Young-Leaf Anthocyanin and Solar Ultraviolet

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ABSTRACT

For six tropical rainforest species, young leaves produced on rapidly flushing shoots had markedly lower reflectance in the UV-B region than did mature leaves and contained higher levels of anthocyanins and total phenols. Progressive changes in these characteristics provide empirical support for an earlier suggestion that anthocyanins in flushing shoots of tropical trees have adaptive value through their ultraviolet absorption.

TRANSIENT CYANIC COLORATION of young leaves is more frequent and usually more intense among woody species of the humid tropical rainforest than among those of other habitats (Richards 1952). Hypotheses concerning possible function of young-leaf anthocyanin include the suggestion (Bünning 1947, cf. Richards 1952:79) that the short wavelength absorption of these compounds protects young leaves against deleterious ultraviolet (UV) radiation. We present some observations on changes during leaf development which support this hypothesis.

The six species chosen (table 1) are part of the forest flora of the Malay Peninsula and are either emergent trees or are found in well-lighted habitats. In the Kuala Lumpur area, all tend to produce frequent flushes of young leaves. All were growing on or near the University of Malaya campus so leaf material could be brought to the laboratory within minutes of being collected. Reflectance of the adaxial surface was measured on the total fluorescence attachment of a Beckman Acta V spectrophotometer.

If UV-screening by anthocyanin was a reality, then one might expect other common but colorless secondary compounds with strong UV absorption to be also involved. We therefore determined concentrations of total phenols as well as anthocyanin in ethanolic extracts of the leaves.

Reflectance spectra for young (5-day-old) and mature leaflets of *Pometia pinnata* (fig. 1) show that the mature leaflet has a higher reflectance at all wavelengths. The marked increase above 700 nm is typical of all leaves. The difference in reflectance is most marked in the short-wave UV, the young leaflet lacking the sharp increase toward shorter wavelength shown by the older leaflet. Other measurements were confined to 287 nm in the critical area, and 500 nm in the middle of the low-reflectance visible range. Values as the leaflet developed (table 2) showed that a large increase in UV reflectance occurred at about the same time (between day 7 and day 14) as a sharp decrease in anthocyanin concentration. Data for all species (table 1) show reflectance in flushing leaves lower than in mature leaves and that, usually, as well as disappearance of anthocyanin there is a marked decrease in total phenols as the leaf matures. The high level of anthocyanin remaining in the mature leaf of *Grewia tomentosa* was somewhat surprising, for it is normally masked by the tomentose nature of the leaf.

The changes in reflectance during leaf development probably result from development of the cuticle and of intercellular spaces within the leaf, the latter being critical for determining leaf reflectance (Allan, Gausman, and Richardson 1973). The changes suggest marked differences in penetrability of the leaf by UV radiation, being higher during the early period of leaf development when the internal tissues are more susceptible to irradiation. This susceptible period more or less coincides with the presence of increased amounts of strongly UV-absorbing polyphenols and anthocyanins. Thus, there is an empirical indication that these compounds do indeed have adaptive value against UV insolation.

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TABLE 1. *Differences in reflectance and in anthocyanin and phenol levels between young and mature leaves of six rain-forest species.*[a]

Species	Family	Habit	Leaf	Reflectance 287 nm	Reflectance 500 nm	Anthocyanin	Phenol
Pometia pinnata Forst.	Sapindaceae	large tree	young[b]	.16	.19	1.6	11.0
			mature[c]	.62	.49	0.0	5.2
Lagerstroemia flos-reginae Retz.	Lythracene	tree	young	.22	.27	2.4	5.5
			mature	.71	.63	0.6	3.7
Mesua ferrea Linn.	Guttiferae	large tree	young	.38	.27	3.2	8.7
			mature	.90	.72	0.1	2.8
Grewia tomentosa Juss.	Tiliaceae	small tree	young	.06	.16	1.1	7.5
			mature	.26	.22	1.0	7.1
Tetracera scandens (L.) Merr.	Dilleniaceae	woody climber	young	.10	.18	6.1	1.4
			mature	.36	.28	0.2	0.7
Ficus viridicarpa Corner	Moraceae	tree	young	.25	.27	3.4	4.6
			mature	.42	.35	0.1	1.5

[a]Each result is the mean of three determinations. Reflectance values are given relative to that of a freshly deposited MgO layer as 1.0. Anthocyanin was determined by the peroxide method and total phenols by the Folin-Ciaccolteau reagent (Ribereau-Gayon 1972), and results are given as absorbance units for extracts from 0.1 g dry weight of leaf per 100 ml of solution.

[b]About day 5 for most species.

[c]From previous flush on same stem.

TABLE 2. *Changes in anthocyanin content and reflectance of developing leaflet of* Pometia pinnata. *All results mean of three samples. Units described in table 1.*

Time (day)	Length (mm)	Anthocyanin	Relative Reflectance 287 nm	Relative Reflectance 500 nm
1	12	2.4	—[a]	—[a]
5	38	3.7	0.05	0.08
14	75	3.1	0.04	0.06
21	135	0.8	0.71	0.63
28	190	0.5	0.95	1.09
35	200	0.4	1.04	1.09
>100	200	0.0	1.05	0.97

[a]Measurement not practicable.

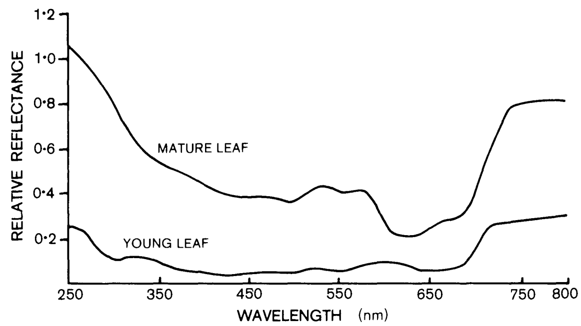

FIGURE 1. Relative reflectance of 5-day-old developing leaflet and mature leaflet of *Pometia pinnata.*

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