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FLORAL PIGMENTS AND NECTAR CONSTITUENTS IN  
THE GENUS *PUYA* (BROMELIACEAE)

Ron Scogin and C. Edward Freeman

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INTRODUCTION

The genus *Puya* (Bromeliaceae) consists of 168 species ranging generally along the Andean corridor of western South America (Smith and Downs 1974). The subgenus *Puya* contains seven taxa which are characterized by the presence of compound inflorescences in which the apical portion of the branches is sterile. The sterile branch ends are widely regarded as an adaptation to provide convenient feeding stations for perching, nectarivorous birds, which act as the principal pollinators of these taxa (Johow 1898). The subgenus *Puyopsis* contains the remaining taxa which lack perches on the inflorescence axis and, in the few cases reported, appear to be principally pollinated by hummingbirds. The present study was undertaken to determine whether a correlation exists between principal pollinator type (and, inadvertently, taxonomy) and either nectar chemistry or floral pigmentation.

MATERIALS AND METHODS

Nectar and floral materials were collected from plants in cultivation at the Huntington Botanic Garden, San Marino, California.

Floral pigment extraction, purification, and identification were according to the methods of Harborne (1967).

Nectar volume was measured directly by uptake into graduated pipettes. Nectar-sugar concentrations were determined using a hand-held refractometer. Brix values were converted to solution volume values (g sugar per 100 ml of solution) using a CRC Handbook table (pg. D-218, 53rd ed.).

Nectar-sugar composition was determined by quantitative high-performance liquid chromatography using the methods of Freeman et al. (1984). A refractive-index detector was used and the solvent was acetonitrile : water (80:20 v/v) at a flow rate of 2.0 ml/min.

RESULTS AND DISCUSSION

*Floral pigments.*—The unusual, malachite-green floral coloration of *Puya alpestris* prompted an examination of floral pigments in *Puya*. For comparison, additional green-flowered and purple-flowered species were also studied.

A delphinidin glucoside with uncommonly low  $R_f$  values in organic sol-

Table 1. Nectar properties of *Puya* species.

Species	Sugar concentration (%)	Nectar volume (ml)	Energy content (cal/fl)	Sugar* composition (% F-% G-% S)
Subgenus <i>Puya</i>				
<i>P. alpestris</i> (Poeppig) Gay	8.2	0.41	131	41-51-8
<i>P. chilensis</i> Molina	12.6	0.16	74	44-49-7
Subgenus <i>Puyopsis</i>				
<i>P. floccosa</i> (Linden) E. Morren ex Mez	33.8	0.06	79	21-26-53
<i>P. venusta</i> Philippi	22.7	0.06	53	27-32-41
<i>P. spathacea</i> (Grisebach) Mez	21.6	0.02	17	15-14-71
<i>P. coerulea</i> Lindley	23.5	0.04	37	17-23-60

\* Percentage by weight of fructose (F), glucose (G), and sucrose (S).

vents and high values in aqueous solvents was determined to be the primary anthocyanin in petals of all six *Puya* taxa examined. This anthocyanin was identified as delphinidin 3,7,3'-triglucoside based upon its chromatographic properties (in four solvents) and spectroscopic characteristics (Yoshitama and Abe 1977). Delphinidin 3,7,3'-triglucoside has previously been reported only as its tricaffeoyl derivative, cinerarin, from *Tradescantia reflexa* Rafin. (Yoshitama, 1978), *Senecio cruentus* DC. (Yoshitama et al. 1975), and *Gibasis consobrina* D. R. Hunt (Stirton and Harborne 1980). Deacylated cinerarin was characterized by Yoshitama and Abe (1977) and agrees in all aspects with the *Puya* anthocyanin.

The commonly occurring 3-glucosides and 3,5-diglucosides of cyanidin and delphinidin were also found distributed among *Puya* species. Delphinidin 3,7,3'-triglucoside, delphinidin 3-glucoside, and delphinidin 3,5-diglucoside were present in the petals of all six *Puya* species. Cyanidin 3-glucoside and cyanidin 3,5-diglucoside were present in the sepals of *P. spathacea* and *P. coerulea*.

*Nectar properties.*—The quantity, sugar concentration, and sugar composition of nectars from the six *Puya* species examined are presented in Table 1.

A clear distinction is to be noted with respect to nectar-sugar concentration and composition between the two taxa principally pollinated by perching birds (*P. alpestris* and *P. chilensis*) and the remaining species. The nectar of taxa adapted to visitation by perching birds is more dilute than that of taxa visited by hovering birds (or insects). A similar, although less dramatic, difference in nectar-sugar concentrations was reported by Pyke (1980) between hummingbird-visited flowers and those visited by perching, Australian honeyeaters.

The sugar composition of nectar produced by *Puya* species visited by perching birds is sucrose poor (average sucrose/hexose ratio of 0.07), whereas

the nectar of hummingbird-visited species is sucrose rich (average sucrose/hexose ratio of 1.44). A similar dichotomy with respect to nectar-sugar composition between flowers visited by different types of birds has been previously noted and examined extensively within the genus *Erythrina* (Baker and Baker 1983).

The energy content per flower among *Puya* species is not reliably diagnostic for the type of bird visitor, although the flowers adapted for perching birds tend to have larger caloric rewards. This is consistent with the results noted by Cruden et al. (1983) who compared the energy content of hummingbird-visited flowers with sunbird-visited flowers and by Pyke (1980) who compared hummingbird-visited flowers with honeyeater-visited flowers.

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