DISTINGUISHING *Carapa guianensis* Aubl. FROM *Carapa procera* D.C. (MELIACEAE) BY MORPHOLOGY OF YOUNG SEEDLINGS.

Simey Thury Vieira FISCH[1], Isolde Dorothea Kossmann FERRAZ[2], William Antonio RODRIGUES[3]

ABSTRACT — Seedling morphology was studied in *Carapa guianensis* Aubl. and *Carapa procera* D. C. from germination to 90 days age. In both species germination is hypogeal and cryptocotylar. Both have rare albino seedlings. Though both species have compound leaves when adult, *C. procera* puts out an average total of six simple leaves at germination, while leaves of *C. guianensis* are compound at all stages. This is the best diagnostic character for separation of the two species at the young seedling stage. Not diagnostic, but none the less useful, is the fact, that polyembryonic seeds are often found in *C. procera*, but not observed in *C. guianensis*.

Key words: *Carapa guianensis* Aubl., *Carapa procera* D. C., seedling morphology, germination, polyembryony.

Comparações Morfológicas da Germinação e do Desenvolvimento das Plântulas Visando a Identificação das Espécies *Carapa guianensis* Aubl. e *Carapa procera* D.C. - Meliaceae.

RESUMO — Estudaram-se aspectos morfológicos de plântulas de *Carapa guianensis* Aubl. e *Carapa procera* D. C. desde a germinação até 90 dias de idade. Ambas espécies possuem germinação hipógea e criptocotilar, e, embora não muito frequente, apresentam plântulas albinas. Apesar de que na fase adulta as duas espécies apresentaram folhas compostas, a plântula de *C. procera* primeiramente lança em média seis folhas simples, enquanto a de *C. guianenis* , desde o início emite folhas compostas. *C. procera* possui comumente semente poliembriônicas, não sendo observado este fenômeno em *C. guianensis.* Portanto, um dos principais descritores morfológicos, para a distinção das plântulas destas espécies, é tipo de folha emitida. A presença ou ausência de poliembrionia, também pode ser um caráter útil para a identificação.

Palavras-chave: *Carapa guianensis* Aubl., *Carapa procera* D. C., morfologia da plântula, germinação, poliembrionia.

INTRODUCTION

The genus *Carapa* is comprised of two commercially valuable tree species native to the Brazilian Amazon, *C. guianensis* Aubl. and *C. procera* D.C. (PENNINGTON *et al.*, 1981). Both species provide wood of excellent quality, similar to mahogany, *Swietenia macrophylla* King (LE COINTE, 1934; CARRUYO, 1972; LOUREIRO *et al.*, 1979). The large seeds of both species produce an oil widely used as a folk medicine (AUBLET, 1977; PINTO, 1956; LOUREIRO *et al.*, 1979).

Thought treated as a single species by popular and commercial taxonomy under the common Brazilian name of " Andiroba", adult plants are botanically distinguishable by inflorescence and leaflet morphology. These characters, however, are not easily observed in the field and no morphologic distinctions have yet

[1] Departamento de Biologia da Universidade de Taubaté - São Paulo, Brasil.
[2] Instituto Nacional de Pesquisas da Amazônia - INPA/CPST, Manaus - Amazonas, Brasil.
[3] Universidade Federal do Paraná, Centro Politécnico, Departamento de Botânica, Curitiba - Paraná, Brasil.

been reported at the early seedling stages. Recognition of new diagnostic descriptors is thus of practical value and is the object of this work.

MATERIALS AND METHODS

Seeds used in the study were collected from plantations established in the 1960' s at the INPA Ducke Forest Reserve (3°8' S, 59°52' W), near the city of Manaus. The plantations are derived from genetic material collected originally at Curua-Una 600 km east of Manaus (ARAUJO & ALENCAR, pers. com.). Some seeds were also taken from trees of unknown origin at the Botanical Garden of Rio de Janeiro. Predation precluded collecting a sufficiently large number of seeds from low-density native tree populations. Data, of seedling morphology were lumped from experiments over five annual fruiting seasons (1986-1990), including some experiments conducted as part of a master's thesis (FISCH, 1990).

Seeds were collected where they fell under the trees, soaked for 14 days in water changed daily, then germinated in sealed clear-plastic bags. This procedure drowns the common borer, *Hypsipyla* sp., and allows the seeds to become turgid (FERRAZ *et al.*, 1987; FERRAZ, 1989).

Successfully germinated seeds were planted in the nursery in black plastic bags with four different treatments. These were combinations of two light intensities (100 % and 50 %) and three substrates: - washed sand; - washed sand : clay (2:1); - washed sand with nutrient solution (DOWNS & HELLMERS, 1975). Soil was weeded as necessary and watered by fine spray.

RESULTS AND DISCUSSION

Both species had a wide range in seed fresh-weight. Fresh weight for *C. guianensis* ranged 1 - 70 g and clustered at 20 -30 g, while *C. procera* ranged 1 - 40 g and was generally smaller between 10 - 20 g. In their natural habitat, seeds of both species germinate at the soil surface. Following the terminology of DUKE (1969) germination is hypogeal and cryptocotylar since the hypocotyl does not grow and the cotyledons remain within the seed coat. This hypogeal-cryptocotylar syndrome is common among heavy-seeded, tropical forest trees (NG, 1976; HLADIK & MIQUEL, 1990).

Germination starts with the rupture of the seed coat in the micropylar region by the thick fused petioles and afterwards the radicle growths (Fig.1a). HARSHBERGER (1902) and ALBUQUERQUE (1987) used the terms "thick tuberous mass" and "minuscule tuber", respectively. Though the petioles and the radicle are thick when they first appear, the term "tuber" should not be employed, as it does not grow thicker with time. Numerous secondary roots arise from the radicle. Their form varies with the texture of the substrate, being longer and thinner in clay soils.

After the radicle has started its growth the proximal portion of the two cotyledonar petioles are also projected out of the seed coat (Fg.1b). In his landmark study of *C. guianensis*, HARSHBERGER (1902) described the cotyledons as "conferruminate", a term synonymous with "syncotylous" (FONTQUER, 1985) or "fused". In this study both species were found to have completely fused cotyledons. The petioles are not fused. In plants germinated in the dark the petioles grow longer and can be observed easily. The epicotyl arises with a down-turned apex in a hook shape between the two cotyledonar petioles (Figs. 1b; 1c). The epicotyl grows in this shape for several days, then the apex turns up and the organ becomes an erect shoot (Figs. 1d; 2).

Both species showed their most rapid stem growth at this stage, reaching a height of 15 cm in 15 days. The first leaves are then produced and stem growth slows. Prior to leaf emergence the reddish shoot produces spiral arranged cataphylls numbering about four in *C. guianensis* but rarely exceeding three in *C. procera* (Tab. 1, Fig. 3).

The first leaves were purplish when very young in both species. In *C. procera* they were simple and entire, though some older seedlings had compound leaves with no more than three leaflets (Tab. 1, Fig. 3). Though PENNINGTON and co-authors (1981) considered simple, entire first leaves to be a trait common to both species, in our study *C. guianensis* was found to have first leaves usually compound, long-peciolate, with 2 - 5 leaflets (Tab. 1, Fig. 3). Only rarely did this species produce simple first leaves. First leaves persist for a long time and therefore constitute a diagnostic character for distinguishing the two species at the seedling stage.

The apparent association between simple first leaves and fewer cataphylls in *C. guianensis* vs. compound first leaves and more cataphylls in *C. procera* points out the need for a study of ontogeny in both species.

Secondary seedlings sometimes appeared in *C. procera*, usually at intervals of days to weeks during seedling growth but occasionally right after germination. Many of these were complete, viable individuals that could be separated after abscission of the cotyledons. The ontogeny of these secondary seedlings was studied by sectioning and staining seeds of *C. procera* with 0.1 % Tetrazolium. As many as four embryo axes were found in a single seed, though corresponding separate parts of the cotyledonar mass could not be distinguished, an observation in agreement with that of HARSHBERGER (1902). The embryo axes were at different distances from the micropyle and this may determine the order of their appearance, those closest to the micropyle probably developing first.

Seeds of *C. procera* clearly can be polyembryonic, but multiple shoots can also arise at the stem-root transition by resprouting from an area of intense meristematic activity. This was indicated by the occurrence of some seedlings with up to four shoot axes sharing the same radicle. Both polyembryony and multiple sprouting may be evolutionary strategies for surviving partial

Table 1. Number of cataphylls and leaf types in 3 months old seedlings of *Carapa guianensis* Aubl. and *C. procera* D.C. by origin, light conditions and substrate.

SPECIES	ORIGIN	Nº	AGE (days)	TREAT-MENT	CATA-PHYLLS		SIMPLE 1 leaf		COMPOUND 2 leaflets		COMPOUND 3 leaflets		COMPOUND 4 leaflets		COMPOIND 5 leaflets	
					mean	s.d	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
C. procera	MAO	24	75	T 1	2,8	1.3	5.6	2.8	0.3	0.5	0.3	1.0	0.0	-	0.0	-
C. procera	MAO	50	90	T2	n.d.		4.7	1.6	0.4	0.7	0.5	0.8	0.0	-	0.0	-
C. procera	MAO	22	75	T3	3,4	1.3	6.9	4.1	1	0.5	0.1	0.4	0.0	-	0.0	-
C. procera	MAO	24	75	T4	2,8	1.2	7.4	2.9	0.2	0.4	0.8	0.9	0.0	-	0.0	-
C. procera	mean	120			3.0		5.8		0.3		0.4		0.0	-	0	-
C. guianensis	MAO	10	75	T1	5,2	2.2	0.0		0.8	0.8	0.4	0.9	4.0	1.4	0.8	0.8
C. guianensis	MAO	49	90	T2	n.d.		0.1	0.3	0.9	1.1	0.6	0.8	2.0	1.4	0.6	0.8
C. guianensis	MAO	10	45	T3	5.0	1.2	0.1	0.3	0.9	1.0	0.8	1.0	2.1	2.1	1.3	1.0
C. guianensis	RIO	10	75	T1	2.9	1.0	0.1	0.3	1.1	1.1	0.6	0.7	1.1	1.1	1.8	0.6
C. guianensis	RIO	10	75	T2	2.9	1.0	0.2	4	1.1	0.9	0.6	0.8	1.3	1.2	1.5	1.1
C. guianensis	mean	89			4.0		0.1		0.9		0.6		2.1		0.9	

- Origin: MAO = Manaus (Ducke Forest Reserve); RIO = Rio de Janeiro (Botanical Garden grounds).

- Treatments: T1: 100% sun, washed-sand; T2: 50% sun, washed-sand; T3: 100%sun, washed-sand: clay (2 : 1); T4: 100% sun, washed-sand with complete nutrient solution.

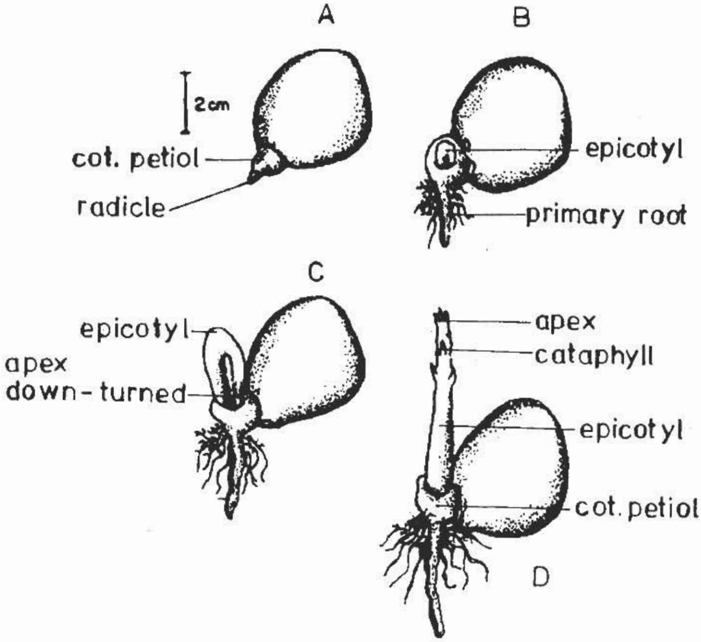

Figure 1. Germination of *Carapa guianensis* Aubl. A) appearance of the petioles and the radicle B) appearance of the epicotyl between the colyledonar petioles. C) growth of the epicotyl in hook shape D) erect epicotyl.

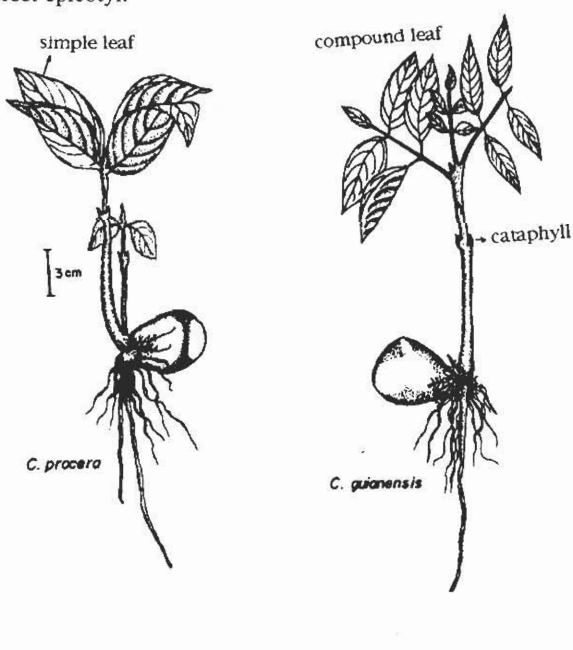

Figure 2. *Carapa guianensis* Aubl. and *C. procera* D.C. seedlings about 3 months after germination. *C. procera* is shown with secondary plant.

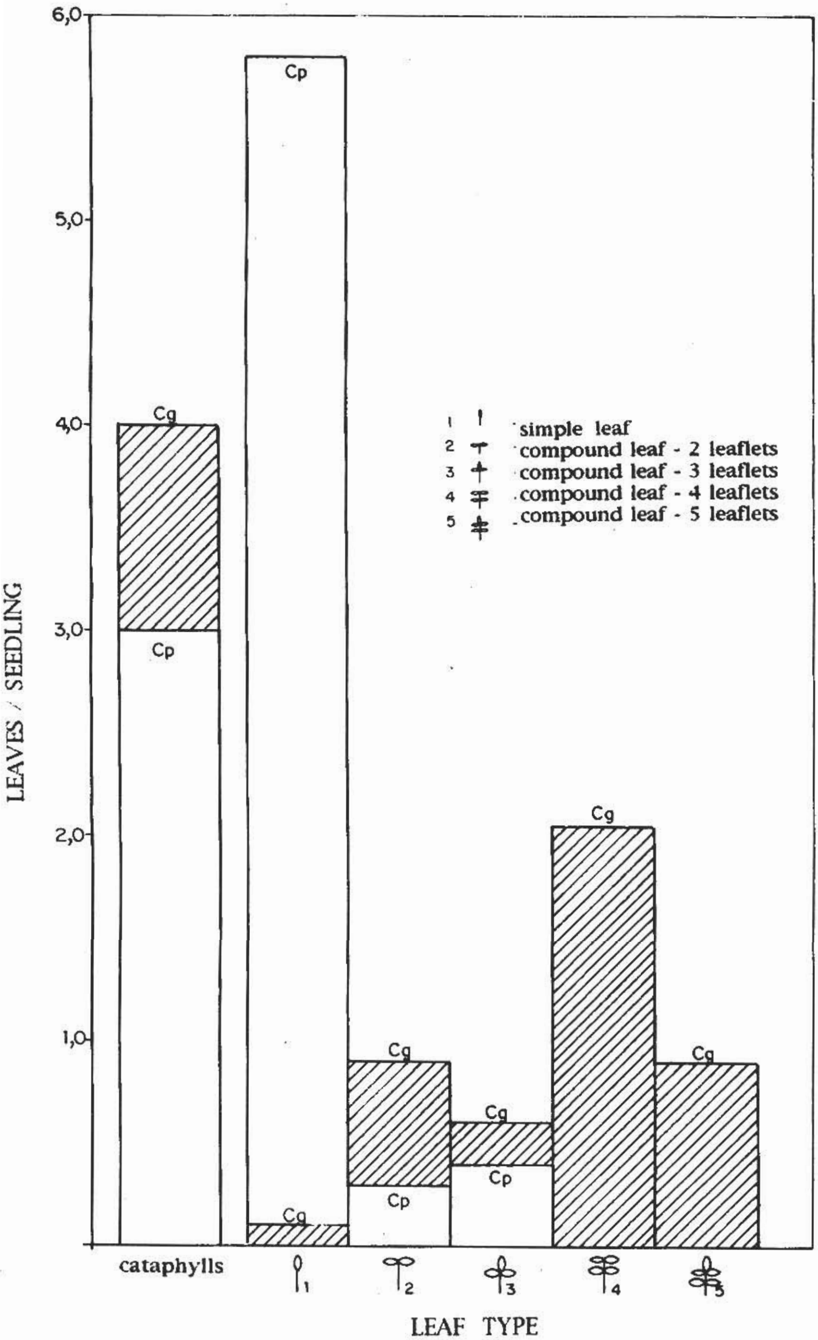

Figure 3. Number of cataphylls and leaf types of 3 months old seedlings of *Carapa guianensis* Aubl. (Cg; n = 89) and *C. procera* D.C. (Cp; n = 120)

consumption by herbivores at the seed and seedling stages.

Albinism occurred at a low rate in seedlings of both species from both forest and nursery. The phenomenon appears to be more common in *C. procera*. The two species had morphologically different albinos. In *C. procera* the albinos had a twisted shoot with slight reddish pigmentation, small white leaves and poor growth. In *C. guianensis* albinos had an erect shoot, white leaves with some greenish pigmentation at the leaf margin and along veins, and were only slightly stunted compared with normal individuals. Because they have no chlorophyll, the albino plants do not survive long.

ACKNOWLEDGMENT

The authors express their gratitude to the technical staff, the volunteer students and all the other persons of the Seed Laboratory INPA-CPST who were involved with the studies of andiroba. We are thankful to Tania Pereira of the Botanical Garden of Rio de Janeiro - RJ for the seed support of *C. guianensis* and Dr. Paulo Cavalcante for literature exchange.

Literature Cited

ALBUQUERQUE, J. M. 1987: *Estudo morfólogico da semente e suagerminação ate a fase de plântula, principalmente deinvasoras de culturas e de essencias florestais da Amazonia*. Tese de Doutorado, Programa de Pós-Graduação em Biologia Tropical e Recursos Naturais, Instituto Nacional de Pesquisas da Amazônia/ Fundação Universidade do Amazonas, Manaus,Amazonas, 137 p.

AUBLET, F. 1977. *Histoire des plantes de la Guiana Française*. J. Cramer (Germany), Vol.1, supl.: 32-34.

CARRUYO, L. I. 1972. *Carapa guianensis* Aublet, sus propriedades y caracteristicas. (IICA ed.) *Simposio Internacional sobre plantas de interes economico de la flora Amazonica.* Turrialba: 249-254.

DOWNS, R. J.; HELLMERS H. 1975: *Environment and the experimental control of plant growth.* Academic Press, New York, 145 p.

DUKE, J. A. 1969. On tropical tree seedlings. I - Seeds, seedlings, systems and systematics. *Ann. Miss. Bot. Gard.*, 56 (2): 125-161.

FERRAZ, I. D. K. 1989: Armazenamento e teor de umidade em sementes de *Carapa procera* D.C. *Anais do 2º Simpósio sobre Tecnologia de Sementes Flores–tais.*Sociedade Brasileira de Sementes, Atibaia, São Paulo: 38.

---- VARELA V. P.; SA, S. T. V. 1987. Germinação e teor de umidade de sementes de andiroba (*Carapa guianensi:* Aubl.). *Resumos do XXXVIII Congresso Nacional de Botânica,* Sociedade Botânica do Brasil, São Paulo: 47.

FISCH, S. T. V. 1990. *Comparações morfológicas e fisiológicas durante os processos de germinação de sementes e crescimento plântulas de Carapa guianensis Aubl. e Carapa procera D. C.* Dissertação de Mestrado. Programa de Pós-Graduação em Biologia Tropical e Recursos Naturais, Instituto Nacional de Pesquisas da Amazônia /Fundação Universidade do Amazonas, Manaus, Amazonas. 85 p.

FONTQUER, P. 1985. *Diccionário de Botânica.* Barcelona, Labor, 1244 p.

HARSHBERGER, J. W. 1902. The germination of the seeds of *Carapa guianensis* Aubl. *Proceedings of the Academy of Natural Science of Philadelphia*: 122-126.

HLADIK, A.; MIQUEL, S. 1990. Seedlings types and plant establishment in an African rain forest. *In*: BAWA, K. S.; HADLEY M. (eds.). *Reproductive ecology of tropical forest plants.* Man and the biosphere (Series): 7. Paris, UNESCO, the Pathernon Group: 261-282.

LE COINTE, P. 1934. *Arvores e plantas úteis (indigenas e aclimadas),nomes verna–culos e nomes vulgares, classificação botanica, habitat, principais aplicações e propriedades.* Belém, Liv. Classica, 486 p. (A Amazônia Brasileira, III).

LOUREIRO, A. A.; SILVA, M. F. DA; ALENCAR, J. DA C. 1979. *Essencias madeireiras da Amazonia.* Manaus, Instituto Nacional de Pesquisas da Amazônia. Vol. 1: 49-54

NG, F. S. P. 1976. Strategies of establishment in Malayan forest tress. *In:* TOMLINSON, P. B.; ZIMMERMANN, M. H. (eds.). *Tropical trees. as living systems.* Cambridge, Cambridge University Press: 129-163.

PENNINGTON, T. D.; STYLES, B. T.; TAYLOR, D. A. H. 1981. Meliaceae. *Flora Neotropica,* 28: 406-419.

PINTO, G. P.1956. Contribuição ao estudo químico do oleo de andiroba. *Boletim Técnico do Instituto Agronômico do Norte*, 31: 195-206.

Aceito para publicação em 1.11.95