RELATIONSHIP BETWEEN BIOMETRIC FACTOR OF THE HOST AND GIANT PIPER'S GROWTH (*Piper decumanum* L.) IN THE EDUCATION FOREST OF PAPUA UNIVERSITY, MANOKWARI

(Hubungan Antara Faktor Biometrik Dari Tanaman Inang dan Pertumbuhan Sirih Raksasa [Piper decumanum L.] di Hutan Pendidikan Universitas Papua, Manokwari)

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Abstract. The biometric factors of the host, soil properties, microclimate, and biologic components are influencing the growth of climber Piper species. However, ecological data is rarely available in scientific journals. This research aims to determine the relationship between host plant biometric factors and *P. decumanum* growth in the University of Papua Manokwari education forest. The data were acquired using the systematic line method, with the hypothetical plot and sampling tree as the center of the plot. The relationship between the host's biometric factor and the growth of *P. decumanum* is evaluated using partial correlation analysis. Stands with a large DBH, high density, and rough bark texture are preferred by *P. decumanum*. The number of individuals and the total height of *P. decumanum* increased with DBH, crown area, branch-free height, total height, crown height, skin texture, and affected shade area. The number of individuals was limited by total height, branch-free height, crown height, skin texture, and crown area. On the other hand, the shaded area prevented *P. decumanum* from growing taller. *P. decumanum* most probably requires a large vertical growing space to share with the same species and other climbing species, possibly requiring support to reach the maximum height of the forest canopy. The adhesive root's ability to cling is influenced by the roughness of the host bark, and a broad shade is required to control the microclimate factors.

Kata kunci: *Piper decumanum*, partial correlation, biometric factors, climbing plant, papua

Abstrak. *Faktor biometrik dari tanaman inang, sifat tanah, iklim mikro dan komponen biologi mempengaruhi pertumbuhan jenis Piper pemanjat. Namun, data ekologi sangat sedikit tersedia pada jurnal-jurnal ilmiah. Penelitian ini bertujuan untuk mengetahui hubungan antara faktor biometric tanaman inang dan pertumbuan jenis P. Decumanum pada Hutan Pendidikan Universitas Papua Manokwari. Data diperoleh dengan menggunakan metode line plot sampling dengan plot hipotesis sampling pohon sebagai pusat plot. Hubungan antara faktor biometric pohon inang dan pertumbuhan P. Decumanum dianalisis menggunakan korelasi parsial. Tegakan dengan diameter besar, kerapatan tinggi, dan tekstur kulit batang keras menjadi pilihan oleh P. Decumanum. Jumlah individu dan total tinggi dari P. Decumanum meningkat dengan nilai diameter, area tajuk, tinggi bebas cabang, tinggi total, tinggi tajuk, tekstur kulit, dan pengaruh area ternaungi. Jumlah individu dibatasi oleh tinggi total, tinggi bebas cabang, tinggi tajuk, tekstur kulit, dan area tajuk. Disisi lain, area ternaungi menjadi pilihan P. Decumanum dari pertumbuha lebih tinggi. P. decumanum kemungkinan besar* *membutuhkan ruang pertumbuhan vertikal untuk berbaji dengan jenis lain yang sama atau spesies liana pemanjat lain yang tidak sejenis yang memungkinkan membutuhkan dukungan untuk mencapai tinggi maksimum kanopi hutan. Kemampuan akan untuk menempel dipengaruhi oleh kekuatan dan kekauan akar tanaman inang, dan naungan yang luas diperlukan untuk mengontrol faktor iklim mikro.*

Keywords: *Piper decumanum, korelasi parsial, faktor biometrik, tumbuhan pemanjat, papua*

PENDAHULUAN

There are an estimated 1,700 species of climbing plants (vines and lianas) in at least 110 families, accounting for 25% of all woody plant species in the world (Gerrido-Perez and Gerold, 2009; Gunatilaka, 2006). The diversity of climbing plant species in New Guinea has not been well recorded. According to Gardner (2013), Sagisolo (2009), and some unpublished botanical records, more than 200 species exist.

The diversity of tropical plants is enhanced by the abundance of climbing plant species. Climbing plants are a physiognomy distinguishing tropical and temperate forests (Croat, 1978; Gentry, 1992), they are a part of a tree crown with a diameter of more than 10 cm (Montgomery and Sunguist, 1978; Putz, 1984). The forest floor contains about 18-22 percent of the youth of climbing plants (Putz, 1984; Putz and Money, 1992). Climbing plants are responsible for 32-36 percent of forest litter (Ogawa et al., 1965). Climbing plants provide a habitat for wildlife such as primates (Riduwan et al., 2019) and a source of food for herbivorous insects (Odell et al., 2019). However, climbing plants can also cause death for the trees they occupy (Ogawa et al., 1965; Putz et al., 1984), changing dynamics and natural regeneration in various biomes (Schnitzer and Bongers, 2002).

Some climbing plants, have essential components and are utilized as traditional medicines (Mikan and Runtuboi, 2019; Tiwari et al., 2018). Climbing plants such as *Nephrolepis* sp., *Ampelocissus* sp., *Calamus aruensis*, *Uvaria grandiflora*, *Diplocyclos palmatus*, *Passiflora* sp., and *Calamus* spp., are used as food, and *Memecylon* sp., *Vitis* sp., *Flagellaria indic*a, are used as tools, and building materials (Waropen Forest Service 2008, 2009).

There are at least 16 species of climbing pipers in New Guinea, with 8 variations of *Piper macropaper* that have been documented and clarified its botanical status (Gardner, 2013; Lisner et al., 2019), while there are at least 8 species in Indonesia New Guinea. The pepper family has a long history as a medicinal plant. *Piper betel* leaves, for example, have been used to lessen the symptoms of bug bites, diminish blood odor, and dry wounds after childbirth. The Manobo tribe of Bayugan, Philippines use *P. Documentum* to treat arthritis, muscle pain, cancer, cysts, diarrhea, poisoning, skin infections, tuberculosis, snake and insect bites, tumors, ulcers, and wounds (Dapar et al., 2020).

Piper decumanum, on the other hand, is not well recognized in Indonesian New Guinea due to its lack of publicity. This species can be found throughout Asia, including New Guinea, China's Tropical Mainland Philippines, India, and Thailand (Dapar et al., 2020; Lisner et al., 2019). This piper is large, with broad leaves and orange-colored ripe fruit, making it an attractive shade plant in the home or office yard.

Climbing plants' growth is influenced by biotic and abiotic variables in their environment. Climbing plant diversity decreases as habitat elevation rises, whereas diversity increases in lowland forests (Schnitzer and Bongers, 2002; Lisner, 2019). Light also encourages diversity of climbing plants, especially in the crevices of tree crowns (Putz, 1984; Lisner et al., 2019). About half of all tropical forest trees serve as hosts for climbing plants (Gerrido-Perez and Gerold, 2009). The roughness of the bark and DBH of the host tree and the tree's abundance play a role in determining the distribution and abundance of climbing plants (Leicht-Young et al., 2010; Mori et al., 2016). Climbing plants use mechanical organs such as tendrils, adhesive roots, and spines to reach the host tree's highest position or spread among the trees. On the other hand, is every mechanical organ compatible with the host's characteristics? There isn't much information available right now. This is because climbing plants are underappreciated as a research issue in plant ecology, despite their importance in tropical forest dynamics (Cai, 2007; Asrianny dan Oka, 2008, Schnitzer and Bongers, 2002).

Climbing piper's ecological record in New Guinea during the last decade has been extremely sparse. Lisner et al. (2019) investigated the presence of eight species of climbing pipers in relationship to habitat characteristics such as the vegetation structure of lowland forests in Papua New Guinea, the nature of the host tree trunk, the height of the location, confection, and marbles. Gardner (2013) discusses eight species of climbing pipers that have reached the end of their taxonomic classification. There are approximately 6 species of *Piper beetle*, *P. caninum*, *P. decumanum*, and *P. majusculum* in the University of Papua's educative forest, however, no information on their growth is available yet. The topic of active component composition dominates the climbing piper study in New Guinea (Dapar et al., 2020), while others are undertaken outside of New Guinea (Kuete et al., 2013; Dauodi et al., 2013; Pathak and Kumar, 2019).

This research is different from the previous study in terms of techniques, particularly the utilization of varying textures of host plants and the lack of climbing piper studies in Indonesia New Guinea. The purpose of this study is to estimate the relationship between the biometric factor of the host plant and the growth of *Piper decumanum* L. in the educative forest of Papua University Manokwari.

MATERIALS AND METHODS

Study Area

In August 2021, data was collected in a natural forest covering 100 hectares. The University of Papua's educational forest (134'04 BT and 0'57" LS) is located east of the Manokwari coastline, between the villages of Aipiri and Anggori. The average daily temperature is 27.20^{o} C, the average air humidity is 83.2%, and the average rainfall is 181.63 mm. The soil is sand-textured, with limestone deposit parent rocks, a yellow-red podsolic soil type, and limestone rocks dominating the shallow soil surface. *Intsia* spp., *Pometia* spp., *Spathiostemon javensis*, *Lepiniopsis ternatensis*, *Horsfieldia* spp., *Mallotus* spp., *Pimelodendron amboinicum*, *Palaquium amboinense*, *Caryota rumphiana*, and *Areca* sp. are the most common plant species.

GPS, phi-band, haga hypsometer, tally sheet, and stationery were among the tools utilized. The host plant species and *Piper decumanum* are the subjects of this study.

Quantitative descriptive approaches are combined with field survey techniques in this study. Data is collected using a systematic line technique with a hypothetical plot and sample tree as the plot center (Sirami et al., 2019).

The research's variable is plant height and individual numbers are used to evaluate the growth of *Piper decumanum*. Botanical names, DBH, branch-free height, total height, crown area, crown height, skin texture character, and shade of surrounding vegetation are all variable biometric factors of host plants.

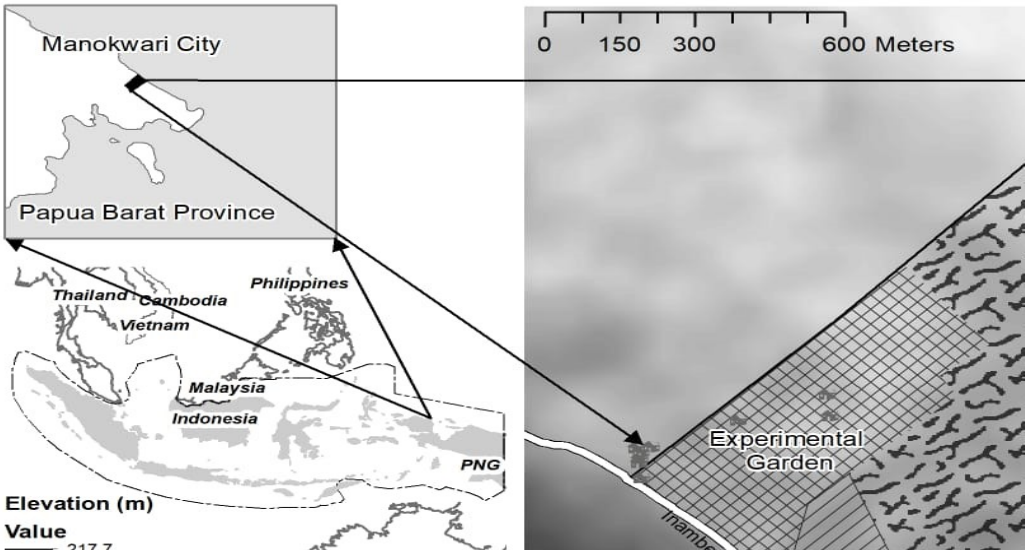

Figure 1. Research location: natural forest

Research Procedures

The edge boundary of the eastern educative forest is used as the baseline, then made a survey line perpendicular to the baseline to the west. The length of the line is adjusted to the shape of the forest edge, and the distance between the line is 100 m. Observations were made 10 m to the left and right of the line. Each discovery of *P. decumanum* and the host plant made an observation plot covering an area of 400 m^2 by placing the host tree at the center of the plot. The measurement of the crown area header is carried out twice, the first indentation on the projection of the diameter of the crown above the longest ground level and the second which is the measurement of the shortest crown projection. The texture of the trunk skin is not frangible, not scaly, and not malleable is categorized as finely given a score of 1; a slightly rough is given a score of 2 when the skin is cell-flexed, and; rough is given a score of 3 when the skin is cracked and scaly. Data are grouped according to the properties and function of variables and are then analyzed using a partial correlation approach.

Data Analysis

The area of the host crown is calculated by the crown diameter. Habitat preferences are identified by calculating individual percentages per host species that is used as a *P. decumanum* host. The relationship between the biometric factors of the host plant and the growth of *P. decumanum* was partially analyzed with the correlation of Product Moment. The dependent variable (y) is the number of individuals and height of *P. decumanum* and the independent variable (x) is a crown area, crown height, shade area, DBH, total height, branch-free height, and stem skin texture. H0: There is no positive significant relationship between the biometric factors of the host plant and the growth of *P. decumanum*; Ha: There is a positive significant relationship between the biometric factors of the host plant and the growth of *P. decumanum*. H0: $\rho = 0$, Ha $\neq 0$, $\alpha = 0,05$, confidence level 95%.

Product moment correlation:

$$r_{xy} = \frac{\sum xy}{\sqrt{x^2 y^2}}$$

t-Test:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where r_{xy}: the correlation between *x* and y, y: the biometric factors of the host plant, *x*: growth of *P. decumanum*, and n: number of samples.

RESULTS AND DISCUSSIONS

We identified 76 tree stands and herbs from 19 species, 19 genera, and 15 families as hosts for 86 individuals of *P. decumanum*, both juvenile and adult. *Meliaceae*, *Moraceae*, and *Myristica* each have two species, while the other family has only one species. Two species have rough trunk skin, four species have slightly rough skin, and thirteen species have a fine texture. Geologic variables, changes in adaption patterns to habitat circumstances, and the effects of plant interactions probably influence variations in species diversity, host structure, and growth parameters of *P. decumanum* (Table 1).

The soil parent material has a significant impact on the availability of critical nutrients such as organic nitrogen (Zhong et al., 2019). In the research site, the soil parent material is limestone sedimentary rock, resulting from the process of lifting the ocean floor around 60-15 million years ago by the endogenic power, which contributes to the formation of sandy soil texture. The fact that there are three distinct sections with extremely different physical features of the soil surface at the research site, namely sand soil, soil with coral, and soil without corals. *P. decumanum* and the host may share the same preference for the composition of the soil because of the parent rock's role, allowing them to grow in the same habitat, which is close to the coast (less than 1 kilometer). Plant roots and soil bacteria benefit from the sand texture in the air and water cycle.

Evolutionary differences in adaptation patterns to habitat elements are influenced by past species interactions, resulting in the generations that are resistant to environmental stress (Straus and Erwin, 2004). Because the habitat of *P. decumanum* is in coastal forests, it's probably that the host plant is resistant to salt vapor and trade winds.

Plant interactions have facilitative, competitive, and exploitative consequences, resulting in environmental changes that affect individual fitness, survival, and reproduction (Balandier et al., 2006). Plant interactions in a community encourage the formation of certain distribution patterns, the retention of the diversity of species, the control of physical size and population density according to the carrying capacity of the growing space, as well as their impact on microclimate control and soil protection.

Table 1. Host plant and *P. decumanum* physical characteristics

Variables	Min.	Max.	Mean±Ds	Var.
DBH (cm)	2	120	8.09±49.9	438.528
Brach-free height (m)	1	22	2.66±16.40	47.23
Total height (m)	1.5	26	4.91±22.27	74.80
Crown area (m^2)	0.0314	28.26	0.16±20.24	100.76
Shade area (%)	60	95	77.37±87.23	24.29
Crown height (m)	0.10	14	1.13±6.98	8.56
Number of Indiv. *P. decumanum*	1	3	0.75±1.51	0.142
P. decumanum height (m)	0.6	11	1.82±7.12	7.040

Relationship of Host Biometric Factors and Growth of *P. decumanum* L.

P. decumanum has a low preference (1.32%) for the hosts *Alstonia scholaris*, *Dysoxylum octandrum*, *Ficus* sp., *Horsfiledia globularia*, *Inocarpus fagifer*, *Kleinhovia hospita*, *Myristica fatua*, *Pandanus* sp., *Premna corymbosa*, *Zysygium* sp., *Terminalia canaliculata*. The preference is moderate in *Lepiniopsis ternatensi* (2.63%) and *Artocarpus alitilis* (3.95%), whereas *Calophyllum inophyllum* (5.26%), *Medusanthera laxiflora* and *Aglaia odorata* have a high preference (6.58%). *P. decumanum* has a very high preference for *Palaquium amboinense* (23.68%) and *Koordersiodendron pinnatum* (53.35%).

The density of plant, size, and bark texture rough are all characteristics of species with a high degree of preference. This contradicts Lisner et al. (2019) finding that piper species avoid high-density host trees. Habitat preferences can be several and are the consequence of habitat selection to maintain a species' genetic variety, as well as to alter a species' biological needs, such as fecundity levels (Rausher, 1984).

The number of individuals and the height of *P. decumanum* is affected by DBH, branch-free height, total height, and crown height (Table 2). Our findings are proven to be similar to the growth of *P. decumanum* in Papua New Guinea's lowland prime forest (Lisner et al., 2019) and to the habit of growing climbing plants in general (Lisner et al., 2019; Leicht-Young et al., 2010; Putz and Mooney, 1992). While, the positive influence of texture roughness on *P. decumanum* height is consistent with previous studies, climbing plants avoid trees with smooth bark textures because they are unsuitable for climbing plant structures (Putz, 1984; Putz, 1980; Muoghalu and Okeesan, 2005). However, the shade provided by surrounding vegetation increases the number of individuals while inhibiting the vertical growth of *P. decumanum*. Total height, branch-free height, crown height, crown area, and texture of host plant bark are all characteristics that limit the number of individual *P. decumanum* plants

Table 2. Correlation of host biometric factors and growth of *P. decumanum*

Variable Correlation	r	r^2	t
Total height >< ∑ *P. decumanum*	-0.069	0.48	-0.598
Brach-free height >< ∑ *P. decumanum*	-0.046	0.21	-0.399
Crown heigh >< ∑ *P. decumanum*	-0.096	0.92	-0.830
DBH >< ∑ *P. decumanum*	0.062	0.40	0.534
Bark texture >< ∑ *P. decumanum*	-0.136	1.84	-1.179
Crown area >< ∑ *P. decumanum*	-0.052	0.27	-0.451
Shade area >< ∑ *P. decumanum*	0.122	1.48	1.054
Branch-free height >< Heigh of *P. decumanum*	0.560	31.41	5.821*
Total height >< Height of *P. decumanum*	0.572	32.74	6.002*
Crown height >< Height of *P. decumanum*	0.375	14.08	3.482*
DBH >< Height of *P. decumanum*	0.501	25.10	5.756*
Bark texture >< Height of *P. decumanum*	0.300	8.99	2.703*
Shade area >< Height of *P. decumanum*	-0.220	4.86	-1.944
Crown area >< Height of *P. decumanum*	0.522	27.26	5.266*

t_{table}=1,993, *=significant

Climbing plants with adhesive roots lack grabbing organs, they prefer the bark of specific plant species and do not grow on all large-diameter trees (Fig. 2); this is related to their passive climbing abilities (Lisner et al., 2019; Putz and Mooney, 1992). The increased number and height of *P. decumanum* due to the rougher the host's bark, larger the DBH, and the high height possibly reflect the effectiveness of the use of adhesive roots. Furthermore, because *P. decumanum* stature probably requires considerable growing space, there is enough vertical growth space to be divided by a maximum of two individuals. The requirement for growing space may also have something to do with the host plant's ability to handle the weight of *P. decumanum*, which is why this species prefers a large DBH host plant. While the shaded area serves in sustaining the microclimate's optimal conditions.

Because DBH and tree crown area are positively correlated (r = 0.755), *P. decumanum* probably obtains another benefit by attaching adhesive roots to plants with large DBH, namely the availability of a microclimate controlled directly by the crown. The volume of the crown, which regulates the microclimate for the growth of this Piper species, is reflected in the height and area of the crown. According to Lisner et al. (2019), the occupancy rate of eight species of piper climbers increased in correlation with the tree DBH.

P. decumanum is a hemiepiphytic climber that uses adhesive roots to climb (Sperotto et al., 2020). Climbing plants with adhesive roots move less vertically (Putz and Holbrook, 1991; Sperotto et al., 2020), allowing them to take advantage of the host's height. However, even if it is slow and low, there is still vertical growth. Adhesive root climber is mostly found in areas with a lot of annual rainfall and short dry seasons (Durigon et al., 2013; Sperotto et al., 2020). As a result, a relatively closed forest shade area is probably better ideal for habitation than an open area since it is more humid. *P. decumanum* was mostly missing from secondary habitats and open areas at the research site. This habitat selection by this species is distinct from the climbing plant group as a whole, which has seen an increase in population in degraded forests and open areas.

Growth constraints caused by host plants are probably a mechanism for maintaining resource usage balance for all climbing plant species that share the same host as *P. decumanum*, however, are not included in our model. Several species of climbing plants and epiphytes are frequently found on one host plant stand with *P. decumanum*, therefore sharing growth space and other resources. As a result, *P. decumanum* possibly reduces its numbers as a strategy of surviving while maintaining its vertical growth. Through competition, two species with overlapping niches can grow together and share resources. Competition can occur if species in the same niche are too close together due to similar resource use patterns, another condition is that resources must be shared among various species and resources must be limited. Thus, growth restrictions in *P. decumanum* are not always caused by biometric factors of the host, however, probably be influenced by other ecological factors.

The model we presented is not yet reliable enough to explain the growth of *P. decumanum.* Skin thickness, active ingredients in the skin, ease of peeling, the water content in the skin, crown volume, physical and chemical properties of soil, microclimate, and other species of climbers in the same host as this species must all be considered to get a more in-depth explanation of the ecology of the growth of *P. decumanum*.

CONCLUSION

DBH, tree height, crown volume, the texture of host plant bark, and vegetation shade area all influence *P. decumanum* growth. When these factors experience an increase in dimension size, *P. decumanum* will be able to increase the number of individuals and their total height; however, when these factors experience a decrease, *P. decumanum* will be unable to increase its population number or vertical growth. Total height, branch-free height, crown height, crown area, and the texture of the host plant skin are all characteristics that limit the number of individual *P. decumanum*.

REFERENCES

Asrianny., dan Oka, N.P. (2008). Keragaman dan kepadatan jenis liana di hutan alam dalam kawasan hutan pendidikan Universita Hassanudin. *Jurnal Parenial*, 5(1), 23-30.

Balandier, P., Collet, C., Miller, J.H., Reynolds, P.E., and Zedaker, S.M. (2006). Designing forest vegetation management strategies based on the mechanisms and dynamics of crop tree competition by neighboring vegetation. *Forestry, 79(1), 3-27.*

Cai, Z.Q. (2007). *Lianas and trees in tropical forests in South China*. [Thesis]. Department of Environmental Sciences, Wageningen University, Wageningen.

Croat, T.B. (1978). *Flora of Barro Colorado Island*. Stanford University Press, Stanford, Ca.

Daoudi, A.E.l., Aeh, Y., Bagrel, D., and Aarab, L. (2013). In vitro anticancer activity of some plants used in Moroccan traditional medicine. *Journal of Medicinal Plants Research*, 7, 1182-1189.

Dapar, M.L.G., Demayo, C.G., Meve, U., Liede-Schumann, S., and Alejandro, G.J.D. (2020). Molecular confirmation, constituents and cytotoxicity evaluation of two medicinal Piper species used by the Manobo tribe of Agusan del Sur, Philippines. *Phytochemistry Letters*, 36, 24-31.

Dapar, M.L.G., Meve, U., Liede-Schumann, S., Alejandro, G.J.D. (2020). Ethnomedicinal appraisal and conservation status of medicinal plants among the Manobo tribe of Bayugan City, Philippines. *Biodiversitas*, 21(8), 3842-3855.

Waropen Forest Service. (2008). *Survei potensi hasil hutan kayu dan bukan kayu di Distrik Masirei dan Fafado Kabupaten Waropen*. Laporan Penelitian: Dinas Kehutanan Waropen, Provinsi Papua dan Fakultas Kehutanan Universitas Papua Manokwari.

Waropen Forest Service. (2009). *Survei potensi hasil hutan kayu dan bukan kayu di Distrik Waropen Bawah dan Demba Kabupaten Waropen*. Laporan Penelitian: Dinas Kehutanan Waropen, Provinsi Papua dan Fakultas Kehutanan Universitas Papua Manokwari.

Durigon, J., Duran, S.M., and Gianoli, E. (2013). Global distribution of root climbers is positively associated with precipitation and negatively associated with seasonality. *Journal of Tropical Ecology*, 29, 357-360.

Gardner, R.O. (2013). Piper (*Piperaceae*) in New Guinea: the climbing species. *Blumea*, 57, 275-294. http://dx.doi.org/10.3767/000651913X665053.

Garrido-Perez, E., and Gerold, G. (2009). Land-use history and the origins and effects of lianas on tree communities. *Erdkunde*, 63(3), 211-227.

Gentry, A.H. (1992). *The distribution and evolution of climbing plants*. *In* Putz F.E and Mooney A.H. (Eds) *The Biology of Vine*. Cambridge University Press.

Gunatilaka, L. (2006). Natural products from plant-associated microorganisms: distribution, structural diversity, bioactivity and implications of their occurrence. *J.Nat. Prod*, 69, 509-526.

Kuete, V., Sandjo, L.P., Wiench, B., and Efferth, T. (2013). Cytotoxicity and modes of action of four Cameroonian dietary spices ethno-medically used to treat Cancers: *Echinops giganteus*, *Xylopia aethiopica*, *Imperata cylindrica,* and *Piper capense*. *Journal of Ethnopharmacology*, 149, 245-253.

Leicht-Young, S.A., Pavlovic, N.B., Frohnapple, K.J., and Grundel, R. (2010). Liana habitat and host preferences in northern temperate forests. *Forest Ecology and Management*, 260, 1467-1477.

Lisner, A., Kaina, G., Sisol, M., Fibich, P., Novotny, V., Weiblen, G.D., and Leps, J. (2019). Determinants of *Piper* (Piperaceae) climber composition in a lowland tropical rainforest in New Guinea. *Folia Geobotanica*, 54(3), 227-238, https://doi.org/10.1007/s12224-018-9334-3.

Mikan, M., dan Runtuboy, Y. (2019). Pemanfaatan jenis tumbuhan sebagai obat tradisional berbasis *ethnomedical knowledge* pada masyarakat suku Mandobo. Jurnal Kehutanan Papuasia, 5(1), 49–55.

Montgomery, G., and Sunquist, M. (1978). *Habitat selection and use by two-toed and three-toed sloths*. In The Ecology of Arboreal Folivores, ed. G. Montgomery. Smithsonian Institution Press, Washington, DC.

Mori, H., Kamijo, T., and Masaki, T. (2016). Liana distribution and community structure in an old-growth temperate forest: the relative importance of past disturbances, host trees, and microsite characteristics. *Plant Ecology*, 217, 1171-1182.

Muoghalu, J.I., and Okeesan, O.O. (2005). Climber species composition, abundance, and relationship with trees in a Nigerian secondary forest. *Afr J Ecol*, 43, 258-26.

Odell, E.H., Stork, N.E., and Kitching, R.L. (2019). Lianas as a food resource for herbivorous insects: a comparison with trees. *Biological Reviews*, 94(4), 1416-1429. DOI: 10.1111/brv.12508.

Ogawa, H., Yoda, K., Ogino, K., and Kira, T. (1965). Comparative ecological studies on three main types of forest vegetation in Thailand. II. Plant biomass. *Nature and Life in South-East Asia*, 4, 49-80.

Pathak, N., and Kumar, R. (2019). *Piper attenuatum* Buch.-Ham. ex Miq. - A review on its macroscopic characters, phytochemistry, medicinal importance, and its comparative study with other Piper species. *Curr Med Drug Res*, 3(2), 1-10.

Putz, F.E., and Holbrook, N.M. (1991). *Biomechanical studies of vines*. In: F. E. Putz & H. A. Mooney (eds.), *The Biology of Vines*. Cambridge University Press, Cambridge.

Putz, F.E., and Mooney, A.H. (1992). *The biology of vines*. Cambridge University Press.

Putz, F.E. (1980). Lianas versus trees. *Biotropica*, 12, 224-225.

Putz, F.E. (1984). How trees avoid and shed lianas. *Biotropica*, 16, 19-23.

Putz, F.E. (1984). The natural history of lianas on Barro Colorado Island, Panama. *Ecology*, 65(6), 1713-1724.

Rausher, M.D. (1984). The evolution of habitat preference in subdivided populations. *Evolution*, 38(3), 596-608.

Riduwan, Prayogo, H., dan Sisillia, L. (2019). Studi keanekaragaman jenis tumbuhan liana sebagai sumber pakan primata di stasiun penelitian cabang panti taman nasional Gunung Palung. *Jurnal Hutan Lestari*, 7(1), 296-304.

Sagisolo, M.R. (2009). *Keanekaragaman jenis liana dan pemanfaatannya oleh masyarkat Kampung Inoduas Distrik Manokwari Utara*. [Karya Ilmiah]. Program Studi D III Konservasi Sumberdaya Hutan Fakultas Kehutanan Universitas Papua, Manokwari.

Schnitzer, S.A., and Bongers, F. (2002). The ecology of lianas and their role in forests. *Trends In Ecology & Evolution*, 17(5), 223-230.

Sperotto, P., Acevedo-Rodríguez, P., Vasconcelos, T.N., and Roque, N. (2020).

Towards a standardization of terminology of the climbing habit in plants. *The Botanical Review*, 86(3), 180-210.

Strauss, S.Y., and Irwin, R.E. (2004). Ecological and evolutionary consequences of multispecies plant-animal interactions. *Annu. Rev. Ecol. Evol. Systi*, 35, 435-466.

Tiwari, P., Nayak, P., Prusty, S.K., and Sahu, P.K. (2018). Phytochemistry and pharmacology of *Tinospora cordifolia*: A Review. *Sys Rev Pharm*, 9(1), 70-78.

Zhong, Q., Zhang, S., Chen, H, Li T., Zhang, C., Xu, X., Mao, Z., Gong, G., Deng, O., Deng, L., Zhang, Y., Pu, Y., and Wang, L. (2019). The influence of climate, topography, parent material and vegetation on soil nitrogen fractions. *Catena*, 175, 329-338.