EXPLORATION OF HIGH ELEVATION LIANA COLONIES ON MT. SLAMET, CENTRAL JAVA, INDONESIA

Received June 8, 2009; accepted June 16, 2009

W.S. HOOVER
New England Tropical Conservatory (NETC), BCIC, 940 Walter Street, North Bennington, VT 05257. USA. Email: netrop@sover.net

DEDEN GIRMANSYAH
Herbarium Bogoriense, Botany Division, Research Centre for Biology-LIPI, Jl. Raya Bogor-Jakarta km 46, Cibinong 16911, Indonesia. Email: Deden_bo@yahoo.com

HARRY WIRIADINATA
Herbarium Bogoriense, Botany Division, Research Centre for Biology-LIPI, Jl. Raya Bogor-Jakarta km 46, Cibinong 16911, Indonesia. Email: Harry_wiria@yahoo.com

JAMES M. HUNTER
New England Tropical Conservatory (NETC), BCIC, 940 Walter Street, North Bennington, VT 05257. USA. Email: info@netrop.org

ABSTRACT
HOOVER, WS., GIRMANSYAH, D., WIRIADINATA, H. & HUNTER, J. M. 2009. Exploration of High elevation liana colonies on Mt. Slamet, Central Java, Indonesia. *Reinwardtia* 13(1): 45–67. — One hundred forty–five individual lianas were distributed on 2 East facing ridges on the second highest mountain on Java, Mt. Slamet (3418 m.), Central Java, Indonesia. Twenty one colonies were observed on small flat areas on ridges. The liana species observed include: *Embelia pergamacea, Toddalia asiatica, Elaeagnus latifolia, Schefflera lucida, Vaccinium laurifolium* and *Lonicera javanica*. Diameter of each liana was measured and liana density/flat area calculated. Floristic collecting was undertaken within the elevational gradient of liana distribution. Data suggest an ecotone transition from lower to upper montane forest is observed between 2200 and 2300 m, though forest types are difficult to determine due to disturbance caused by fire at the upper elevations. Observing lianas at these unusuall high elevations with near pluvial rainfall, contradict established scientific theory concerning global distribution and abundance of lianas.

Keyword: Liana, Rainfall, Elevation, Mt. Slamet, Central Java

ABSTRAK
HOOVER, W. S., GIRMANSYAH, D., WIRIADINATA, H. & HUNTER, J. M. Eksplorasi koloni liana dataran tinggi di G. Slamet, Jawa Tengah, Indonesia. *Reinwardtia* 13(1): 45–67. — Seratus empat puluh lima liana tersebar di 2 lokasi yang menghadap punggung bukit sebelah timur G. Slamet (3418 m, gunung kedua tertinggi di Jawa), Jawa tengah, Indonesia. Dua puluh satu koloni terekam pada area datar punggung tersebut. Jenis–jenis liana yang tercatat adalah: *Embelia pergamacea, Toddalia asiatica, Elaeagnus latifolia, Schefflera lucida, Vaccinium laurifolium* dan *Lonicera javanica*. Diameter tiap–tiap liana diukur dan kepadatan liana dihitung. Data menunjukan daerah transisi (*ecotone*) terdapat pada ketinggian 2200 sampai 2300 m dpl, walaupun tipe hutannya tidak dapat di identifikasi karena bekas terbakar. Hasil pengamatan liana pada daerah dengan curah hujan yang sangat ekstrim tinggi dan ketinggian yang tidak biasanya tersebut bertentangan dengan teori keilmuan tentang distribusi global dan kelimpahan liana.

Kata Kunci: Liana, Curah hujan, Ketinggian, G. Slamet, Jawa tengah

INTRODUCTION

Botanists observing tropical forests and climbers in the 19th and early 20th centuries noted the abundance of lianas at lower elevations and a decrease of these plants with increasing elevation (Treub 1883, Schenk 1892–3, Davis and Richards 1933–34, and Richards 1936). Such observations on lianas came to define a physiognomic characteristic of lowland tropical forests (Webb 1959, Grubb *et al.* 1963, Grubb and Whitmore 1966, Ashton 1964, Richards 1964, Whitmore 1984, 1988). Croat (1978) goes so far as to say the presence of woody climbers is the single most important physiognomic character distinguishing tropical from temperate forests. Ashton (2003) considers 800–1200 m. an ecotone transition between lowland and lower montane forest, emphasizing that different mountains have different characteristics, and vegetation types along tropical mountains cannot be identified by single, standard elevational definitions. In considering the transition from upper montane to subalpine, Kartawinata (2005) suggests the boundary be considered 2300 m., differing from Steenis *et al.* (1972) report that 2400 m. be the boundary, with much historical debate about elevation zones and tropical mountain vegetation. Kartawinata's (2005) paper may be considered a benchmark for identifying botanical and ecological research needs in Indonesia, including lianas; this paper is one of the first specific contributions ever on lianas of Indonesia.

At the time Putz and Mooney (1991) published *The Biology of Vines*, research on lianas was limited compared to other plant groups. Gentry (1991), from this book, likely provides the first global data base on distribution and evolution of climbers; his report based on 56 neotropical and 32 paleotropical sites, all of which are lowland except for 9 montane neotropical forests sites, which are only briefly mentioned. Since 1991, scientific literature on lianas has expanded greatly, with many papers examining eco–physiological characteristics of climbers. Longino (1986) may have been the first to observe a negative correlation between growth and rainfall, while Schnitzer's (2005) paper summarizes current eco–physiological research and provides explanation for global patterns of liana abundance and distribution based on 69 neo–tropical lowland sites; elevation is not a factor mentioned in his work. Most of the literature on lianas over the past years has focused on neo–tropics, with comparatively limited research from SE Asia, though a number of papers are noteworthy (see for example: Jacobs 1976, Putz 1984, 1985, 1987, Campbell & Newberry. 1993, Pinard & Putz., 1993, Caballe 1994, Babweteera 2000, Dattaraja & Sukumar, 2004 and Parthasarathny *et al.* 2004). Kartawinata (2005:126) goes so far as to say, "Studies on lianas and epiphytes should be promoted further since to date they have been neglected", in reference to Indonesia.

In the Mountain Flora of Java, Steenis *et al.* (1972) illustrate 12 species of lianas and about 14 other vine species having woody characteristics, noting that *Toddalia asiatica* and *Vaccinium laurifolium* are 2 species from this present study mentioned by van Steenis *et al.* (1972). *V. laurifolium* is documented to occur as a shrub on the summit of Mt. Gede/Pangrango complex, outside of the plots (Sadili *et al*. 2009) as well as having been observed to occur epiphytically (Wiriadinata, *pers. comm.*). *Lonicera javanica* is noted to be a highly invasive vine with a cosmopolitan distribution, likely considered a weed (Dillenburg *et al*. 1993).

Mt. Slamet (3418 m, 7 14'23.8" S. lat.; 109 13'.8" E. long.) was selected for exploration because it is the second highest mountain on Java (Fig. 1 and 2); reporting the highest precipitation on the island is from the town of Baturden on the South slope of Mt. Slamet, averaging about 7000 mm/year (Fig. 3, Berlage 1941 and Indonesian Meterological and Geophysical Institute) and 2^{nd} highest reported rainfall in Indonesia (Schmidt & Ferguson 1951). Rainfall is noted to have exceeded 10,000 mm/year at Baturden (Fig. 1).

Early exploratory research on Mt. Slamet is extensive though appears limited to primarily lowland tropical forest, likely due to the relative inaccessibility of upper elevations due to extensive forest cover. The first botanist to explore Mt. Slamet appears to be G.F.W. Junghuhn with exploration made primarily between 1940–1945 (Steenis –Kruseman 1950). The Cyclopedia of Malaysian Plant Collectors (Steenis–Kruseman 1950) lists the following botanists as having undertaken exploration of Mt. Slamet, together with many other locations in Indonesia, with their concentrated years of exploration: S.H. Koorders 1893–1914, P. de Monchy 1897, M. Raciborski 1897–1902, F.A.F.C. Went 1898–1930, C.A. Backer 1907–1948, L.G. den Berger 1917–1926, H.J. Lam 1924–1925, J. Jeswiet 1926, Hagederon 1926, C.G.G. J. van Steenis 1928–1940, F. Verdoorn 1935, F.C. Drescher 1958.

Recent expeditions and collecting trips to Mt. Slamet are recorded from Bogor Herbarium's digital library including: Sulistyani (1995), Arifiani (2001), Rahman (2001), Susana (2002), and Wiriadinata (2004) NETC sponsored expedition involving the present authors.

This paper reports on liana colonies forming a component of upper elevation tropical forest along two east–facing ridges on Mt. Slamet, Central Java, Indonesia, indicating lianas, in rare instances, are not restricted to lowland tropical forests but can become abundant at high elevations. Further, Mt. Slamet's liana colonies thrive under pluvial–like rainfall conditions, furthering the distinction of this habitat. These liana data from Mt. Slamet contradict much of the conventional thinking on climbers.

METHODS

General floristic collecting was undertaken along the entire elevation gradient from lowland until high elevation and data of vine were collected follow standard methodology for censuring and measuring liana (Schnitzer *et al.* 2006 and Gerwing *et al.* 2006). Specimens were collected and put between old news paper, pored with alcohol 70% put into big plastic bag and sent to Herbarium Bogoriense for drying and identification.

RESULTS

Herbarium specimens collected from the 6 species of lianas were identified at Bogor Herbarium and data summarized in Table 1. A clear distinction is observed between the elevational distribution and abundance of the 4 "lower elevation" species *Embelia pergamacea*, *Elaeagnus latifolia*, *Toddalia asiatica* and *Schefflera lucida* and the 2 "upper elevation" species *Vaccinium laurifolium* and *Lonicera japonica.* The former 4 species are much less abundant, with 41 individuals (28%) and distributed between 1935 to 2357 m, than the latter 2 species, with 104 individuals (72%) and distributed between 1966 to 2591 m; only 9 individuals of *Vaccinium* are found at the "lower elevation" with 55 found at the "upper elevation".

Table1. Vine Species from Mt. Slamet

Species/Family/Local Name	No. of Individuals	No. of Colony	Elevation (m)		Trunk diameter (cm)	
			Range	Mean	Range	Mean
Embelia pergamacea A.D.C. (*Myrsinaceae*) Gang	9	1	1935 –1935	1935 +/– 0	2.6 –3.3	3.0 +/– 0.2
Toddalia asiatica (L.) Lam. (*Rutaceae*). Kuwut	9	4	1951 –2357	2243 +/– 169	1.4 – 4.5	2.4 +/– 1.1
Vaccinium laurifolium var. *laurifolium* Miq. (*Ericaceae*), Kematus	64	13	1966 –2591	2401 +/– 75	1.6 – 7.6	3.4 +/– 1.5
Elaeagnus latifolia L. (*Elaeagnaceae*) Duren	11	3	1981 –2149	2068 +/– 60	1.4 – 3.2	2.6 +/– 0.6
Schefflera lucida L. (*Araliaceae*) Tanganan	12	3	1981– 2316	2283 +/– 97	1.5 – 4.9	2.9 +/– 1.1
Lonicera javanica DC. (*Caprifoliaceae*) Blebur	40	4	2499 –2591	2552 +/– 22	1.3 – 3.7	2.2 +/– 0.5

Table 2. Colony Size and Distribution on Mt. Slamet Ridges 1 and 2

		Total Elevation Change (m)		No of Colony		No of Vines		Total Colony Size (square m)		No of vines / square meter		Mean Diameter (cm)	
Ridge 1	lower ½	655	321	15	8	96 (66%)	34 (35%)	1025.17	675.17	0.18	0.18	3.2	3.3
	Upper ½		290		7		62 (65%)		350.00		0.19		3.0
Ridge 2		61		6		49 (34%)		1268.50		0.12		4.4	

Table 2 indicates colony size and distribution of liana between both ridges. Ninety–six colonies of lianas (66%) are distributed on Ridge 1, while Ridge 2 has 49 colonies of lianas (34%). The elevation gradient of Ridge 1 is 655 m., while Ridge 2 has 61 m. of gradient change. Observing colony size of available habitat for the liana, a distinction is noted between the 2 ridges. Ridge 1 has a total of 1,025 m^2 of flat colony surface area, or colony size; flat is a relative term in so far as we are on a steep mountain ridge. Nonetheless, the lianas were observed restricted to these flat areas since these locations were the only places where the lianas grew, and not on steep areas. Ridge 2 has a total of 1,268 m2 of flat colony habitat for the lianas, representing roughly 20% more habitat surface than

Table 3. Vine Species Diversity/ Colony and Individual Colony Data

Ridge\ Colony No.	Species	No. of Individuals	Colony size (Square Meters)	Elevation (meters)	Mean Diameter (cm)			No of lianas/ square meter
1\1	*Embellia pergamacea*	9	17.2	1935	2.98	+/–	0.23	0.523
1\2	*Toddalia asiatica*	2	2.25	1951	1.51	+/–	0.11	0.889
1\3	*Vaccinium laurifolium*	2	16.72	1966	4.93	+/–	1.58	0.120
1\4	*Elaeagnus latifolium*	2	59.5	1981	2.63	+/–	0.34	0.034
1\5		1	59.5	1981	4.93	+/–	0.00	0.017
1\6	*Elaeagnus latifolium*	6	20	2057	2.68	+/–	0.50	0.300
1\7	*Vaccinium laurifolium*	6	400	2149	2.55	+/–	0.65	0.015
	Elaeagnus latifolium	3	400	2149	1.80	+/–	0.33	0.008
1\8	*Vaccinium laurifolium*	1	100	2256	4.62	+/–	0.00	0.010
	Schefflera lucida	1	100	2256	4.77	+/–	0.00	0.010
	Toddalia asiatica	1	100	2256	3.18	+/–	0.00	0.010
1\9	*Toddalia asiatica*	1	50	2301	4.46	+/–	0.00	0.020
	Vaccinium laurifolium	7	50	2301	2.41	+/–	0.65	0.140
1\10	*Vaccinium laurifolium*	8	25	2316	2.42	+/–	0.17	0.320
		10	25	2316	2.45	+/–	0.73	0.400
1\11	*Vaccinium laurifolium*	3	25	2347	3.87	+/–	1.94	0.120
	Toddalia asiatica	5	25	2347	2.1	+/–	0.74	0.200
1\12	*Vaccinium laurifolium*	6	25	2408	4.03	+/–	1.70	0.240
1\13	*Vaccinium laurifolium*	9	100	2469	2.99	+/–	1.71	0.090
1\14	*Lonicera javanica*	10	100	2499	2.36	+/–	60.00	0.100
1\15	*Lonicera javanica*	3	25	2591	2.86	+/–	0.28	0.120
2\16	*Vaccinium laurifolium*	2	10.5	2591	5.33	+/–	0.11	0.190
2\17	*Vaccinium laurifolium*	7	130	2560	3.50	+/–	1.50	0.054
2\18	*Vaccinium laurifolium*	5	930	2560	4.36	+/–	2.23	0.005
	Lonicera javanica	21	930	2560	2.02	+/–	0.63	0.023
2\19	*Vaccinium laurifolium*	7	150	2545	3.34	+/–	1.13	0.047
2\20	*Vaccinium laurifolium*	1	33	2530	5.73	+/–	0.00	0.030
2\21	*Lonicera javanica*	6	15	2491	1.99	+/–	0.09	0.400

Ridge 1, even with only 61 m. of elevation change, and being much shorter in distance. Overall liana density, measured by number of vines/ha is significantly different between the two ridges: Ridge 1 has a mean density of 1800 lianas/ha., while Ridge 2 is lower with a mean of 1200 lianas/ha. The opposite situation is observed for mean liana diameter: Ridge 1 having a mean liana diameter of 3.2 cm. and Ridge 2 having a mean of 4.4 cm.

From Table 2, focusing on Ridge 1 with its 655 m. of elevational gradient presents its own set of interesting data. Most notable is greater abundance of lianas at the upper elevations: 34 lianas (35%) observed on the lower half of Ridge 1 and 62 lianas (65%) observed at the upper half of the ridge. The elevational gradient is not exactly divided in half for a "lower half" and an "upper half" because of plot locations, but the elevational dividing point is between Plot 8 (2,256 m) and 9 (2,301 m). The elevational change for the lower half is 321 m. and for the upper half is 290 m. Colony size for habitat is significantly different between "lower" and "upper" halves: the lower half of the gradient has 675 m^2 of surface colony area while the upper colony surface area is 350 m^2. Mean diameter is different between the lower and upper halves of the ridge also: the lower with a mean diameter of 3.3 cm. and the upper with a mean of 3.0 cm.

Species diversity on colonies is of interest (Table 3). The lowest 6 colonies, from 1,935 m to 2,057 m on Ridge 1, are each consists of a single species. *Embelia pergamacea*, with 9 individuals, is observed only on colony number 1 and is not observed anywhere else on the 2 ridges. A similar situation for single species occupancy occurs at the highest most elevations also, where single species mostly dominate individual colonies: on Ridge 1, colonies 12–15 are each occupied by *Vaccinium laurifolium* or by *Lonicera japonica*. On Ridge 2, colonies 16–21, the same species occur with one or the other exclusively, except on the largest colony observed (930 m^2), number 18, which includes both species, though dominated heavily by *Vaccinium.*

The middle elevation colonies on Ridge 1 are of interest from a multiple species standpoint: Colonies 7–11, ranging from 2,149 m to 2,347 m are occupied by 2 species on each flat area, except for colony number 8 (2,256 m), the only plot observed to have 3 species, *V. laurifolium, Schefflera lucida* and *Toddalia asistica*, with just one individual of each species.

Colony number 8 (2256 m) is 100 m^2 of flat surface and is of special interest. Aside from its uniqueness with 3 species, if ranked, colony number 8 has one of the lowest liana densities (.01) of all colonies on Mt. Slamet, is the middle–most colony on Ridge 1, and the diameters of each liana rank among the largest measured: the *Schefflera* ranks 4th largest, *Vaccinium* ranks 5th and the *Toddalia* is 12th, out of a total of 145 lianas colonies. Such circumstances suggest explanation other than just coincidence. The uniqueness of colony 8 suggests there may be other ecological or climatic characteristics of interest, at or near, this elevation, to be discussed below. Of the 21 colonies occupied by these lianas on Mt. Slamet, 14 (66%) are dominated by a single species, 6 (29%) diversified with 2 species each and colony number 8 (5%) with 3 species.

Table 4 is a list of the general flora collected within the elevational range of the lianas (1935–2591 m) on Mt. Slamet and compares the elevations of these collections with those of other sites throughout Java. Including the lianas, 19 species of general flora were collected. Other species were collected below and above the lianas, though are not included in this report. Interestingly, 8 species collected on Mt. Slamet from our expedition achieve elevational records for Java including: *Saurauia microphylla*, *Schefflera aomatica*, observed once, and *S. lucida*, a Mt. Slamet liana abundantly observed for this study, *Vaccinium laurifolium*, from this study, *Peperomia tomentosa*, only the 2nd specimen collected on Java, *Smilax odoratissima*, *Elatostemma strigosum* and *Antrophyum reticulatum*. Most of the general flora collected are common to Java, as indicated by the abundant collections from the island. When the Mt. Slamet lianas are examined by rarity on Java, *Vaccinium laurifolium* var. *laurifolium* has only been collected 8 other times on the island, and is the most abundant vine observed on Mt. Slamet (64 individuals); this species observed as an epiphyte, also (Wiriadinata, *pers. comm*.). *Elaeagnus latifolia* has only been collected 14 times on Java, with 11 individuals on Mt. Slamet (Abdulhadi *et al.* 1998, Kartawinata 2005).

DISCUSSION

Mt.Slamet's high elevation liana colonies appear distinct as a tropical ecology observation. This discussion will examine these liana colonies in terms of a number of parameters including: forest type, elevation, taxonomic diversity, precipitation, pioneering capability of lianas and fire as a cause for disturbance. How each of these parameters is related to reported observations in tropical ecology will be discussed, indicating the distinction of Mt. Slamet's upper elevation forest.

Forest Type

A central observation regarding Mt. Slamet's upper elevation forest is its secondary nature, based on disturbance caused by fire, more of which will

Tale 4. General Species List from Mt. Slamet

No	Family, Genus, Species	Collection from Java			Our 2004 Mt. Slamet Collections	Elev. record
		#	Elev. Range	Elev. Mean		
1	Actinidiaceae *Saurauia microphylla* vriese	10	1400–1900	1500	1900&2500	X
2	Araliaceae *Schefflera aromatica* (Bl.) Harms *Schefflera lucida* L.	11 17	1400–1900 1300–2229	1782 1632	2000 2300	X X
3	Asteraceae *Gynura aurantiaca* DC.	31	600–2550	1560	2200	
4	Caprifoliaceae *Viburnum lutescens* Bl. *Lonicera javaniva* DC.	53 31	150–3000 1000–3200	1112 1598	2500 2700	
5	Cyperaceae *Carex filicina* Nees	20	1400–3020	2349	2500	
6	Elaeagnaceae *Elaeagnus latifolia* L.	14	250–2000	1211	2300	
7	Equisetaceae *Equisetum debile* Roxb.	65	100–2680	1317	2500	
8	Ericaceae *Vaccinium laurifolium* var *laurifolium* Bl.	8	600–2300	1596	1500/2500/2900	X
9	Fagaceae *Lithocarpus spicatus* (Sm) Rehd et Wills	44	93–2403	1150	2600	
10	Myrsinaceae *Ardisia javanica* DC. *Embelia pergamacea* DC.	87 20	93–3000 300–2400	2500 2100	2500 2100	
11	Piperaceae *Peperomia laevifolia* Miq. *Peperomia tomentosa* Dietr. *Piper caninum* Bl.	91 1 96	200–2200 1642 25–2708	1425 1642 546	1700/1900 1900/2200 2000/2100/2700	X
12	Polypodiaceae *Microsorium nigrescens* Bl.	35	200–2000	1061	1900	
13	Ranunculaceae *Ranunculus blumei* Steud *Thalictrum javanicum* Bl.	92 58	700–3300 1000–3300	2007 2739	1690/2500/2800/29 50 2500	
14	Rutaceae *Toddalia asiatica* (L.) Lam.	47	93–2600	1719	2600	
15	Saxifragaceae *Dichroa febrifuga* Lour.	91	500–3000	1530	1400/2200/2800	
16	Smilacaceae *Smilax odoratissima* Bl. *Smilax zeylanica* L.	30 63	900–2200 500–2000	1642 626	1300/1900/3000 1900	X
17	Symplocaceae *Symplocos cochinchinensis* (Lour.) Moore	12 7	150–3020	1532	2600	
18	Urticaceae *Elatostemma strigosum* (Bl.) Hassk. *Pilea angulata* Bl. *Urtica bullata* Bl.	9 38 12	970–2933 800–2600 1500–2600	1707 1460 2049	2200/2950 2000 2100	X
19	Vittariaceae *Antrophyum reticulatum* (Forst.)Kaulf.	64	5–1846	450	2000	X

be said below. An observational gradient of disturbance is evident along Ridge 1 from 2300 m. to the "burn–off zone" at 3,076 m. Lower elevational forest, estimated from 1850–2300 m., may be the richest montane forest we have observed in Indonesia (Hoover *et al.* 2004), suggesting its disturbance is relatively limited. Above 2300 m, indications of more recent disturbance are observed, with the distribution of lianas being a prime indication since total number of lianas increases dramatically after 2300 m (Fig. 9).

It is important to attempt identification of the type of forest in which these Mt. Slamet lianas are growing, which is montane. Ashton (2003) points out it is often difficult to distinguish floristic, structural and physiognomic elements separating lower montane from upper montane forest, thus describing an ecotone transition between these vegetation zones. Standard elevational benchmarks for forest transitions are unreliable because mountains have different heights and are subject to varying climatic conditions. The studies by Grubb *et al.* (1963) and Grubb and Whitmore (1966) in Ecuador, Whitmore's (1984) studies of tropical mountains of Asia and throughout the tropics and (Whitmore 1998) all are classic studies of tropical forest zonation in relation to elevation. More recent studies have continued to examine complex issues regarding vegetational zonation on SE Asian tropical mountains, with little agreement among scientists; see for example, but not limited to Osawa (1991), Kitayama (1992), Gioda *et al.* (1993), Aiba and Kitayama (1999), Beaman *et al.* (2001) and Kartawinata (2005). Nonetheless, Ashton (2003) makes a clear case for transitional/ecotone tropical forest zones that can be effectly applied in the field.

Table 4 lists the general flora associated with the lianas of Mt. Slamet and compares the elevational ranges and means of these species with the same species collected throughout Java. It is predictable a number of floristic elevational records (8) would be achieved since Mt. Slamet is the second highest mountain on Java. Examining species associated with lianas suggests a floristic composition representative of lower montane forest on Java, also suggested by Ashton (*pers. comm.),* with elevational records achieved by these species simple because forest habitat extended by high elevation. The forest observed along the elevational gradient up to 2200 m. is likely lower montane with an ecotone transition roughly occurring between this elevation and 2300 m.; within this elevation range occur a number of distinctions in the liana data:

1. Plot 8 (2256 m), being the only plot observed with 3 species of lianas, occurring in the middle of the gradient and concentrated with 3 of the largest diameter lianas observed.
2. The 4 "lower elevation" species do not exceed 2347 m, while the 2 "upper elevation" species are concentrated above 2301 m at colony number 9, with only 9 *Vaccinium* occurring below 2300 m.
3. Fig. 9 indicate data at the 2201–2300 m elevational range category are distinct since each of the parameters (total number of individuals, mean lianas/m^2 and mean trunk diameter are respectively lowest, one of the smallest and highest.

The disturbed nature of the upper elevation forest complicates identification of forest type, be it lower or upper montane, and at what elevation forest transition occurs is difficult to assess. However, the data indicate distinction around 2200–2300 m.

It is of interest to note Kartawinata (2005) states, "the altitude of 2300 m is the meeting point of dominant species of upper montane forest and sub–alpine forest, hence the elevation of 2300 may be suggested as the boundary between montane zone and subalpine differing from the boundary at altitude 2400 m. previously defined by van Steenis et al (1972)". Mt. Slamet is distinct from the Mt. Gede/ Pangrango complex since no vegetation exists on the top 400 m of Mt. Slamet. Fire has completely burned off the top of Mt. Slamet, while Mt. Gede/ Pangrango has experienced a limited recent fire history. None–the–less, 2300 m certainly appears to be a critical elevation for SE Asian tropical forests. Regarding Mt. Slamet, the elevational range around 2200–2300 m. may to be an ecotone transition zone between lower and upper montane forest.

Though not part of this study, it should be pointed out that *Lonicera* lianas were observed on the upper most sections of Ridge 2 at approximately 2700 m, but they appeared to be very young plants, with diameters of less than 10 mm. Evidence of fire was observed on the trunks of small trees. It was difficult to assess this forest as upper montane, due to the apparent disturbance caused by fire, but there still appeared to be enough distinguishing characteristics such as low stature and single canopy tree stratum, few shrubs, and microphyll leaf size to distinguish this burned forest as upper montane.

Elevation

In itself, the presence of lianas on mountain slopes is not unusual. Steenis *et al.* (1972) report on 14 different species of lianas in the Mt. Flora of Java, with an additional number of climbers having woody characteristics. Most of Steenis *et al.* (1972) liana are observed at elevations closer to 1000 – 1500 m., much less than the Mt. Slamet site beginning at 1935 m and above. Gentry (1991) lists his 9 montane forest sites of the neotropics where lianas are present by elevation. The Pasochoa, Ecuador (3,010 m) site is higher than Mt. Slamet's liana site, though this Ecuadorian site is based on only a 0.1 ha and the data extrapolated. All Gentry's 9 montane sites are listed as a single elevation, whereas the Mt. Slamet site is along an elevational gradient from 1,935 – 2,591 m. Aside from this report and Gentry's (1991), elevation is generally not a factor in the great volume of recent literature since Putz and Mooney (1991) published their "Biology of Vines". In order to establish data standards, Schnitzer (2005), "…omitted forests that were classified as subtropical, montane and premontane to reduce confounding the differences in latitude, elevation, and temperature among the sites." A review of the last 18 years of liana literature indicates research is restricted to lowland tropical forest, primarily of the neotropics, where elevation is not a parameter examined. Therefore, the distinction with Mt. Slamet's lianas is their colony structure distributed along a 655 m elevational gradient, with the greatest abundance of plants found at the higher elevations, particularily because of *Vaccinium laurifolium* and *Lonicera japonica*.

Taxonomic Diversity

The 6 lianas observed at Mt. Slamet, *Embelia pergamacea* (*Myrsinaceae*), *Elaeagnus latifolia* (*Elaeaganaceae*), *Toddalia asiatica* (*Rutaceae*), *Schefflera lucida* (*Araliaceae), Vaccinium laurifolium* (*Ericaceae*) and *Lonicera japonica* (*Caprifoliaceae)* represent families that are different from the limited Asian data sets available. Gentry's (1991) 3 Asian sites were collected from lowland forest in Kalimantan, and would be expected to be different, with his 7 most common liana families being: *Annonaceae, Apocynaceae, Fabaceae, Loganiaceae, Rubiaceae, Connaraceae* and *Dilleniaceae*. Considering the taxonomic composition of the lianas at his 9 Neotropical upland Andean sites, only the *Ericaceae* is shared with the Mt. Slamet site, though he is only reporting the most common families, noting that lianas from many other families are observed. Of interest is that Gentry (1991) points out that the *Asteraceae* is the most speciose Neotropical montane vine family and in general Andean montane forest climbers are dominated by a hemiepiphytic habit, as opposed to ground based woody lianas, like the 6 Mt. Slamet, species, further distinguishing this site.

Precipitation

Precipitation at Baturden, Central Java is ranked as the second highest measured in Indonesia, averaging over 7,000 mm/year for the last 93 years (Fig. 3a). (For interest's sake the 5 highest measured rainfall sites in Indonesia are, by site, province, mean rainfall/year in mm, and the years data were collected (Berlage 1949 and Schmidt & Ferguson 1951): 1. Sungai Batoeng, W. Sumatra, 7752 mm, 1929–1936; 2. Tenjo, Batuaden, C. Java, 7069 mm, 1919–1941; 3. Tombo, Ond., C. Java, 6656 mm, 1889–1941; 4. Patoengkrinono, C. Java, 6649 mm, 1897–1941; 5. Pagilaran, C. Java, 6379 mm, 1896–1941. There may well be wetter areas in Papua.) This is nearly a "Pluvial" level of rainfall by the Holdridge (1967) system for Neotropical Life Zones, referring to this system because there appears to no eqivalent category for SE Asia. Pluvial Forest is benchmarked at 7400 mm/year and above by Gentry (1991). Though precipitation is not known specifically at the Mt. Slamet liana site, its adjacency to Baturaden suggests the site is very wet. (Appendix 2 shows old historical maps for rainfall stations and rainfall patterns at Baturaden (number 25) and Mt. Slamet, noting stream density on the south slope. Further, the next most adjacent sites to our Mt. Slamet liana site, besides Baturden being the closest, include sites due East, with each site number and mean rainfall: number 23J jelegong – 6012, number 23a Noesakambang – 5952 and number 24 Redjasari – 5565 mm Berlage 1949) For reference, Gentry (1991) only reports on 2 of his liana sites where rainfall exceeds Baturaden: Tutunendo, Colombia with 9000 mm/year at an elevation of 90 m. and Mt. Cameroun, Cameroun with 8000 mm/year at 230 m. elevation, both lowland sites. No precipitation data are available for any of Gentry's (1991) 9 montane forest sites.

A review of available literature suggests liana abundance and distribution is negatively correlated with precipitation. The mechanistic explanation for global liana patterns of distribution offered by Schnitzer (2005) is based on a data set including 66 tropical forests: 24 dry forests, 31 moist forests and 11 wet forests. Schnitzer's (2005) explanation for greater abundance and distribution of lianas in dry forest habitats involves the adaptive capability of lianas to exploit dry seasonal conditions through faster growth rates compared to trees, and a deep root system allowing plants to obtain necessary water. Research supporting Schnitzer's (2005) overall theory is spread far and wide in the recent literature noting particularily, but not limited to: Longino (1986), who may have been the first to observe this negative correlation between liana abundance and precipitation, Gartner *et al.* (1990), Ewers *et al.* (1991), Opler *et al.* (1994), Philips *et al.* (2002), Restom and Nepstad (2004), and Kalacska *et al.* (2005). Thus, Mt. Slamet's liana community distributed over 655 m of elevational gradient in a "hyper–

wet", high elevation forest appears distinctive for global tropical ecology.

Pioneering Capability of Mt. Slamet Lianas and Fire as a Cause for Disturbance

Noted throughout tropical literature, are lianas pioneering capacity to invade disturbed habitats, in reference to tree fall gaps, hurricanes, and logging sites (see for example: Putz *et al.* 1984, Balee and Campbell 1990, Fisher and Ewers 1991, Babweteera *et al.* 2000, Schnitzer 2005, Avalos *et al.* 2007. Additional tropical literature primarily from SE Asia describes the ecological effects of disturbance caused by fire. See for example: Kartawinata (1993), Riswan (1982), Riswan and Kartawinata (1988, 1989, 1991), Sadili *et al.* (2009) describe the effects of fire on vegetation patterns on Mt. Gede Pangrango complex, West Java, Indonesia.

Similarily, Mt. Slamet is a volcano and the effects of fire were apparent on the trunks of the *Acacia sp*. and *Anaphalis viscida* at the subalpine zone, as well as at a section of upper montane forest at 2700 m. on Ridge 2, observed above the liana site. It is proposed that fire may be an environmental factor effecting the upper elevation forest on Mt. Slamet, and contributes directly to the presence of the lianas, due to their pioneering ability. Though the specific liana colonies showed no direct or immediate evidence of fire, this does not preclude the possibility that fire has burned areas along the ridges now occupied by lianas, thus disturbing the ecology of the forest and allowing lianas to invade with their rapid growth rates and form the colonies observed. The distribution of lianas on Mt. Slamet may be explained by the disturbance caused by fire, particularily, the greater abundance of *Lonicera* and *Vaccinium* at the upper elevations, as mentioned above.

It is our hypothesis that fire has been a frequent factor influencing the upper elevational forest ecology of Mt. Slamet for much of its history, to a point where the steep upper section of the mountain on its South face, estimated at 800 or more meters of elevational gradient, is basically a "vine or liana forest", not in the sense of Balee & Campbell (1990) or Perez–Salicrup (2001) Amazonian Liana Forests but a localized one. We hypothesize that by rotating from the steep South side of the mountain to the much less steep east side of the mountain, montane forest will become more prevelant, and thus exhibit a gradient in liana abundance and density. Rotating further to the NE side of the mountain, where the present site has been documented, one observes even fewer lianas than the east side. In other words, the highest liana density and abundance has not been observed and documented, but is predicted for the South slope. The steep upper South slope has likely been effected not only by fire, but also by landslides due to being so steep, as

Fig. 1. View of Mount Slamet showing upper section of western ridge from Baturaden

can be observed in Fig. 2, thus causing further disturbance of this area and promoting the pioneering capability of lianas to invade and dominate the ecology. At this point, we plan a dry season observational trip up the South slope to document photographically whether the hypothesized liana community exists as a "Liana Forest" at a local scale.

Climate Change

It would be irresponsible not to mention the possible effects of climate change on montane forest of Mt. Slamet, especially in view of Svenning & Condit (2008) commentary on the lack of research on climate change in the tropics. Perhaps climate change has contributed to a shift in montane forest vegetation on Mt. Slamet since this liana community appears unusual. Rainfall data from Baturaden (Fig. 3) suggest a decline in precipitation over the last 93 years, still leaving precipitation very high on Mt. Slamet's South and East slopes. Such a shift in rainfall may be explained in a number of ways. 1. Overall global climate change is effecting rainfall patterns locally in Java. 2. Forest clearing; perhaps up through the 1950's much of the lowland coastal area of Central Java was forested and by the early 1960's this forest was destroyed.

Philips *et al.* (2002) and Wright *et al.* (2004) have data suggesting sharp increases in liana abundance and productivity in neo–tropical forests, while Schnitzer (2005) acknowledges the possible effects of climate change on liana abundance and distribution. From the standpoint of elevation shifts of biota in the tropics, Colwell *et al.* (2008) present a new concept for approaching climate change in the tropics, with perhaps future consideration being given to applying this model to the upper elevation lianas on Mt. Slamet. Certainly, mankind's assult on nature may produce consequential changes in vegetation with perhaps more ecological circumstances like Mt. Slamet being observed in the future.

Of interest to the history of tropical ecology and research on lianas, is the important role of Longino, sparked in part by Colwell *et al.* (2008) paper, in which Longino is one of the authors. As mentioned above, Longino (1986) paper in *Biotropica* may likely be the first research to document the negative correlation between lianas and precipitation; an observation of great importance to global tropical ecology, witnessed by the great volume of post–1991 literature concerning this observation. Of the many important post–1991 studies, Longino does not appear to have contributed much beyond the original, critical observation in 1986. Gentry (1991:14) does not make reference to this paper, though his data report, "It is probably not altogether coincidental that the neotropical site with the highest liana density (Jauneche, Ecuador) occurs in an area with a marked dry season that is transitional between moist and dry forest." What is the explanation for J.T. Longino's highly influential, original observation on lianas being elaborated by other scientists who published much more?. Curiously, a similar question can be asked about why Dr. Enrique Forero, Universidad National in Bogota, Colombia, was not a second author with Gentry on the many papers he published on work in Colombia, where Forero was his active partner and undertook

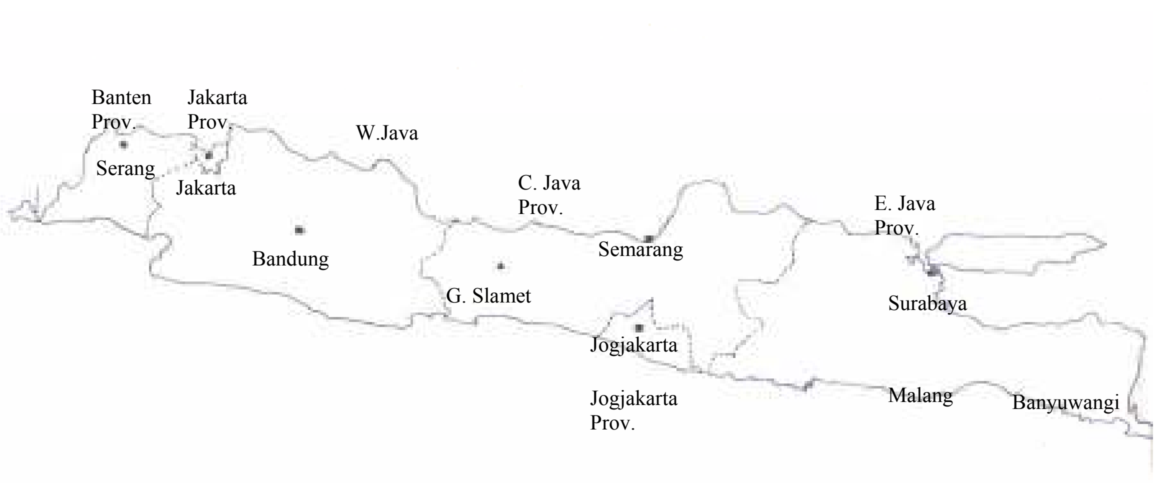

Fig. 2. Map of Java Island with Mount Slamet, showing major cities in Provinces

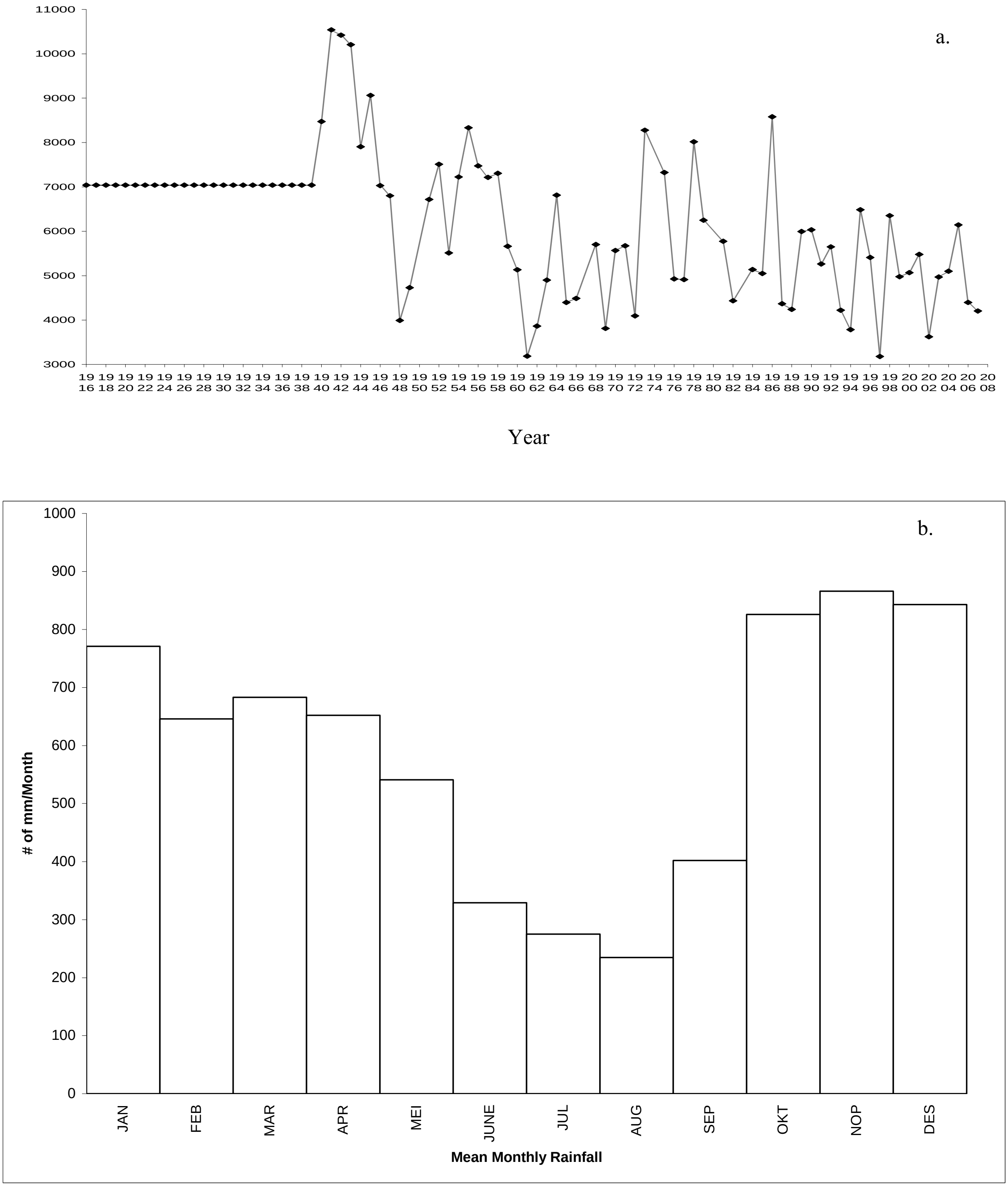

Fig 3. Rainfall Data for Baturaden, Central Java (Berlage 1949).

a. Annual from 1916–2008
b. Monthly Mean Rainfall

Fig. 4. *Toddalia asiatica* A. Habitat of liana mixed with other vegetation on medium tree estimated 12 m tall on plot 2, 1951 m, B. Colony of liana trunks, C. Habit, D. Fruit cluster

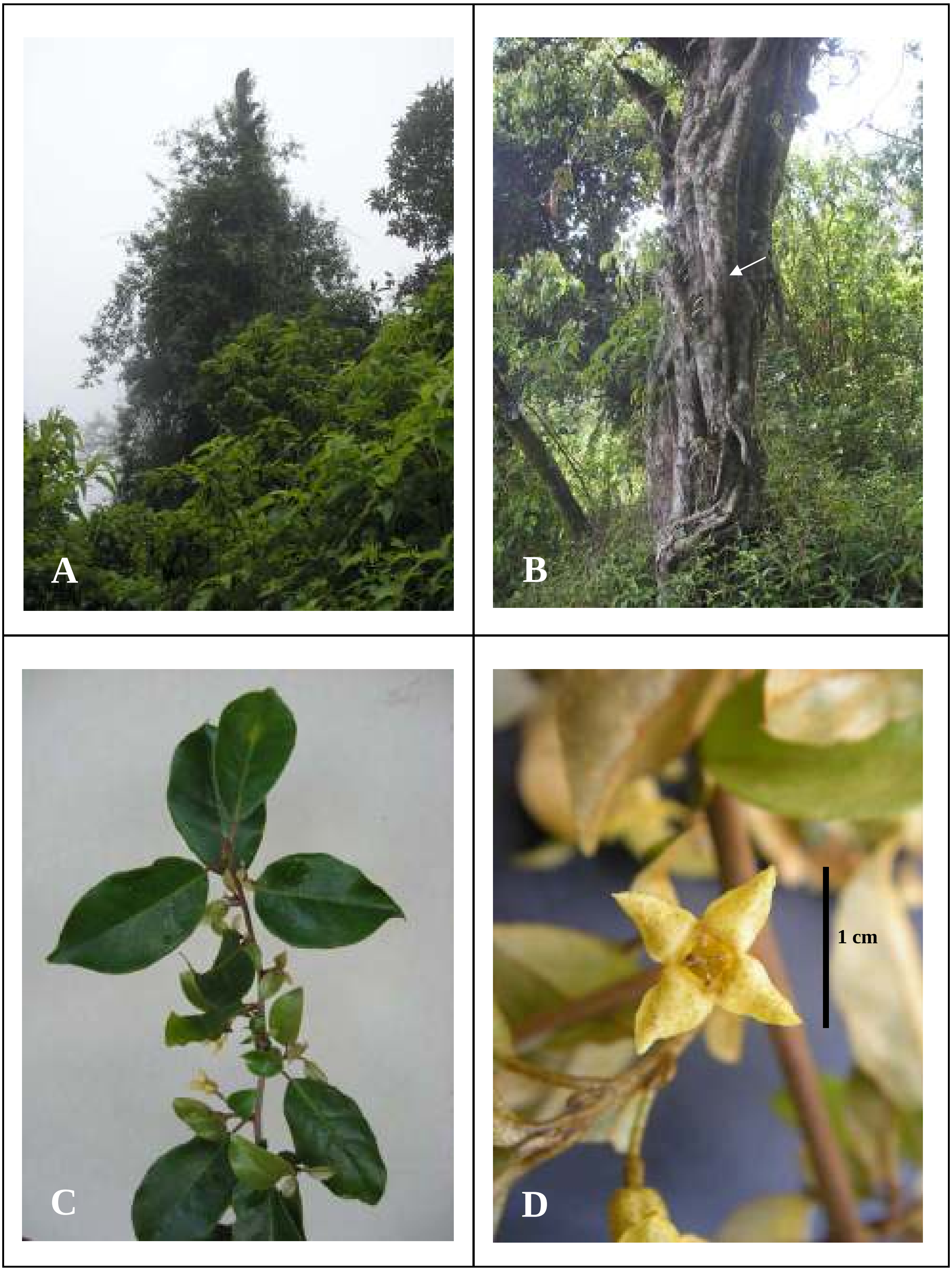

Fig. 5. *Elaeagnus latifolia*, A. Habitat showing liana covering estimated 10 m tall *Melastomataceae* tree at plot 4, 1981 m B. Liana trunk on tree, C. Habit, D. Dioecious flower

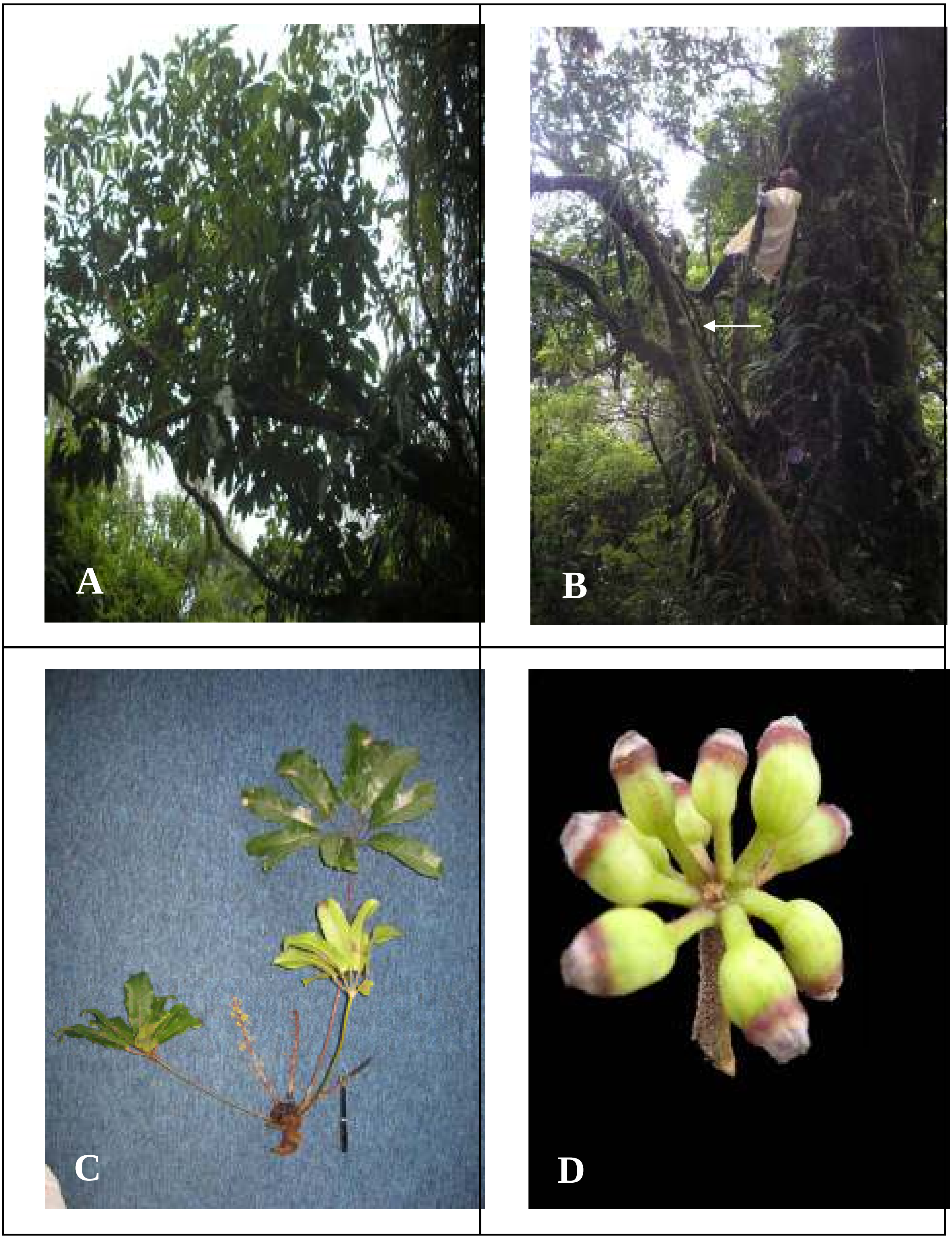

Fig. 6. *Schefflera lucida* A. Habitat showing clump of secondary branches sprouded from main trunk which is climbing on large possible *Lithocarpus* tree, plot 5, 1981 m, B. Six or more liana trunks on large tree estimated 15 m tall, C. Habit, D. Flower buds

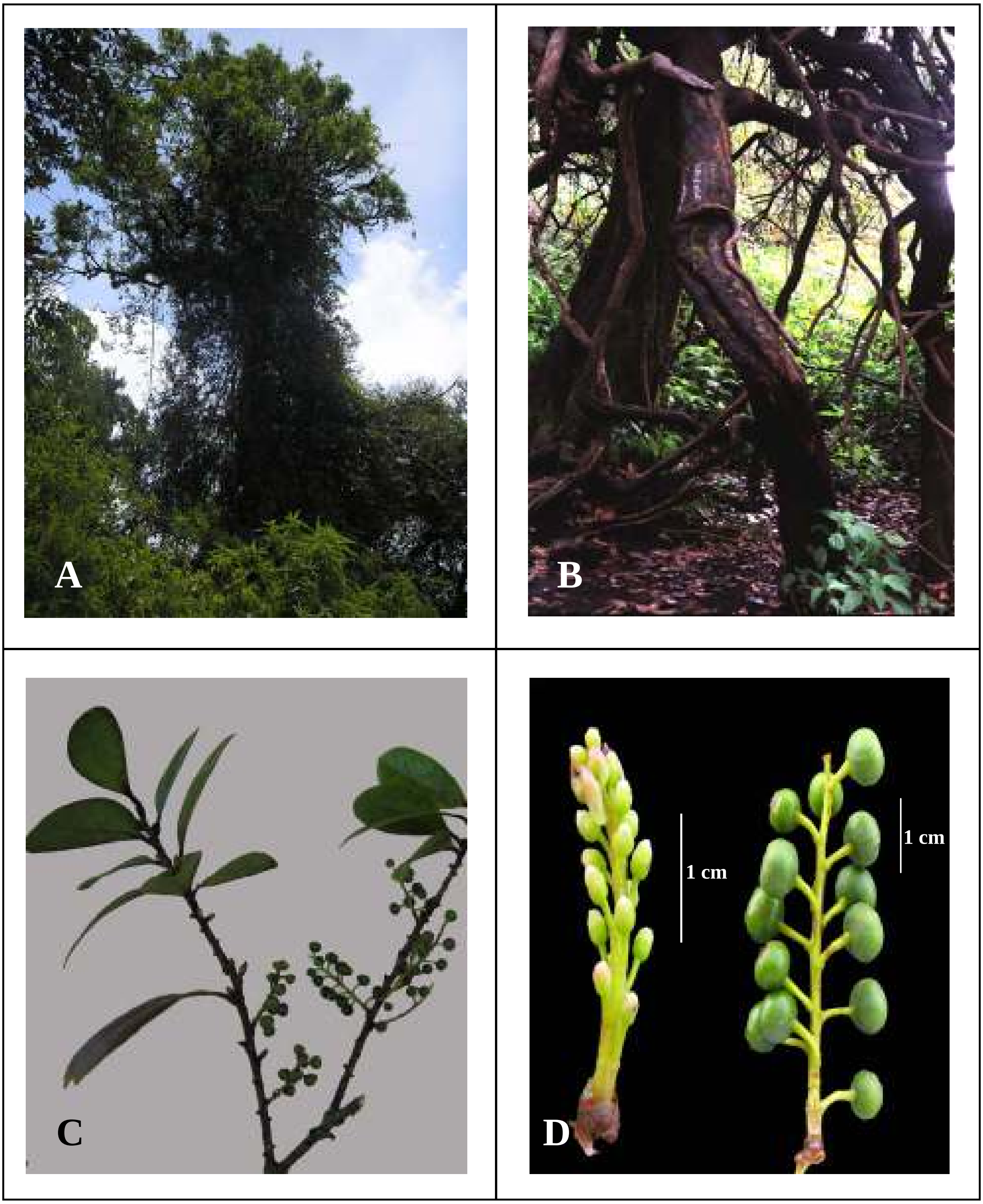

Fig. 7. *Vaccinium laurifolium* A. Habitat of large liana on *Schefflera* sp. tree trunk estimated 15 m tall on plot 3, 1966 m, B. Colony of lianas at base of tree, C. Habit, D. Flower buds and fruits

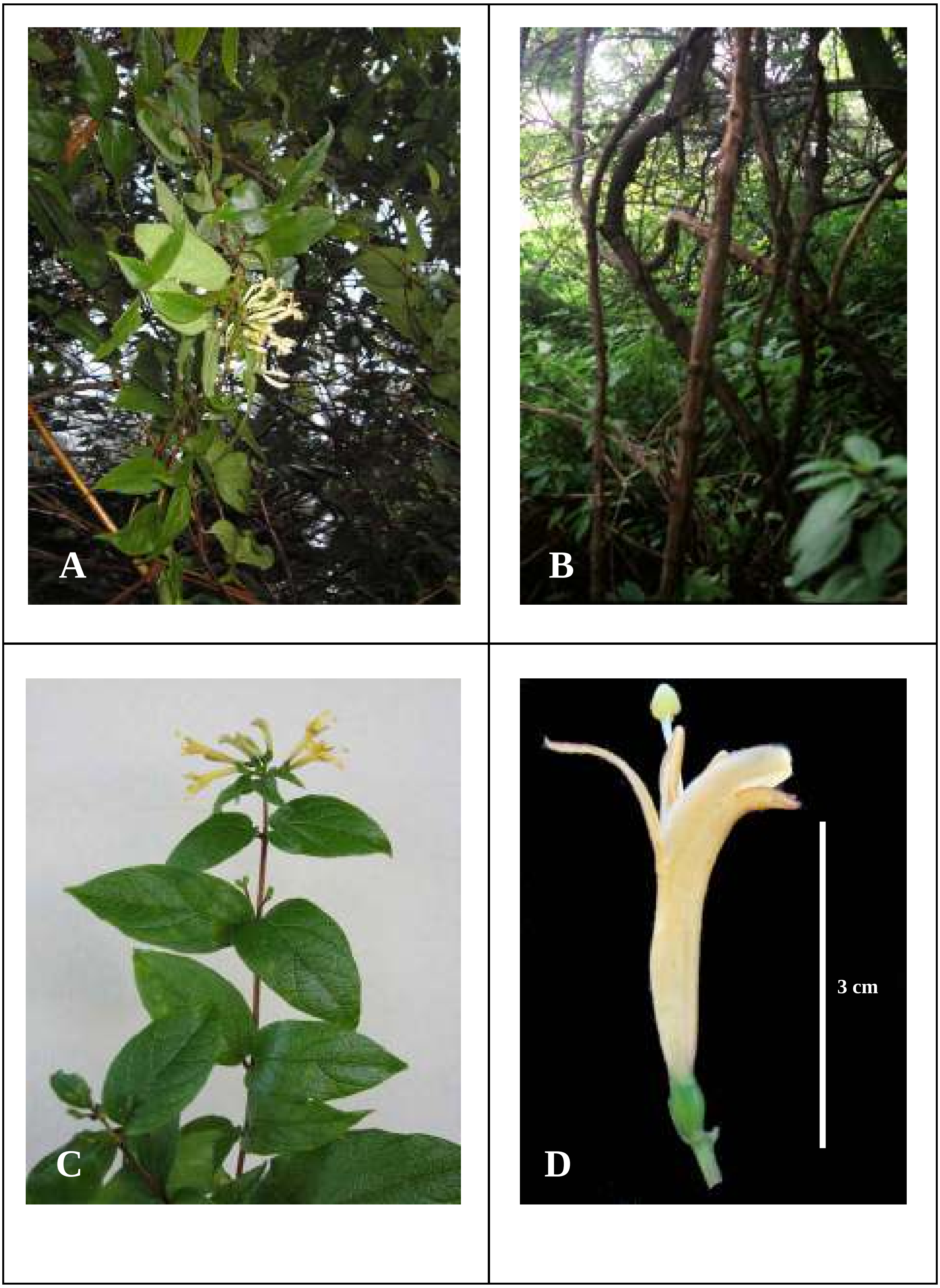

Fig. 8. *Lonicera javanica* A. Habitat of liana on tree trunk, B. Colony of liana trunks on plot 14, 2499 m, C. Habit, D. Single dioecious flower

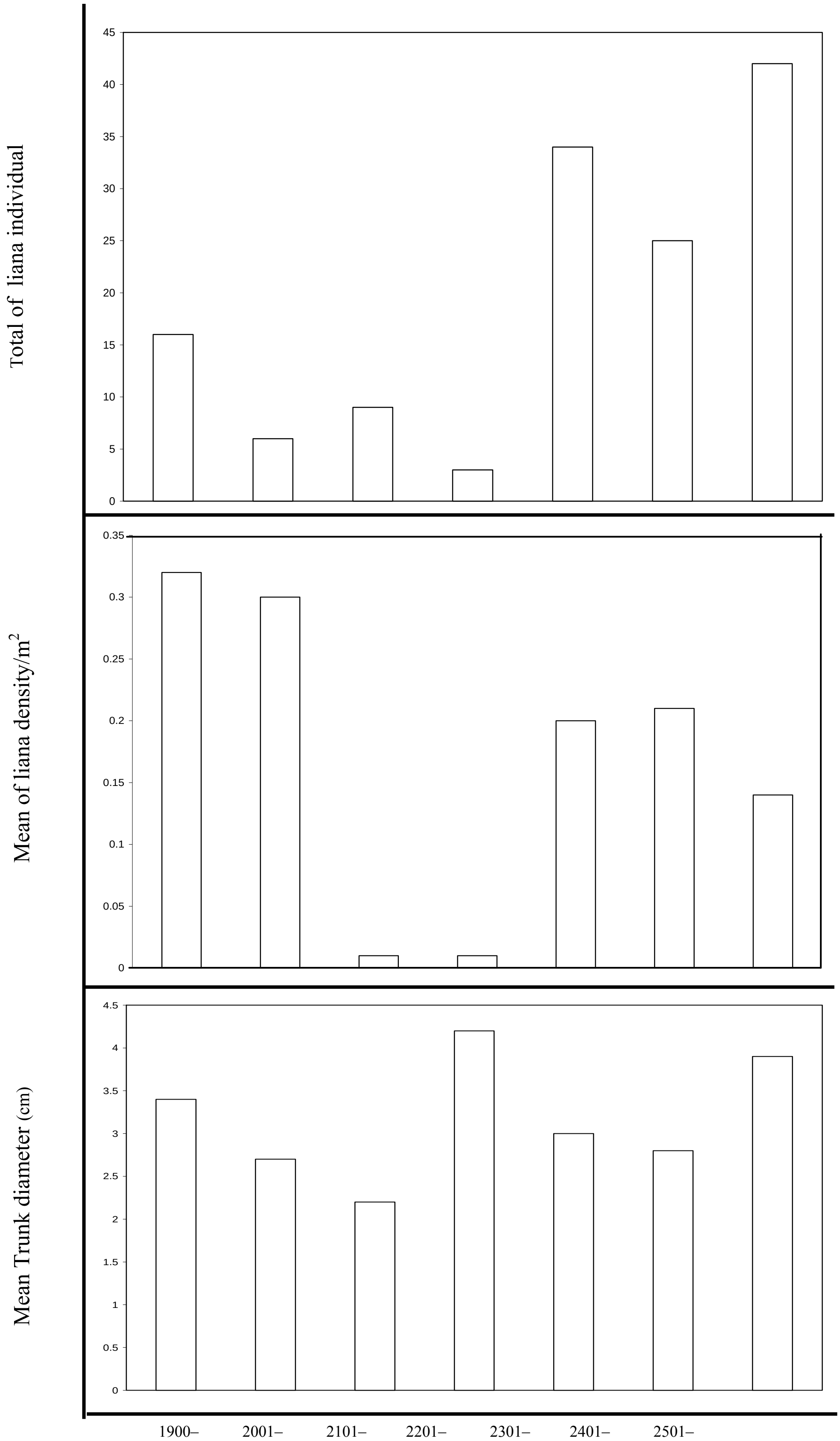

Fig 9. Total of liana individual, mean of liana density/m^2 and mean trunk diameter within elevational ranges on Mt. Slamet.

much of the work in the Pluvial Forests of the Choco Phyto–geographic Region? Such issues remain to be answered by a Historian of Science. In the meantime, study of the high elevation lianas of Mt. Slamet, Central Java, Indonesia will continue.

LITERATURE CITED

AIBA S. and KITAYAMA, K. 1999. Structure, Composition and Species Diversity in an Altitude Substrate Matrix of Rainforest Tree Communities on Mt. Kinabalu, Borneo. *Plant Ecology* 140: 139–157.

APPANAH, S. *et. al.* 1992. Liana Diversity and Species Richness of Malaysian Rainforests. *J. Trop. For. Sci.* 6: 116–123.

ASHTON, P. F. 1964. *Ecological Studies in the Mixed Dipterocarp Forests of Brunei State*. Oxford Forestry Memoirs 25.

ASHTON, P. F. 2003. Floristic Zonation of Tree Communities on Wet Tropical Mountains Revisited. *Perspectives in Plant Ecology, Evolution and Systematics* 6: 87–104.

APRIYANTI, N. 2006. Nepenthes baru dari Gunung Slamet Hingga Negeri Jiran. *Trubus* 435: 112–113.

ARIFIANI, D. 2001. *Inventarisasi Tumbuhan Ke Gunung Lawu dan Slamet, Jawa Tengah. Januari dan Oktober* 2001. Laporan Perjalanan Propinsi Jawa Tengah.

AVALOS, G.; MULKEY, S.S. & KITAJIMA, K. 1999. Leaf Optical Properties of Trees and Lianas in the Outer Canopy of a Tropical Dry Forest. *Biotropica* 31: 517–520.

AVALOS, G. and AVALOS, G. 1999a. Photosynthetic Acclimation of the Liana *Stigmaphyllon lindenianum* in Light Changes in a Tropical Dry Forest Canopy. *Oecologia* 120: 474–484.

AVALOS, G. 1999b. Seasonal Changes in Liana Cover in the Upper Canopy of a Neotropical Dry Forest. *Biotropica* 31: 186–192.

BABWETEERA, F. 2000. Effect of Gap Size and Age on Climber Abundance and Diversity in Budongo Forest Reserve, Uganda. *Afr. J. Eco.* 38: 230–237.

BALEE, W. & CAMPBELL, D.G. 1990. Evidence for the successional status of liana forest (Xingu river Basin, Amazon Brazil). *Biotropica* 22: 36–-47.

BEAMAN, J.H., ANDERSON, C. & BEAMAN, R.S. 2001. *The Plants of Mount Kinabalu. 4. Dicotyledonous Families Acanthaceae to Lythraceae*. Natural History Publications (Borneo) and Royal Botanic Gardens, Kew.

BERLAGE, H.P. 1949. *Rainfall in Indonesia: Mean Raifall figures for 4339 rainfall stations in Indonesia, calculated from observations made during the period 1879–1914.* De Unie. Batavia. :212.

CABALLE, G. 1994. Ramet Profliferation by Longitudinal Splitting in the Gabonese Rainforest Liana *Dalhousiea africana* S.Moore (*Papilonaceae*). *Biotropica* 26: 266–275.

CAMPBELL, E.J.F. and D.M. NEWBERRY. 1993. Ecological Relationships between Lianas and Trees in Lowland Rainforest in Sabah, East Malaysia. *J. Trop. Ecol.* 9: 469–490.

CLINEBELL, R.; PHILIPS, O.L.; GENTRY, A.H.; STARK, N. & ZURING, H. 1995. Prediction of Neotropical Tree and Liana Species Richness from Soil and Climatic Data. *Biodiversity and Conservation* 4: 56–90.

COLWELL, R.K.; BREHM, G.; CARELUS, C.L.; GILMAN, A.C. & LONGINO, J.T. 2008. Global Warming, Elevational Range Shifts and Lowland Biotic Attrition in the Wet Tropics. *Science* 322: 258–261.

DATTARAJA, H.S. and R. SUKUMAR. 2004. Tropical Dry Forest Diversity of Mudumalai, Southern India. *Inside CTFS* 2004: 8–9.

DAVIS, T.A. and P.W. RICHARDS. 1933–34. The Vegetation of Moraballi Creek, British Guinea; an Ecological Study of a Limited Area of Tropical Rain Forest. Parts I and II. *J. Ecol.* 21: 350–384; 22: 106–155.

DAVIS, T.A. 1933. Biology of Plants and Animals Occuring in the Higher Parts of Mount Pangrango–Gedeh in West–Java. *Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam Afdeeling Natuurkunde (Tweede Sectie)* 31: 1–288.

DILLENBURG, L.R., D.F. WHIGHAM, A.H. TERAMURA and I.N. FORSETH. 1993. Effect of Below and Aboveground Competition from the Vines *Lonicera japonica* and *Parthenosissus quinquefolia* on the Growth of the Tree Host *Liquidambar styraciflua*. *Oecologia (Berlin)* 93: 48–54.

GARTNER, B.L.; BULLOCK, S.H.; MOONEY, H.A.; BROWN, V.B. & Whitlock, J.L. 1990. Water Transport Properties of Vine and Tree Stems in a Tropical Decidious Forest. *Amer. J. Botany* 77: 742–749.

GENTRY, A.H. 1982. Patterns of Neotropical Plant Species Diversity. In M.K. HECHT, B. WALLACE AND G.T. PRANCE (Eds.). *Evolutionary Biology* 15: 1–84. Plenum Press, New York, NY.

GENTRY, A.H. 1988. Changes in Plant Community Diversity and Florsitic Composition on Environmental and Geographic Gradients. *Ann. Miss. Bot. Gard.* 75: 1–34.

GENTRY, A.H. 1991. The Distribution and Evolution of Climbing Plants. In F.E. Putz and H.A. Mooney (Eds.). *The Biology of Vines*. :3–49. Cambridge University Press, Cambridge.

GERWING, J.J.; SCHNITZER, S.A.; BURNHAM, R.J. ; BONGERS, F.; CHAVE, J.; DEWALT, S.J.; EWANGO, C.E.N.; FOSTER, R.; MARTINEZ–RAMOS, M.; PARREN, M.; PARTHASARATHY, N.; PEREZ–SALICRUP, D.R.; PUTZ, F.E. & THOMAS, D.W. 2006. A standard Protocol for Liana Censuses. *Biotropica* 38: 256–261.

GIODA, A., J. MALEY, R.E. GUASP and A.A. BALADON. 1993. *Some Low Elevation Fog Forests of Dry Environments: Application to Paleoenviron-*

ments. Tropical Montane Cloud Forest. Proceedings of an International Sysposium. HAMILTON, L.S.; JUVIK, J.O. & SCATENA, F.N. (Eds.) : 97–101. East–West Center, Honolulu.

GRUBB, P.J., LLOYD, J.R.; PENNINGTON, T.D. & WHITMORE, T.C. 1963. A Comparison of Montane and Lowland Forest in Ecuador. I. The Forest Structure, Physiognomy and Floristics. *J. of Ecol.* 51: 567–601.

GRUBB, P.J., & WHITMORE, T.C. 1966. A Comparison of Montane and Lowland Forest in Ecuador. II. The Climate and its Effects on the Distribution and Physiognomy of the Forests. *J. of Ecol*. 53: 303–333.

HOLDRIDGE, L. 1967. *Life Zone Ecology*. Tropical Science Center, San Jose, Costa Rica.

HOOVER, W. SCOTT. 1974. *Begonia* Collecting in Colombia. *The Begonian* 41 (2).

HOOVER, W. SCOTT. 1980. Collecting Begonias in Papua New Guinea. *The Begonian* 47 (1).

HOOVER, W. SCOTT. 1985. Summary of 1984 South American Collecting Expedition. *The Begonian* 52: 28–32.

HOOVER, W. SCOTT. 1989a. Summary of 1987–88 Expedition to Ecuador. *The Begonian* 56: 46–50.

HOOVER, W. SCOTT. 1989b. Ecuador's Forest Refuge. *The Explorers Journal* 66: 166–169.

HOOVER, W. SCOTT. 1991. Notes on a Novel Abaxial Leaf Epidermis in Ecuadorian *Begonia parviflora*. *J. Arnold Arboretum* 71: 259–264.

JACOBS, M. 1976. The Study of Lianas. *Flora Malesiana Bulletin* 29: 2610–18.

KALACSKA, M., CALVO–ALVARADO, J.C. & SANCHEZ–AZOFEIFA, G.A. 2005. Calibration and Assessment of Seasonal Changes in Leaf Area Index of a Dry Tropical Forest in Different Stages of Succession. *Tree Physiology* 25: 733–744.

KARTAWINATA, K. 1993. A wider view of the fire hazard. :261–266. In BROOKFIELD, H.; BYRON, Y. (Eds.). *Southeast Asia's environmental future: the search for sustainability*. United Nations University Press, Tokyo.

KARTAWINATA, K. 2005. Six Decades of Natural Vegetation Studies in Indonesia: 95–140. In SOEMODIHARDJO, S. & SASTRAPRADJA, S. D. (Eds.). *Six Decades of Science and Scientists in Indonesia*. Naturindo, Bogor, Indonesia.

KITAYAMA, K. 1992. An Altitudinal Transect Study of the Vegetation on Mt. Kinabalu, Borneo. *Vegetatio* 102: 149–171.

LONGINO, J.T. 1986. A Negative Correlation between Growth and Rainfall in a Tropical Liana. *Biotropica* 18: 195–200.

OSAWA, M.1991.Structural Comparison of Tropical Montane Forests along Latitudinal and Altitudinal Gradients in South and East Asia.*Vegetatio* 97: 1–10.

OPLER, P.A., BAKER, H.G. & FRANKIE, G.W. 1994. Seasonality of Climbers: A Review and Example from Costa Rican Dry Forest. Pp. 377–391. In PUTZ, F.E. & MOONEY, H.A. (Eds.). *The Biology of Vines*. Cambridge University Press, Cambridge.

PARTHASARATHNY, N.S., MUTHURAMKUMAR, S. & REDDY, M. S. 2004. Patterns of Liana Diversity of Tropical Evergreen Forests of Peninsular India. *For. Eco. Manage.* 190: 15–31.

PEREZ-SALICRUP, D.R. 2001. Effect of liana-cutting on tree regeneration in a liana forest in Amazonia Bolivia. Ecology 82: 389–396.

PHILIPS, O.L.; MARTINEZ, R.V.; ARROYO, L.; BAKER, T. R.; KILLEN, T.; LEWIS, S.L. & MALHI, Y. 2002. Increasing Dominance of Large Lianas in Amazonian Forest. *Nature* 418: 770–774.

PINARD, M.A. & PUTZ, F.E. 1993. Vine Infestation of Large Remnant Trees in Logged Forest in Sabah, Malaysia: Biomechanical Facilitation in Vine Succession. *J.Trop. For. Sci*. 6: 302–309.

PUTZ, F.E., LEE, H.S. & Goh, R. 1984. Effects of Post–Felling Silvicultural Treatments on Woody Vines in Sarawak. *Malaysian Forester* 47: 214–26.

PUTZ, F.E. 1985. Woody Lianas and Forest Management in Malaysia. Commonwealth *Forestry Review* 64: 359–65.

PUTZ, F.E. & CHAI, P. 1987. Ecological Studies of Lianas in Lambir National Park, Sarawak, Malaysia. *J. of Ecology* 75: 523–31.

PUTZ, F.E. & MOONEY, H.A. 1991. *The Biology of Vines*. Cambridge University Press, Cambridge.

PUTZ, F.E. & WINDSOR, D.M. 1987. Liana Phenology on Barro Colorado Island, Panama. *Biotropica* 19: 334–341.

RAHMAN, E. 2001. *Eksplorasi Tumbuhan Liar Berpotensi obat dan Tanaman Hias de Jawa Tengah 17–29 April.* Laporan Perjalanan Propinasi Jawa Tengah.

RESTOM, T.G. & NEPSTAD, D.C. 2004. Seedling Growth Dynamics of a Deeply Rooting Liana in Secondary Forest in Eastern Amazonia. *For. Ecol. and Man.* 190: 109–118.

RICHARDS, P.W. 1936. Ecological Observations on the Rain Forest of Mt. Dulit, Sarawak. Parts I and II. *J. of Ecol.* 24: 1–27; 340–360.

RICHARDS, P.W. 1964. *The Tropical Rainforest: An Ecological Study.* Cambridge University Press, Cambridge.

RISWAN, S. 1982. *Ecological Studies on Primary, Secondary and Expermimentally Cleared Mixed Dipterocarp Forest and Kerangas Forest in East Kalimantan, Indonesia.* Ph.D. Thesis, University of Aberdeen.

RISWAN, S & KARTAWINATA, K. 1988. Regeneration after Distrubance in Kerangas (Heath) Forest East Kalimantan, Indonesia. :61–85. In S. SOEMODIHARDJO (Ed.). *Some Ecological Aspects of Tropical Forest of East Kalimantan: A Collection of Research Reports.* MAB Indonesia Contribution N. 48.

RISWAN, S and KARTAWINATA, K. 1989. Regeneration after Disturbance in Lowland Dipterocarp Forest in East Kalimantan, Indonesia. *Ekologi Indonesia* 1: 1–8.

RISWAN, S and KARTAWINATA, K. 1991. Species

Strategy in Early Stage of Secondary Succession Associated with Soil Properties Status in a Lowland Mixed Dipterocarp Forest and Kerangas Forest in East Kalimantan. *Tropics* 1: 13–34.

SADILI, A.; KARTAWINATA, K.; KARTONEGORO, A.; SOEDJITO, H. & SUMADIJAYA, A. 2009. Structure and Composition of Subalpine Summit Habitats on Mt. Gede Pangrango Complex, Cibodas Biosphere Reserve, West Java, Indonesia. *Reinwardtia* 12: 391–404.

SCHENCK, H. 1892–1893. Beitrage zur Biologie und Anatomie der Lianen. I. Beitrage zur Biologie der Lianen. Bot. Mitt. Trop. Hft. 4. II. Beitrage zur Anatomie de Lianen. Ibid. 5.

SCHMIDT, F.H. & FERGUSON, J.H. 1951.*Rainfall Types Based on Wet and Dry Period Ratios for Indonesia with Western New Guinea.* Verhandelingen Djawatan Meteorologi dan Geofisika. Djakarta 42.

SCHNITZER, S.A. 2005. A Mechanistic Explanation for Global Patterns of Liana Abundance and Distribution. *Amer. Nat.* 166: 262–276.

STEENIS, C.G.G. J. VAN, HAMZAH, A. & TOHA, M. 1972. *The Mountain Flora of Java.* Brill, Leiden.

STEENIS–KRUSEMAN, M. J. VAN. 1950. *Malaysian Plant Collectors and Collections Being a Cyclopedia of Botanical Exploration in Malaysia and a Guide to the Concerned Literature up to the Year 1950*. Noordhoff– Kolff., Djakarta.

SULISTYANI. 1995. Distribusi Paku–pakuan pada hutan lereng Selatan Gunung Slamet Baturden. KPH Banyumas Timur. *Biosfera* 4: 20–30.

SUSANA, R. 2002. Dari kaki Gunung Slamet Menembus Pasar Dunia. Kompas. Selasa 9 April 2002.

SVENNING, J. & CONDIT, R. 2008. Biodiversity in a Warmer World. *Science* 322: 206–207.

TREUB, M. 1883. Observations sur les plantes Grimpantes du Jardin Botanique de Buitenzorg. *Ann. Jard. Bot. Buitenz.* 3: 160–183.

WEBB, L.J. 1959. A Physiognomic Classification of Australian Rainforest. *J. of Ecol*. 47: 551–570.

WHITMORE, T.C. 1984. *Tropical Rainforests of the Far East*. Clarendon Press, Oxford.

WHITMORE, T.C. 1998. *An Introduction to Tropical Rainforests.* Clarendon Press, Oxford.

WIRIADINATA, H. 2004. *Pengumpulan Data Tumbuhan Pengunungan de Gunung Slamet, Jawa Tengah 13–19 Maret 2004*. Laporan Perjalanan Propinsi Jawa Tengah.

WRIGHT, S.J.; CALDERON, O.; HERNANDEZ, A. & PATON, S. 2004. Are Lianas Increasing in Importance in Tropical Forests? A 17 year Record from Panama. *Ecology* 85: 484–489.

APPENDIX 1.

A. Rainfall map of section of central Java, showing Mt. Slamet, Baturaden from an old undated map providing Mean Number of Rainy days during the driest four months of the year (Kloninklijk magnetsxh meterologisch observatorium te Batavia, gemiddeld aantal tegendagen gedurende de droogste vier maanden van het jaar). Arrow indicating Mt. Slamet and Baturden.

B. Rainfall Station Map of section of Central Java, Showing Baturaden, Mt. Slamet (Overzichtskaart van de ligging en namen der regenstation F Java & Madoera 1941). Arrow indicating station 12.

APPENDIX 2. Circumference of Individual Lianas on Mt. Slamet

Ridge# Plot #/ Species and Individual	**Circumference (cm)**	**Ridge# Plot #/ Species and Individual**	**Circumference (cm)**	**Ridge# Plot #/ Species and Individual**	**Circumference (cm)**	**Ridge# Plot #/ Species and Individual**	**Circumference (cm)**
Ridge 1		5	7.5				
Plot 1		6	5	Plot 11		Plot 15	
E. Pergamacea		7	6	*V. laurifolium*		*L. javanica*	
1	9	*E. latifolia*		1	13.5	1	8.5
2	9	1	4.5	2	17.5	2	10
3	9.5	2	6	3	5.5	3	8.5
4	9			*T. asiatica*			
5	10	Plot 8		1	10.5	Plot 16	
6	10	*V. Laurifolium*		2	7	*V. laurifolium*	
7	8	1	14.5	3	5.5	1	17
8	10.5	*S. lucida*		4	5	2	16.5
9	10	1	15	5	5		
10	9	*T. Asiatica*				Plot 17	
		1	10	Plot 12		*V. laurifolium*	
Plot 2				*V. laurifolium*		1	10.5
T. asiatica	4.5	Plot 9		1	20	2	5.5
1	5	*T. Asiatica*		2	12	3	12
2		1	14	3	8.5	4	15.5
		V. laurifolium		4	7.5	5	7.5
Plot 3		1	6.5	5	18.5	6	7.5
V. laurifolium	19	2	6	6	9.5	7	18.5
1	12	3	10				
2		4	6.5	Plot 13		Plot 18	
		5	11	*V. laurifolium*		*V. laurifolium*	
Plot 4		6	7	1	8	1	24
E. latifolia	9	7	6	2	7	2	10
1	7.5			3	6.5	3	12.5
2		Plot 10		4	21	4	16.5
		V. laurifolium		5	15.5	5	5.5
Plot 5		1	7	6	5.5	*L. javanica*	
S. lucida 1	15.5	2	7.5	7	5.5	1	11.5
		3	8	8	6	2	8
Plot 6		4	8.5	9	9.5	3	7
E. latifolia		5	7			4	8.5
1	10	6	7.2	Plot 14		5	5
2	6	7	7.2	*L. javanica*		6	5
3	7.5	8	8	1	7	7	5.5
4	10	*S. lucida*		2	5.5	8	4.5
5	9	1	5	3	8	9	5
6	8	2	6	4	4.5	10	4.5
Plot 7		3	6	5	10	11	5.5
V. laurifolium		4	6.5	6	6	12	5
1	10	5	7	7	9.5	13	4
2	10.5	6	6.5	*8*	8	14	10.5
3	9	7	8	*9*	9.5	15	4.5
4	8	8	9	*10*	6	16	7.5
		9	11			17	6
		10	12			18	5.5
						19	7
						20	7
						21	6.5
						22	8

Ridge# Plot #/ Species and Individual	**Circumference (cm)**	**Ridge# Plot #/ Species and Individual**	**Circumference (cm)**	**Ridge# Plot #/ Species and Individual**	**Circumference (cm)**
Plot 19		Plot 20		Plot 22	
V. laurifolium		*V. laurifolium*		*L. javanica*	
1	15.5	1	18	1	6.5
2	12			2	6.5
3	13	Plot 21		3	6
4	12	*V. laurifolium*		4	6
5	6.5	1	64	5	6
6	8.5			6	6.5
7	6				