

marking ants, and doing trials simultaneously or at night.

Table 1: Recruitment of *P. clavata* to honey cache at La Selva Research Station, Costa Rica.

Nest & Site#	Distance from nest (m)	Time started	Ant upset by marking	#min after start that ants arrive	#ants that come	Site on trail (Y/N)	Comments
1:1	1.5	0945	no	30	28	yes	no control cache
1:2	2.5	1126	yes	300	19*	no	cache not checked in between times
1:3	4	1630	no	120	2	no	marked ant went to #3 trails merged
1:4	4.4	1630	no	39	7*	no	control site found 3 ants
1:5	5	0930	no	45	10*	no	control found 4 ants
2:8	1	0957	yes	75	1	no	4 ants at control
2:3	1.3	1033	yes	420	3	no	
2:5	3	1051	yes	—	—	no	not revisited
2:6	3	1755	no	15	5	yes	control not found
2:9	6	1202	yes	—	—	no	did not pause at honey
2:2	9	1023	yes	90	20	yes	very well used trail
2:7	14	0955	yes	—	—	no	another ant passed but did not stop
2:1	14.2	1011	yes	320	6*	no	well used area, marked ant not present
2:4	15	1044	yes	—	—	no	
2:10	16	1750	yes	—	—	no	ant only came to within 2cm of honey

Literature Cited

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NYCTINASTY IN PENTACLETHRA MACROLOBA

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Abstract (D.G.)

We studied the regulation and location of nyctinasty (movement of plants through the day) in Pentaclethra macroloba. Sixteen seedlings at the La Selva Field Station, Costa Rica, were subjected to several opposing light regimes.

We verified that the cycles of daylight regulate the timing of opening and closure of P. macroloba leaves. Seedlings in all treatments followed the new light regime within 1.5 days. Also, in seedlings that had half of the leaves subject to a different light regime, half of the plant adapted to the new cycle. The mechanism that controls leaf movement is therefore located locally within the leaf. The seedling in constant dark maintained a cycle of leaf movement, but it fell out of phase with outside conditions. The leaves of the seedling in constant light remained open after 12 hours.

An internal clock cued by changes in light intensity appears to be very important for the timing of leaf movement. The leaves normally open just before daybreak and close before dusk. We hypothesize that the change from light to dark at the end of the day is critical for calibrating the timing of leaf movement for the next day.

Introduction (G.K.)

Pentaclethra macroloba is a leguminous tree that comprises a major part of the La Selva canopy. Its bipinnate leaves are opened during the day but close completely at night. The resting position of the leaves is closed; the trees have to expend energy to keep the leaves open (Assman, 1982). The leaves are only open when it is energetically worthwhile, when it is light and the leaves are able to photosynthesize. The effect of this system is that at night the exposed leaf area is greatly reduced. The system possibly evolved to reduce dessication due to unnecessary nighttime transpiration and/or to reduce leaf losses to nocturnal herbivores.

This study was designed to identify and describe the mechanism that regulates the nyctinasty in P. macroloba. We specifically wanted to establish: (1) whether the light/dark regime that a plant is exposed to is the critical factor in regulating leaf movements, and (2) whether leaf movement is synchronized throughout the plant or is regulated by each individual leaf. In addition, we hoped to be able to describe the workings of the system in some greater detail from the trends observed over the course of several days.

Methods (G.Y.)

We potted 16 *Pentaclethra macroloba* seedlings from the arboretum at La Selva Biological Reserve, Costa Rica, and placed them inside the old lab building, under conditions of constant fluorescent lighting and 77°F air conditioning. Each seedling ranged in height from 20 to 40cm; 2 of them had 3 leaves, 10 of them had 4 leaves, and 4 of them had 5 leaves. They were all less than 3 years old.

We randomly established one control and 3 treatment groups, each group consisting of 4 seedlings. The control seedlings were exposed to light from 0600 to 1800 and to darkness from 1800 to 0600. Treatment one seedlings were exposed to darkness from 0600 to 1800 and to light from 1800 to 0600. The last two treatments contained exposing half of each plant to light, the other half of each plant was kept in darkness, enclosed in plastic which was wrapped in duct tape. For Treatment two seedlings, the light exposed half was switched at 0600 and 1800. For Treatment three seedlings, the exposed half was switched at 1200 and 2400.

All seedlings were first placed in the lab on Feb. 6 at 1200, at which time we began Treatment three. We began the control and Treatments one and two at 1800. Every three hours we recorded for each seedling the average angle between leaflets, and we recorded the light and dark halves of seedlings separately for Treatments two and three. We concluded our experiment on Feb. 9 at 2400.

Results (D.G.)

Treatments one, two, and three all show a shift in the timing of opening and closing of leaflets towards the new light regime. In all cases, after 35hrs. the treatment plants are on a cycle that is different from the control. For treatment one, a 12 hour shift in the light regime produced an approximately 9 hour shift in the cycle of opening and closing leaves. In treatments two and three, half of the plants became out of phase with the other half. The results from treatment two are very similar to the control and treatment one, which had no intra-plant variations in light regime (Figure 1, top and bottom). Therefore, we have concluded that the timing of photoperiodism in *P. macroloba* is dependent on a light sensitive mechanism localized within the leaf. Figures 1 and 2 contain the data for all the treatments and the control.

The seedling left in constant dark maintained nyctinastic cycles however; it changed its cycle to 20 hours open and 4 hours closed. The seedling left in constant light never closed significantly after 12 hours in light.

Discussion (T.G., G.Y.)

Our experiment demonstrated that the nyctinastic cycles of *P. macroloba* were affected by light/dark regimes. The plants altered their cycles to match the new light/dark regimes. They had their leaves open during hours with light and closed for hours of darkness. This system could be beneficial to the tree in the following ways: 1) saving on energy required to keep the leaves open; 2) reducing water loss through transpiration at night when photosynthesis cannot occur; 3) prevention of nocturnal herbivory by not having all the leaves open and available to the herbivores. On the other hand, the nyctinasty could be a non-beneficial characteristic, remaining from a time when such a characteristic may have been an adaptation to a different environment.

The fact that we were able to manipulate selected leaves to follow light/dark regimes opposite those of other leaves on the same seedling indicates that nyctinasty in *P. macroloba* operates on a local level, each leaf independent of other leaves in the same tree. Because these trees can grow to be over 30m tall, leaves functioning in response to their own environmental conditions could be beneficial, as different areas of the tree can be subject to very different light conditions. For example, understory leaves would not be required to remain open when only canopy leaves are receiving light.

Our results were not entirely as expected and defied simple explanation. Control leaves opened in expectation of light and closed in expectation of darkness. In leaves kept in constant darkness, the opening/closing cycle continued to function almost perfectly; in leaves kept in constant light, the cycle was rapidly abandoned. Thus, the presence of light was not the immediate cue which opened leaves, nor was it necessary to maintain the cycle.

The following model is derived from our results. [Note that our model refers to complete darkness, not relative darkness such as that experienced during a midday rainstorm.]

- 1) In the normal cycle, leaves begin to close before the end of 12 hours of darkness and begin to close before the end of 12 hours of light (see Figure 1, Control).
- 2) The change from light to darkness cues the leaves to stay on the normal cycle.
- 3) If a light period lasts longer than 12 hours, leaves which have closed on schedule open prematurely remain open, and abandon the normal cycle less than 6 hours later (see Figure 2, Bottom, seedling in constant light).
The first moment of darkness resets the leaves on an almost (perfectly normal) cycle; leaves rapidly begin to close, and in less than 12 hours begin to open again in expectation of light (see Figure I, Treatment one).
- 4) If a period of darkness lasts longer than 12 hours, the leaves maintain a normal cycle which gradually shortens and falls out of synchrony with outside conditions (see

Figure 2, Bottom, seedling in constant darkness).

Our model may accurately predict the behavior of *Pentaclethra macroloba* in nature, but we did not directly test this. A complex biochemical mechanism, consisting of an internal clock influenced by phytochromes (Raven et al., 1981), could potentially control a nyctinastic mechanism in a manner consistent with our model. Such biochemical mechanisms are poorly understood, but further research may shed some light on nyctinasty in *Pentaclethra macroloba*.

Figure 1 Degree of secondary leaflet closure with varying light regimes in *Pentaclethra macroloba* (chart between figures applies to both top and bottom).
Top: Average of four treatment seedlings and four control seedlings.
Bottom: Half of seedling was subjected to opposing light regimes compared to the other half. Averages of three seedlings.

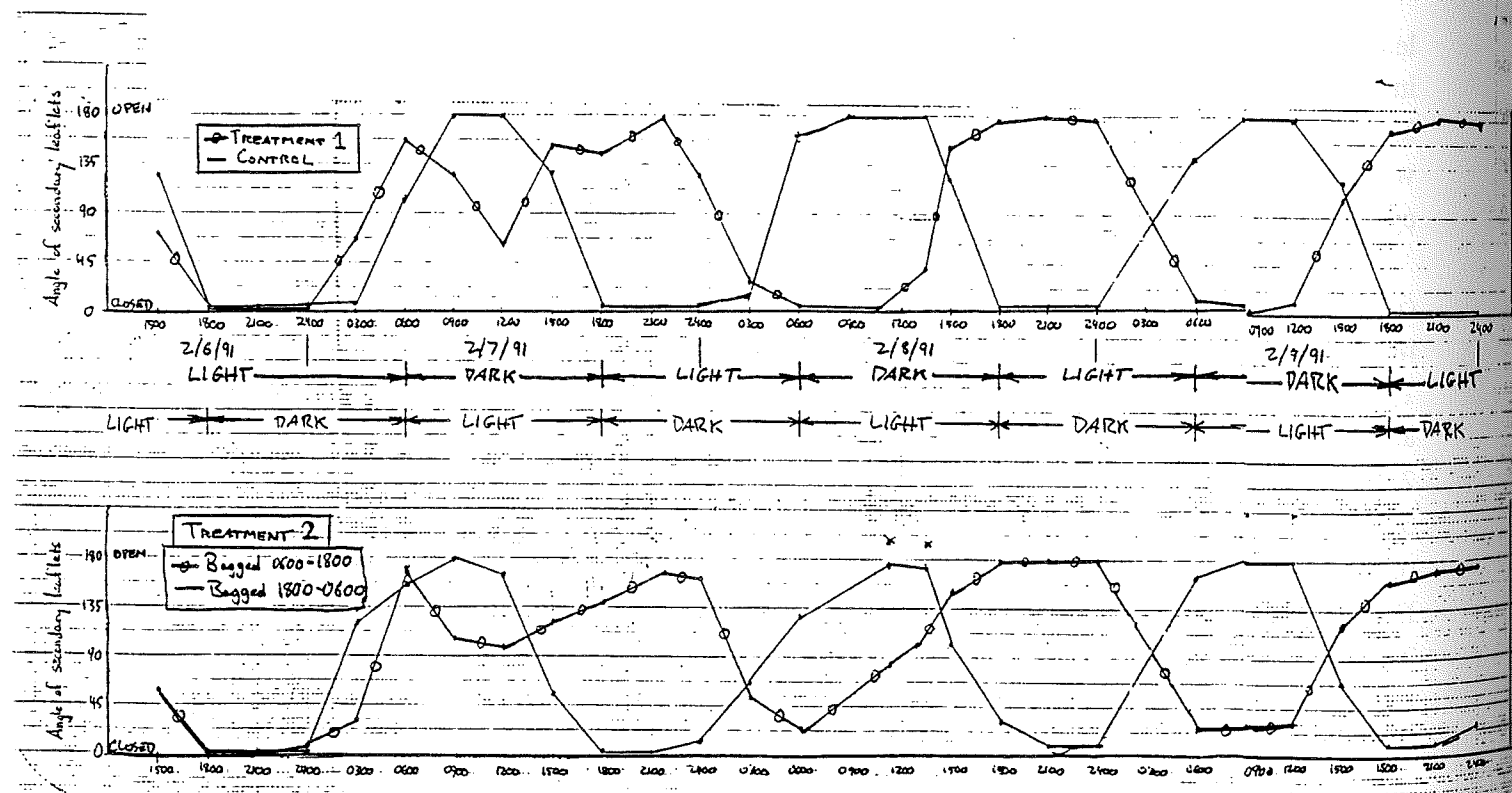
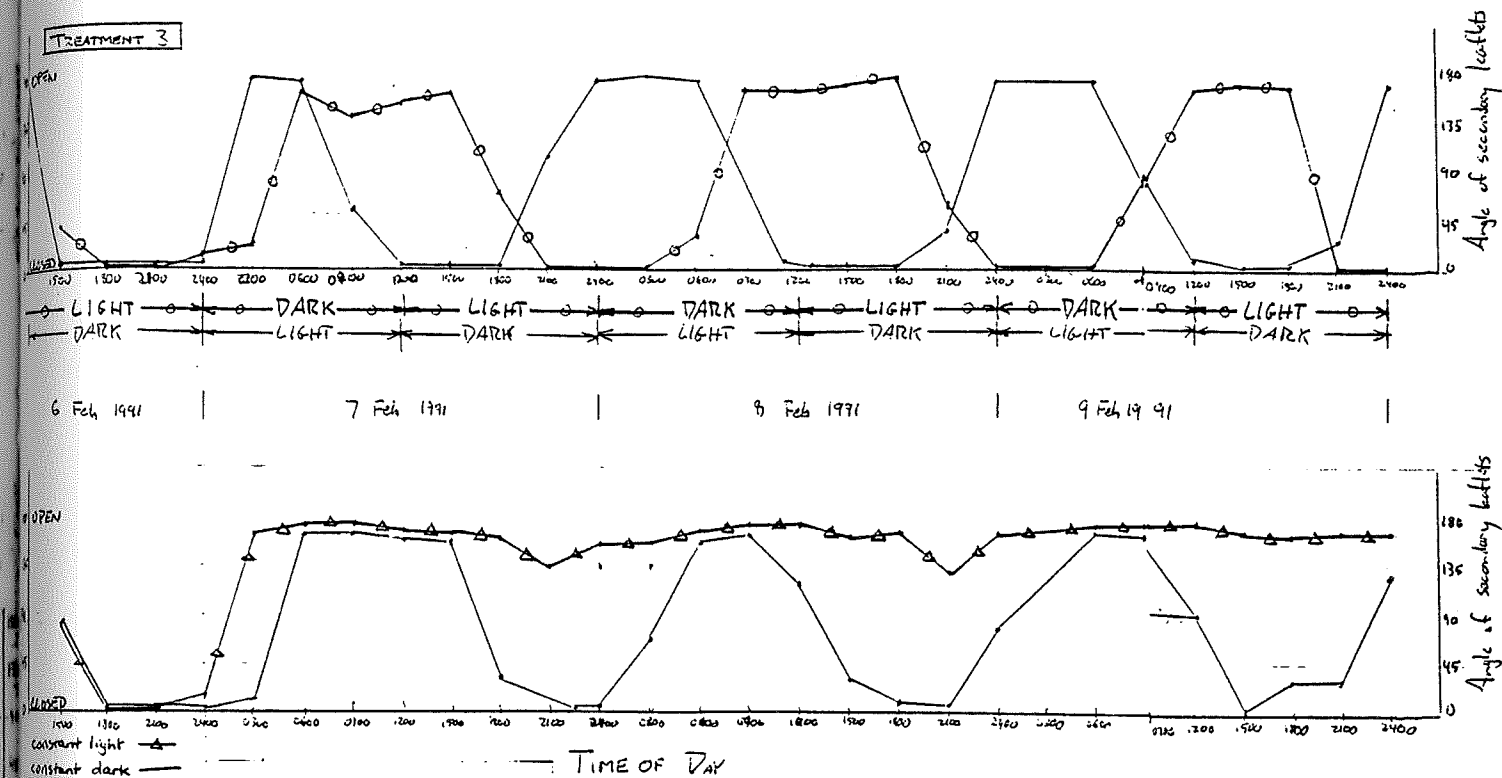


Figure 2 Degree of leaf closure in *Pentaclethra macroloba* in response to varying light regimes. Top: Half of plant out of phase with other half. Average of four seedlings. Bottom: One seedling in constant light and one seedling in constant dark.



Literature Cited

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- Raven, P.H., Ray Evert and Helena Curtis, *Biology of Plants*, 3rd Edition, Worth Publishers, USA, 1981.