

HIMALAYAN WOODBINE *PARTHENOCISSUS HIMALAYANA* (ROYLE) PLANCHON (FAMILY VITACEAE) – AN ECOLOGICALLY UNDERRATED WOODY LIANA IN THE MONTANE MOIST CONIFEROUS FOREST IN SHIMLA CITY (HIMACHAL PRADESH, INDIA)

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ABSTRACT

Changes in abiotic factors like light, temperature, humidity and soil moisture cause rapid proliferation of lianas in fragmented forests in urban areas. Controlling the abundance of lianas through manual removal has to be regulated as the fruits of lianas are an important food source in temperate forests. Photo-documentation of frugivory on *P. himalayana* through direct observation highlights the importance of this liana species for birds and mammals.

Keywords: Temperate, Liana, Fragmentation, Frugivory, Urban forests, Urban Planning

INTRODUCTION

Climbing plants are a substantial component of the plant community in a forest. Climbers can be divided into three categories - herbaceous vines, woody shrubs and woody vines (lianas) (Kokou *et al.*, 2002). Herbaceous vines climb to a few feet, and are not able to reach the canopy of the host tree. Woody shrubs climb without tendrils or adventitious

roots, using fissures in the bark of host trees. Lianas are mostly woody, tall (up to 30 m) and may reach up to the canopy of host trees (Jongkind & Hawthorne, 2005).

Climbers play a significant ecological role in carbon sequestration and controlling soil erosion (Klinge & Rodriguez, 1973; Putz, 1983). Lianas help maintain the micro-climate in a forest. Liana species diversity provides niches and contact amongst trees, which allows arboreal animals to travel among the tree tops. Climber species contribute to the diet of numerous animals (Sarvalingam *et al.*, 2015).

Lianas are a functional group characterized by great morphological and anatomical plasticity, which enables them to adapt to a wide range of conditions (Rowe & Speck, 2005). Most lianas are not physiologically well adapted to cold climates (as the structure of their vascular system increases the risk of freezing-induced xylem embolism (Ewers *et al.*, 1991; Schnitzer, 2005)). To reduce this mortality risk, several temperate lianas in the genera *Vitis*, *Parthenocissus* and *Toxicodendron* display early bud set and leaf senescence, which result in a shorter active growth season compared to other woody species of the same climate (Stiles, 1982). Several

liana species can spread horizontally, growing among herbaceous forest-floor communities, and remain self-supporting until conditions change (e.g., increased light and support availability) (Selaya & Anten, 2008).

Very few studies have been done on climbers in India. In tropical forests, 25% of woody plants diversity is contributed by lianas (Schnitzer & Carson, 2001), and yet they are unnoticed in many forest records and in forest ecological practices (Phillips *et al.*, 2005). The low attention to lianas is possibly due to general absence of taxonomic studies. [Polunin & Stainton (1984) mention Vitaceae species are 'difficult to distinguish in the field'. A new phylogenetic classification of Vitaceae has been published in 2018 (Wen *et al.*, 2018)]. Moreover, climbers are weeded out in silviculturally managed forests; therefore, they are a threatened group of plants, and need to be documented. (Rahman *et al.*, 2020).

Forest fragmentation reduces species richness, and in more isolated fragments, affects the movement of animals. Fragmentation impacts ecological functions such as seed dispersal, and decreases ecosystem services such as carbon sequestration, pollination and nutrient cycling (FAO & UNEP, 2020). Several studies (Schnitzer & Carson, 2001; Londré & Schnitzer, 2006; Ladwig & Meiners, 2010a).show that lianas proliferate rapidly in fragmented and disturbed forests. Forest fragmentation causes the tree canopy to open up, which increases light-availability and raises ambient temperature. These are probably the main reasons for the increasing abundance of lianas in disturbed ecosystems worldwide (Schnitzer & Bongers, 2011). In secondary tropical and temperate forests, lianas are typically more abundant than in primary forests and can be a natural part of succession, increasing

over 30–70 years post disturbance, before declining (Capers *et al.*, 2005; Letcher & Chazdon, 2009; Ladwig & Meiners, 2010; Letcher, 2015). In secondary forests, data from Amazonia and Panama show that liana biomass can increase (from 5-10% (Schnitzer & Bongers, 2011; Van der Heijden *et al.*, 2013)) to 30% of total woody biomass (Gerwing & Farias, 2000). In extreme cases, lianas may even dominate the woody vegetation following temperate forest disturbance (Fike & Niering, 1999; Royo & Carson, 2006).

Habitat fragmentation in urban landscapes is characterized by small remnants of vegetation patches insulated from each other by an anthropized matrix. Concentration of impervious surfaces creates urban heat islands (UHI). UHI can induce thermal and hydric stress and phenological changes in sensitive species (Godefroid & Koedam, 2007; Grimm *et al.*, 2008; White *et al.*, 2002; Zhang *et al.*, 2004). A study (Bergeron & Pellerin 2014) found that the richness of indigenous pteridophytes was lower in urban forests affected by UHI, likely because UHI cause soil dryness. Lianas are not physiologically drought-resistant species (van der Sande *et al.*, 2013). However, they usually have a deep and extensive root system that enables them to get water from deeper sources of ground water, which could give them an advantage in dry conditions (e.g., Jackson *et al.*, 1995; Schnitzer, 2005). The relatively high temperatures and low humidity in disturbed forest habitats (edges, gaps, young forests) (Murcia, 1995; Collinge, 1996) result in elevated evapo-transpiration, giving lianas a competitive advantage. In a study (Brice *et al.*, 2014) conducted in the forests of the metropolitan Montréal area (Quebec, Canada) on six liana species, it was found that lianas benefited from urbanization. Lianas were more abundant in disturbed forests and in edge habitats than in less

disturbed forest and core habitats (Brice *et al.*, 2014). In another study conducted in Queensland, Australia in five forest fragments (23–58 ha in area) and five nearby intact-forest sites, fragmented forests had a significant increase in liana abundance (Campbell *et al.*, 2018).

Urban forests are important habitats for native biodiversity. The urban forests in Shimla are fragmented patches of various sizes, separated by urban roads and/or built spaces. So far, ten species of climbers have been recorded in the city forests and open meadows which are reported in the present paper [Table 1]. Three of these climbers are woody lianas (*Parthenocissus*, *Hedera* and *Pergularia*) that reach up to the canopy of deodar trees (*Cedrus deodara*). Extensive colonisation of deodar host trees by lianas

(mainly *Parthenocissus himalayana* (Vitaceae) and *Hedera nepalensis* (Araliaceae)) was observed in one such forest patch in Kasumpti locality of the city.

Public messages and campaigns are conducted from time to time to weed out vines from urban forests in Shimla, and from elsewhere in the state. These campaigns do not mention which species of woody liana needs to be weeded out. Also, the reason for proliferation of native lianas in city forest patches – i.e. fragmentation – is not addressed in these campaigns (Himachal Watcher (2016, 2020), Tribune News Service (2023)).

Table 1. Climbers observed in the urban forests of Shimla.

Species	Family	Habit
1. <i>Hedera nepalensis</i>	Araliaceae	Liana
2. <i>Parthenocissus himalayana</i>	Vitaceae	Liana
3. <i>Pergulariaroylei</i>	Apocynaceae	Liana
4. <i>Clematis buchananiana</i>	Ranunculaceae	Woody shrub
5. <i>Clematis connata</i>	Ranunculaceae	Woody shrub
6. <i>Rosa brunonii</i>	Rosaceae	Woody shrub
7. <i>Trichosanthes</i> sp.	Cucurbitaceae	Herbaceous climber
8. <i>Rubia cordifolia</i>	Rubiaceae	Herbaceous climber
9. <i>Dioscorea</i> sp.	Dioscoreaceae	Herbaceous climber
10. <i>Ipomoea purpurea</i>	Convolvulaceae	Herbaceous climber

METHODS

Study Area

The photo documentation of feeders on *Parthenocissus himalayana* berries was conducted in September 2023 through direct observation at Kasumpti locality (31.07°N, 77.18°E) (1960 m), in Shimla city (c.1,800– 2,500 m), Himachal Pradesh, India situated in the Western Himalayas amid the Himalayan Moist Temperate Forest type (forest classification according to Champion and Seth, 1968). The author photographed the species from her apartment balcony overlooking the Kasumpti forest. The species feeding on the fruiting liana were photographed with a digital camera from time to time, as they appeared on the liana-draped deodar trees. The author has surveyed the forest patches in the city for flora and fauna for more than a decade.

Documented Liana Species

The plant species *Parthenocissus himalayana* (Royle) Planchon (Family

Vitaceae) is a large woody climber. It is distributed from Pakistan to Sikkim, S.W. China and Burma in coniferous forests at 1800-3300 m. *P. himalayana* flowers April-May, and sets fruit from August to September. Leaves trifoliate with three ovate long-pointed, sharply toothed, stalked leaflets, which are shining dark green above and pale beneath, lateral leaflets asymmetrical. Flowers yellow-green, in spreading flat-topped clusters. Petals c. 5mm, petals and stamens 4-5. Leaflets mostly 10 cm, bristly-haired on the veins beneath, Tendrils branched. Berry black, c. 8 mm, ripen in September (Polunin & Stainton, 1984).

RESULTS

The fruits of *P. himalayana* were seen to be consumed by seven avian species and two mammalian species. The bird species included resident species, local migrants and long-distance migrants. [Table 2, Figure 1]. (Two of the species photographs were taken earlier from the same location in 2014 and 2016).

Table 2. Species observed feeding on the berries of *P. himalayana* in Kasumpti locality.

Species	Scientific name	Status	Feeding Guild
Birds			
1. Slaty-headed Parakeet	<i>Psittacula himalayana</i>	Resident	Frugivore
2. Great Barbet	<i>Psilopogon virens</i>	Resident	Frugivore
3. Wedge-tailed Green Pigeon	<i>Treron sphenurus</i>	Summer migrant	Frugivore
4. Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	Resident	Insectivore
5. Black Bulbul	<i>Hypsipetes</i>	Local migrant	Omnivore

	<i>leucocephalus</i>		
6. Brown-fronted Pied Woodpecker	<i>Dendrocopos auriceps</i>	Resident	Insectivore
7. Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	Resident	Omnivore
Mammals			
8. Himalayan Langur	<i>Semnopithecus schistaceus</i>	Resident	Herbivore
9. Rhesus Macaque	<i>Macaca mulatta</i>	Resident	Herbivore

DISCUSSION

Frugivore assemblages

Frugivorous birds have been much less frequently studied compared to other feeding guilds. Studies suggest that frugivory may be more common than expected in non-tropical habitats (e.g. Herrera & Jordanao, 1981; Herrera, 1984). A species is classified as a 'frugivore' if >50 percent of its diet comprises of fruits. Studies on frugivory use direct observations, fruit-fall traps and camera traps. Camera traps enable observation of animals that are highly sensitive to human presence, and of nocturnal animals (Tongkok *et al.* 2020). Mammals, birds, reptiles and insects are consumers and dispersers of seeds of fleshy fruits in temperate forest ecosystems (Willson, 1991; Koike & Masaki, 2019; Tongkok *et al.* 2020).

Jayasekara *et al.* (2007) in the tropical rainforests of Sri Lanka used automatic cameras to monitor frugivore visits at 15 species of fruiting trees (including a woody vine), recording visits to piles of fruits placed in the arboreal and on the terrestrial layers. They recorded 23 animal

species at the fruiting trees, out of which seven were bird species (Not all the known local frugivore bird species were, however, captured by the automatic camera). The study found that frugivore assemblages differed between arboreal and terrestrial layers, and between diurnal and nocturnal periods. Birds were the dominant component of the diurnal assemblage and mammals dominated the nocturnal assemblage.

It is likely that several more of the bird species from Kasumpti locality, including residents and summer migrants, consume berries of *P. himalayana* (for a list of bird species in Kasumpti, see Chauhan & Jolli, 2022). Eight other species of mammals previously recorded by the author in Kasumpti forest (one species each of deer, mongoose, marten, weasel, gliding squirrel, jackal, bat, and rodent) may also be consumers of the berries.

Seasonality of fruiting

Spatiotemporal patterns of fruit availability in forests have been studied (e. g. Fogden, 1972; Karr, 1976) local fluctuations being more evident with increasing latitude. In temperate forests,

fruit bearing plants are mostly concentrated in clearings and forest-edges (e.g. Auclair & Cottam, 1971; Herrera, 1984), and fruit production is concentrated during autumn and winter. In seasonal tropical forests, it is concentrated during the rainy season (Naoy *et al.*, 2018). In a study (Majeed *et al.*, 2022) conducted on climber species in semi-mountainous Jhelum District (Punjab, Pakistan) at elevation ranging up to 1000m, majority of the climber species were found to flower during the months of March–April (28.04%), followed by August–September (26.31%). This was similar to the observations made in the Pakistani Himalayas and in the Kashmiri Himalayas in India (Majeed *et al.*, 2022). Among the ten climbers recorded in the urban forests of Shimla in the present study, about half the species bloom in summer and the other half in the monsoons.

Feeding guilds and migration

Patchy distribution of fruits in time and space causes long periods of fruit scarcity over vast areas, and resultant diet and habitat shifts in the avian fauna (Foster 1977). Year-round frugivory is almost absent in temperate birds (Herrera, 1984). Frugivore species composition also change seasonally, particularly in temperate regions (Naoy *et al.*, 2018; Chauhan & Jolli, 2022). Frugivory is common in temperate forest birds in North America and is most prevalent during late summer and autumn, the season of southward migration of many bird species. In a three-year study conducted in Illinois, US on eight bird-dispersed shrubs and vines, it was found that the 11 bird species studied tended to concentrate on one or two particular fruit species each year (Malmborg & Willson, 1988).

Several species of herbs/shrubs/trees bearing small fleshy fruits/seeds/nuts in different seasons were seen to be

consumed by birds across feeding guilds in Kasumpti. *P. himalayana* and *R. brunonii* bear abundant clusters of fleshy berries (rose-hips in the case of the latter) that ripen just when the summer migrant bird species such as the Wedge-tailed Green Pigeon are preparing to migrate to the Indian plains. (See a list of summer migrants in Chauhan & Jolli, 2022. A few more species were recorded in 2021–2023). These two climber species no doubt provide the birds with calories to help them migrate. There are two species of resident frugivore birds in Kasumpti – Great Barbet and Slaty-headed Parakeet. The latter migrates to adjacent lower altitude forests in the dead of winter, and reappears periodically when the weather improves. On the other hand, species like the Black Bulbul are mobile over a larger area, and appear in the Kasumpti forest from time to time.

Forest fragmentation and lianas

Globally, forest fragments (up to 100 ha) are estimated to possess 13%–75% less diversity than comparable non-fragmented forests (Haddad *et al.*, 2015), with the majority of the lost diversity often being the most iconic components, such as large mammals and trees (Chiarello, 1999; Gibson *et al.*, 2013; Laurance, 1997b; Laurance *et al.*, 2000; Oliveira *et al.*, 2008). Nevertheless, in the tropics, forest fragments provide a repository for the preservation of many rare and endangered species and threatened ecosystems. Forest fragments should therefore, not only be retained, but managed effectively, which necessitates an understanding of their ecology. One of the major ecological interactions altered by the relationship between trees and lianas. A decrease in canopy cover, which is found on forest edges or in tree-fall gaps, is well known to favour liana proliferation (Schnitzer & Carson, 2001, 2010; Schnitzer *et al.*, 2000, 2014). which detrimentally impacts trees

and modifies functioning of forest fragments (by limiting seedling recruitment Schnitzer & Carson, 2010; Schnitzer *et al.*, 2000), damaging saplings and decreasing tree growth and fecundity (Stevens, 1987), competing with trees for limited resources (Pasquini *et al.*, 2015; Reid *et al.*, 2015; Rodríguez-Ronderos *et al.*, 2016; Schnitzer *et al.*, 2005), increasing tree mortality (Ingwell *et al.*, 2010), reducing carbon storage capacity (Durán & Gianoli, 2013; van der Heijden *et al.*, 2013; Schnitzer *et al.*, 2014), re-distributing nutrients (Kazda, 2015; Powers *et al.*, 2004; Schnitzer & Bongers, 2011), altering tree-species composition (Clark & Clark, 1990; Laurance *et al.*, 2001; Schnitzer & Bongers, 2002), threatening epiphytic ferns (Magrach *et al.*, 2014), and limiting or changing the trajectory of tree-species succession within treefall gaps (Schnitzer & Bongers, 2005; Schnitzer & Carson, 2001, 2010; Schnitzer *et al.*, 2000). Thus, understanding the ecological interactions between lianas and their host trees is critical for successfully managing remnant forest fragments (Campbell *et al.*, 2018). Another study states that many lianas do not have significant adverse effects on their host trees, and indeed in some cases can facilitate forest recovery following disturbance. Many lianas help to protect forests from extreme weather, fire and weed invasion resulting in a “bandage effect” that allows tree seedlings to survive and grow where they might otherwise die (Campbell *et al.*, 2015; Marshall *et al.*, 2020).

Several studies (Vidal *et al.*, 1997; Parren & Bongers, 2001; Emmons & Gentry, 1983) on the effectiveness of liana cutting recommend selective liana cuttings opposed to blanket liana cutting. Many studies warn against blanket liana cutting in managed forests because lianas provide essential food and much needed canopy structure to many forest animals. Large

lianas in primary forest in tropical lowlands form liana tangles that are crucial for threatened understorey animals (Michel *et al.*, 2015). Liana cutting is only appropriate for excessively abundant, structural parasitoid species in heavily disturbed areas, where they are most likely to arrest succession. Further research is needed to quantify the approximate level at which the density or biomass of lianas in a tree becomes problematic (Schnitzer & Bongers, 2002; Marshall *et al.*, 2020). Also, it will be useful to know the percentage of host trees (that carry liana species) in primary moist coniferous forests in the western Himalaya, in order to help decision-making for managing lianas in urban forest fragments.

Native lianas are a part of the forest ecosystem in Shimla, and have only proliferated due to fragmentation of the habitat. Any management of woody lianas has to be carefully done after identifying the forest patches that show proliferation (e.g. more than 80% trees hosting woody lianas) and the liana species to be controlled. Instead of uprooting the lianas growing on mature host trees, a method of pruning of lianas should be devised so that they may grow back in the spring. Smaller trees (e.g. < 6 inches DBH) especially those planted in afforestation drives in open areas, are affected more by woody lianas, therefore, these should be prioritised for liana removal. Langurs and macaques cause heavy defoliation of woody lianas when they are feeding in an area, and are an effective natural control.

CONCLUSION

Light, temperature, humidity and soil moisture are important factors that affect the species composition on the forest floor. Liana abundance is affected by these factors. Control measures of liana abundance in urban forests should bear in mind the importance of lianas as a source

of food to the vertebrate fauna. Measures to prevent forest fragmentation should be devised; and habitat restoration should be implemented in urban forests.

REFERENCES

- Auclair, A. N. & G. Cottam. 1971. Dynamics of black cherry (*Prunus serotina* Erhr.) in southern Wisconsin oak forests. *Ecol. Monogr.* 41, 153-177.
- Bergeron, A. & S. Pellerin, 2014. Pteridophytes as indicators of urban forest integrity. *Ecological Indicators* 38: 40–49.
- Brice, M. H., A. Bergeron & S. Pellerin. 2014. Liana distribution in response to urbanization in temperate forests. *ÉCOSCIENCE* 21 (2): 1–10 (2014).
- Campbell, M. J., W. Edwards, A. Magrach, M. Alamgir, G. Porolak, D. Mohandass & W. F. Laurance . 2018. Edge disturbance drives liana abundance increase and alteration of liana–host tree interactions in tropical forest fragments. *Ecol. Evol.* 8:4237–4251. <https://doi.org/10.1002/ece3.3959>
- Capers, R. S., R. L. Chazdon, A. R. Brenes & B. V. Alvarado. 2005. Successional dynamics of woody seedling communities in wet tropical secondary forests. *J. Ecol.* 93, 1071–1084. doi: 10.1111/j.1365-2745.2005.01050.x
- Champion, H.G. & S. K. Seth. 1968. *A Revised Survey of the Forest Types of India*. Government of India, New Delhi.
- Chauhan, A. & V. Jolli. 2022. Composition and other Ecological Characteristics of Mixed-species Bird Flocks of Temperate Forests in Himachal Pradesh, India. *Indian Forester* 148(10): 1028-1039. DOI: 10.36808/if/2022/v148i10/165734.
- Chiarello, A. G. 1999. Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. *Biological Conservation* 89, 71–82. [https://doi.org/10.1016/S0006-3207\(98\)00130-X](https://doi.org/10.1016/S0006-3207(98)00130-X)
- Clark, D. B. & D. A. Clark. 1990. Distribution and effects on tree growth of lianas and woody hemiepiphytes in a Costa Rican tropical wet forest. *Journal of Tropical Ecology* 6, 321–331. <https://doi.org/10.1017/S0266467400004570>
- Collinge, S. K., 1996. Ecological consequences of habitat fragmentation: Implications for landscape architecture and planning. *Landscape and Urban Planning* 36: 59–77.
- Durán, S. M, & E. Gianoli. 2013. Carbon stocks in tropical forests decrease with liana density. *Biology Letters* 9, 20130301. <https://doi.org/10.1098/rsbl.2013.0301>
- Emmons, L. H. & A. H. Gentry. 1983. Tropical forest structure and the distribution of gliding and prehensile tailed vertebrates *Am. Nat.* 121: 513-524.
- Ewers, F. W., J. B. Fisher & K. Fichtner, 1991. Water flux and xylem structure in vines. Pages 127–160 in F. E. Putz & H. A. Mooney (eds). *The Biology of Vines*. Cambridge University Press, Cambridge.
- FAO & UNEP. 2020. *The State of the World's Forests 2020*. Forests, biodiversity and people. Rome. <https://doi.org/10.4060/ca8642en>
- Fike, J. & W. A. Niering. 1999. Four decades of old field vegetation development and the role of *Celastrus orbiculatus* in the northeastern United States. *J. Veg. Sci.* 10: 483–492. doi: 10.2307/3237183.

- Fogden, M. P. L. 1972. The seasonality and population dynamics of equatorial forest birds in Sarawak. *Ibis* 114: 307-343.
- Foster, M. S. 1977. Ecological and nutritional effects of food scarcity on a tropical frugivorous bird and its fruit source. *Ecology* 58: 73-85.
- Gerwing, J. J., and D. L. Farias. 2000. Integrating liana abundance and forest stature into an estimate of total aboveground biomass for an eastern Amazonian forest. *J. Trop. Ecol.* 16: 327–335. doi: 10.1017/S0266467400001437
- Gibson, L., A. J. Lynam, C. J. A. Bradshaw, F. He, D. P. Bickford, D. S. Woodruff, S. Bumrungsri, W. F. Laurance, 2013. Near-complete extinction of native small mammal fauna 25 years after forest fragmentation. *Science* 341: 1508–1510. <https://doi.org/10.1126/science.1240495>.
- Godefroid, S. & N. Koedam, 2007. Urban plant species patterns are highly driven by density and function of built-up areas. *Landscape Ecology* 22: 1227–1239.
- Grimm, N. B., S. H. Faeth, N. E. Golubiewski, C. L. Redman, J. Wu, X. Bai & J. M. Briggs, 2008. Global change and the ecology of cities. *Science* 319: 756–760.
- Haddad, N. M., L. A. Brudvig, J. Clobert, K. F. Davies, A. Gonzalez, R. D. Holt, T. E. Lovejoy, J. O. Sexton, M. P. Austin, C. D. Collins, W. M. Cook, E. I. Damschen, R. M. Ewers, B. L. Foster, C. N. Jenkins, A. J. King, W. F. Laurance, D. J. Levey, C. R. Margules, B. A. Melbourne, A. O. Nicholls, J. L. Orrock, D-X. Song & J. R. Townshend. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances* 1: e1500052
- Herrera, C.M. 1984. Habitat-consumer interactions in frugivorous birds. In: Cody, M. L. (ed.) *Habitat Selection in Birds*. Academic Press, New York, USA, pp. 341–365.
- Herrera, C. M. & P. Jordano. 1981. *Prunus mahaleb* and birds: The high-efficiency seed dispersal system of a temperate fruiting tree. *Ecol. Monogr.* 51: 203-218.
- Himachal Watcher. 2016, 2020. Facebook videos. Weblinks: (#SHIMLA: Special Message and a Request to People <https://fb.watch/p5vyR449Kp/>), (Climbers Are Killing Green Trees in Shimla <https://fb.watch/p5zbJED1xG/>)
- Ingwell, L. L., S. J. Wright, K. K. Becklund, S. P. Hubbell & S. A. Schnitzer. 2010. The impact of lianas on 10 years of tree growth and mortality on Barro Colorado Island, Panama. *Journal of Ecology* 98: 879–887. <https://doi.org/10.1111/j.1365-2745.2010.01676.x>
- Jackson, P. C., J. Cavelier, G. Goldstein, F. C. Meinzer & N. M. Holbrook, 1995. Partitioning of water resources among plants of a lowland tropical forest. *Oecologia* 101: 197–203.
- Jayasekara, P., U. R. Weerasinghe, S. Wijesundara & S. Takatsuki. 2007. Identifying Diurnal and Nocturnal Frugivores in the Terrestrial and Arboreal Layers of a Tropical Rain Forest in Sri Lanka. *ECOTROPICA* 13: 7–15.
- Jongkind, C. C. H. & W. D. Hawthorne. 2005. A botanical synopsis of the lianas and other forest climbers. Forest climbing plants of West Africa: diversity, ecology and management, pp. 19-39.
- Karr, J. R. 1976. Seasonality, resource availability, and community diversity in

tropical bird communities. *Am. Nat.* 110: 973-994.

Kazda, M. 2015. Liana–nutrient relations. In S. Schnitzer, F. Bongers, R. J. Burnham, & F. E. Putz (Eds.), *Ecology of lianas* (pp. 309–322). Wiley-Blackwell Publishing, Oxford.

Klinge, H. & W.A. Rodrigues. 1973. Biomass estimation in a central Amazonian rain-forest. *Acta Cient. Venez.* 24(6): 225-237.

Koike, S. & T. Masaki. 2019. Characteristics of fruits consumed by mammalian frugivores in Japanese temperate forest. *Ecological Research* 1–9. DOI: 10.1111/1440-1703.1057

Kokou, K., P. Couteron, A. Martin & G. Caballe. 2002. Taxonomic diversity of lianas and vines in forest fragments of southern Togo. *Revue d'écolog.* 57: 1-18.

Ladwig, L. M. & S. J. Meiners. 2010. Spatiotemporal dynamics of lianas during 50 years of succession to temperate forest. *Ecology* 91, 671–680. doi: 10.1890/08-1738.1

Ladwig, L. M. & S. J. Meiners. 2010a. Liana host preference and implications for deciduous forest regeneration. *Journal of the Torrey Botanical Society* 137: 103–112.

Laurance, W. F. 1997. Responses of mammals to rainforest fragmentation in tropical Queensland: A review and synthesis. *Wildlife Research* 24: 603–612. <https://doi.org/10.1071/WR96039>

Laurance, W. F., P. Delamonica, S. G. Laurance, H. L. Vasconcelos & T. E. Lovejoy. 2000. Conservation: Rainforest fragmentation kills big trees. *Nature* 404: 836. <https://doi.org/10.1038/35009032>

Laurance, W. F., D. Perez-Salicrup, P. Delamonica, P. M. Fearnside, S. D'Angelo, A. Jerozolinski, L. Pohl & T. E. Lovejoy. 2001. Rain forest fragmentation and the structure of Amazonian liana communities. *Ecology* 82: 105–116. [https://doi.org/10.1890/0012-9658\(2001\)082\[0105:RFFATS\]2.0.CO;2](https://doi.org/10.1890/0012-9658(2001)082[0105:RFFATS]2.0.CO;2)

Letcher, S. G. (2015). Patterns of liana succession in tropical forests. In S. A. Schnitzer, F. Bongers, R. J. Burnham and F. E. Putz (Eds.), *Ecology of lianas* (pp. 116–130). John Wiley & Sons Ltd., Oxford.

Letcher, S. G. & R. L. Chazdon. 2009. Lianas and self-supporting plants during tropical forest succession. *For. Ecol. Manage.* 257: 2150–2156. doi: 10.1016/j.foreco.2009.02.028

Londré, R. A. & S. A. Schnitzer, 2006. The distribution of lianas and their change in abundance in temperate forests over the past 45 years. *Ecology* 87: 2973–2978.

Magrach, A., J. Rodríguez-Pérez, M. Campbell & W. F. Laurance. 2014. Edge effects shape the spatial distribution of lianas and epiphytic ferns in Australian tropical rain forest fragments. *Applied Vegetation Science* 17: 754–764. <https://doi.org/10.1111/avsc.12104>

Majeed, M., L. Lu, S. M. Haq, M. Waheed, H. A. Sahito, S. Fatima, R. Aziz, R. W. Bussmann, A. Tariq, I. Ullah & M. Aslam. 2022. Spatiotemporal Distribution Patterns of Climbers along an Abiotic Gradient in Jhelum District, Punjab, Pakistan. *Forests* 13: 1244. <https://doi.org/10.3390/f13081244>

Malmberg, P.K. & M. F. Willson. 1988. Foraging Ecology of Avian Frugivores and Some Consequences for Seed Dispersal in an Illinois Woodlot. *The Condor* 90: 173-186.

- Marshall, A.R., P. J. Platts, R.L. Chazdon, H. Seki, M. J. Campbell, O. L. Phillips, R. E. Gereau, R. Marchant, J. Liang, J. Herbohn, Y. Malhi & M. Pfeifer. 2020. Conceptualising the Global Forest Response to Liana Proliferation. *Front. For. Glob. Change* 3: 35. doi: 10.3389/ffgc.2020.00035
- Michel, N. L., W. P. Carson & T. W. Sherry. 2015. Do collared peccaries negatively impact understory insectivorous rain forest birds indirectly via lianas and vines? *Biotropica* 47, 745–757. doi: 10.1111/btp.12261
- Murcia, C., 1995. Edge effects in fragmented forests: Implications for conservation. *Trends in Ecology & Evolution*, 10: 58–62.
- Naoy, S., T. Masaki & S. Sakai. 2018. Effects of temporal variation in community-level fruit abundance on seed dispersal by birds across woody species. *American Journal of Botany* 105(11): 1792–1801. doi:10.1002/ajb2.1173
- Oliveira, M. A., A. M. M. Santos & M. Tabarelli. 2008. Profound impoverishment of the large-tree stand in a hyper-fragmented landscape of the Atlantic forest. *Forest Ecology and Management* 256: 1910–1917. <https://doi.org/10.1016/j.foreco.2008.07.014>
- Parren, M. & F. Bongers. 2001. Does climber cutting reduce felling damage in southern Cameroon? *For. Ecol. Manage.* 141: 175–188.
- Pasquini, S. C., S. J. Wright & L. S. Santiago. 2015. Lianas always outperform tree seedlings regardless of soil nutrients: Results from a long-term fertilization experiment. *Ecology* 96: 1866–1876. <https://doi.org/10.1890/14-1660.1>
- Phillips, O.L., R. Vásquez Martínez, A. Monteagudo Mendoza, T.R. Baker & P. Núñez Vargas. 2005. Large lianas as hyperdynamic elements of the tropical forest canopy. *Ecology* 86(5): 1250–1258.
- Polunin, O. & A. Stainton. 1984. *Flowers of the Himalaya*. Oxford India Paperbacks, New Delhi. (pp. 77–79).
- Powers, J. S., M. H. Kalicin & M. E. Newman. 2004. Tree species do not influence local soil chemistry in a species-rich Costa Rica rain forest. *Journal of Tropical Ecology* 20: 587–590. <https://doi.org/10.1017/S0266467404001877>
- Putz, F.E. 1983. Liana biomass and leaf area of a “tierra firme” forest in the Rio Negro Basin, Venezuela. *Biotropica* 15(3): 185–189.
- Rahman, A. U., S. M. Khan, Z. Saquib, Z. Ullah, Z. Ahmad, S. Ekerin, A. S. Mumtaz & H. Ahmad. 2020. Diversity and Abundance of Climbers in Relation to their Hosts and Elevation in the Monsoon Forests of Murree in the Himalayas. *Pak. J. Bot.* 52(2): 601–612. DOI: [http://dx.doi.org/10.30848/PJB2020-2\(17\)](http://dx.doi.org/10.30848/PJB2020-2(17))
- Reid, J. P., S. A. Schnitzer & J. S. Powers. 2015. Short and long-term soil moisture effects of liana removal in a seasonally moist tropical forest. *PLoS ONE* 10: e0141891. <https://doi.org/10.1371/journal.pone.0141891>
- Rodríguez-Ronderos, M. E., G. Bohrer, A. Sanchez-Azofeifa, J. S. Powers & S. A. Schnitzer. 2016. Contribution of lianas to plant area index and canopy structure in a Panamanian forest. *Ecology* 97: 3271–3277. <https://doi.org/10.1002/ecy.1597>
- Rowe, N. & T. Speck, 2005. Plant growth forms: An ecological and evolutionary perspective. *New Phytologist* 166: 61–72.

- Royo, A. A. & W. P. Carson. 2006. On the formation of dense understory layers in forests worldwide: consequences and implications for forest dynamics, biodiversity, and succession. *Can. J. For. Res.* 36: 1345–1362. doi: 10.1139/x06-025
- Sarvalingam, A., A. Rajendran & R. Sivalingam. 2015. Wild edible plant resources used by the Irulas of the Maruthamalai Hills, Southern Western Ghats, Coimbatore, Tamil Nadu. *Ind. J. Nat. Prod. Res.* 5(2): 198-201.
- Schnitzer, S. A., 2005. A mechanistic explanation for global patterns of liana abundance and distribution. *American Naturalist* 166: 262–276.
- Schnitzer, S. A. & F. Bongers. 2002. The Ecology of Lianas and Their Role in Forests. *Trends in Ecology & Evolution* 17(5): 223-230. DOI: <https://www.sciencedirect.com/science/article/pii/S0169534702024916?via%3Dihub>. © 2002 Elsevier. https://epublications.marquette.edu/bio_fa/c/741
- Schnitzer, S. & F. Bongers. 2005. Lianas and gap phase regeneration: Implications for forest dynamics and species diversity. In F. Bongers, M. P. E. Parren, & D. Traore (Eds.), *Forest climbing plants of West Africa: Diversity, ecology and management* (pp. 59–72). CABI Publishing, Wallingford. <https://doi.org/10.1079/9780851999142.0000>
- Schnitzer, S. A. & F. Bongers, 2011. Increasing liana abundance and biomass in tropical forests: Emerging patterns and putative mechanisms. *Ecology Letters* 14: 397–406.
- Schnitzer, S. A. & W. P. Carson, 2001. Treefall gaps and the maintenance of species diversity in a tropical forest. *Ecology* 82: 913–919.
- Schnitzer, S. A. & W. P. Carson, 2010. Lianas suppress tree regeneration and diversity in treefall gaps. *Ecology Letters* 13: 849–857. <https://doi.org/10.1111/j.1461-0248.2010.01480.x>
- Schnitzer, S. A., M. E. Kuzee & F. Bongers. 2005. Disentangling above- and below-ground competition between lianas and trees in a tropical forest. *Journal of Ecology* 93: 1115–1125. <https://doi.org/10.1111/j.1365-2745.2005.01056.x>
- Schnitzer, S. A., J. W. Dalling & W. P. Carson. 2000. The impact of lianas on tree regeneration in tropical forest canopy gaps: Evidence for an alternative pathway of gap-phase regeneration. *Journal of Ecology* 88: 655–666. <https://doi.org/10.1046/j.1365-2745.2000.00489.x>
- Schnitzer, S. A., G. M. F. van der Heijden, J. Mascaro & W. P. Carson. 2014. Lianas in gaps reduce carbon accumulation in a tropical forest. *Ecology* 95: 3008–3017. <https://doi.org/10.1890/13-1718>.
- Selaya, N. G. & N. P. R. Anten, 2008. Differences in biomass allocation, light interception and mechanical stability between lianas and trees in early secondary tropical forest. *Functional Ecology* 22: 30–39.
- Stevens, G. C. (1987). Lianas as structural parasites: The *Bursera simaruba* example. *Ecology* 68: 77–81. <https://doi.org/10.2307/1938806>
- Stiles, E. W., 1982. Fruit flags: Two hypotheses. *American Naturalist* 120: 500–509.
- Tongkok, S., X. He, M. J. M. Alcantara, C. Saralamba, A. Nathalang, W. Chanthorn,

W. Y. Brockelman & L. Lin. 2020. Composition of frugivores of *Baccaurea ramiflora* (Phyllanthaceae) and effects of environmental factors on frugivory in two tropical forests of China and Thailand. *Global Ecology and Conservation* 23 e01096.

<https://doi.org/10.1016/j.gecco.2020.e01096>

Tribune News Service. Dec 07, 2023. Shimla MC begins drive against climber vines. Weblink:

<https://www.tribuneindia.com/news/himal/shimla-mc-begins-drive-against-climber-vines-569507>

Van der Heijden, G. M., S. A. Schnitzer, J. S. Powers & O. L. Phillips. 2013. Liana impacts on carbon cycling, storage and sequestration in tropical forests. *Biotropica* 45: 682–692. doi: 10.1111/btp.12060

Van der Sande, M. T., L. Poorter, S. E. Schnitzer & L. Markesteijn, 2013. Are lianas more drought-tolerant than trees? A test for the role of hydraulic architecture and other stem and leaf traits. *Oecologia* 172: 961–972.

Vidal, E., J. Johns, J. J. Gerwing, P. Barreto & C. Uhl. 1997. Vine management

for reduced-impact logging in eastern Amazonia. *For. Ecol. Manage.* 98: 105–114. doi: 10.1016/S0378-1127(97)00051-0

Wen, J., L. M. Lu, Z. L. Nie, X. Q. Liu, N. Zhang, S. Ickert-Bond, J. Gerrath, S. R. Manchester, J. Boggan & Z. D. Chen. 2018. A new phylogenetic tribal classification of the grape family (Vitaceae). *Journal of Systematics Evolution* 56: 262–272. <https://doi.org/10.1111/jse.12427>

White, M. A., R. T. Nemani, P. E. Thornton & S. W. Running, 2002. Satellite evidence of phenological difference between urbanized and rural areas of the eastern United States deciduous broadleaf forest. *Ecosystems* 5: 260–273.

Willson, M. F. 1991. Dispersal of seeds by frugivorous animals in temperate forests. *Revista Chilena de Historia Natural* 64: 537–554.

Zhang, X., M. A. Friedl, C. B. Schaaf, A. H. Strahler & A. Schneider. 2004. The footprint of urban climates on vegetation phenology. *Geophysical Research Letters* 31: L12209, DOI: 10.1029/2004GL020137



Fig 1: Slaty-headed Parakeet



Fig 2: Great Barbet



Fig 3: Wedge-tailed Green Pigeon



Fig 4: Wedge-tailed Green Pigeon, female

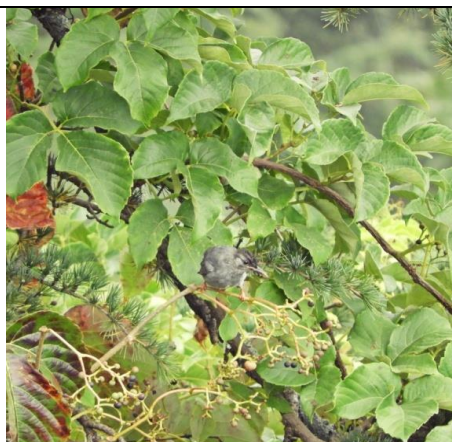


Fig 5: Himalayan Bulbul 	Fig 6: Black Bulbul 
Fig 7: Red-billed Blue Magpie 	Fig 8: Himalayan Langur 
Fig 9: Rhesus Macaque 