thalli remained intact and grow during the entire period of observation. This type of thalli were observed in i.e. *Bulbothrix isidiza*, *Canoparmelia owariensis*, *Coccocarpia palmicola*, *Crocynia* sp., *Coenogonium* sp. and *Heterodermia microphylla* 2) Partially degenerated and regenerated, where by a portion of the thalli disappeared at one point in time and later resumed growing. The lichens *Placynthiella* sp., *Sacograpta labyrinthica*, *Chapsa platycarpella* and *Opegrapha prosodea* had this kind of thalli, 3) Incomplete thalli, by which part of the thalli degenerated without regeneration. They were noted from *Bacidia* sp., *Bigrantia* sp., *Leptogium* sp and *Fissurina* sp. 4) completely degenerated thalli, which the whole thalli disappeared from the habitats. They are represented by *Bulbothrix queenslandica*, *Canoparmelia owariensis*, *Relicinopsis rahengensis* and *Pyxine coccifera*.

Table 1. Survival of 598 thalli of tropical lichens in three different ecosystems at Khao Yai National Park during March 2004 - May 2009.

Forest types	Crustose			Foliose		
	Initial	Final	Survivors (%)	Initial	Final	Survivors (%)
LMF	62	46	74	100	89	89
TRF	200	193	97	103	70	68
DDF	18	8	44	115	59	51
Total	280	247	88	318	218	69

Crustose + Foliose	Initial	598
	Final	465 (78%)
	Death	133 (22%)

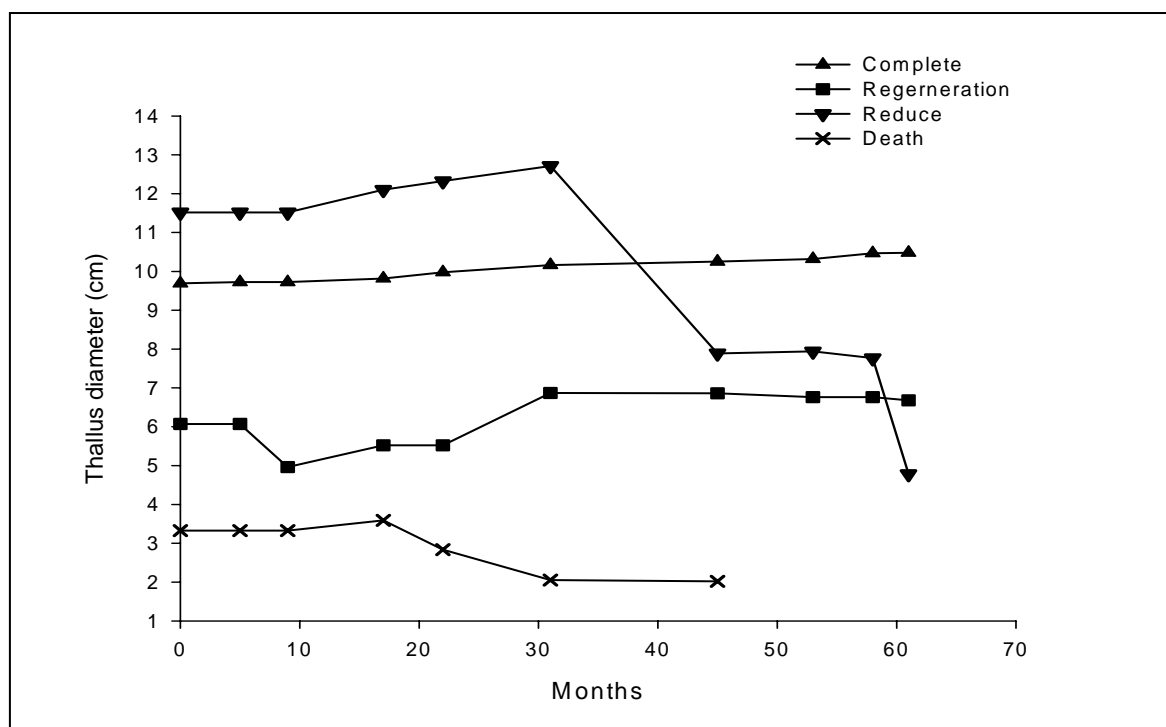


Figure 1. Different growth pattern of some selected thalli of tropical lichens observed during March 2004- May2009 in LMF, TRF and DDF at Khao Yai National Park

The proportions of these statuses were different depending on thallus forms and habitats (Table 2). Most of the crustose and the foliose thalli were partially degenerated and resume growing, accounting for 48% and 34% respectively. Proportions of complete and death thalli were comparable among the crustose lichens, 14% and 12%. However, the foliose had higher proportion of death over completed thalli, 31% and 19% respectively (Table 2). Several causes of changes in statuses of thalli can be identified. These were overgrown by bryophyte, fragment of barks of host trees, nested by insect and animal, competition with adjacent lichens and fallen trees.

Table 2. Status of lichens thalli observed during March 2004 - May 2009 in three tropical forests at Khao Yai National Park.

Status of lichens	5 years (%)					
	Crustose		Foliose		Total (Crustose+Foliose)	
	no. of thallus	%	no. of thallus	%	no. of thallus	%
Complete	40	14	60	19	100	17
Regenerations	135	48	109	34	244	41
Reduced	72	26	49	15	121	20
Death	33	12	100	31	133	22
Total	280	100	318	100	598	100

Growth rate of lichens: Growth rate of lichens was shown in (Table 3). The highest growth rate among the crustose lichens, up to 7.08 mm/year, was measured from *Byssloma* sp. in the LMF, whilst the minimum of 0.03 mm/year was measured from *Graphina* sp., and *Fissurina* sp., in the LMF and TRF. The foliose lichens, *Bulbothrix isidiza*, from in the LMF had the highest individual growth rate up to 36.96 mm/year, whereas growth rate as low as 0.12 mm/year was measured from *Erioderma mollissimum* in the LMF. Large different in growth of lichen, even in the same type of forest, was probably due to different stage of thallus development during the period of observation. Small thalli during lag phase generally have low growth rate, whilst those during the log or exponential phase have the highest growth rates. Intrinsic character, which different among species, is another factor that influences growth rate. Various factors may contribute to slow growth of the crustose compared with foliose species. Loosely interwoven of hyphae as well as loosely attached on substrate of the foliose thalli favor water absorption and gas exchange result in higher CO₂ assimilation, which enhance growth.

Table 3. Growth rate of tropical lichens during 5 years (2004-2009) in three forests at Khao Yai National Park.

Forest type	Growth rate (mm/yr)							
	Crustose lichens				Foliose lichens			
	no. of thallus (175 ^a)	Maximum	Minimum	Average	no. of thallus (165 ^b)	Maximum	Minimum	Average
LMF	35	7.08	0.03	2.62 ±1.54	78	36.96	0.12	5.05± 1.95
TRF	135	5.52	0.03	1.71±0.58	43	12.84	0.36	3.64±1.13
DDF	5	5.4	2.4	3.24±0.11	44	13.92	0.72	2.85 ±2.38
Average		6.00	0.82	2.52±0.77		21.24	0.40	3.85±1.11

^a number of area increased thalli

Relative growth rate of lichens and thallus size: The crustose thalli had relative growth rates ranged from 0.64 - 2.12 mm/mm /yr. Most of them had less correlation between thallus sizes and relative growth rates, with correlation coefficient ranged from 0.36 - 0.43, except *Pyrenula* sp. which had r as much as 0.99 (Figure 4). By contrast, most of the foliose thalli had higher relative growth rates, 3.66 - 6.04 mm/mm/years, and higher correlation between thallus size and RGR with correlation coefficient ranged from 0.69 - 0.71 (Figure 5). Most of the crustose thalli had relatively low RGR, which could be during lag phase or stationary phase of the growth pattern. This point needs longer investigation. However, the *Pyrenula* sp. growth pattern demonstrated that observation of this species was performed during log and stationary phases of development. The thalli had high RGR (log phase) when thallus was 2- 4 cm, and declined substantially to stationary phase when thallus grew beyond 4 cm. The foliose thalli had log phase of development until thalli attended diameters about 1-3 cm in most species, and then decline to stationary phase after thalli were larger than 4 cm (figure 5).

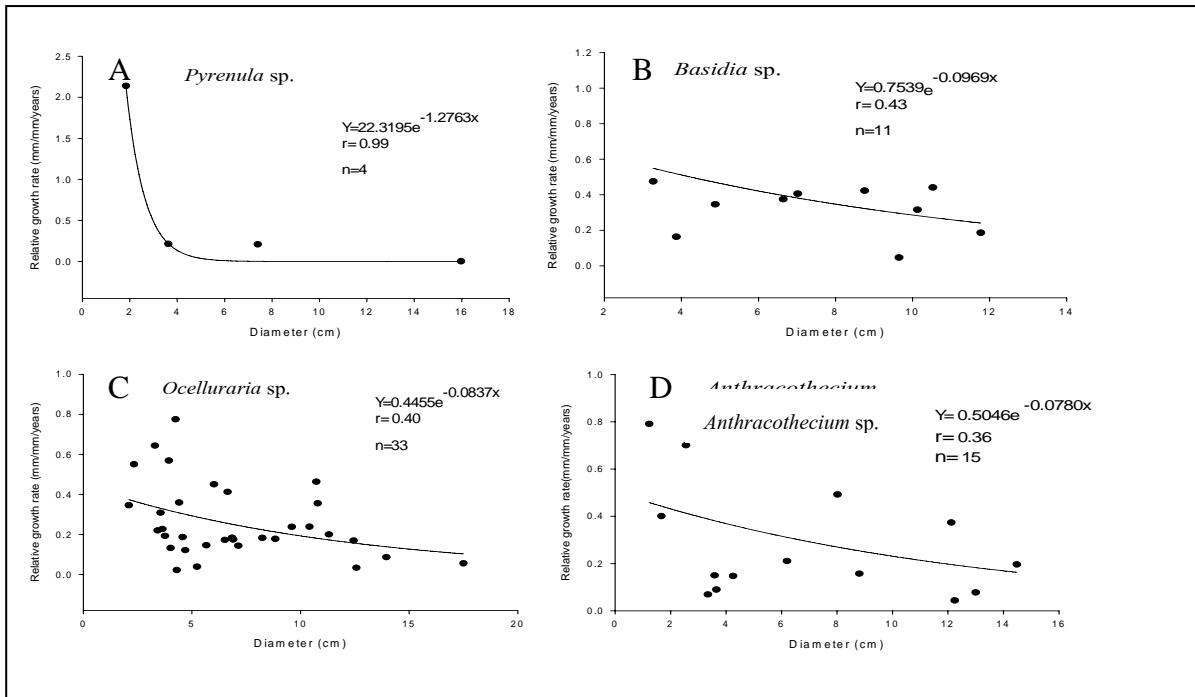


Figure 4. Relative growth rates of crustose lichens (mm/mm/year).observed during March 2004-May 2009 at KYNP. *Pyrenula* sp. (A), *Basidia* sp. (B), *Ocellularia* sp. (C) and *Anthracothecium* sp. (D).

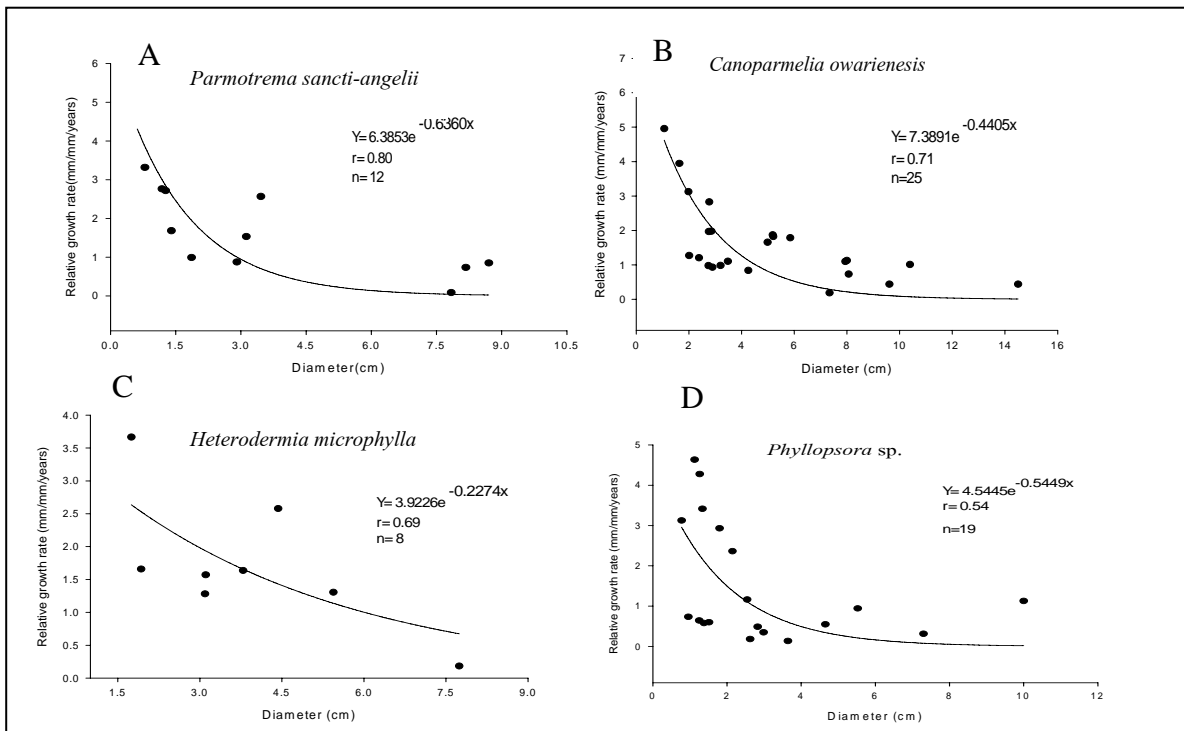


Figure 5. Relative growth rates of foliose lichens (mm/mm/year).observed during March 2004- May 2009 at KYN. *Parmotrema sancti-angelii* (A), *Canoparmelia owarienesis* (B), *Heterodermia microphylla* (C) and *Phyllopsora* sp. (D).

In conclusion, this study demonstrated dynamic of lichen thalli under different climate. It served as fundamental information for assessing population and community structure changes under climate change, which lead to precautionary measured for conservation. Maximal utilization of lichens during the fastest phase of growth among several species can also be drawn.

References:

1. Palmqvist, K.; Dahlman, L.; Jonsson, A.; Nash III, T. H. *Lichen Biology* **2008** , 182-215.
2. Nash III, T.H. *Lichens Biology* **1996**, 88-120.
3. Hale, M.E. *The lichens* **1973**.
4. Osathanon, N. *MSc thesis* **2004**.
5. Polyiam, W.; Boonpragob, K. 33rd *Congress on Science and Technology of Thailand* **2007**.

Acknowledgments: We would like to thank the number of Lichens Research Unit at Ramkhamhaeng University and the officers at Khao Yai National Park for any kind help in field works, the Royal Forest Department and Resource and Environmental Management Division for the permission to collect data in the field. This work was supported by Thai government.

Key words: lichen, growth rate, relative growth rate