EFFECTS OF HEIGHT AND COLOR ON FLOWER VISITATION IN *PASSIFLORA VITIFOLIA*

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Abstract. The effects of *Passiflora* flower height and color on the success of attracting hummingbirds was tested. 62 flowers were observed on 27 January 1992. Data collected for each flower included height from ground, distance from branch origin, color of intracorolla filaments, and sequence and timing of flowering within each plant. All flowers that were open on 27 January were closed the following day. 32 of 62 had successive buds available for flowering. The majority of plants opened new flowers at two and three day intervals. One vine successively flowered three days in a row. Visitation of flowers greater than 50cm above-ground occurred significantly earlier in the day than of flowers on or near ground level (χ^2=7.91, p<.005). 75% of bicolored flowers were visited, while only 42% of red flowers were visited on 27 January. Pollen of flowers visited earlier in the day may have a better chance of being delivered to conspecifics. Results suggest that flowers blooming higher off the ground may have greater male fitness due to earlier visitation by hummingbirds. Flower color may also be a factor affecting visitation. (SAW)

INTRODUCTION (SAW)

Passiflora vitifolia is a vine commonly found in moist forests of Costa Rica. It produces bright red flowers that are primarily hummingbird pollinated (Janzen 1983). It is thought that these flowers remain open for only one day. In some circumstances one day may not give a flower sufficient time to attract pollinators. What are some factors that may increase the chances of being pollinated? Since this plant is a vine, the flowers are found at ground level and at various heights throughout the understory (Janzen 1983). *P. vitifolia* is also dimorphous in color. Some flowers are entirely red while in others the erect intracorolla filaments are white. Will height of flower and flower color play a role in this vines' reproductive success? Hummingbirds are known to trapline *P. vitifolia* and may do so more efficiently at greater heights while simultaneously avoiding predators on the ground. Hummingbirds are also attracted to the color red (Forsyth and Miyata 1984). I hypothesized that flowers higher in the understory will be visited sooner than flowers on or near ground level. I also predicted that entirely red flowers will attract more and earlier hummingbird visitation than flowers that are white and red.

METHODS (SAW)

On 26 January 1992, all *P. vitifolia* that were flowering or had buds available for flowering within the first 100m of the Rio Claro trail, Corcovado National Park were flagged. Observations began 27 January. Of the 111 plants previously marked, 62 plants opened flowers. Each of the 62 flowers were marked and observed on 27-30 January. Flowers were measured for height off ground and distance from branch origin. Color of intracorolla filament was recorded. Flowers were observed throughout the day at 2 hour intervals starting at 0600. Visitation by hummingbirds was determined by a disturbance in the pollen pattern on any of the 5 anthers. Time of visitation was recorded at the first observation of disturbance. Final observations were taken at 1600. If a flower had not been visited at this time it was considered "not visited".

RESULTS (SAW)

Overall Flower Classification. Of the 62 flowers observed, 29 were >50cm from the ground (tall) and 33 were <50 cm (short). 50 individuals were bicolored and 12 were entirely red.

Table 1. Flowers not visited relative to color and height.

	Tall (>.5m)	Short (<.5m)
Red	1	7
Bicolored	0	4

Table 2. Number visited flowers relative to color and height.

	Tall	Short
Red	0	5
Bicolored	28	17

Table 3. Number flowers visited and not-visited relative to height. (χ^2 = 7.91, p<.005)

	Visited	Non-Visited
Tall	28	1
Short	22	11

Visited vs. Non-Visited Flowers With Respect to Height. 50 of 62 marked individuals were visited by 1600. The remaining 12 flowers were not visited. Of these 12 avoided flowers, 5 were bicolored and 7 were red; 11 were short (5 bicolored, 6 red) and 1 was tall (red). Height had a significant effect on flower visitation (χ^2=7.91, p<.005; Tables 1, 2 and 3).

Visited vs. Non-Visited Flowers With Respect to Color. Of the 50 visited flowers, 45 were bicolored and 5 were red; 28 were tall (all bicolored) and 22 were short (17 bicolored, 5 red). 76% of the bicolored flowers were visited, while only 42% of red flowers were visited. Color had a significant effect on flower visitation (χ^2=14.5, p<.005; Table 4).

Table 4. Number flowers visited and not visited relative to color. (χ^2 = 14.5, p < .005)

	Visited	Non-Visited
Red	5	7
Bicolored	45	5

Table 5. Number flowers visited before and after noon relative to color.

	Early	Late
Red	2	3
Bicolored	36	9

Early vs. Late Visitation With Respect to Color. Of the 50 observed visitations, 38 occurred before 1200 (early) and 12 occurred after 1200 (late). Early flowers consisted of 36 bicolored flowers and 2 red flowers. Late flowers included 9 bicolored and 3 red. Although time of visitation was not significantly affected by color, 95% of the bicolored flowers were visited early while only 40% of the red flowers were visited early (Table 5).

Early vs. Late Visitation With Respect to Height. Of the 50 flowers visited, 28 were tall (24 early, 4 late) and 22 were short (14 early, 8 late). Although time of visitation was not significantly affected by height, 86% of tall flowers were visited early while 64% of short flowers were visited early (Table 6).

Successive Flowering. All 62 flowers that were opened on 27 January were closed on the next day. 32 of the 62 ob-

served plants that flowered on the 27th had available buds for future flowering. Of those 32, 3 bloomed the 28th (<10%), 13 the 29th (40%), and the remaining 16 opened on the 30th (50%). Color and height have no significant effect on time between successive flowering (Tables 7, 8).

Table 6. Number flowers visited before and afternoon relative to height. ($\chi^2 = 3.29$, $p > .05$)

	Early	Late
Tall	24	4
Short	14	8

Table 7. Number of flowers open on successive days with respect to height.

	28th	29th	30th	
Tall	3	6	8	17/29=59% w/bud avail bloomed
Short	0	7	8	15/33=46% w/bud avail bloomed

Table 8. Number of flowers flowering on successive day with respect to color.

	28th	29th	30th	
Red	1	4	0	5/12=42% w/bud avail bloomed
Bicol-ored	2	9	16	27/50=54% w/bud avail bloomed

Discussion (SAW)

One day open is sufficient time for the majority of *P. vitifolia* flowers to be visited by its prospective pollinators and my results suggest that height and color have an effect on time of visitation. Early visitation is probably a measure of an overall increased frequency of pollination and is beneficial because it allows more time for cross pollination.

Flowers higher up may have been visited earlier due to their accessibility to hummingbirds; the birds may spend less energy traplining flowers at higher levels. Hummingbirds may benefit from obtaining the nectar reward without expending excess energy by having to continually adjust foraging height. Flowers higher up may also enable hummingbirds to avoid ground predators.

Flower color is also important, and the combination of white on red may attract prospective pollinators more consistently. Although hummingbirds are attracted to red, more red is not necessarily better, their eyes are sensitive to specific color cues and bicolored *P. vitifolia* may be the more obvious visual device.

Other factors affecting visitation may include the presence of parasitic insects, insect larvae on the plant and nectar robbery. The demolition or occupation of flowers may deter visitation. Many questions are still unanswered: should flowers emerge on alternating days or flower continually? Producing a flower every day may deplete a flower's energy resources and possibly compromise color vitality. Sequential flowering allows each plant to maximize on pollination opportunities while a mast flowering strategy may exhaust reproductive resources without maximizing visitation. Consistent presence of flowers in an area offers the pollinators a reliable food source, this may prevent them from leaving an area to search for new resources, as in some *Musa* spp. (Gomez, pers. comm.). In representing a dependable energy source *P. vitifolia* may be ensuring its own future pollination.

Literature Cited

Smiley, J. T. 1983. *Passiflora vitifolia.* In *Costa Rican Natural History*, ed. D. H. Janzen. Chicago: University of Chicago Press, pg. 299-301, 598, 730.

Forsyth, A. and Miyata, K. 1984. *Tropical Nature.* New York: Macmillan Publishing.