Mist Variation and Epiphytic Orchid Abundance in a Monteverde Cloud Forest

Christopher Frohlich

Department of Environmental Studies, University of Colorado, Boulder

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ABSTRACT

There has been an observed increase in the frequency of days with no mist during the dry season in Monteverde (Pounds et al. 1999). This trend towards an increasingly dry environment could have detrimental effects on epiphytic orchids. The purpose of this project was to investigate the effect of mist level as well as mist frequency and branch direction on orchid abundance in 12 *Daphnopsis americana* (Lauraceae) host trees. Mist collectors were placed on 24 sample branches within the first horizontal angle of primary branches and mist was collected for eight days from all directions. Abundance counts of total orchids as well as the subtribe Pleurothallidinae were conducted on the first 1.5 ms of all sample branches. Northeastern branches received the greatest mean amount of mist. A significant difference was not observed in abundance of orchids or pleurothallids on any direction of sample trees (Kruskal-Wallis test, $H = 5.805$ $p > 0.05$), however, a higher density of both orchids and pleurothallids was observed on northeasterly branches. Both pleurothallid and total orchid abundance was significantly affected by the number of days of recorded mist as well as the total amount of mist at the sample branches (Simple regression). This study shows that mist levels as well as frequency of mist may be determining factors in total orchid abundance. The increase in the number of dry days in Monteverde may result in the decrease in orchid abundance.

RESUMEN

Ha habido un aumento observado en la frecuencia de días sin la niebla durante la temporada seca en Monteverde (Pounds et al. 1999). Esta tendencia hacia un ambiente cada vez más seco podría tener los efectos perjudiciales en las orquídeas epiphyticos. El propósito de este proyecto debía investigar el efecto del nivel y la frecuencia de la niebla y dirección de rama en la abundancia de orquídeas en 12 Daphnopsis sp. (Lauraceae), los árboles del anfitrión. Los recaudadores de la niebla se colocaron en 24 ramas dentro del primer ángulo horizontal de ramas primarias, las cantidades de la niebla se recogidos por ocho días, de todos direcciones y cuentos de abundancia de orquídeas totales y también el subtribe Pleurothallidinae se cuentados en el primer 1.5 ms de todas las ramas. Las ramas del noreste recibieron la cantidad más grande de la niebla. Una diferencia significativa no se observó en la abundancia de orquídeas ni Pleurothallids en ninguna dirección de árboles de muestra (la prueba de Kruskal Wallis, $H = 5.805$ $p > 0.05$), sin embargo, una densidad más alta de tanto las orquídeas y Pleurothallids se observado en ramas del noreste. Ambos Pleurothallid y la abundancia total de la orquídea fueron afectados significativamente por el número de días que recibieron la niebla y también la cantidad total de la niebla en las ramas de la muestra (el regresión simple). Este estudio exhibe que aumentos y también la frecuencia de la niebla puede determinando los factores en la abundancia total de orquídea. El aumento del número de días secos en Monteverde puede tener el resulto de la disminución en la abundancia de orquídeas.

INTRODUCTION

Tropical montane forests of Monteverde support one of the worlds' most abundant epiphytic orchid populations. Epiphytes contribute a significant portion to this community in terms of overall diversity (Nadkarni 1986). Almost half of total epiphyte species consist of one family, Orchidaceae (Kress 1986). An important factor influencing the success of these plants in the tropical montane rainforest is the availability of large quantities of windblown mist and cloud water (Nadkarni 1986). Because epiphytic orchids have no contact with the ground they must rely almost entirely on small inputs of nutrients contained in atmospheric moisture and dust for their survival (Nadkarni 1986).

The amount of research done on microclimate requirements of orchids is little but some authors have shown epiphytes vary in their distribution throughout different zones of host trees (Johansson 1974, Steeg and Cornelissen 1989). This variation may be related to microclimatic differences across regions of a tree (Hietz and Hietz-Seifert 1995). Microclimatic differences may include variation in temperature, substrate composition, light level, and, of specific interest to this study, moisture from mist and cloud water. These subtle differences create numerous microhabitats to which orchids may be specialized.

Microclimate variation is probably more pronounced in the dry season in Monteverde. This is a consequence of strong southwestern directionality of trade winds during the months of November until late April (Nadkarni and Wheelwright 2000). These winds carry nutrient laden mists to tree crowns and makes survival possible for epiphytes. Because of strong directionality of winds, mist should be delivered unequally across a tree crown, thus creating climatic variation on small spatial scales.

Tropical plants have lower tolerances for climatic conditions than their temperate counterparts (Stevens 1985). These tolerances may be further decreased in epiphytic orchids due to their reliance on smaller nutrient inputs from mist and cloud water. Therefore, slight differences in mist levels within a tree crown may result in a large variance in abundance of orchids. Pleurothallidinae, an orchid subtribe, may be more sensitive to microclimate variation due to their small size and lack of water storing pseudobulbs. As a result of these morphological differences they may show greater variation in abundance between populations due to different mist levels. The climatic sensitivity of these plants may make them an ideal bioindicator organism, thereby contributing to their importance in this study.

Ongoing research by Pounds and coworkers on climate change in Monteverde documents an increase in the frequency of days with no reported precipitation during the dry season (Pounds et al. 1999). An increasingly dry environment could have detrimental effects on epiphytic orchids. Past studies on plant distribution have shown that epiphyte success is more closely related to variation in precipitation than total annual precipitation during the year (Gentry and Dodson 1987). An increase in the number of consecutive dry days may in turn result in a decrease in epiphytic orchid abundance in Monteverde.

This study examines the effect of mist levels and mist frequency on orchid abundance on trees in a pasture adjacent to cloud forest. I predict that orchid abundance should correspond directly with mist levels. Northeast trade winds should cause the north-facing branches to have higher levels and more frequent mist. Consequently, orchids should attain highest abundance on north-facing branches.

MATERIALS AND METHODS

Study Site

My study site was located north of La Estación Biológica at Monteverde, Costa Rica. The area was a 2.5 ha pasture at an approximate elevation of 1530 meters, surrounded by Lower Montane Wet Forest life zone (Holdridge classification system, Haber et al. 1996). This life zone receives an average annual rainfall of 2,500 mm of rain with an additional 500 - 2000 mm of moisture in the form of windblown mist. I conducted my study at the end of the dry season between April 10 until May 8, 2002.

Mist Collection and Orchid Abundance Counts

I collected mist from 12 Daphnopsis americanus (Lauraceae) host trees. I chose one or two branches per tree that met the following criteria: 1) they were oriented horizontally; 2) they were located in Zone Four (Johansson 1974, see Figure 1). I placed one mist collector at each branch and noted the direction that the branch faced (NE, NW, SE or SW). I measured mist for seven days and one time after two days lapsed. The collectors were made of a mesh tube covered by a plastic roof that led into a funnel and collecting vial. Within 12 trees I placed 24 mist collectors corresponding to each of the four cardinal directions with a repetition of six samples per direction. I measured mist for eight days from all mist collectors. After mist data were collected I conducted abundance counts on the same zone four branches. Both orchid and pleurothallid abundance was recorded for 1.5 m of each Zone Four branch, starting ten cm away from the crotch of the tree.

Statistical Methods

All statistical tests that I conducted considered total orchid abundance as well as the abundance of the subtribe Pleurothallidinae. I ran a Kruskal-Wallis test to compare orchid abundance versus branch direction as well as differences in daily mist levels. I also conducted a Mann-Whitney U-test on the effect of variation in mist levels by branch direction. I conducted an ANOVA test for variation in daily mist by branch orientation and day. I also conducted a simple regression to analyze the effect of both total mist levels and total days of recorded mist on orchid abundance.

RESULTS

The 24 sample branches contained a total of 579 orchids; of this number 271 individuals were pleurothallids. The average amount of mist collected varied widely across the days, ranging from zero ml to 30.5 ml. The average number of orchids found on host branches was 24 (range = one to 24). The average number of pleurothallids per host branch was 11 (range = one to 68)

There was a significant effect of both direction and day on the amount of mist collected daily (Table 1). The difference was significant for day eight vs. all others (day eight was consistently higher) and day six vs. three and four (day six was higher). Day eight showed the greatest amount of mean mist, receiving at least 24.5 ml more mist than all other days (Table 2). Also, northeastern branches received the greatest mean daily mist (Table 3).

A significant difference was not observed in abundance of orchids nor pleurothallids on any direction of sample trees (Kruskal-Wallis test, $H = 5.805$ $p > 0.05$), however, a higher density of both orchids and pleurothallids was observed on northeasterly branches (Figure 2) Both pleurothallid and total orchid abundance were significantly affected by the number of days of recorded mist at the sample branches (Figures 3 and 4). The total amount of recorded mist per branch significantly affected orchid and pleurothallid abundance (Simple regression in both figure 5, and 6).

DISCUSSION

This study shows that mist levels as well as frequency of mist are important in determining orchid abundance. Orchids in general, and pleurothallids, in part, are most abundant where daily mist levels are highest and most frequent. In general, this is on the northern sides of trees; however, there was no statistically significant effect of branch direction on orchid or pleurothallid abundance. If a larger sample size were to be collected I believe that branch direction would appear to have a greater influence on orchid abundance.

The strong correlation between the number of misty days and orchid and especially pleurothallid abundance is evidence in support of claims that epiphytic orchids need consistent, yet not necessarily large amounts of water (Gentry and Dodson 1987). Pleurothallidinae appear to have a higher sensitivity in their response to consecutive wet days, or number of total days of recorded mist, than other orchids. This may be explained by their lowered water storing capabilities and therefore an increased sensitivity to drought. Water reserves contained within pseudobulbs of other orchid families may be essential to buffer against drought during the dry season.

This study provides evidence that orchids respond to small-scale variation in climatic conditions, a factor thought important in promoting explosive speciation in orchids (K. Masters 2002, personal communication). Different selective pressures, such as varying precipitation may result in distinct genetically isolated groups within a single tree. The correlation between orchid speciation and variation in climatic conditions has been suggested, yet has not been thoroughly researched in previous studies. A topic of interest for future research may be to compare mist levels in relation to genotypes of orchid populations.

This study focused on orchids on trees in a pasture with a strong directional wind pattern. The results of a similar experiment may differ for orchid populations on forest trees. Within a forest, mist variation should be different due to factors such as decreased wind strength. Decreased directionality of wind may affect dispersal of orchid seeds and therefore result in a less dominant north facing distribution.

One factor that should be noted concerning this experiment was that all orchid individuals were counted with no distinction between adults and juveniles. The presence of juvenile individuals may indicate that conditions are suitable for germination but they may not reflect suitability for adults. For instance, individuals may germinate in the rainy season when precipitation is more abundant, however, dry season stress or mortality may inhibit these individuals reproduction.

The results of this study underscore the significance of recent research showing that Monteverde cloud forests are drying. Since 1976 the frequency of dry days in Monteverde have shown a sporadic yet steady increase (Pounds 1999). It is critical at this time to investigate the effects of decreasing precipitation events on Monteverde's epiphytic community. Due to significant abundance differences in response to varying mist levels as well as daily precipitation frequency, epiphytic orchids may serve as an important indicator organism in measuring the effect of regional decrease in mist on the montane cloud forest community.

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Table 1. *Two way ANOVA Results of the effect of day number and direction on daily mist. Table includes DF, F-Value for direction, day number and combined Direction and day. There was no significant difference in the variance of mist (p > .05).*

	DF	F- Value	P-Value
Direction	3	2.834	0.0402
Day #	7	31.984	< 0.0001
Direction * Day	21	.503	0.9660
Residual	152		

Table 2. *Comparison of daily mean mist (mL) collected from all branches (Fisher's PLSD). Table includes days, mean difference and P-Value. Only significant values are reported. Day eight showed the greatest mean mist difference. Day eight was consistently wetter than all other days and day six was wetter than day three and four.*

DAYS	**MEAN DIFFERENT (mL)**	**P-VALUE**
1 vs. 8	-29.300	<0.0001
2 vs. 8	-28.735	<0.0001
3 vs. 6	-6.035	0.0207
3 vs. 8	-30.683	<0.0001
4 vs. 6	-7.170	0.0062
4 vs. 8	-31.817	<0.0001
5 vs. 8	-29.078	<0.0001
6 vs. 8	-24.648	<0.0001
7 vs. 8	-28.172	<0.0001

Table 3. *Comparison of total mean mist (mL) collected from each branch orientation. (Fisher's PLSD test). Table includes Directions, mean difference and P-Value. The north east direction collected the greatest amount of total mist. Only significant values are reported.*

Comparison by Branch Direction	Mean Difference (mL)	P-value
NE vs. NW	3.964	0.0280
NE vs. SE	4.948	0.0091
NE vs. SW	3.708	0.0396

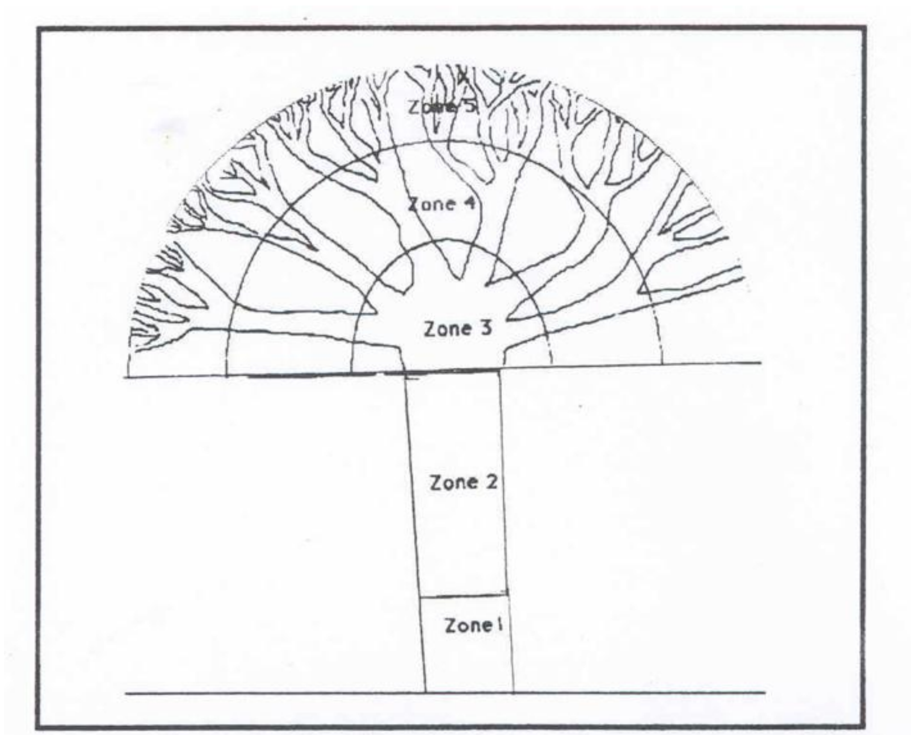

Figure 1. *Tree zones as described by Johansson (1974). Mist was collected and abundance counts were taken from Zone 4 areas.*

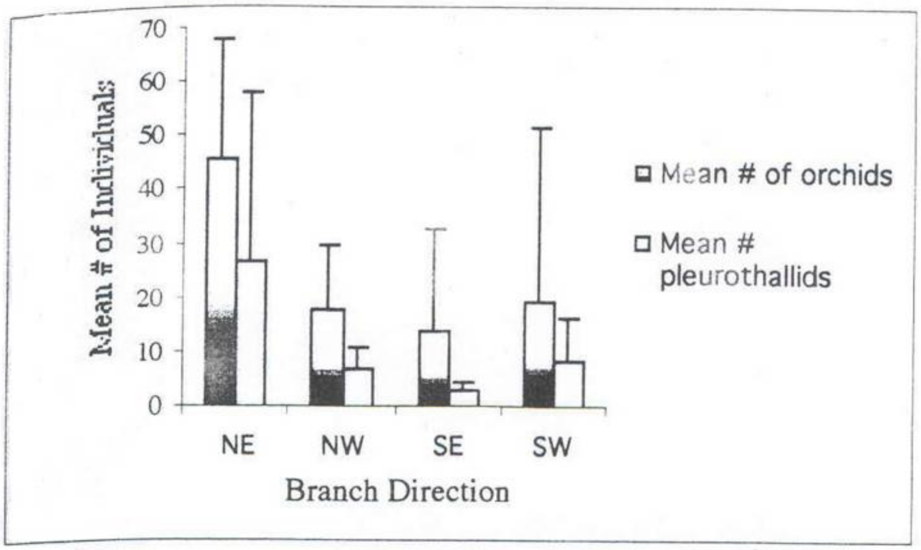

Figure 2. *Mean number of orchids and pleurothallids per branch orientation. The abundance of neither orchids nor pleurothallids showed no significant correlation between branch direction (Kruskal-Wallis non-parametric test, orchids = H = 5.805 p > 0.05 pleurothallids = H = 5.611, p > 0.05).*

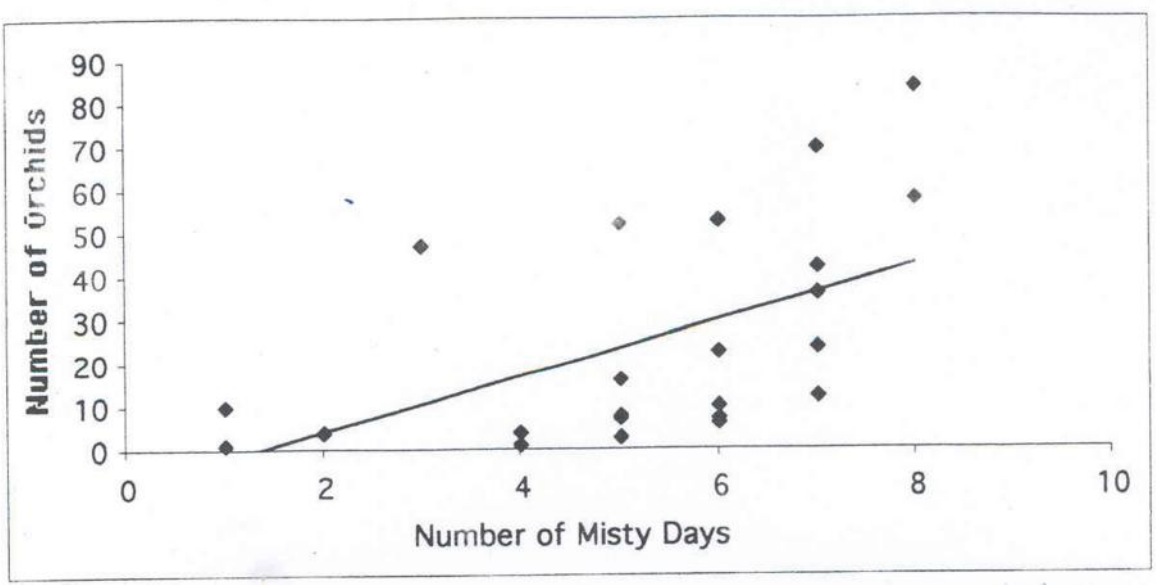

Figure 3. *Relation between total number of orchids and number of days in which mist was recorded at sample branches. A significant difference was correlated between the number of mist days and overall orchid abundance (Simple Regression, $R^2 = 0.316$, $P = 0.0043$, $n = 24$)*

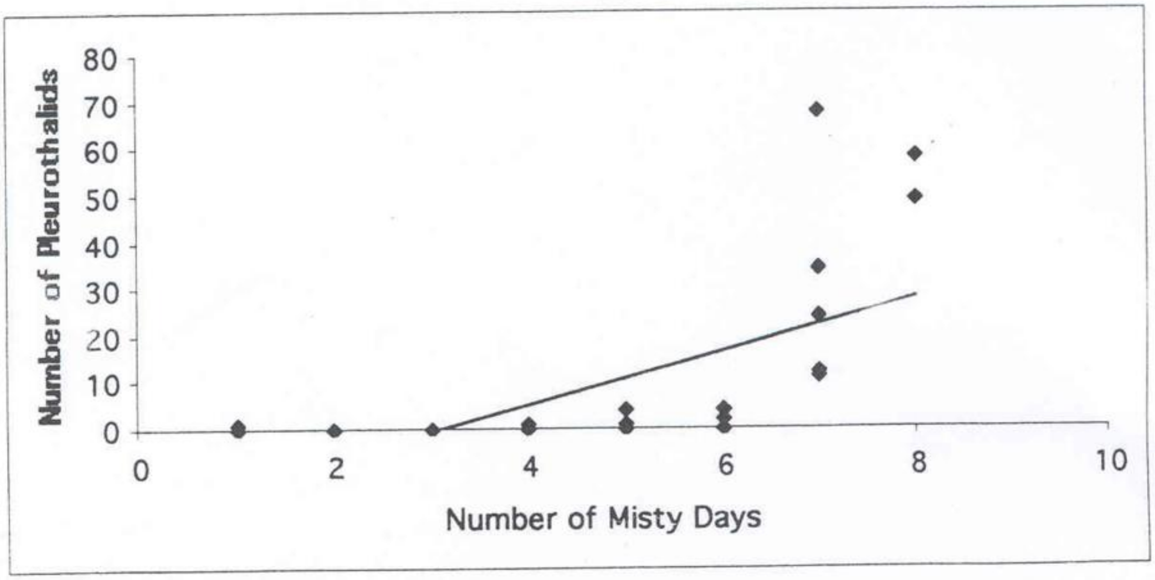

Figure 4. *Relation between total number of pleurothallids and number of days in which mist was recorded at sample branches. The total number of pleurothallids per branch were significantly affected by the total number of recorded mist days (Simple regression, $R^2 = 0.362$, $P = 0.0019$, $n = 24$).*

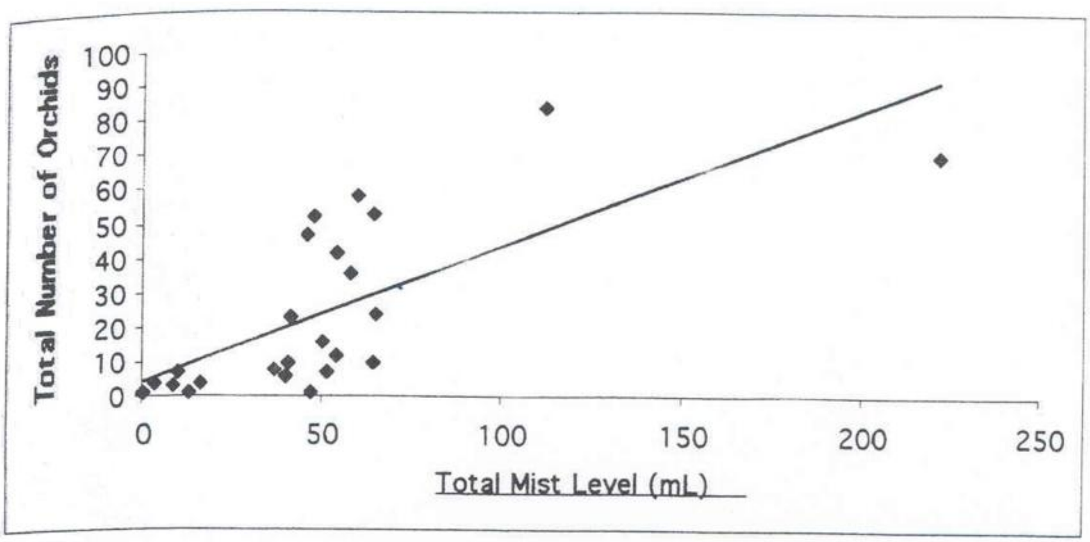

Figure 5. *A comparison between the total orchid count and the amount of mist collected for all branches. There was a significant difference shown between the levels of mist and total number of orchids (Simple regression, $R^2 = 0.501$, $P = 0.0001$, $n = 24$).*

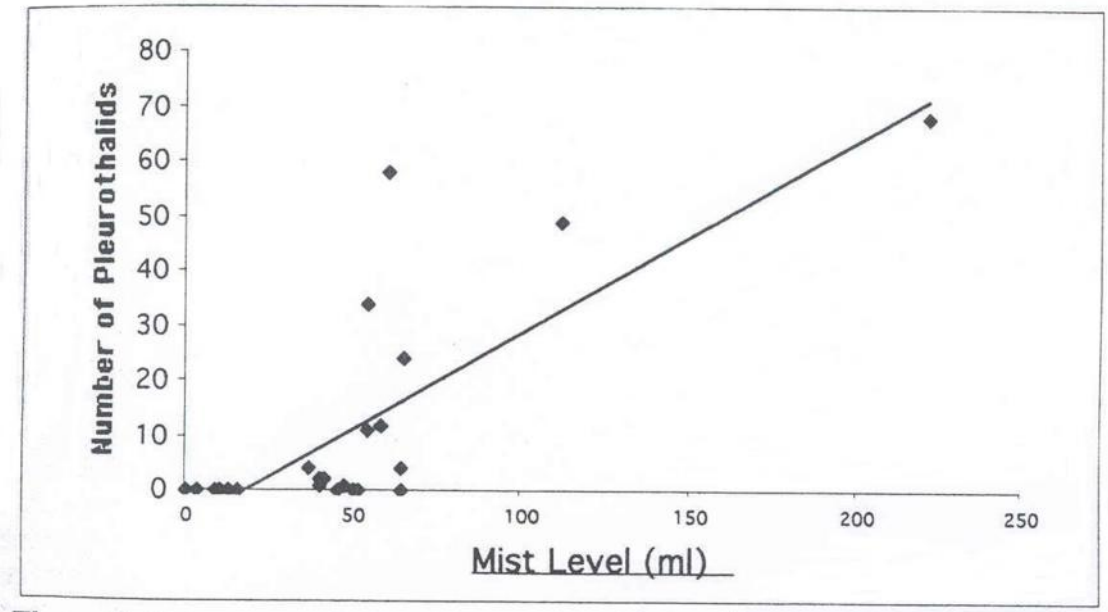

Figure 6. *A comparison between the amount of mist in mL and total pleurothallid abundance for all branches showed a significant correlation between higher recorded mist levels and higher abundance of pleurothallid orchids (Simple regression, $R^2 = 0.593$, $P < 0.0001$ $n = 24$).*