



# A survey of cyanogenesis in palms (Arecaceae)

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## Abstract

We surveyed leaf material of 545 individual palms representing 108 genera and 155 species for cyanogenesis using the Feigl-Anger test. We detected HCN production in only two species of one genus, *Drymophloeus*. Additional smaller surveys of shoot meristems and roots revealed cyanogenesis only in the shoot meristem of one species of *Dypsis*. Our results indicate that cyanogenesis is rather rare in the family. © 2000 Elsevier Science Ltd. All rights reserved.

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## 1. Introduction

Cyanide production is a widespread phenomenon in plants, with cyanogenic compounds present in many species across the plant kingdom (Hegnauer, 1977). These compounds are often ecologically significant and can be hazardous to human health when they occur in crop plants. Although cyanogenesis has arisen independently in several lineages, it is a good taxonomic marker for several groups of plants (e.g., Passifloraceae; Olafsdottir et al., 1989).

Cyanogenic plants typically store cyanide in the form of cyanogenic glycosides. These plants release HCN only after tissue damage brings apoplastic  $\beta$ -glucosidases into contact with vacuolar glycosides. Some phenotypically acyanogenic plants

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contain cyanogenic glycosides but lack appropriate  $\beta$ -glucosidases. In these, HCN can be liberated with the addition of exogenous enzyme.

There is little information on the frequency and taxonomic distribution of cyanogenesis in palms. Gibbs (1974) and Thomsen and Brimer (1997) did not detect cyanogenesis in their surveys of 13 species in three subfamilies and 8 species in two subfamilies, respectively. In contrast, Dahlgren et al. (1985) listed the presence of cyanogenic compounds as a common feature of the palm family. Quisumbing (1951) summarized reports by Herbert (1922) and Kalaw and Sacay (1925) of HCN production in the leaves of 11 species representing four subfamilies of palms. Kaplan et al. (1983) reported cyanogenesis in an additional palm species.

The question of whether cyanogenesis is present and taxonomically widespread in the palm family prompted our survey of 155 species. While this survey represents only a small number of the ca. 2500 species in the family, it includes representatives from all six subfamilies recognized in the most recent family-level classification (Dransfield and Uhl, 1998).

## 2. Materials and methods

Palms cultivated at Fairchild Tropical Garden and the Montgomery Botanical Center (Miami, FL), as well as in two private collections, were the sources of plant material used in this study. Samples collected from 548 individual palms were screened for cyanogenesis and for the presence of cyanogenic glycosides. These included 107 genera, sampled from all six palm subfamilies. For each accession, up to ten individuals were tested, depending on the number of plants available.

Production of HCN was detected in each sample qualitatively, using Feigl–Anger test strips. These were prepared as described by Brinker and Seigler (1989). A 1% solution (w/v) of tetrabase [4,4' methylenebis(*N,N*-dimethylaniline), Sigma M-6527] in chloroform was mixed with an equal volume of 1% copper ethylacetoacetate in chloroform. Strips of Whatman No. 1 filter paper were soaked in this mixture for a few minutes, and were then left to dry. When exposed to HCN, Feigl–Anger strips undergo a color change from very pale green to bright blue.

Approximately 50 mg of fresh leaf tissue were collected from each plant sampled. The tissue was cut into several pieces and placed in the bottom of a 5 mL glass shell vial. A few drops of toluene were added to lyse the cells, and each vial was capped with a Feigl–Anger test strip suspended above the tissue. Test strips were checked after 24 h at room temperature. Tissue from *Passiflora suberosa* L., a species known to be cyanogenic (Olafsdottir et al., 1989), was used as a positive control.

To samples that tested negative, we added a mixture of  $\beta$ -glucosidases. The solution used for this second test was a crude enzyme preparation isolated from snails (Sigma G-7017), diluted to a concentration of 2000 units/mL in 0.1 M phosphate buffer (pH 5.0). Approximately 50  $\mu$ L of enzyme solution were added to each vial, and test strips were checked after incubation at room temperature for 24 h. Amygdalin (Sigma A-6005), a cyanogenic glycoside isolated from apricot seeds, was used as a substrate to test the activity of the glucosidases.

We conducted a smaller survey of palm shoot meristems (palm hearts) and a survey of tips and sections of mature roots. Sampling was limited by the number of palms available for destructive harvesting. The tests for cyanogenesis were performed as described for leaf tissue, using approximately 100 mg of tissue for each test and approximately 100  $\mu$ L of glucosidase solution.

### 3. Results and discussion

The results of our survey of leaf material are shown in Table 1. Of 167 accessions tested, we detected cyanogenesis in only five. We found two species of *Drymophloeus* (Arecoideae: Ptychospermatinae) that have cyanogenic activity in the leaves. All samples of seedling and mature *Drymophloeus pachycladus* were cyanogenic, and two mature individuals of *Drymophloeus subdistichus* were also found to be cyanogenic. Less consistent results were obtained from a sample of *D. subdistichus* seedlings (S-217-97) which are the offspring of one of the cyanogenic adults (76-335 A). Although all ten seedlings were grown under uniform environmental conditions, four were cyanogenic while six were acyanogenic. This observation indicates polymorphism in the trait for cyanogenesis. *Drymophloeus subdistichus* and *D. pachycladus* are believed to be sister species (Zona, 1999). Other more distantly related species of *Drymophloeus* were found to be acyanogenic. Both of the cyanogenic species are from lowland wet forests of the Solomon Islands. None of the other Solomon Island palm taxa in our survey (e.g., *Ptychosperma salomonense*, *Gulubia macrospadix*, *Heterospathe salomonense*, *Areca macrocalyx*) was cyanogenic.

Addition of exogenous enzyme solution to the acyanogenic samples did not trigger cyanogenesis, indicating that the mixture of  $\beta$ -glucosidases was unable to catalyze the release of HCN from any compounds in these samples. This suggests that none of these samples contained measurable levels of cyanogenic glycosides.

We did not corroborate Herbert's (1922) report of cyanogenesis in the leaves of *Adonidia merrillii*, *Cocos nucifera*, *Dypsis madagascariensis*, *Ptychosperma macarthurii*, or *Roystonea regia*. Likewise, we did not confirm his report of HCN in the shoots and roots of *R. regia* or in the shoots of *P. macarthurii*. Furthermore, we were unable to confirm the observations of cyanogenesis in the leaves of *Areca catechu* (Kalaw and Sacay, 1925) and the leaves of *Allagoptera arenaria* (Kaplan et al., 1983). Ferreira et al. (1982) detected HCN in a chemical analysis of *Bactris gasipaes* shoot meristems prepared commercially as edible palm hearts, but our two accessions of *B. gasipaes* were acyanogenic.

Herbert (1922), Kalaw and Sacay (1925) and Kaplan et al. (1996) conducted their analyses using various implementations of the sodium picrate (Guignard) test summarized by Hegnauer (1986). In comparison to the Feigl–Anger method used in our surveys, the sodium picrate test is more susceptible to false positive reactions (Hegnauer, 1986). While this is likely to be the major cause of the disparity in our results, other reasons may be ecological factors or differences in the physiological condition of the samples.

Table 1

Results of cyanogenesis survey in leaf tissue of 167 palm accessions. Accession numbers refer to plants in cultivation at Fairchild Tropical Garden or the Montgomery Botanical Center

| Species   | Individuals |         |     |
|---|-------------|---------|-----|
|   | Accession   | Sampled | HCN |
| <b>SUBFAMILY ARECOIDEAE</b>   |             |         |     |
| <i>Actinorhysis calapparia</i> (Blume) Scheffer                     | 88-514      | 2       | —   |
| <i>Adonidia merrillii</i> (Becc.) Becc.                             | s.n.        | 7       | —   |
| <i>Aiphanes ulei</i> (Dammer) Burret                                | 90-359      | 3       | —   |
| <i>Allagoptera arenaria</i> Kuntze                                  | 64-817      | 3       | —   |
| <i>Allagoptera arenaria</i> Kuntze                                  | 71-442      | 2       | —   |
| <i>Alsmithia longipes</i> H.E. Moore                                | 94-1037     | 1       | —   |
| <i>Archontophoenix purpurea</i> Hodel & Dowe                        | 93-298      | 3       | —   |
| <i>Areca catechu</i> L.   | 83-34       | 1       | —   |
| <i>Areca catechu</i> L.   | 87-239      | 2       | —   |
| <i>Areca guppyana</i> Becc.   | 93-294      | 2       | —   |
| <i>Areca macrocalyx</i> Zipp. ex Blume                              | 95-1409     | 2       | —   |
| <i>Areca triandra</i> Roxb.   | S-68-97     | 5       | —   |
| <i>Arenga hookerana</i> (Becc.) T.C. Whitm.                         | S-74-97     | 5       | —   |
| <i>Arenga westerhoutii</i> Griff.                                   | 87-604      | 4       | —   |
| <i>Asterogyne martiana</i> (H. Wendl.) Hemsl.                       | 93-315      | 1       | —   |
| <i>Attalea crassispatha</i> (Mart.) Burret                          | 91-440      | 5       | —   |
| <i>Bactris gasipaes</i> Kunth                                       | 66-342      | 1       | —   |
| <i>Balaka burretiana</i> Christophersen                             | 96-1286     | 5       | —   |
| <i>Beccariophoenix madagascariensis</i> Jum. & H. Perrier           | 95-1212     | 5       | —   |
| <i>Bentinkia nicobarica</i> (S. Kurz) Becc.                         | S-34-98     | 5       | —   |
| <i>Brassiophoenix drymophloeoides</i> Burret                        | 97-1601     | 5       | —   |
| <i>Brassiophoenix drymophloeoides</i> Burret                        | S-20-97     | 5       | —   |
| <i>Burretio kentia hapala</i> H.E. Moore                            | 91-385      | 2       | —   |
| <i>Butia capitata</i> (Mart.) Becc.                                 | 96-681      | 4       | —   |
| <i>Calyptronoma occidentalis</i> (Sw.) H.E. Moore                   | 93-1032     | 2       | —   |
| <i>Carpentaria acuminata</i> (H. Wendl. & Drude) Becc.              | s.n.        | 5       | —   |
| <i>Carpoxydon macrospermum</i> H. Wendl. & Drude                    | 96-1551     | 5       | —   |
| <i>Caryota urens</i> L.   | S-81-97     | 5       | —   |
| <i>Cocos nucifera</i> L.  | 91-294      | 5       | —   |
| <i>Cyrtostachys renda</i> Blume                                     | 58-1122     | 2       | —   |
| <i>Deckenia nobilis</i> H. Wendl. ex Seemann                        | 94-1482     | 1       | —   |
| <i>Deckenia nobilis</i> H. Wendl. ex Seemann                        | 96-1355     | 5       | —   |
| <i>Desmoncus polyacanthos</i> Mart.                                 | 89-499      | 4       | —   |
| <i>Dictyosperma album</i> (Bory) H. Wendl. & Drude ex Scheffer      | 95-1241     | 5       | —   |
| <i>Drymophloeus litigiousus</i> (Becc.) H.E. Moore                  | 96-1491     | 5       | —   |
| <i>Drymophloeus litigiousus</i> (Becc.) H.E. Moore                  | 96-1516     | 5       | —   |
| <i>Drymophloeus oliviformis</i> (Giseke) Miquel                     | 75-453A     | 1       | —   |
| <i>Drymophloeus pachycladus</i> (Burret) H.E. Moore                 | S-239-97    | 10      | +   |
| <i>Drymophloeus pachycladus</i> (Burret) H.E. Moore                 | 81-498      | 1       | +   |
| <i>Drymophloeus</i> cf. <i>subdistichus</i> (H.E. Moore) H.E. Moore | 88-622 C    | 1       | +   |
| <i>Drymophloeus subdistichus</i> (H.E. Moore) H.E. Moore            | S-217-97    | 10      | ±   |
| <i>Drymophloeus subdistichus</i> (H.E. Moore) H.E. Moore            | 76-335 A    | 1       | +   |
| <i>Dypsis cabadae</i> (H.E. Moore) Beentje & J. Dransf.             | 2282 B      | 1       | —   |
| <i>Dypsis decaryi</i> (Jum.) Beentje & J. Dransf.                   | 95-1202     | 5       | —   |

Table 1—continued

| Species  | Individuals |         |     |
|--|-------------|---------|-----|
|  | Accession   | Sampled | HCN |
| <i>Dypsis lutescens</i> (H. Wendl.) Beentje & J. Dransf.             | 98-1122 A   | 1       | —   |
| <i>Dypsis madagascariensis</i> (Becc.) Beentje & J. Dransf.          | S-218-97    | 5       | —   |
| <i>Dypsis</i> sp.  | 96-626      | 3       | —   |
| <i>Elaeis guiniensis</i> Jacq.                                       | 94-613      | 5       | —   |
| <i>Elaeis oleifera</i> (Kunth) Cortès                                | 88-211 A    | 1       | —   |
| <i>Euterpe oleracea</i> Mart.  | 94-793      | 1       | —   |
| <i>Gastrococcus crispera</i> (Kunth) H.E. Moore                      | s.n.        | 5       | —   |
| <i>Geonoma densa</i> Linden & H. Wendl.                              | 94-914      | 3       | —   |
| <i>Gulubia macrospadix</i> (Burret) H.E. Moore                       | 88-412      | 2       | —   |
| <i>Heterospatha salomonensis</i> Becc.                               | S-118-97    | 10      | —   |
| <i>Howea belmoreana</i> (C. Moore & F. Mueller) Becc.                | 92-515      | 5       | —   |
| <i>Howea forsteriana</i> (C. Moore & F. Mueller) Becc.               | 93-778      | 3       | —   |
| <i>Hyospathe elegans</i> Mart.                                       | 91-466      | 3       | —   |
| <i>Iguanura wallichiana</i> (Mart.) Becc.                            | 87-269      | 1       | —   |
| <i>Iriartea deltooides</i> Ruiz & Pav.                               | 94-1112     | 2       | —   |
| <i>Kentiopsis oliviformis</i> (Brongn. & Gris) Brongn.               | 77-146 C    | 1       | —   |
| <i>Lemurophoenix halleuxii</i> J. Dransf.                            | s.n.        | 1       | —   |
| <i>Linospadix longicuris</i> (Becc.) Burret                          | 81-613      | 1       | —   |
| <i>Manicaria saccifera</i> Gaertn.                                   | 93-495      | 2       | —   |
| <i>Marojejya darianii</i> J. Dransf. & N.W. Uhl                      | 97-107      | 1       | —   |
| <i>Nenga pumila</i> (Mart.) H. Wendl. in Kerchove                    | 96-1073     | 3       | —   |
| <i>Neoveitchia storckii</i> (H. Wendl.) Becc.                        | 89-196 A    | 1       | —   |
| <i>Nephrosperma vanhoutteanum</i> (Van Houtte) Balf.                 | 92-140      | 2       | —   |
| <i>Nephrosperma vanhoutteanum</i> (Van Houtte) Balf.                 | 96-1357     | 4       | —   |
| <i>Normanbya normanbyi</i> (W. Hill) L.H. Bailey                     | 74-472 C    | 1       | —   |
| <i>Oenocarpus bataua</i> Mart.                                       | 96-1441     | 3       | —   |
| <i>Oenocarpus distichus</i> Mart.                                    | 88-579      | 1       | —   |
| <i>Oncosperma tigillarum</i> (Jack) Ridley                           | 64-72       | 2       | —   |
| <i>Orania sylvicola</i> (W. Griffith) H.E. Moore                     | S-70-97     | 1       | —   |
| <i>Orania trispatha</i> (J. Dransf. & N.W. Uhl) Beentje & J. Dransf. | 95-1148     | 1       | —   |
| <i>Phoenicophorium borsigianum</i> (Koch) Stuntz                     | 89-205      | 1       | —   |
| <i>Phoenicophorium borsigianum</i> (Koch) Stuntz                     | 96-1358     | 5       | —   |
| <i>Pinanga dicksonii</i> Blume                                       | 96-722      | 4       | —   |
| <i>Pinanga negrosensis</i> Becc.                                     | 92-160      | 2       | —   |
| <i>Polyandrococos caudescens</i> (Mart.) Barb. Rodr.                 | S-75-95     | 5       | —   |
| <i>Ptychococcus</i> cf. <i>arecinus</i> (Becc.) Becc.                | 95-1397     | 5       | —   |
| <i>Ptychosperma hentyi</i> Essig                                     | 95-1218     | 1       | —   |
| <i>Ptychosperma macarthurii</i> (H. Wendl.) Nicholson                | 74-330 A    | 1       | —   |
| <i>Ptychosperma salomonense</i> Burret                               | 69-624      | 3       | —   |
| <i>Ptychosperma watianum</i> Essig                                   | 76-398      | 3       | —   |
| <i>Reinhardtia gracilis</i> (H. Wendl.) Drude ex Dammer              | 95-1110     | 5       | —   |
| <i>Roscheria melanochaetes</i> (H. Wendl.) H. Wendl. in Balf.        | 86-176      | 1       | —   |
| <i>Roystonea regia</i> (Kunth) O.F. Cook                             | 81-516      | 5       | —   |
| <i>Satakentia liukiensis</i> (Hatusima) H.E. Moore                   | S-196-97    | 5       | —   |
| <i>Socratea exorrhiza</i> (Mart.) H. Wendl.                          | 93-133      | 4       | —   |
| <i>Solfia samoensis</i> Reching                                      | 96-1500     | 5       | —   |
| <i>Syagrus botryophora</i> (Mart.) Mart.                             | 94-1217     | 5       | —   |

Table 1—continued

| Species   | Individuals |         |     |
|---|-------------|---------|-----|
|   | Accession   | Sampled | HCN |
| <i>Syagrus stenopetala</i> Burret                         | 94-577      | 5       | —   |
| <i>Veitchia arecina</i> Becc.                             | 96-1342     | 5       | —   |
| <i>Veitchia winin</i> H.E. Moore                          | 96-1940     | 4       | —   |
| <i>Wallichia siamensis</i> Becc.                          | S-72-97     | 5       | —   |
| <i>Wettinia hirsuta</i> Burret                            | 86-409      | 1       | —   |
| <i>Wodyetia bifurcata</i> A.K. Irvine                     | 96-21       | 5       | —   |
| SUBFAMILY CALAMOIDEAE                                     |             |         |     |
| <i>Calamus caryotoides</i> Mart.                          | 64-98 F     | 1       | —   |
| <i>Calamus concinnus</i> Mart                             | 71-120      | 2       | —   |
| <i>Calamus microcarpus</i> Becc.                          | 95-1462     | 10      | —   |
| <i>Calamus peregrinus</i> Furtado                         | 97-1588     | 5       | —   |
| <i>Calamus</i> sp.  | 64-129 A    | 1       | —   |
| <i>Daemonorops curranii</i> Becc.                         | 87-637 A    | 1       | —   |
| <i>Daemonorops margaritae</i> (Hance) Becc.               | 87-638      | 1       | —   |
| <i>Mauritia flexuosa</i> L. f.                            | 93-737      | 1       | —   |
| <i>Mauritia flexuosa</i> L. f.                            | 98-1403     | 1       | —   |
| <i>Mauritiella armata</i> (Mart.) Burret                  | 96-1444     | 1       | —   |
| <i>Mauritiella armata</i> (Mart.) Burret                  | 94-768      | 5       | —   |
| <i>Metroxylon vittense</i> (Wendl.) Benth. & Hook. f.     | 89-197 B    | 1       | —   |
| <i>Pigafetta elata</i> (Mart.) H. Wendl.                  | s.n.        | 1       | —   |
| <i>Raphia farinifera</i> (Gaertn.) Hylander               | 95-1154     | 3       | —   |
| <i>Raphia taedigera</i> (Mart.) Mart.                     | 94-803      | 3       | —   |
| <i>Salacca magnifica</i> J.P. Moge                        | 95-1220     | 1       | —   |
| SUBFAMILY CEROXYLOIDEAE                                   |             |         |     |
| <i>Chamaedorea adscendens</i> (Dammer) Burret             | 92-535      | 3       | —   |
| <i>Chamaedorea elatior</i> Mart.                          | 88-133      | 1       | —   |
| <i>Chamaedorea elegans</i> Mart.                          | 93-043      | 5       | —   |
| <i>Chamaedorea metallica</i> O.F. Cook ex H.E. Moore      | 68-213      | 2       | —   |
| <i>Chamaedorea plumosa</i> Hodel                          | 93-107      | 2       | —   |
| <i>Chamaedorea schiedeana</i> Mart.                       | 93-10490    | 2       | —   |
| <i>Chamaedorea seifrizii</i> Burret                       | 57-678 A    | 1       | —   |
| <i>Chamaedorea tepejilote</i> Liebm.                      | s.n.        | 5       | —   |
| <i>Hyophorbe indica</i> J. Gaertner                       | 95-1214     | 3       | —   |
| <i>Hyophorbe verschaffeltii</i> H. Wendl.                 | S-238-87    | 5       | —   |
| <i>Pseudophoenix lediniana</i> Read                       | S-183-97    | 5       | —   |
| <i>Pseudophoenix vinifera</i> (Mart.) Becc.               | 96-1416     | 5       | —   |
| <i>Ravenea glauca</i> Jum. & H. Perrier                   | 96-727      | 1       | —   |
| <i>Ravenea hildebrandtii</i> C.D. Bouché                  | 61-378      | 2       | —   |
| <i>Synechanthus warscewiczianus</i> H. Wendl.             | 94-380      | 1       | —   |
| SUBFAMILY CORYPHOIDEAE                                    |             |         |     |
| <i>Acoelorrhaphe wrightii</i> (Griseb. & H. Wendl.) Becc. | s.n.        | 5       | —   |
| <i>Borassodendron machadonis</i> (Ridley) Becc.           | 96-1054     | 5       | —   |
| <i>Chamaerops humilis</i> L.                              | RM 157 A    | 1       | —   |
| <i>Chelyocarpus ulei</i> Dammer                           | 61-173      | 1       | —   |

Table 1—continued

| Species   | Individuals |         |     |
|---|-------------|---------|-----|
|   | Accession   | Sampled | HCN |
| <i>Chuniophoenix hiananensis</i> Burret                               | S-212-97    | 9       | —   |
| <i>Chuniophoenix nana</i> Burret                                      | 81-78       | 5       | —   |
| <i>Coccothrinax proctorii</i> Read                                    | S-192-97    | 5       | —   |
| <i>Colpotherinax cookii</i> Read                                      | 93-559      | 1       | —   |
| <i>Corypha umbraculifera</i> L.                                       | 95-1501     | 5       | —   |
| <i>Corypha utan</i> Lamarck   | 95-1092     | 2       | —   |
| <i>Crysophila warscewiczii</i> (H. Wendl.) Bartlett                   | S-26-98     | 5       | —   |
| <i>Guhaia argyrata</i> (Lee & Wei) Lee, Wei, & J. Dransf.             | 89-278      | 3       | —   |
| <i>Hyphaene coriacea</i> Gaertn.                                      | 95-1155     | 5       | —   |
| <i>Itaya amicarum</i> H.E. Moore                                      | 96-1453     | 5       | —   |
| <i>Johannesteijsmannia altifrons</i> (Reichb. f. & Zoll.) H. E. Moore | 86-574      | 1       | —   |
| <i>Kerriodoxa elegans</i> J. Dransf.                                  | 95-1330     | 5       | —   |
| <i>Licuala grandis</i> H. Wendl.                                      | S-79-97     | 5       | —   |
| <i>Licuala triphylla</i> Griff. ex Mart.                              | 95-1494     | 5       | —   |
| <i>Livistona decipiens</i> Becc.                                      | 96-231      | 5       | —   |
| <i>Lodoicea maldivica</i> (Gmelin) Pers.                              | 98-1574 A   | 1       | —   |
| <i>Nannorrhops ritchiana</i> (Griff.) Aitchison                       | 65-39 A     | 1       | —   |
| <i>Phoenix acaulis</i> Buchanan-Hamilton ex Roxb.                     | 86-524      | 3       | —   |
| <i>Phoenix reclinata</i> Jacq.  | 92-165      | 1       | —   |
| <i>Phoenix roebelenii</i> O'Brien                                     | 57-127      | 3       | —   |
| <i>Pritchardia</i> sp.  | 93-691      | 5       | —   |
| <i>Rhapidophyllum hystrix</i> (Pursh) H. Wendl. & Drude               | 62231 E     | 1       | —   |
| <i>Rhapis excelsa</i> (Thunberg) Henry in Rehder                      | S-202-96    | 5       | —   |
| <i>Rhapis subtilis</i> Becc.  | S-203-96    | 5       | —   |
| <i>Sabal mauritiiiformis</i> (Karst.) Griseb. ex H. Wendl.            | 97-658      | 5       | —   |
| <i>Sabal mexicana</i> Mart.   | 93-1053     | 5       | —   |
| <i>Sabal yapa</i> Wright ex Becc.                                     | S-199-97    | 5       | —   |
| <i>Satranala decussilvae</i> Beentje & J. Dransf.                     | s.n.        | 1       | —   |
| <i>Schippia concolor</i> Burret                                       | S-213-97    | 5       | —   |
| <i>Serenoa repens</i> (Bartram) Small                                 | s.n.        | 5       | —   |
| <i>Thrinax morrisii</i> H. Wendl.                                     | S-8-97      | 5       | —   |
| <i>Thrinax radiata</i> Lodd. ex J.A. & J.H. Schultes                  | 96-1520     | 5       | —   |
| SUBFAMILY NYPOIDEAE   |             |         |     |
| <i>Nypa fruticans</i> Wurm  | 82-473      | 5       | —   |
| SUBFAMILY PHYTELEPHANTOIDEAE  |             |         |     |
| <i>Aphandra natalia</i> (Balslev & Henderson) Barfod                  | 90-82       | 1       | —   |
| <i>Phytelephas seemanii</i> O.F. Cook                                 | 94-1149     | 5       | —   |

The results of the shoot meristem survey are shown in Table 2. Of the 18 species sampled, only *Dypsis lutescens* (Arecoideae: Dypsidinae) was found to be cyanogenic. The leaf material from one of the same accessions (98-1122A) was not detectably cyanogenic, nor were leaves of other species of *Dypsis*. Shoot meristems sampled from

Table 2

Results of shoot meristem survey for 20 accessions

| Subfamily     | Species   | Accession | HCN |
|---------------|---|-----------|-----|
| Arecoideae    | <i>Arenga engleri</i> Becc.                               | 76-419 A  | –   |
| Arecoideae    | <i>Bactris gasipaes</i> Kunth                             | 66-342    | –   |
| Arecoideae    | <i>Bactris gasipaes</i> Kunth                             | P 891 A   | –   |
| Arecoideae    | <i>Caryota mitis</i> Loureiro                             | X-9-34    | –   |
| Arecoideae    | <i>Dypsis cabadae</i> (H.E. Moore) Beentje & J. Dransf.   | 2282 B    | –   |
| Arecoideae    | <i>Dypsis decaryi</i> (Jum.) Beentje & J. Dransf.         | 95-1202   | –   |
| Arecoideae    | <i>Dypsis lutescens</i> (H. Wendl.) Beentje & J. Dransf.  | P 3072 B  | +   |
| Arecoideae    | <i>Dypsis lutescens</i> (H. Wendl.) Beentje & J. Dransf.  | 98-1122 A | +   |
| Arecoideae    | <i>Elaeis guineensis</i> Jacq.                            | s.n.      | –   |
| Arecoideae    | <i>Oncosperma tigillarum</i> (Jack) Ridley                | 64-72 D   | –   |
| Arecoideae    | <i>Ptychosperma macarthurii</i> (H. Wendl.) Nicholson     | 74-330 A  | –   |
| Arecoideae    | <i>Roystonea regia</i> (Kunth) O.F. Cook                  | s.n.      | –   |
| Arecoideae    | <i>Syagrus botryophora</i> (Mart.) Mart.                  | 92-1220   | –   |
| Calamoideae   | <i>Calamus</i> sp.  | 64129 A   | –   |
| Ceroxyloideae | <i>Chamaedorea sefriezii</i> Burret                       | P 2704    | –   |
| Coryphoideae  | <i>Acoelorrhapha wrightii</i> (Griseb. & H. Wendl.) Becc. | P 2313 A  | –   |
| Coryphoideae  | <i>Chuniophoenix nana</i> Burret                          | 81-78     | –   |
| Coryphoideae  | <i>Livistona</i> sp.                                      | s.n.      | –   |
| Coryphoideae  | <i>Phoenix reclinata</i> Jacq.                            | 92-165    | –   |
| Coryphoideae  | <i>Washingtonia robusta</i> H. Wend.                      | s.n.      | –   |

Table 3

Results of root tissue survey for 22 accessions

| Subfamily          | Species  | Accession | HCN |
|--------------------|--|-----------|-----|
| Arecoideae         | <i>Adonia merrillii</i> (Becc.) Becc.                    | s.n.      | –   |
| Arecoideae         | <i>Areca triandra</i> Roxb.                              | S-200-97  | –   |
| Arecoideae         | <i>Arenga hookerana</i> (Becc.) T.C. Whitm.              | S-74-97   | –   |
| Arecoideae         | <i>Balaka burretiana</i> Christophersen                  | 96-1286   | –   |
| Arecoideae         | <i>Carpentaria acuminata</i> (H. Wendl. & Drude) Becc.   | s.n.      | –   |
| Arecoideae         | <i>Drymophloeus pachycladus</i> (Burret) H.E. Moore      | S-239-97  | –   |
| Arecoideae         | <i>Dypsis decaryi</i> (Jum.) Beentje & J. Dransf.        | 95-1202   | –   |
| Arecoideae         | <i>Dypsis madagascariensis</i> (Becc.) Beentje & Dransf. | S-218-97  | –   |
| Arecoideae         | <i>Euterpe precatorea</i> Mart.                          | 96-1443   | –   |
| Arecoideae         | <i>Roystonea regia</i> (Kunth) O.F. Cook                 | s.n.      | –   |
| Arecoideae         | <i>Satakentia liukuensis</i> (Hatusima) H.E. Moore       | S-196-96  | –   |
| Arecoideae         | <i>Solfia samoensis</i> Rechinger                        | 96-1500   | –   |
| Arecoideae         | <i>Syagrus botryophora</i> (Mart.) Mart.                 | 92-1220   | –   |
| Calamoideae        | <i>Mauritia flexuosa</i> L. f.                           | 93-737    | –   |
| Ceroxyloideae      | <i>Chamaedorea adscendens</i> (Dammer) Burret            | 6-522     | –   |
| Ceroxyloideae      | <i>Hyophorbe verschaffeltii</i> H. Wendl.                | S-238-97  | –   |
| Coryphoideae       | <i>Licuala grandis</i> H. Wendl.                         | S-73-97   | –   |
| Coryphoideae       | <i>Phoenix reclinata</i> Jacq.                           | 92-165    | –   |
| Coryphoideae       | <i>Rhapis subtilis</i> Becc.                             | S-203-96  | –   |
| Coryphoideae       | <i>Sabal yapa</i> Wright ex Becc.                        | S-199-97  | –   |
| Phytelephantoideae | <i>Aphandra natalia</i> (Balslev & Henderson) Barfod     | 90-82     | –   |



*Dypsis decaryi* and *D. cabadae* were acyanogenic. At least 16 species of *Dypsis* are used locally in Madagascar as sources of edible palm heart, but hearts of three species in the genus are reportedly bitter or toxic (Dransfield and Beentje, 1995). Although none of the *Dypsis* species sampled in our shoot meristem survey are known to be toxic, they are not recognized as sources of edible hearts.

None of the root samples we surveyed had any detectable cyanogenic activity, as shown in Table 3.

From the results of our survey, we conclude that cyanogenesis in leaves is rare in the palm family. Since separate plant organs within the same plant may differ in their cyanogenic potential, we cannot extrapolate from these results to the cyanogenic activity of flowers and fruits. Our surveys of roots and shoots are insufficient to allow us to draw conclusions regarding the frequency of cyanogenesis in these organs throughout the family. The observation of polymorphism in our sample of *Drymophloeus subdistichus* individuals fits a pattern found in many other surveys of taxa across the plant kingdom (e.g. Aikman et al., 1996). Because polymorphism is common within cyanogenic plant taxa, any future studies of palm roots, meristems, or reproductive structures should include multiple individuals of each species.

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