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Some Observations on Seed Germination, the Seedling, and Polyembryony in the Needle Palm *Rhapidophyllum hystrix*

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The needle palm, *Rhapidophyllum hystrix* (Pursh) H. A. Wendl. & Drude, is a rare shrubby, caespitose (or single-stemmed), mainly acaulescent, dioecious species belonging in the subfamily Coryphoideae (Dransfield and Uhl 1986). It is restricted to the coastal plain of the south-eastern United States with a scattered distribution from central Florida north to Georgia and west to Mississippi (Shuey and Wunderlin 1977). This paper discusses aspects of seed germination, seedling morphology and development, and the occurrence of polyembryony in *R. hystrix*.

Several gross morphological features readily distinguish the needle palm from other sympatric palms such as *Sabal palmetto* Lodd. ex Schultes and *S. minor* (Jacq.) Persoon; namely the multi-ribbed leaf segments, the extremely reduced inflorescence (especially the female), and the spiny leaf bases (the spines may reach a length of 40 cm). Because of the short female inflorescence axis, mature fruits are consistently trapped among the spines and leaf bases and frequently these seeds germinate upon the parent plant with no possibility of surviving (Fig. 1). These seedlings eventually perish after exhausting the food stored in the endosperm of the seed. In addition, many seedlings can be found growing at the base of the parent plant (Fig. 2); these have little chance of surviving (pers. obs.), being outcompeted for

light, nutrients, and moisture by the parent plant.

Methods

A large population of *Rhapidophyllum* in central Mississippi has been studied for several years. From this population seeds were collected in December 1984 and December 1985 and several germination experiments undertaken. Seedlings from the wild were transplanted into the greenhouse and their development monitored. Seedling morphology and development was described based on these seedlings.

Two separate treatments were employed, prior to the planting of *Rhapidophyllum* seeds, in the germination experiments. In the first treatment, 44 seeds, with pericarps removed, were placed in moistened peat moss in polyethylene bags and stored in a refrigerator at 3-5° C for 12 days (=stratification). After removal from cold storage the seeds were scarified (filing through the seed coat) until the endosperm was visible and then planted. The second treatment involved removal of the pericarp from 77 fruits followed immediately by planting. These seeds were neither stratified nor scarified. Seeds in which the pericarp only was removed (second treatment) were collected on 16 December 1984 and planted on 17 December 1984. They were monitored until the conclusion of the



1. *Rhapidophyllum hystrix* seedlings growing among the spines and leaf bases of parent plant. $\times\frac{1}{2}$.
2. *Rhapidophyllum hystrix* seedlings growing in the soil directly beneath the parent. $\times\frac{1}{2}$.

Table 1. Summary of germination experiments for *Rhaphidophyllum hystrix*. Treatments: pr, pericarp removed; sc, scarified; st, stratified. Both experiments were concluded on 1 June 1986.

Date Planted	Treatment	Sample Size	Days to First Germination	#/% Germinated
1/01/86	(1) pr, sc, st	44	42	8/18.2
12/17/84	(2) pr	77	435	11/14.3

experiment on 1 June 1986 (530 days). Seeds collected in December 1985 were stratified from 20 December 1985 until 1 January 1986, at which time they were scarified and planted; this experiment (first treatment) was concluded 150 days later on 1 June 1986.

All seeds were placed, ca. 8–10 per 15 cm pot, in a 1:1:1 mixture of sterilized soil: perlite: shredded (sieved) pine bark and placed in a glass greenhouse (21° C during the day and 13–18° C at night). No bottom heat was provided.

Results and Discussion

Germination Experiments. In this study two germination treatments were tested in an attempt to determine conditions necessary for seed germination in *Rhaphidophyllum*. Table 1 summarizes the results. The stratification-scarification treatment resulted in the earliest germination, in which the first seed germinated 42 days after planting, and by the conclusion of the experiment (150 days after sowing) 18% (8 of 44 seeds) had germinated. The seeds that were planted directly into the potting media after pericarp removal, but without the stratification and scarification pretreatments, required 435 days for the first seed to germinate. At the conclusion of the experiment (530 days from sowing) 14.3% (11 of 77 seeds) had germinated. Seeds of *Rhaphidophyllum* have been reported to take from 6 months to 2 years to germinate (Popenoe 1973, Shuey and Wunderlin 1977, Wagner 1982). One treatment employed here resulted in a substantially faster

germination time of only 6 weeks. Wagner (1982) planted 15 *Rhaphidophyllum* seeds and only one (6.7%) of these had germinated after 195 days. The extended period usually required for *Rhaphidophyllum* seeds to germinate may contribute to its reduced fecundity.

Seed Germination. As with most palms, seed germination in *Rhaphidophyllum* is hypogeal. There are three basic variations in germination in palms: remote-ligular, remote-tubular, and adjacent-ligular (Tomlinson 1961, Moore and Uhl 1973). *Rhaphidophyllum* illustrates the remote-ligular type. In this type of germination, a ligule extends from the distal end of the cotyledonary sheath. All subsequent leaves in *Rhaphidophyllum* are also ligulate. In contrast, most other palms with ligulate cotyledons do not possess ligules on subsequent leaves (Tomlinson 1960b).

Figure 3 shows the morphology of a recently germinated *Rhaphidophyllum* seedling. The elongated cotyledonary petiole and the ligule are quite distinctive. Figure 4 shows various stages of seedling development from emergence of the radicle at 2 days (a) to development of the eophyll at 8 weeks (d). In the remote-ligular type of germination the radicle breaks through the seed coat and, along with the cotyledonary sheath (which contains the hypocotyl) and the cotyledonary petiole, grows away from the seed. The cotyledonary petiole in *Rhaphidophyllum* reaches a length of ca. 10 cm. Its growth is positively gravitropic which serves to thrust the young seedling into the soil. We would like to emphasize, however, that

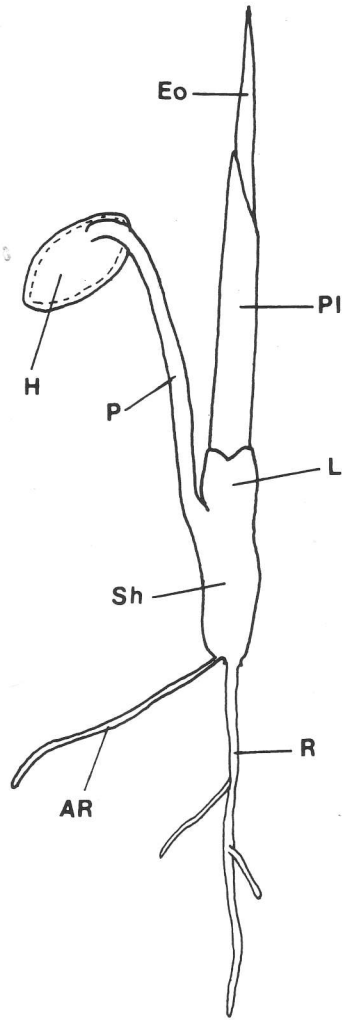
many of the seeds remain on the parent plant where the seedlings are thrust into the leaf bases and establishment is not possible (Fig. 1). After the cotyledonary petiole grows away from the seed the cotyledonary sheath splits allowing the plumule and successive leaves to grow to the soil surface. The plumule (which is white) and first eophylls (which are green) are all narrow linear leaves which facilitates their movement up through the soil (Tomlinson 1960a).

According to Tomlinson (1960b, 1961) remote-tubular and remote-ligular germination appear to be ecological adaptations of palms to xeric habitats. However, a substantial number of palms in mesic habitats exhibit remote-ligular or remote-tubular germination. Nevertheless, these sites are still susceptible to arid conditions, especially if the seeds are exposed to the air for extended periods of time as they are in *Rhapidophyllum*. Consequently, a type of germination which serves to physically bury the young seedling would be an ecological advantage.

Prior to germination (at least a month) the seed forms a haustorium which develops from the distal end of the cotyledon. The haustorium is characteristic of palm seeds in general. This structure has also been called a suctorial or suctional organ (Thiselton-Dyer 1910, Tomlinson 1960a) since it digests the endosperm and transfers this food reserve via vascular connections to the developing seedling. The importance of this source of nutrition for the seedling is indicated by the observation that *Rhapidophyllum* seedlings quickly died when severed from the seed and its endosperm. The haustorium is somewhat convoluted which increases its surface area and maximizes the hydrolytic and enzymatic breakdown of the endosperm.

The Seedling. The seedling stage in *Rhapidophyllum* is quite long. There is a gradual, prolonged transition from the seedling through the juvenile to the adult. We have arbitrarily defined the seedling

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3. Drawing illustrating the morphology of a recently germinated seedling of *Rhapidophyllum hystrix*. $\times 1.8$. Details: Eo, eophyll; Pl, plumule; L, ligule; P, cotyledonary petiole; H, haustorium within seed; Sh, cotyledonary sheath; R, primary root; AR, adventitious root.

stage as that period of time when the plant has simple, undivided leaves. The juvenile stage begins when a plant starts to develop palmate leaves with few to several segments, while the adult stage is defined by the onset of reproduction. According to Shuey and Wunderlin (1977), *Rhapido-*

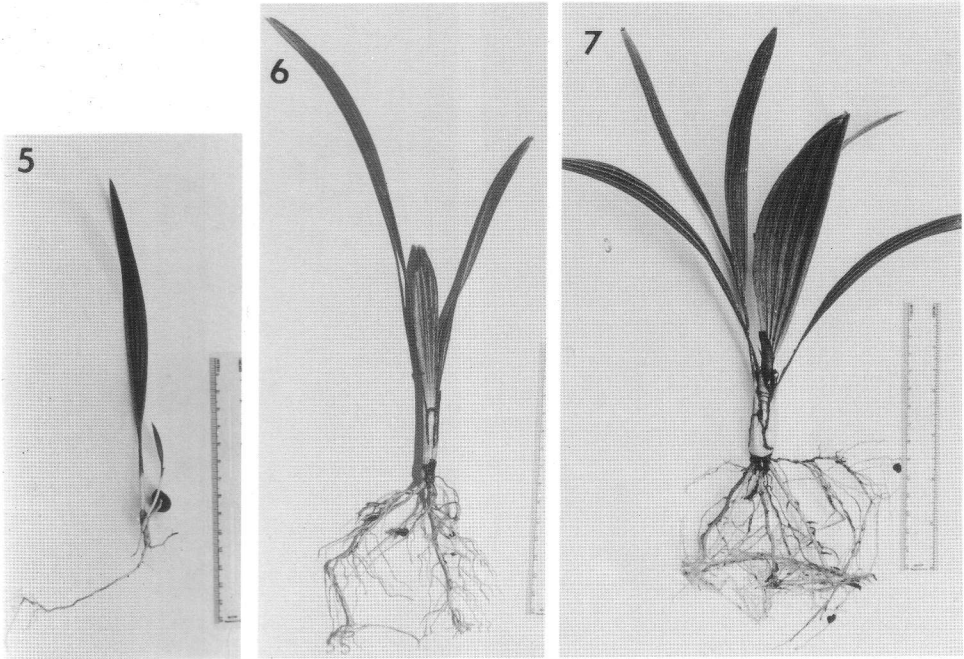


4. Four stages of seedling development in *Rhipidophyllum hystrix*. (a) radicle just emerging at ca. 2 days, (b) seedling 2 weeks old, (c) seedling 4 weeks old, and (d) seedling 8 weeks old. Note the elongation of the cotyledonary petiole (arrow) which serves to thrust the growing seedling into the soil.

phyllum seedlings first begin to produce divided leaves about three years after germination. This time frame corresponds closely to our greenhouse-grown seedlings, which at 3½ years had begun to develop slightly palmate blades. On the average, seedlings produced 9 simple, linear leaves before the formation of the first divided leaf blade. The first palmate blades were found to have either two or three segments. The seedling in Figure 7 is estimated to be 3 years old and still has simple, undivided leaves. For purposes of comparison,

Figure 5 is of a seedling 5 months old while Figure 6 is of a seedling 2 years old. Table 2 lists morphological characteristics for leaves from 2 year old seedlings. Although there was a wide range in leaf dimensions, the number of major veins per leaf was fairly constant, ranging from 3 to 5.

In the wild, no seedlings over 3 years in age (based on size comparisons with greenhouse seedlings) have been found growing beneath the parent, and only a very few have been seen growing in the



5-7. Later stages of seedling development in *Rhipidophyllum hystrix*. 5) Seedling at ca. 5 months (note the 2 seedlings developing from one seed). 6) Seedling at 2 years. 7) Seedling at 3 years. Note that all leaves are still undivided.

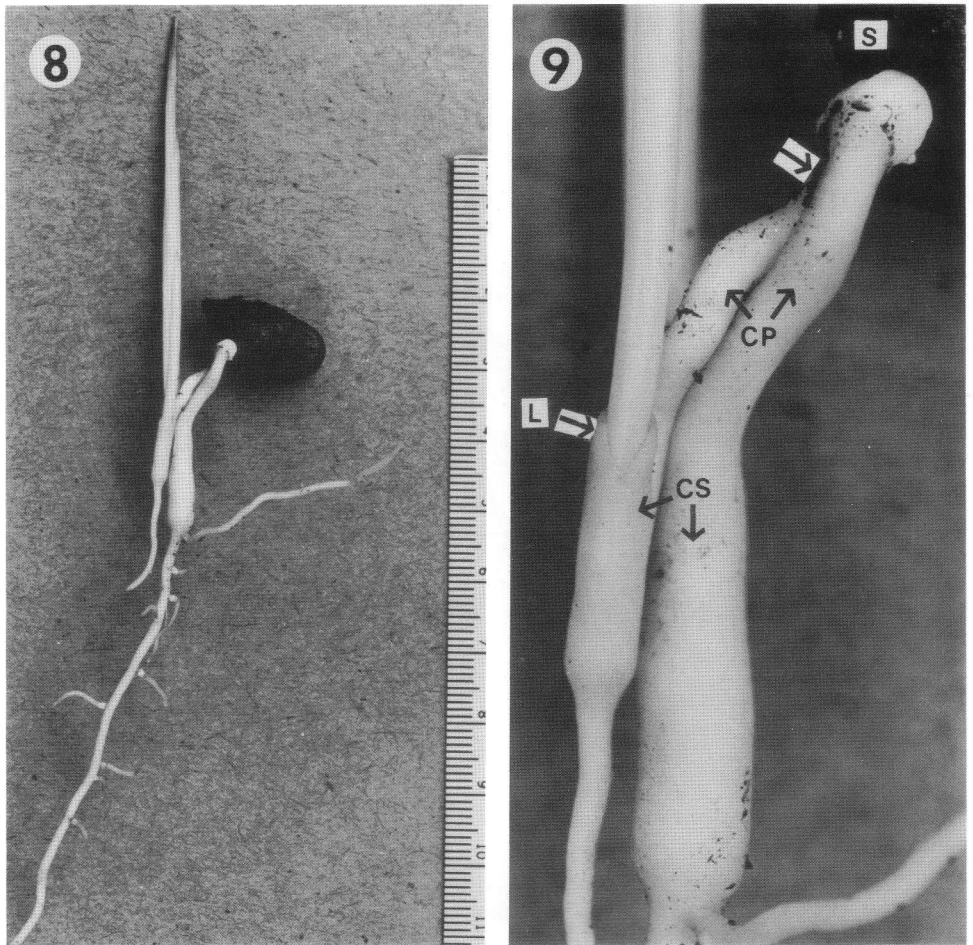
open. There is no known effective dispersal agent for *Rhipidophyllum*, although Manley (1967) thought mice chewed on the ripe fruits.

Polyembryony. During the germination experiments, one seed produced two seedlings. This resulted from the embryo splitting in two (cleavage polyembryony). However, one of the "twins" was definitely more vigorous than the other (Figs. 5, 8-10). The two seedlings were joined to a common petiole just beyond its emergence

from the seed; below this point the seedlings were independent having separate cotyledonary sheaths, radicles and plumules (Fig. 9). However, they were both dependent on a common food reserve from the same endosperm. After 8 months both seedlings were still growing (Fig. 10). A comparison of Figure 5 (at 5 months) with Figure 10 shows that the smaller seedling had grown very little, if any, during these 3 months, while the larger seedling had grown substantially.

Table 2. Morphological characteristics of 2 year old seedlings of *Rhipidophyllum hystrix*. All leaves are still entire and all measurements are for fully developed leaves.

Characteristic	Mean \pm s.d.	Range	Sample Size
Leaves per plant	3.6 \pm 0.8	2-5	16
Leaf length (cm)	17.5 \pm 3.6	10.0-24.4	45
Leaf width (cm)	1.9 \pm 0.6	0.8-3.4	53
Major veins per leaf	4.0 \pm 0.4	3-5	53

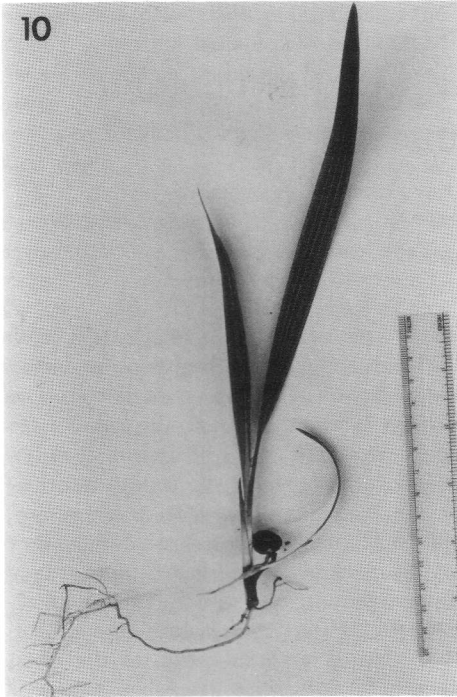


8-10. Polyembryony in *Rhipidophyllum hystrix*. 8) The double seedling resulted from the embryo splitting in two (cleavage polyembryony). Ruler is metric. 9) Close-up of part of Figure 8. Note the point where the 2 seedlings had split (arrow). Details: CP, cotyledonary petiole; CS, cotyledonary sheath; L, ligule; and S, seed. 10) The double seedling at 8 months. Note how much more one seedling has developed and compare with 5 month stage in Figure 5.

In palms, polyembryony is rare. The occurrence of multiple seedlings derived from one seed has been reported by Davis (1979) for the coconut *Cocos nucifera* L. and by Fisher and Tsai (1979) for the date *Phoenix dactylifera* L. Fisher and Tsai also reported on polyembryony in the palm *Syagrus (Rhyticocos) amara* (Jacq.) Glassman, which had three seedlings that had emerged from the same "eye", each with a separate cotyledonary stalk. These

developed either from a single carpel which had three separate embryos or a single embryo which had divided to produce identical triplets.

Rhipidophyllum is apocarpic. Its gynoecium consists of three separate carpels, only one of which normally develops (occasionally 2 or 3 carpels from a flower reach maturity, pers. obs.). The double seedling shown in Figures 5, and 8-10 was derived from a single uniovulate car-



pel; the two seedlings are joined by a common petiole and consequently are genetically identical, a result of cleavage polyembryony. At the moment the occurrence of polyembryony for the needle palm is only a curiosity.

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