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The Number of Wide Vessels in Petiolar Vascular Bundles of Palms: an Anatomical Feature of Systematic Significance

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Abstract

The most frequent number(s) of wide vessels per large vascular bundle was determined in transverse sections of petioles from 213 species of palms, representing all of the major taxonomic groups. Most palms display one or two or a combination of one and two wide vessels per bundle. Relatively few species commonly have more than two wide vessels per bundle. The coryphoid major group is the most variable, but the variation follows the subdivisions of the group. Most of the other major groups are more uniform in this feature, and many can be characterized by a specific number of wide vessels in the bundles of their petioles. This character supports some previous conclusions about relationships among the major groups.

Introduction

Certain anatomical features of the vegetative organs of palms are of diagnostic value in distinguishing among the taxonomic groups of palms (Tomlinson, 1961, 1969; Parthasarathy, 1968; Klotz, 1977). Some of these features help to clarify systematic relationships among extant groups of palms (Moore, 1973), and may possibly provide a basis for assessing the taxonomic affinities of fossil palms.

The present study is a survey of one anatomical feature—namely, the number of wide vessels per vascular bundle in transverse section of petiole. The objective of the study is to observe the degree to which the taxonomic groups of palms can be characterized with regard to this feature.

Materials and Methods

The data were obtained from transverse sections made with a razor blade or sliding microtome. Two hundred thirteen species in 153 genera were examined. Most of the species were represented by only one specimen. Thus, the meaningful sampling is more at the level of the taxonomic group than at the level of individual species, and the results presented here should be considered tentative. A list of the species examined and collection data on the specimens are available (Klotz, 1977).[2]

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[2] Data from the following additional specimens (all from Colombia) are included in Table 1:

Catoblastus radiatus (Cook & Doyle) Burret (*Moore & Dransfield 10223*); *Phytelephas* sp. (*Moore & Dransfield 10224*); *Socratea* sp. (*Moore & Dransfield 10228*); *Syagrus sancona* (HBK) Karsten (*Moore & Dransfield 10218*).

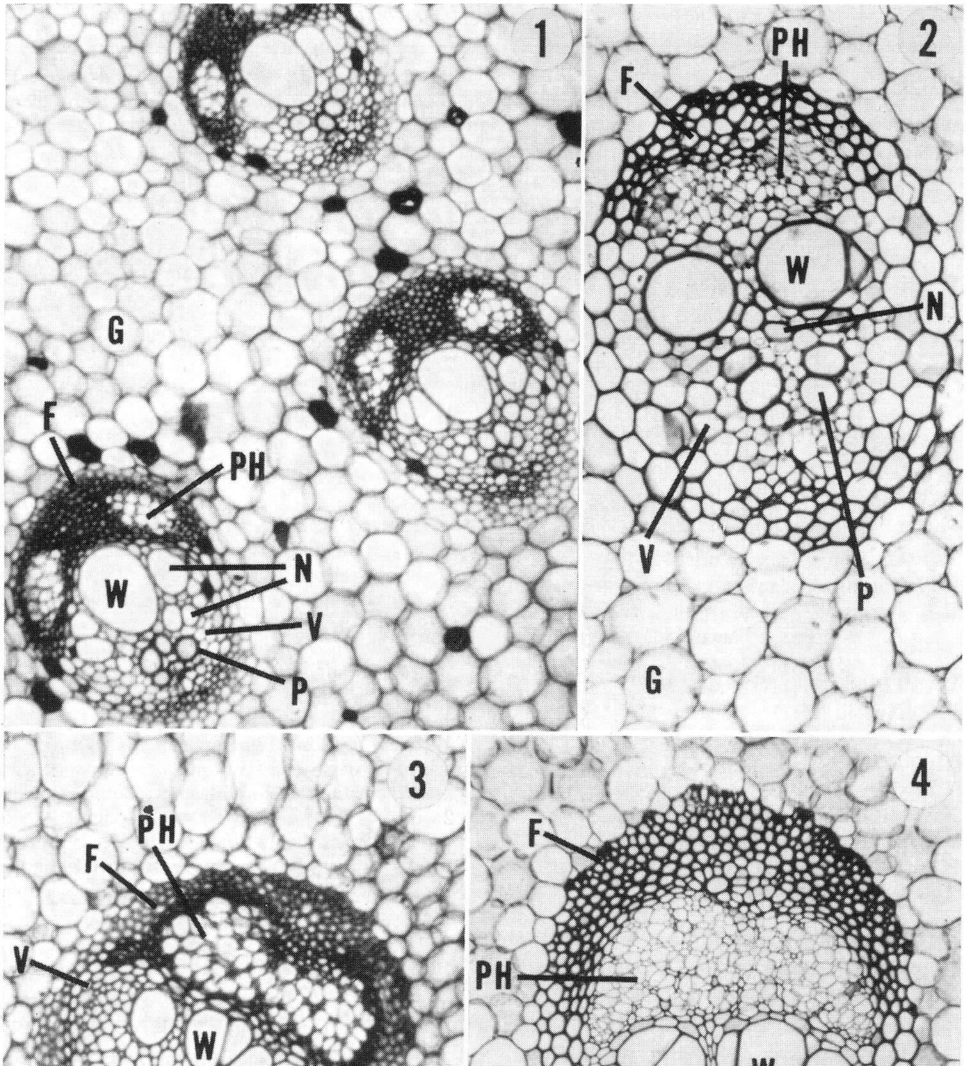
Table 1. Most frequent number(s) of wide vessels in petiolar vascular bundles of palms

The classification is that of Moore (1973). The number of species (or of genera and species) examined is given in parentheses after the name of each group. In groups in which more than one condition was observed, the number of specimens for each condition is indicated as a superscript in parentheses.

I.	Coryphoid major group	
	A. *Trithrinax* alliance	
	i. *Trithrinax* unit	
	Trithrinax (2)	2
	Rhapidophyllum (1)	2–5
	Trachycarpus (1)	1–4
	Chamaerops (1)	1
	ii. *Chelyocarpus* unit (3:4)	2
	iii. *Schippia* unit (1)	2
	iv. *Rhapis* unit (3:3)	1
	v. *Thrinax* unit (3:5)	2
	B. *Livistona* alliance (12:14)	1
	C. *Corypha* alliance	
	Nannorrhops (1)—two specimens	2; 1–4 (most frequently 2–3)
	Corypha (1)	1
	D. *Sabal* alliance (1:2)	1; 1–3
II.	Phoenicoid (1:2)	2
III.	Borassoid	
	A. *Borassus* alliance (4:4)	$1^{(2)}$; $1–2^{(2)}$
	B. *Hyphaene* alliance (2:2)	2
IV.	Lepidocaryoid (19:33)	$1^{(32)}$; $1–2^{(1)}$
V.	Nypoid (1:1)	1
VI.	Caryotoid (3:6)	$1^{(5)}$; $1–2^{(1)}$
VII.	Pseudophoenicoid (1:2)	2
VIII.	Ceroxyloid (2:3)	1–2 & clusters; 1–3 & clusters; 2
IX.	Chamaedoreoid (6:14)	2
X.	Iriarteoid (6:11)	$1–2^{(2)}$; $2^{(9)}$
XI.	Podococcoid (1)	1
XII.	Arecoid (44:45)	$1^{(36)}$; $1–2^{(3)}$; 1 & clusters$^{(1)}$; 1–2 & clusters$^{(1)}$; $1–3^{(1)}$; $2^{(2)}$; 2–3 & clusters$^{(1)}$
XIII.	Cocosoid (26:38)	$1^{(37)}$; $2–5^{(1)}$
XIV.	Geonomoid (6:11)	$1^{(2)}$; $1–2^{(5)}$; $2^{(4)}$
XV.	Phytelephantoid (3:4)	2

The petioles were sampled at about mid-length, except in 10 specimens that lacked pronounced petioles. In these specimens, the proximal part of the rachis was sampled, between insertions of the pinnae. The data from these specimens fit the patterns of their respective groups.

The samples included only the large vascular bundles from the central part of the petiole. Peripheral vascular bundles were not considered. In certain specimens, irregular clusters of vessels occurred in the position of the wide vessels in some vascular bundles (Fig. 4). This condition was indicated in Table 1 as "clusters." However, occasional pairs of laterally contiguous vessels were simply interpreted to represent intervessel contact areas and were counted as one vessel in the sample. Care was also taken not to count two vessel elements separated by a perforation plate as two distinct vessels. Deter-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mining the most frequent number or numbers of vessels in vascular bundles was difficult or uncertain in some specimens because information on the three-dimensional arrangement of vessels in petiolar vascular bundles is lacking. However, bundles apparently near the point of branching or anastomosing were not included in the sample.

The numbers in Table 1 indicate the condition for the majority (≥¾) of the vascular bundles in the sample.[3] If no single number comprises a ¾ majority, the codominant values are listed.

The delimitation of the categories of bundles (one-vessel, two-vessel, several-vessel) is somewhat arbitrary. For example, *Serenoa repens* (Bartr.) Small (Fig. 1) exhibits configurations intermediate between one and several wide vessels but is classified as having one wide vessel per vascular bundle. In general, if one or two wide vessels are markedly wider than the other vessels in the vascular bundle, only these widest vessels are considered in classifying the vascular bundle.

Results and Discussion

One (Fig. 1) or two (Fig. 2) wide vessels are observed in transversely sectioned vascular bundles of the petiole in the majority of species examined (Table 1). Only a few species characteristically display several (more than two) wide vessels per vascular bundle (Fig. 3). Some of the major groups are relatively uniform in this feature and possibly have a characteristic number of wide vessels per vascular bundle in the petiole—e.g., the lepidocaryoid and chamaedoreoid major groups. Other major groups are quite variable —e.g., the coryphoid, borassoid, arecoid, and geonomoid major groups.

The coryphoid major group was observed to be the most variable major group in this character. The variation follows the pattern of the coryphoid generic alliances and generic units. Variability is greatest in the most primitive generic alliance (the *Trithrinax* alliance) and within the most primitive generic unit of this alliance (the *Trithrinax* unit). The *Trithrinax* unit contains species [*Rhapidophyllum hystrix* (Pursh) H. Wendl. & Drude, *Trachycarpus fortunei* (Hook.) H. Wendl.] with more than two wide vessels per vascular bundle. This configuration approaches the "type I" vascular bundle of Cheadle and Uhl (1948), which these authors believed to be the most primitive in the monocotyledons. The New World genera of the *Trithrinax* alliance (*Trithrinax*, *Rhapidophyllum*, and the *Chelyocarpus*, *Schippia*, and *Thrinax* units) generally have two wide vessels per bundle whereas the Old World genera of this alliance (*Trachycarpus*, *Chamaerops*, and the *Rhapis*

[3] This criterion was not strictly followed by Klotz (1977). Thus, some of the values reported in that work were altered for this publication, but the basic trends and conclusions regarding the major groups have remained unchanged.

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1–4. Transverse sections of petiolar vascular bundles. 1, vascular bundles mostly with one wide vessel—*Serenoa repens*, × 120; 2, vascular bundles mostly with two wide vessels—*Iriartea ventricosa* Mart., × 140; 3, vascular bundles with several (about four) wide vessels—*Nannorrhops ritchiana*, × 130; 4, vascular bundle with an irregular cluster of vessels (indicated by arrow)—*Orania appendiculata* (F. M. Bailey) Domin, × 110. Details: *f*, fibers; *g*, ground parenchyma; *n*, narrow tracheary elements of metaxylem; *o*, obliterated tracheary elements of protoxylem; *p*, tracheary elements of protoxylem; *ph*, phloem; *v*, parenchyma of vascular bundle; *w*, wide vessel of metaxylem.

unit) generally have one wide vessel per bundle. The *Livistona* alliance is much more uniform than the *Trithrinax* alliance in this character, but the *Corypha* alliance is variable: *Corypha umbraculifera* L. has one wide vessel per bundle whereas two is the modal number for the composite of both samples of *Nannorrhops ritchiana* (Griff.) Aitch. (Although the two samples of *Nannorrhops* differ from each other quantitatively, they both exhibit a similar range of numbers.)

The other major groups are more uniform than the coryphoid major group. Two wide vessels per bundle prevail in the species of *Phoenix* examined. The borassoid palms are more variable, with one or two or a mixture of one and two wide vessels per bundle. The lepidocaryoid, nypoid, and caryotoid palms mostly have one wide vessel per bundle. In contrast, the following series of three closely related major groups—pseudophoenicoid, ceroxyloid, and chamaedoreoid—is largely characterized by two wide vessels, as is the iriarteoid major group, which bears other morphological resemblances to the chamaedoreoid major group (Moore, 1973). The podococcoid, arecoid, and cocosoid palms are mainly of the "one-vessel" type, but there are exceptions in the latter two groups—notably the cocosoid *Jubaea chilensis* (Mol.) Baill. (two to five vessels), and three of the five triovulate arecoid species examined. These species are considered to be relatively primitive within their respective major groups (Moore, 1973). The geonomoid palms exhibit the same variety of configurations as the borassoid palms. The phytelephantoid palms have two wide vessels per bundle.

Most of the relevant data for comparison with those of the present study are from the works of P. B. Tomlinson (1961, 1966, 1969). His list of genera "mostly with 2" wide vessels per vascular bundle (Tomlinson, 1961) agrees well with that of the present study (with the possible exception of *Sabal*), and his claim that the remaining groups that he examined mostly have one vessel per bundle also agrees. However, in his list of genera "mostly with several (more than two)" vessels per vascular bundle, only *Rhapidophyllum* and *Jubaea* are in agreement with the present observations. The others in his list were observed to have only one or two wide vessels per vascular bundle in the present survey. This discrepancy may be due to the fact that Tomlinson (1961) obtained his sections from the upper part of the petiole, just below the insertion of the lamina or lowest leaflet. At this level, the bundles (and vessels within the bundles) might exhibit branching related to the departure of traces into the lamina or pinnae.

Tomlinson's (1966) observation of two wide vessels per bundle in petiole of *Asterogyne spicata* (H. E. Moore) W. Boer (as *Aristeyera spicata*) is in agreement with the present data for the geonomoid palms. In the ceroxyloid major group, Tomlinson (1969) observed mostly two wide vessels per bundle in *Ceroxylon* sp. and *Ravenea* spp., but in *Juania australis* (Mart.) Drude ex Hook. f. he observed more than two per bundle—perhaps about three to five, according to photomicrographs. Thus, the ceroxyloid major group is variable in this character, although two may be the modal number for the group.

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PALM QUESTIONS AND ANSWERS

Q. The trunks of my coconut palms appear to be bleeding. What is wrong?

A. The stem bleeding disease of the coconut palm is more common in South Florida than most people realize. The fungus, *Endoconidiophora paradoxa* (Dade), is associated with the stem bleeding disease and is reported to be a wound parasite entering the host plant through wounds or growth cracks on the stem. Stem injuries such as those inflicted by knives or those produced by steel climbing spikes are important areas of entry for the fungus. It is also believed that the activity of termites can serve as an entry area for the fungus. Palms damaged physiologically by heavy fertilization followed by a drought or excessive rains followed by a drought also tend to be more susceptible to disease entry. This disease has also been reported in the palmyra palm and the arecanut palm.

The actual bleeding is characterized by the exudation of a dark reddish-brown liquid from the growth cracks and wounds on the stem trickling down for a distance of several inches to several feet.

One of the recommendations for control of the stem bleeding disease is to completely excise the infected area on the trunk followed by dressing with pruning paint and a copper fungicide. The use of steel climbing spikes should be avoided where possible in order to reduce the mechanical wounds that serve as a primary means of entrance for the fungus.

Applications of a fungicide to the stem of a coconut may provide adequate protection. Also, thoroughly disinfecting climbing spikes with Lysol, Clorox, etc., between trees should help reduce the spread of the disease. Reducing stem cracks can bring about a reasonable degree of disease control by judicious attention to horticultural practices by avoiding extremes in moisture and fertilization which influence the quality and quantity of stem cracks of the coconut palm.

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