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Diaspore and seedling morphology of *Livistona chinensis* (Jack.) R. Br. Ex. Mart. (Arecaceae)

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Abstract

Knowledge of the anatomical structures of the seed and embryo can contribute to understanding the germination process and interpreting germination and vigor tests. Thus, the objective of this study was to describe morphologically the diaspores (seeds with adhered endocarp) and seedlings of Livistona chinensis. Biometric parameters of the diaspores (width, length, weight of one thousand diaspores, and number of diaspores kg-1) were collected, and their water content was measured. One hundred diaspores were sown in plastic trays containing vermiculite as a substrate. To describe the morphology of the diaspore and the initial seedling growth, evaluations were performed by monitoring the germination process from the first week, at each stage of development, until the emergence of the first eophyll. Morphological descriptions were based on specific terminology and schematized with the aid of a clear camera attached to a stereomicroscope. Germination is characterized as being of the remote tubular type. The diaspores have an oval shape with an average length of 16.37 mm and an average width of 10.25 mm, and the seeds are albuminous with a rigid endosperm, peripheral lateral cone-shaped embryo, and little differentiation. The first leaf is simple and lanceolate, with parallel venation, composed of broad veins arranged longitudinal.

Keywords: Biometry, Germination, Palm tree.

Introduction

Livistona chinensis (Jack.) R. Br. ex. Mart., belongs to the Arecaceae family, popularly known in the Americas as the Chinese fan palm and false latvia. It is the most cultivated palm in its genus, and although it originates from the Asian continent, it is widely distributed in the Americas. It is a solitary palm that presents an erect, ringed, fissured stem, with a diameter of about 28 centimeters. The leaves are fan-shaped, with few remnants of the leaf base in the apical region, measuring about 20 centimeters in diameter. The inflorescences are branched, dense, arranged in a pendulous manner between the leaves. The fruits are ovoid or ellipsoidal, glaucous and shiny, with orange flesh during maturation (Lorenzi et al., 2004; Kobori et al., 2009).

According to Lorenzi et al. (2004), it is native to China, Japan, Taiwan, Bonin and Ryukyu Islands. It is a very rustic species, capable of developing well in both full sun and partial shade, but it has slow growth. It is widely cultivated in tropical and subtropical climates, as well as temperate regions worldwide. It is frequently used in landscaping of parks and gardens throughout Brazil, both as a standalone plant and in groups or rows.

The commercial propagation of palm trees is done through seeds (Pivetta et al., 2007), and it is necessary to deepen the knowledge about the particularities of each species. Understanding the anatomical structures of the seed and embryo can contribute to the understanding of the germination process and to the interpretation of germination and vigor tests (Rodrigues et al., 2015).

The classification of seed weight or size is a strategy that can be adopted to standardize emergence and initial growth of seedlings (Carvalho & Nakagawa, 2012). The study of the morphology of fruits, seeds, and seedlings in the early stages of development contributes to improving knowledge of the reproductive process

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of plant species and provides support for seedling production, in addition to being fundamental for understanding the process of plant establishment under natural conditions (Silva et al., 2012). Furthermore, studies focused on the biometry of fruits and seeds represent an important tool for understanding the seed germination process, due to its easy and rapid application (Araújo et al., 2012).

Research on biometry of fruits and seeds of palm trees have been carried out by several authors, among them Batista et al. (2011), with *Syagrus oleracea* (Mart.) Becc.; Luz et al. (2012) with *Archontophoenix cunninghamii* H. Wendl. & Drude; Felizardo et al. (2015) with Oenocarpus bataua Mart.; Rodrigues et al. (2015) with *Bactris marajá* Mart.; Pêgo & Grossi (2016) with *Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.; Viana et al. (2016) with *Livistona rotundifolia* (Lam.) Mart.; Silva et al. (2017) with *Attalea maripa* (Aubl.) Mart., and Moura et al. (2019) with *Syagrus coronata* (Mart.) Becc.. No studies were found on the morphology of structures or the germination process of the *L. chinensis* species.

In view of these considerations, the objective of this work was to morphologically describe the diaspores (seeds with adhered endocarp) and seedlings of *Livistona chinensis*.

Material and Methods

The work was carried out at the Vegetable Seed Laboratory of the Department of Agricultural Production Sciences and the Plant Morphology and Anatomy Laboratory of the Department of Applied Biology to Agriculture of São Paulo State University (Unesp), School of Agricultural and Veterinarian Sciences, Jaboticabal, SP.

Clusters of *Livistona chinensis* were harvested from ten 30-year-old trees grown in the Palms Collection at São Paulo State University (Unesp), School of Agricultural and Veterinarian Sciences, Jaboticabal, SP. The fruits had a greenish-blue color and were considered mature (Lorenzi et al., 2004).

After fruit harvesting, the following methodology was carried out according to Kobori et al. (2009). The fruits were immersed in water at room temperature for 24 hours. The depulping process consisted of manually removing the epicarp and mesocarp of the fruits by rubbing them against a 3 mm steel sieve. The diaspores (seeds with attached endocarp) were rinsed with running water and shade-dried for 24 hours. Before the experiment was set up, visually selected seeds were chosen by removing malformed, damaged, or below-standard ones.

The biometric data of the diaspores were obtained, including width, length, weight of a thousand diaspores, and the number of diaspores per kilogram, as well as their water content. The width and length measurements were performed using a digital caliper (graduated in millimeters) on a sample of 100 diaspores. According to the Rules Manual for Seed Analysis (Brazil, 2009), the number of diaspores per kilogram and the mass of a thousand diaspores were determined. To obtain the water content, five replicates of 20 diaspores were used, following the oven-drying method at 105 °C ± 3 °C for 24 hours (Brasil, 2009).

One hundred diaspores were sown in plastic trays (50 × 25 × 6 cm) containing about 5 cm of vermiculite, according to Kobori et al. (2009), and kept under room temperature conditions in the Horticultural Plant Seeds Laboratory of the Department of Agricultural Production *Sciences*, São Paulo State University (Unesp), School of Agricultural and Veterinarian Sciences, Jaboticabal, SP. Watering was done to keep the substrate always moist, and the amount administered was adjusted according to the needs of each plot.

For the description of the morphology of the diaspore and the initial growth of the seedling, evaluations were carried out by monitoring the germination process from the first week, at each stage of development, until the first eophyll emergence. The material was sent to the Laboratory of Morphology and Plant Anatomy of the Department of Applied Biology to Agriculture, São Paulo State University (Unesp), School of Agricultural and Veterinarian Sciences, Jaboticabal, SP, where the external and internal faces of the diaspores, as well as the embryo, up to the development of the seedling, were schematized with the aid of a clear chamber attached to the stereomicroscope. The morphological descriptions were based on the terminology used by Tomlinson (1961).

Results and Discussion

The germination of *L. chinensis* seeds began on the fourth day after the experiment was set up, with the emergence of the germination button. The probable explanation is that these seeds were harvested at the ideal stage of physiological maturity and, after processing (depulping), under adequate moisture and temperature conditions, they began the resumption of the germination process. According to Kobori et al. (2009), *L. chinensis* seeds have a high germination percentage (96 to 99%), regardless of temperature and light regime.

The seed moisture content presented an average value of 19.31%, which may indicate that this species does not have recalcitrant performance because, according to Marcos Filho (2005), recalcitrant seeds have a higher moisture content at the time of fruit dispersal, about 30 to 70%. The weight of 1000 diaspores was 1157.7 grams and 1 kilogram contained 860 diaspores. According to Lorenzi et al. (2004), one kilogram of *L. chinensis* seeds contains approximately 375 fruits and 750 diaspores. This variation can be explained by the fact that the authors studied matrices of different origins. Viana et al. (2016), studying the germination of another Livistona species, *L. rotundifolia*, found that the weight of 1000 diaspores was 1085.9 grams and 1 kilogram contained 921 diaspores, values similar to those found in this study.

Santos et al. (2018) infer that the variability in different biometric classes of fruits and seeds is related to biomass partitioning and/or nutritional conditions of the mother plant during fruit filling. It is also added that the average number of seeds positively influences the mass of the fruit pyrene in palms (Moura et al., 2010).

The diaspores of *L. chinensis* have an oval shape, with an average length of 16.37 mm and an average width of 10.25 mm (**Figure 1**A). The seeds are albuminous, with a hard endosperm occupying almost the entire interior of the diaspore (Figure 1B). Viana et al. (2016) also described the diaspore of *Livistona rotundifolia* as globular and with most of it occupied by a hard endosperm. The species *Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf., *Archontophoenix cunninghamii* H. Wendl. & Drude, *Roystonea borinquena* OF Cook, *Astrocaryum acaule* Mart., and *Syagrus oleracea* (Mart.) Becc also have seeds formed by a hard albuminous endosperm, as reported by Batista et al. (2011); Luz et al. (2012); Bueno et al. (2013); Pêgo & Grossi (2016); Corrêa et al. (2019). According to Reis et al. (2012), the rigidity of the woody endocarp of palm fruits is attributed to the tissue's constitution by sclerified cells with thickened and intensely lignified walls.

The embryo is lateral, peripheral, conical, and poorly differentiated (Figures 1B and 1C), as reported by Alves & Demattê (1987) in seeds of some palm species of

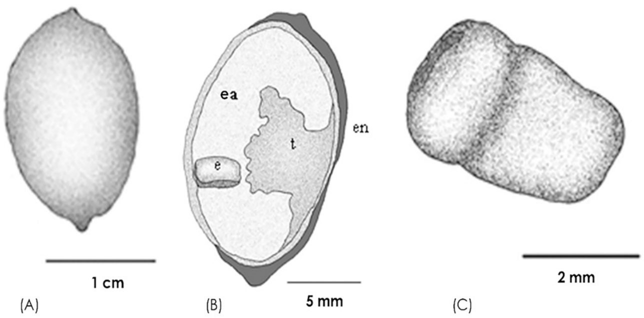

Figure 1. Aspects of *Livistona chinensis* (Jack.) R. Br. ex. Mart. diaspores: A - frontal view (external) of the seed; B - longitudinal section of the seed exposing the embryo, endosperm, and seed coat invagination; C - embryo. Legend: **e** - embryo; **en** - endocarp; **ea** - endosperm or albumen; **t** - seed coat invagination.

the Livistoninae subtribe. The embryo of *Syagrus oleracea* (Mart.) Becc, as described by Batista et al. (2011), is similar to that of this study.

The species *Archontophoenix cunninghamii* H.Wendl. & Drude also presents an embryo similar to that of this research, being classified as peripheral basal and poorly differentiated with approximately 4 mm in length, conical in shape, with one concave end and the other rounded and tapered (Luz et al., 2012)

According to Rodrigues et al. (2015), palm seeds may also have embryos with different shapes, as observed in *Bactris marajá* Mart., where the embryo is conical, small, and has a homogeneous milky-white color. According to Tomlinson (1990), the embryo of palm seeds has a proximal region that houses the embryonic axis, and a distal region that corresponds to the cotyledonary limb.

The beginning of germination occurred between the 4th and 47th day, with the opening of a circular operculum in the endocarp from which a bulbous and hollow structure called the cotyledonary petiole emerges (**Figure 2**A). This structure results from the elongation of a single cotyledon, which internally functions as an organ for the absorption of reserves, called a haustorium (Figures 2 and 5). Similarity in the germination process was reported by Luz et al. (2012) for the species *Archontophoenix cunninghamii* H.Wendl. & Drude.

According to Tomlinson (1961), palm germination can be of two types, adjacent and remote, with the latter subdivided into ligulate remote and tubular remote or alygulate. The germination of *Livistona* seeds is of the tubular remote type, as observed by Viana et al. (2016) with the species *Livistona rotundifolia*.

Carvalho et al. (2015), studying the species *Maximiliana maripa* (Aublet) Drude, reported tubular remote germination, with elongation of the cotyledonary petiole and sheath, without the presence of ligule. The presence of ligule was observed in palms of the genus *Oenocarpus* spp. by Oliveira et al. (2010). However, it is possible to notice that even though they are from different genera, species of the Arecaceae family have similar morphological characteristics for seeds and seedlings.

According to Orozco-Segovia (2003), this type of germination is considered an ecological advantage for species because it keeps the embryonic axis below the soil surface. In this type of germination, the elongation of the cotyledonary petiole is remarkable, and the ligule is not observed (Meerow & Broschat, 1991), as can be seen in (Figure 2).

As the cotyledonary petiole grows, the reserve

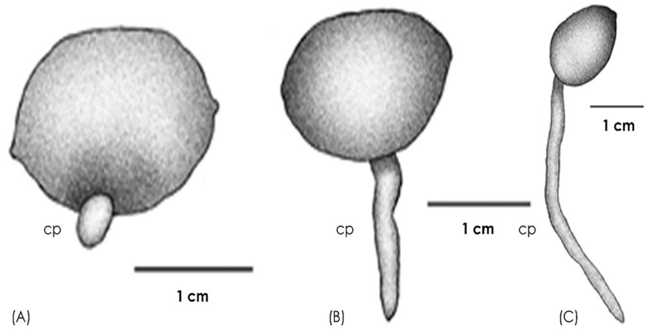

Figure 2. External morphological aspects of the germination of *Livistona chinensis* (Jack.) R. Br. ex. Mart. seeds: A - B - C - phases of progressive growth of the cotyledonary petiole. Legend: **cp** - cotyledonary petiole.

material (endosperm) is gradually consumed. This cotyledonary petiole grows to approximately 5 cm, at which point it begins to dilate at its end (**Figure 3**A), where the growth of the primary root and the opening of a longitudinal fissure from which the aerial part (plumule) emerges begin. At this stage, the appearance of secondary roots can be observed (Figure 3C).

The plumule is composed of an incomplete leaf, called the sheath, which covers the first complete juvenile leaf, called the eophyll (**Figure 4**). The first leaf of *L. chinensis* is simple and lanceolate, with parallel veins composed of broad longitudinal nerves. Similar results were found for other palm species (Batista et al., 2011; Carvalho et al., 2015; Viana et al., 2016). According to Tomlinson (1961), subsequent leaves of seedlings that exhibit remote tubular germination expand their blades and begin their independent growth process.

In contrast to these results, Luz et al. (2012), studying the external morphological aspects of the germination phases of *Archontophoenix cunninghamii* H. Wendl. & Drude seeds, reported that the primary leaf of this species is bifid, with typical parallel veins.

(**Figure 5**) shows internal sections of *Livistona chinensis* seeds, showing the embryo, endosperm, and the invagination of the seed coat at different stages of seed germination and seedling growth. According to this representation, as the cotyledonary petiole grows, the haustorium develops internally, functioning as an organ of reserve absorption, gradually consuming the endosperm (Figure 5B and 5C), which previously occupied the entire interior of the seed. For a better understanding, Figure 5 should be viewed together with Figures 2, 3, and 4, by following the development of the seedling.

The haustorium is typical of embryos of Arecaceae and contributes to the hydrolysis of lipid, protein, and carbohydrate reserves, as well as the mobilization of nutrients from the endosperm to the emerging seedlings (Verdeil & Hocher, 2002). Consistent with Tomlinson (1990), the consumption of nutritional reserves from palm seeds

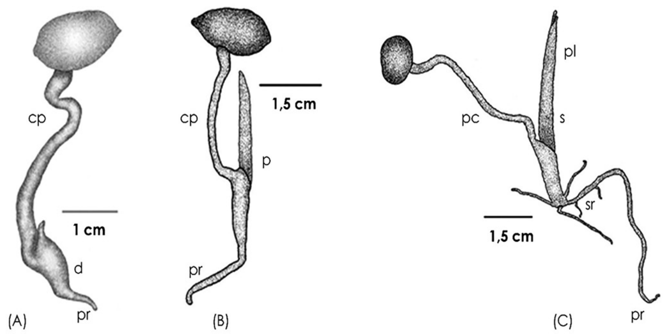

Figure 3. External morphological aspects of the germination of Livistona chinensis (Jack.) R. Br. ex. Mart. seeds: A - beginning of the dilation of the cotyledonary petiole tip; B - differentiation of the longitudinal fissure and the primary root; C - growth of the primary and secondary roots, opening of the sheaths, and emergence of the first eophyll or primary leaf. Legend: **cp** - cotyledonary petiole; **d** - dilation; **pr** - primordium of the primary root; **s** - sheath; **p** - plumule; **pl** - primary leaf; **pr** - primary root; **sr** - secondary root.

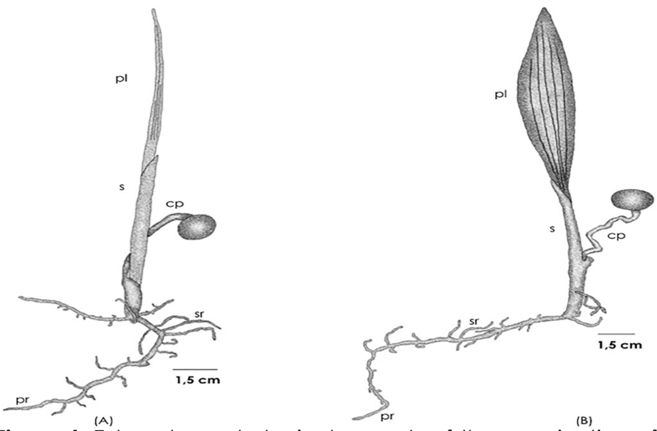

Figure 4. External morphological aspects of the germination of Livistona chinensis (Jack.) R. Br. ex. Mart. seeds: growth of the primary root and secondary roots, growth of the first leaf or primary leaf. Legend: **cp** - cotyledonary petiole; **pr** - primary root; **sr** - secondary root; **s** - sheath; **pl** - primary leaf or first leaf.

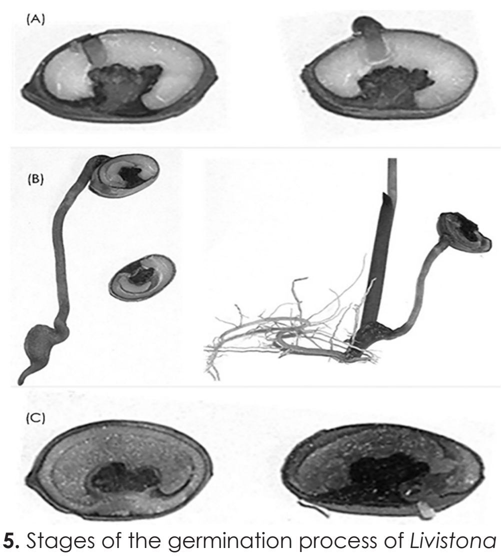

Figure 5. Stages of the germination process of *Livistona chinensis* (Jack.) R. Br. ex. Mart. seeds: A - emergence of the cotyledonary petiole; B - seedling development and consumption of reserves by the haustorium; C - different stages of haustorium development and endosperm consumption.

by the haustorium and the concomitant photosynthetic production by the eophyll mark the end of the seedling stage.

Biometry and morphology of fruits, seeds, and post-seminal development are important information for plant identification, species differentiation, and storage and germination of ornamental palm seeds, as well as for most ornamental species. They also contain valuable information for future studies (Pêgo et al., 2013).

The results found in this study indicate that the species of the genus Livistona have similar morphological characteristics for both diaspores and seedlings, as verified by Viana et al. (2016). It is important to emphasize that, even though these are characteristics present in several palm species, they should not be generalized to all species of the Arecaceae family.

Conclusion

Germination is of the tubular remote type. The diaspores are oval in shape and the seeds are albuminous, with a rigid endosperm and a lateral, peripheral, conical and poorly differentiated embryo.

The first leaf is simple and lanceolate, with parallel venation, composed of wide veins arranged longitudinally.

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