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Contributions to the genus *Euterpe* Mart.

**Strudwick, Jeremy, Ph.D.
City University of New York, 1993**

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A

CONTRIBUTIONS TO THE GENUS EUTERPE MART.

by

Jeremy Strudwick

A dissertation submitted to the Graduate Faculty in
Biology in partial fulfillment of the requirements for
the degree of Doctor of Philosophy, The City University
of New York.

1993

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This manuscript has been read and accepted for the Graduate Faculty in Biology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract**CONTRIBUTIONS TO THE GENUS EUTERPE MART.**

by

Jeremy Strudwick

Adviser: Professor Jack Valdovinos

This work focuses upon the neotropical palm genus Euterpe Mart. Its taxonomic and nomenclatural history is treated in depth. The prolific palm specialist, H. E. Moore, called the nomenclatural problems of the genus the most vexing among palms. Euterpe has been split by some into two genera, Euterpe and Prestoea. The differences between the two are inconsistent and Euterpe should be maintained as one at present, without recognition of Prestoea.

Euterpe is of significant economic importance. The most utilized species is E. oleracea. This species is the major world source of heart of palm and it's

fruits provide a 'mush' (food liquid) which is a major part of the diet of tens of thousands in the Amazon estuary. Detailed studies of it's many uses, and especially these two major ones, were made in the Amazon estuary and are included here. Extensive information is provided on the multiple use of the entire genus based upon in-depth literature searches.

E. oleracea is abundant and important in agroforestry systems in the Amazon estuary. Such a system is described here, and the abundance and frequency of this species, especially as illustrated by the author's extended profile, plotted and drawn from Amazonian forest, is provided. The most important center of today's palm heart industry is the Amazon estuary. Since E. oleracea has multiple stems, it can yield sustained, renewable harvests, especially when harvesting is managed. To illustrate this, a study is included which observed the management of the forest practiced by one company on the large island of Marajó in the estuary. Conservationists should recognize the importance of economic forces and support systems such as this one that combine economics and conservation.

A detailed pollination study provides data on the floral morphology, biology, floral arrangement and

phenology of E. oleracea, as well as insect visitors and behaviour. Scarab beetles are most strongly implicated as pollinators, although many others may be involved also. Finally, preliminary leaf anatomical studies of transverse commissures presented here show some difference between Euterpe and Prestoea but do not warrant recognition of the latter.

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ENVIRONMENTAL NOTE

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DEDICATION

This thesis is dedicated to my wife,

Gail L. Sobel

**She is the finest human being I have ever met
and the best thing that ever happened in my life.**

INTRODUCTION

This dissertation focuses upon the genus Euterpe Mart. in the family Palmae. Since Euterpe is an economically important genus occurring in threatened tropical forest habitats of the New World, the areas in need of work are various. They include economic botany, ethnobotany, agroforestry, conservation, biology and taxonomy. Contributions to each of these areas are made in this dissertation. Some background information on the problem and why it was selected as a topic in need of work will help to introduce the dissertation. This introductory background will also include a summary of the diversity of the genus and its taxonomic problems so that the reader will have a better picture of the genus and what is currently understood about it.

Research and fieldwork is urgently needed in tropical forest areas of the world due to their rapid destruction, a problem which is multiplied by the large number of species found there. Palms are often a dominant or significant element of these forests. They are perhaps the most economically important family in tropical areas, especially to poorer peoples and indigenous populations in developing countries. The

palm family, however, remains one of the most poorly studied of families, excepting three well-known and valuable species, namely the coconut, date palm and oil palm. As is the case with most of the palms, herbarium collections of Euterpe are poor and quite inadequate for a definitive taxonomic study. The large size of leaves and inflorescences have most often caused collectors to avoid collections altogether. Moreover, only a small percentage of existing collections are good representative samples. While most plants of other families can be represented in a herbarium by a single sheet, a good collection of Euterpe that I saw was represented by eighteen sheets (Maguire and Politi 28009). Such fine collections are extremely rare. Many of the existing specimens do not contain adequate features to define the genus, let alone its species. Some specimens have leaves only. Fruits, when present, are often in different stages of maturity which makes comparisons difficult. Entire inflorescences are rarely collected. Photographs are important in palm collecting but are virtually non-existent in herbaria. Fieldnotes are also of utmost importance since many diagnostic features cannot be represented in the herbarium (for example, one of the diagnostic features of E.oleracea is that it has multiple trunks). In many specimens such notes are grossly insufficient or absent. Given the

paucity of collections and the inconsistency of characters and information recorded, it is impossible to make rational comparisons between herbarium collections. Because of this a useful classification has eluded past workers. This will remain an impossible task until good observations and collections are made from throughout the range of Euterpe. Such a task was beyond the range of this thesis.

Species estimates in Euterpe have varied from 18 (Moore 1973) to 49 (Glassman 1972). These are found from sea level up to relatively high altitudes for palms, occupying a variety of habitats from Amazonian swamp forests to the tops of Venezuelan tepuis. Some species are island endemics and others have very restricted local distributions. The geographical range is from northern Argentina and Bolivia in the south to Central America, Trinidad and Tobago in the north. Species are most abundant in Colombia, Venezuela and Brazil. The last extensive systematic treatment of Euterpe was that of Burret in 1929, when the genus Prestoea was included in Euterpe. Moore (1963) separated the two genera, listing differences between them. However, the taxonomic characters that Moore used do not stand up to field studies. Like Moore, the palm specialist R. Read (pers. comm.) recognizes two genera,

but states that other features are required for their separation, such as equal length inflorescence bracts in Euterpe as opposed to distinctly different length bracts in Prestoea. Since bracts are rarely present in existing collections this cannot be tested without further fieldwork. Galeano Garcés, a Colombian palm specialist, states that based upon field observations, Moore's circumscriptions do not hold up in many of the Colombian species (pers. comm.). Some of them exhibit characters used to define one genus, while paradoxically showing others used to define the other genus. The problem is further illustrated by the difficulty recent authors have had in placing newly discovered species within the Euterpe/Prestoea complex, something which is bound to reoccur with several other undescribed species.

Besides the taxonomic confusion there are special economic and conservation considerations in Euterpe that make it a priority for study. Several of these considerations hinge upon the heart-of-palm industry. Heart-of-palm is a gourmet food sold mostly in cans. Other names for it include 'palm cabbage', 'palmito' and 'millionaire's salad'. It is the inner portion of the growing apex of the palm shoot. When it is removed, the shoot dies. Euterpe is recognized as having one of the best edible hearts and various species are cut down for

this. Greatest production of heart-of-palm is from Euterpe species in Brazil, where the annual harvest is worth ca. \$120 million. Overcutting of certain single-stemmed Euterpe species has led to them becoming more scarce and possibly endangered. The pressure put upon wild Euterpe populations has been reflected by changes in location of palm-heart industries. In Brazil many of the canneries moved from the south-east, where the overexploited, single-stemmed E. edulis died after cutting, to the Amazon estuary where the multi-stemmed E. oleracea is a more reliable source because it is able to regenerate vegetatively after cutting. In Costa Rica a species of Euterpe was also overexploited for its heart. It is doubtful whether this species will survive the cutting (Balick 1976). The Brazilian Association of Palm Heart Exporters (ANFEP, pers. comm.) is planning a marketing drive to increase palm-heart sales in the U.S. from the current \$2 million per year to as much as \$100 million. Canneries are already in operation in countries such as Ecuador and Peru. Further factories are being considered, for example in Colombia. The projected increased market and the establishment of more canneries could well threaten more species. Given this background information I would like to explain how and why I came to choose the genus Euterpe for study.

I selected this genus for several reasons. I had interests in economic botany, ethnobotany, plant biology, plant conservation, taxonomy and languages. Much work has been done in temperate regions of the world on these topics in science. The tropics presented a region where the flora was poorly known and high in diversity, as well as endangered in many areas due to habitat destruction etc.. This made it an area in pressing need of research if the plants and knowledge related to them was to be recorded or conserved. Among the flora of these regions the palms were especially in need of work, due to both their size, which had precluded easy study, as well as their great economic importance - primarily to local people in the tropics, but also to the whole world. I thus selected this family. Euterpe was in special need of research and presented many facets for study that encompassed my interests. Conservation of the species was linked in part to their economic exploitation. How the species are utilized as well as experimental methods which would help in their conservation, such as agroforestry and forest management, were some of the areas that invited work.

As part of my dissertation I made a field trip to the Amazon estuary of Brazil. Here I studied the

region's relatively sophisticated palm-heart industry which utilizes E.oleracea. It was evident that even though there is some attempt by certain companies to harvest palm-heart in a rational fashion, there is still random unsupervised cutting. Such cutting was at least partially responsible for the demise of the Costa Rican species and could be happening in other areas where locally restricted, single-stemmed species occur. To the rural poor, these species may represent a quick cash income, since canneries will pay money for what is brought to them. Important and little known species may soon be lost.

Euterpe has already been recognized as a palm of economic potential and as a research priority (NAS 1975). It has many other uses including fodder for domestic animals, cellulose for paper, thatch, fertilizer, shading, sweets, cakes and a garden ornamental of considerable potential. Fruits from native stands of the açai palm (E. oleracea) are made into a nutritious food/drink which is a major and essential element of the diet of tens of thousands of inhabitants of eastern Amazonia. Ethnobotanical data from other species which may be used in the same way could play an important role in the improvement of its nutritional value. The fruits are also used in a

popular Brazilian ice-cream consumed locally in eastern Amazonia. Plans for marketing a powdered form of the fruits (invented by CPATU, the Center for Research on the Humid Tropics, Belém, Brazil) and the use of this to create a national market for the ice cream (by Kibon, the largest ice cream company in Brazil) could lead to further stress upon E. oleracea populations. A thorough knowledge of E. oleracea is essential for its future development.

The case has been made above for the necessity of studies in Euterpe as well as my reasons for interest in this group. It was beyond the scope of this dissertation to finance the fieldwork needed to accomplish a taxonomic revision of the genus. Fieldwork in the Amazon estuary of Brazil was possible however, and this opportunity was taken to make some of the studies noted above as being in need of research. These studies all focused upon E. oleracea, since it is the most economically important species in the genus. Thorough accounts of its uses, processing, habitats and habit are provided in the ethnobotany chapter of the thesis. The palm's importance in the lives of thousands of people in the estuary region also becomes clear in this chapter. To help better understand the biology of E. oleracea, pollination studies were also made of this

species while in the region.

Agroforestry systems are a practical and innovative (at least in terms of their recent popularity as a research topic) approach to the problems of tropical forest conservation. In the Amazon estuary E. oleracea is a dominant element of the forest. Its high productivity and ability to regenerate vegetatively make it ideal for in situ management. It thus could play a central role in conservation of these estuarine forests. Because of this a detailed study was carried out to determine the role of E. oleracea in agroforestry systems in the várzea forests of the region. This study also helped to illustrate the importance of this plant in the lives of the local inhabitants of the region who manage these systems. The results of this research is presented in the chapter on agroforestry.

It has been noted that palm heart industries have shifted from eastern/south-eastern coastal Brazil (following a demise in the populations of E. edulis due to apparent over-exploitation) and are now concentrated upon E. oleracea in the Amazon estuary. Because of this it is extremely important to monitor the effects of the growth of this new industry center upon E. oleracea populations and in turn upon the native forests. One

promising method of optimising the productivity of the palm whilst simultaneously preserving the populations, as well as the local and interdependent flora and fauna is to supervise the extraction of the palm in an organized fashion. Such methods could be invaluable in conserving local forests, soils etc.. To examine this solution a study was made of one of these systems in operation. The results of this are presented in the chapter on conservation and management. Once again the value and potential importance of this method and industry to local people is discussed.

The need for taxonomic studies in Euterpe has been outlined above as well as the limitations upon this imposed by restricted access to the field. The first step toward any taxonomic revision, however, is a thorough review and understanding of the taxonomic literature and history of the genus. For Euterpe in particular, this is of the utmost necessity. To quote H. E. Moore Jr., the most prolific worker in palms of the New World in the latter half of this century: "the application of the generic name Euterpe poses perhaps the most perplexing, vexing, and intricate nomenclatural problem among the palms" (1963). Moore's 1963 paper attempted to rectify the problem but was unsatisfactory in clearly and thoroughly explaining or justifying his

solution. In order to properly understand the history of the genus and the problem, a thorough study has been made in this dissertation of all the works that were ever done on the genus. This will serve as the first step towards the taxonomic revision of the group and is presented in the history chapter of the thesis. This work was able to be carried out through library work and without the need for further fieldwork. Laboratory studies of herbarium leaf material were also carried out to add to the taxonomic understanding of the problems of distinction between the genera Euterpe and Prestoea.

Finally, it is important to understand the range of uses known until now of the different species of Euterpe. These are of significance if the genus is to be developed, so that it's complete potential be understood. Furthermore, it is of importance, if conservation measures are needed for different species, based upon an understanding of their ethnobotanical potential. Reports on uses vary from accounts of obscure indigenous tribal use to more economically important uses by urban society. Thus a thorough literature survey has been undertaken and is presented in the first part of the ethnobotany chapter.

HISTORY

The use of the name Euterpe dates back to 1788 when Joseph Gaertner described Euterpe globosa and E. pisifera in volume 1 of his two volume work, 'De Fructibus et Seminibus Plantarum' (pp. 24-25, tab. 9. fig. 3). Gaertner did not state the etymology of the name Euterpe. Euterpe is a Greek name derived from 'eu', meaning 'well' and 'terpein', 'to please', (Beeler 1960; Oxford English dictionary 1933), literally meaning 'the Well-pleasing' (Liddell and Scott 1897). Beeler (1960) gave a brief description of the origin of the name. Euterpe was one of nine Muses of Greek mythology, the Muses traditionally being 'the daughters of Zeus, father of the gods, by Mnemosyne, goddess of memory'. In the 'Dictionary of Mythology, Folklore and Symbols' (Jobes 1962), we are told the following under the entry Euterpe: 'Greek muse of harmony and lyric poetry; patroness of joy and pleasure. She invented the double flute. Portrayed with a musical instrument, usually a flute. Her name signifies charmer. She probably typifies an aspect of breeze'. Hodge (1965) states that "the Greek from which the name Euterpe was derived means 'forest grace'", an interpretation which seems to

involve some poetic license since the name appears to have no direct connection with forests. It has, however, often been noted by authors on palms that various species of Euterpe, (e.g. E. oleracea Mart., E. precatória Mart.), are exceedingly graceful, a fact due largely to the delicate appearance that the vertically pendulous pinnae give, en masse, to their crowns.

There has been considerable controversy this century as to which palms Gaertner really had in mind when he described the genus Euterpe. Some have believed Gaertner's Euterpe was meant for Old World palms and thereby completely unrelated to the New World palms to which it has generally come to be applied. Gaertner did not state the origin of the fruits he described, only that those of E. pisifera were in the seed collection of the garden at Leiden. Whatever the truth be about the true identity of the palms he described, however, the name, with its connotations of mythical, feminine and artistic beauty, seems most appropriate for those palms commonly associated with it today.

When Gaertner described Euterpe (1788) he cited the pre-Linnaean Old World palm "Pinanga sylvestris globosa" of Rumphius (Herbarium Amboinense 1, p.38, t.5 f.1A) as a synonym of his first-named species, E.

globosa. Rumphius was one of the first naturalists to describe palms for European scholars (Uhl and Dransfield 1987). 'Herbarium Amboinense' was his major work, being descriptions of not only palms but many other plants of the Moluccas and neighboring regions (Meijer 1962). The work was published posthumously in six volumes between 1741 and 1755. Although Rumphius' polynomial plant names have no validity since they pre-date Linnaeus' 'Species Plantarum' (1753) and its system of binomial nomenclature, the descriptions of many valid binomials of Linnaeus and later authors, including that of Gaertner's E. globosa, cite Rumphius' original work. Gaertner's citation of the Rumphian palm would later be used to argue that the name Euterpe belongs with Old World palms only.

Gaertner (1788) gave a two-line description of the genus Euterpe (l.c. 24): 'Flores sexu distincti in eodem spadice. Spathae partiales, singulis floribus subjectae. Bacca supera unilocularis, monosperma. Albumen ruminatum. Embryo lateralis.' Translated, he notes flowers of distinct sexes in the same spadix, spathes partial, placed one to each below the flowers, fruit unilocular above, single seeded and albumen ruminant with lateral embryo. Gaertner's descriptions of the two species include only characters of the fruits

and seeds, which is right in line with the title of his work, "De Fructibus et Seminibus Plantarum". Since his two-line description of the genus describes other parts of the palms (for example spadix and spathes) and he cites only the seed collection at Leiden and Rumphius as sources, it is not clear how he arrived at these statements. Perhaps his observations come directly from Rumphius' work or he saw more material which he does not mention.

For both E. globosa and E. pisifera (l.c. 24 - 25, t.9. f.3) Gaertner gives detailed descriptions of the pericarp, placenta, seed, integument, albumen and embryo. It is clear from the illustrations that there are some strong differences between the fruits of the two species. The two most notable differences are the marked rumination of E. globosa compared to faint peripheral rumination in E. pisifera ('prope peripheriam parce ruminatum') and the small size of the embryo compared to the seed in E. globosa, which in E. pisifera is large in relation to the seed ('dimidio semine transverso paulo longior'; over half the width of the seed). It will be seen that such differences would later lead taxonomists to separate Gaertner's species into two different genera. Beneath his description of the two species Gaertner adds two notes; that Euterpe

differs from Areca in the lateral position of the embryo and that there is a huge difference in the form of the spadix if Rumphius l.c. is followed ('in spadicis forma, ingens invenies discrimen, si Rumphius l.c. consulere velis'). Again it is unclear whether Gaertner knew the spadix of Euterpe himself or, perhaps, was relying on Rumphius' description of *Pinanga sylvestris globosa*. The fact that Gaertner specifically mentions Rumphius as the source of information in making this comparison between the spadices of Euterpe and Areca confirms, however, that Gaertner was at least basing some of his conclusions about parts other than the fruit on second-hand information.

Three years later in the second volume of his work on fruits and seeds (1791, 269, t.139. f.4) Gaertner describes Euterpe pisifera B (written as a Greek 'B'), the 'B' presumably denoting that this is a variety of his earlier named species. In synonymy with this he places *Areca foliis integerrimis*, citing Jacq. hist. amer. 278. t.170 and Linn. syst. veg. 986. His source of seeds he cites as 'Hermann. Pr. arg.', noting also the French common name 'chou palmiste'. This third taxon of Gaertner is illustrated with a strong apical protuberance, the embryo almost basal (not lateral as in his two earlier taxa) and the umbilical sulcus extending

toward the seed apex, characters which clearly distinguish it from E. globosa and E. pisifera. These differences and others would bring later authors to split Gaertner's three Euterpe taxa into three separate genera.

The next author to take up the name Euterpe and describe new species under it was Martius in the second volume of his detailed and impressive work, 'Historia Naturalis Palmarum'. Here I will go into some depth since it is important to establish the concept of the genus used by Martius. This work was a monumental treatment of palms notable for its detailed descriptions and its beautiful and detailed oversize color plates. Martius went into much greater depth than Gaertner in describing Euterpe, being able to give details of the entire palm, having had the advantage of collecting specimens and observing the palms during an extensive period in the field in Brazil, from where two of his first named species, E. oleracea and E. edulis, came. The importance and significance of his work has often been recognized by palm taxonomists and further details of 'Historia Naturalis Palmarum', his nomenclature, work and life are to be found in Dransfield and Moore (1982), Egge (1979) and Stafleu and Cowan (1981, 330). 'Historia Naturalis Palmarum', a three volume work, was

published in fascicles at different dates between 1823 and 1853. However, the parts of volume 2 which contain most of his information on Euterpe were published in 1823 and 1824.

When Martius first treated Euterpe in the first fascicle of *Historia Naturalis Palmarum*, volume 2 (1823, 28) he cited 'Gaertn. de fruct. et sem. 1. p.24. t.9. f.3' (1788) as the original point of authorship. Here, Martius gave a detailed, full-page description of the genus, including extensive additional observations on the spathes, spadices, male and female flowers and their components, floral arrangement, bracts subtending the flowers, pollen, trunk, wood, fronds, petioles and their convolute bases (leaf sheathes), geographical distribution, habitat, habit and demography. The details suggest that his descriptions must have been based on extensive field observations as well as, no doubt, good specimens. Included are such features as subsagittate, bilocular anthers, papyraceous calyces of both sexes, flowers sunken in depressions in the rachillae, and the stigmatic remains placed toward one side on the fruit. He also notes the elegant, pectinate (comb-like) and pendulous pinnae ('pinnis concinnis pectinato-dependantibus'). His description of fastigiate, simple branches of the spadix which are

erect at flowering and divaricate (well spread out) at fruiting, along with his description of the elegant, pendulous pinnae, are observations that could be based only on seeing these palms in the living state. For geographic distribution he cites places in both Asia and the Americas including the East Indian archipelago and Madagascar. Martius' inclusion of these Old World areas is, presumably, based upon his identification of his Euterpe with Gaertner's Euterpe, specifically Gaertner's citation (1788) of the Rumphian palm under E. globosa. As for New World distribution Martius lists Brazil, previously Hispanic America ('America, quae Hispanorum fuit') and the Antilles, ranging from the equator to 28 degrees latitude ('ab Aequatore per plagas aequinoctiales ultra circulos tropicos ad gradum vigesimum octavum usque degit'). For ecological distribution he notes young forests in shady, low-lying, preferably wet places and more rarely high mountains. Of demography he says Euterpe is loosely gregarious or at least not spaced very far apart ('plerumque laxe gregariae, vel haud longe a se invicem sparsae').

The majority of Martius' details, some of which are given above, are given under the heading 'Character Naturalis'. Above this he gives a five line description of the diagnostic characters of Euterpe entitled

'Character Essentialis'. It is felt worthwhile to include a translation of this diagnostic concept of Martius here: 'Monoecious on the same spadix. Spathes two, membranaceous. Flowers sessile, bracteate. MALE FLOWERS. Calyx of three sepals. Corolla of three petals. Stamens six. FEMALE FLOWERS. Calyx of three sepals, corolla of three petals, convolute-imbricate. Stigmata three, sessile. Ovary trilocular. Fruit single-seeded. Endosperm ruminant. Embryo lateral.'

Martius' generic diagnosis adds to Gaertner's in the description of the flowers, the trilocular ovary and the two membranaceous spathes. At least one contradiction can be found between Martius' 'essential characters' and 'natural characters', since in the latter he says the embryo is lateral or towards the base, the former position only having been stated in his diagnosis.

Pages 29-34 and plates 28-32 of *Historia Naturalis Palmarum*, volume 2, were published in the second fascicle of the work in 1824, probably prior to April 13 according to Stafleu and Cowan (1981, 330). Here, Martius describes and illustrates E. oleracea, E. ensiformis and E. edulis. E. oleracea is treated in greatest depth with 3 plates (l.c., t. 28-30) and 3

pages of text (29-31), including over a page of general description and a page and a quarter of detailed legend for Plate 30. This plate illustrates clearly many developmental stages from seed through germination to second seedling leaf, as well as cross-sections of the mature crownshaft, showing a sequence of developing inflorescences between the leaf sheathes and an immature inflorescence which has been removed. Somewhat confusingly, the legend for fig. 25 of Plate 30 is given under the description of E. ensiformis, while Plate 30 is attributed only to E. oleracea at the page headings where the species' names and accompanying plate numbers are given. However, this part of Plate 30 must illustrate E. ensiformis, since it is noted after the legend, 'given to us by Pavon', and Pavon was the co-author of Martinezia ensiformis Ruiz and Pavon, given as a synonym under E. ensiformis. Plate 28 shows the habit of E. oleracea. A large and smaller tree are illustrated, both with single stems. The legend states that these are the large and small varieties of the species, depicted from the banks of islands in the mouth of the Amazon. From my own experience this is indeed the habitat and a region where the species commonly known today as E. oleracea is found (Strudwick and Sobel 1988). It is characterized, however, by multiple stems, a point of some confusion since this is neither

illustrated nor mentioned by Martius. The remaining plate (Tab. 29), illustrates an entire inflorescence, fruiting rachilla, parts of the flowers and a segment of a frond.

Martius lists E. globosa Gaertner as a synonym to his E. oleracea, followed by a question mark, indicating, presumably, that he is unsure of this. He also lists 'Manaca Maravitanorum' or 'Palmito' of Humboldt, Gen. et Sp. 1, p. 252 (1816) as common name synonyms. At the end of his description he notes that there is extreme variation in E. oleracea, saying that it can often be much smaller in all respects. As a consequence he notes the possibility that Gaertner's E. pisifera B may also belong here.

With only fruit to go by it was, no doubt, difficult for Martius to be sure of the identity of E. oleracea with E. globosa Gaertner. There are, however, several shared features that are striking, such as the thickish covering of fibers, ruminant endosperm and similar sized lateral and conical embryo. The situation seems to justify Martius' use of the name Euterpe for his new species (the similarities of the fruit alone suggesting the same genus) as well as the question mark designating his uncertainty of specific affinity to E.

oleracea.

A further point of confusion, if the genus is to be based on Martius as it would later be proposed, is Martius' lack of any mention of the multiple stems in the illustration of the habit of E. oleracea, and similarly of the use of the fruits for the very popular liquid from the species known today under this name around Belém and the island of Marajó, [as described recently by Strudwick and Sobel (1988), but long known in the region (for example, see Wallace 1853)]. It would seem that Martius may have been confused, at least in certain aspects, with the species that has come to be known today as E. edulis, which does have a single stem and has long been used principally for palm heart. This point of confusion would later be taken up by Barbosa Rodrigues. A final point of interest is Martius' illustration of bifid seedling leaves for E. oleracea, a character to be used by later authors in dividing up the genus, and also witnessed by the current author to be a true character of the species known today as E. oleracea.

Also described at this time is Euterpe ensiformis Mart. (l.c. 32, t.30. f.xxv, t.31) with Martinezia ensiformis Ruiz & Pavon (1798) as a synonym. The third

and final species described here by Martius is E. edulis (l.c. 33-4, t.21. f.8., t.32). Earlier references are given as 'Palma Jocara' or 'Jucoara' (Marcgravius & Piso 1648) and 'Cocos de Palmito' or 'Cocos de Jissara' (Maximilian 1821). The fruits are said to be highly desired by Indians for the preparation of the drink called 'Cao-hy'. This ethnobotanical note again adds some confusion regarding the true identity of E. oleracea, since it is the species commonly known under this name whose fruits are used in the preparation of a highly esteemed drink. Once again, this would be taken up later by Barbosa Rodrigues.

Martius adds some remarks under the heading 'OBSERVATIO' (l.c. 34) on published names possibly belonging with E. oleracea or congeneric with Euterpe. One of these is Areca oleracea Jacq. and the remaining three are non-binomials attributed to Sloane, Brown and Plukenet. Martius seems to infer that some or all of these are synonymous. He also seems to feel that the Caribbean taxa are different to the Brazilian taxa but resolution of the problem must be left to a later date. The consideration of Caribbean taxa here probably accounts for Martius' earlier comments that the genus occurs in the Antilles.

On April 13, 1824, Martius' 'Palmarum Familia' was published (Martius, 1824a). This 24 page work has been noted to be the first attempt at arranging the diversity of the palm family in an organized fashion (Uhl and Dransfield 1987). Within the family six 'series' were recognized, Euterpe Gaertn. being placed in 'series V', Arecinae, with ten other genera. Diagnostic characters for the series were 'spathes none, or one to several complete. Ovary trilocular. Fruit single seeded.' Of the remainder, Hyospathe Mart. and Geonoma Willd. were separated as pinnatifid, while Ptychosperma Labill., Kunthia Humb., Areca L., Oenocarpus Mart., Seaforthia R. Br., Iriarteia R. et P. and Wallichia Roxb. were keyed out as pinnately leaved along with Euterpe. Short generic diagnoses were given for each. For Euterpe, several features not included in his earlier list of 'essential characters' (Hist. Nat. Palm. 2:28, 1823) were mentioned. These were: male flowers several in the upper part of the rachis or paired with single female flowers, rudimentary pistil; fruit dullish dark violet with small tubercles, excentric stigmata, fibrous; stem slender, tall, annulate; fronds terminal, pectinate-pinnate; spadices with whitish coating, infrafoliar, patent, simply branched, fruiting branches divaricate.

On page 24 of 'Palmarum Familia', under the genus Aiphanes, Martius noted 'Aiphanes Praga Willd. anne Euterpes species?' and in 1825 Sprengel published the name Euterpe Praga from Nova Andalusia, in place of Aiphanes Humb. At the same time Sprengel made two other transfers. Areca oleracea Jacq. of the Caribbean became E. caribaea while E. aculeata of South America was transferred from Aiphanes Willdenow. Sprengel's inclusion of these species in Euterpe broadened the generic concept to include somewhat curved, oblong fruits (of E. caribaea) and fronds with greatly varying numbers of pinnae from E. Praga ('foliolis multijugis') to E. aculeata ('foliolis 4jugis').

In volume 3 of 'Historia Naturalis Palmarum', p. 165, Martius published an extended and emended diagnosis for Euterpe. Glassman (1972), Read (1979), Uhl and Dransfield (1987) and others give the date of publication as 1837, which is the date cited in the ICBN Nom. Cons. for genera p. 319, 1983 (pers. comm. Read). According to Stafleu and Cowan (1981), however, p. 165 was published in the seventh fascicle on September 23, 1838. Under Euterpe, Martius cites his own earlier description (Hist. Nat. Palm. 2: 28-34. 1823-1824) as well as Sprengel (1825). Particularly significant, however, is Martius' reduction at this point of the

connection of Gaertner's Euterpe to his own. Martius reduces his citation of Gaertner to a very doubtful one. He states that his Euterpe is 'barely' connected to Gaertner's Euterpe of 1788 and definitely not connected to Gaertner's E. pisifera B of 1791 ('vix Gaertn. Fruct. Sem. 1. p. 24. t.9. f.3. nec 2. p.269. t.139. f.4.'). His grounds for this change are not given. The features not mentioned in his earlier generic diagnoses (Hist. Nat. Palm. 2:28. 1823, 'Characteres Essentiales'; Palm. Fam. 1824) are: spathes leathery, membranaceous, interior one complete; masculine flowers with sepals imbricate, corolla aestivation valvate and stamens distinct, or confluent only in the receptacle; endocarp thin, membranaceous with connate nucleus; embryo lateral to sub-basal; stem smooth; petiole bases forming long sheath; pinnae acuminate; spadix covered with granulose or scurfy, dark brown or whitish indument; flowers, especially lower and feminine, with separate bracts and subtending, opposing bracteoles, light yellowish-brown or light red ('ochroleuci aut rosei'); fruit globose, violet. Martius here emends his earlier omission of the sometimes sub-basal embryo. It is also notable that while he distances his description from the connection to Gaertner, his description of the nucleus connate to the endocarp is very similar to Gaertner's (1788)

comment regarding the integument of E. globosa, 'a nucleo non solubile' (not separable from the nucleus). There are several obvious similarities in the fruits, in fact, but at this point this one is noteworthy. Three species of Euterpe are also put into synonymy by Martius in this part of 'Historia Naturalis Palmarum', these being E. caribaea Spreng., E. filamentosa Bl. (manuscript name) and E. pisifera B Gaertn. with Oreodoxa oleracea (p. 166), Areca nibung (p. 173) and A. rubra (p. 176) respectively. At this last point (p. 176) Martius also hints that Gaertner's E. pisifera may be the same as E. pisifera B Gaertn. ('et forsán quoque ejusdem auctoris a'). With the naming of Oreodoxa oleracea Martius appears to resolve his earlier queries as to the possible identity of several Caribbean names with Euterpe. Under this species he lists the names he had considered as possible congeners to Euterpe or synonyms to E. oleracea (Hist. Nat. Palm. 2:34, 1824, discussed above in the present chapter). These names include E. caribaea Spreng., and thereby Martius rejects a Caribbean distribution for Euterpe.

Endlicher (1837) lists five tribes of palms in Genera Plantarum. Euterpe is placed in Arecinae Mart., the group being increased to hold several more genera with some genera transferred in from other tribes of

Martius (Palm. Fam. 1824) and others transferred out. Endlicher attributes Euterpe to Martius, citing 'Hist. Nat. Palm.' pp. 28-34 and 165. He expunges the connection to Gaertner, stating 'nec Gaertner' after his description. Endlicher adds that the inner spathe is smaller than the outer, the anthers are basally attached, the fruits unilocular, the interior spathe is sessile and the genus is comprised of Brazilian forest palms. With this last statement he accounts neither for E. ensiformis of Peru nor E. Praga of Nova Andalusia.

Several generic characters which appeared in Martius' 'Character Naturalis' (Hist. Nat. Palm. 2:28, 1823) but not in his 'essential' diagnosis are listed in Endlicher's diagnosis (l.c.) as follows: interior spathe forming a girdle; male flowers with ovate, carinate-concave sepals, petals ovate or lanceolate, erect, filaments subulate, anthers linear, subsagittate; ovary trilocular with two of these smaller (Martius, l.c. p. 28, says abortive); gregarious palms with stem apex often flexuose, stem interior fibrous, soft, fruits dark violet.

Kunth (1841) gives a synopsis of Euterpe, including four species, E. oleracea, E. ensiformis, E. edulis and E. praga. Both genus and species are

described in some detail. The generic description cites Martius and Endlicher, omitting Gaertner ('nec Gaertn.'). No new features appear to be introduced and clear reference is made where a feature is attributable to Endlicher only, rather than Martius, including one mistaken reference since Martius also described coriaceous-membranaceous spathes (Hist. Nat. Palm., 1837, p. 165). Under E. oleracea Kunth notes the synonym E. globosa Gaertn. with the same question mark included originally by Martius (l.c., 1824, p. 29). As a footnote he notes (translated) that "Gaertner included 'Pinangam globosam Rumph.' which is the same as 'Arecae spicatae'" ('conf. Arecae spicatae'). For E. praga he inserts a question mark ('E.? Praga') as did Martius (Palm. Fam. 1824), citing Sprengel (1825) also. In Kunth's description, however, the flowers of this species are said to be hermaphrodite, a marked discrepancy from any of the generic descriptions of Euterpe to that date.

Besides Kunth's work two further publications of significance to Euterpe appeared in 1841. That of Oken remained obscure and unconsidered by authors in general until Merrill (1950) published on it. Oken described E. brasiliana of Brazil, citing Martius' original description of E. oleracea. The words 'oleracea Mart.'

appear in bold type after 'E. brasiliiana', suggesting that Oken considered the former name a synonym of the latter. Oken describes E. oleracea as the common species ('Die gemeine'), giving it a Caribbean distribution. He says this is the 'Choux Palmiste' of markets and cites Jacquin, Sloane, Browne and Plukenet as earlier references. These are the same references that Martius (Hist. Nat. Palm. 2:34, 1924 and discussed twice above in this chapter) had included with Oreodoxa oleracea, and since no voucher is listed it must be assumed it is this species that Oken names E. oleracea. The third and final species Oken discusses is E. edulis. To the genus Euterpe Oken gives the name Cabbage Palms ('Die Kohlpalmen').

Graham was the third author for 1841 on Euterpe with the description of the Mountain Euterpe, E. montana, based upon a plant grown in the Botanical Garden, Edinburgh and originally from Grenada in the Caribbean. Of particular interest are the male and female flowers arranged in pairs (no mention of triads), the inner valve of the spathe three times longer than the outer and the flowers said to be indented into the spadix. While the inflorescences are infrafoliar there is no apparent crownshaft, the first occasion that the lack of this feature was noted in a new species

description for the genus. A six line latin diagnosis is accompanied by a detailed two page description in English and clear, colored illustration of habit, inflorescence and its parts and fruits, although there is no written description of the latter. Areca montana Hort. Cantab. is the only synonym given.

Three years later four new species of Euterpe, all from Bolivia, were described by Martius based upon discoveries of d'Orbigny and appearing in that explorer's account of his South American voyage (1844). Color illustrations of habit, fruits and stems are given for all species, as well as of flowers for two species. The fruits are all illustrated externally and for some reason only one of the descriptions states the internal character of the endosperm, that being E. precatorea which becomes the first Euterpe described with non-ruminate endosperm. For the first time type specimens are cited, all with d'Orbigny numbers, a point well worth noting in such a complex history of a genus. Two of the new names, E. andicola and E. haenkeana are attributed to Brongniart. Detailed descriptions of locality and habitat are given in French for each species, probably by d'Orbigny and not Martius since there is some discrepancy between the latin formal descriptions and French portions. Of interest to the

evolution of the generic concept is the open nature in E. andicola of the leaf bases, which are said not to form a distinct crownshaft, and the disposition of the spadices between the lower leaves. In the latter feature it differs from all previously described Euterpe and its ecological position is also extreme (the upper extreme of the woody vegetation of the Andes), especially when compared to the lowland Brazilian species. The plate which accompanies E. haenkeana shows it to have no crownshaft and it would appear that either the illustrator or the author has confused this species with E. andicola since the description of both better fits the other's illustration. E. precatória Mart. was named for a fairly common palm growing in dense forests near the banks of the river Machupo in the hot inundated plains several hundred miles east of the Andean foothills in the Province of Moxos. The fourth species, E. longevaginata, was distinguished by its extra long crownshaft (4-5 feet) and the size of its fruit ('globuli sclopetarii majoris magnitudine') and came from about half way up the Andes on the north-east slopes of the eastern Cordillera of Cochabamba.

On September 1, 1845, a second edition of Fascicle 7 of Martius' *Historia Naturalis Palmarum* was

published. The nomenclatural significance of this second printing for certain palms has been clarified by Dransfield and Moore (1982). Calyptrocalyx Blume, is a addition to the second edition, appearing on p. 230 (Martius l.c.). Pinanga of Rumphius is listed as synonymous to Calyptrocalyx, and under C. spicatus Martius places E. globosa Gaertn. Fruct. 1. p. 24 as a synonym. He notes, however, that this is only as far as the citation under E. globosa of Pinanga globosa of Rumphius but not as far as Gaertner's description or illustration of the fruit ('quoad Rumphii citatum, nec vero quoad fructum descriptum et t. 9. illustratum'). In effect this negates the only link of Euterpe to Old World palms but leaves open the true identity of Gaertner's fruits and therefore Euterpe itself.

On september 19, 1845, the eighth fascicle of *Historia Naturalis Palmarum* was published. In it, Martius places Sprengel's E. aculeata in synonymy with Martinezia aiphanes Mart.. A new name, 'E.? vinifera', also appears under both fig. 18 and 19, but there is no legend for the latter. The plate (figures) in question is used to show trunk form variation in different palms, but the notably swollen upper trunk is not seen in other species of Euterpe and, in fact, Read (1968: 194. *Gent. Herb.* 10) has noted that this is synonymous with

Pseudophoenix vinifera (Mart.) Beccari.

Martius provided a synopsis to all the palms in the ninth fascicle of *Historia Naturalis Palmarum*, published on March 15, 1849. Euterpe is treated on pages 309-310. By this time ten species are recognised by Martius, these being E. oleracea, E. edulis, E. ensiformis, E. brevivaginata, E. longevaginata, E. montana, E. precatória, E. Haenkeana, E. andicola and, still uncertainly, 'E.? Praga'. Under E. edulis he notes the possibility of dividing from this a variety with non-ruminate endosperm, 'ab hac forsan distinguenda alia contubernalis, albumine aequabili' [originally (l.c. 33) he described this species with ruminate endosperm]. The only new species described is E. brevivaginata, for which 'Palma dactylifera, fructu globoso minor' of Plumier is cited as the original reference. This species was from the forests of eastern Martinique. No crownshaft is mentioned and of further interest the leaf sheath is said to be short and triangular. An eleventh name, E. Manihot Lodd. Hort., from 'Demarary', is noted after the tenth and last numbered name of Euterpe. As for geographic distribution at this point in time Martius recognizes 4 Bolivian species, 1 Peruvian, 2 Brazilian, 1 Venezuelan and 2 from the Caribbean.

Wallace (1853), in his account of palm trees of the Amazon, wrote of three species he knew from that region. Interestingly he breaks recent tradition and cites Gaertner as the authority for the genus Euterpe. A nameless species occurring mostly on dry land in virgin forests on the banks of the Rio Negro is described as generally larger than, but closely allied to E. oleracea. E. catinga is described as a new species from dry sandy soils of 'Catinga' forests on the upper Rio Negro. Of interest are the crownshaft always red and the roots growing high above the ground forming a distinct cone. A variety (perhaps of E. oleracea) with white fruits from the island of Marajó is said to have been heard of. Probably here Wallace is referring to the plant known today from that region as 'açai branco', (literally, 'white açai'), which actually produces yellow fruits.

Oersted (1858) was the first to describe Euterpe from Central America. Oersted follows Wallace in attributing Euterpe to Gaertner only. Two new species were described, E. macrospadix from Nicaragua and E. longepetiolata from Costa Rica. Particularly outstanding are the very long petioles (2-3 feet) and peduncles (1.5 feet) of E. longepetiolata.

In 1862 Linden published the catalogue name E. gracilis, of Amazon origin, as a nomen nudum. In the same year Grisebach and Wendland described E. Mana.le from Cuba.

In 1865 Engel described the first Euterpe species for Colombia. Of three species, two were new; the third was said to be closely allied to, yet different from, E. oleracea, but lacking sufficient grounds for publishing a new name. Only E. purpurea was described with fruits. Seemingly characteristic of many Euterpe described to this point the style was positioned in the middle of the side. This palm was found in moist shady cool forests at 6000-8000 feet. E. karsteniana was from between 1-2000 feet. Under the heading 'Euterpe oleracea (sp. nova?)' the third taxon is said to come from moist temperate forest between 1500-2500 feet. Engel's descriptions are fairly detailed and in Latin. No type specimens are indicated.

Pritzel named E. Menziesii in 1866 which was later said not to be a palm (Glassman 1972).

In 1871, Richard Spruce wrote an account of equatorial South American palms, particularly Amazonian palms, of which he had personal experience or had

collected specimens. Of particular note is the first mention of the caespitose nature of a species of Euterpe. From Peru, Spruce mentions 'two very pretty Euterpes', the large one known as 'chonta' and the smaller as 'chontilla'. A third is mentioned, known also as 'chontilla', of which Spruce says the 'habit is almost that of Geonoma, but the leaves, the edible cabbage, and the fruit, are all of Euterpe'. However he is unable to give names for any of these three palms. Of Euterpe, Spruce remarks that 'all the species are notable for their concinnately pinnated leaves, with pendulous pinnae' as well as their long, cylindrical, deciduous leaf sheathes and crownshafts. One exception he notes is 'E. caatinga' of Wallace, which has spreading pinnae which 'merely droop at the tips'. An interesting additional character listed by Spruce, also for this species, is the 'mass of soft flat deep purple threads' at the mouth of the tubular leaf sheath. Spruce also introduced a new name, Euterpe mollissima, which he notes to be a manuscript name, citing specimens he had received at Kew.

Scheffer (1873), in writing about various palms of the group Arecinee, gave a latin generic description of Euterpe with some additional notes in French. Like Wallace and Oersted, he cites only Gaertner as the

authority for Euterpe. In his description he notes the caespitose character of the genus, remarking 'perhaps always'. Previous latin and generic descriptions appear to have been unaware of this. Scheffer adds his doubts as to the inclusion of E. brevivaginata and E. andicola in Euterpe since their triangular leaf sheathes are not found in any closely related genus. Similar doubt is expressed for E. precatória on account of its non-ruminate endosperm. He was the first author to note the caespitose character of E. oleracea stems. He notes that this observation was based upon the only garden specimen of Euterpe available to him, which no doubt accounts for his query that this character could be present in the entire genus. Scheffer also noted the strong resemblance of Euterpe and E. oleracea to the Old World genus Oncosperma. The strongly pendent pinnate pinnae, caespitose stem, crownshaft and infrafoliar inflorescence certainly do give this impression on first site, as I myself noted on seeing a specimen in the Royal Botanic Garden at Peradeniya, Sri Lanka. Scheffer notes, however, that Oncosperma differs in the presence of spines, the branching pattern of the spadix, the lack of numerous fibers in the fruit and anthers not versatile.

Barbosa Rodrigues (1875) published on Euterpe in

Brazil. He disputed the work of Spruce (l.c.) and Wallace (l.c.), arguing that they had incorrectly applied their specific names and he switched their names to different taxa. He also names the new species, E. longibracteata, from the upper river Tapajós south of the Amazon. A Barbosa Rodrigues voucher specimen is cited for all three names he applies.

Based upon works of Wendland, Kerchove de Denterghem (1878) published a treatment of palms and list of palm species and synonymies known to that date. This treatment was based largely on characters of the fruit and seed and recognized 119 genera. Euterpe Mart. fell into the group Euarecinees (34 genera) with unilocular fruit, and within the large group Arecinees (83 genera) defined by the positions of the raphe and the embryo. In this scheme, the curvature of the fruit and lateral position of the stigma placed Euterpe within a small group of four genera along with Oncosperma Bl., Clinostigma Wendl. and Nephrosperma Balf.. Of 29 names for Euterpe, nineteen are recognized and ten listed as synonyms. E. acuminata Wend., E. decurrens Wend. and E. zamora Hort. Lind. appear as names for the first time. None of these are accompanied by descriptions and therefore are nomina nuda as they appear in this work. The new combination E. globosa B. Gaertn. is mistakenly

published for E. pisfera B. Several other names are placed in synonymy for the first time. While not exhaustive (at least four names, mostly nomina nuda, are missing), Kerchove de Denterghem's treatment is a useful point of reference for Euterpe being the most complete listing of species since Martius' Synopsis (1849) with the useful additional feature of the listing of synonymies.

In 1881 Linden published a list of 228 palms said to have been introduced and put into commerce for the first time by the Linden establishment. Two new Euterpe names appeared; E. elegans of Colombia and E. Puruensis of the Rio Purus (a river running from Peru well into Brazil). Both appear as nomina nuda.

Drude (1882) gives a fairly good, concise update and treatment for pertinent species of Euterpe in his treatment of the genus for Flora Brasiliensis. Four species are recognised and the new varietal name, E. catinqua Wallace var. aurantiaca Drude, is given to E. caatinga Barb. Rodr.. Economic uses are given for each palm. Geographic distributions are updated for all species and some voucher specimens cited (e.g. Glaziou! n. 8065); the first instance in a treatment on Euterpe that this has been done. The genus range is increased

with a citation of the Guianas and also, interestingly, the West Indies, based upon this range being given for E. oleracea. Drude maintains Gaertner as the authority for Euterpe, but notes that Martius modified the authority citation to read 'Euterpe Gartn (em. Mart.)'.

Disagreeing with Drude (l.c.), Barbosa Rodrigues (1882) maintained that E. catinga Wall. var. aurantiaca Drude was a distinct species. Barbosa Rodrigues therefore introduces the new name E. controversa for it. Barbosa Rodrigues' use of common names in his discussions and in choosing scientific names for taxa make his publications quite confusing to follow. Nevertheless, if Wallace (1853) really did use the common name of one taxa for the specific epithet of another, as Barbosa Rodrigues contends, Barbosa Rodrigues' apparent frustration and actions can be sympathized with.

The 1883 work of Bentham and Hooker was a particularly significant one in the history of Euterpe. In it, the new genus Prestoea Hook. f. was created. To this day the distinction of this genus from Euterpe has not been satisfactorily established. Interestingly, however, Prestoea was based not upon a Euterpe, but upon Hyospathe pubigera Griseb. & Wendl. of Trinidad.

Generic descriptions of both Euterpe and Prestoea are provided in this work and the chief distinctions are as follows. Prestoea had flowers without bracts with minute cupular bracteoles, female flowers globose, ovule basal and erect, leaf sheath fibrous-reticulate, short, open and expanded and was low-growing with reed-like stems while Euterpe had bracteate flowers with two ovate acute bracteoles, female flowers ovoid, ovule parietal, subglobose and pendulous, leaf sheath very elongate-cylindrical and was tall. The ovule position is emphasized. Beneath the description of Prestoea it is noted that E. montana Grah. of Grenada is probably congeneric. For Euterpe, Bentham and Hooker give Gaertner as the authority but exclude his citation of Rumphius. Without explanation they list E. pisifera Gaertn. as the type, when E. globosa was the first species listed by Gaertner (1788). Distinctive characteristics (several that are of interest because alternative conditions had previously been included in Euterpe) they list for Euterpe include spadices infrafoliar, flowers in pits, stems single or clustered and leaf sheathes entirely cylindrical. The genus is said to have eight species, occurring only in the American Tropics and West Indies. Some inconsistencies between species are noted and the genus said to be badly defined. For example, male sepals are more or less

orbicular and broadly imbricate in E. oleracea Mart. and E. catinga but minute ovate acute in E. edulis Mart. and E. ensiformis Mart. while E. catinga has a non-fibrous, thinly crustaceous (in the dry state) pericarp and non-ruminate endosperm but E. oleracea has densely fibrous and fleshy pericarp and ruminate endosperm.

Im Thurn, in 1884, attempted to make a "complete record" of the contemporary state of knowledge of the palms of British Guiana, including descriptions of several new species. Where possible he included common names, uses and details of where he had seen each species. E. stenophylla, described as new, is said to occur throughout the forest region. Professor Trail of England in particular is credited for identification of specimens of Im Thurn and Jenman, while some specimens had been sent also to Drude. Many uses are listed.

Drude (1887) gave the first phylogenetic classification of the palms (Uhl & Dransfield 1987) recognizing five subfamilies. Euterpe was placed in subfamily Ceroxylinae, tribe Arecineae, subtribe Areceae. Within this subtribe Prestoea was placed in Areceae anomalae and Euterpe in Areceae Infracoliaceae. This last is a large group of 23 genera and Drude notes that it is the most similar in build of the whole

Arecineae tribe. Euterpe and Oenocarpus are the only two neotropical genera, of the Areceae infrafoliaceae. The remainder are from the Indian floral kingdom with one from the Mascarenes. About ten species of Euterpe are recognized from the Antilles, tropical Andes and Guyana to southern Brazil. E. oleracea, E. edulis, E. precatória and E. Catinga Wall are recognised as important and all named species said to produce a drink from the fruits as well as palm heart. Now Drude gives Martius as the authority for Euterpe adding 'nicht Gartn.'

Baillon (1895) recognized about nine species for Euterpe giving Gaertner as the authority for the genus. His work consists of a 23-line latin description of the genus. No species are named. In the same year Vilmorin added the new name E. speciosa hort. to the literature as a synonym under another palm, Howea Belmoreana Becc. Presumably, this name had been used in some horticultural context.

In keeping with his interest in common names, Barbosa Rodrigues (1901), in a conspectus of the Brazilian species of Euterpe, lists eight species under their common names. All were named by himself. These species are first separated into two sections. Section

1, Integra, is defined by its bifid seedling leaves, while section Pinnata has segmented seedling leaves of six linear divisions. Two species fall into section Integra. E. edulis Mart. is listed as one of these. Barbosa Rodrigues argues that Martius (1824) made a mistake in the naming of E. oleracea and E. edulis. He contests that Martius mistakenly gave the name E. oleracea to go with his original description and plate of leaf development, arguing that Martius must have meant to call this E. edulis. Barbosa Rodrigues adds an interesting and informative analysis of the root meaning of the common names of these palms. Two new species are named in Barbosa Rodrigues' paper. The bifid seedling leaves of the first of these, E. badiocarpa, cause Barbosa Rodrigues to note an apparent and interesting correlation in the genus between this feature and ruminant endosperm. E. badiocarpa is said to be from virgin forests of the Rio Negro and the surroundings of the city of Manaus. E. jatapuensis is said to be from humid forests on the Rio Jatapu in the Province of Amazonas. Barbosa Rodrigues' paper is of particular interest because of its observations on the seedling leaf as a taxonomic character.

In an article on the palms of Puerto Rico, Cook (1901), under a discussion of his recently created genus

Roystonea, suggested that E. acuminata Willd. probably belonged to a distinct genus. In a separate discussion under his new genus Acrista, Cook became the first to question and discuss the proper application of the name Euterpe and its validity for New World palms. Cook states 'the generic name Euterpe Gaertner, which is commonly applied to a considerable series of American palms related to the present', (Acrista), 'was in reality established for the Malayan genus for which the name Calyptrocalyx Blume is now in use, Pinanga sylvestris globosa Rumphius being cited by both Gaertner and Blume as the original in the one case of Euterpe globosa, and in the other of Calyptrocalyx spicatus'. He goes on to note that Blume said the name Euterpe should remain with Gaertner's seeds which belonged to arecoid palms of the Mascarene Islands. Cook notes that neither Martius nor others had disposed of this suggestion but that Gaertner's fruits possessed an apical stigma which excluded any American Euterpe. While these are interesting points that Cook raised it seems misleading to state that Gaertner established the name Euterpe 'for the Malayan genus' which Blume called Calyptrocalyx. Gaertner's citation of Pinanga sylvestris globosa merely showed that he considered this to be identical to the fruits he described. Since the origin of the fruits wasn't given, they could have been

from anywhere and the genus was not necessarily restricted to Malaya. Cook seems to use his discussion of the proper application of the name Euterpe to reject assigning a new Puerto Rican species to Euterpe, instead erecting the new genus Acrista, naming the new species A. monticola. By doing this he also implies that "the considerable series of American palms" related to A. monticola, and then known as Euterpe, should also be renamed. In this vein he also rejects the name of the Brazilian E. oleracea Mart., creating the new genus Catis. He also rejects the specific name oleracea on the grounds of possible confusion with several other taxa for which it had been used, changing the name to C. martiana. While Martius or later authors had never discussed or resolved the true relation of Euterpe Mart. with Euterpe Gaertn., Cook's actions nevertheless seem somewhat drastic since he himself does not definitively solve the problem. Cook's 1901 paper is significant in the history of Euterpe since it was the beginning of a series by Cook and others this century to question the proper application of the name.

In 1903 Barbosa Rodrigues' lavish and oversize two volume work, Sertum Palmarum, somewhat resembling Martius' Historia Naturalis Palmarum, was published. In addition to the classification and descriptions of

Brazilian palms another section is devoted to geographical distribution where Euterpe species are mentioned several times. In the classification four tribes are given. Under tribe Areceae Barbosa Rodrigues describes the new subtribe Euterpeineae in which he places Euterpe, Oenocarpus, and Jessenia, with Gaertner as the authority for Euterpe. The observations on Euterpe and conspectus of its sections and species which follow are virtually identical to those described above in Barbosa Rodrigues, 1901, as are the descriptions of E. badiocarpa and E. jatapuensis and the ensuing discussion of the name confusion between E. oleracea and E. edulis. Descriptions of the different species are accompanied by some impressive color plates showing habit and other details. Interestingly the name Euterpeinae has recently been published as a new subtribe by Dransfield and Uhl (1986). The type cited by Dransfield and Uhl is Euterpe Martius, while Barbosa Rodrigues cited Gaertner as his authority. Barbosa Rodrigues also spelled his subtribe with an extra "e".

In 1904 Cook criticized the methods of Martius in his free assignment of names to species unrelated to those for which the names originally stood and similarly criticized his free emendments. He went on to argue the affinities of Oreodoxa with Euterpe, noting that earlier

authors may have mistakenly believed Oreodoxa to be bisexual due to the presence of large pistillodes in the staminate flowers. Once again he argued that Oreodoxa acuminata was a Euterpe in the sense of Martius, as proposed by Wendland. He named the new tribe Acristeeae with eight genera, including within it palms generally placed previously in Euterpe. These eight genera were Roystonea Cook, Hyospathe Mart., Prestoea Hook., Jessenia Karsten, Oenocarpus Mart., Oreodoxa Willd., the new genus Plectis Cook and Acrista Cook (formerly E. oleracea Mart.). Cook argued that the "method of types" and adherence to a few simple nomenclatural rules could help solve the vast nomenclatural tangles of his day, a point which, had it been followed, could no doubt have served to avoid much of the nomenclatural controversy and confusion in the complex history of Euterpe. Cook's new genus Plectis with its single species P. oweniana of Guatemala would later be deemed synonymous with E. macrospadix Oersted (Glassman 1972).

In 1906 Wright named two new species from British Guiana, E. jenmanni and E. ventricosa. Both were from Georgetown, the latter cultivated in the Botanic Gardens. Of note was the ventricose character of the stems. These species would later be identified as two Roystonea species (Glassman 1972).

Following the opinion of his earlier articles (ex. 1901), Barbosa Rodrigues (1907) refutes Huber (1904), arguing again that Martius incorrectly applied the names of E. oleracea and E. edulis, the one with the other. In an attempt to clarify the matter a detailed discussion of the common names "assahy" and "yicara" as applied to these species, is given. Characters used by Martius are said to be confused between the two taxa, and the possible source of confusion said to be the state of Maranhao, where Barbosa Rodrigues notes the common names were sometimes confused. He also discusses the meaning and applications of words such as "oleracea" and "palmito" to justify his argument. Strengthening his earlier opinions Barbosa Rodrigues officially switches Martius' names to E. edulis (Mart.) Barb. Rodr. and E. oleracea (Mart.) Barb. Rodr.

Drude (1908) gave an update to the palm family and its literature for Engler and Prantl's supplement to 'Die natuerlichen Pflanzenfamilien' for 1899-1904. Cook's three recent genera Plectis, Acrista and Catis are briefly summarized. Drude noted that while Cook had given the name Catis to Euterpe oleracea, Barbosa Rodrigues (1901) had maintained the species along with E. edulis and E. precatória. Nine genera were given in the key to the tribe Acristeeae, which is taken from Cook

(1904). Drude noted that Cook's 1904 work had been brought about because of Urban and Dammer (1903), who had united the genera Roystonea and Oreodoxa.

In part 1 of an article on the indigenous palms of Cuba Beccari (1912, pp.253-276) disagreed with Cook (1901) who had renamed the palms commonly known as Oreodoxa, having substituted the name Roystonea. Beccari noted that Cook's grounds for doing this had been that he recognized the type of the genus, O. acuminata Willdenow, as a genus distinct from later named Oreodoxa species. Beccari argues that O. acuminata belongs in the genus Euterpe Gaertner. He states that therefore the name Oreodoxa is unattached and valid for later named species. In support of his argument he says that O. acuminata Willdenow is a typical Euterpe due to its ruminant albumen. A clear illustration (p.256) is offered to support his belief. In his conspectus of the genera of Cuban palms Euterpe and Oreodoxa are both placed in the tribe Arecae, the former separated initially from the latter by female flowers with imbricate petals as opposed to 'female flowers with valvate petals more or less united at their base'.

In part 2 of his article on Cuban palms (1912,

pp.351-377) Beccari discusses the genus Euterpe at length. In my opinion, this is the best discussion of the genus from its first inception by Gaertner (1778) up to the year 1912. Beccari argues that Martius (1823) was correct in referring his E. oleracea to the genus Euterpe Gaertner and that Cook's (1901) assumption that Euterpe Gaertner was proposed for Old World palms only was a mistake. Beccari also believed that E. globosa Gaertner and E. oleracea Mart. were distinct species, and that the former was in fact the species of Euterpe common in the Greater and Lesser Antilles, and known under several other more recent names. In support of this he notes Gaertner's description for E. globosa, of 'bacca cum brevi acumine' (fruit with brief apical point). Beccari goes on to note that while the fruits in reality have lateral stigmatic remains, they in fact appear as 'a small apical acumen' when deprived of the perianth, as was the fruit depicted by Gaertner. Beccari notes that in E. oleracea Mart. of Brazil, these remains are plainly lateral. He concludes that Acrista monticola Cook is really E. globosa and that 'the genus Euterpe remains as understood by Martius, Scheffer, Bentham et Hooker, Drude, Barbosa Rodrigues etc., Catis and Acrista' (erected by Cook) 'being synonyms'. In essence then, Beccari's major divergence from those authors, excluding Cook, was his positive recognition of

E. globosa Gaertner and its sure generic relation to E. oleracea Mart.

Another point of interest is that Beccari states that "E. globosa must be considered as the type of the Genus Euterpe as being the first so named" and goes on to say that Bentham and Hooker (1883) "considered as the type of the Genus Euterpe the second species figured by Gaertner, the E. pisifera". Beccari's reasoning is, however, incorrect, since the order of publication in a particular work does not give priority, only date (pers. comm. Read). As for the genus Prestoea Hook f., Beccari gives this as a synonym to Euterpe Gaertn. (along with the query "partim?"). In his discussion, he goes on to note that Euterpe is not homogeneous due to the presence of both ruminant and non-ruminant endosperm in the genus. He proposed that the true members of Euterpe should be considered as those with ruminant endosperm, like the type E. globosa, while those with non-ruminant endosperm should be placed in a subgenus, which he named Euterpopsis. In with E. globosa he grouped E. oleracea Mart. and E. acuminata (Willd.) Wendl., E. edulis Mart, E. precatória Mart. and E. catinga Wall. While noting that he had been unable to find any correlative features in the flowers in support of this separation he also noted that Barbosa Rodrigues' (1901) separation of the

genus into two groups, based upon bilobed versus radially divided primordial fronds, demonstrated a positive correlation to the state of the endosperm. Read, however (pers. comm.), notes that rumination of the endosperm has been shown to be of little value in distinguishing between palm genera, for example between Veitchia H. A. Wendland and Adonidia Beccari. The excellent illustration of E. globosa fruits and citation of specimens seen add to the value of Beccari's paper, especially the latter which had not been done in such a thorough manner by any previous author.

Dammer (1915) described two new Euterpe species from Roraima in Guyana and Venezuela. They are of interest here because of several features that were not typical or common in the genus. E. roraimae had short, narrow stems and was said to be remarkable due to the nature of the hair-covering of the petiole and rachis. Interestingly, the leaf segments are said to be spreading rather than drooping and the leaf sheath to be obliquely open. The second species, E. tenuiramosa, occurring at slightly lower elevations (1500-1700 m), is notable for its long petioles (almost equal to the rachis) and long peduncle (longer than the rachis).

Broadway (1916) published a name (E. Broadwayae

Becc.) he attributed to Beccari, the first record of Euterpe in Tobago. An interesting character was the 'fluffy' flowering parts. No latin description or specimen citation was given.

Hauman (1919) published the name E. egusquizae Bertoni as part of the palm flora of Argentina. Glassman (1972) lists this as a synonym of E. edulis Mart..

In 1920 Beccari published a more detailed and latin description of the palm Broadway had discovered in Tobago. Of nomenclatural interest, he publishes a different spelling to that of Broadway (l.c.), naming the species E. Broadwayana Becc., sp. nov. (not E. Broadwayae).

In a discussion of the genus Oenocarpus (Burret 1928) the new name Euterpe frigida [H.B.K.] was published with a query, based on Burret's belief that Oenocarpus frigidus (H.B.K.) Spr. and Oreodoxa frigida H.B.K. were more likely a Euterpe.

The most comprehensive treatment of Euterpe ever done was that of Burret in 1929. In his synopsis 39-40 species were recognized. Of these, twenty four were

species published by earlier authors, including five listed as imperfectly known, and two were combinations resulting from the inclusion of Prestoea pubigera and P. carderi within Euterpe. Thirteen were new species; these included nine from Colombia based upon Kalbreyer specimens collected between 1878 and 1881. A further eight names were listed as synonymies belonging in other genera, nine other names given as synonyms under other Euterpe species, while a further eight names were listed as nomina nuda. In all, Burret accounts for sixty five names of Euterpe up to and including his 1929 paper.

Burret named his Colombian species E. simplicifrons, E. parviflora, E. latisecta, E. brachyclada, E. brevicaulis, E. oocarpa, E. dasystachys, E. Kalbreyeri, and E. microcarpa. From Costa Rica E. brachyspatha and E. decurrens were named, while E. megalochlamys was from Peru and E. chaunostachys from Ecuador. The fact that 39-40 species are recognized is accounted for by Burret's publication of the new name E. concinna under his species number 28, the earlier published E. controversa Barb. Rod..

For several species named by earlier authors Burret adds new specimen citations and information based upon material he had seen and taken from collectors'

notes. Besides the role of Kalbreyer in providing material upon which Burret's new Colombian species were based, Hubner was also important for new information, collections and photographs for several of the Brazilian species. While Hubner's photographs are said by Burret to be good and are also documented with numbers, they are, unfortunately, not published along with this work. For several of the Barbosa Rodrigues species Burret notes 'Barbosa Rodrigues non vidi', presumably indicating that he had not seen a specimen of them. For about eight other species named by earlier authors, later collections are cited by Burret followed by an exclamation point, possibly indicating that he is designating these as neotypes since in most of these cases it appears no type was designated in the original publication. For example, under E. longepetiolata, named by Oersted in 1858, is written 'Tonduz 12924!' collected in 1898. Other species have several specimens cited under them in this fashion.

Burret preserves Gaertner as the authority for Euterpe, as did Beccari (1912), basing the genus upon E. globosa Gaertner (1788) with the exclusion of the citation of Rumphius and of E. pisifera. Within Euterpe he includes Oreodoxa Willd., Prestoea Hook. f., Acrista O.F.Cook and Catis O.F.Cook. He concurred with Beccari

(l.c.) that E. globosa Gaertn. is identical to a West Indian species of Euterpe, noting that the illustrations (of Gaertner, 1788) were good and could not be misinterpreted. For Prestoea (under E. pubigera) he notes that the fruits described by Hooker can hardly be separated from the fruit of the genus Euterpe. Hooker's description of Prestoea (1883) was based upon one species, P. pubigera, which formerly was named as Hyospathe pubigera Gris. et Wendl.. Noting that Hooker had divided Prestoea from Euterpe because of the basal and erect ovule position in the former as compared to the parietal and pendulous position in the latter, Burret dismisses the distinction between the two genera saying that an examination of the female blossoms of Hyospathe pubigera show the ovule to be lateral and pendulous, exactly corresponding to Euterpe.

In a discussion of his concept of Euterpe, Burret states his agreement with Wendland, Barbosa Rodrigues and Beccari, maintaining the genus as one; noting the presence of ruminant and non-ruminant endosperm in the genus he adds that, like Beccari, he could find no completely correlative features to support a division into two groups based upon the two endosperm conditions. Using Beccari's categories, he notes that at one point he thought he had found correlative features. Most of

Euterpe sensu stricto (ruminant) had a filament with the anther connected by a knee shaped link while in Euterpopsis (non-ruminant) the filament was straight. Furthermore, in Euterpopsis (minus E. edulis) the anthers were longer, the filament hardly extending beyond them at the base, and the petals of the male flowers were obtuse. More importantly, he notes, the female flowers and fruits in Euterpe sensu stricto sit superficially on the surface of the rachillae while in Euterpopsis they are considerably sunken. However, he continues, E. oleracea and its relatives, all with ruminant endosperm (Euterpe sensu stricto) have the 'Euterpopsis features' of no knee link on the filaments, male petals obtuse, filaments scarcely extending beyond the long anthers at their bases and flowers considerably sunken in the rachillae. Burret concludes that he prefers the view that E. oleracea and relatives form a connecting group between Euterpe sensu stricto and E. precatorea and its relatives which have homogenous endosperm (Euterpopsis). Finally, in his discussion of the genus, he notes that his 'new species even though still incompletely known, enlarge considerably the current concept of Euterpe, since they include almost stemless species and those with divided and incompletely divided fronds' (direct translation; underlining added to emphasize dramatic new features in the genus).

Burret accomodates the three groups of Euterpe he recognizes by including the intermediate group within Euterpe sensu stricto as a subsection, Bothrostachys Burret (= E. carderi, E. roraimae, E. stenophylla, E. badiocarpa and E. oleracea). The remainder of Euterpe sensu stricto are placed in subsection Leiostachys Burret. Besides the distinguishing characters noted above, subsection Leiostachys has male flowers with more or less acuminate petals and spathes seemingly firm, while subsection Bothrostachys has spathes apparently thinner and rachillae very densely and shortly fuscous or white-tomentose. Section Euterpopsis is defined by homogeneous endosperm, immersed pistillate flowers, non-geniculate filaments inserted in rectilinear fashion and peduncle somewhat shorter than the rachis. Euterpe sensu stricto is said to have bilobed primary fronds while in Euterpopsis they are radially pinnatisect. Clearly, however, this character was known for very few species.

In 1931 Burret described a further new species, E. montis-Duida, collected from 5500-6000 feet during exploration of Mount Duida, Venezuela. Fruit and male flowers were not available for description.

Burret continued to be the major worker in

Euterpe through 1940. During the 1930's he published a number of new species in the German journal Notizblatt. Some issues of this journal are hard to procure now, possibly due to destruction during the Second World War. Euterpe andina (1932) was described from 2000 m in the West Cordillera of Colombia. A notable feature of this palm was its fire-red spadix and lilac male flowers. Another new species, E. panamensis, was named from Panama. Unusually, the juvenile plant was described; the seedling leaves were described as digitate - flabellate - pinnatisect.

Euterpe was the subject of some discussion by Bailey (1935). Under a treatment of the Royal Palms, Bailey gave a comparison of Euterpe to Roystonea. Separately, Bailey felt Euterpeopsis to be generically distinct from the rest of Euterpe but said more evidence was necessary to substantiate this point. Due to the uncertainty of E. globosa Gaertn. he questions the validity of the generic name Euterpe, suggesting that "it might have been better if at the beginning the name had been eliminated as a nomen incertum". He sympathized with Cook's (1901) opinion and rejection of the name, but nevertheless believed the name should be retained as most writers had done so.

Burret continued to publish new species, naming E. trichoclada, E. aphanolepis and E. Langloisii in 1936. E. trichoclada, from 1000 m in the West Cordillera of Ecuador, is interesting because of the dense almost shaggy, yellow hair-covering of the spadix branches, (this feature making it sound similar to E. broadwayae). Fruits of E. trichoclada were said to be among the largest of the genus. Interestingly, the stigma is said to be positioned at the top of the fruit (Gaertner's drawing of E. globosa showed this position). Especially characteristic were the strongly developed bracts at the base of the spadix branches, a character little-mentioned for earlier species. It was placed in the Leiostachys group of Euterpe sensu stricto. E. aphanolepis had a pink peduncle and grew at 2400 m in the Central Cordillera of Colombia. E. langloisii was from Trinidad and was placed in section Euterpopsis.

In 1939 Burret named another new species, E. Schultzeana, from primary rainforest at 200 m in East Ecuador. This species, Burret says, fits in none of the former groups of Euterpe. By its homogeneous endosperm it fits within section Euterpopsis, but in all other respects differs from this group. Many other characters, Burret notes, are shared with the first few

species of Euterpe sensu stricto, subsection Leiostachys (Burret 1929). These characters, which separate these species from other members of subsection Leiostachys, are given as dwarf habit, small flowers which are scarcely sunken in the rachillae, small spadix with few branches and a long peduncle which is longer than the rachis and long petiole. For the new species Burret creates the new and third section of the genus Meteteurpe, including with it a brief latin diagnosis. To section 1, which he previously called Euterpe sensu stricto, he gives the new name Euterpotypus. Section 2 remains as Euterpopsis (non ruminant species). Burret concludes that more than ever this new species affirms that it is not convenient to divide Euterpe into two genera based upon ruminant versus non-ruminant endosperm, noting that Bailey had recently suggested this possibility. In defense of his opinion he reaffirms his view that he has no doubts about the genus Euterpe.

In 1939, on the occasion of his publication of a new genus and species from Cocos Island, Rooseveltia frankliniana, Cook took the opportunity to give a full explanation of his previously expressed view that the name Euterpe should remain attached to Gaertner's fruits and could and should not be used for any American palm.

His argument is convincing, especially when he notes that Martius himself had placed the name Euterpe Gaertner in synonymy under Areca in the third volume of his 'Historia Naturalis Palmarum', while in the same volume he had used Euterpe Mart. for the New World genus. Cook also discusses the genera Acrista, Catis and Oreodoxa, which he had earlier named or recognized in the place of certain commonly recognized Euterpe species, and their relation to Rooseveltia. Closely related to Rooseveltia, says Cook, is Plectis oweniana, which he had described from Guatemala in 1904. He notes that there is good material and photographs of this at the U.S. National Herbarium, where he worked. Excellent material of Rooseveltia frankliniana was also available to him and based upon this he gives an unusually in depth comparison of several pages on many aspects, not normally documented in palm descriptions, for the two species. The best and most comprehensive photographic comparison (of the two palms and their component parts and stages) that I have seen for any palms in the Euterpe complex, is included. E. macrospadix Oersted and E. longipetiolata Oersted from Costa Rica, both of which are also said to be well represented in the U.S. National Herbarium, are said to differ from Rooseveltia and Plectis by being small, slender palms with ruminant seeds and simple-leaved seedlings. Both Rooseveltia

frankliniana and Plectis oweniana have since been identified with E. macrospadix while E. longepetiolata has been placed in Prestoea (Glassman 1972). The merging of Rooseveltia frankliniana and Plectis oweniana with E. macrospadix seems worthy of careful scrutiny since Cook appears to have done such a thorough job in this publication. Some of the outstanding differences of Rooseveltia to Plectis oweniana noted by Cook, are the short-jointed trunk, shorter petiole and inflorescence, smaller inflorescence bracts and broadly grooved seed, among many others. An extended and detailed description of P. oweniana is also included in this paper. Cook made little reference to Burret in his paper and did not deal directly with Burret's views on the genus.

In 1940 Bailey wrote an article on Euterpe in the West Indies, naming a new species, E. dominicana, from Dominica in the British West Indies. He also discussed the validity of the generic name Euterpe (in response to Cook 1901 and 1931) and recognized the genus Prestoea, accounting for the different species in the latter and listing the characters he attributes to the two genera. E. dominicana was placed in section Euterpopsis. Regarding the name Euterpe, Bailey disagrees with Cook, concluding that Gaertner's full description of the fruit

of E. globosa and its picture (1788) prove that the genus Euterpe was undoubtedly founded for the West Indian E. globosa. Bailey notes that in this opinion he is in agreement with Beccari 1912, and Burret 1929. He notes that Euterpe is not entirely homogeneous and that four other generic names applied previously to the group 'may afford a basis for segregation as knowledge of the group develops'. Bailey refers E. pubigera (Trinidad) and E. montana (Grenada) to Prestoea. From Euterpe Bailey says Prestoea 'differs in bearing basal and erect not parietal and hanging ovules, leaf sheath short or not evident, thicker shorter rachillae and other technical characters'. Besides P. pubigera and P. montana, the third and final species included in the genus to this time, according to Bailey, is P. Carderi of Guatemala. As for the characteristic features of Prestoea, Bailey notes that the genus appears to lack a developed crown-shaft, have short and rigid rachillae with swollen bases and a divaricate or horizontal orientation, and have a small and stiff spadix. He continues; 'these features are conspicuous and I have not observed them markedly in Euterpe, in which the rachillae are usually long and slender, less divaricate and often parallel with rachis, the basal swelling not so prominent. A particular mark of separation of Prestoea lies in the petals of the pistillate flower

which do not have connivent valvate tips but are convolute-imbricate'. He notes that 'until the entire Euterpe group can be studied with ample material it will be impossible to arrive at a stable conclusion' as to the distinguishing features. Regarding the lack of crownshaft in Prestoea he notes that he would consider this a 'good generic character' should it hold up in the future.

Burret published his final species of Euterpe in 1940, with one in each of three separate papers in Notizblatt. E. subruminata (1940) from British Guiana was said to be distinct from all other species by its shallow rumination, the numerous dense ruminations being only .5 - .75 mm long. Burret used this feature to demonstrate the weakness of Bailey's suggestions that ruminations might be a basis for dividing the genus in two. E. microspadix (1940a) was from primary swamp forest in Eastern Ecuador with mahogany-brown stems and carmine-red fruiting spadix. E. petiolata (1940b) from swamps and forests in the Amazon river region of northern Matto Grosso, Brazil, was described from a specimen with the additional benefit to Burret of a photograph. It was placed in section Euterpopsis.

At the conclusion of Burret's publication of new

species in Euterpe, it can be said that, in general, he gave fairly full and detailed descriptions of his species, as well as providing a type specimen and sometimes even citing a photograph, a useful and seemingly rare occurrence to this point in Euterpe's history. It seems also that he had several collectors, especially from Ecuador and Brazil, who often sent him apparently fairly good material upon which he could base descriptions. In particular, he can be noted for the large number of new species which he named for Colombia, his critical and comprehensive synopsis, his discussion of the problems of dividing the genus, the new subtaxa he proposed for Euterpe and his inclusion within the genus of species assigned by some previous authors to Prestoea, along with his discussion of this genus.

Bailey was the principal worker to publish on Euterpe in the 1940's, naming six new species in the decade, four of which were from Trinidad and Tobago. E. dominicana (1940, above) from Dominica has already been discussed. The remaining species, E. roseopadix (1943) was from 1900 m in Panama. Features of note in the genus for this species include the long (1m) petiole, bright pink spadix, pinnae splitting at the base as if two or three of them were attached together, and in particular the branched rachillae, which I have not

noticed in earlier descriptions. Moore would later refer this species to Prestoea (Glassman 1972). Bailey placed E. roseospadix, with its ruminant endosperm, in section Euterpotypus. Interestingly, another species was published simultaneously that Bailey did place in Prestoea as P. sejuncta, noting: 'This makes five recognized species of the genus Prestoea, which lacks the crownshaft of Euterpe and differs in floral and fruiting characters'. Good illustrations (of herbarium material apparently) are included for both species in this paper.

In writing on the palms of Trinidad and Tobago (1947) Bailey recognized 6 species, four of these new ones. E. pubigera is accounted for in Prestoea. The four new species are E. tobagonis, E. pertenius, E. Beardii and E. confertiflora. Useful characters are included which were not often mentioned in earlier papers, including descriptions of the number of stems and the state of the crownshaft. Of interest, when considering the specific character of caespitose vs. non caespitose trunks, E. Broadwayae is said to exhibit both solitary and multiple trunks while E. langloisii may occur with several single trunks growing together. In E. tobagonis the crownshaft is 'not evident', a condition contrary to Bailey's description of the genus

and earlier remarks (1943, above). Some of the other features of interest for the new species include rachillae sometimes forked near the base, undulate and bright red at first on exposed surfaces (E. tobagonis), and the very slender rachillae (2 mm at the middle), small and scattered flowers and uniformly alternate pinnae of E. pertenuis. Photographs and good drawings are used to illustrate the six species recognized.

Again in this paper Bailey discusses the history and validity for New World palms of the name Euterpe. Now, he says, he has monographed the palms of the Mascarene Islands east of Madagascar from where Blume had suggested Gaertner's seeds (E. globosa 1788) might have come. Bailey says that although Dictyosperma and Acanthophoenix show similarities, the Gaertner illustration of the fruits and seeds of E. globosa 'has not been matched so far in any part of the world other than its range in the western hemisphere'. He still identifies the illustration with E. globosa (as it was contemporaneously understood) although he does note that the agreement with the many fruits he has studied is 'not always perfect'. 'Placement of the embryo is particularly convincing', he says. Bailey also dicusses the question of Catis and Acrista, names proposed by Cook to replace Euterpe. The former he dismisses since

it lacked a proper generic description. Acrista, he says, was proposed by Cook for a mountain palm of Puerto Rico, which he says was E. globosa. Cook, he says, had mistakenly dismissed the New World palms from being E. globosa Gaertner on account of the description of an apical point. Bailey notes, however, that E. globosa sometimes has this apical point and so Cook's opinion was unfounded. Regarding his own opinion on the possibility of dividing Euterpe in two, Bailey notes again the runcate versus non-runcate endosperm, and the flowers sunken in pits in the rachillae versus not sunken. However, he says, 'herbarium material is not yet sufficient to warrant publishable conclusions, for it does not show inflorescences, spathes, crownshaft, or very much of the leaf structure, and the habit of the tree is mostly unknown'. Bailey calls Euterpe 'The Manac Palms' in this paper, a name similar to 'Manaca' which had been published as a common name previously for certain species. Here, however, the name is not explained, nor are common names given for any of the species described.

Merrill's 1950 publication has been discussed earlier under Oken, 1940.

Dugand (1951) described three new species of

Euterpe all based on types collected by Cuatrecasas in Colombia. E. cuatrecasana, with chestnut or red-violet crownshaft, dark reddish inner spathe, and from the Pacific littoral forest, was placed in section Euterpotypus Burret subsection Bothrostachys Burret. E. rhodoxyla, also from Pacific littoral forests, was placed in section Euterpopsis. From several other species E. rhodoxyla is distinguished, among other characters, by not having vertically pendant leaflets. Another noteworthy feature is the rosy color of the bark and stem wood, for which the epithet was given. E. zephyria was from the western Andes between 2000-3000 m. and placed in section Euterpotypus subsection Leiostachys Burret. Interesting characteristics of the species included a green-red to purple crownshaft and rachillae with conspicuous long bracts (5.4 cm x 1 cm wide) at their bases. In general, Dugand's paper appears to give good descriptions and accurate citation of type specimens. Noteworthy are the inclusion of descriptions of each species' crownshaft, although stem number is unfortunately omitted. The types are represented by several sheets and the institution of deposition is cited; an improvement over Burret who did not mention this, leaving their whereabouts to be speculated upon but which may have been lost in the Berlin herbarium. Cuatrecasas' collection of much

material represents a distinct improvement for the herbarium worker in palms. In addition Dugand gives apparently complete specimen label information, which is useful. One drawback of his descriptions is the complete lack of illustrations or photographs.

Steyermark (1951) published E. ptariana, from between 1585-1600m on Ptari-tepui in Venezuela. The observations of scales, hairs, their location and color as well as of the color of the leaf sheaths are interesting for their possibilities as characters.

In 1957 Moore made an official transfer to Euterpe of a palm described as Malortiea simiarum by Standley and Williams in 1952. The new name was E. simiarum and the species was from mixed forest between 1300-1500m in Nicaragua. Fruit was not collected, but surprisingly there are several aspects of the description which sound atypical for Euterpe. These features include its habit, which was acaulescent, the leaf shape, with the pinnae progressively longer including terminal pinnae which were substantially longer than the middle ones, the mention of a female spadix (possibly this was seen after male flowers had fallen off?) with a long peduncle, and especially the fact that the spadix was said to have only two branches.

In 1963 Moore discussed in detail the typification of the genus Euterpe and the distinctions between Euterpe and Prestoea. Moore states that Beccari (1912) had designated E. globosa Gaertn. as type of the genus Euterpe Gaertn. and Burret had further typified it in the same way, removing Hooker's (1883) designated type, E. pisifera Gaertn., to the genus Heterospathe. Moore discusses the history of the association of E. globosa Gaertn. with Old World palms and then does the same for New World palms. He states that Martius excluded his reference to Euterpe Gaertn. under his treatment of Euterpe on p. 165, Hist. Nat. Palm. 3, 1837, when he wrote 'vix Gaertn....'. Here it appears Moore is mistaken, since vix means scarcely, meaning that Martius was not certain enough to rule out the synonymy. Moore goes on to state that 'Euterpe Martius non Gaertner, then, has since been followed by nearly every student of palms'. This statement seems most misleading. While several authors may have used this designation, these authors were mostly in the nineteenth century and it is not apparent that any of them studied Euterpe in great detail. Three of the four authors who appear to have critically examined the question of the correct use of Euterpe, and in great detail, namely Beccari, Burret and Bailey, had concluded that E. globosa Gaertner was positively identifiable with a West

Indian species (then referred to commonly under Gaertner's name), and therefore accepted Euterpe Gaertner without any reference to Martius (e.g. see Bailey 1947, p.419). The fourth author, Cook, had rejected Gaertner's name altogether for New World palms and therefore did not need to consider Martius. Discussing Beccari's (1912) affirmation that E. globosa Gaertner was indeed the West Indian species, Moore notes that besides the mistaken apical acumen cited by Gaertner (but which Beccari did account for), Beccari had failed to account for Gaertner's lateral embryo which in the West Indian species is distinctly basal. Again Moore's argument is flawed here. Beccari stated that when deprived of the perianth, as he noted Gaertner's fruit had been, it is impossible to tell if the stigmatic point on the fruit was apical or lateral. It follows logically from this that if mistaken as apical and illustrated with a lateral embryo, if the orientation of the fruit were turned 90 degrees then the stigmatic point would be lateral and the embryo basal, as Moore states it in fact is in the West Indian species. Not accounting for this and because of the differences he notes and the lack of type material cited by Gaertner (or discovered by any later authors), Moore rejects the association of E. globosa Gaertner with the West Indian species. Moore continues on to note that he

and some other writers consider Euterpe, as interpreted by Burret, to comprise two distinct genera, for one of which 'the name Prestoea is currently in use'. In Prestoea Moore places Euterpe subsection Leiostachys Burret, 'excluding one (species) and adding others since described'. He continues that if Beccari's application of E. globosa is followed, since it falls within subsection Leiostachys, 'the name Euterpe will be applied to the least well-known species....compounding existing confusion'. In other words, Prestoea sensu Moore would be called Euterpe. Moore also wished to avoid the nomenclatural changes which would occur (if this were done) for the remainder of Burret's Euterpe, which would then have to take on Cook's name of Catis or Plectis. If Burret's Euterpe were not divided and the name Euterpe Martius (which Moore was proposing) were rejected, then, Moore notes, the older name Martinezia Ruiz et Pavon or Oreodoxa Willdenow would have to be used and would be troublesome since both had been much confused in the literature. Moore felt that the best way to accommodate the two genera that he recognized within Euterpe sensu Burret, and keep the name Euterpe for what he considered the best-known species while at the same time avoiding the nomenclatural changes he considered undesirable, was to reject Euterpe Gaertner and in its place designate E. oleracea Mart. as

lectotype of Euterpe Mart.. In this particular paper he therefore officially designates E. oleracea as type . He also proposed (unofficially) 'a twofold conservation - of Euterpe Martius against Euterpe J. Gaertner, Martinezia Ruiz et Pavon, and Oreodoxa Willdenow; and of Prestoea J.D. Hooker against the same Martinezia and Oreodoxa, the inclusion of Euterpe J. Gaertner being made unnecessary if it is rejected'. I sympathize with Moore's admitted frustration and irritation regarding the lack of type material for E. globosa Gaertner and the possible inconsistencies between it and the West Indian species and therefore his action in rejecting Euterpe Gaertner. Nevertheless, going against common nomenclatural practice and conserving a name (Euterpe Mart.) that had already been used by an earlier author (Gaertner), is also frustrating and irritating and I wonder whether it would have been better to use one of Cook's names for Euterpe in the narrow sense and Martinezia or Oreodoxa for Euterpe in the broad sense or for Prestoea Hook.. I am not entirely cognizant, however, of the confusion involved with Martinezia and Oreodoxa, nor of the detrimental implications of changing the name of the better-known Euterpe species. Neither am I certain of the distinctness of Euterpe and Prestoea, even though I am not sure that this last question should be allowed to affect the matter.

Moore goes on in this paper to summarize the nomenclatural and taxonomic distinctions between Euterpe Martius and Prestoea J.D. Hooker as he saw them. He said the two taxa differed at a generic level 'in every important characteristic save that of fruit and seed', and could be 'distinguished readily in the field by the inflorescence alone and in the herbarium by additional characteristics'. These differences, as Moore outlined them, follow, with the Prestoea condition bracketed:

Euterpe medium to large palms (small to medium); prominent crownshaft (leaf sheathes more open); petiole short (long); inflorescence infrafoliar (usually interfoliar in bud, sometimes later infrafoliar) subtended by 2 subequal bracts (markedly unequal), the inner more or less dorso-ventrally compressed and incipitous (terete and rostrate) inserted close to the outer (at some distance above it) on the more or less dorso-ventrally compressed short peduncle (more or less terete, usually elongate); rachillae densely white- to brown appressed-tomentose or velutinous (glabrous to puberulent or floccose-lepidote), laxly spreading - pendulous (stiffly ascending or divaricate in all directions) from somewhat dorso-ventrally compressed rachis (terete), not bulbous at the base (markedly bulbous); flowers in distinct depressions (superficial), pistillate subtended by 2 prominent erect bracteoles

(low explanate), staminate above the pistillate (lateral), not prominently bracteolate (sometimes visibly bracteolate); staminate flowers with broadly imbricate (essentially distinct, imbricate at base only), rounded to subacute (acute) scarcely keeled sepals (strongly keeled), filaments not inflexed at the apex in bud (inflexed); seedling leaves pinnate (bifid at apex). In this last character Moore is definitely wrong, since E. oleracea Mart. has bifid seedling leaves that I have seen in the Amazon estuary. Moore also noted that the fruits of the two genera were virtually indistinguishable, though more Euterpe were non-ruminate, more Prestoea ruminate. While their range coincided Euterpe was said to occur more in poorly-drained areas at low elevations, Prestoea more on well-drained mountain slopes at moderate to high elevations. Finally, as a result of his elimination of E. globosa Gaertner, Moore notes that the correct name for Beccari's and others' E. globosa becomes Prestoea montana (Graham) Nicholson or E. montana Graham. Moore's proposed conservations and rejections regarding the names Euterpe and Prestoea were only suggested and explained in this paper (1963) but were formally proposed in Moore 1964. At this time Moore gives Euterpe and Prestoea about 28 and 35 species respectively, as he defines them. Moore's proposals

were officially accepted in McVaugh 1968. In the acceptance of Euterpe Mart. over Euterpe Gaertner, it is stated that E. pisifera Gaertn., and not E. globosa Gaertn., had been indicated by Blume, Martius and J.D. Hooker as lectotype for Euterpe Gaertner.

Glassman (1964) named E. williamsii from cloud forest between 1300-1400m in Nicaragua, placing it in subsection Leiostachys Burret (Prestoea sensu Moore).

Wessels Boer (1965) gave an informative and extensive account of the palms of Suriname. The work is good and valuable, I believe, because it is based upon one year's fieldwork in Suriname, during which time the author was able to see much of the country and make an 'almost exhaustive collection' of the palm species native there. Wessels Boer discusses again E. globosa Gaertner, having obtained material from Gaertner's fruit collection, but apparently not of the original material. With reference to Moore (1963) he says, 'I fail to understand why the name Euterpe Martius should be conserved versus Euterpe Gaertner' and proposes instead that a neotype (Wright #1468 from Cuba) be selected for E. globosa Gaertner. Wessels Boer says Euterpe is a most natural genus. Hyospathe pubigera, he says, is a small Euterpe, separated as Prestoea by J.D.

Hooker, but not accepted by most palm authorities. He rejects Moore's 1963 'restoration' of Prestoea, saying Moore overestimated 'the supposed distinguishing characters' which were only 'gradations of the same features and not fundamentally distinct at all'. Due to their occurrence over the same range but apparently different ecologies (as noted by Moore 1963) he suggests 'Prestoea consists of various specialized species adapted to rather extreme environmental conditions'. Wessels Boer makes some interesting comments on the value of certain generic and specific characters for Euterpe. Under E. precatoria he notes that the degree of pendency of the leaflets is an unreliable character in Euterpe, depending upon the age of the tree and the intensity of the light. E. badiocarpa, he says, is synonymous with E. oleracea, noting, 'the single trunk character is without much value, as it is often found in young and poorly developed specimens', and further, 'the size of the fruit is variable and not dependable as a species character, the brown color is typical for not yet completely mature fruits, turning into blackish purple at full maturity'. In these observations the value of studying the plants in the field is apparent, as well as the need to carefully reevaluate species which have been separated based upon such characters. For Suriname, Wessels Boer recognizes E. precatoria and

E. oleracea only.

Despite the differing opinions on Prestoea new species continued to be published in the genus. Moore (1965) writes 'the distinctions between Euterpe and Prestoea have recently been clarified by the writer' and names the new P. allenii from Panama. In the same paper he makes the transfer of Euterpe roseospadix to P. roseospadix and distinguishes between the three Prestoea he recognizes from Panama.

At this point it is convenient to note that while the history of Euterpe here written is not attempting to be exhaustive regarding the publications on Prestoea, I am including certain publications when convenient since the genus has been so intertwined with Euterpe. Ideally the coverage would be complete but at this point and in this work it is not considered practicable to do so.

As a prolific worker in palms for the period, Moore continued to publish new species in Prestoea and Euterpe, as he had circumscribed them, with three new ones from the tepuis of the Guianas and Venezuela in 1969. E. aurantiaca was from 1500m on Cerro Cipapó Venezuela and was placed in section Euterpopsis. Moore notes that the 5 tepui species of Euterpe (including E.

montis-duidae, E.ptariana, E. roraimae and E. erubescens) 'are characterized by buff to ferruginous indument on the inflorescence branches in contrast to the white or pale yellow indument of most lowland species'. E. erubescens, from 1660m and apparently wet or swampy ground on Auyan-tepui and from around 2000m on Chimantá Massif, both in Venezuela, was also placed in section Euteropsis. Description of vestiture for both species is detailed. E. erubescens had the interesting character of brick-red sepals. Another species from the summit of Cerro de la Neblina was said to be very similar to E. erubescens but to differ in certain aspects. More complete material was said to be needed in order to decide the identity or novelty of the material. Prestoea Steyermarkii, from 1400m on Chimantá Massif, Venezuela, and from ca. 1250m on Cerro Venamo near the border with British Guiana, interestingly had an infrafoliar inflorescence.

Wessels Boer (1972) treated Palmae for the 'Botany of the Guayana Highland'. Here, he changes his earlier designation to agree with Moore's nomenclatural changes, writing Euterpe auct. non Gaertner, Martius. Nevertheless, he still keeps a very broad concept of Euterpe, including within it Prestoea. For what other authors call Prestoea he makes the interesting

observation of its predominantly reduced habit being correlated to a retention of juvenile foliar characteristics. Interestingly characters used by Steyermark to separate E. ptariana from E. roraimae as a new species are said to have only represented different stages of development. In all, Wessels Boer recognizes four species for the Guayana Highlands.

Mattos (1977) named the new variety E. edulis var. clausa from the state of Sao Paulo, Brazil.

Read (1979) treated palms for the 'Flora of the Lesser Antilles', following Moore's 1963 circumscriptions for Euterpe and Prestoea but distinguishing the genera solely on crownshaft, segment habit, inflorescence indument, flower set, stamen - filaments and seedling leaves (pers. comm. Read). He did not use prophyll and peduncular bract relationships. It is also noted that he was distinguishing between only two species. E. dominicana was the only Euterpe recognized for the region. For Prestoea only P. montana was recognized, but it was noted that this was an 'extremely variable species, possibly to be considered as several distinct subspecies following more intensive study'. Good illustrations of both palms are included.

In 1980 Moore named three Prestoea species, all from South America.

Galeano Garces (1986) wrote an interesting paper on the Euterpe/Prestoea conflict. In it she published a new species from 950-1200m in Antioquia, Colombia, which she named P. simplicifolia. Features of interest for the generic complex included 'its huge, simple, oblong, and short-petiolate leaves', which were bifid at the apex, its large inflorescence (171 cm) with 'peduncle as long as or longer than the rachis' and its inflorescence reddish in fruit when fresh. Referring to her own limited field and herbarium work in Colombia, and regarding Moore's (1963) delimitation of Prestoea and Euterpe, Galeano Garces notes, 'most differences established by him are not broadly usable, unless for extreme species', for which she gives the examples E. cuatrecasana, E. kalbreyeri and P. decurrens (H.Wendl. ex Burret) H.E. Moore. Even these show incongruencies to Moore's categories, she notes, the two Euterpes having bulbous bases to the rachillae, a character ascribed only to Prestoea by Moore. Furthermore, E. cuatrecasana has bifid eophylls, again ascribed only to Prestoea, she says. Other species, she notes, seem to be transitional and not readily able to be ascribed to either genus as circumscribed by Moore. Collections

identified as E. purpurea Engel and E. oocarpa Burret have habit, crownshaft, rachillae indument and flower shape of Prestoea but have the short petiole, short peduncle, closely inserted prophyll and peduncular bract, and somewhat compressed rachis of Moore's Euterpe. On account of these problems, Galeano Garces says she considered following Euterpe sensu Burret and calling the new species Euterpe, but, awaiting a better understanding of the whole complex and in particular the distinction between Prestoea and Euterpe, she followed Moore's recent ideas on the group. She also notes (pers. comm. Read) that chemical and anatomical studies have supported two separate genera.

Henderson and Steyermark (1986) described the new Prestoea humilis for a Venezuelan palm growing between 1000 - 1400m. In the same year, Henderson described Prestoea darienensis from 1130m in Darien, Panama. P. darienensis was said to differ from all other described species of Prestoea and Euterpe 'by its much larger inflorescence, erect at anthesis and in fruit'. Henderson says that three morphologically distinct groups can be recognized within Prestoea sensu Moore. Group one he defines with 'well-developed rachis with numerous rachillae and seeds with ruminant endosperm'. He notes that 'this group contains many of the character

states that Moore (1963) listed for Euterpe'. The crownshaft, he notes, however, has a different structure to that of Euterpe sensu Moore, appearing more like that of Oenocarpus. Group two he characterizes with a 'well-developed stem, weakly developed crownshaft, inter- or infrafoliar inflorescences, markedly unequal prophyll and peduncular bract, well-developed rachis with many rachillae, and seeds with ruminant endosperm'. Group three he characterizes with 'weakly developed stem, absence of crownshaft, interfoliar inflorescences, markedly unequal prophyll and peduncular bract, short rachis with few rachillae, and seeds with either ruminant or homogeneous endosperm'. This latter, Henderson calls a morphologically diverse group containing 'species somewhat intermediate with group two'. It is interesting to record here the species that Henderson lists as examples for group one, since he notes the similarity to Euterpe sensu Moore, and if Euterpe is considered in a narrow sense then these species might be included within it or perhaps considered intermediate between the two genera. These examples are P. megalochlamys (Burret) Moore, P. allenii Moore, P. montana (Graham) Nicholson, E. oocarpa Burret, E. purpurea Engel, P. acuminata (Willdenow) Moore, and E. zephyria Dugand.

Henderson and de Nevers (1988) discussed palms of Panama. New species of Prestoea were described while E. brachyspatha, E. williamsii and E. simiarum were placed in synonymy under P. longepetiolata. E. simplicifrons was transferred to Prestoea.

Fernandes (1989) described a new species, E. espiritosantensis, from the state of Espirito Santo, Brazil. In the same year, Bernal et al discussed Columbian palms. E. brachyclada, E. dasystachys and E. latisecta were transferred into Prestoea while E. latisecta was placed in synonymy with E. kalbreyeri. All were designated with neotypes.

Most recently, Henderson et al (1991), described E. luminosa from Peru. This species does not seem to belong with Euterpe because of it's ellipsoid fruits, since all other fruits of the genus are globose. However, it's overall appearance does seem similar.

CONCLUSION

The true identity of Gaertner's Euterpe globosa fruits has never been established and it is very difficult to do this when the fruits have never been located and most probably never will be. Although certain authors, such as Beccari (1912), have been certain of them belonging to the West Indian species, I believe that a complete modern comparison of all the fruits in the palm family would be required to definitively say this. With all probability it would at best be possible to assign them to Euterpe in the broad sense as recognised by Burret and others. No doubt it would take an extremely painstaking study of the fruit of all members of the Euterpe complex to attempt to assign them to a specific taxon, and given the similarity of fruits in the genus and the absence of the original fruits it seems that this may be almost impossible. Although it is 'niggling' that the fruits of Gaertner do look like those of the Euterpe complex, the fact that it is virtually impossible to assign them to a particular species makes Moore's (1963) action of designating E. oleracea Mart. as lectotype for the genus seem reasonable. This will remain so until such time as the studies named above have been completed.

This acceptance of E. oleracea Mart. as lectotype takes care of the typification of the genus. It does not account for the correct naming of the genus. Cook's (1901 and 1904) arguments against the use of the name Euterpe are valid in part. It would have been better if the name Euterpe had been rejected long ago since there is no type material and the drawings cannot with certainty be tied to the genus. Cook is wrong, however, to use the argument that the name was meant solely for Old World palms since Gaertner only cited Pinanga sylvestris globosa as a synonym and did not state the origin of his fruits, leaving open the possibility that they were from the New World and Gaertner considered the species to occur in both hemispheres. Again, however, since the fruits cannot with certainty be tied to a taxon, it is felt worthwhile, until such time as definitive evidence should become available, to accept Moore's conservation of the name Euterpe Mart., even though I personally find it extremely annoying that the method of types and rules of nomenclature should have been strictly adhered to long ago and was not. Should definitive evidence eventually become available it would be worthwhile to return to Euterpe Gaertner.

The final question is that of the distinctness of the genera Euterpe and Prestoea. At this point I

believe there is insufficient evidence to separate the two genera and it is better to maintain all species in the genus Euterpe as done by Burret. Moore's generic features have not held up and I feel there is little advantage to having created and maintained two genera when the limits of the genera are not clear. Transfers of species should not have been made until such time as a thorough study of complete material of both 'genera' is possible, which may not be until some time in the future since more material is needed, more information on field characteristics and also on the amount of variation of certain features within individual taxa. Most recently Galeano Garces paper (1986) bears this argument out, although the overlap and confusion has often been pointed out. She says 'most differences established by him are not broadly usable, unless for extreme species' and even these do not fit his categories, she adds. Even though a great deal of variation has been introduced into the Euterpe complex over more than two centuries, and there may well be more than one genus, the evidence does not hold together sufficiently at this time to warrant the use of two genera and I feel this has only added to the taxonomic confusion. Scientists should not run to create new genera, species or new names by transfer until they are fairly certain of what they are doing.

ETHNOBOTANY AND ECONOMIC BOTANY OF EUTERPE Mart.Introduction

The ethnobotany and economic botany of Euterpe has never been reviewed and summarized. Many of the references are obscure and scattered, yet clearly it is of great importance to bring all this work together for a genus of such ethnobotanical and economic importance. Most of the references are in foreign languages. Since I am familiar with 6-7 languages and am familiar with methods of translation, this has facilitated this work. All the species lie within the tropics, all within threatened or potentially threatened forest habitats. Both the many species and the cultures that utilize them with their first-hand knowledge of processing etc., represent an invaluable resource for future possible utilization of the genus to its maximum potential. The literature survey that follows will provide a sound data base for future rational utilization and conservation efforts for Euterpe. The initial part of this chapter presents this survey, dealing in depth with the more obscure ethnobotanical references to the genus and then briefly summarizing some of the works which have been more industrial or technical in nature, and relating to

major economic uses or projects. Much of the information in this review has come from my individual survey of the literature. The remainder has come from a work in which I collaborated in making detailed translated abstracts, for a comprehensive survey of the literature that exists on palms and their uses (Balick, Beck and Collaborators 1990).

The second major part of this chapter focuses upon Euterpe oleracea Mart., the most important species, economically speaking, at the current time. Original observations and details, many of which have not been documented before, are presented, based upon studies made by Strudwick and Sobel (1988) in the Amazon estuary of Brazil.

Literature Survey of Ethnobotanical & Economic Uses

Gaertner (1791) made early reference to the ethnobotanical use of Euterpe when he noted the French common name for Euterpe pisifera B as 'chou palmiste'. This means palm cabbage, referring to the edible apical portion of the stem. Martius (1824) further attested to the usefulness of the genus by naming two of his first three species in the genus E. oleracea and E. edulis. The word 'oleraceus' means 'pertaining to kitchen gardens' in Latin while 'edulis' means edible (Stearn, 1973). Indeed, E. oleracea, as I have witnessed myself, is abundant in the 'kitchen gardens' of inhabitants of the Amazon estuary. For uses of E. oleracea Martius noted the edible palm heart and the splitting of the trunk to make small beams. Interestingly, Martius made no mention of the use of the fruits for the popular liquid made from the species known as this today in the Amazon estuary. For E. edulis, Martius notes the fruits are highly desired by Indians to make the drink called 'Cao-hy' and the fronds used to cover constructions and make baskets or other useful items. This ethnobotanical note adds some confusion regarding the true identities of E. oleracea and E. edulis, since it is the former, as understood today, whose fruits are widely used for a highly esteemed drink.

Oken (1841) gives the name Cabbage Palms ('Die Kohlpalmen') to the genus Euterpe, reflecting their use for the edible palm heart. This name would be widely used by later authors. D'Orbigny (1844) gave an account of his South American voyage, including a latin description of the new species, E. precatoria, by Martius. In his own French notes D'Orbigny states that this species grew close to the banks of the River Moxos near the San-Joaquin Mission in the province of Moxos, Bolivia. He notes that the Jesuits regarded the very rounded seeds good for making rosaries. The natives of the eastern regions of the province took great care to collect the seeds every year in the month of April in order to sell them in the rest of the province, from where the rosaries that were made from them were exported to the towns of the plateaus. Because of this, he notes, the Spanish had named this palm 'palma de rosario' (rosary palm).

Wallace (1853), in his classic 'explorer' style account, gave the most extensive account seen in English of the use of Euterpe oleracea Mart. for the 'assai' beverage prior to Strudwick and Sobel (1988). He describes the use of the palm in the city of Pará, known today as Belém in the state of Pará. Justice to his style and account is best achieved by quoting directly.

"A very favourite drink is made from the ripe fruit, and daily vended in the streets of Pará. Indian and negro girls may be constantly seen walking about with small earthen pots on their heads, uttering at intervals a shrill cry of Assaí--i. If you call one of these dusky maidens, she will set down her pot, and you will see it filled with a thick creamy liquid, of a fine plum colour. A penny-worth of this will fill a tumbler, and you may then add a little sugar to your taste, and will find a peculiar nut-flavoured liquid, which you may not perhaps think a great deal of at first; but, if you repeat your experience a few times, you will inevitably become so fond of it as to consider "Assaí" one of the greatest luxuries the place produces. It is generally taken with farinha, the substitute for bread prepared from the mandiocca root, and with or without sugar, according to the taste of the consumer." Wallace continues, "During our walks in the suburbs of Pará we had frequently opportunities of seeing the preparation of this favourite beverage. Two or three large bunches of fruit are brought in from the forest. The women of the house seize upon them, shake and strip them into a large earthen vessel, and pour on them warm water, not too hot to bear the hand in. The water soon becomes tinged with purple, and in about an hour the outer pulp has become soft enough to rub off. The water is now

most of it poured away, a little cold added, and a damsel, with no sleeves to turn up, plunges both hands into the vessel, and rubs and kneads with great perseverance, adding fresh water as it is required, till the whole of the purple covering has been rubbed off and the greenish stones left bare. The liquid is now poured through a wicker sieve into another vessel, and is then ready for use. The smiling hostess will then fill a calabash, and give you another with farinha to mix to your taste; and nothing will delight her more than your emptying your rustic basin and asking her to refill it." Wallace concludes, "the inhabitants of Pará are excessively attached to this beverage, and many never pass a day of their lives without it. They are particularly favoured too, in being able to get it at all seasons, for though in most places the trees only bear for a few months once in the year, yet in the neighborhood of Pará there is so much variety of soil and aspect, that within a day or two's journey, there is always some ripe Assaí to supply the market. Boys climb up the trees to get it, with a cord round the ankles" ... "and with its own leaves make a neatly interlaced basket to carry it home. From the great island of Marajó, its igaripés and marshes, from the rivers Guamá and Mojú, from the thousand islands in the river, and from the vast palm swamps in the depths of the forest,

baskets of the fruit are brought every morning to the city, where half the population look to the Assai to supply a daily meal, and hundreds are said to make it, with farinha, almost there main subsistence."

Wallace also mentions the use of trees of Euterpe for palm heart, which he briefly describes as follows. "The undeveloped leaves in the centre of the column form a white sweetish mass, which when boiled somewhat resembles artichoke or parsnep, and is a very good and wholesome vegetable. It may also be eaten raw, cut up and dressed as a salad with oil and vinegar. As, however, to obtain it the tree must be destroyed, it is not much used in Pará, except by travellers in the forest who have no particular interest in the preservation of the trees for fruit." Once again here is a confusing case of an author not mentioning the multiple stems of E. oleracea. This is of note since this allows this species to survive when selected stems are cut. The use of E. oleracea stems for making rafters is also noted.

Wallace also describes a new species in this work, Euterpe catinga. He notes that this species, from the upper Rio Negro, has a smaller fruit than the assai palm, yet "more pulpy matter", so that it produces more

of the assai beverage than E. oleracea. The liquid produced from the new species is said to be "sweeter and more finely flavoured than that of any other". However, he notes, fruit production per tree is much lower and therefore it takes four or five trees to equal the production of a single spadix of E. oleracea.

In 1871 another British explorer, Spruce, after visiting the Amazon, wrote that only the drink, from what he believed to be correctly called E. edulis Mart. at Pará, was called 'Açai', but not the palm itself, which was called 'Yuçára'. From the junction of the Rio Negro and Amazon he describes the cylindrical leaf sheathes or "cabbage" of E. oleracea Mart. as '4 feet long'. It should be noted here that he is in dispute with the nomenclatural identifications of Wallace (ibid) and the current popular understanding of E. oleracea Mart.. Of E. caatinga Wallace, Spruce notes that the mesocarp 'though thin, is soft and sweet, and makes a better drink than even the common Assai or Manaca (E. oleracea); but where the palm grows on almost bare flats of granite rock that are inundated with every shower, the pulp is so grumous or gritty as to be unserviceable;' and that this characteristic held true throughout the mouth of the Casiquiari and at the Venezuelan frontier where he had mostly seen this

species. In this same work on equatorial South American palms, Spruce mentions a palm from Peru which he knew only as 'chontilla'. Of this palm he says 'the habit is almost that of a Geonoma, but the leaves, the edible cabbage, and the fruit, are all of Euterpe'. He notes that this palm is so slender that walking-canes are made from it.

In his treatment of Euterpe for Flora Brasiliensis, Drude (1882) recognized E. oleracea Mart., E. edulis Mart., E. precatória Mart., E. catinga Wallace and E. catinga Wallace var. aurantiaca Drude. The fruit of the first four taxa is said to be used for the porridge or wine often known under various spellings of 'Assai'.

Im Thurn (1884) attempted a 'complete record' of the palms of British Guiana, including three Euterpe species. Two of these are clearly distinct species, E. oleracea Mart. being listed by name only. It seems clear, however, that Im Thurn's E. edulis Mart. and E. stenophylla, sp. nov. Trail, are really E. oleracea Mart. and E. precatória Mart. respectively, as these palms are understood today. Im Thurn gives good ethnobotanical notes for both species. Under E. edulis he notes local names as 'manicole' (Creole), 'wassí'

(true Carib), 'manaka' (Arawak) and 'morrokke' (Warrau). Im Thurn writes, "the uses to which the various parts of the manicole are put are many. The split stem is used by Indians for flooring huts in muddy places and in houses raised on piles; and these laths are used by creoles and East Indian and Chinese immigrants for making palings and partition walls in their houses. Smaller laths split off from the stem are also occasionally used, to string the geonoma leaves for thatch on; but laths from the booba palm (Socratea exorhiza. Wendl:) are preferred as much more durable, for this purpose. Pieces of the unsplit stem of the manicole are also used, after having been half divided in the middle and bent into the shape of a boat's "knee", to fasten down the thatching of the ridge of houses thatched with the leaves of the troolie (Manicaria saccifera). The thin and easily withered leaves of the manicole itself are seldom used as thatch, and then only for temporary huts, erected by Indians while travelling. Bundles of the easily procured leaves are often used to cover and shelter hammocks and other properties in the Indians' canoes. The cabbage when boiled makes a most excellent vegetable, tasting like thistle-artichokes; but this fact seems little known, and the article is seldom made use of in this colony, either by Indians or others. From the ripe fruit an

excellent chocolate-like drink is easily and occasionally, but here seldom, prepared. The inner skin of the spathe is used, instead of paper, for cigarettes, by the Arawak and Warrau Indians; whereas the Carib tribes more commonly use for this purpose layers of the bark of a forest tree (Lecythis). For E. stenophylla Im Thurn notes that "the frond is not so fibrous and tough in texture" as the above-discussed species, and therefore "the Indians say they never cut them for thatching purposes, as they shrivel up in a few days." Local names are given as "wabò" (true Carib), "rayhò" (Arawak) and "weenamòri" (Warrau). Im Thurn notes, "the cabbage is eatable and a drink may be prepared from the fruit, as in the case of E. edulis; but, unlike the latter species, the fronds are of little use as thatch and the stem which is said not to split so easily, is not often used". Im Thurn also made reference to uses of Euterpe in an anthropological account of Indians of the Guianas (1883).

Christy (1884) discusses the use of Euterpe for palm hearts in the West Indies and compares the system of extraction in this region to that used in British Guiana. Peckholt and Peckholt (1889) included Euterpe in an extensive work on palms of Brazil, their uses and especially their chemical compositions.

Barbosa Rodrigues (1901) gives an interesting and informative explanation of the origin of the name 'açai'. He notes that this name is correctly used for the liquid made from the fruits of certain Brazilian Euterpe. It is an Indian name coming from the three syllables 'uá' (fruit), 'ça' (cord) and 'y' (liquid). Literally, it then means 'liquid from the fruits from the cord', referring to the long, straight rachillae on which the fruits lie

In his oversize work 'Sertum Palmarum' (1903) Barbosa Rodrigues includes some more information on the uses of Brazilian Euterpe. E. badiocarpa Barb. Rodr. is said to have the largest fruits and be used for the 'vin d'Assahy' (açai wine). E. controversa Barb. Rodr. is also said to be used for the wine, and this to be similar to that made from E. edulis "mais moins bon, car il est un peu astringent" (but less good because it is a little astringent). It's small palm heart is said to be eaten and "ses tiges sont employées pour faire des girâos et d'autres ouvrages" (it's stems are used to make 'girâos' and other things - translation of 'girâos' not found; possibly meaning a hinged wooden structure such as the V-shaped brackets on thatched roofs). The wood of E. oleracea Mart. is said to be used for walls and house roofs, which last half a century. The 'wine'

from this species is said to be very nutritious. An interesting new use is the extraction of an oil from the fruit which is "très limpide, verdâtre et un peu amère" (very clear, greenish and slightly bitter). In 1907 Barbosa Rodrigues would go on to discuss the correct application of scientific names for E. oleracea Mart. and E. edulis Mart.. For the latter he notes that although it's fruits are larger than those of the former, they are very rarely used as food. E. edulis did have a long palm heart, however, which was very sought after, eaten raw or cooked and put into a salad with vinegar, oil, salt and pepper.

Le Cointe (1924) includes Euterpe in an analysis of the oils produced by palms of the Brazilian Amazon. Pittier includes E. edulis in a manual of useful plants of Venezuela (1926). While this species does not occur in Venezuela he does give its common name of 'palmiche de Rio Negro'. It is said to provide an edible heart. E. oleracea is said to have an edible heart as well as edible young inflorescences and it's wood to be used in house construction. Barrett (1928) listed Euterpe as a palm which is used to produce sugar from it's sap. This appears to be an error and is all the more likely so, since this work is of a compendium nature and I have not seen this use listed elsewhere. Pereira (1929) wrote a

dictionary on the useful plants of the state of Sao Paulo, Brazil. In it, E. edulis was noted to have edible fruits used in a beverage. The heart of E. oleracea was edible, the leaf fiber used to make cord and the wood used to make canes, braces, walking sticks and cables. Since E. edulis is the only species known in Sao Paulo, there is apparently nomenclatural confusion here.

Marcus (1931) included Euterpe in an article in which Brazilian oil palms were analyzed. Devez (1932) included E. oleracea in a dictionary-style work on useful plants of Guyana. It's fruit was edible and had an oil-rich kernel, while it's trunks were used in construction. Bondar (1942) included E. edulis and E. precatória as producers of palm heart in Brazil which could be utilized in several recipes which are provided. Palm heart is noted to be well-liked in North America. Recipes are given and include palm heart soup, palm heart empanadas and palm heart with shrimp. Avencio Villarejo (1943) wrote a geographical and ethnographic study of the province of Bajo Amazonas in the Brazilian Amazon. E. edulis was said to provide an edible fruit and it's trunk to be used for flooring in houses. The trunk of E. oleracea was said to be used for arrows, bows and clubs, the palm heart to be edible.

Stahl (1944) wrote on the useful plants of Suriname. The fruits of Euterpe oleracea were used to make ice creams and sherbets. Its leaves were used for thatching which was, however, less durable than thatching from Geonoma multiflora. Its trunks were used for boards and palisades. Moscoso (1945), treating Dominican palms, noted that in high elevations campesinos used the very small leaf sheathes of Euterpe globosa for roofing ('techar sus bohíos'). The fruits were used to feed pigs ('cerdos cimarrones'). Munsell et al (1949-50) wrote that the palm heart of E. longepetiolata in Costa Rica is roasted, used in salads or as a vegetable.

Dugand (1951) tells us that the thin, somewhat bland epicarp of his new species, E. rhodoxyla of Colombia, is edible. This is of particular interest since it extends the range of Euterpe whose fruits can be used as a beverage. In the same year Steyermark named E. ptariana from the remote Ptari-tepuí in Venezuela. Noting the local name of 'manaca-si-yek', he says that the palm heart is edible. Again, this underlines the extremely widespread utility of the genus, having its roots in indigenous cultures. The names 'manac palms', 'manaca' etc. appear to be common for Euterpe in this region of its range.

Lévi-Strauss (1952) discussed the use of wild plants in tropical South America. The fruits of E. oleracea, E. precatoria and E. edulis were used to make beverages or mushes (I like that word, it really describes what is made from E. oleracea fruits well!). Leaves of E. edulis and E. oleracea were used by Indians for thatching. Of course, Euterpe is listed for palm heart.

Hodge and Taylor (1957) treated the ethnobotany of the Island Caribs of Dominica. Euterpe dominicana was often felled for its good-tasting palm heart which was either boiled or eaten raw. Fiber from the roots was used in basket-making, while ridge caps for buildings were frequently made from trunks split in two. Edible grubs of Calandra palmarum, the palm beetle, were harvested from its rotted trunks. Leaves of young individuals were woven into thatching. Civrieux (1957) surveyed the indigenous names and some uses of palms, including Euterpe, among 33 indigenous tribes of Amazonian Guayana.

Loomis (1958) included Euterpe in a horticultural discussion on the best methods for the preparation and germination of palm seeds. Hodge (1959) discussed the mountain cabbage palm, Euterpe globosa (also known as

Prestoea montana) of the Antilles. It is noted to have an edible palm cabbage (palm heart).

Towle (1961) wrote about the ethnobotany of pre-Columbian Peru. Euterpe was included as one of two genera of palms that were known to be important at this time. The fruits of E. edulis were used to make a beverage and there are also illustrations of monkeys and parrots eating palm hearts. Since E. edulis does not occur in Peru I speculate that this palm could be E. precatória. Acosta-Solis (1961) wrote about the products of the forests of Ecuador. E. cuatrecasana was said to yield fruits which produce a fine oil while the leaves were used for thatch.

Hodge (1965) wrote an article on 'palm cabbage'. Euterpe is said to yield the best quality and its production and preparation is briefly discussed. Munier (1967) also wrote about palm hearts in his paper "Le chou-palmiste". He noted that palm hearts are eaten by natives of the American, African and Asian tropics and that it could be consumed raw, fried, roasted, in a salad or preserved. Some palms were noted to have edible hearts while others could be very bitter. Euterpe oleracea was said to be preferred in Brazil. France was said to import as much as 300 tons per year.

Holmberg (1969) made an anthropological study of the Siriono people of Eastern Bolivia. The common name of "assayi" is given as a palm which provides useful products. This is interesting since this name is given in Brazil to E. oleracea yet this species is not known to occur in Bolivia. I feel that most probably this name is referring here to E. precatória. Palm hearts from a variety of species are noted to be a major part of the diet in a table which gives the monthly food supply. Moore (1969) notes that the 'bud' (palm heart, most probably) of his new species, E. erubescens, is said to be edible. This species was from 1660-2000 m on the Venezuelan tepuis, a very high altitude.

Pedrosa Macedo (1970, 1971, 1973 and 1975) wrote a series of papers which focused on E. edulis and its use for palm heart. These are of particular interest because they focus upon a species which has not often been written about in the botanical literature, yet it has a good heart, has been much exploited and in particular is single-stemmed, meaning it dies when harvested. Large areas of native stands of E. edulis are said to have been destroyed along the Atlantic coast of Brazil where this palm occurs. Methods for successful reforestation are discussed. E. edulis is estimated to occupy 28 million hectares in Brazil and

Paraguay (this species also occurs in northern Argentina). Various laws are listed that were designed to help conservation while stimulating the industry. Germination techniques are discussed as well as sustained management of wild populations. Various areas of research and research contacts are listed. The heart of this palm is noted have about 25% more protein than that of E. oleracea. Use of this species for cellulose is also mentioned.

Costa et al (1974) did an in depth study of Euterpe oleracea as a source of raw material for the production of pulp and paper in the Amazon estuary, Brazil. Regarding the present industrialization of this palm for palm heart production it was said that 60 million specimens were needed for the production of 12 million kilograms of the canned product. This corresponded to the work of the eleven factories currently in production. It was concluded that the trunk was suitable for the production of industrial-use paper while the leaves were suitable for fine papers. Many good features were said to belong to this palm. These included excellent cellulose, low lignin content and the intense proliferation of offshoots giving a renewable source of raw material as well as avoiding the necessity of replanting (as is necessary with many

trees). Costa stressed the importance of this palm as a principal source of basic alimentation for large numbers of people in the Amazon estuary. Because of this he said methods should be found to sustain this aspect of it's use while developing the other uses.

In a detailed study of the anatomy of the fruit of E. oleracea, Paula (1975) noted that the young endosperm is rich in inulin and protein. With age it becomes rich in oils, while oil constitutes 13.4% of the mesocarp and protein 1.5%. Prance and Freitas da Silva (1975) wrote about trees of the Manaus area in the Brazilian Amazon interior. Besides it's use for alcoholic and non-alcoholic beverages, E. oleracea is used as an ornamental in the city of Manaus, particularly in gardens, while it's oil is used as an antidiarrheal. (This common horticultural use in gardens was also observed by myself in Belem and is noted later in this chapter).

Mattos and Mattos (1976) gave more detail on E. edulis, commonly referring to it as 'palmito juçara'. Three varieties are mentioned (vermelho, branco and macho or encapado). France and the United States are said to be the principal importers of palm heart. Animals such as rodents and birds are said to consume

the fruits of E. edulis. It's uses include leaves for thatching, fruits for a beverage, seeds as animal feed and as a fertilizer when rotted, cellulose production and paper, wood for rural construction and for urban scaffoldings, water conduits and firewood. Similarly to Macedo (ibid) information on cultivation, natural regeneration and the necessity of preserving wild populations is provided.

Balick (1976) wrote a brief article on "the palm heart as a new commercial crop from tropical America" in which he described a project to cultivate Bactris gasipaes in Costa Rica. Great destruction of wild stands of a native Euterpe species, for it's palm heart, is noted to have occurred. Advantages of B. gasipaes are outlined.

Anderson (1977 and 1978) wrote about palm use among the Xiriana-teri, a tribe of Yanomamo Indians in the northern part of the state of Amazonas, Brazil. While other South American tribes produce beverages from Euterpe and other genera, this use is practically unknown by this tribe. E. precatoria, locally called 'amoki', is considered superior for palm heart, although most local species are also utilized for this. The wood of E. precatoria provides the most valuable lumber,

being both durable and easy to work. It's primary uses are for wall slats, shelves and table tops. It's fruits are used to produce a black dye and the inflorescences for brooms. Anderson notes having seen another species of Euterpe being used for this latter purpose in the Chocó rain forest on the Pacific coast of Colombia.

Beckerman (1977) wrote about the use of palms by the Bari Indians in the Maracaibo peninsula of Venezuela and Colombia. A species of Euterpe or Prestoea is used as an important fruit source, the dark blue fruits being chewed raw and the seed spat out. Dransfield and Soenarko (1977) described some Indonesian recipes involving the use of palm hearts from Euterpe and other genera, as well as other palm product ingredients. Schultes (1977) reviewed promising structural fiber palms of the Colombian Amazon, including E. oleracea as one of these and citing E. precatoria for it's edible fruits. (I note that E. oleracea, however, has not been shown to exist in Colombia).

Snow and Snow (1978) noted that half of the diet of the interesting, cave-dwelling oilbirds in Trinidad and Venezuela consisted of palm fruits, including E. langloisii. Acero Duarte (1979) elaborated on the principal useful plants of the Colombian Amazon. The

Tikuna Indians make a green dye from the crownshaft of E. precatória. The Indian beverage of chicha is made from the fruits while it's light wood, with an air-dried weight of 0.47 gm. per cc., is used for indigenous construction.

Balick (1979) wrote an article on the use of palms by the Guahibo Indians in the "Las Gaviotas" region of the Colombian Llanos. Of E. precatória he notes "the long graceful leaves of this palm are used to cover canoes, protecting the occupants from sun and rain. An arched wooden framework is constructed and thatched with these leaves. Because of their small size and light weight, Euterpe fronds are superior for this purpose to other types of foliage. Formerly, the Guahibo were said to have used leaves of this species to cover the entrances to their provisional houses" which are described in detail. For these entrances "an insect-proof screen was created by weaving the many thin pinnae of 'manacáy' together into a mat, and placing it over the hut entrance at night or occasionally during the day". ('Manacáy' is the Guahibo name for E. precatória). The use of the palm trunk for corrals and consumption of it's succulent palm heart are also noted.

Bodley and Benson (1979) discussed the ecology

and importance of palms in subsistence agriculture among the Shipibo Indians of Amazonian Peru. Population densities as well as habitat preferences are provided for all the palms as well as utilization patterns and the number of different species used by each household. Euterpe is used for walls, floors, posts, it's edible fruits and palm heart.

Cayon Armella and Aristizabal Giraldo (1980) listed plants used by the Embera-Chami Indians in the Chocó group. The wood from a species of Euterpe was said to be used for making blowgun darts and as firewood. Vargas (1981) suggested Euterpe as a possible genus of palms represented in plant motifs on ancient wooden carved and painted vases of the Incas. Williams (1981) wrote an extensive paper on the useful flora of Central America. Palm hearts are said to be extracted from E. longepetiolata, which is now said to have become rare. Glenboski (1983) studied the ethnobotany of the Tukuna Indians in the state of Amazonas, Colombia. Euterpe is one of ten palms utilized. Local names, habitat, parts used and processing methods are given.

Johnson (1983a and 1983b) made an assessment of germplasm of multipurpose palms, classifying each species as: improved/cultivated; being in an incipient

state of domestication; or semi-wild/wild. E. oleracea and E. edulis were included in the second category. In 1985 the same author again discussed multipurpose palms. Euterpe is included with several other palms and their multiple uses discussed.

Mejia (1983) discussed the palms from the region around Jenaro Herrera, a town on the Ucayali river in Amazonian Peru. E. precatoria fruit is used for a beverage and it's palm heart is eaten. Plotkin and Balick (1984) included Euterpe in a review of the medicinal uses of South American palms. Similarly, Euterpe was included in the results of a computerised literature search for natural product chemicals and pharmacologies (NAPRALERT 1984). Gulick and Van Sloten (1984) included E. oleracea in a directory for tropical fruits and tree nut germplasm.

Johnson provided a translation of the neglected and interesting Brazilian publication by Pesce (see Pesce 1985). This work on oil palms and other oilseeds of the Amazon was originally published in 1941. The fruits of the six recognized Amazonian species of Euterpe are noted to be oily. E. oleracea and E. precatoria (both referred to as "common açai") are said to have fruits with a "gray, somewhat dense, oily

mesocarp". The use of these for production of a popular regional beverage is noted. The text continues, that if oil production from the beverage "is the objective, the liquid is heated with water until the oil floats to the top and can be skimmed off. This process is inefficient and yields are low: nearly 100 kg of fruit are required to produce one liter of mesocarp oil. However the fruits are so abundant that a farmer can at any convenient time extract some oil.... A fresh common açai fruit has a moisture content of 25% and weighs an average of 1.5g. The dry fruit contains 4% oil which is dark green in color, has an agreeable odor and a flavor which resembles that of bacaba branca oil" (Oenocarpus distichus). "If it were refined, this oil would have the same attractive qualities of bacaba branca and pataua oils" (*Jessenia bataua*). A brief table listing analysed characteristics of the mesocarp oil said to be for both Euterpe species is then presented.

Anderson et al (1985) described the role of E. oleracea in an agroforestry scheme in the Amazon estuary. The present author was a co-author in this and the results are presented in the agroforestry chapter of this thesis. Padoch et al (1985) discussed a market-oriented agroforestry system practiced by mestizo farmers in Tamshiyacu in Amazonian Peru. E. precatória

provided fruit and palm hearts. Boom (1986) reported on the utilization of palms by the Chácobo Indians in northeastern Amazonian Bolivia. It is stated that "Panabi (Euterpe precatoria) is unquestionably the palm most used for roof thatch by the Chácobo.....

Generally, the Indians will thatch their roofs with a combination of leaves from the panabi and mani, Phenakospermum guyanense (L. C. Rich.) Endl. ex Mig. (Strelitziaceae). A less important use of the leaves is to employ them as make-shift brooms. The leaves are used medicinally to alleviate chest pains: the pinnae are shredded and boiled in water to produce a decoction which, when cooled, is drunk. The fruits are eaten after being soaked in water to soften them or are made into a drink to which sugar is often added to sweeten it. To my knowledge, the Chácobo do not eat the heart of this palm even though it is palatable", he states.

Galeano-Garces (1986) states that the leaves of her new species, E. simplicifolia, are used for thatching in an area of Antioquia, Colombia, where the palm is locally called 'Lindona'. Pinheiro and Balick (1987) included Euterpe in their translation of Pio Correa's dictionary of useful plants of Brazil.

Strudwick and Sobel (1988) gave extensive descriptions of the uses of *E. oleracea* in the Amazon estuary. The results are given in the latter section of the present chapter.

Anderson (1988) included a drawing of *E. oleracea*, with uses of its component parts labelled. These included leaves (fibers, cellulose, animal ration, fertilizer), palm heart (animal ration), fruits (leather curing, anti-diarrhetic), stem (electrical insulation) and roots (anthelmintic). References or sources for these uses are not provided.

Barfod and Balslev (1988) studied the use of palms by two separate groups of Indians, the Cayapas and Coaiqueres, in lowland northwestern Ecuador. The Cayapas eat the raw fruits of *E. chaunostachys*, while their preferred palm hearts come from this same palm as well as *Prestoea sejuncta*. *E. chaunostachys* is also the preferred palm heart of the Coaiqueres.

De Granville (1989) notes that Grenand et al (1987) cited the following uses for *E. oleracea* in French Guiana. The crushed roots provide a juice which can be used instead of salt with food while the palm heart could be dried and powdered or crushed to yield a

liquid which is sometimes used to heal skin. Ricci (1989) notes that Aublet (1775) discussed the use of palms in general for palm heart in a work on French Guiana, so it is probable that Euterpe was also being used at this time in this area. Indigenous use, of course, no doubt goes back for countless more years.

Strudwick (1990) described the harvesting and commercial management of E. oleracea in the Amazon estuary. These studies are included in the Conservation and Management chapter of this thesis.

Technical Accounts of Euterpe Products and Industries.

Since certain Euterpe products, (particularly palm hearts, and to a lesser, but locally very important degree, the açai liquid), are of widespread importance and economic value, a number of studies have been done which analyze nutritional values, discuss processing methods etc.. This information is too technical in nature to be discussed in this work but a brief overview of some of these works will stand as an indication of what has been done and guide for bibliographic purposes.

McNair (1930) studied the characteristics of various vegetable oils. Euterpe was described as having semidrying oil. Pesce (see Pesce 1985, but originally published in 1941) has been discussed above, but provided an analysis of the mesocarp oil from E. oleracea and E. precatoria. Munsell et al (1949-50) analyzed the food composition of many plants of Honduras, Guatemala, El Salvador and Costa Rica in Central America. 13 chemical constituents of the palm heart of E. longepetiolata in Costa Rica were analyzed.

Altman (1956) analyzed the seed of E. oleracea, which constitutes 83% of the fruit (17% is pulp, used for the beverage). While I note that the seed is widely

used in the Amazon estuary as pig fodder and compost, Altman noted that it did not appear to have value as a food or manure since it had only 0.7% nitrogen. He also lists the protein (4.34%), cellulose (34.41%) and lignin (7.72%) contents. In 1958 Altman discussed the industrial exploration of oil-yielding Amazonian plants. E. oleracea pulp was said to yield 7.5-13% oil. Leung and Flores (1961) provided the food composition and further bibliographies for many Latin American foods from plants, including E. longepetiolata. Pechnik et al (1962) reviewed studies performed on many native Amazonian food plants (including E. oleracea) and their chemical compositions.

Pedrosa Macedo published a string of studies on the Euterpe palm heart industry in Brazil. In 1970 he reported on the tremendous value of palm hearts from E. edulis as well as the number of seeds produced by each tree. In 1971 he detailed the economic figures of production in Brazil (9.5 million dollars of exported palm heart between 1960-1969). He estimated the future rapid demise of natural populations and outlined methods of germinating seeds. In 1973 he outlined methods for the sustained management and needed reforestation of E. edulis populations along the Atlantic coast of Brazil. In 1975 Pedrosa Macedo et al outlined the eleven laws

that were enacted to stimulate the industry and conservation of E. edulis. 28 million hectares were estimated to be occupied by E. edulis in Brazil and Paraguay. Germination, management, reforestation, nutritional content and current areas of research were discussed.

Calzavara (1972) reviewed and studied the agricultural potential and commercial importance of E. oleracea in the Amazon estuary. Besides the technical aspects of cultivation, reforestation and management of this palm, Calzavara lists several studies which focused upon the chemical analysis of different parts of the fruit. Several pages are devoted to this and many component chemicals and their percentages listed. A brief analysis of E. edulis done by an earlier worker was also reported.

As noted earlier, Costa et al (1974) did an in-depth study of Euterpe oleracea as a source of raw material for the production of pulp and paper, concluding that the trunk was suitable for the production of industrial-use paper while the leaves were suitable for fine papers. Experimental trials were carried out on plots of the palm in its natural habitat of the island of Marajó in the Amazon estuary. A

considerable amount of agronomic and ecological data in the form of inventories of the palm's frequency, size, number of stems per plant etc., is provided in the text and in extensive appendices. Extensive data and supplementary bibliographies on local Amazonian soils, technological analyses of the stem and leaves and their suitability for paper production, as well as multiple-use possibilities of the palm are supplied.

Cardoso and Leao (1974) outlined the commercial importance of E. edulis and E. oleracea for palm heart in Brazil. A number of studies on cultivation were discussed. The 'Fundação Instituto Brasileiro Geografia e Estatística' (1977) surveyed 55,000 Brazilian families and the foods they eat. Chemical analyses of the fruits of E. oleracea and E. edulis were included in this work.

Various studies have also been done on the preservation and canning of palm hearts in Brazil (e.g. Zapata and Quast, 1975; Andrade and Belda, 1976). Quast and Bernhardt (1978) reported on progress in palm heart processing techniques. Both E. oleracea and E. edulis were discussed. Collection, processing and packaging are reviewed as well as attempts to avoid browning of the palm hearts. It is noted that generally attempts at cultivation have been unsuccessful.

More recently Ricci (1989) described industrialization efforts in French Guiana, including field studies, management, transportation and canning. Operations began in 1983.

Strudwick (1990) described a commercial management scheme for palm heart production from E. oleracea in the Amazon estuary. This study is included in the Conservation and Management chapter of this thesis.

Observations on the Uses of Euterpe oleracea Mart.
in the Amazon Estuary, Brazil.

Euterpe oleracea Mart. and its uses were studied during a trip to the Amazon estuary (Brazil) from late September to November, 1984. The species, widespread in the Amazon Basin, is better known to local inhabitants as "açai" (pronounced a-sigh-ee) and plays an important part in their daily life and in commerce. As can be seen from the historical part of this dissertation, Euterpe species are New World palms. The 18 (Moore, 1973) to 49 (Glassman, 1972) species are distributed from southern Brazil, northern Argentina, Paraguay and Bolivia in the south and throughout the width of South America to Central America and Dominica in the north. They occur from sea level up to relatively high altitudes for palms (ca. 3000 m), and occupy a variety of habitats from Amazonian várzea forests to the tops of Venezuelan tepuis.

The genus Euterpe, recognized as one of promising economic value, is in need of research (NAS, 1975; FAO, 1983; personal communications with Read, Dransfield and Uhl). Various species are exploited for heart-of-palm and some may be threatened because of this (for example

see Balick, 1976). Taking heart-of-palm from a single-stemmed species kills the palm. Açai, unlike its south-east Brazilian relative E. edulis, has more than one stem and thus regenerates after cutting. The palm-heart industry in Brazil thus now involves much greater use of açai in the Amazon estuary than formerly. Its worth is approximately \$120 million annually with both internal and export value. Açai, a vigorous palm, appears to have the potential for repeated and multiuse cropping. Its frequency and some of its uses in an 'agroforestry' situation were touched upon in a previous paper I co-authored (Anderson et al., 1985) based upon work done on Ilha das Onças, one of the sites visited for the research discussed here. Brief references have been made in the English language literature to some of the different uses of Euterpe, by Wallace (1853) and others. Euterpe has been mentioned various times as a source of heart-of-palm (e.g., Balick, 1976; FAO, 1983; Hodge, 1965; NAS, 1975). However, these works have not treated the multiple uses of E. oleracea or gone in depth into its ethnobotany. Due to the importance of Euterpe in Brazil the majority of studies are in Portuguese. Many of these focus upon the heart-of-palm industry and deal with preservation and canning (e.g., Andrade and Belda, 1976; Zapata and Quast, 1975;), and cultivation and growth (e.g., Amaral, 1973; Bovi and

Cardoso, 1975) among other subjects. Certain studies, such as those by IDESP (1974) and Calzavara (1972) have focused upon açai's agronomic potential. This latter study is probably the most concise and comprehensive summary of the uses, commercial importance, nutritional composition, productivity, ecology, botany and agronomy of açai. However, there remains little in the English literature on this palm which is of such importance not only locally, but also as an export. The taxonomy and the ethnobotany of the genus as a whole remain poorly understood, yet these aspects should be clearly understood in order for proper conservation measures to be taken for both germplasm and species as appropriate. The original observations presented here (as in Strudwick and Sobel, 1988) help bring E. oleracea to the English speaking public and illustrate it's many uses and local importance in the Amazon estuary, Brazil.

Study Area

The places visited lie within the Amazon estuary. Several rivers converge here, emptying out into the Atlantic Ocean in the north-eastern corner of Brazil, between the states of Pará to the south and Macapá to the north. The principal city and main port of the

region is Belém, the capital of Pará. It lies at the mouth of the River Guamá near its confluence with the River Acará. In the estuary of these two rivers and across a wide channel from the Pará mainland, where Belém is situated, lie several islands. Directly across from Belém, about 2.5 km, lies the Ilha das Onças. Beyond these islands (about 40 km at its nearest point to the northwest of Belém) lies the island of Marajó. In between is a wide channel, often rough and dangerous channel for the smaller boats traversing it. This channel carries to the Atlantic Ocean, via the bay of Marajó, the vast amounts of water pouring out from the south-eastern corner of the Amazon basin - not only from the rivers named above but also in great volume from the river Tocantins at the south-western end of the channel and the river Pará at its western end. This whole water mass is heavily tidal.

The vast island of Marajó forms the northern bank of the channel, situated as it is between the estuaries of the already mentioned rivers to its south and the Amazon river to its northwest and along its northern shore. It is more narrowly divided from land along its western extremes, mostly by the river Jacaré. To its east lies the Atlantic Ocean. Very roughly rectangular in shape, it is about 250 km from east to west at its

widest point and about 185 km from north to south at its longest point towards the west. Our observations were made in Belém, the Ilha das Onças, along the southwestern and western shores of Marajó and from here along rivers penetrating towards the center of the island. Specifically, our boat followed a course from Belém and Ilha das Onças westward along the channel south of Marajó and the river Pará to the town of Sao Sebastiao da Boa Vista on the southern shore of Marajó. A few days were spent here and in a nearby forest and savanna. We continued north-westwards to Breves, up the river Breves. Northwards of Corcovado, we followed the rivers 'Furo dos Macacos' and Aramá, eventually looping around into the river Anajás, which flows westward from well into the interior of the island. It took us to Anajás and we then followed the river Moçoos about 6 hr or so upstream to the small river 'Igarapé Frances'. This was our innermost penetration of the island and we traced the same route back to Belém. Various stops were made along the way to study the different aspects of the açai palm and its uses.

Description of Euterpe oleracea (Açai)

Açai is multi-stemmed, pinnately leaved and with

distinct, smooth, green to yellowish crownshafts below the leaves (Figs. 1, 2). The palm may be short (ca. 4 m at first flowering in some cases, depending on local conditions) to tall, (over 30 m), but the stems always remain relatively slender. Sometimes green in younger portions, they are predominantly light gray to light grayish-brown in color, occasionally with lichens making light patterns on them. A small or sometimes more elongate ring of aerial roots can often be seen around the base of the trunk. These roots sometimes have small wart-like protrusions on them (called pneumathorhizes by De Granville, 1974). The young roots may be bright red in color. Inflorescences may be present singly or several at a time, borne at a slightly erect angle at first or somewhat lower when weighted down by fruit later on. Inserted at the top of the trunk, below the crownshaft, they are often clearly visible. From the central stiff axis of the inflorescence the many erect rachillae (inflorescence branches) splay out at various wide angles after bursting from the inflorescence sheaths, forming a broad, sparse shape, ca. 60 cm long (Fig. 3). The predominant color in the inflorescences seen from ground level is the whitish-gray to light buff color of the rachis and rachillae. The flowers are small (ca. 5 mm across) but quite attractive up close. The main color in both male and female is a palish

FIG. 1. Euterpe oleracea in Marajó rural garden, showing multiple stems, pinnate leaves and graceful habit.

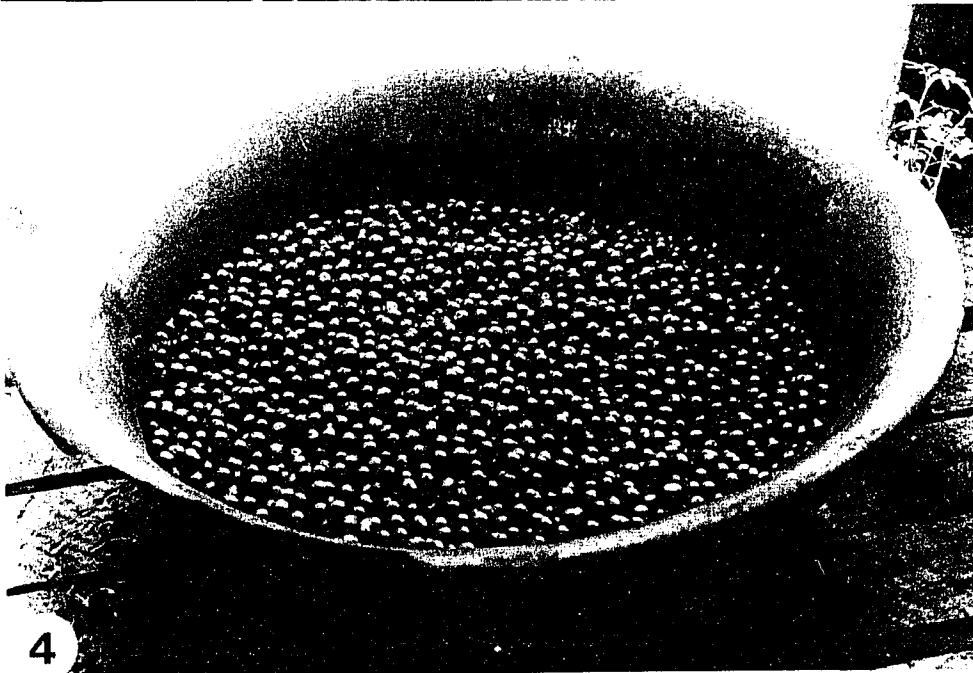
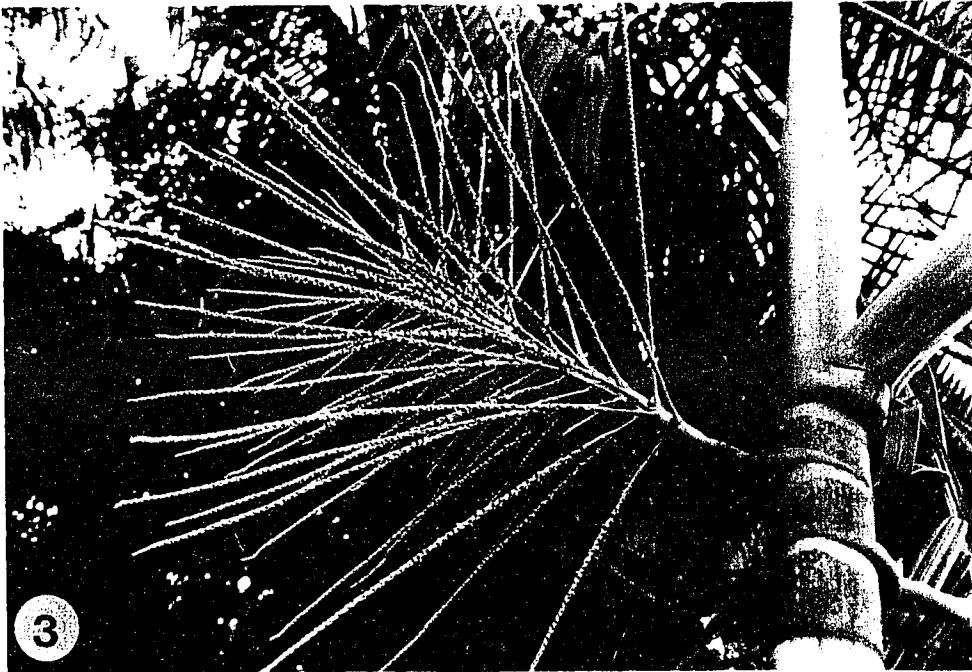
FIG. 2. Crownshaft of Euterpe oleracea formed from the leaf sheathes.

FIG. 3. Inflorescence of Euterpe oleracea showing its position below the crownshaft and its simple straight rachillae.

FIG. 4. Marble-sized dark purple fruits of Euterpe oleracea in ceramic bowl dyed inside with Licania sp.



Figs. 1-2



Figs. 3-4

purple to maroon. Fruits are globose, ca. 1.5 cm across, green when young and usually a darkish purple when mature (Fig. 4). They each contain one seed, accounting for most of their volume, and are surrounded by thin, but coarse and stringy fibrous sheaths. Around these lie the outer coat, a thin, dryish but slightly oily coating, giving the fruits their purple color.

One of the most characteristic features of açai is the way in which the leaflets of its pinnate leaves seem to droop almost vertically downwards. Its appearance was most vividly described by R. Read (pers. comm.) who said that its drooping leaflets give the appearance of falling rain. E. oleracea is without doubt one of the most graceful of all palms, a fact which has lead others before me to make similar remarks about this and other members of the genus.

Habitats of E. oleracea

The majority of the region visited is tidal, due to the influence of the Atlantic. Açai, especially prevalent on the banks of rivers, grows abundantly in the area in the várzea (seasonally flooded), and in certain mud-bank / island situations. It appears to

need some kind of firm ground beneath it and several times was seen growing behind a belt of Montrichardia sp., (Araceae), which has a woody stem which can withstand the daily tidal flooding while it bears its arrow-shaped leaves at its apex above water. While Montrichardia grows in the mud, behind it the ground is higher, more permanent, not subjected to daily flooding, and supports açai. Another palm, Mauritia flexuosa, occupies similar swampy habitats and can often be seen growing in association with açai or close by, but apparently in areas somewhat further from the influence of the main rivers than açai. In one place, on an island opposite S. Maria at the confluence of the rivers Jacaré, Furo dos Macacos and Aramã, a clear and striking zonation of the three species was observed. Toward one end of the narrow island a dense zone of Montrichardia covered the tidal water edge. Behind lay a thick zone of açai in similar abundance, and on the slightly more protected ground grew a forest of the tall, thick-trunked, M. flexuosa with its crown of massive palmate leaves and huge scaly-fruited infructescences. All the land was fairly low and probably flooded to some degree at one time or another. What was so particularly striking was the fact that all of these plants were growing in practically pure stands with only slight mixing on the edge of the Mauritia and Euterpe zones. It

appears likely that these three plants might form a mechanism for colonizing mud or sand banks. The seeds of açai were seen floating in abundance after removal of their outer flesh at S. Sebastiao da Boa Vista and it therefore seems highly probable that they might be adapted to rapid colonization of such river areas since germination was also observed to be rapid. Just beyond the Mauritia zone and taking the position of açai and Montrichardia on the other shore of the narrow island was a stand of Rhizophora sp. trees with their long stilt roots anchoring them to the ground beneath the waters edge.

Besides its frequency at the waters edge açai is common within the low-lying forests where it can be occasionally seen growing to 30 m or more, protruding from the canopy. At the waters edge, especially on the river Moçoes in the interior of Marajó, it was noted that the tall açai stems would bend way out over the water, then twist upwards, as if reaching for the light. It was not ascertained whether this was purely in response to the light or whether it could have been initiated by the tall palms partially falling over in heavy floods. Given plenty of light, as in some riverside situations, or where planted in the open, or where surrounding forest vegetation is cleared, açai

FIG. 5. Picturesque grove of 'açai,' showing the typical close association with rural riverside homes.



Fig. 5

forms a vigorous but lower growing palm which bears its inflorescences much closer to the ground. In one instance, where planted, the daughter stem of a sturdy young plant bore its fruit less than 2 m from the ground.

Association of E. oleracea with Rural Riverside Homes

One of the most striking things about açai, especially noticeable from a boat, is the tremendous frequency and abundance with which it is found around the small and scattered dwellings which nestle between the surrounding flood-plain forest and the river. These are the dwellings of the 'caboclos' (rural peasant farmers), who inhabit the region (Fig. 5). Such areas, away from Belém, constitute the majority of land along the rivers in the parts we visited, along with unpopulated forests. A typical garden we visited was like a grove of açai with the house nestling between it and the river. Raised walkways led from the house to the toilet and other points outside. The rivers of the area are mostly fairly wide and this dwelling, as with many others, sat right on the edge of a broad expanse of muddy or 'white river' water. Because the area is tidal, a raised walkway or small pier was constructed out from

the front of the house to allow one to pass from a boat to a wooden walkway leading to the house. The raised walkways of about 1 m around the açai garden allow for the seasonal flooding when the rivers of the Amazon estuary area rise considerably. At other times of the year the ground is not flooded daily. In front of the house a kitchen garden, another common characteristic of the region, was present. For this a platform constructed from açai trunks laid side by side to give a large square floor, raised on wooden posts like the pier, etc., to keep it above high water levels, was built. All areas of the house and surrounding buildings are similarly raised from ground level (Fig. 14). The kitchen garden itself consisted of baskets and other containers (such as an old canoe) with plants such as tomatoes, and other vegetables and herbs.

The heavy concentration of açai around dwellings appeared to be caused by their inhabitants, by their clearing other trees, (allowing açai to predominate, since it forms a natural part of the surrounding vegetation), by their planting it, by discardment of seeds, or all these methods together. The close association of the riverside dwellers and açai is evident from its many uses and importance to them. A good example is the making of the açai liquid. In this

operation the person may stand right next to their açai garden, using the fruits and simultaneously casting out the seeds to perhaps become new plants for future harvest (Fig. 6), or for other uses mentioned later.

The Açai Liquid

The principal use of açai palm to the local people is for the production of a liquid. Açai, as the liquid is called locally, is a variably thickish (depending on how it is prepared), usually dark pinkish-purple (sometimes yellow) kind of cold soup prepared from the fruit (Fig. 7). It is usually not drunk, but eaten with a spoon, and forms a major and basic part of the diet of many of the numerous inhabitants of the region. Those who consume it often appear strong and full of energy. Conversations with and observations of individuals and families showed it to be loved and desired by the very young to the very old. Short periods without it appear to result in a kind of 'withdrawal symptom,' since a craving is developed for it (at least in certain cases). The crew of our small boat were good examples of this since, on more than one occasion, they diverted our course without any prior warning off on some unexplained course, ending up in a scramble to the riverbank and up

FIG. 6. Marajó woman making the açai liquid right next to the 'açai garden' where she casts out the seeds.

FIG. 7. 'Açai branco' (left) and 'açai preto' fruits and liquids.



Fig. 6

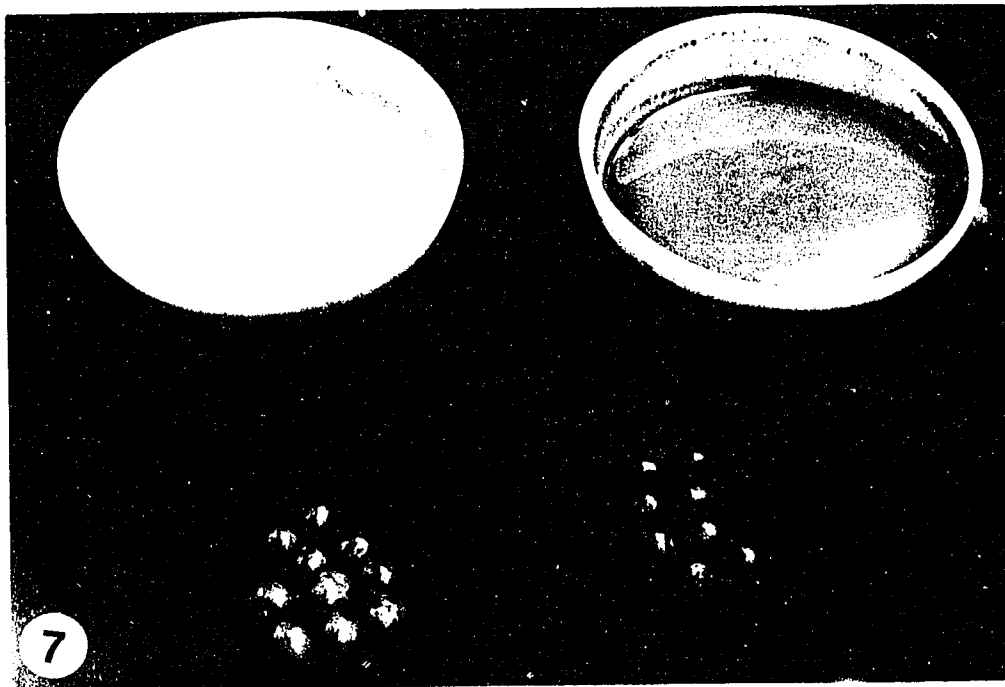


Fig. 7

an açai palm with good ripe fruit ready for making açai, to fulfill their cravings. There is a popular consensus and saying in the region, that when one is without açai one feels a lacking or emptiness in the stomach. Açai forms such an important part of the diet that up to 2 liters of it can be consumed by an individual in one day. It is eaten for breakfast, dinner or lunch or all three. It is said popularly to be strong in iron, and consumption of the liquid appeared to turn human feces black. In a nutritional analysis of the liquid, Motta (1946) noted an Fe content of 0.0009%. Its taste is unique, difficult to describe, but roughly creamy, metallic and slightly oily. Some newcomers like it immediately (Balée, pers. comm.). After trying it several times I felt that I was developing a taste for it. Its taste is perhaps more acceptable to newcomers when presented in some other recipes, to be described later.

The açai liquid is so popular that there are special establishments in small and large towns which make and sell it. These are denoted by the presence of a red, usually wooden or metal sign on a post outside (Fig. 8). Sometimes "AÇAI" is written on the sign, but the convention is so much a part of daily life that this is often not done. Crowds or lines sometimes form to vie

for the end of the day's supply.

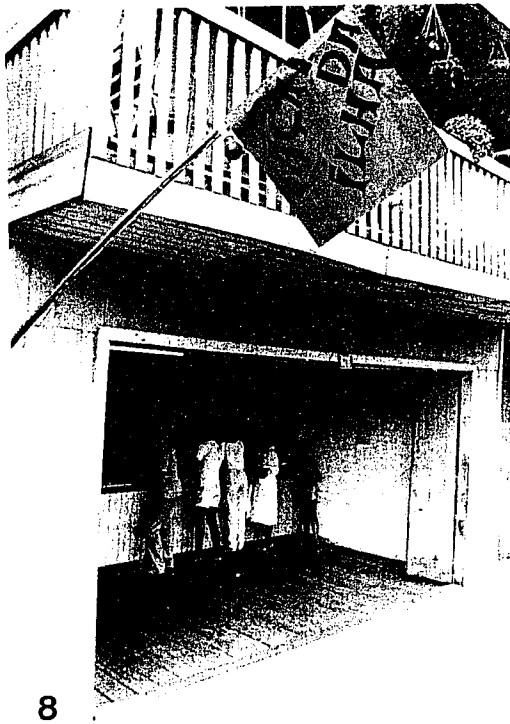
The majority of the inhabitants of the region (particularly outside Belém) are poor, many existing only by subsistence farming of forest products, animals, etc., and use açai heavily. Nevertheless, açai is not a product looked upon as being only for poorer peoples, but is popular throughout all socioeconomic levels (Fig. 9). Since açai is such an abundant plant in the region and produces so bountifully, it is natural that local people should use açai's products so much, especially one, such as the açai liquid, which can assuage much of the poorer people's daily hunger needs. Many of them make their own açai from the many trees around their dwellings or occurring in the forests. No wonder then, that it is seen in such abundance around these dwellings. Mixed with either river shrimp, farinha, sugar, biscuits, other items, or combinations of these, it forms the basis of their diet. Many people eat it alone or with sugar, while the addition of farinha (manioc flour) and sugar is also very popular (Fig. 10). Some people sell the fruits in larger markets, such as that of Belém, for money to buy other things. In Belém the fruits arrive in the dawn hours by the basketload from the surrounding regions. During the period of this study a large quantity was coming from Ilha das Onças.

FIG. 8. A large açai store in Belém, with the typical red açai sign.

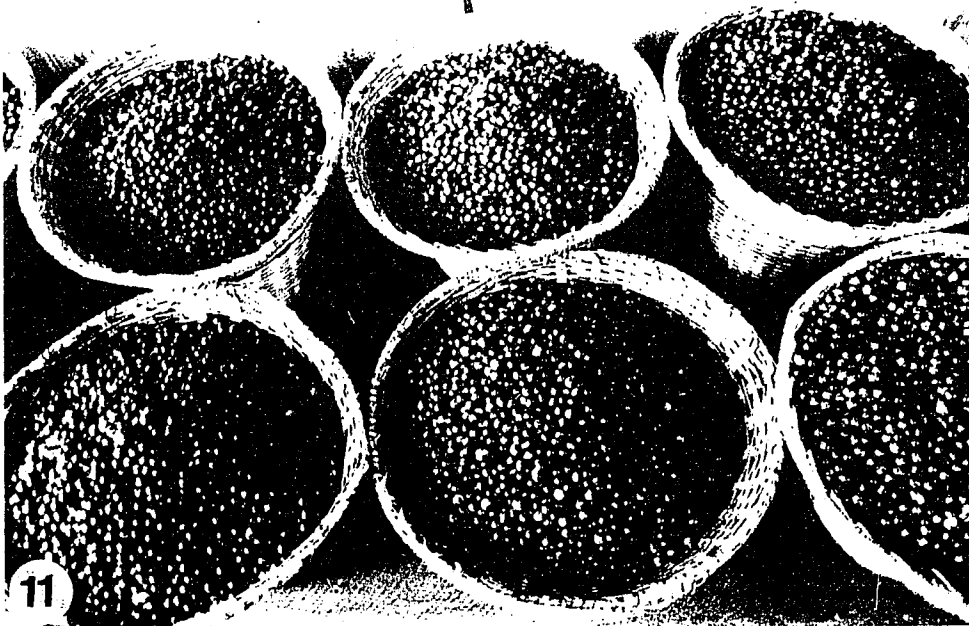
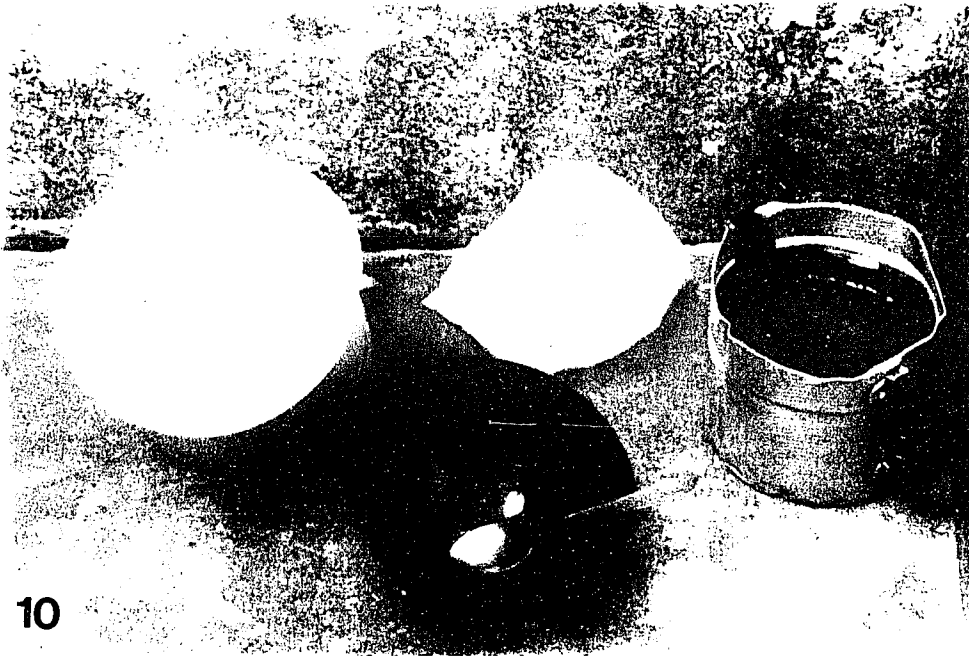
FIG. 9. The use of açai seedlings as a table centerpiece and young plants (background) as containerized ornamentals for indoors or outdoors, and the naming of this Hilton International restaurant, Belém, after açai, illustrates the plant's popularity in the region among all socioeconomic levels.

FIG. 10. Typical ingredients mixed with açai (right) are sugar and farinha (manioc flour), as seen here.

FIG. 11. Large baskets of açai fruits awaiting processing into the açai liquid in an açai store. These were purchased earlier at a Belém dawn market after harvesters brought them in by boat from the surrounding region.



Figs. 8-9



Figs. 10-11

It is then often bought directly by the owners of the açai-making stores (Fig. 11). The larger such operations are, the more sophisticated the machine or method used to make the liquid.

The açai-making operation basically involves the removal of the mesocarp from the seed. It is then mashed up fine with varying amounts of water, to make the thickish liquid. There are different ways of carrying this out. There are wooden grinding machines turned by hand to remove the edible coating from the seed, and different kinds of metal ones. One of the larger stores visited in Belém had three very modern machines in use. These were of metal, powered by an electric motor and driven by a belt (Fig. 12). The açai fruits are poured in top and the liquid comes out the bottom. What happens to all the leftover seeds will be discussed later. In one of the larger rural houses visited outside Belém there was a similar machine in use for the family's needs (Fig. 13).

In the stores the liquid is often sold in liter plastic bags. Alternatively, customers bring their own containers to be filled up. In one of the more sophisticated stores, at the time we were in Belém, there were three qualities of açai being sold. The

FIG. 12. An electrically powered metal açai liquid-making machine in a modern açai store in Belém.

FIG. 13. An electrically powered, belt-driven machine in a rural riverside home on Ilha das Onças.

FIG. 14. Typical setting in a caboclo dwelling in Marajó for manual açai liquid making.



Figs. 12-14

qualities depended on how many times it had been passed through the machine for fineness, how thick and creamy it was or how much diluted with water. The prices were approximately 30, 45 and 75 cents (U.S) per liter. There is an all-year-round harvest and supply of açai which we were informed by store owners and market people was due to different seasons of maturity of the fruits in different regions. At some seasons it was said to be more expensive than at others in Belém, attributable to the fact that it is locally scarcer at certain times of the year and must be brought in from greater distances.

Two kinds of the açai liquid are found, of which the purple kind, 'açai preto', is by far the commonest. On occasion a yellow kind can also be found (Fig. 7), known as 'açai branco'. We were informed the latter is also made from açai (E. oleracea) and shown a multiply trunked plant which fit its description and was used for 'açai branco', although it was not fruiting at the time. Some people much prefer one of these two kinds to the other. In one town two neighboring families were found, one of which had only 'açai preto' in their garden, the other with only 'açai branco'. Both had recently planted all of their plants or had clumps of seedlings ready for transplanting. A strange story concerning the two different colored kinds is popular in parts of the

region. It is said that when planted next to açai preto the fruits of açai branco also become purple. Pires (pers. comm.) notes that individuals of açai branco occur in wild among stands of açai preto and that there is a possibility that this might be a recessive genetical trait which appearing in only a fraction of the individuals produced from seed. Such an explanation may account for why people would have this concept, since on planting yellow fruited seeds, a high percentage of purple fruited individuals might result.

The home-made liquid is prepared altogether differently than as described above, using the hands (Fig. 14). Some argue that açai tastes better made this way and that this could be due to the salt from the hands. To obtain fruits, ripe infructescences are located from the ground. Men or boys usually climb the trees. To do this a 'peconha' (climbing belt) is usually fashioned in the forest. This climber's belt goes around the feet and is used to help secure the grip of the feet to the trunk as it is climbed. One way of making it is from the strong but flexible fallen leaf sheath of E. oleracea. This method was demonstrated in Ilha das Onças. By twisting and bending a section of this around the knee it can be knotted into a secure loop about 25 cm in diameter forming the peconha. The making of an

alternative kind of peconha, from the leaf, and their method of use is described in greater detail and illustrated in the heart-of-palm section.

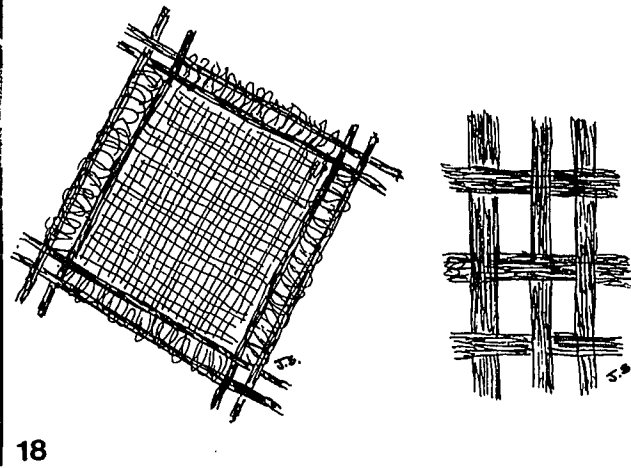
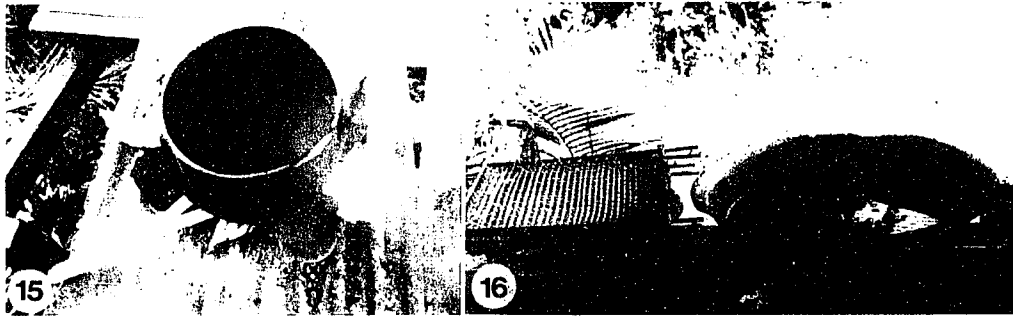
Once the tree has been climbed, the ripe infructescence is cut off at its base and the climber descends with it. The fruits are then shaken or stripped from the rachillae and placed in a basket or burlap bag to be carried back to the house. Next, some water is warmed (Fig. 15) and placed in a large, low, wide ceramic or metal bowl (Fig. 4). The ceramic bowls are sometimes coated inside with a layer of dye from Licania sp. ('Caripé', Chrysobalanaceae). The fruits are placed in the warm water for a short period (ca. half an hour) to help soften the mesocarp (Fig. 16), and to remove any dirt or debris, which floats or sinks in the water. Next comes the hard work, which in this manual mode of preparation we only observed being done by women. The junior author participated in some of the açai liquid making activities and can verify that it is hard work. The fruits must be vigorously worked by the hands to loosen and remove the softened mesocarp from the seed. After removing the water the initial pulping of the fruits takes place in the large bowl (Fig. 17). After much of the mesocarp has been pulped, a sequence of two hand made sieves are used (Figs. 18, 19). The first used

FIG. 15. Warming water to soak açai fruits.

FIG. 16. Açai fruits soaking in warm water in ceramic bowl to soften the mesocarps.

FIG. 17. Initial mashing of the açai fruits after softening of the mesocarps.

FIG. 18. Caroceiro (left), showing general construction of both this and the paneira fina. Close up of cross-weave (right) of the caroceiro made from Aruma (Ischnosiphon sp.) showing ca. 1 cm square holes which retain the açai seeds but allow flesh to fall through.



Figs. 15-18

and larger-meshed of these is called the 'caroceiro'. The second, finer meshed sieve is called the 'paneira fina', and is used for making a finer pulp or liquid from the unmashed portions of the açai flesh already passed through the caroceiro. Beneath the paneira fina a large bowl is placed to collect the açai liquid. Both sieves are square, approximately 50 cm. by 50 cm., with narrow cross-strips woven at right angles with slight gaps between them to give a mesh with the desired straining effect (Fig. 18). Those documented had a framework of two dowel-like pieces on each of four sides, making a total of eight altogether, onto which is woven the inner mesh which acts as the sieve. The outer 'dowels' are placed to alternate along their overlapping ends with the dowels from the proximate side giving strength and rigidity. This rigid framework sits upon the rim of the container beneath, which catches the açai liquid.

Similarly, as the two strainers sit one upon the other while the fruits are first being mashed through the caroceiro, their similar size and outer frames allow the user to mash vigorously on the mesh part since the two frames, along with the wide bowl rim beneath gives good total stability and rigidity (Fig. 20). The inner mesh is interwoven with the ends of each cross-weave

piece looped and knotted around the dowels to secure it. From its double loop around the dowels each piece is woven into a finishing area beneath and just inside the frame. It is bent back and cut to give a neat, secure finish. On both sieves the frames were made from pieces of the palm locally called paxiuba (Socratea exorrhiza), slightly rounded in cross section, ca. 1 cm wide, and dark brown in color. The cross-weave strips were very light brown on one side and somewhat darker on the other. Certain strips were woven with the reverse side showing, dividing the mesh visually into four equal squares. In the paneira fina the strips were ca. 5 mm wide. The space left between the weave was about 1-2 mm wide, giving a fine straining effect. Where the mesh had been worked the most in the center the pieces had become worn in width and thickness, and because of this the space between them had increased. After prolonged use some get holes worn in their centers and need replacing. The plant from which these strips are made was locally called Arumã (Ischnosiphon sp.). We were informed of the names of plants used for these items by their owners and users. The caroceiro had its cross-weave made from slightly wider strips of Arumã than those used for the paneira fina, with much wider (ca. 1 cm) gaps left between them. This allows all the flesh removed from the açai fruits to pass through while retaining all the

seeds. The word caroço in Portuguese actually means fruit pit (stone or seed) so the meaning of caroçeiro is the "item used for removing the seeds," which is exactly what it does.

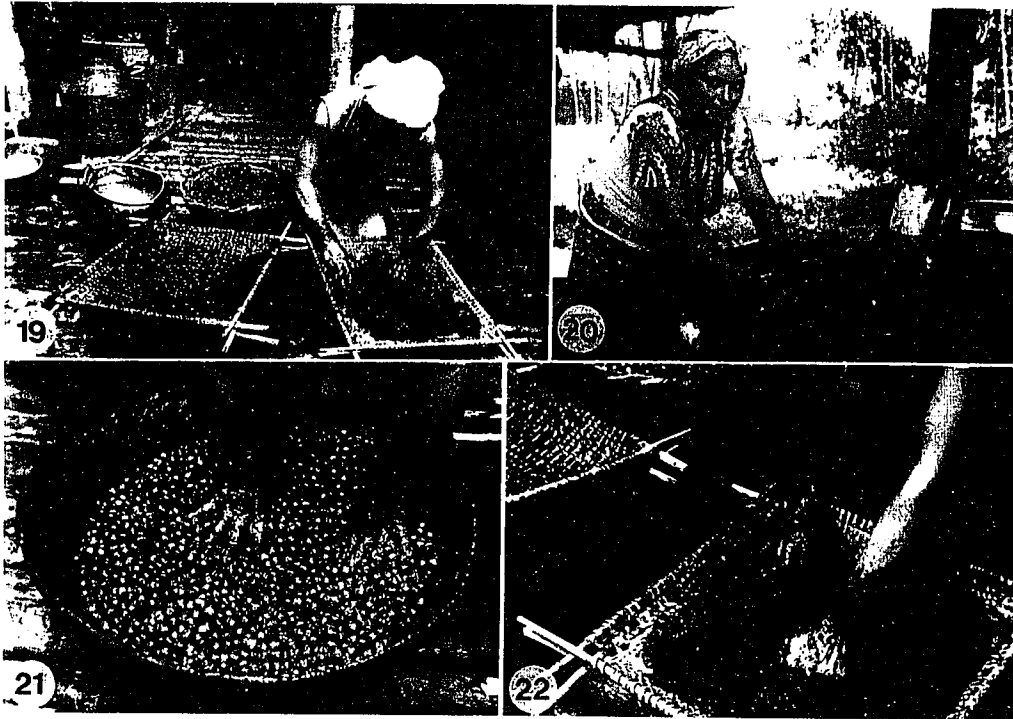
The flesh is removed from the seed by rapidly kneading, moving and energetically working the fruits with their softened skins on the caroçeiro. As noted above, during this operation the caroçeiro sits on top of the paneira fina which in turn sits on the rim of the bowl (Fig. 20). In the process of making açai, the hands and lower wrists of the woman become covered by the purplish-pinkish mush which she is vigorously creating. A limited quantity of water is poured over the seeds and caroçeiro-mesh to wash more flesh through to the paneira-fina below. Any liquid run-off is caught by the bowl beneath and can be collected and passed over the mush again to avoid too much dilution with water. After as much flesh as possible has been strained through the caroçeiro the seeds are placed back in the original bowl. Here they are worked vigorously a second time to remove any persisting mesocarp (Fig. 21). They are then returned to the caroçeiro where the cleaned seeds are retained after everything else has been passed through. The flesh is further vigorously sieved through the paneira fina, the caroçeiro having been put aside (Fig.

FIG. 19. The two square hand-made 'sieves' used for making the açai liquid by hand. The caroceiro (left) is used first, the paneira fina (with a finer mesh) is used last.

FIG. 20. The caroceiro, positioned on top of the paneira fina which sits on the rim of the liquid container. The fruits can be vigorously mashed upon this firm framework.

FIG. 21. Fruits being mashed a second time in bowl to remove any persisting mesocarp.

FIG. 22. Mashing açai mesocarp flesh in the paneira fina to produce the thick liquid.



Figs. 19-22

22). This results in an even more mushy purple mass which eventually, perhaps after passing more than once through the mesh, and after pouring more liquid over it, is all passed through to the bowl beneath as the final thickish soup-like açai. Enough for one day's family consumption is made on a daily basis.

Use of the Açai Liquid as a Base for Other Products

Besides its great and primary use as a subsistence food, the açai liquid can also be made into a variety of other products. The most well known and popular of these is a regionally popular purple ice-cream (Fig. 23). This is also available as 'açai branco' ice-cream which can be made from the purple fruits (Pires, pers. comm.). Due to its great regional popularity and the fact that the açai palm characterizes much of the surrounding region's appearance, the Belém Hilton Hotel has even named a fine restaurant after the plant ('Restaurante Açai'). Here are available such other items as an açai milk-shake (Fig. 24) and mousse (Fig. 25). The Hilton chef (Fig. 26) has created these and a variety of other delicious items (Fig. 27) using the açai liquid as a base. These include açai chocolates (Fig. 26) and a rich açai gateau (Fig. 28). Being more similar to modern Western foods,

FIG. 23. The popular purple açai ice-cream.

FIG. 24. Açai milkshake.

FIG. 25. Açai mousse.

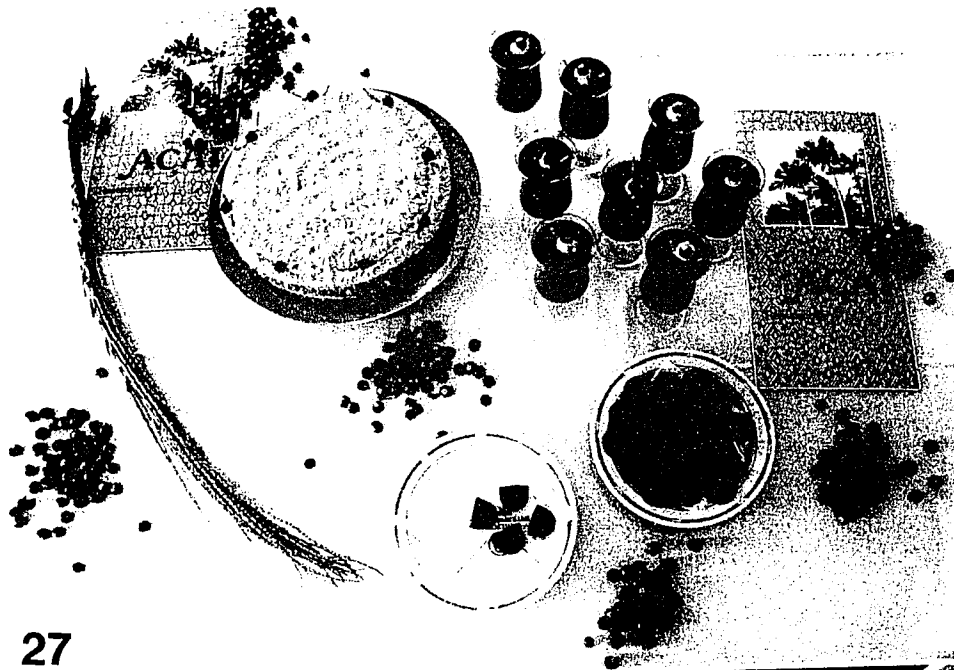
FIG. 26. Belém Hilton International pastry chef creating açai chocolates.

FIG. 27. A variety of products made from the açai liquid. 'Açai' Restaurant of the Hilton International, Belém.

FIG. 28. Rich gâteau ('torta de açai') made with the açai liquid and decorated with fruits and parts of rachillae.



Figs. 23-26



27



28

Figs. 27-28

these products make a more subtle introduction to the unique taste of açai, for the person unaccustomed to the native cuisine, than does the liquid alone.

Use of the Seeds

Once defleshed, the light brown açai seeds (over 1 cm in diam.) remain, fresh and washed clean with water. The area where the açai liquid is made is often the open kitchen or back 'porch' (Figs. 6, 14) common to many of the rural riverside dwellings. Right outside is usually forest or a garden area. Much of the time animals are kept in this garden area, either penned up, tethered in the open, or running free. Many of them eat the açai seeds and there is usually an abundant supply, often just dumped right onto the ground outside the area of preparation. Pig-pens are often built in this area, and the seeds can be dropped right from the *caroceiro* into the pen for the pigs to feed on (Fig. 29). The quantity of seeds, which seemed to be the principal food of the pigs, is great, and anywhere we visited there were always piles of them either waiting for the pigs or being munched on.

Everywhere that açai is made seeds are left over

in great quantity, especially where the liquid is made for commercial sale. In Belém the seeds could be seen, piled up in huge quantities, near every açai-making store, filling sheds especially constructed for them or waiting in large trash containers - not for a garbage man to collect but to be taken away for other uses (Fig. 30). A very rich soil to grow plants in is made from rotted-down açai seeds, and widely used in the region. The organic soil formed, after composting them for some time, is a dark blackish brown when moist. Especially popular in the rural riverside homes where they make their own soil (Fig. 31), it is widely used for the plants in their kitchen gardens.

The abundance of seeds left over for these purposes is easy to understand, considering the vast quantities of açai produced and consumed, coupled with the fact that the seed coat flesh from which it is made is a relatively small part of the fruit. The seeds, (over 1 cm in diam.), are about the size of a marble. When present in the large numbers resulting from making the liquid, they soon heap up wherever they are dumped, making large mounds (Fig. 30). In the very warm, moist climate of the region they soon sprout, and at the rear of houses where açai is made, indeed, any corner where the seeds sit for any time, there is a profusion of

FIG. 29. Pigs feeding on discarded açai seeds.

FIG. 30. Heap of açai seeds piled up outside açai store to be taken away for other uses.



Figs. 29-30

sprouting seeds and seedlings (Fig. 32).

**Use and Extraction of Palm Hearts
from Euterpe oleracea**

Besides the açai liquid, the other main product from açai is palm heart. Euterpe oleracea is currently the world's principal source, with the Amazon estuary being the principal producing region. Factories both large and small and of varying degrees of sophistication are found situated at the edges of rivers (Figs. 33, 34). Here palm hearts are brought in by boat for processing, bottling or canning, then transported to Belém or elsewhere, where many different labels are applied. Depending on the quality, some are exported while others are consumed in Brazil. The better and less fibrous quality generally goes for export. France is the major world consumer of palm heart (ca. \$8 million annually), while the United States imports about \$2 million annually.

There is a large internal market for palm heart in Brazil and a variety of dishes can be found in Brazilian restaurants. Although the taste of the raw heart is quite bland, it has a soft, artichoke like

FIG. 31. Marajó woman demonstrating rich, dark organic soil for growing plants made from leftover açai seeds.

FIG. 32. Seedlings sprouting profusely in shaded alley behind açai store in Belém.

FIG. 33. A palm heart factory in Sao Sebastiao da Boa Vista, Marajó. Note layers of discarded açai leaf sheaths (left foreground).

FIG. 34. Women at dock cut leaf sheaths off palm hearts brought in by boat.

FIG. 35. Cutting the flexible 'true' palm heart into sections, which sit in a bath of water, salt and citric acid to await canning.



Figs. 31-32



Figs. 33-35

texture and a pleasant, weakly acidic taste after canning. It is often served as a salad either alone or on a bed of lettuce, and can be made into a delicious hot cream soup resembling cream-of-asparagus in taste but creamy white in color. Palm heart pizza is another common preparation, where it is chopped, cooked and served on United States-style pizza (tomato sauce and cheese) slices. This was also recently observed in an Argentine owned pizzeria in New York City. In another recipe found in Belém, palm hearts were prepared within a thin pocket of dough, empanada style.

The palm heart itself consists of the tender, whitish immature leaves. Once removed it is a flexible cylinder about 60 cm long by about 2-3 cm in diameter (Fig. 35). In Euterpe oleracea it is neatly packaged within the cylindrical crownshaft (Fig. 2), lying at the very center. The outside of the crownshaft consists of the outermost and oldest leaf sheath which, beneath the point of attachment of the petiole, spreads out to encircle the crownshaft for most of its length with a coarse, green to yellow, fibrous sheath. Within are concentric layers of younger and younger leaf sheathes (Fig. 36). Within this tough protective casing lie the still smaller, immature leaves, yet to emerge. Less fibrous the younger they are, only the youngest in the

very center are edible. When the edible portion free from any fibrous tissue is very narrow, they may be kept for Brazilian consumption. Some foreign markets will also accept certain degree of fibrousness in texture, others will not.

Various palm heart management and harvesting methods are employed, which may be tied into domestic or commercial systems aimed at sustaining a supply for the future. Regeneration of E. oleracea appears rapid, both vegetatively by multiple shoots produced from the base and by rapid germination of numerous seeds on the forest floor. These factors, along with the frequency of the palm in riverside forests of the region, appeared to give a potentially abundant supply of palm heart. In some cases palm hearts are harvested by independent individuals cutting down every stem of sufficient size to yield a saleable heart. However, in order to sustain a steady supply from one area it would appear that selective cutting of only a certain number of stems per individual is preferable, comparable to the selective pruning of any plant where stems or parts are removed to allow other parts to develop more strongly. In the case of açaí a double benefit occurs through this method since the stems cut yield the current harvest. Furthermore, since E. oleracea is such a frequent and

important component of várzea forests and river/forest margins of the region, such controlled cutting could be of significance in conserving both soils and native forests.

To harvest the heart the entire stem may be cut down with an axe or the harvester may climb up and cut through the base of the crownshaft with a machete in order to bring down the entire crown (Fig. 37). To climb, a quickly made 'peconha' (climbing belt) is fashioned in the forest. One method using the leaf sheath of açai was described previously. Another method demonstrated by palm heart harvesters involves the use of a fresh green açai leaf, still attached to the crown (Figs. 38 - 42). Here, a leaf is selected (at ground level) from an açai crown. While still attached to the crown it is twisted along its length so that a strong cord about 2 - 3 cm in diameter is produced by the many leaflets twisted around the rachis (Fig. 38). Standing away from the crown it is then twisted several times around the wrist enabling the person to walk in toward the base of the leaf (Fig. 39). It is severed and strongly knotted to form the climbing belt (Fig. 40). To climb, the two feet are placed through the belt which is held toward the ankles and the ball of the foot with the feet slightly apart (Fig. 41). The climber places his

FIG. 36. Stack of cut palm hearts in the forest. Note their concentrically arranged fibrous sheaths which must be removed to get the edible heart.

FIG. 37. Palm heart worker holding the crown including the whole crownshaft which he has severed from an açai trunk he has climbed.

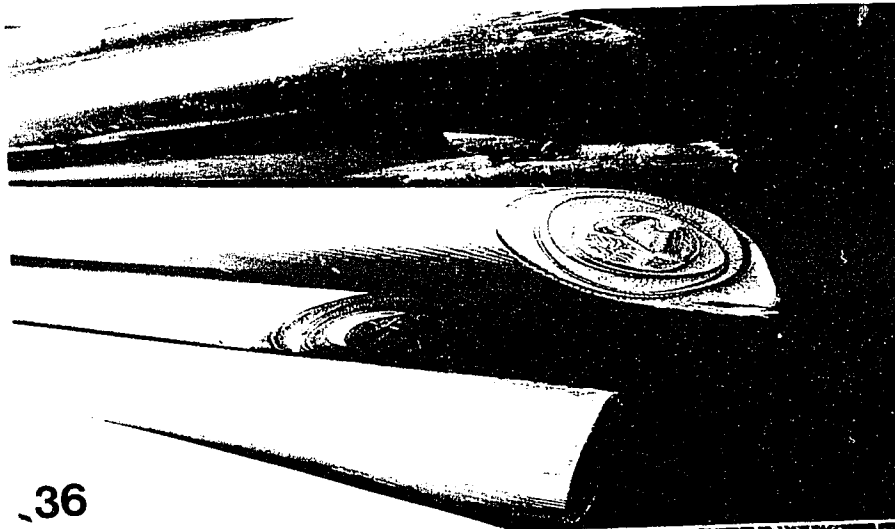
FIG. 38. Making a peconha (climbing belt) from an açai leaf still attached to the crown by twisting the leaflets around the rachis.

FIG. 39. Twisting the twisted leaf around the wrist.

FIG. 40. The peconha made from the twisted, then knotted, leaf.

FIG. 41. The peconha is positioned toward the back of the feet.

FIG. 42. Using the peconha to climb the açai trunk.



36



37

Figs. 36-37



Figs. 38-42

feet around the narrow trunk (perhaps 15 cm wide) using the two sides of the belt at the back of his feet to help grip the trunk (Fig. 42). The tree is shimmied up in small hops using the two hands together which can easily grip around the narrow trunk to pull the climber upward. Between each hop the feet are secured in place with the use of the peconha.

Once the crown has been brought down, the cylinder containing the palm heart is cut away (Figs. 43 - 45). After severing the crownshaft around the base of the outermost leaf sheath, the lowermost two or three leaves are cut off, using a machete, leaving only the very base of the petioles protruding. The remaining part of the crown is severed by cutting through the cylinder of leaf sheathes just above this (Fig. 43). To remove the petiole stubs and encircling leaf sheathes, the latter are cut along their length, one at a time, opposite the petiole, so that the entire piece can be removed (Fig. 44). The procedure is repeated, but with several of the fibrous leaf sheath cylinders retained to avoid bruising and discoloration of the tender hearts during transportation to the factory from the forest (Fig. 45). The heart must be preserved for three days or more in this way while the workers remain in the forest. At the factory other workers may be employed to strip off more

FIG. 43. The cylinder containing the palm heart severed from the crown. It consists of the crownshaft area and the basal two or three leaf bases.

FIG. 44. Removing a leaf sheath by cutting along its length with a machete.

FIG. 45. With several sheaths removed, the palm heart, still with some inner leaf sheaths covering it, is ready for its journey to the factory.



Figs. 43-45

leaf sheathes at the unloading jetty (Fig. 34). The final and innermost coarse sheathes are only removed when inside the factory, revealing the tender central cylindrical hearts. These are immediately cut into uniform 10 cm sections. To do this a wooden cutting block may be used with divisions along one side into which the cutting knife slots, thereby cutting the exact sized pieces desired (Fig. 35). These are then placed in a water, citric acid and salt bath (Fig. 35), then transferred into cans with this solution (Fig. 46). The cans are then machine sealed. Finally, the cans are left in a bath of steaming hot water for sterilization before boxing up for shipment out and subsequent labelling.

Use and Potential of Euterpe oleracea in Horticulture

Horticulturally, the açai palm is of great potential value. Its slender multiple stems, along with its graceful, vertically pendulous leaflets make it extremely ornamental. Riverside areas where stands of açai occur are thus attractive and where groves occur around riverside dwellings a particularly ornate picture results (Fig. 5). In Belém açai is frequently planted in gardens, even in apparently sandy soils away from any open body of water. Here again it makes a beautiful

FIG. 46. Cans filled with palm heart sections waiting to be sealed.



Fig. 46

ornamental tree. It grows naturally in both open areas and forest shade. However, individuals in the open, with increased light, appear more sturdy, more attractive, and may produce inflorescences at relatively low heights (2 m or less). Germination of fresh seed discarded after açai making appears rapid and profuse in the hot humid local conditions. In the Belém Hilton small plants were used in tubs on patios or indoors while the seedlings with their bifid leaves made an interesting and unusual centerpiece for the tables (Fig.9). Outside Belém cultivation was also noted in some gardens. In one case seedlings of both açai branco and açai preto were being grown (Fig. 47).

Besides using the tree horticulturally, the use of various parts of the plant in horticultural practice is also worth noting. The use of the composted seeds as an organic soil has been discussed above. The numerous leaf sheaths left over outside palm heart factories (Fig. 33) are also valued by locals for the dark organic soil they produce on decomposition. Both the leaves (Fig. 48) and the infructescence skeletons left after removal of the fruits (Fig. 49) are used as a mulch around the bases of other economic plants, the former under Musa cv and the latter under Theobroma cacao for example.

FIG. 47. Marajó woman holding seedlings of açai branco taken from her garden.

FIG. 48. Fallen açai leaves used as a mulch around a Musa cv.

FIG. 49. Discarded infructescences used as a mulch around the base of Theobroma cacao.

FIG. 50. Two fresh açai leaves woven together to begin a carrying basket. Note the two rachi (at top).



Figs. 47-50

Other Uses

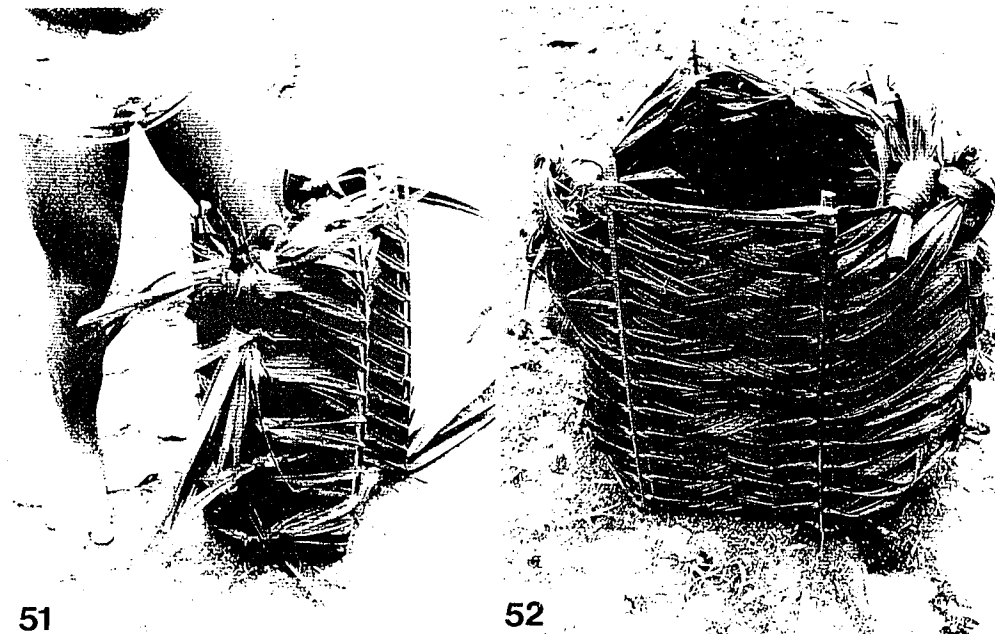
Green açai leaves may be rapidly woven into baskets in the forest by experienced hands (Figs 50 - 52). Two leaves are laid down on the ground with their rachis slightly separated. The pinnae of the adjacent sides of the leaves are interwoven to unite the two (Fig. 50). The entire structure is then bent into a square-cornered 'U' shape with the two rachis thus forming four uprights and the already woven section forming the base and two sides. The free pinnae are then woven and knotted together (Fig. 51) to form the completed basket (Fig. 52). Carrying straps are fashioned from plant material such as stringy bark and broad leaves such as from Musa, may be placed inside to help hold in items such as fruits collected in the forest. The açai leaves are also woven tightly around objects such as game caught in the forest, so that they can be carried home. The use of leaves and leaf sheaths as climbing belts has been discussed above. The spent inflorescences with their many stiff but flexible, simple rachillae are used as brooms and fashioned into dolls. They are commonly used for bedding for the pigs in pens in the riverside dwellings (Fig. 53).

The trunks of açai, fairly constant in width along

FIG. 51. The outer pinnae knotted together to make the basket's sides.

FIG. 52. Completed carrying basket from açai leaves.

FIG. 53. Pig pen with bedding of discarded açai infructescences and fencing made from açai trunks.



Figs. 51-53

their length (perhaps ca. 15 cm), smooth and without persistent leaf bases, are usually in plentiful supply around forest dwellers' houses. They are widely used for fencing (e.g. pig-pens, Fig. 53) and flooring. They are used for the floors of outer areas of the houses, raised perhaps 1 m from the ground to allow for the seasonal flooding of the riverside areas. On these floors tasks such as açai making might be carried out (Fig. 14), or the kitchen garden may be located. The trunks are also laid out several wide along stretches of muddy várzea forest floor to form a drier path and more secure footing for carrying palm heart out of the forest (Fig. 54).

Conclusion

In this section some of the major and minor uses of Euterpe oleracea have been touched upon. The palm is clearly important in many ways to the local inhabitants, particularly as a significant element of their diet. It plays a substantial role in the economy as both palm heart and the açai liquid. Beyond this, its frequency and ecological niche suggest that it plays a major role in certain Amazonian estuarine ecosystems. In this role it could be of value in future Amazonian conservation

FIG. 54. Palm heart harvesters walking on path on muddy forest floor made from açai trunks laid side by side.



Fig. 54

efforts. Such efforts could also be argued for because of its economic values. E. oleracea is a very wide ranging species. Since it is shown here to have such a high degree of importance in the relatively limited study area, comparative studies throughout its distribution, including the Guianas and Venezuela, are merited.

CONSERVATION AND MANAGEMENT.

CAN COMMERCIAL MANAGERS AND TROPICAL FOREST
CONSERVATIONISTS WORK TOGETHER? A SYSTEM FOR EUTERPE
OLERACEA PALM HEART PRODUCTION IN THE AMAZON ESTUARY.

Introduction

The ethnobotany, economic botany, habit and habitats of Euterpe oleracea (Fig. 55) in the Amazon estuary have been discussed in detail in the ethnobotany chapter of this dissertation, and the following chapter largely published in Strudwick, 1990. As has been shown, together with use of the fruits, palm heart is the most important use in the region in terms of geographic extent and economics. 1982 figures (I.B.G.E. 1984) showed a total of almost 100,000 tons of palm heart production for Brazil. Of this, almost 93,000 tons came from the eastern part of the state of Pará where the Amazon estuary is located. Within this region lies the large island of Marajó, and it is here that this study focuses. The Marajó area accounts for 85,000 tons or 85% of Brazil's total production of palm heart.

In this chapter some possible benefits of planned

commercial management systems for the palm heart industry and for soil and forest conservation in general are discussed and a working example of a commercial management scheme is described. Some background into related management studies is also provided. It is not suggested that this or similar schemes are the answer to the complex subject of tropical forest conservation. For instance, the example presented does not allow for conservation of all plants (and therefore probably other organisms linked to those plants) within the area, since selective cutting is practiced. However, the scheme described does involve a fairly large commercial enterprise manipulating and using a native forest in situ without the introduction of exotic species. Clearly this is a preferable form of land use from the conservationist's viewpoint than the felling of forests and in their place cultivating the land and introducing exotic monoculture crops. The author suggests that this 'symbiosis' of commercial ventures using native forests is a realistic and valuable model towards meeting the interests both of developing countries and of conservationists.

Since the heart of a palm includes the apical meristem of the palm shoot, and most palms are unable to branch, harvesting a palm heart kills the stem from

which it is taken. Thus, in single stemmed species, harvesting the palm heart results in the death of the entire palm. The genus Euterpe has long been the major world source of palm heart. The wild populations of certain single-stemmed species, such as E. edulis, have suffered because of this. However, since E. oleracea is multi-stemmed (Fig. 56), removal of palm hearts from this species does not kill the entire plant. The palm heart industry in the Amazon estuary is largely supplied by the cutting of this species from the native, seasonally flooded, river-margin forests and this is now the major world source of palm heart. Many palm heart factories are dotted along the numerous rivers in the estuary region in areas surrounded by these forests.

Palm hearts may be brought to the factories by both private individuals and by individuals employed or supervised by the factory management. Without a planned scheme of management, in certain cases all the palm heart in a given area may be cut, resulting in the complete removal of forest cover. In order to maintain a steady supply of palm heart, and thus ensure the continued operation and success of a factory, it is clearly preferable to manage an area of forest so that it will yield a continued supply. Studies have been made in both Brazil and Venezuela (Calzavara, 1972;

FIG. 55. Euterpe oleracea, showing typical habit and habitat in the Amazon estuary.

FIG. 56. Euterpe oleracea, showing its characteristic multiple stems.



Figs. 55-56

Urdaneta, 1981) of methods of management that might best supply the demands of the industry. These have involved either plantations or wild stands of Euterpe oleracea. Costa et al (1974) made a detailed study of E. oleracea as a forest multi-use palm, focusing upon the production of cellulose and fibers from the leaves and stems.

Both Calzavara and Costa et al focused upon E. oleracea in the Amazon estuary. A brief summary of these works will provide background for the discussion of the operating system to be described and discussed in this chapter. Both the studies of Calzavara and of Costa et al were theoretical studies based upon data collected from trial plots of E. oleracea in the forests. It is of interest to examine a commercial system that is actually being used, to see how a management scheme works in practice in the 'real world' (a commercially operative system). This will be seen in the body of this chapter.

Calzavara calculated the number of individuals of E. oleracea, number of stems per individual and different sizes of those stems per individual per hectare for several different soil types and areas within the Amazon estuary. These included varzea and terra firme, subdivided into yellow latosol and

concretionary latosol. Planting trials were also carried out. Factors influencing productivity, such as soils and shade, were discussed. Cultivation practices for other crops in the region, such as sugar cane and rice, were discussed, as well as timber extraction from the forests. Methods for reforestation of areas which would bring about a high productivity for E. oleracea were presented. Two kinds of reforestation methods were presented. One was for areas that had previously been used for annual crops (rice etc.), the other was to exploit areas with a high natural concentration of the palm, removing unexploitable species. Methods for weeding, planting, handling pest problems, and specific problems associated with the flooded forests of the varzea were discussed. Finally, the necessity of having an organized managed operation where an area could be divided and worked in a systematic fashion was stressed. Suggestions for what percentage of each sized stem for each individual should be cut in a rotation of successive years were presented.

Costa et al (1974) stressed that until recently E. oleracea was known only in the region as the source of the açai liquid. Now it was receiving great interest as a source of palm heart and as a source of paper and cellulose, the latter being the focus of his work. The

authors noted that decimation of E. edulis populations in the south of Brazil was being followed by similar overexploitation with this species, which would deprive many of either the basic element of their diet (the açai liquid) or of the living many riverside dwellers make from collecting and selling the fruits. For this reason, it is stated, studies into the rational management of E. oleracea forests were essential to balance all demands on the plant. To investigate this, floristic inventories of the palm were necessary. To accomplish this, aerial photographs were taken of a 73,000 hectare area of Marajó from which different vegetation types were distinguished. From this, two locations were selected for study. One area totalled about 14 hectares and was inventoried for the number of individuals of the palm and number and height of adult stems and juvenile offshoots, with their positions mapped. In the other area, experimental managed plots were set up and the same inventory carried out. Local soils and their characteristics were described in detail. Tabulated results and extensive appendices were provided. The management plots were merely inventoried but underwent no management rotation. Detailed analyses were carried out for the purposes of cellulose production etc.. Estimates of potential productivity of natural stands based upon the inventories and other

studies are given for cellulose, palm heart and the açai liquid. It is suggested that vast amounts of raw material goes to waste when palm hearts are harvested since all but the heart is left to rot on the forest floor. (Current author's observations: this seems an excellent point and motivation for the suggested cellulose industry. However, this would deplete organic matter that may get reincorporated into the ecosystem. Since many of these forests are periodically to regularly inundated, perhaps this would not be a problem since it could be that many things are carried away while other alluvial sediments are deposited.) Costa et al proposed building cellulose processing factories next to the palm heart factories in order to accomplish this.

Studies such as the two described above by Calzavara and Costa et al in Brazil may, in fact, have led to the development of management schemes such as the one described in this chapter. I have no evidence, however, to show that the management suggestions or phases were ever implemented by the researchers or others after them, except the similar commercial operation which is presented in this chapter.

More recently Ricci (1989) has described efforts towards palm heart industrialization efforts in French

Guiana. Two schemes were initiated in 1983 and 1985 which followed field studies. The forest was managed in a similar fashion to the scheme described in this chapter. Workers were brought in from the state of Pará, Brazil. Wages were said to be higher than in Brazil and the necessity of reducing costs, especially those associated with transport of the palm hearts from the forests to the factory, was stressed. Monitoring of the schemes suggested that the first complete harvest of palm heart from the managed areas was not detrimental to the ecosystem but it was noted that further studies would be needed to assess the impact of continued harvesting.

Legislation has been introduced in Brazil in the past (Carneiro 1970) to regulate the cutting of the palm and to attempt to enforce replanting. Other factors, besides its commercial importance for palm heart, place demands upon the industry to ensure the palm's continued abundance in the Amazon estuary. Since the açai liquid prepared from the fruits is such an important staple of the region, the palm heart industry has been blamed locally for leading to a demise in E. oleracea populations in the past and consequent increases in the price of the liquid.

A primary conservation issue is the conservation of tropical rain forests. Clearly, one of the driving factors in destruction of these forests is economic growth in developing countries. Ideal conservation strategies for such areas might include satisfactory economic return combined with conservation of native biota and soils. Laws governing what individuals may do are difficult, if not impossible, to police and enforce in tropical wildernesses. Were a commercial enterprise to police and conserve parts of an ecosystem for economic gain, a good 'symbiosis' could result, which would satisfy conservationists, private enterprise and politicians.

In October 1984 the author witnessed a situation such as that described above in operation on the island of Marajó. This enterprise is described in this chapter as an example of an apparently successful commercial/conservation synthesis. Clearly, from a short visit the author cannot make conclusions about the long-term effects of this management system, nor of such details as what forest species are eliminated, how reproduction of species is affected, how wildlife presence is affected etc.. However, personal observation showed the area to have retained the overall appearance of a natural forest and healthy soil. It is

not suggested here that this management system be used like a 'monoculture' throughout the region. It is suggested, however, that such enterprises deserve serious consideration in a realistic approach to conservation. The author is unable to say what percentage of the palm heart industry uses this scheme at present but enquiries with various management personnel of the factory involved revealed that it was being used by them in other areas also. To my knowledge, this scheme has not been reported in the English literature. Describing it here may be useful for agroforesters and conservationists interested in suitable schemes for this region. Furthermore, it shows a scheme in practice, rather than just a theoretical situation and, as such, demonstrates greater viability and credibility.

Often, business interests are seen as being in conflict with conservation interests; a common attitude seems to be to view commercialism and private enterprise as 'the enemy'. Such an attitude, it is argued here, is unproductive, unhealthy and impractical, leading to a polarization of interests. By presenting the example described here, it is suggested that both interests might be served in certain situations by private enterprise, given thoughtful management strategies.

Most importantly, ways should be sought to accommodate both, especially in developing countries where economic improvement is often, and with good reason, the key driving force.

Methods

Description of the management scheme is based upon personal observations, conversations with different levels of management and workers of the palm heart factory and a map of the managed area. The work was carried out in October, 1984.

Management Scheme

The palm heart factory which serves as the center for the operation described here is located in a town on the large island of Marajó in the Amazon estuary, Brazil. The town is small and isolated (as are all towns of this region) and is situated well into the interior of the island. Palm hearts are delivered by boat here from the surrounding regions and processed as described previously (Strudwick & Sobel, 1988) and in this dissertation. Some of these are brought by private

individuals who cut them from areas not under the control of the factory. Other land, however, is controlled by the factory and managed specifically for the production of palm heart. The area described here is actively managed by the palm heart company and is located about 6 hours by small motorized passenger boat upstream from the factory, well into the interior of Marajó.

The area under management (Fig. 57), as is common with E. oleracea habitats in the region, is subject to seasonal flooding. In fact, palm heart production from the factory is greatest from January to May since waters are higher and boats used to transport palm heart are able to get closer to the areas of production, enabling more palm heart to be brought in. During this period the managed land is flooded to an average depth of ca. 75 cm by the water from the adjoining rivers (Fig. 57). At other seasons, palm hearts must be bundled and carried by hand (Fig. 58) or secured in 'backpack'-like baskets (Fig. 59) to get them out of the forest to the riverside where they can be loaded into a boat for transport to the factory. This takes considerably more time and effort.

The land is managed by the factory under contract

FIG. 57. Map of the managed area. Note the proximity of rivers and the systematic division of the area into rectangular units.

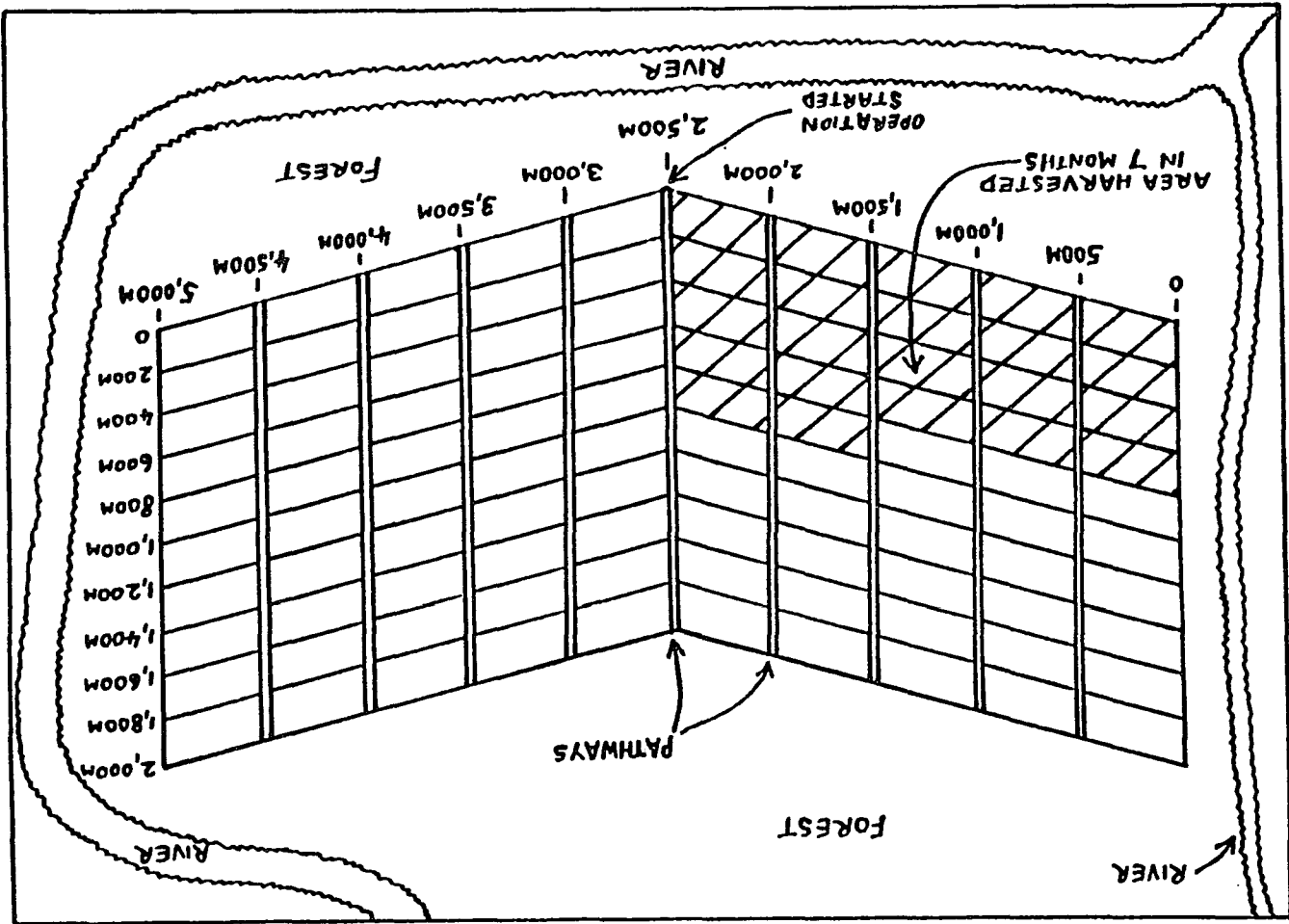


FIG. 57

from other owners, including a timber extraction company. Not long ago (probably several decades) the area was virgin forest. Prior to management for palm heart only Virola and other selected timber trees were removed from the area. Besides providing good wood, this also promotes better development of Euterpe oleracea, probably due in part to better light penetration.

In order to manage the palm heart extraction area it is divided up into a grid so that workers can be moved through it in a systematic fashion without retracing their steps or missing an area. When they return they will move through it in the same chronological sequence, allowing equal time for the redevelopment of harvestable palm heart in all parts. The area is a slightly hinged rectangle measuring 5,000 m in one direction, 2,000 m in the other and is divided into smaller rectangles of 200 m by 500 m (Fig. 57).

The factory pays workers to clean the area of undesirable vegetation and debris at the same time as harvesting palm heart. The purpose of this is to get it into an optimum state for the future production of palm heart. A forest framework remains which is not dense, allowing sufficient light penetration for good palm

FIG. 58. Bundle of Euterpe oleracea palm hearts in protective surrounding leaf sheathes ready for carrying. A twisted leaf of the palm has been used to tie it.

FIG. 59. Euterpe oleracea palm hearts being carried out of the forest in 'backpack-like' basket.

FIG. 60. Managed area several months after palm heart harvest. Note its clean, open nature. The narrow trunks are Euterpe oleracea. The base of the large trees shows that a forest framework is maintained.



Fig. 58



Figs. 59-60

heart production (Fig. 60). Other workers are paid on a daily basis solely to cut paths and keep them clear so that harvested palm heart can be carried out of the forest during the dry season (Fig. 59). In the rainy season access is by canoe. The workers who harvest the palm hearts are called palmiteiros (Fig. 61) and are able to cut and process about 100 stems per day. On average there are approximately 700 harvestable stems per 100 x 100 m area. The number of palmiteiros who come to the site varies between three and eleven per day but the average is about six.

When observed the project had been in operation for about seven months. It was estimated that it would take a total time of just over two years to completely harvest the entire area. Upon completion the project would go to another area, to return here when the palm heart grew to a sufficient size to harvest again (probably only a year or two later). It would begin again where it first started. This point and the area covered in the first seven months are indicated on the map (Fig. 57).

To encourage the palmiteiros to follow this management scheme they were paid 70 cruzeiros per palm heart delivered to the factory at the time of

observation. Palm heart brought from non factory supervised schemes fetched only 30 cruzeiros (the exchange rate during this period was approximately 2,800 cruzeiros per U.S. dollar). Obviously this method of payment is a strong incentive for palmiteiros to work for the factory and follow a rational management scheme. As mentioned above, palmiteiros operating on the factory-managed land must prepare the forest for optimal future productivity. All stems of sufficient size to yield a good palm heart are cut and processed (Fig. 62) ready for transport to the factory (described in detail, Strudwick & Sobel, 1988). All the leaves from the crown of the palm are removed during this process and remain in the forest as an organic mulch (Fig. 63). At the same time as harvesting the palm hearts, the palmiteiros must remove lower layers of brush, small shrubs and saplings, to allow young plants and seedlings of Euterpe oleracea to survive and grow. In the tropical heat and humidity the cut vegetation, stems, palm leaves and debris left after removal of the outer leaf sheathes from the palm hearts, take only three months to rot down, leaving the forest floor clear (Fig. 60). Only a small portion of the stem containing the palm heart leaves the site, therefore the amount of organic matter on site will remain similar. Once the area is cleaned and the organic debris has rotted down,

FIG. 61. One of the 'palmiteiros' who harvests the palm heart and cleans the forest.

FIG. 62. Palmiteiros cutting outermost sheathes from the palm heart. These sheathes add to the organic matter in the forest.

FIG. 63. Leaves from the crown of Euterpe oleracea left to rot down after harvesting palm heart.

FIG. 64. Profusion of Euterpe oleracea seedlings where forest was cleared by palmiteiros.



Figs. 61-64

greater germination of E. oleracea appears to occur (Fig. 64), increasing the frequency of the palm in the forest. Cut, fallen and rotting palm leaves are cleared from the base of each palm to allow free growth of young shoots. Other tree species of over 2 cm width are left to become the future framework of the forest and for possible use as timber.

To ensure that the management scheme is adhered to the factory has a supervisor at the site full time. The palmiteiros spend two weeks at the site, then return down river to the factory and town, where they get paid and have their homes and families. Some of their wives are employed inside the factory. They have four days break before returning upstream.

Conclusion

The palm heart factory described here has been in operation for only a short time but was the only visible sign of large scale commercial employment for local people. As such it probably is an important source of income for some families in the town. Because the company's management system is carefully planned and supervised it will probably provide a steady source of

palm heart so that the industry can be sustained in the area, as well as the jobs it supplies. This is significant because several factories in the Amazon estuary were seen to have closed, most likely due to fluctuating supplies of palm heart cut without management from the wild. This managed system also appears to help conserve native forest cover. Even if the conserved species are selected while others are removed, the manipulated forest can be viewed as a framework which, it is surmised, aids in soil conservation and the preservation of a percentage of other native flora and fauna. The system also allows selective harvesting of timber. Other palm heart operations of the same company in different areas, using similar management methods, have been in practice for over ten years, demonstrating the apparent sustainability of the system. Since the system regulates cutting of palm heart, confining it to a designated area, as well as discouraging palm heart cutting from the wild by paying much less for material cut at random from the wild, it presumably frees up a great deal more plants of E. oleracea for fruit harvesting for the important açai liquid, both for subsistence-use and for the commercial cottage industry (as described in this dissertation). The company operating this system is one of the major palm heart

companies in Brazil. This fact might be a reflection of the success of its palm heart forest management methods. It is not suggested here that this is, or should be, the only management system used for palm heart production from Euterpe oleracea. It does however provide a good role model for combining apparent economic growth and stability with conservation efforts in the region. Conservation of tropical forests and soils as well as economic growth of developing countries are real and important issues today. Commercial management systems which satisfy the aims of both these causes should be carefully considered by conservationists. Ways should be sought to work with commercial enterprises wherever possible and to work within the realism of economic development forces.

AGROFORESTRY

Background

During my field studies in the Amazon estuary, the açai palm, Euterpe oleracea Mart., was seen in varying growing conditions. It is clearly an abundant palm around the many waterways of the region. Much of the time it was seen associated with local inhabitants' houses, clearly being used by them to supply them with the açai liquid and other products, such as pig fodder, organic compost, walkways etc.. These situations and uses have been described in detail in the ethnobotany chapter of this thesis. In other locations it was being managed or exploited on a fairly large scale for palm hearts. This situation has been described in the chapter on management. In many other localities the palm is growing where there appears to be no or little human interference. One particularly interesting growing situation was described in the ethnobotany chapter. Here, there was a distinct zonation and large belt of açai on an apparently fairly recently colonized mudbank in the middle of a large river. The zonation was interesting because it involved clear zones of other apparent mudbank colonizing plant species, such as

Montrichardia, Rhizophora and Mauritia flexuosa, perhaps suggesting a method of colonization or succession for this common estuarine feature (mudbanks).

The abundance of E. oleracea and its great use and connection to the people of the Amazon estuary were clearly observable facts. It had not been shown however, to what, if any, degree, the riverine people with the palm surrounding their dwellings, were manipulating or managing the forest themselves. Was the palm just a natural bounty for them or did they manipulate their forest 'gardens' in some way to get it to produce best for them, or to get it to be so abundant in the closest areas surrounding their homes. Was there some kind of agroforestry scheme at work?

As part of my fieldwork in Brazil I worked on a study aimed at solving this very question. With my co-workers we mapped and quantified the occurrence of the açai palm in a particular riverine homestead situation where the home was nestled on the bank of a river and between the surrounding varzea (seasonally flooded) forest. At the same time the inhabitants were quizzed on what they did to the forest, how they used it etc., so that we could come up with a true picture of what degree of manipulation, if any, was going on.

Questions were also asked to determine the exact use that all the species in the area were actually being put to. By doing this the actual manipulation of the forest could be discovered. We published the results of this study in Anderson et al, 1985, and in this chapter I will describe the background for this work, methods employed and our results. Since the focus of this dissertation is Euterpe, those aspects of the work which emphasize E. oleracea will be stressed, although it will be seen that this palm is central to the entire vegetation studied as well as the existence and the economy of the family who were the focus of this research. Further, since an agroforestry system is being described, by definition it involves the role of other interwoven species. Thus these will be discussed at times also.

Introduction

Agroforestry systems have previously been stated to be a viable land-use alternative in the Amazon estuary (Hecht 1982, National Research Council 1982) and provide a variety of commercial and subsistence products. Such systems usually contain a diversity of species and include the important retention of forest

cover. In the tropics in particular, this is especially important in preventing erosion, maintaining soils, recycling nutrients etc.. Since these systems, as will be seen with the one discussed in this chapter, are often created by local inhabitants with their roots in the area, they are also 'comfortable' or acceptable to those people where monocultures etc. might not be. Rural inhabitants who depend on the land often have an intimate knowledge of local flora and fauna which outsiders do not. Thus these people are excellent guardians or conservers of land and biota in areas whose existence might be threatened by removal of forests and implementation of other land use(s). Especially where it can be shown that there is an economic advantage in keeping such systems in operation or encouraging the creation of more of these systems, there is a strong case for investigating agroforestry situations carefully. Most studies to the date of this research had dealt with indigenous populations with little mainstream society involvement (for example see Posey 1983). For this reason the situation presented here is of particular interest because the family studied lived in Amazonian forest, yet in close proximity to and constant commercial contact with a major city quite close to them. Of yet more interest are the difficult conditions that areas such as the one studied in the

Amazon estuary present for plant growth in general. With the sustained periods of tidal and seasonal flooding in the varzea, very specialized plant adaptations such as pneumatophores, buttresses and large amounts of lenticels on aerial roots (such as are evident with the açai palm) are essential for vegetation to withstand the soil inundations and accompanying lack of oxygen. Thus a form of forest utilization where such specialized native flora are abundant is particularly valuable for this region.

Materials and Methods

This study took place on the Ilha das Onças, a fairly small island in the Amazon estuary about 2.5 km across the water from Belém. It focused upon the property of one family. This property belonged to Ms. Alice Damulakis who lived there with her family. The home sat on a piece of land that occupied about 500 hectares and fronted on to the small river called Furo Santo Antônio which penetrated through the island. The family's main subsistence and economic activities included fishing, collecting forest products and rearing a limited amount of livestock. Three management areas were identified. The Quintal (garden area) had less

than 50% tree cover and surrounded the house (the house was about twenty meters from the river and people leaving or arriving at the property would do so via boat, embarkation being at the river bank at this point). A high percentage of herbs and shrubs were able to be grown in the Quintal due to the relative lack of shade from trees. The second area was the Floresta Manejada (managed forest). This too had a tree cover generally less than 50% and was situated directly outside the Quintal, continuing to some distance away (Fig.65) as well as in other scattered locations in the forest. These areas were moderately manipulated. Finally there was Mata (forest). This area had a relatively closed coverage of trees, vines and underbrush. These areas of Mata had various histories, including areas of secondary forest where clearing had occurred for some reason in the past as well as areas of primary forest. All three of these identified areas are illustrated in figure 65. For each of these zones the resident family acted as informants in describing fully any methods of management employed.

In order to properly describe the ethnobotany and ecology of the different zones a transect was made from the house and out into the forest. In this way the extent of the management zones, their proximity to the

house and their component vegetation could be mapped. This transect was 10 m wide, 170 m long and subdivided into plots of 10 x 10 m to facilitate mapping. All vegetation equal to or above 1.5 m in height was included in a profile of this transect (Fig. 65). All the bases of these plants were mapped to show their exact location. Their crown widths were also recorded for accurate representation on the profile, as well as their heights. All these features were accurately represented to scale on the profile. I also made drawings of all the vegetation in this profile in the field so that when I drew the profile, including in it all the other data, it would be as accurate a representation of this piece of tropical forest as possible. Various photographs taken within the forest were unable to present a discernible, or any kind of, rendition of a transect of vegetation of this magnitude.

The vegetation of the Floresta Manejada was inventoried over an area of 50 x 50 m about 100 m from the house and included a 25 x 10 m section included in the transect illustrated in Fig. 65. All the woody plants in this square with a diameter at breast height of over 3 cm were mapped. Specimens of all the plants in the area were collected for identification and were deposited with the Museu Goeldi in Belém and the New

York Botanical Garden. The abundance of each species was calculated by the total number of stems in the area and the frequency was calculated by the presence of the species in 25 subplots of 10 x 10 m. Dominance was calculated by the sum of the base areas of the stems. For a comparison with the Mata area an inventory was carried out in the same fashion in an area of forest without evidence of previous use or clearing. This area was both relatively low and damp which may account for some of the difference in the vegetation there.

Specimens collected were shown to the family and other local informants to gather data on local names, uses and management practices.

Results

The house was situated on one of the highest points in the area in order to avoid flooding as much as possible. This too allowed the cultivation of species in the Quintal which may otherwise not tolerate the local conditions. The river in front of the house supplied shrimp and fish for the family.

Following is a description of the three

recognized management areas, emphasizing the role of Euterpe oleracea and omitting data on other elements which are not considered essential to this thesis.

1) The Quintal comprised an area of about 0.4 ha. It was highly managed and served for various purposes including drying clothes, storing shrimp-traps etc.. Primarily it was like a kitchen garden. Right next to the house all native trees were removed to allow domestic activities etc.. Further out (see Fig. 65) species with little use were eliminated while those with particular value, such as E. oleracea and Hevea brasiliensis (the rubber tree), were encouraged. The reduction of forest cover in this area allowed a great variety of species to grow. Of the 68 species collected in this area, 81% had been planted by seeds, cuttings, in baskets and by other methods. 66% of the species in the Quintal had been introduced from outside Ilha das Onças. Some of these, such as Theobroma cacao (the cocoa plant), were reproducing themselves spontaneously now. Herbs, shrubs and trees were all present in this area and various forms of care was taken of them, such as weeding, hoeing etc.. The lack of tree dominance and forest cover in this area allowed the invasion of frequent undesirable vegetation and so management for this area was relatively intense and energy consuming.

The great degree of usefulness of the species in this area is evident from the fact that 93% of the species found there were used. Uses included medicines, food, ornamental plants, attraction of game, fertilizer and ornamental value. Organic matter from the forest was brought in to help fertilize the Quintal. As can be seen from the profile of the Quintal (Fig. 65), this area had a large concentration of bananas (Musa spp.) and açai. The açai occurred naturally.

2) The Floresta Manejada had a relatively continuous forest cover and thus relatively little forest floor vegetation as is demonstrated in the profile (see Fig. 65). Thus this area is much less actively managed than the Quintal, since the natural forest framework limits invasive or 'problem' species. Certain plants are thinned or removed in this area while others are favored.

Euterpe oleracea is the most frequent and abundant species in this area. This is apparent from looking at Fig. 65 as well as the abundance and frequency results of the inventory. It's abundance was 50.5% while it's frequency was 19.4%. By comparison, the next in abundance was Theobroma cacao at 14.9% while this same species was also next in frequency at 14.5%.

FIG. 65. Profile of vegetation drawn by the author, showing the three identified areas of forest in an area 170 x 10 m. Plants' true positions, heights and widths are shown. Note the frequency of Euterpe oleracea in the different sections. House just out of view to left.

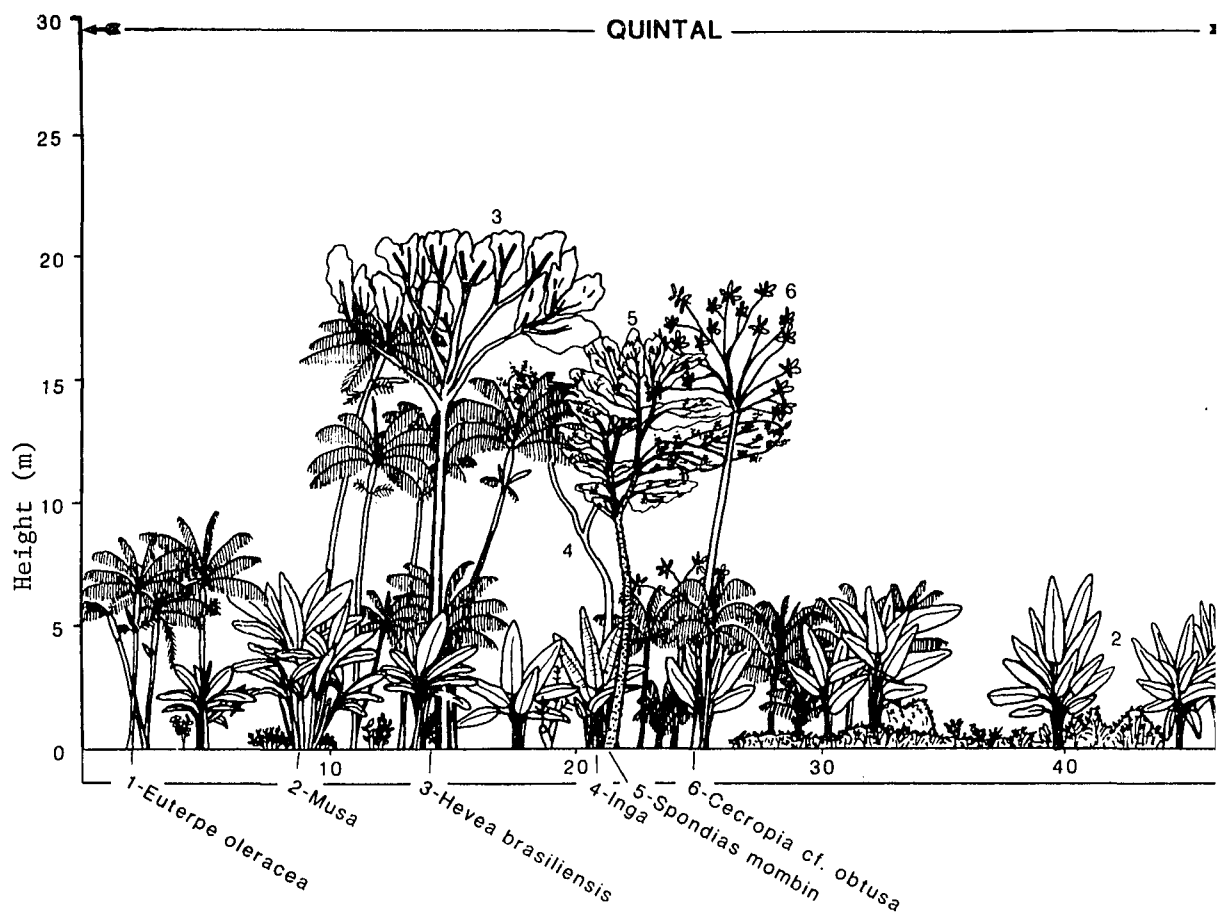
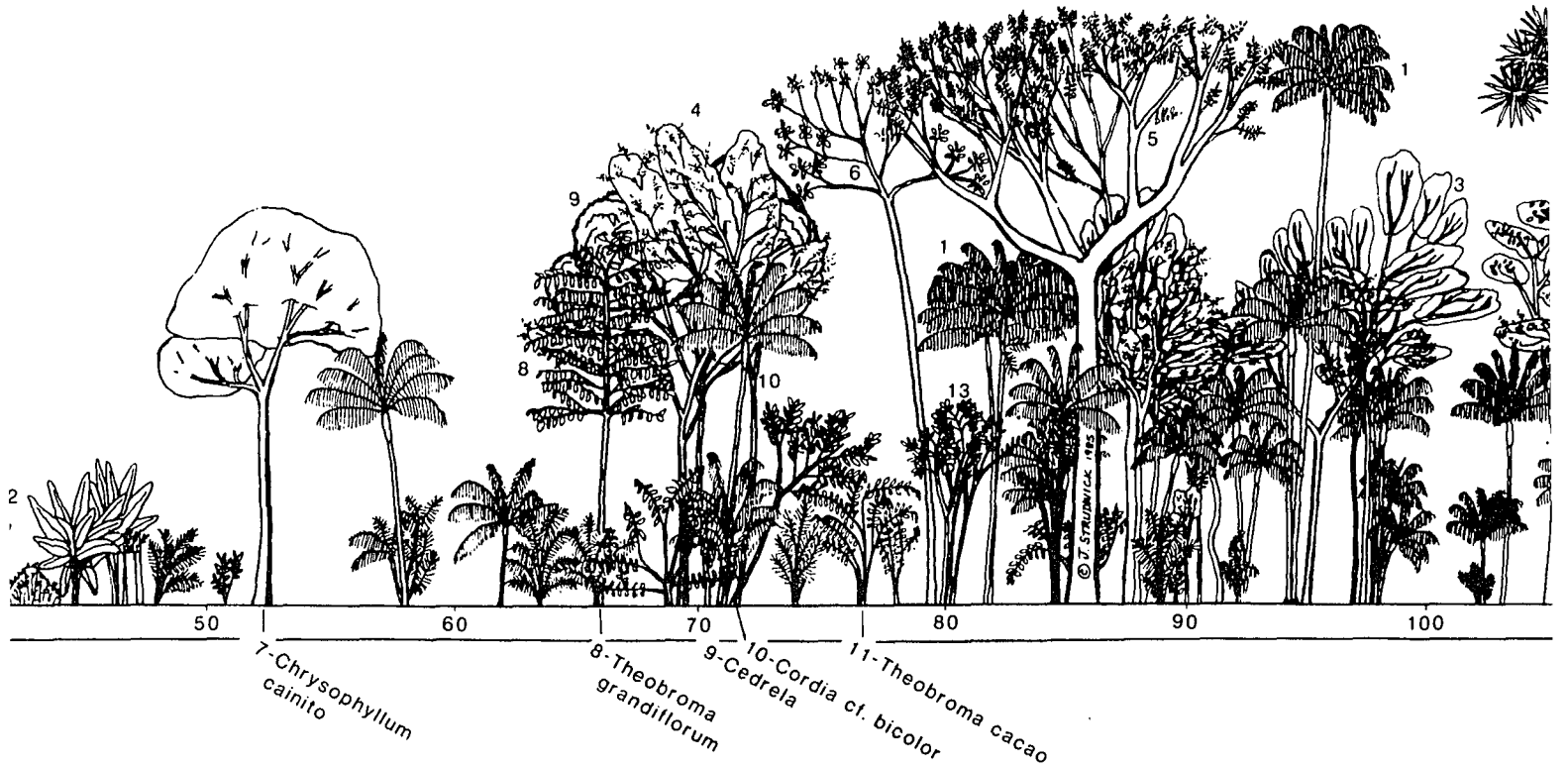
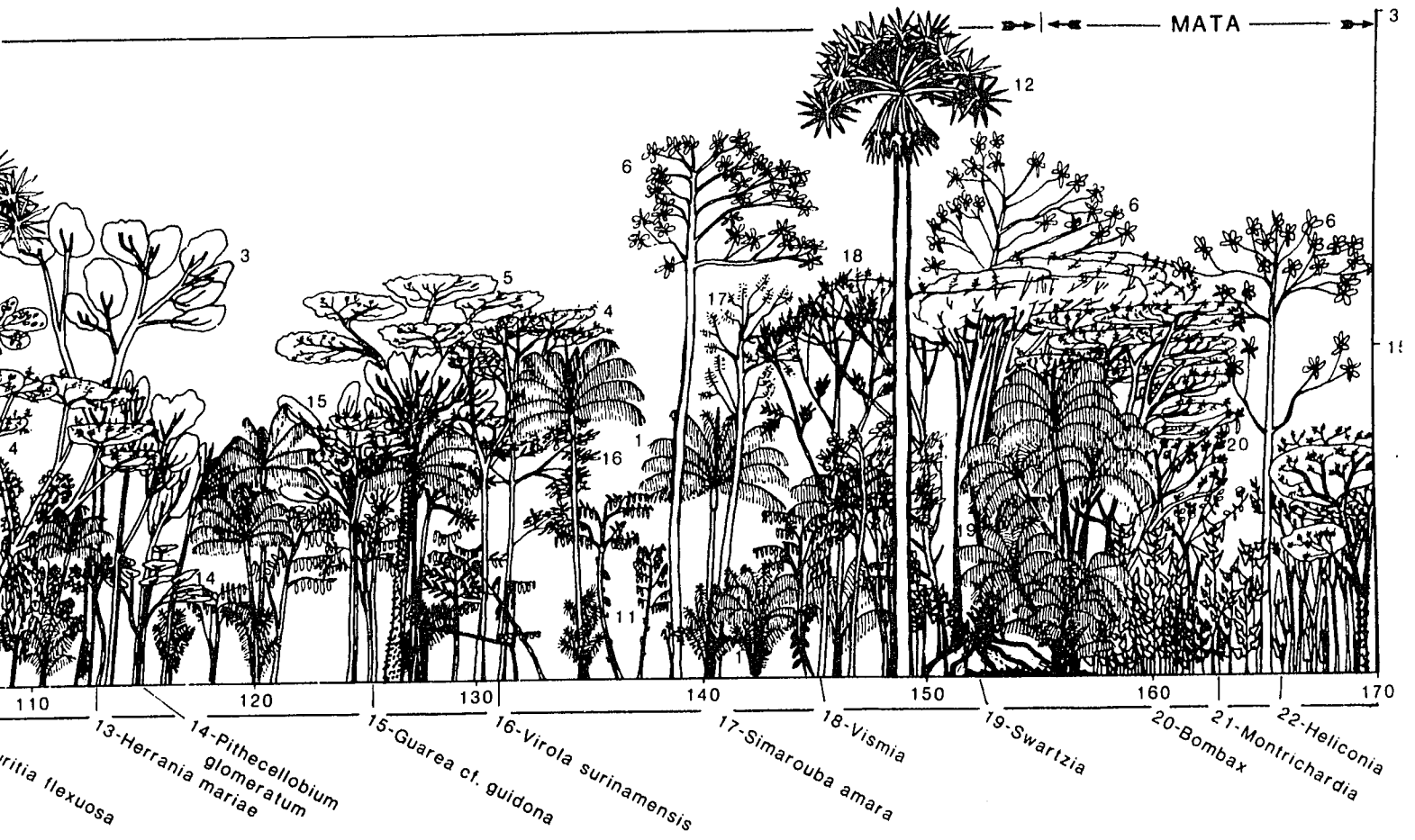


Fig. 65





According to local informants E. oleracea is also the most economically important species on Ilha das Onças.

While normally açai palms can have 12 or more stems, collection of fruits for the açai liquid was said to be better from plants with 2-3 mature stems and so the rest of them would be removed for their palm heart. This management technique is most evident when comparing the inventoried Floresta Manejada and Mata areas. In the Floresta Manejada the mean number of stems per açai specimen was 6.5, whereas in the Mata it was 9.5. Also, the further one went from the house, the more açai became the primary objective of manipulation or management in order to increase it's productivity. As well as thinning the stems of açai, other species were thinned or removed to allow the açai to produce better. Vines and ground layer vegetation were almost entirely removed in these areas while trees that interfered with the crowns of açai would be cut. The results of this thinning and cutting are evident in a comparison of the sum of the basal areas of the trees between the Floresta Manejada and the Mata. The basal area in the former was 7.8621 sq. meters while in the latter it was significantly higher at 9.9713 sq. meters. The majority of the cut species had little importance except for firewood. It appeared that other species, such as

rubber, were also favored in this management scheme. Organic material, such as fallen açai leaves, were often placed as an organic supplement at the base of favored plants, while cleaning of the forest floor involved the removal of plants such as the very spiny palm, Astrocaryum murumuru, to facilitate access etc..

The Floresta Manejada had a high percentage of useful species. Again, both introduced and native species were present in this area. Açai and rubber and the giant palm Mauritia flexuosa (which can be seen in the profile, Fig. 65) are examples of native species while cocoa and Theobroma grandiflorum are introduced. Collectively the species of the Floresta Manejada had a great number of uses. Of 20 identified species 18 had uses, most of them multiple. These uses included drinks, food, medicine, construction, boat-building, furniture, fibers, game attraction for hunting purposes, fuelwood or charcoal, utensils etc..

3) The zones of Mata had continuous forest cover, many vines and a thick shrub layer. There was a high percentage of useful plants and again the açai palm was abundant, it's stems representing 60% of those present. The representation of this forest in Fig. 65 shows a particularly dense area, since this portion of the

transect straddled a stream (hence the presence of Montrichardia which is an indicator of the water - see profile). Vegetation around stream and riverbanks in the region can be particularly dense due to the presence of more light at the river banks. Useful species included Virola surinamensis, Spondias mombin and Hevea brasiliensis. The Mata zone also served as a place for pigs belonging to the family to forage.

Conclusions

It is clear from this study that the forests around this home were being actively managed. This, together with the vast degree of uses, made this a successful and economically productive agroforestry system that is tailored to the varzea forest type. The two described forest areas, Floresta Manejada and Mata, both included E. oleracea, the açai palm, as the most abundant species. The family made frequent trips to the Ver-O-Peso market in Belém to sell it's fruits for making the açai liquid. The family also, like many others in the region, use the liquid as a principal subsistence product and were illustrated doing this in the ethnobotany chapter. The fact that this palm was also the most economically important plant in this

agroforestry system makes this species of paramount importance when it's ecological success is coupled with it's economic value. Since it occurs in unmanaged forest areas which are also in great abundance, it obviously has the potential to be of even more economic value in the area. The palm was not planted, although in the vicinity of the house it could have sprung up from seeds left aside from the liquid-making. It was, however, manipulated, since stems were deliberately harvested (for palm heart) in order to make the remaining stems bear better fruits. The Floresta Manejada was also being managed as a whole since certain species were eliminated and certain underbrush cleared, while other species had been introduced. It was clearly, however, not highly labor intensive. The abundance of native trees in this area provided a stable forest framework somewhat similar to the managed palm heart forest described in the Management chapter. This family's forest appeared to be significantly higher in species diversity, although that statement, of course, would have to be quantified. No doubt also this forest provides a stable natural environment and habitat for numerous native organisms, such as birds, reptiles, mammals etc..

Since this study was carried out, Anderson and

co-authors have continued to work on agroforestry schemes centered upon E. oleracea in the Amazon estuary (Anderson and Jardim 1989; Anderson 1990). Clearly agroforestry is an important area of research in the tropics as a means of combatting deforestation. Several approaches to and aspects of this problem as it pertains to Amazonia were presented in a symposium volume (Anderson 1990a). Within this volume Anderson (1990) adds new interpretations to the study I have presented in this chapter, having studied new experimental plots involving E. oleracea agroforestry management on Ilha das Onças. He had also studied similar islands within the region. Anderson discusses the concepts of 'extraction' and 'forest management'. The former is said to be the removal of forest "resources with no provision for their replacement". Regarding management, Anderson describes the kind of forest management where E. oleracea is encouraged, such as I have described in this chapter, as "tolerant" forest management. As noted, these practices involve a native forest which is thinned to increase light, eliminate competitors etc., as well as encouraging productivity by pruning E. oleracea stems etc.. Above all, the essential element recognized in such management schemes are the local rural populations who manage them. The 'caboclos' of this region are noted to be the descendants of

Amerindians who have mixed with European settlers. These people are said to represent a fountain of knowledge and willingness in manipulating the forests, without which such schemes would be impossible.

Anderson and Jardim (1989) have added new and interesting data regarding the costs and benefits of E. oleracea agroforestry schemes by establishing and studying trial plots on Ilha das Onças which mimic management practices described above. Some plots were left wild (controls), others subjected to thinning of 'less desirable' species, others to pruning of E. oleracea clumps to reduce the number of stems per individual and a fourth set to both thinning and pruning. This study focused on measuring the productivity of E. oleracea fruits, so important economically for the production of the açai liquid. Results showed that selective thinning of competitors significantly increased fruit production. Management increased profits from these areas by almost 50%, although this figure still only represented about \$110 annual income per hectare. Nevertheless, such schemes are noted to be sustainable indefinitely, unlike intensive annual cultivation schemes. Schemes such as these are noted to be common in the Amazon estuary, a region where floodplain forests are noted to cover

25,000 sq. km, and of which E. oleracea has been estimated to dominate 40% (10,000 sq. km), (Calzavara 1972).

Finally, and also of interest, especially when related to the chapter on management, Anderson and Jardim (ibid) note that the pruning experiment is similar to the extraction of palm heart, and the data thus demonstrate that palm heart extraction appears to increase fruit production. The two 'industries' are thus deemed to be compatible, a point which is encouraging when considering the commercial yet managed removal of palm heart described elsewhere in this thesis.

POLLINATION OF EUTERPE OLERACEA Mart.

Introduction

Henderson (1986) has reviewed pollination studies in the palm family. Previous workers had considered the family to be either wind or insect pollinated or both. Schmid (1970a and 1970b) is noted to have done one of the first detailed studies of a wild palm in its native habitat and so it is apparent that in depth studies are rather lacking in the family, although others had made more extensive observations in cultivated situations (for example Knuth, 1904-5). Once again, the large size of many palms has, no doubt, been instrumental in prohibiting more frequent and detailed studies. Henderson concluded that there were three basic pollination syndromes in the family, cantharophily (beetles), mellitophily (bees) and myophily (flies). Wind pollination, although often stated to be the predominant method by earlier authors, was concluded to be uncommon. Early works by natural historians such as Martius (1823) and Wallace (1853) had documented palm-insect pollination associations. However, the majority of workers since then and up to the 1970's had supposed wind pollination to be the norm.

Henderson (ibid) noted that for the tribe to which Euterpe belongs, Areceae, the largest of the palm tribes, there was considerable diversity in syndromes, including cantharophily, mellitophily, myophily and mixtures of these. Both protandry and protogyny are found within the group. In the subtribe Euterpeinae, the type genus being Euterpe, there are six genera (Uhl and Dransfield, 1987). Pollination observations for three of the genera were mentioned by Henderson (Hyospathe, Prestoea and Euterpe). All three were noted to be protandrous, monoecious and to bare unisexual flowers in triads. Bees were probable pollinators of Prestoea decurrens in Costa Rica, staminate anthesis lasted 10-14 days followed by two days of non-flowering and three days of female flowering (Bullock, 1981). P. montana, the common Caribbean species, (E. globosa Gaertn.), was said to be pollinated by honeybees and small flies (Bannister, 1970). Henderson gave very brief personal observations on E. oleracea in his review of the other literature. Bees were the only insect visitors mentioned while information on the number of days for staminate and pistillate anthesis was vague. In a species of Hyospathe in eastern Ecuador male flowers produced nectar, falling after one day (Skov, pers. comm., in Henderson, 1986). Male flowering lasted six days, with female flowering starting four days later

and lasting several days. There were few insect visitors observed but these included bees, ants and beetles. Ants were said to be most numerous and attracted by an exudate.

In his studies of the agronomic potential of E. oleracea in the Amazon estuary, Calzavara (1972) discussed the inflorescence and fruiting but did not discuss pollination, except to note that it was outcrossing and effected mainly by members of Hymenoptera. The prophyll was noted to stop growing well before the rest of the inflorescence, so that the peduncular bract (the prophyll and peduncular bract are the two large somewhat lignified sheathes which surround the large inflorescence bud during it's development) pierced it as it continued to grow. The number of male and female flowers on the rachillae was variable and the female flowers were absent from the upper third of the rachillae, only the two male flowers remaining in these otherwise triads. On average there were 37,042 male flowers and 8,868 females per inflorescence. Only one third of these reached maturation. The number of stems per tree, plant age and soil conditions were said to affect flower number. In favorable conditions of soil and light, flowering of new trees was said to commence in the third year after planting with economic

production feasible after 5 or 6 years. During the flowering season, 6-8 inflorescences were said to be produced, which, after opening and pollination, took about six months to become completely mature fruit. Calzavara noted that a more profound study of flowering was needed.

Since virtually nothing had been done to study the entire pollination cycle for Euterpe oleracea and record insect visitors and their behaviour, the pollination studies that follow were made for this dissertation to add to our knowledge of this important plant. Questions addressed included the possibility of fruit development in the absence of cross pollination, as well as chronology of the cycle, insect visits and behaviour, comparative stages of development of different inflorescences within an individual, possible scents and exudates, floral coloration etc. These aspects were addressed in the two separate studies outlined below.

Methods

These pollination studies concentrated on two different localities in the Amazon estuary, Brazil. One

of these was a natural habitat of E. oleracea. This study was made during the course of a field trip that was made entirely by boat and required the continual moving after short periods from site to site along the rivers of the region and Amazon estuary. Because of this, detailed on-site observations were limited to one night and the following morning, but a longer term experiment was also set up. This site was located at the water's edge on the property of Francis Asbury Lawton on the Rio Jaruzinho in the southwestern part of the island of Marajó, about three hours boat ride from Breves. At this site observations were made on an individual with multiple stems (Fig. 66), whose base was tidally flooded daily at this time of year (October 23). One stem was selected from this plant for observations. This stem had four inflorescences in different stages of development which were all observed. Notes were taken on inflorescence morphology, arrangement and phenology as well as insect visitors, which were also collected. One local informant referred to this tree as 'açai branco', the common name for the greenish-yellow fruited variety of E. oleracea. This could not be substantiated however, since mature fruits are needed to determine this and none were available at this time. A tall ladder was used to reach the inflorescences (Fig. 66).

FIG. 66. Euterpe oleracea individual studied for pollination on the bank of the Rio Jaruzinho. Ladder, with it's base in the water, was used for access to inflorescences.



Fig. 66

Two inflorescences on this and another individual were isolated from external pollen sources prior to opening of the inflorescence bud. This was achieved by securing large plastic bags around them (Fig. 67). The outermost upper and lower bracts of the inflorescence were removed immediately prior to this since they would interfere with the surrounding bag upon opening. Extremely fine mesh gauze vents were constructed in the bags to allow moisture to escape without allowing insects or pollen in, since the tropical conditions would produce much condensation with the possible consequence of rotting within the bag. The opening of the bag was securely tied around the base of the inflorescence rachis with 'tree tangle-foot' grease (obtained from Forestry Supplies company, U.S.A.) smeared between the opening and the rachis to exclude all insects or possible entry. When our boat returned to this area after a two week interval the bags were checked to ensure that excess humidity and fallen flowers were not causing problems. While a large number of decaying fallen flowers had accumulated in the base of the bags, both inflorescences appeared healthy (Fig. 68). These inflorescences were removed according to my instructions nine weeks later and the brought to Belém by some very helpful Americans who were working and living in the area. Here I inspected the inflorescences

FIG. 67. Euterpe oleracea showing plastic bag secured around inflorescence to test for the possibility of fruit development in the absence of pollinators.

FIG. 68. Close up of rachillae and flowers within plastic bag. Note the excessive moisture within the bag.

FIG. 69. Inflorescence in the process of opening. The lower bract has broken open while the upper bract remains stiff and in tact in it's original position.



Fig. 67

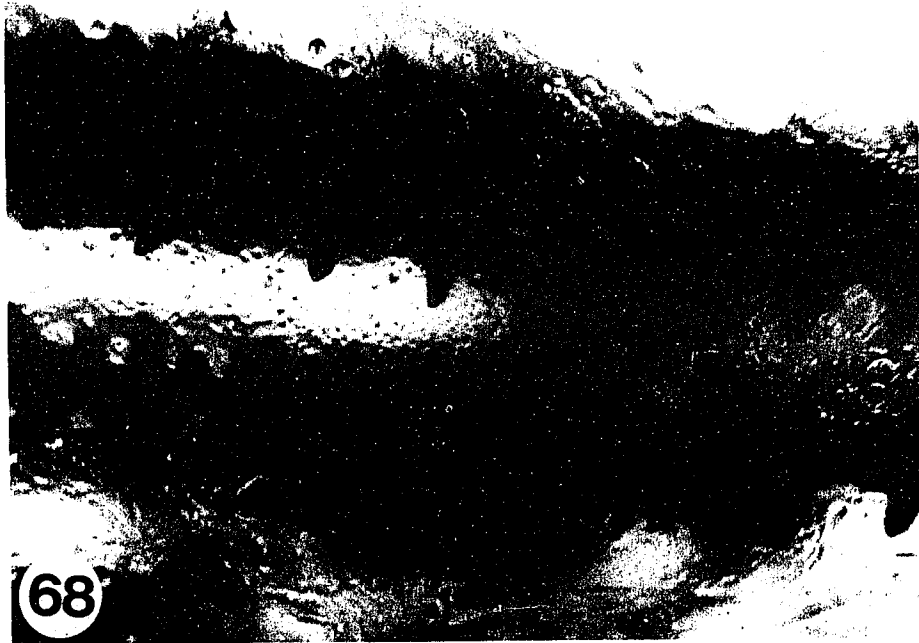


Fig. 68



Fig. 69

for their condition and any possible signs of fruit development.

The second pollination study took place during a prolonged period in Belém. Detailed observations were made daily over a fifteen day period in November on an individual located on the grounds of the Botany department of the Museu Goeldi. Again, observations were made by using a ladder to reach the inflorescences. Notes were taken on inflorescence and floral morphology, coloration, scent, phenology and insect visitors. Collections were made of insects by use of a net and preserved by either a kill-jar containing ethyl acetate or by freezing. They were later examined microscopically for pollen adhering to their bodies so that they could be implicated as possible pollen vectors. Observations were made as frequently as possible during the study and the times listed in the results indicate when observations were made rather than when special activity was occurring.

Results

Rio Jaruzinho Site

Four inflorescences were present simultaneously on one stem. The youngest of these was the top one, the bottom one the oldest. The top inflorescence was positioned at the node immediately below the base of the crownshaft, the inflorescences being revealed as the ensheathing leaf bases, which constitute the crownshaft, fall away. Detailed observations of this inflorescence will follow the briefer observations of the lower three inflorescences. Unless otherwise stated, all the observations that follow were made in the late evening.

The second inflorescence from the top was at the next node and positioned 160 degrees radially on the axis from the top inflorescence. On this inflorescence all the male flowers had fallen off, leaving only female flowers. On these flowers the papery white calyx was persistent while inside it were three tightly closed petals which were red to deep purple on the portion which was exposed. The gynoecium was divided at its apex into three stigmatic lobes which were slightly paler in color and held out stiffly at an angle of about 75 degrees from the axis of the flower. These female

flowers were quite dense on the lower two thirds of the rachillae. The entire inflorescence was held out at an angle of about 60 degrees from the stem and the two main bracts which entirely ensheath the inflorescence prior to its opening were missing (fallen off).

The third inflorescence from the top was positioned at 110 degrees continuing in the same radial sequence from the second inflorescence (270 degrees from the top one). It had young fruits which were green and their papery calyx was still persistent, as were the stigma lobes which remained attached to the fruits. The fruits were about 7-8 mm in diameter while the rachillae were pale cream colored.

The fourth and lowest inflorescence was three nodes lower than the third inflorescence and was slightly hanging down (slightly over 90 degrees from the stem axis) as well as slightly broken at the peduncle, something which could have been natural or could have happened when the tree was climbed. This inflorescence bore only green fruits, up to 1.5 cm in diameter, which is quite large for açai fruits. The stigmatic lobes were still persistent.

On all three of the lower inflorescences it was

noted that for the lower third to one half of each inflorescence, the rachillae were positioned on the rachis such as to be either lateral or abaxial but not adaxial.

Moths were observed on the second inflorescence while ants were seen on the second and third inflorescences.

The uppermost inflorescence was in the process of opening (Fig. 69). The lower bract was hanging down at a point about one third the distance from its base, where it had broken open. The upper bract was still straight, against the enclosed rachillae, held at an angle of about 60 degrees from the main stem. The lower bract was light in color and cream colored inside while the upper bract was brownish inside. The open lower bract allowed the condition of the flowers upon inflorescence opening to be observed by artificial light, since it was now dark (Fig. 70). Both male and female flowers were present, the males being more advanced in their development. The male flowers were protruding from the ensheathing calyx, although they basically appeared in a closed immature state. Only the outside of the petals were visible and these were purplish-pink on the outside. Female flowers were

FIG. 70. Unopened flowers on the rachillae just after the inflorescence has opened. The photograph was taken in artificial light since night had recently fallen.

FIG. 71. Some of the first male flowers to open on the *Euterpe oleracea* individual at the Museu Goeldi, Belém. Note the coloration.

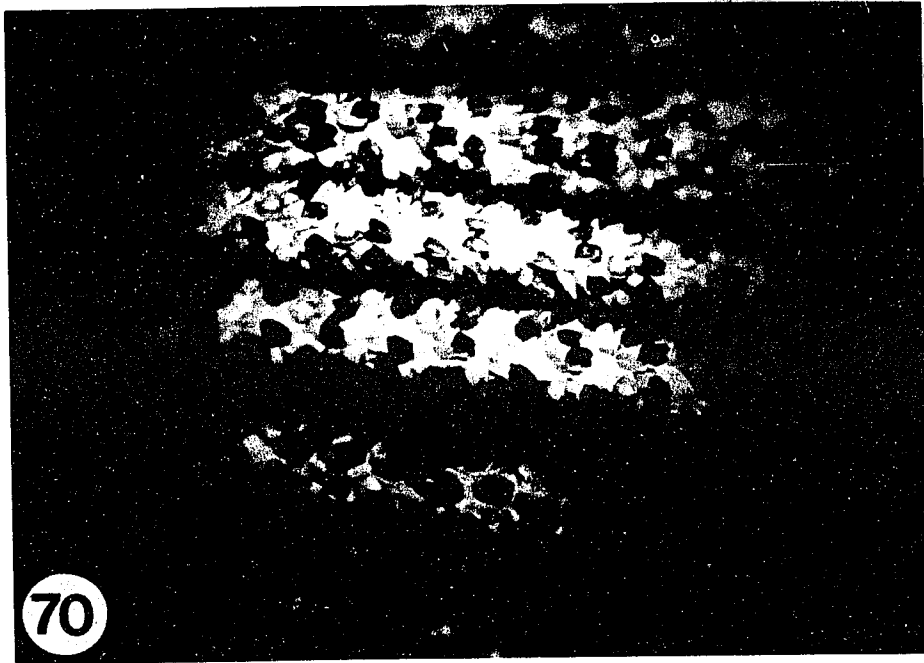


Fig. 70

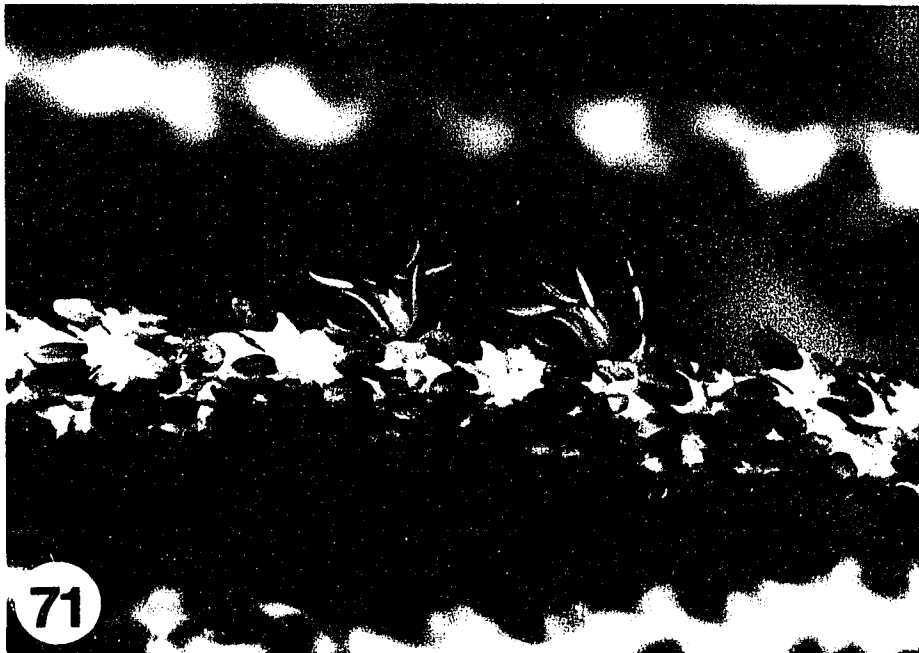


Fig. 71

still wrapped inside the calyx, with just the very end poking out - basically they looked closed and immature (these can be detected in Fig. 70). The rachillae on which the flowers were born were papery white. The rachillae of the upper part of the inflorescence were all grouped together and either horizontal or slightly pendulous. A few flowers had fallen off and were seen to be contained in the lower bract. Female flowers were primarily confined to the lower two thirds of each rachilla. When both male and female flowers were present (all of this lower two thirds), they were borne in triads.

After 45 minutes of observation the lower bract was hanging ready to fall. Meanwhile on an adjacent stem and another individual there were different stages of development noted. On the other individual there was a leaf sheath about to fall off.

Further observations were made at 8 a.m. the next morning. The female flowers of the second inflorescence from the top were judged to be receptive for fertilization due to their ripe appearance. Lots of small black bees were interested in this inflorescence. There were few (virtually none) ants present and 2-3 small brownish wasps were seen around the inflorescence.

Wind was seen to drive the small black bees away. Neither of the bee species observed was seen visiting the female flowers, but merely walking along the rachillae. On the uppermost inflorescence, the prophyll (upper bract) was now almost completely open and about to fall off.

On an adjacent stem and a nearby individual there were two inflorescences which were entirely enclosed by the two outer bracts. These inflorescences were bagged (Fig. 67, explained under Methods) after removal of the bracts to test for fruit development in the absence of outside pollen sources.

11 days after these first observations I had the opportunity to check on the progress of this experiment when our boat passed through the area again. Both the bags were in good shape as were the inflorescences within them (Fig. 68). In one of them, many male flowers had fallen into the bottom of the bag but they were not rotting. Most flowers on the inflorescence were still unopened. A few male flowers were open on this inflorescence while other male flowers had not yet opened. None of the female flowers were open yet. The second inflorescence bagged was obviously in a more immature state than the first since very few flowers had

fallen and none were yet open. I was concerned that the large number of fallen flowers in the first bag, which were soaking in water, would lead to rotting eventually.

Mrs. Melissa Lawton, an extremely helpful and interested person, brought these entire inflorescences in tact within their bags to Belém for me to examine at the beginning of January, about nine weeks after our last visit to her property. Upon examination there appeared to have been at least some initial development of the fruit since the ovaries were somewhat swollen. Both the inflorescences had been collected, and remained, in good condition, thus rotting had not been the problem I anticipated.

Belém site

Observations on this specimen of Euterpe oleracea were carried out daily over a fifteen day period and confined to one inflorescence. The observations made will be presented in a chronological sequence.

Day 1. 5.30 p.m. The inflorescence was unopened and the lower bract was golden-brown.

Day 2.

8.10 a.m. The inflorescence had opened out. The lower bract was gone and the rachillae were splayed out.

9.00 a.m. The inflorescence was observed at close range from this point on using a ladder. Open male flowers were present (Fig. 71) and there were many insect visitors. A scent was noted. The flowers had a pale reddish-purple color. The bees that were visiting were identified as Trigonid bees by Bill Overall of the Museu Goeldi and he also identified two species of ants. He suspected the bees were probably pollen robbers and the ants not to be probable pollinators since they were terrestrial and probably could not cover enough distance to pollinate.

4.00 p.m. Most flowers which had been open in the morning had fallen off or were about to fall. Therefore most of the flowers present were closed since they had not yet opened. The top bract which was yellowish-brown outside was still just hanging on. It appeared that more male flowers would open the next day.

Day 3.

8.20 a.m. Some male flowers were open with a majority of those showing any activity being in the process of opening. The anthers of all these flowers appeared not to have dehisced yet (Fig. 71). A large scarab beetle,

which had also been present the previous day, was observed to be apparently eating in the center of a flower. Ants were attacking it or at least congregated around it. The beetle was fluorescent bluish-green and ca. 2.5 cm long. No bees were present.

9.15 a.m. Many more insects were present and many male flowers open, probably more than on day 1. The insects included small flies, a large fly, bees (Fig. 72), many ants and the same large beetle. 2 glistening drops of clear exudate were noted just less than half way down the sterile pistil column (pistillode) which is present in the male flowers. These drops were located either side of the column and were presumed to be a nectar attractant. At this time the anthers had a straight line running longitudinally along their centers, indicating that they were dehisced. The bees were apparently collecting pollen from them. The flowers were noted to be somewhat stiff and waxy, possibly indicating that this condition would help them stand up to ravaging by insects.

2.15 p.m. Most of the opened flowers were still on the inflorescence. Many small flies were visiting but there were no bees now. Many ants, especially a red kind, were crawling along some of the rachillae. The flowers had their filaments splayed out and the anthers were recurved on either side of the filament with wavy edges

FIG. 72. A bee visiting the male flowers, possibly a pollen robber. Note the presence of many flowers and the pollen sac on the bee's leg, and the flower colorations.



Fig. 72

to the dehisced pollen chambers (Fig. 73). The pistillode was split into two or three divisions at its apex and had a slight pinkish coloration at the tip. Pollen from the dehisced anthers was observed lodged between the base of the petals and the androecium, which could possibly be picked up by insects' legs.

2.30 p.m. There was a heavy rain for fifteen minutes which is noted in case it had some effect on the day's floral activities.

4.45 p.m. Most of the opened flowers had fallen off. The remaining ones were loose and it appeared more would open the next day.

Day 4.

7.15 a.m. The day was rather dull for the normal sunny conditions and no flowers were open yet.

11.00 a.m. Many male flowers had opened and there was much insect activity. Four of the large fluorescent scarab beetles were present. They were crawling over the inflorescence and had their mouthparts buried in the middle of flowers.

Day 5.

6.15 p.m. 9-10 male flowers were found in a poor state but still on the inflorescence, therefore the sequence of flowering with male flowers opening in the morning

FIG. 73. Author's drawing of anther after dehiscing.
Note the wavy edges where the anther has split open and
the pollen visible within.

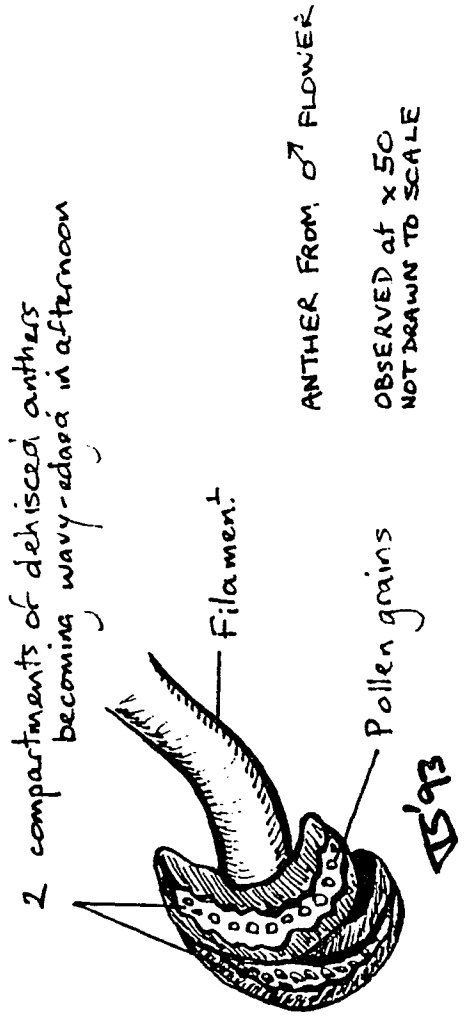


Fig. 73

and falling by late afternoon had no doubt been followed.

Day 6.

1.45 p.m. Many male flowers were present, giving a stronger odor than previously noticed, somewhat like almond essence. Many insects, including many ants, were present. Four pairs of the fluorescent scarab beetles were noticed, apparently copulating with each other. The female beetle (underneath in the copulating position) was apparently feeding on the male flowers.

Day 7.

1.00 p.m. Many male flowers were open but few male flowers now remained on the inflorescence. Again there was a fairly strong almond essence scent, 3-4 pairs of the copulating beetles were observed and the females had their heads buried in the male flowers.

Day 8.

3.00 p.m. There were still male flowers open but many lacked their center parts. These had either been eaten or lacked parts. Few flowers now remained on the rachillae, most of those remaining being females (unopened still). The top half of the rachillae were virtually devoid of flowers with the main concentration

being near the base of each rachilla.

Day 9.

3.00 p.m. Only a few flowers were open and these had only petals. It is surmised that the two sets of flowers on these ultimate two days never had additional parts.

Day 10.

4.15 p.m. No flowers of any kind were open (Fig. 74).

Day 11.

9.30 a.m. The first female flowers were opening. Ants were present as always, some visiting flowers.

2.00 p.m. 9-10 female flowers were counted with their stigmas protruding conspicuously.

4.15 p.m. A few flowers were still present with their stigmas protruding through the petals.

Day 12.

12.30 p.m. Again the female flowers were open (Fig.75), apparently receptive and possibly producing nectar.

Many insects were present and appeared to be taking nectar. Medium sized flies appeared to be regurgitating droplets of a clear liquid, perhaps nectar. The same species of beetle that visited the male-ripe

FIG. 74. Rachilla between male and female flowering stages. Note the absence of many flowers (all males have gone) compared to fig. 70. All these unopened flowers are females.

FIG. 75. Female flowers after opening. Note the color, illustrating an insect attractant.



Fig. 74

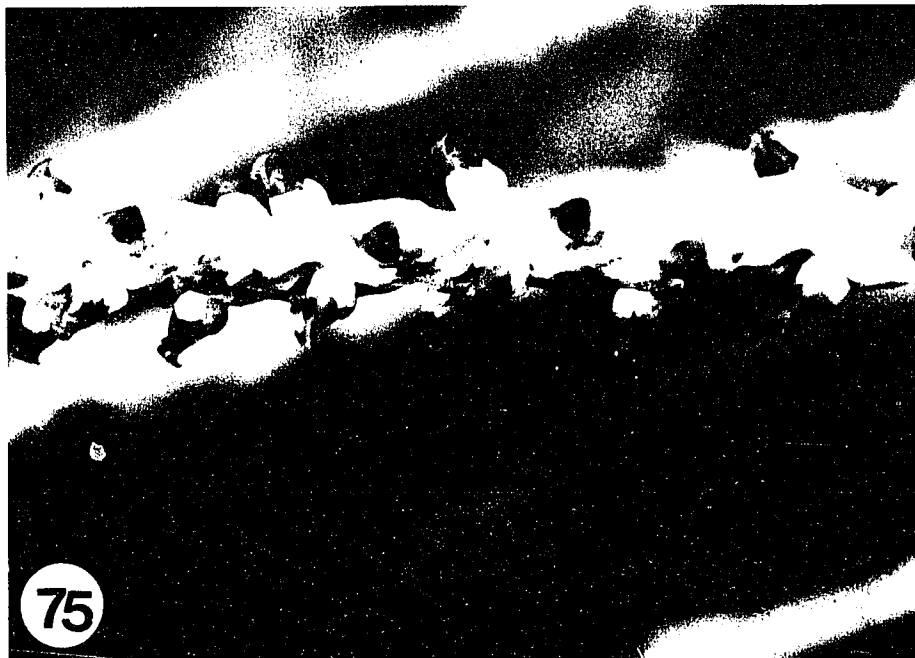


Fig. 75

inflorescences were systematically walking up and down the rachillae, visiting flowers that they bumped into. No insects were seen to be chewing on the flowers. In one 45 minute period only one beetle was observed. It's behaviour was closely observed. It had two antennae which swept back and forth as it moved up and down the rachillae. These antennae had digitate processes like the fingers on a hand which it moved through the air in front of it. It was not clear whether these touched the stigmas or not, but when reaching a flower and sucking it folded in it's processes on the antennae. Several species of small fly were noticed, the smallest of these being the most abundant on the rachillae. The ants present were not stopping at flowers but surrounded and attacked one fly, although this fly may have been dead already. All the stigmas were palish pink in color.

Day 13.

9.30 a.m. The female flowers were still out on this day and a large individual of the scarab beetle was visiting several flowers.

10.30 a.m. Two large scarab beetles were eating or sucking from the female flowers. They clambered up and down the rachillae, walking over flowers and visiting several flowers on one rachilla. One beetle walked from one rachilla to another. When disturbed the beetles

would fly away. In both these morning observations a slight perfumed odor was present.

2.45 p.m. No scarabs were present but small flies and ants were. The flies were visiting the female flowers. Two species of ant were present, a large black one where only one was seen while the other was numerous. All the female flowers which were out appeared to have been out all day. Many of these flowers had turned from their light pinkish-maroon color to a dark blackish-purple, perhaps indicating that they had been pollinated or fertilized. Another possibility was that they had been mutilated in some way by visiting insects, especially perhaps the scarab beetles. From the fact that in most cases the darkened flowers were concentrated on individual rachillae, at this point it was concluded that this was probably caused by the scarab beetles since their behaviour was to move slowly along individual rachillae. Another possibility was that senescence of flowers followed a pattern of some rachillae aging earlier than others. The flies which were present were more mobile in their behaviour and therefore more random in their movement. About 67 rachillae were counted to be present in this inflorescence. Seven had significantly darkened flowers at this point. One rachilla was counted to have 54 total female flowers open, 20 of which had turned or

were turning the dark purple color. At this point an examination of the female flowers was made. In what appeared to be a fresh, receptive condition the calyx was papery white (Fig. 75). Inside this were three tightly wrapped overlapping petals (Fig. 76) which were waxy, darkish purple in their upper half and a lighter pale pinkish-white in their lower portion, some of which was obscured by the calyx. The gynoecium was divided into three stigmatic lobes which appeared to be either glandular or pollen covered on their inner surfaces (Fig. 76). On some of the flowers the tips of the stigmatic areas had turned dark purple and were starting to contract or wilt (Fig. 77). On others, the stigmatic tips were quite curled up, the whole of all three visible stigmatic lobes turning dark purple (Fig. 78). On yet others one or more of the apices of the stigmatic lobes was missing, perhaps having been chewed off (Fig. 79). One flower was observed where only one of the three stigmatic tips appeared to have turned dark purple. In the case of one particularly notable flower, but also observed in several others, the ovary area appeared to have turned hard and whitish, perhaps an indication that they had already been fertilized and fruit development was beginning.

FIG. 76. Author's drawing of female flower in mid-afternoon.

FIG. 77. Author's drawing of female flower in mid-afternoon.

FIG. 78. Author's drawing of female flower in mid-afternoon.

FIG. 79. Author's drawing of female flower in mid-afternoon.

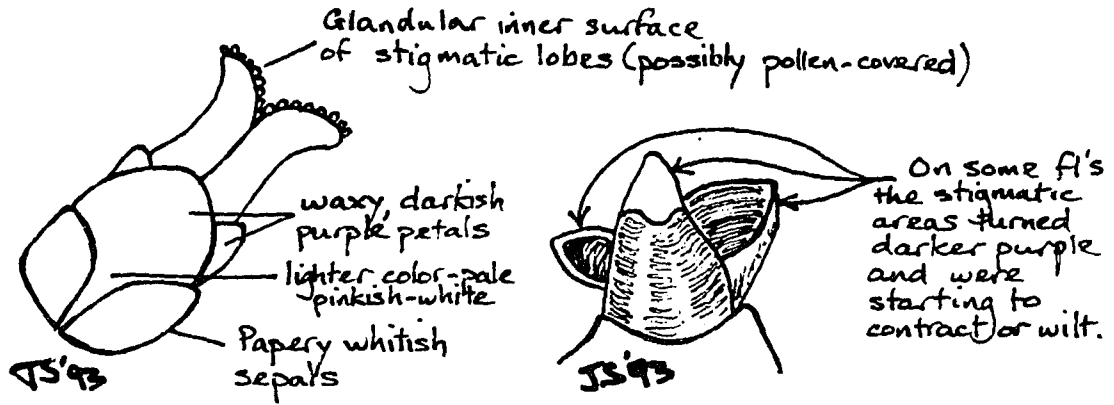


Fig. 76

Fig. 77

♀ FLOWER

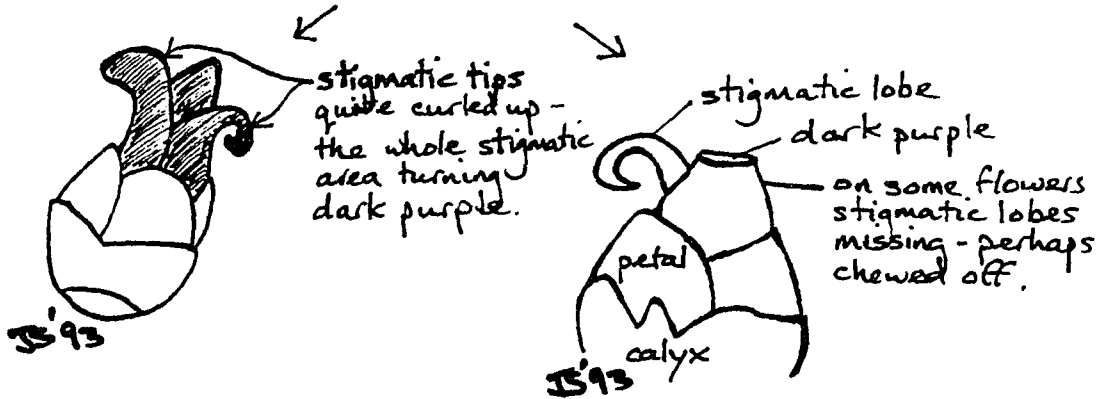


Fig. 78

Fig. 79

Day 14.

9.50 a.m. One scarab beetle was observed on a rachilla and flew away when disturbed for a photograph.

Day 15.

6.50 a.m. Just a few ants were seen and no other insects. The majority of the flowers in the inflorescence had turned dark purple by this point.

9.30 a.m. Only three or four ant individuals were noted and no other insects, presumably indicating that the inflorescence was no longer attracting insect visitors.

At this point the pollination cycle of the inflorescence was judged to be complete and no further observations were made.

Upon return to the United States the insect visitors collected were brought to the American Museum of Natural History and tentatively identified by Dr. Toby Schuh with comments that are included below on associated behaviours. Besides those identified as Trigonid bees earlier the other identifications were as follows: at least 2 species of Acalypterate flies, Mussida mastica (a fly) and another parasitic fly species (which was therefore not a pollinator), Tephyrid fruit flies (whose larvae are plant feeders), two or

more Melaponide bee species (one of them possibly Trigona), many different species of ants (which are usually looking for nectar and at best would be accidental pollinators), a species of Cercopidae in the order Homoptera (definitely not a pollinator since as larvae and adults they feed on juices which they extract from plants) and finally the scarab beetles which probably belong to the subfamily Rutelinae. The larvae of these scarabs feed on rotting wood and could feed on vegetation such as roots.

Insects were examined under a dissecting microscope for pollen with the following results. No apparent pollen was visible on the flies although Dr. Schuh noted that some of the flies could move from plant to plant. A species of Hymenoptera had pollen over its body and head. Several ants that had been visiting male flowers had 2-3 pollen grains on them, especially on the tail part of their body, although Dr. Overall's comments that it is unlikely for terrestrial ants to carry pollen to another tree with a receptive female inflorescence seem to make these highly improbable pollinators. Other ant species were found to have no traces of pollen. Some ant species were observed microscopically to have finely hairy bodies which would make a good pollen trap and these were noted to have some possible pollen

traces. A small bee which had been visiting the Marajó tree had quite a lot of pollen stuck in hairs on it's body, while another species visiting the same plant also had pollen stuck to parts of it's body. Several of the scarab beetles collected from the Belém pollination study had pollen grains on various parts of their bodies (Fig. 80), including the legs, but especially in hairs on the lower side of their bodies between their two sets of front legs (Figs. 80, 81 and 82). One set of these hairs was positioned directly beneath the head (Figs. 80 and 81) and the other directly above the extension of the breast plate (Fig. 82). Many pollen grains were found in these areas, apparently due to the insects' positioning over the flowers they visited to feed upon. This was documented by collections from both male and female flowers. They had numerous pollen grains adhering to a fringe of hairs directly beneath the head. One individual was also noted to have gummed-up, whitish, sugary-looking substances around a possible mouth area, quite probably from sucking nectar from the flowers. This individual was also noted to have five tick-like insects adhering to it's thorax immediately above the breast plate and below the fringe of hairs (Figs. 80 and 81).

On various occasions the scarab beetles were

FIG. 80. Underside of scarab beetle with head at top. Note the 'breast-plate' projecting upwards to just over half way up the photograph. Note the hairs in the upper portions of the body and below the head, and the pollen grains adhering to the area where there are hairs.

FIG. 81. Note the abundance of hairs here on the underside of the scarab beetle's body, immediately below the head, and the pollen grains adhering to them (small whitish-clearish dots). The four largish white objects in the center of the photograph are small insects which were adhering to this part of the body.

FIG. 82. Underside of scarab beetle showing the top of the 'breast-plate' illustrated in fig. 80. Note the hairs in this area and the pollen grains adhering to them.



Fig. 80



Fig. 81

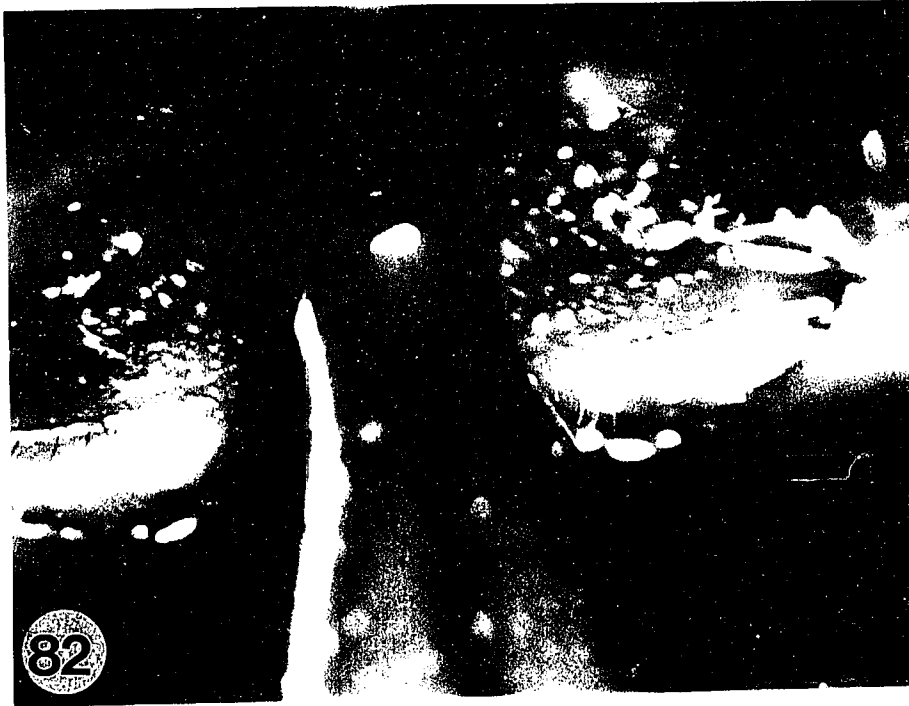


Fig. 82

noted to fly in to the inflorescence from other areas and similarly to leave and fly off somewhere else when disturbed. This mobility also implicates them as probable pollinators since they could easily move from individual to individual, visiting male and female flowers within a short space of time.

Discussion

In the way of discussion and conclusions it is thought best to first summarize the observations outlined in the results section to give a more simplified picture of flowering cycles, both overall and on a daily basis, as well as patterns of insect behaviour linked to these cycles. I must note, however, that it is dangerous to rely on generalizations in drawing conclusions, since many factors can come into play. For example, on two days a particularly strong almond essence-type scent was noted, and this was accompanied by four pairs of scarab beetles mating while feeding. This pattern was not noted daily, hence the danger of perhaps oversimplifying and summarizing as if there was an exactly repeated daily pattern. For most precise information, therefore, the reader is directed to the results section. The two situations studied will

be discussed separately since each had a different focus as well as methodology.

The following summarizes observations from the Rio Jaruzinho site. This plant was in its natural habitat at the water's edge although the land nearby was cleared for a garden and house. Four inflorescences were present on one individual in late October. Borne on successive or closely spaced nodes, three successive inflorescences were radially separated by 160 degrees and 110 degrees respectively. Inflorescences were held at about 60 degrees from the stem axis while the lowermost was at just over 90 degrees, possibly since it was heavily laden with fruit. From top to bottom, stages of development on these four inflorescences were as follows: 1 - Inflorescence opening; 2 - Female flowering stage; 3 - Young fruits present, green, 7-8 mm diameter, papery calyx persistent; 4 - Fruits still green, up to 1.5 cm diameter, calyx persistent. The female flowers had tightly closed petals, red to deep purple on their exposed portion. The stigmatic lobes were held at 75 degrees from the flower's axis, slightly paler in color than the petals. Male and female flowers were borne in triads where both were present. Female flowers were more frequent in the lower two thirds of the rachillae, largely absent from the apical portions.

This appears adaptive since lower parts of the rachillae could mechanically better support developing fruit. Male flowers were present for the entire length of the rachillae. Their petals were purplish-pink on the outside prior to complete flower opening. Upon bursting from the ensheathing inflorescence bracts, rachillae were papery white, turning cream in later stages of inflorescence development. In the lower one half to one third of the inflorescence they were inserted and positioned laterally or abaxially, but not adaxially. At the same moment rachillae in the upper part of the rachis were either horizontal or slightly pendulous. During female flowering both the main inflorescence bracts had fallen. Female flowers appeared receptive by 8 a.m., attracting many different kinds of insects, including ants and wasps. Many small black bees were present, but were not seen to visit female flowers, just to be walking along the rachillae. Again it is noted that these observations were limited to a short time.

Examination of fruit development in two infructescences which had been isolated by bagging, appeared to show slight swelling of the ovaries. However, further study of this is required. Swelling was very slight, probably about eight weeks after female flower development. Since swelling was noted much

earlier in the prolonged Belém study, it is probable that true fruit development would have been much more conspicuous. Since these individuals were suggested to be açai branco, further isolation of verified individuals of this as well as açai preto are merited. The suggestion by locals that açai branco changes from its yellow color to the 'black' form, when planted near the black form, also merits further investigation to see if there is any genetic basis for this.

Observations of the individual on the Museu Goeldi grounds can be summarized as follows. The inflorescence was first observed with the inflorescence closed, the lower bract being golden-brown in color. By 8 a.m. the next morning (day 1 of flowering) it opened, the lower bract had fallen and the rachillae were splayed out. The top bract, yellow-brown on its outside, hung on for several days. The inflorescence had about 67 rachillae. By 9 a.m. the first morning, open male flowers were present, with many insect visitors. Flowers were pale reddish-purple, stiffish, and somewhat waxy, probably to help withstand insect ravaging. Following is a sequential account of flowering and insect visits and behaviour. Many days' observations have been combined to give a generalization of these sequences. It should be noted that the days

cited here are one less numerically than the days given in the results section, since day 1 in the Results section of this chapter was the day prior to the beginning of flowering.

Male flowering took place for eight days although on the seventh and eighth days no androecium was observed. By the sixth day very few male flowers were left on the inflorescence although many were still open. By the seventh day the top half of the rachillae were virtually devoid of flowers, since the males were virtually finished and females were mostly absent from this area. On the ninth day no flowers of any kind were open. Female flowering commenced on day 10, about 10 flowers opening. By day 12 the flowers on 7 of the 67 rachillae had significantly darkened flowers. On one rachilla 54 flowers were open, 20 of which had turned, or were turning, dark purple. By the fourteenth day the majority of female flowers had turned dark purple and female flowering was judged to be completed, there being no insect visitors except a few ant individuals. This helps confirm that a combination of flower color and scent (there was no scent remaining) probably attracts insects, not perhaps just rachillae color which may have been an attractant for scarab beetles (beetle-pollinated inflorescences were said to be cream colored by

Henderson, 1986). Female flowering lasted four days and the complete cycle thirteen days.

Daily activities included the following during male flowering. On a dull day by 7.15 a.m. no flowers were yet open. On other days by 8.20 a.m. some male flowers were open while many were in the process of opening. Anthers appeared not to have dehisced yet. Scarab beetles were seen. By 9 a.m. Trigonalid bees were seen which collected pollen from the now dehisced anthers. These may have been pollen robbers. Several species of ants were observed. Many different insects were seen and scarab beetles continued to feed from the center of flowers. Many of these insects, including small flies and some large ones, persisted through different stages of the morning. By 9.15 a.m., 2 glistening drops of clear exudate were coming from just under half way down the pistillode, located on either side of the column. This was probably a nectar attractant. Scent was noted and many flowers were open; the number of flowers increasing from day one to day two. At 11 a.m. many flowers were open. There was much insect activity, with four scarabs present, crawling over the inflorescence, their mouthparts feeding in the middle of flowers. At 1 p.m. many flowers remained open. There was a strong almond essence smell and 4

pairs of copulating scarabs were present. At 1.45 p.m. the strong odor remained. Many flowers remained open. Many insects, including ants, were present. 4 pairs of scarabs copulated while the females fed from the flowers. At 2.15 p.m. flowers remained open. Filaments were now splayed out, the anthers recurved on either side of the filament. Sometimes pollen had fallen into the flower corolla. The pistillode was split into 2-3 divisions, with a slight pinkish coloration at the tip. Many small flies were visiting, no bees, but many ants. Male flowers remained open at 3 p.m, although insect visits appeared to have ceased. By between 4-5 p.m. most flowers had fallen and by 6.15 p.m. only 9-10 remained.

Following is a summary of daily activities during female flowering. These flowers had a papery white calyx closely surrounding 3 stiffish, overlapping petals, which changed during their cycle from light pinkish-white to darkish purple in part. The gynoecium was divided into 3 stigmatic lobes which also changed from pale pink to dark purple during their cycle, contracting, wilting or curling up. The ovary area turned hard and whitish later in the cycle, perhaps indicative of fertilization and fruit development. By 9.30 a.m. female flowers were open and a slight perfumed

odor was being given off. Various ants were observed, some visiting flowers. Large members of the scarab species were seen visiting several flowers. At 9.50 a.m. scarabs continued to visit and at 10.30 they were observed sucking from the flowers. The same perfumed odor persisted. The scarabs clambered up and down the rachillae, walking over flowers and visiting several flowers on one rachilla, also walking over to another rachilla. At 12.30 p.m. flowers appeared receptive, producing nectar; stigmas were still pale pink. Many insects were present taking nectar. Medium sized flies were apparently regurgitating nectar. The scarabs walked systematically up and down rachillae, their antennae sweeping back and forth in front of them, visiting flowers they bumped into, and sucking on nectar. Several small fly species were seen, the smallest, possibly a Drosophilid, being most abundant. Different ants were present. By 2.45 p.m. many flowers had turned from a light pinkish-maroon to a dark blackish-purple, probably due to either pollination, fertilization, insect ravaging or senescence - this sequence may be correlated to the scarab behaviour since it occurred on specific rachillae. At this time of day no scarabs were seen, just some small flies visiting flowers and some ant species, one of them numerous. The flies moved randomly among rachillae.

Following is a summary of insect visitors to both study sites and of their behaviour, as well as a discussion of possible pollinators. Identified insect visitors included Trigonid bees, many ant species, 2 species of Acalypterate flies, Mussida mastica (a fly), a parasitic fly species, Tephyrid fruit flies, 2 or more Meloponide bee species, a Cercopidae species in the order Homoptera and Scarab beetles, probably in the subfamily Rutelinae. Other species remained uncaptured and unidentified.

Although sometimes searching for nectar, terrestrial ants are very unlikely pollinators. The scarabs appear to be good candidates for pollinators, given their mobility to fly from tree to tree, and the pollen adhering to hairs on their lower side, in the general area of the head, where they would be feeding and coming into contact with the sexual parts of the flowers. This is in addition to their habit of clambering over flowers and feeding on them, and their systematic walking up and down rachillae, visiting a number of flowers, coupled with the apparent ripening of flowers on individual rachillae. Furthermore, their frequent presence during both male and female flowering, and their repeated behaviour of copulating while the females fed from the flowers during periods when a

strong almondy scent was emanating from the inflorescence, suggests that their life cycles could be tied in with that of the palm. Indeed, Henderson (1986), noted that various authors had recognized that scent in palms attracts beetles.

Flies and bees were also observed on both male and female stages, the flies with greater frequency. Flies were thus possible pollinators, although I wonder if certain flies, especially since they were sometimes noticed later in the day after other insects had left, were coming to feed on waste materials from other insects. I have no direct evidence to support this, except that some flies are known to go to waste materials. Some flies were definitely feeding from flowers. On male flowers bees were seen collecting pollen and loading it into their sacs etc.. Bees, however, and interestingly, were never seen visiting female flowers, even though somehow attracted to the inflorescence. This lends credence to the suggestion that at least some of them are pollen robbers. Henderson (1986), however, said he saw them collecting nectar from females.

Wind pollination cannot be ruled out, although at no time were 'clouds' of pollen observed as one

observes in certain conifers during pollen release. Overall (pers. comm.) said that pollen of E. oleracea could be carried several hundred meters, making wind pollination a possibility.

Certain studies such as those of Syed (1979 and 1981) have shown that many different insect species can be involved in the pollination of one palm species, and Overall (pers. comm.) suggested the possibility for E. oleracea, including wind pollination. Henderson (ibid) said bees visited both males and females, while Calzavara (1972) mentioned Hymenoptera as pollinators.

Henderson recognized three widespread insect pollination syndromes in palms. For beetle pollination the following points are in agreement with features of E. oleracea. Inflorescences were cream colored (the rachillae only) and odoriferous. Many other features, however, such as nocturnal anthesis and stamens numerous, did not fit the syndrome, neither did I consider the odor to be "musty". Scarab beetles were thought to possibly be important pollinators in the family although their host specificity was questioned. It is interesting that the scarabs are outside the Nitidulidae and Curculionidae beetle families which were noted to be the principal beetle pollinators of palms.

In agreement with Henderson's description of a bee pollination syndrome, E. oleracea shares the following: male and female flowers colored and developing after bract fall (partially), protandry, nectar production, fewer stamens, sweet scent, female flowering temporally separated from male flowering and more short-lived than male flowering.

For a fly pollination syndrome in palms, Henderson included Drosophilidae as understory palm pollinators, and these I saw visit E. oleracea. In certain situations and times of it's life cycle, E. oleracea grows in the understory so it is possible that flies could play a role in these cases.

In conclusion, from all the information it appeared most likely that scarab beetles were probable pollinators, especially since their life cycle appeared linked to the plant's. Bees may be possible pollinators although they weren't seen visiting individual female flowers. Henderson (1986) and Calzavara (1972) implicate bees, but Overall (pers. comm.) noted pollen robbing behaviour. Flies may also pollinate, as may wasps or other less frequent visitors. Ants, though frequent and numerous, probably do not pollinate. Wind pollination cannot be excluded at this point. E.

oleracea often occurs in dense stands by rivers where it would be exposed to wind, making this mode a possibility. Overall (pers. comm.) also suggested various modes of pollination could be in effect for different growing situations, for example in sheltered forest. All these modes seem possible although the wind effect would need investigating further.

The work presented here certainly suggests the possibility of more than one syndrome at work. The colored flowers, nectar and scent suggest a bee syndrome as defined by Henderson, while the whitish-cream rachillae suggests a beetle syndrome. The presence of copulating scarabs when the almond essence odor was at it's strongest, however, seems strong evidence that they may be attracted by this. Clearly there was also an attractant in the flowers that lead them to feed from them. The limitations of this study should also be noted, in that the specimen primarily studied was in a botanical garden setting and perhaps not all the natural pollinators would be present.

ANATOMY

Introduction

As has been shown in the History section of the dissertation, recent workers have considered there to be two genera within Euterpe Gaertn., which had been accepted as a large genus earlier by Burret (1929) and others. Moore (1963) and others have recognized two genera, Euterpe Mart. and Prestoea J. D. Hooker. If there are two genera, they have not been satisfactorily separated, and have caused confusion for palm taxonomists. The problems of distinguishing between the genera have been noted by Galeano Garces (1986) and others. Clearly, more studies are needed to come to terms with this problem.

Leaf anatomy has been shown by various workers to be a useful tool in palm taxonomy at both the generic and specific levels (especially Tomlinson, 1961, and others including Uhl, 1978 and 1972 and Glassman, 1972a). It may thus be a useful tool in clarifying problems of Euterpe, such as whether it merits division into two genera.

Euterpe is a pinnately leaved palm, usually with relatively narrow and thin pinnae. This makes it a 'manageable' subject for leaf anatomy studies. Furthermore, leaf material is almost always available from herbarium material, when flowers or other characters may not be. Thus a brief pilot study of leaf anatomy has been done in order to investigate its merit. Transverse commissures are leaf veins, found in palms, that travel across the pinnae, transverse to the characteristic parallel and longitudinal veins which are so characteristic of monocots in general. Sometimes they connect principal longitudinal veins, while they may also be fragmented, making patterns on the leaf which do not connect the other veins. Tomlinson (1961) suggested they may be of use at the generic level and others have also used them in palm taxonomy. Uhl (1972) used them in a study of the Chelyocarpus alliance. In his masterful study of anatomy in the major groups of palms, Tomlinson made the following observations of transverse commissures in Arecoideae palms, to which group Euterpe belongs: "transverse commissures always at same level as longitudinal veins, infrequent, narrow, vascular tissues fairly conspicuous and with normal orientation, sheathed by 1-2 layers of sclerotic or thin-walled parenchyma; in Welfia transverse commissures wide, sheathed by fibers, and including ph. strands"

(phloem). Tomlinson has clearly studied transverse sections of the pinnae to note these features. Uhl made leaf clearings and examined the patterns formed by the transverse commissures, which are displayed in photos (1972, p. 107). For Euterpe itself, Tomlinson (ibid) noted: "transverse commissures uncommon, at the same level as the longitudinal veins, narrow, sheathed by sclerotic parenchyma". For cell inclusions, some of which which may also be noted in clearings, Tomlinson noted in Euterpe: "stegmata frequent in long continuous files adjacent to the fibres of the lamina. Silica-bodies rather small, more or less spherical, each enveloped by thick basal wall of silica-cell". For my own studies I opted to use leaf clearings as outlined below.

Materials and Methods

Since the study's objective was to examine any consistent differences between Euterpe and Prestoea, material was selected to represent both groups. Pinnae of the following taxa and collections was taken from herbarium sheets at the New York Botanical Garden: E. precatorea Mart. (Moore 9539), E. erubescens H. E. Moore (Steyermark 103997), E. oleracea Mart. (Balick 904),

P. tenuiramosa (Dammer) H. E. Moore (Moore 9717), P. montana Nichols (Henderson 3) and Prestoea sp. (Balslev 4274). In order to give an accurate representation of the pinna, material was taken to include the mid-vein of the pinna as well as one leaf margin. Approximately 2.5 cm in pinna longitudinal length was taken to allow patterns to be revealed. If material was not too brittle then it was cut carefully with scissors from the herbarium sheet. If brittle it was softened for a few minutes in the immediate area of the sample with water and detergent for penetration, or Aerosol OT solution (Ayensu 1967). The methods of Martens and Uhl (1980) were largely followed in the preparation of cleared, stained material from these samples. Samples may be first rehydrated and fixed for indefinite storage in glycerine alcohol (as per Martens and Uhl, *ibid*), especially if other anatomical work is to be done on the material. In this case they would then follow the steps outlined below. Otherwise they may be directly prepared as follows. Place in 5% NaOH overnight (or up to about 7 days if not warming) in a 60 degree C. oven. Wash in three changes of deionized water (two hours each). Place in one third strength commercial bleach until clear. Wash thoroughly in distilled water. If desired, the specimens can be stored permanently in glycerin alcohol at this point, or one can proceed to the next

step. For staining and preparing permanent mounts the following steps were followed: 50% EtOH (15-30 minutes); 70% EtOH (15-30 min.; material may be stored for 18 hours or longer at this step); 95% EtOH (15-30 min.); Safranin (for red staining) overnight; three separate baths of absolute alcohol for one minute each; xylene/absolute alcohol 50:50 (five min.); xylene (30 min.); xylene again (30 min.); xylene/resin (balsam) for 5 min.; mount on slide with resin. Specimens were drawn at various magnifications using the camera lucida. The following magnifications are represented in Figures 83-88. E. precatória x 20, E. erubescens x 26, E. oleracea x 28, P. tenuiramosa x 24, Prestoea sp. x 24 and P. montana x 14. In Figure 89, all these magnifications are further reduced, but all by the same per cent.

Results

All the Euterpe species showed a fragmented pattern of transverse commissures, almost without any connection of adjacent main veins (Figs. 83-85 and 89). All the Prestoea species showed multiple transverse commissures joining adjacent main veins (Figs. 86-88). Certain taxa, particularly P. montana (Figs. 87 and 88),

show some intermediacy, having both a good number of fragmented t.c.'s as well as continuous ones. E. oleracea and E. precatoria show considerable similarity in their sparse patterns. P. tenuiramosa showed dark-staining flecks (Fig. 86) scattered all over the lamina, which could be tanins, silica-bodies or other inclusions. Veins are represented exactly to the scale and order of magnitude at which they were observed in all the Figures (83-89). Primary veins are the largest and are the mid-ribs. Secondary veins are in all cases the leaf margins. Third and fourth order veins can be located in the figures.

Discussion

The results support the concept of two groups since all Euterpe had fragmented t.c.'s while all Prestoea had continuous t.c.'s. The flecks seen in P. tenuiramosa are interesting and could be of diagnostic significance. Tomlinson (1961) examined E. oleracea and E. broadwayana Becc. for his studies, noting t.c.'s to be uncommon in Euterpe. This, no doubt, means infrequent, since their presence is clear from my study, but they are not abundant in E. oleracea and E. precatoria. They are, however, more frequent in

FIG. 83. Transverse commissures of Euterpe precatoria.
Note the lack of continuous t.c.'s.

FIG. 84. Transverse commissures of Euterpe erubescens.
Note the lack of continuous t.c.'s.

FIG. 85. Transverse commissures of Euterpe oleracea.
Note the lack of continuous t.c.'s.

FIG. 86. Transverse commissures of Prestoea tenuiramosa. Note the presence of continuous t.c.'s.

FIG. 87. Transverse commissures of Prestoea sp. Note the presence of continuous t.c.'s.

FIG. 88. Transverse commissures of Prestoea montana.
Note the presence of continuous t.c.'s.

FIG. 89. Comparison of three Euterpe spp. with three Prestoea spp. Note the lack of continuous t.c.'s in all three Euterpe spp. (left side of plate) while all the Prestoea spp. (right side of plate) have continuous t.c.'s.

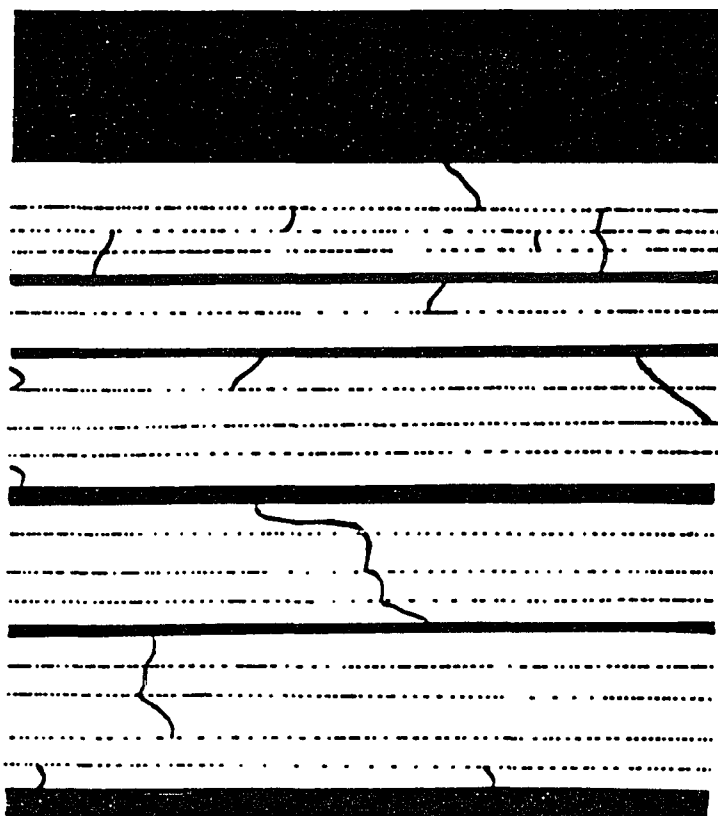


Fig. 83

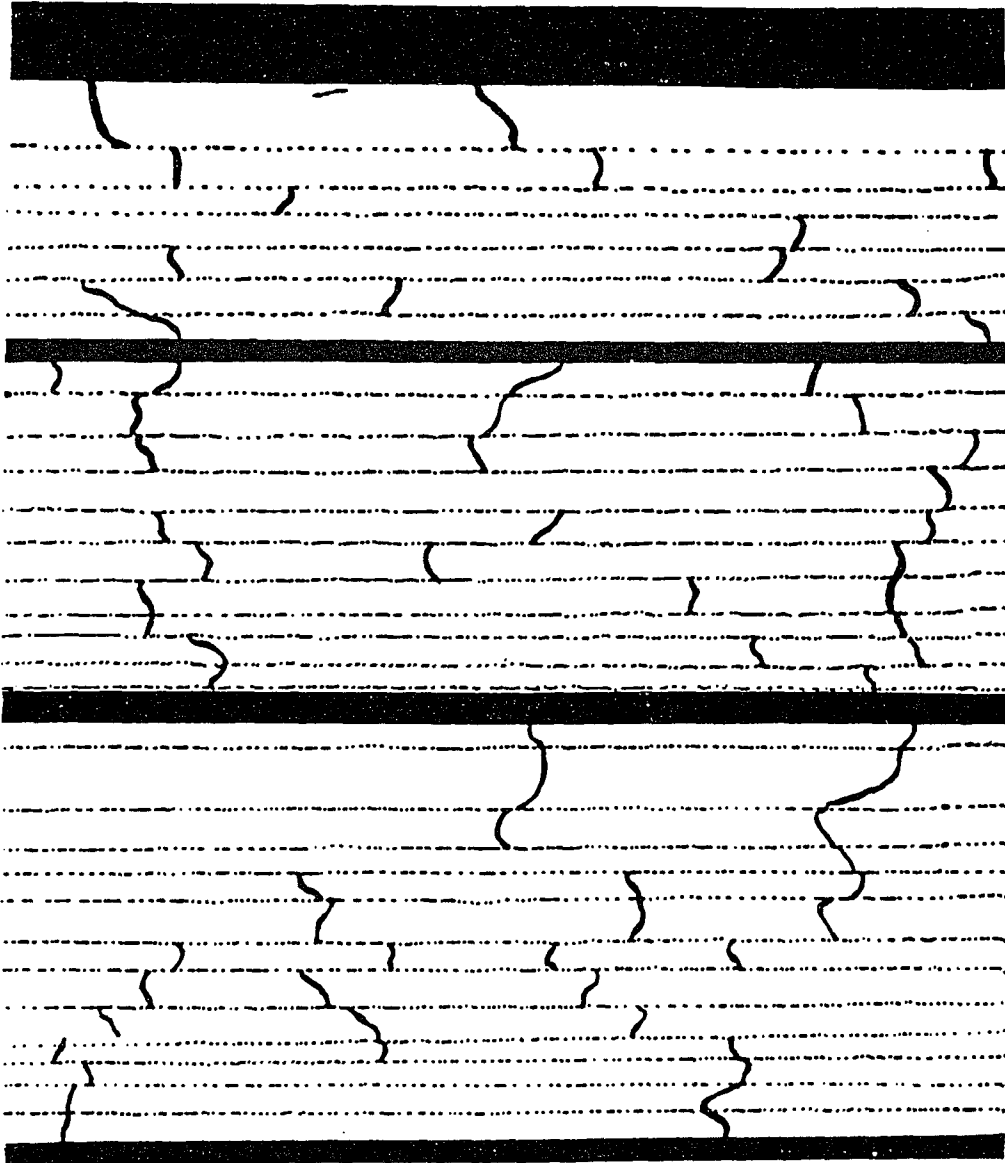


Fig. 84

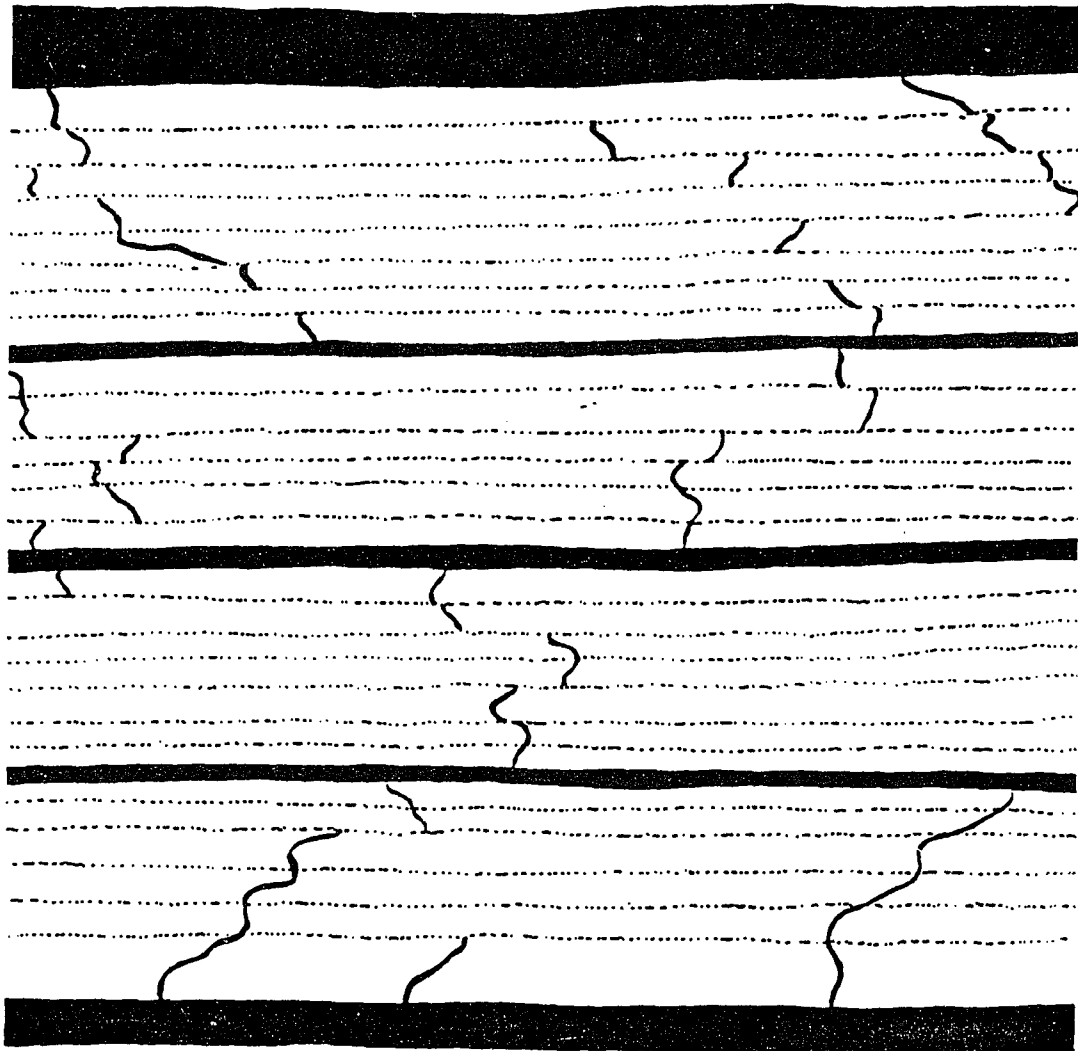


Fig. 85

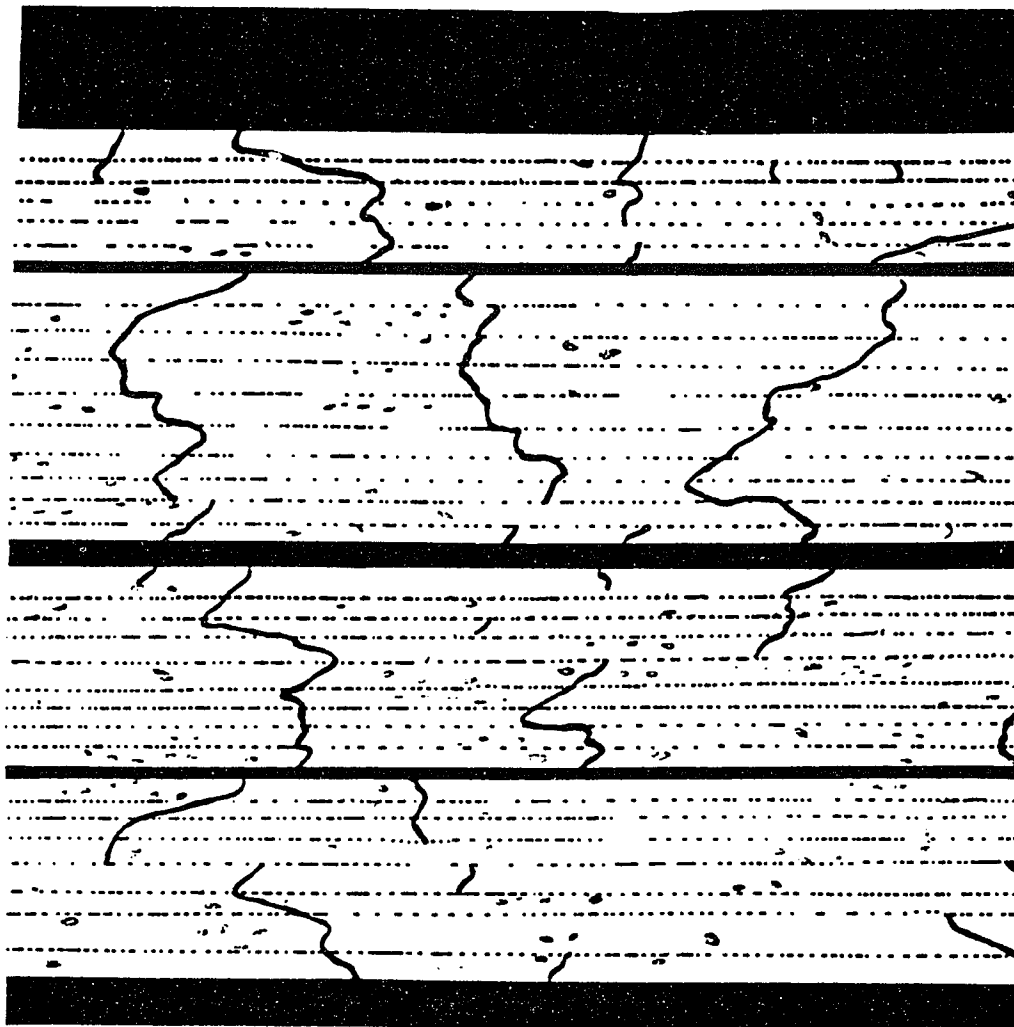


Fig. 86

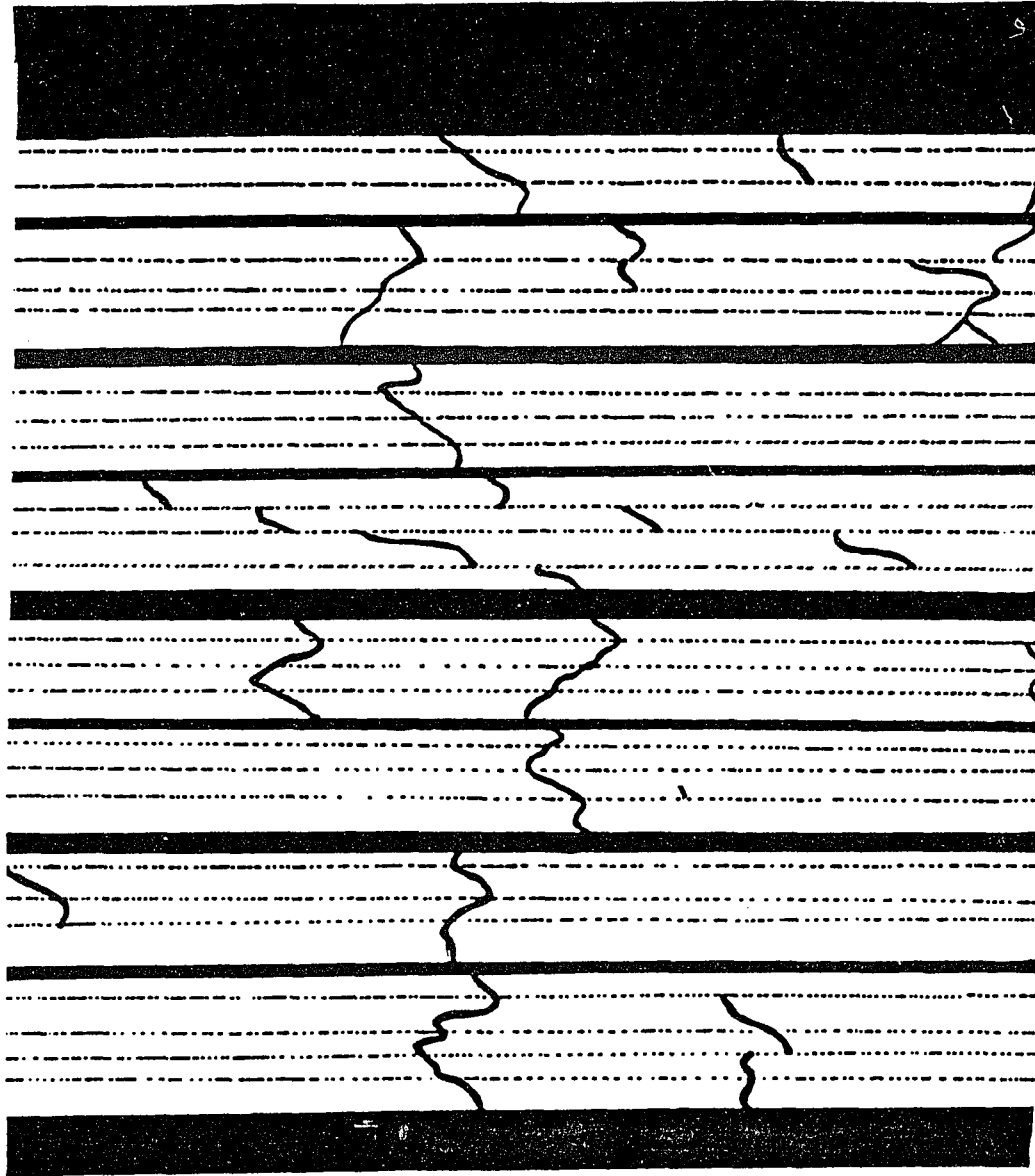


Fig. 87

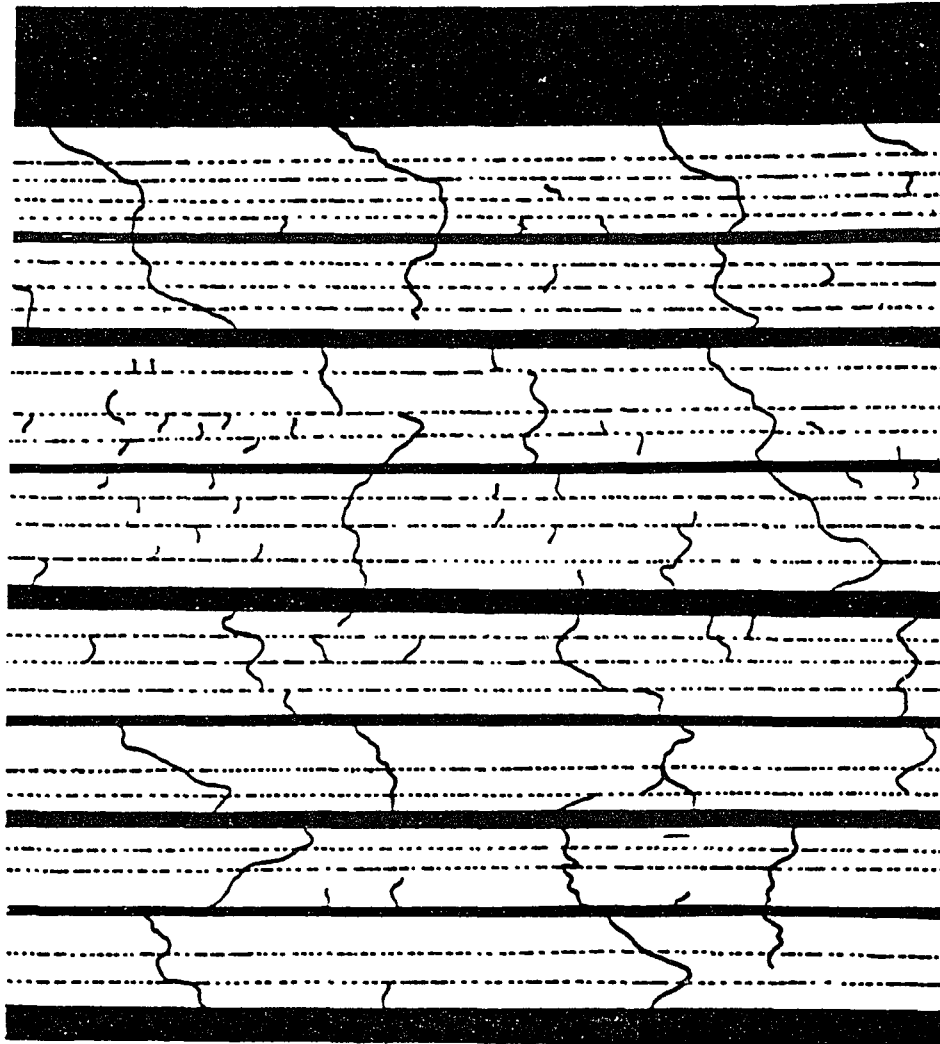


Fig. 88

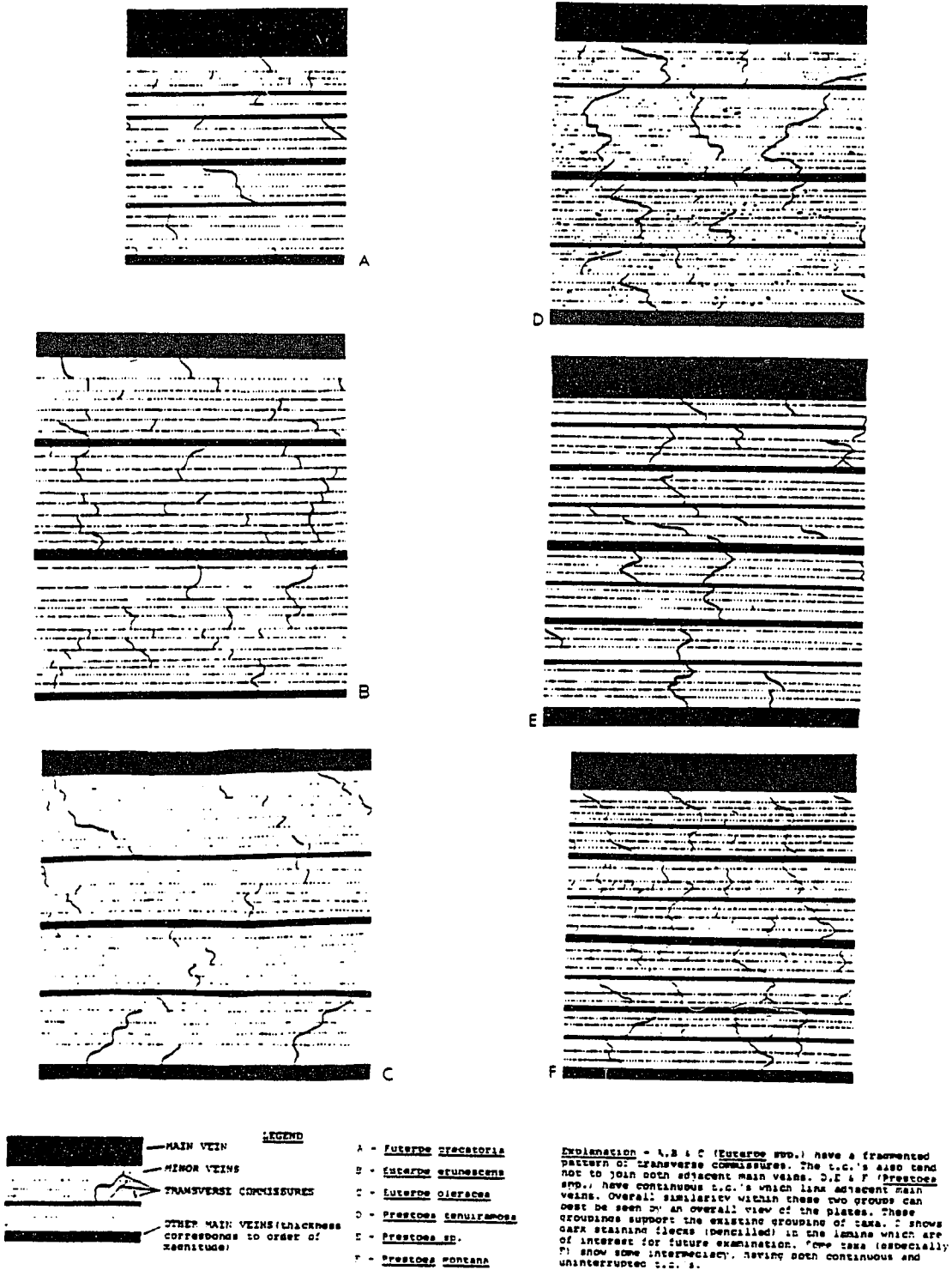


Fig. 89

EUTERPE and PRESTOEA VENATION PATTERNS

E. erubescens (Fig. 84). Interestingly, this is a highland species and perhaps there is some correlation. Both the other Euterpe species are lowland species. The similarity of E. oleracea to E. precatoria is not surprising since the crowns and leaves of these species are similar and they share a similar and often close geographic distribution, perhaps indicating a close relationship. Although differences between the two groups, Euterpe and Prestoea, are apparent in transverse commissures, more taxa would have to be studied to draw further conclusions. I still remain sceptical as to the possibility of dividing these taxa into two genera, given many other unclear characteristics between them.

CONCLUSIONS

This dissertation has focused upon several areas in the genus Euterpe that were in need of work. These included taxonomic and nomenclatural history as it relates to understanding the genus today, ethnobotanical and economic uses of the genus, and anatomy as it relates to the taxonomy. The thesis also concentrated on the most economically important species, E. oleracea. This species was studied in the Amazon estuary, where it appears to be at it's most utilized. It's pollination, role in agroforestry situations and in forests that are commercially managed for the palm heart industry are all studied and discussed. The most in depth study to date of it's all around importance and utility to the region is also included.

From the studies in the History of Euterpe presented here it is concluded that with our current state of knowledge of the genus it is better to stick with the nomenclatural decision of Moore (1963), leaving the name as Euterpe Mart.. Even though I would be happier to recognize Euterpe Gaertn., until such time as a complete and in depth study of all the fruits of Euterpe and Prestoea is done, it is impossible and

unreasonable to base the genus on Gaertner's fruit drawing. For lectotypification, it is also better at this stage to stick with Moore's designation of E. oleracea Mart.. This species was well described and illustrated and makes a good lectotype, again being far preferable to the use of E. globosa Gaertn. at this time, whose fruits were discussed above and are unable to be placed with certainty. However, some authors have noted discrepancies, notably Barbosa Rodrigues, of Martius' description and illustrations of E. oleracea with the common açai of the Amazon estuary, upon which it was supposedly based. I second these feelings, especially since for a botanist who spent as much time in the field as did Martius, it seems impossible that he could have erred in noting E. oleracea's multiple stems. It also seems unlikely that he could have erred in assigning it pinnately-leaved seedlings as opposed to the bifid eophylls it possesses, since the seedlings are so abundant, both in it's habitats, as well as in the açai-making locations around Belem etc.. I therefore propose that this be further investigated. Regarding the distinctness of Euterpe and Prestoea, it has been shown that past authors have had differing opinions on this, and only since about the 1950's has there been a tendency to group them separately. There are still no satisfactory parameters for distinguishing the two and I

believe they should be left as one. It is of no value to transfer species from the former Euterpe into Prestoea until such time as there is shown to be very good and sound grounds for separation. Such steps only add to nomenclatural confusion and further obsolete names in an already overcrowded nomenclatural world. Perhaps some authors are just interested in getting their name after a taxa, or another publication, without first being assured that their science is good. The detailed history presented here, I hope, will serve as the basis for the taxonomy of the group to be built upon.

In the survey of ethnobotanical and economic literature it was shown that a wide variety of species of Euterpe have a wide variety of uses. This should serve as a basis for any further development projects within the genus. Clearly, E. oleracea is the most economically important species and probably the most intensely used in terms of the number of people it serves, it's frequency and it's wide variety of uses. Comparative studies of other species and other areas (for example E. precatória or E. oleracea in other geographic locations) would be of interest. The immense importance of E. oleracea to the Amazon estuary and it's people are clear from the study of it's uses in that

area. Also, it is clear that other species have been decimated in other areas (ex. Costa Rica, S.E. Brazil) due to over exploitation. E. oleracea has the great advantage of it's cespitose habit, regenerating itself naturally and offering multiple stems to be selectively harvested from. Since it's fruits are so highly important as a basic food source to the people of the Amazon estuary though, it's relatively new-found utility as the principal source of heart-of-palm for the large and commercial industry should be carefully monitored. It is for this reason that studies such as the two presented in this thesis are so important. Agroforestry and supervised commercial management are shown to protect and foster the natural populations of the plant. The agroforestry system clearly allows the continued utilization of the plant for the fruits (for the açai mush). This is also related to the proximity of the agroforestry system to a domicile. The commercial system also, apparently, allows fruiting of the plant. This location, however, was much further from domesticity, and therefore probably to the need or normal range for collection of the fruits. Both systems, furthermore, are of great value in preserving the native forest framework, since E. oleracea is such a basic element of the varzea forests of the region. Above all, as discussed in the thesis, the commercial

scheme offers the chance for the forces of capitalism (business) and tropical forest conservation to work together, an apparently rare combination from what is generally reported. The potential value and importance of conservationists 'softening' in their view of commercialism, in attempts to find joint solutions is judged to be great.

The biology of Euterpe has hardly been studied and the treatment of pollination in E. oleracea offers the first extended observations into the floral biology of the genus. Many insects visit the plant and are possible pollinators. These include flies, bees and wasps. The most likely pollinators are scarab beetles, although quite possibly a multiple pollination syndrome is at work. Wind cannot yet be excluded as a syndrome.

Studies in the anatomy of Euterpe and Prestoea support the concept of differences between the two groups. Extensive studies in the anatomy are required to see if this is a field where 'comfortable' distinctions between two groups can be found. Perhaps this will be better than other delimitations, such as presence of crownshaft, endosperm ruminations etc.. Again, it is underlined that for the time being Euterpe should be maintained as one genus including Prestoea.

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