

Overview of the biology and ecology of *Lepanthes eltoroensis* Stimson: knowns and unknowns. Elvia Meléndez-Ackerman, PhD, Raymond L. Tremblay, PhD

Basic info on the biology and ecology of the orchid.

Small epiphytic plants with leaves that range 18-24 mm 7-9mm produce no more than 2 simultaneous flowers at the same time, the flowers survive are open on the inflorescence about 10 days and fruits that take up to 6wks to develop prior to dehiscing. Fruits have about ± 2000 seeds per fruit (but this needs to be rechecked). Seeds have no endosperm (thus no seed bank is expected) and seeds require an endophytic mycorrhiza to germinate (typical of all orchids). Fruit set in *Lepanthes eltoroensis* is infrequent. In one study, most individuals never had a fruit (83%) during the survey period of 16 consecutive months ending in January 1996; out of total of 148 adults plants which were followed, only 17 had one or more fruits (Tremblay 1996).

Evidence shows that the distribution of *L. eltoroensis* individuals on a host tree is not random. For example, within a tree most orchids appear to be most frequent along the north-west quadrant (Tremblay & Velazquez-Castro 2009, Figure 1). This is likely a result from the lack of moss cover in the southeast quadrant of the trees. In other local *Lepanthes* the presence of moss has been shown to be an important factor influencing orchid presence (*L. caritensis*, Tremblay *et al.* 1998) and abundance (Garcia Cancel *et al.*, 2013). Orographic rain /cloud formation at YNF is mostly influenced by the presence of the Trade Winds which run from the northeast. Tus, we hypothesize that microenvironmental differences across the bole of the tree hosts (North = wetter and cloudier, South = dryer and more light exposure) may develop as the result of processes related to wind direction. In turn, these microhabitat variation may lead to differential moss cover and perhaps variation in *Lepanthes* orchid densities across the tree trunks as well.

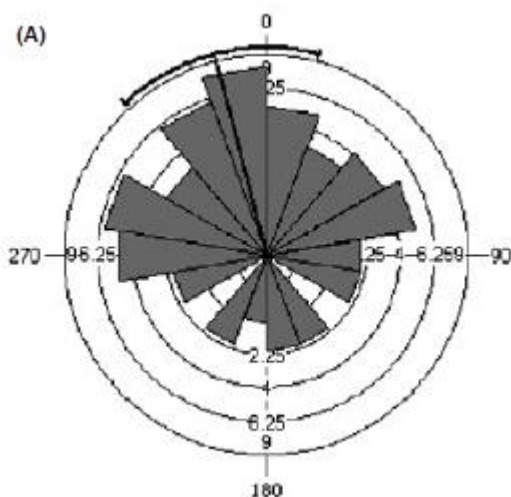


Figure 1. Graphical representation of the concentration of orchids on the bole of trees along the tradewinds trail and the El Toro trail of 58 trees where orchids were observed. The zero degree represents the magnetic north (From Tremblay & Velazquez-Castro 2009).

I. Potential risks

Here we discuss risks within the framework of general categories of population extinction (Botkin and Keller, 2014) namely 1) environmental risks (those related to population declines brought about by fast environmental changes (habitat change/climate change), 2) population risks (those brought about extremely low population sizes or allee effects, 3) genetic risks (negative effects brought about low genetic variability), 3) catastrophic risks (risk of population decline due to catastrophic disturbances).

1. Environmental Risks (Extreme Climate Variation and Habitat Change)

For Puerto Rico and the Caribbean climate projections indicate a 2 to 5 °C temperature increases by the year 2100, drier wet seasons and even drier dry seasons (Jennings et al., 2014 and references therein). Climate research for the Caribbean and PR also predicts an increase in the frequency of extreme events (e.g. heat waves, droughts, hurricanes) for the region (Jennings *et al.*, 2014, Méndez-Lázaro *et al.*, 2015). As a result, species in cloud forest ecosystems may be the most at-risk due to their sensitivity to moisture variation and limited options for migration. Thus, we hypothesize that predicted changes may have direct or indirect effects on *L. eltoroensis* based on what we know either about the species itself or from the biology of closely related species.

a. Direct Effects: Data From *L. rupestris* (a more common orchid) (Olaya-Arenas *et al.* 2009) showed:

- a) a negative correlations between the average number of seedlings and the number of dry days,
- b) between the average number of fruits and minimum average temperature (with 6 month lag), and
- c) between the average number of adults and the maximum temperature with a 1-yr response lag .

Given than life history stages are similar to *L. eltoroensis* and the species are closely related it is not unreasonable to assume that similar relationships may be found in *L. eltoroensis*, nor to assume that relationships may be even stronger in the later given its restricted distribution to very wet environments. We know that leaf area is positively correlated with the number flowers in a related species, *L. caritensis* (previously *L. sanguinea*: Agosto-Pedroza and Tremblay 2003, Figure 2). So the relationship between climatic variables and reproduction may result from factors that influence growth rate.

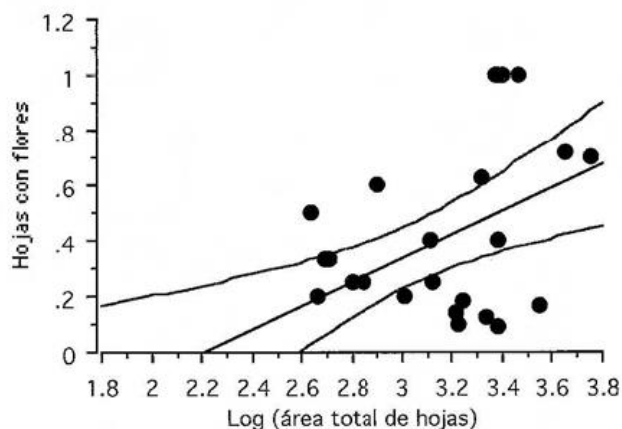


Figure 2: The relationship between total leaf area and flower production in *L. caritensis* (previously *L. sanguinea*).

Projected changes in hurricane frequencies (and associated habitat changes: increased light exposure, reduction in relative humidity) may negatively affect the growth rate of populations in *L. eltoroensis*. In natural experiments at LEF after Hurricane Georges, non-transplanted populations of *L. eloroensis* had negative growth rates while transplanted populations to better habitats within the forest had positive growth rates (Benitez-Joubert and Tremblay, 2003). We know from data from *L. rupestris* (a related species) populations at the Luquillo National Forest (LEF) that growth rates in *Lepanthes* are non-linearly related to light conditions (Fernandez *et al.*, 2003). Thus, to the extent that temperature changes influence cloud cover at LEF, growth rates in *L. eltoroensis* should be influenced as well through changes in light environments.

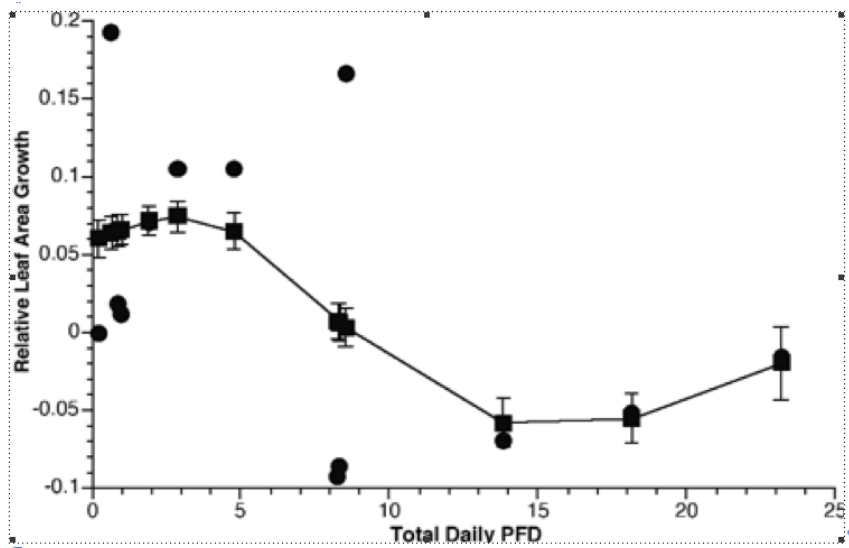


Figure 3: Relationship between the Photon Flux density (an index of photosynthetic light availability) and growth rate of individuals at a site. The relationship is clearly non-linear, excess light result in reduced growth rates. Figure not previously published but results mentioned in the Fernández *et al.*, 2003 paper.

b. Indirect Effects: Changes in bryophyte cover and composition because of climate change may have important implications to *L. eltoroensis*. Data from *L. rupestris* shows that orchid density was positively associated with bryophyte species richness (Garcia *et al.*, 2013). Other studies suggest that bryophyte cover can be important for growth and establishment in *Lepanthes* (Crain 2012 and references therein).

2. . Catastrophic Risks (Increase in Hurricane Frequencies)

Climate models predict an increase in the frequency of hurricanes for the Caribbean Area (Jennings et al., 2014). *Lepanthes eltoroensis* has shown an extremely narrow distribution which makes this species vulnerable to large scale disturbances. Known sites are limited to the El Toro Trail and the Tradewinds Trail located within the El Toro Wilderness Area of the El Yunque National Forest in Puerto Rico. However, it is not clear if the trail itself has any influence on the presence/absence of orchids on host trees or the abundance of orchids on a host tree. We know that there are more trees with orchids on the Tradewinds Trail than the El Toro Trail but it is unclear if the orchid is present at other areas within the El Toro Wilderness if self. Current work is re-assessing the distribution of this species and its potential for distribution expansion.

3. Population Risks (small population sizes, infrequent reproduction).

It is possible that *L. eltoroensis* may experience declining population growth related to **inherent** demographic characteristics and processes which may be influenced negatively by Environmental and Catastrophic risks. For example, in *L. eltoroensis*, opportunities for establishment may be limited by the fact that fruit production is limited. Less than 20% of individuals reproduce and most subpopulations (60% of host trees) have very few individuals (<15). Also, the distribution of number of individuals (seedling, juvenile and adults) vary enormously among trees (Tremblay & Velazquez-Castro 2009, Figure 4).

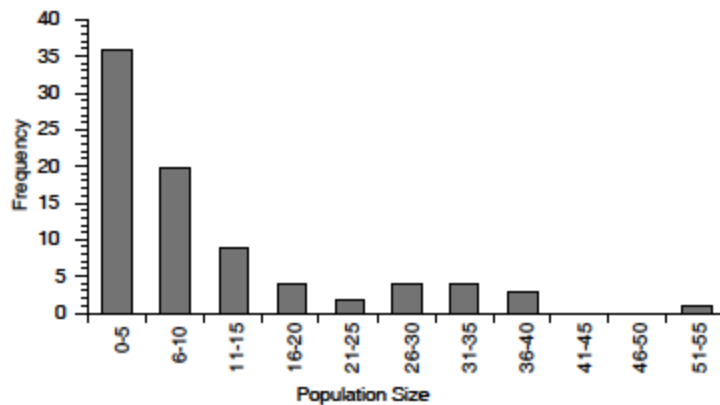


Figure 4. Frequency distribution of host trees as a function of the number of orchids they carry (ie. population size)

4. Genetic risks (due to the potential for low genetic variability)

- a. *Low effective population sizes* - Because the distribution of individual orchids is not random and given that reproductive effort is highly variable among individuals, it is expected that the effective population size (N_e) will be much smaller than the standing population size (N). Using three different methods for evaluating N_e for three *L. eltoroensis* populations, we found that N_e spans from 9% to 3% of the standing population. This basically suggest that the adult individuals behave as though they

comprise less than 9% of the standing adult population. Prior surveys of 148 adults showed that they behave as though there is less than 13 adult individuals in the population (Tremblay 1996, Tremblay and Ackerman 2001). Effective population size is influenced by the lifespan of individuals, using an alternative method for estimating life span, the preliminary results for *Lepanthes eltoroensis* is that the demographic lifespan ranges in the order of 30 to 50 years (Tremblay 1996). Thus this suggests that individuals that attain adulthood tend to survive many years (similar to old growth trees). However, there is an extremely large variance in survivorship, thus for every individual that attains adulthood, many many seedling and juveniles die. Those that survive have an opportunity to contribute offspring to the next generation, however at the same time it decreases the likelihood of genetic diversity in the population as a whole because very few individuals are responsible for the majority of seeds produced. Variance in life span of *Lepanthes* varies by stage and increases as they reach later stages (Tremblay 2000, Rosa-Fuentes & Tremblay. 2007).

- b. *Low gene flow estimates* - Estimates of gene flow in *Lepanthes eltoroensis* among populations/demes/groups of individuals on trees seems to be limited (Tremblay & Ackerman 2001). Using two different estimates of gene flow both estimates were below two, which suggest there is less than two effective migrants per generation (the effective generation of the orchid) namely $Nm = 1.54$ (Slatkins method) and Nm (Wright) = 0.89). Thus in both cases, values suggest that most mating may be among individuals within a host tree, thus potentially resulting in high inbreeding which in turn could lead to low genetic variability and inbreeding depression. On the other hand, this species is likely an obligate cross pollinated species as other *Lepanthes* have been demonstrated to be (Tremblay, Pomales-Hernández and Méndez-Cintrón 2006), which is a mechanism to reduce inbreeding.

II. Preliminary estimates of extinction probabilities by R. L. Tremblay using old census data. (NOTE all analysis done below are new and not published and not to be used to develop recommendations for species reclassification).

Here are preliminary simulations of extinction time for three populations of *Lepanthes eltoroensis* surveyed monthly from for 16 months ending in January 1996 using data from Tremblay (1996). The data was used to simulate population growth rates for each population (Figure 5). Results show that the mean monthly lambda (intrinsic population growth rate) for each site is below 1 (0.985, 0.998, 0.987). However, when converted to yearly rates the lambda

are substantially lower than 1.00 (0.834, .865, .855). In ALL populations the proportion of plants (plant density) for each of the different stages would be expected to decrease except in Figure 5b, (top right) where adults seem to have a higher survivorship at that particular site. Overall, there is insufficient recruitment for population stability. Thus, using these preliminary results and the traditional approach of estimating the parameter in the models one would predict extinction in less than 25 years (Figure 5).

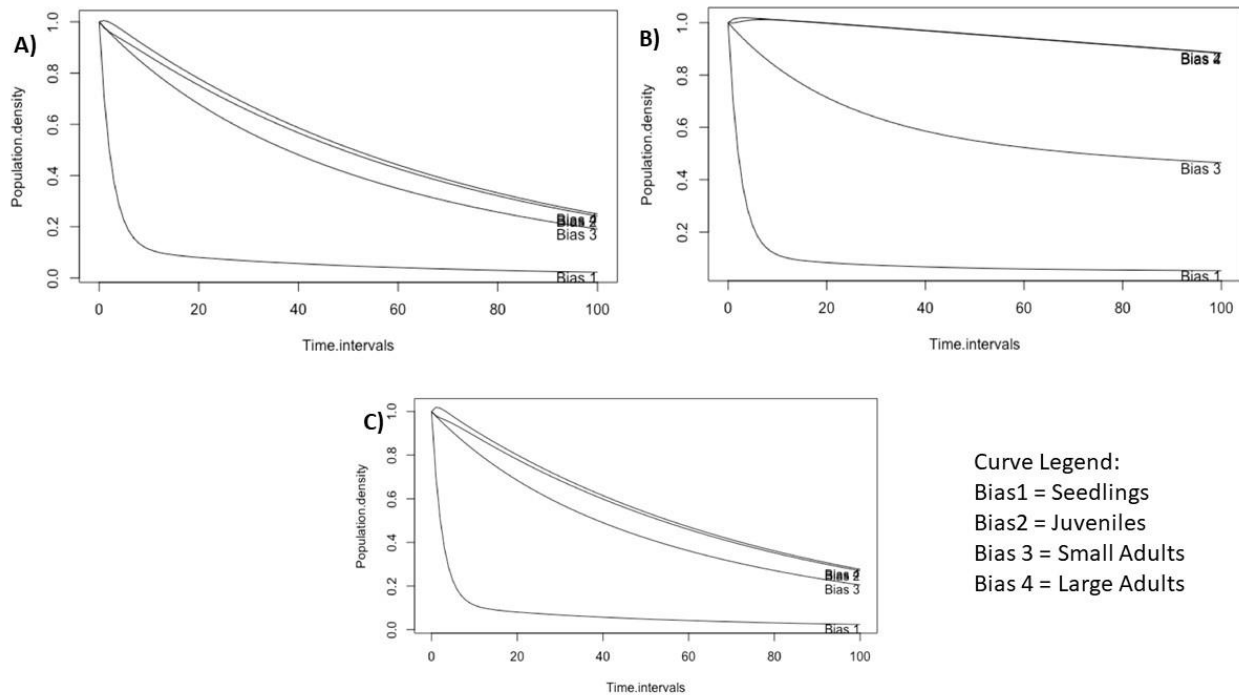


Figure 5. Modelled plant density of different demographic stages of *L. eltoroensis* as a function of time intervals for three populations. Each time interval represents one months with 12 representing one year and 100 representing ~ 8 years. The “y” axis represents the number of individuals of each stage (plant density) at the beginning of the survey, thus 100% of the individuals of each stage were alive at time 1.

These simulations, however, must be taken with caution for two reasons:

- First, the data used to calculate some transition probabilities had problems with small sample sizes.
- Second, the traditional approach for doing population dynamics analysis using matrices assumes that the parameter estimates are very close to “reality”.

That may be acceptable for large sample size from large populations, but it is unlikely to be acceptable for small sample size (typical of rare and endangered species). Our working team is developing new method modelling methodology to address this issue.

III. Recommendations based on experience

- Collect long-term data (at least two years) to evaluate demographic transition probabilities effectively and in a way that can be related to climate and habitat (moss, aspect location, light environment etc.) variability.
- Re-localizing orchids from fallen trees to after a hurricane can have a positive impact on survivorship. (Benitez-Joubert and Tremblay 2003).
- New populations can be established by relocating the orchids on non-occupied (by orchids) trees (preliminary analysis confirms this, not published).
- However, to increase survivorship of the orchid it is **imperative** that the bark holding the orchid be transferred also (Do not yank the orchid from the tree), use a knife and remove the plant with the bark.
- Orchids on the fallen trees all die, starting with the smallest one (within a few months), but even the larger adults succumb later on. (Information gathered when locating plants after Hurricane Georges).

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