PN ABR-891

MANAGEMENT REPORT

Covering Period : September 1993-February 1994

Submitted to the Office of the Science Advisor

U.S. Agency for International Development

SUSTAINABLE USE, DIVERSITY, CONSERVATION STATUS, AND ECONOMIC POTENTIAL OF BOLIVIAN PALMS

Principal Investigators: Andrew Henderson

New York Botanical Garden, Bronx, NY 10458

Mónica Moraes

Herbario Nacional de Bolivia, Casilla 10077, La Paz, Bolivia

Project Number: 12.585

Grant Number: HRN-5600-G-00-2026-00

A. I. D. Grant Project Officer: Michael Benge

Project Duration: 3 September 1992 to 30 September 1995

SCIENTIFIC SUMMARY

Over the last months we have made the following scientific progress. Henderson extracted information on 56 Bolivian palms, mostly from the Amazon region of Bolivia, from a project he is working on, and sent the information to Moraes. This will form part of the survey on diversity of Bolivian palms that is being carried out, as well as part of the survey on distribution, uses, and conservation status. Moraes prepared a list of 131 names reported for Bolivian palms, and compared it with five published contributions dealing with synonymy and new records (Appendix 1). As a result of this survey, 14 genera and 36 species require further taxonomic treatment (Appendix 2); and 15 genera and 30 species need further collecting (Appendix 3).

The palm herbarium of La Paz herbarium now has over 250 collections. Currently over 50% of these collections have been entered into a database by Oviedo.

SCIENTIFIC ISSUES

The project is on schedule, and there is no need for consultants or training; nor is there any need to restructure the project.

MANAGERIAL ISSUES

No managerial issues have arisen over the last six months. The timetable and budget remain unchanged, and both are on schedule.

SPECIAL CONCERNS

None changed.

COLLABORATION, TRAVEL, TRAINING AND PUBLICATIONS

In October 1993 Moraes, Sarmiento and Oviedo travelled for 10 days to the central and southern region of the Department of Beni for palm collecting. Between October and November 1993 Moraes travelled for two weeks and took part in aerial surveys of palm populations in the eastern and northern regions of Beni in order to collect records on distributions.

In November and December 1993 Vargas travelled to the Department of Santa Cruz for two weeks per month for Parajubaea survey and local interviews. Vargas gathered data on current harvesting, conservation status, and uses (Appendix 4).

During March and April 1994 Sarmiento travelled to the border between La Paz and Beni for Geonoma survey with the Chimane ethnic group.

Moraes took part in two Ph.D. level courses at Aarhus University, Denmark in January and February 1994. She presented her first Ph.D. exam in the form of a seminar on "Taxonomy and natural history of Bolivian Palms" (Appendix 5).

Sarmiento presented his work plan for the Geonoma project at Aarhus University in February 1994 (Appendix 6).

REQUEST FOR AID OR BOSTID ACTIONS

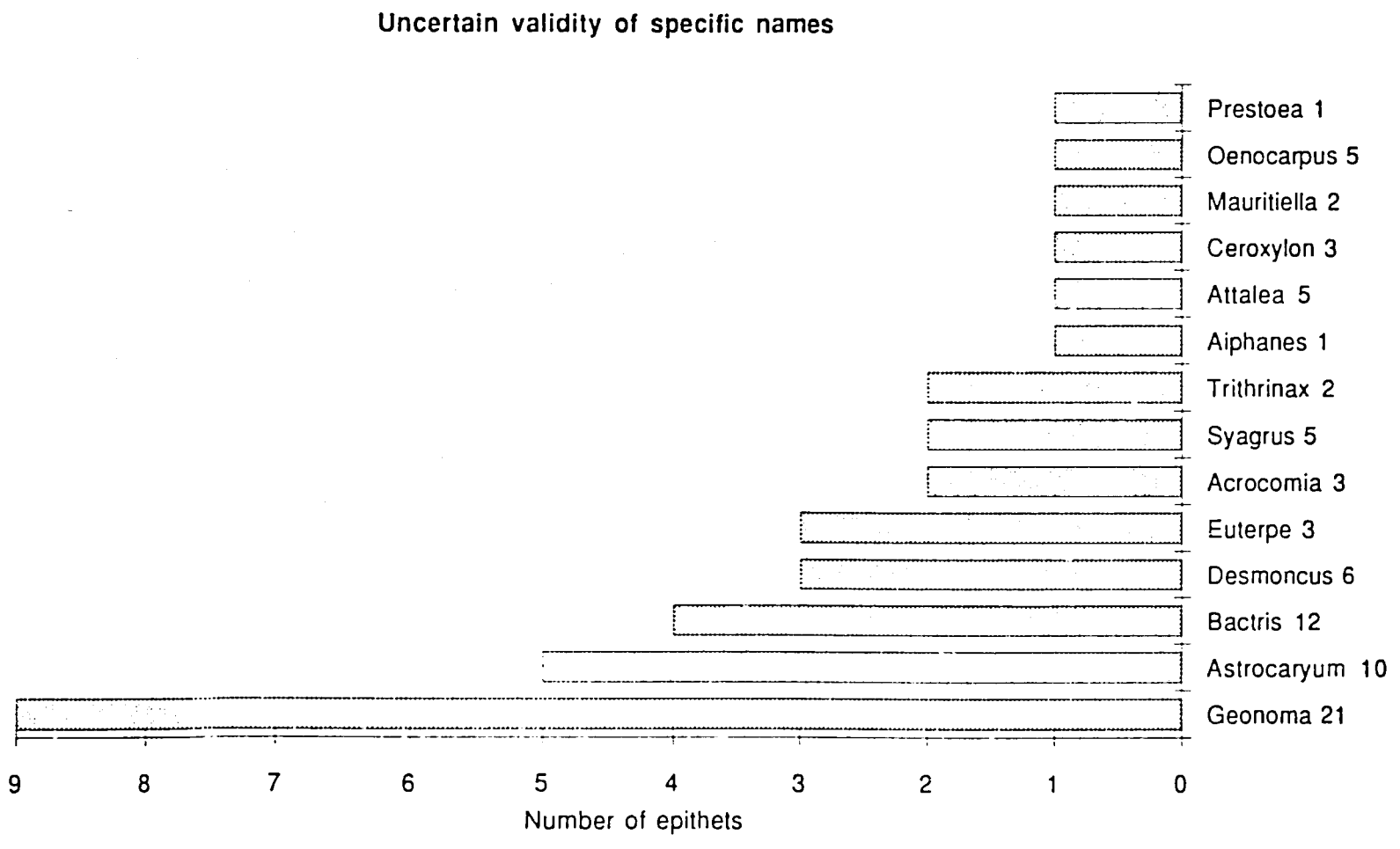
None requested.

Appendix 1

1989 (B & M)	1990 (M)	1993 (M)	1994 (M &)	1994 (H)
		Acrocomia aculeata	Acrocomia aculeata	Acrocomia aculeata
Acrocomia chuntа				
Acrocomia total		Acrocomia aculeata		
			Alphanes aculeata	Alphanes aculeata
Alphanes caryotifolia				
Alphanes truncata	Alphanes truncata	Alphanes truncata		
Allagoptera leucocalyx	Allagoptera leucocalyx			
Astrocaryum acaule				
Astrocaryum aculeatum		Astrocaryum aculeatum		Astrocaryum aculeatum
	Astrocaryum campestre			
Astrocaryum chonta		Astrocaryum chonta		A. murumuru var. murumuru
		Astrocaryum gratum		
				Astrocaryum gynacanthum
				Astrocaryum huaimi
Astrocaryum huaimi		Astrocaryum huaimi		
		Astrocaryum macrocalyx		
		Astrocaryum murumuru		Astrocaryum murumuru
		Astrocaryum turumoides		
		Astrocaryum ulei		
Astrocaryum ulei				
Astrocaryum vulgare				
				Attalea butyracea
				Attalea elchieri
				Attalea maripa
				Attalea phalerata
				Attalea speciosa
				Bactris brongniartii
				Bactris concinna
				Bactris elegans
Bactris fauclus				Bactris gasipaes
Bactris gasipaes		Bactris gasipaes		Bactris glaucescens
Bactris glaucescens		Bactris glaucescens		Bactris hirta
				Bactris acanthocarpa var. acanthocarpa
Bactris humilis				
				Bactris major var. infesta
Bactris infesta				Bactris gasipaes
Bactris insignis				Bactris riparia
Bactris inundata			Bactris macana	Bactris macana
				Bactris major
Bactris major				Bactris marala
Bactris marala				
Bactris montícola				Bactris riparia
				Bactris oligoclifrons
Bactris simplicifrons				Bactris major var. socialis
Bactris socialis				Bactris trailliana
			Coroxylon parvifrons	
Coroxylon parvifrons				
Coroxylon pityrophyllum		Coroxylon pityrophyllum		
			Coroxylon vogellanum	
				Chamaedorea angustisecta
				Chamaedorea pinnatifrons
Chamaedorea bullinensis				
Chamaedorea concarpa				
Chamaedorea fragans				
Chamaedorea lancifolata				Chamaedorea angustisecta
Chamaedorea leonis	Chamaedorea leonis			
Chamaedorea macrostoma			Chamaedorea pinnatifrons	Chamaedorea pinnatifrons
			Chamaedorea pauciflora	Chamaedorea pauciflora
			Chamaedorea pospiglziana	
Chamaedorea pospiglziana				Chelyocarpus chuco
Chelyocarpus chuco		Chelyocarpus chuco		
Cocornicia alba	Cocornicia alba	Cocornicia alba		Desmoncus orthacanthos
Desmoncus kahnianii				
Desmoncus latisectus				
Desmoncus leptospatha				Desmoncus mitis
Desmoncus mitis	Desmoncus mitis			Desmoncus orthacanthos
Desmoncus orthacanthos				Desmoncus polyacanthos
Desmoncus polyacanthos	Desmoncus polyacanthos			
Desmoncus setosus				
Dictyocaryum lamarckianum	Dictyocaryum lamarckianum	Dictyocaryum lamarckianum	Dictyocaryum lamarckianum	
Euterpe edulis		Euterpe precatoria		
			Euterpe glziana	
Euterpe precatoria		Euterpe precatoria		Euterpe precatoria
Euterpe precatoria		Euterpe precatoria		Euterpe precatoria
Euterpe precatoria		Euterpe precatoria	Euterpe precatoria	Geonoma macrostachys var. acaule
Geonoma acaule				
				Geonoma brevispatha
Geonoma brevispatha				Geonoma brongniartii
Geonoma brongniartii				
Geonoma deversa		Geonoma deversa	Geonoma deversa	Geonoma deversa
Geonoma deversa		Geonoma deversa		
			Geonoma oligoramosa	
Geonoma elegans				
Geonoma eusepatha			Geonoma eusepatha	Geonoma interrupta var. eusepatha
			Geonoma interrupta	Geonoma interrupta
				Geonoma maxima var. chelidonura
Geonoma jussiaea				
			Geonoma jussieuana	Geonoma jussiaea
Geonoma lasiolepis				Geonoma lepidopetala
Geonoma lepidopetala				Geonoma macrostachys
Geonoma macrostachys				Geonoma maxima
Geonoma maxima				
Geonoma mejalosperma		Geonoma mejalosperma		
Geonoma mitiqyana			Geonoma mitiqyana	
Geonoma oligoramosa				
Geonoma pauciflora				
Geonoma pinnatifrons				
Geonoma pulchra				Geonoma stricta
Geonoma undata			Geonoma undata	
Geonoma weberbauerii		Geonoma weberbauerii	Geonoma weberbauerii	
Hyospathe elegans	Hyospathe elegans		Hyospathe elegans	Hyospathe elegans
Iriartea deltoidea	Iriartea deltoidea	Iriartea deltoidea	Iriartea deltoidea	Iriartea deltoidea
Jessenia bataua ssp. bataua	Jessenia bataua ssp. bataua	Jessenia bataua		Jessenia bataua
Mauritia flexuosa	Mauritia flexuosa	Mauritia flexuosa		Mauritia flexuosa
Mauritiella aculeata		Mauritiella aculeata		Mauritiella macrocarpa
Mauritiella armata		Mauritiella aculeata		
				Mauritiella macrocarpa
Mauritiella macrocarpa		Mauritiella macrocarpa		Attalea maripa
Oenocarpus bataua		Oenocarpus bataua		
			Oenocarpus bataua	Oenocarpus bataua
				Oenocarpus distichus
Oenocarpus mapora var. mapora		Oenocarpus mapora		Oenocarpus mapora
Oenocarpus tarampate				Oenocarpus distichus
Orbignya humilis				Attalea elchieri
Orbignya phalerata	Orbignya phalerata	Orbignya phalerata		Attalea speciosa
Parajubaea torallyi	Parajubaea torallyi	Parajubaea torallyi	Parajubaea torallyi	
Phytelephas macrocarpa	Phytelephas macrocarpa	Phytelephas macrocarpa		Phytelephas macrocarpa
		Prestoea montana		
Scheelea biophrarpus				Attalea phalerata
Scheelea princeps	Scheelea princeps	Scheelea princeps		Socratea exorrhiza
Socratea exorrhiza	Socratea exorrhiza	Socratea exorrhiza		Socratea salapatii
Syagrus botryophora				
Syagrus cardenasii	Syagrus cardenasii			
Syagrus flexuosa				Syagrus petraea
Syagrus petraea	Syagrus petraea			Syagrus sancona
Syagrus sancona		Syagrus sancona	Syagrus sancona	
Trithrinax biflabellata		Trithrinax biflabellata		
Trithrinax brasiliensis				
Trithrinax schizophylla		Trithrinax schizophylla		
				Wendlandiella gracilis
	Wendlandiella	Wendlandiella		
	Wettinia			Wettinia aequata

BEST AVAILABLE COPY

Appendix 2


Uncertain validity of specific names
Prestoea 1
Oenocarpus 5
Mauritiella 2
Ceroxylon 3
Attalea 5
Aiphanes 1
Trithrinax 2
Syagrus 5
Acrocomia 3
Euterpe 3
Desmoncus 6
Bactris 12
Astrocaryum 10
Geonoma 21
9
8
7
6
5
4
3
2
1
0
Number of epithets

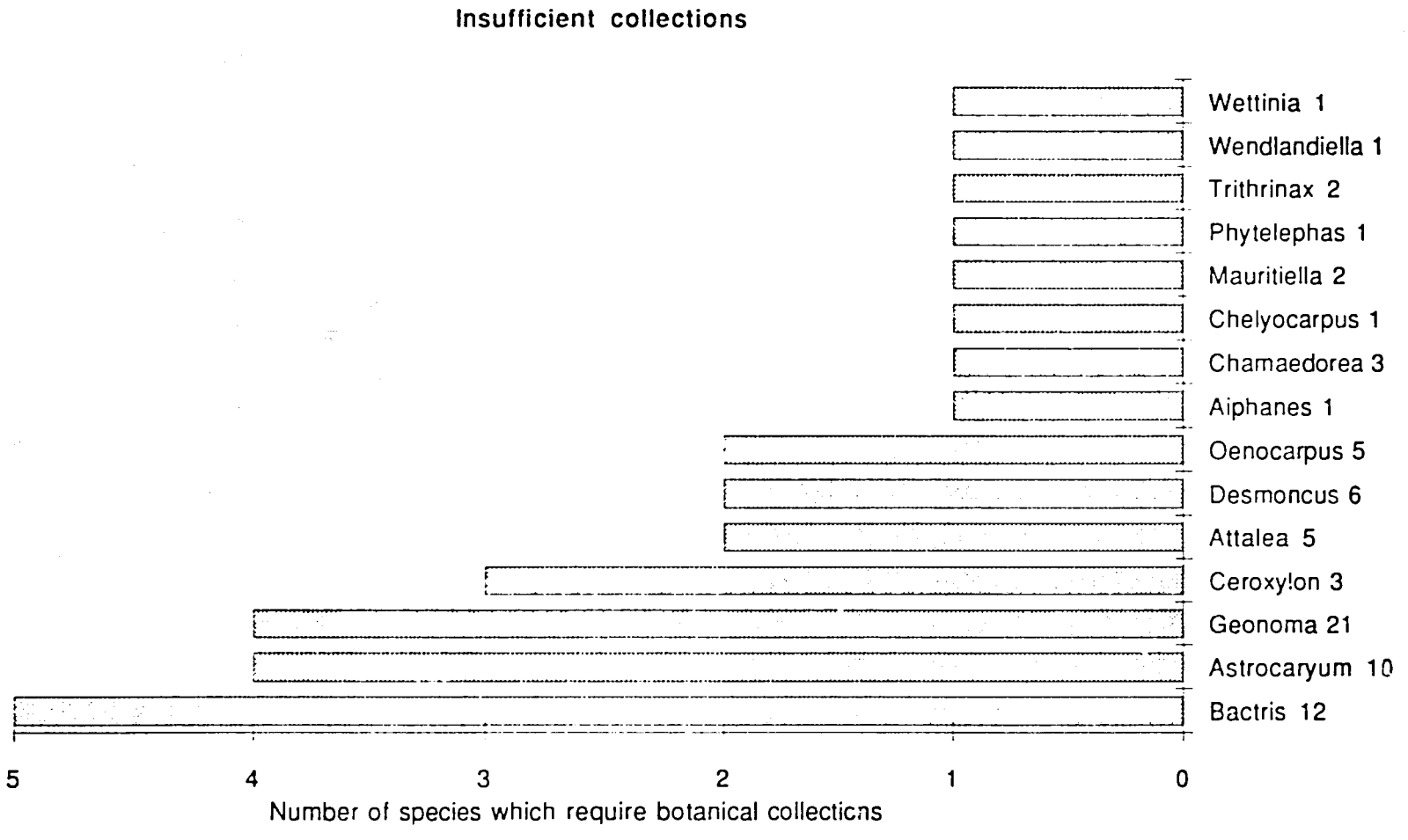

Insufficient collections
Wettinia 1
Wendlandiella 1
Trithrinax 2
Phytelephas 1
Mauritiella 2
Chelyocarpus 1
Chamaedorea 3
Aiphanes 1
Oenocarpus 5
Desmoncus 6
Attalea 5
Ceroxylon 3
Geonoma 21
Astrocaryum 10
Bactris 12
5
4
3
2
1
0
Number of species which require botanical collections

FOTO Nº 1.
Ladera con una mancha de palma zunkha, lugar elegido para parcela de investigación. Localidad de El Palmar.

FOTO Nº 2
Emplaquetado de inflorescencias sobre la nueva parcela de investigación Localidad de El Palmar.

BEST AVAILABLE COPY

FOTO Nº 3
Cosecha de la zunkha en palmas chicas, por el método del redondeo. Tramo entre El Palmar y Mataralcito.

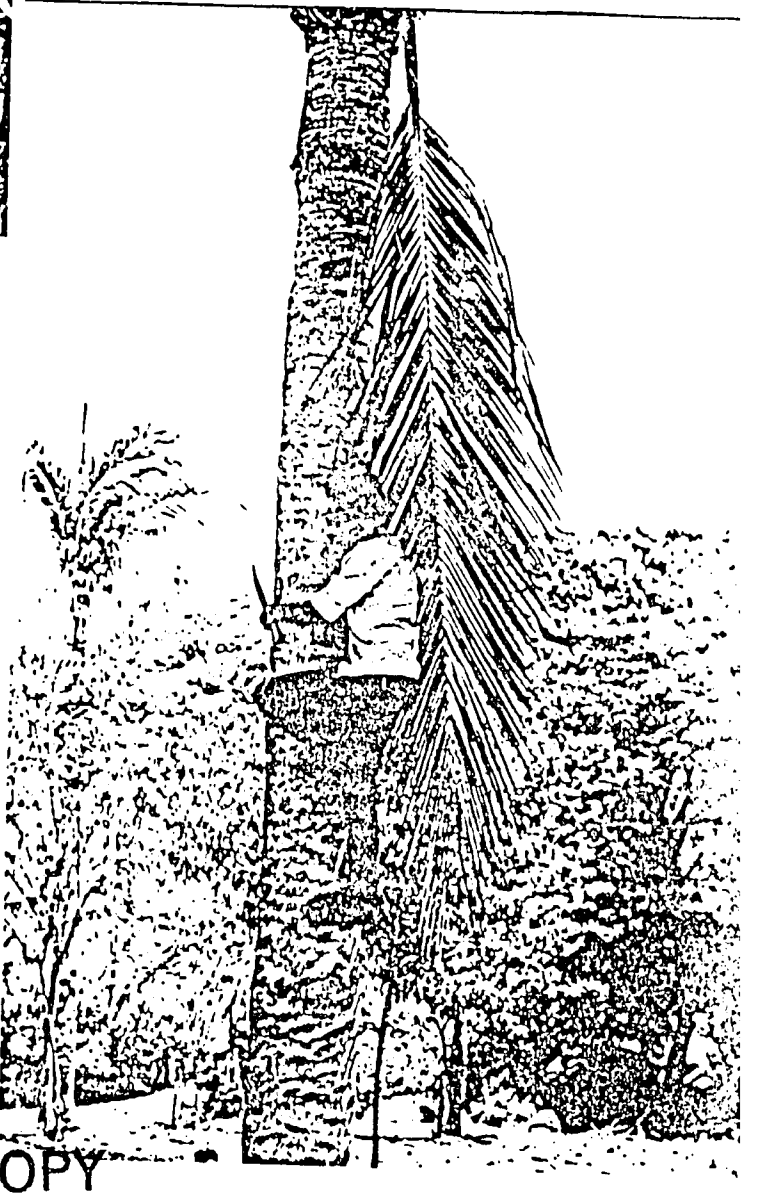


FOTO Nº 4
Palmas altas presentan gradas en su estipite, para subir hasta la corona y cosecharla. Localidad de El Palmar.

BEST AVAILABLE COPY

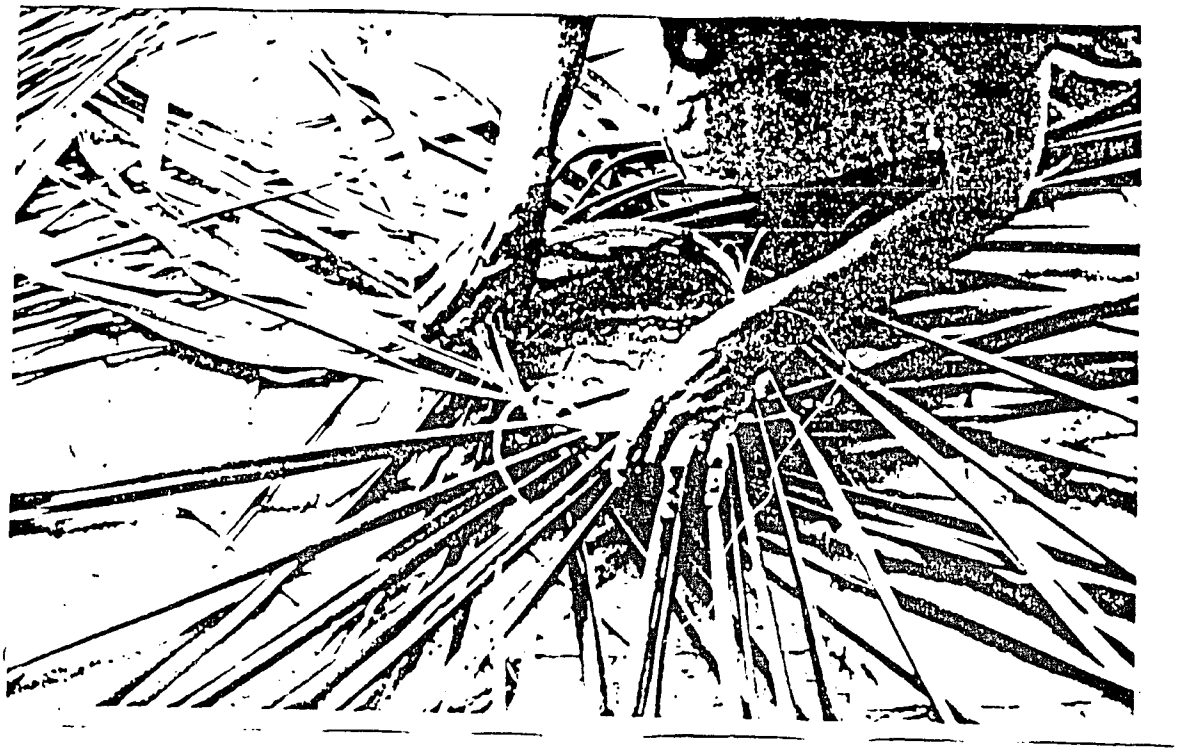


FOTO Nº 5. Proceso para la fabricación de un canasto usando dos hojas en buen estado, las cuales se parten y acomodan para proceder a tejer los foliolos. Loc. El Palmar.

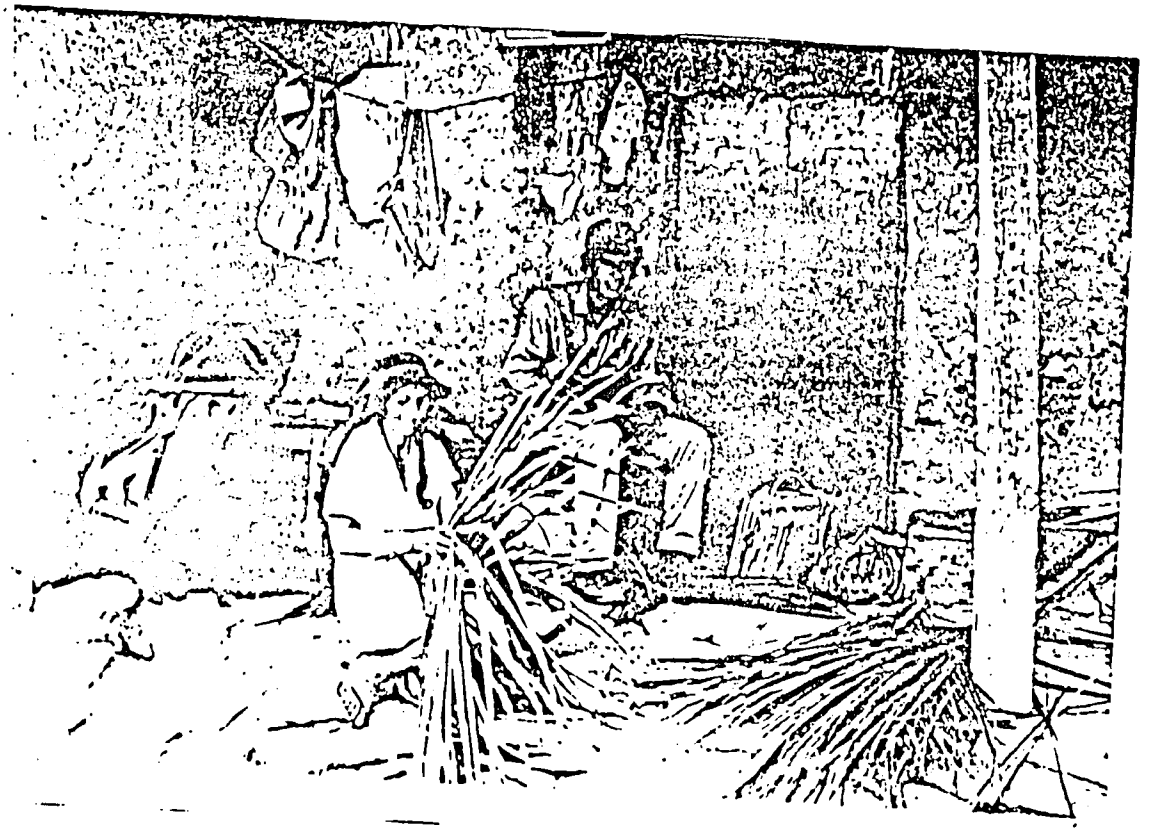
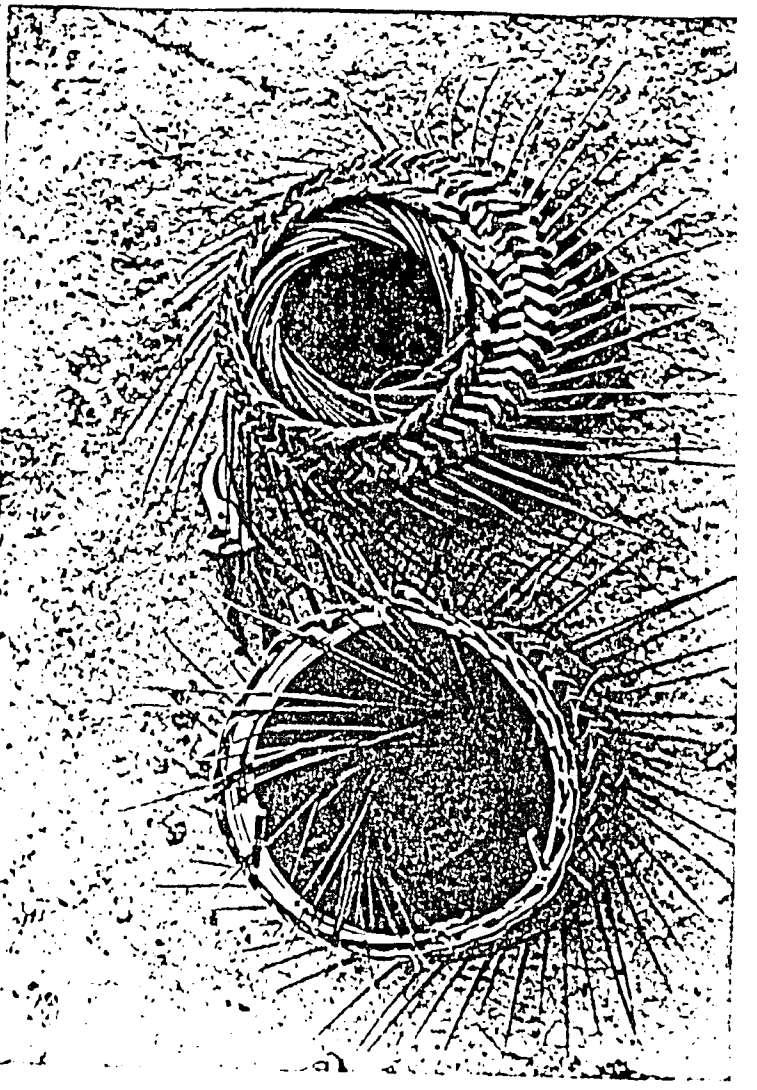


FOTO Nº 6. La Sra. Adela Montaño al igual que sus hijas dedican algún tiempo para la fabricación de canastas. Loc. El Palmar.

BEST AVAILABLE COPY



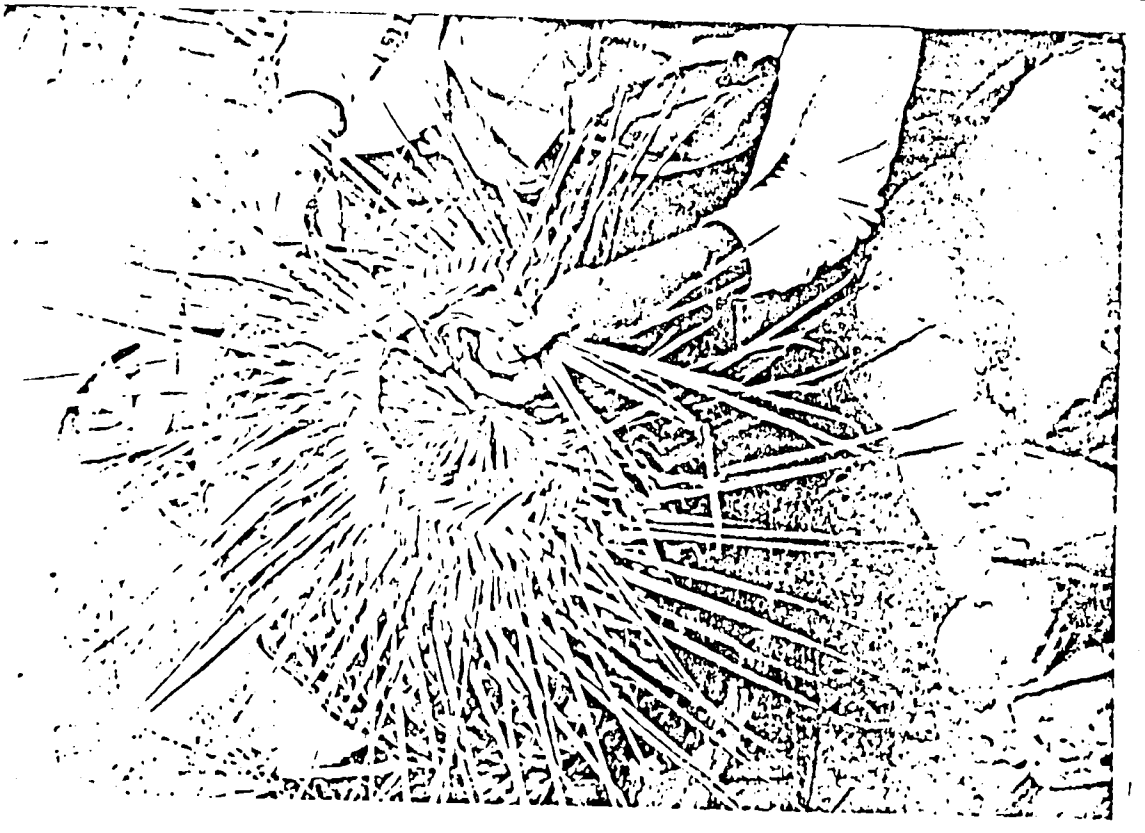


FOTO NO 7, 8 y 9
Tejido y acabado
de un canasto c
hojas de la pal
de zunkha, en l
loc. El Palmar.

BEST AVAILABLE COPY

11

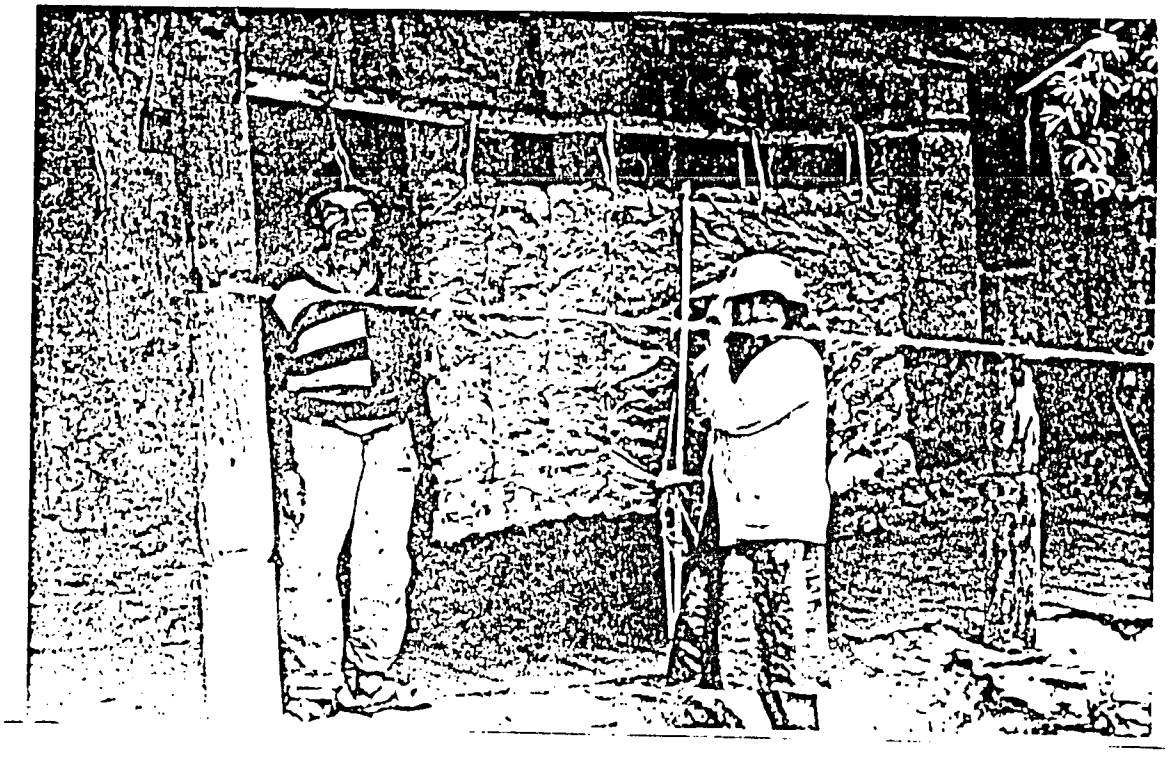


FOTO NO 10
Preparación de colchones con la fibra "zunkha". Loc. El Palmar.

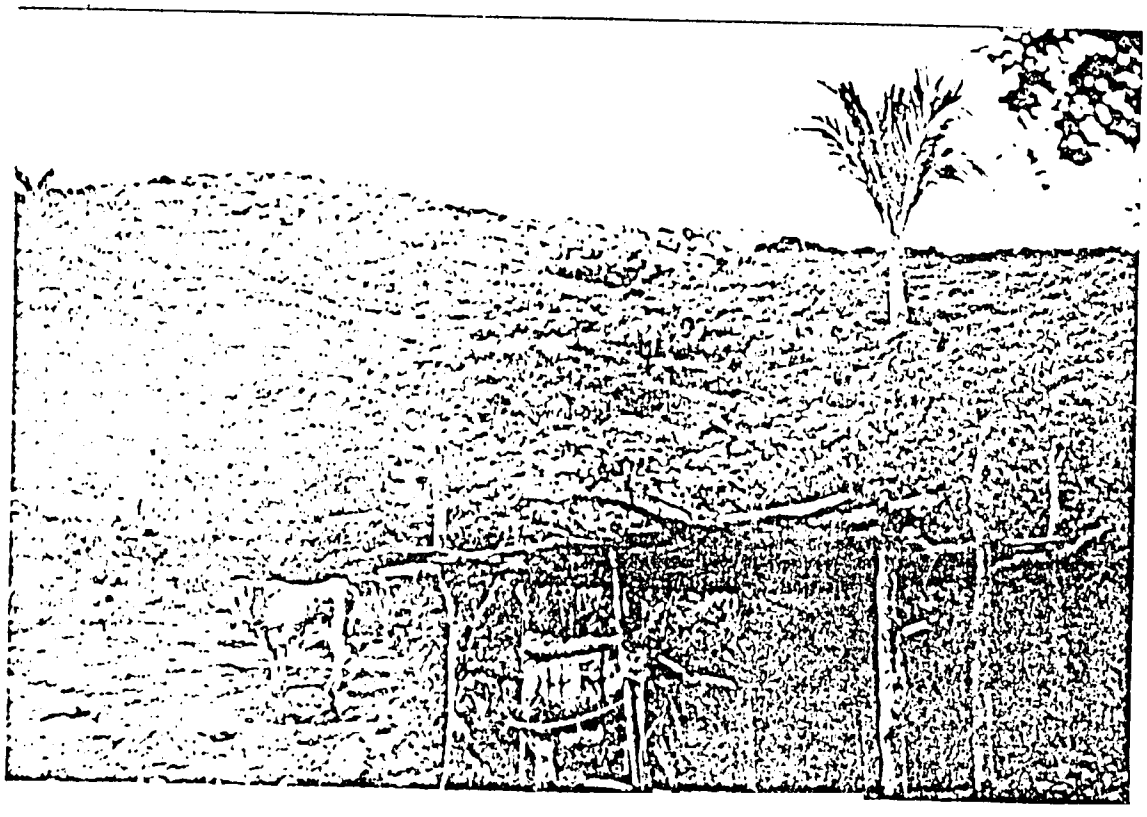


FOTO NO 11
El transporte de productos elaborados hacia los mercado es a través de animales de carga. Loc. El Palmar.

BEST AVAILABLE COPY

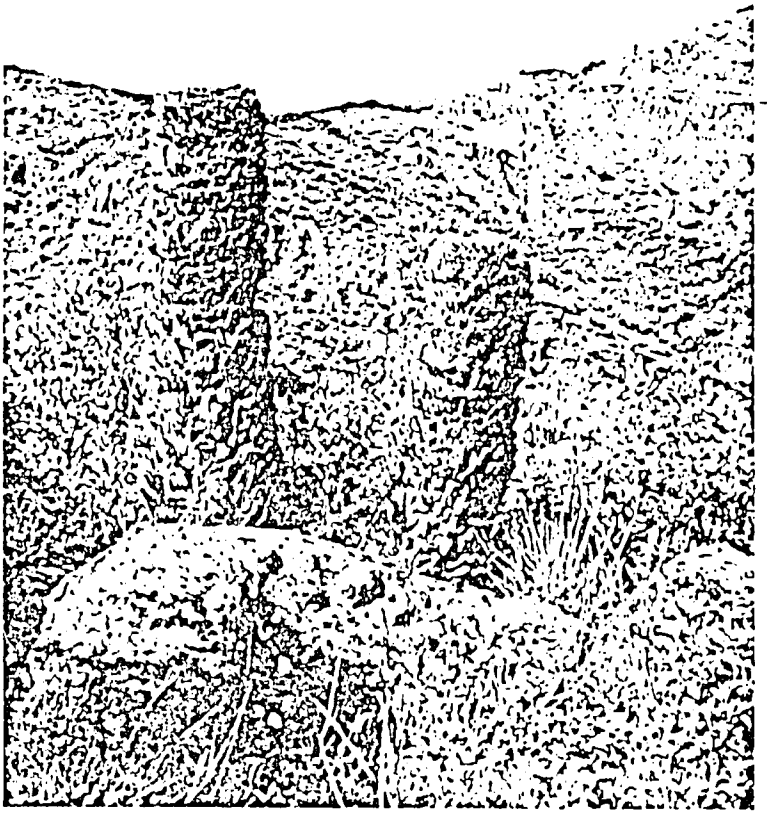


FOTO Nº 12
Palmas que murieron
por vuelco después
de una cosecha severa.
Loc. El Palmar.

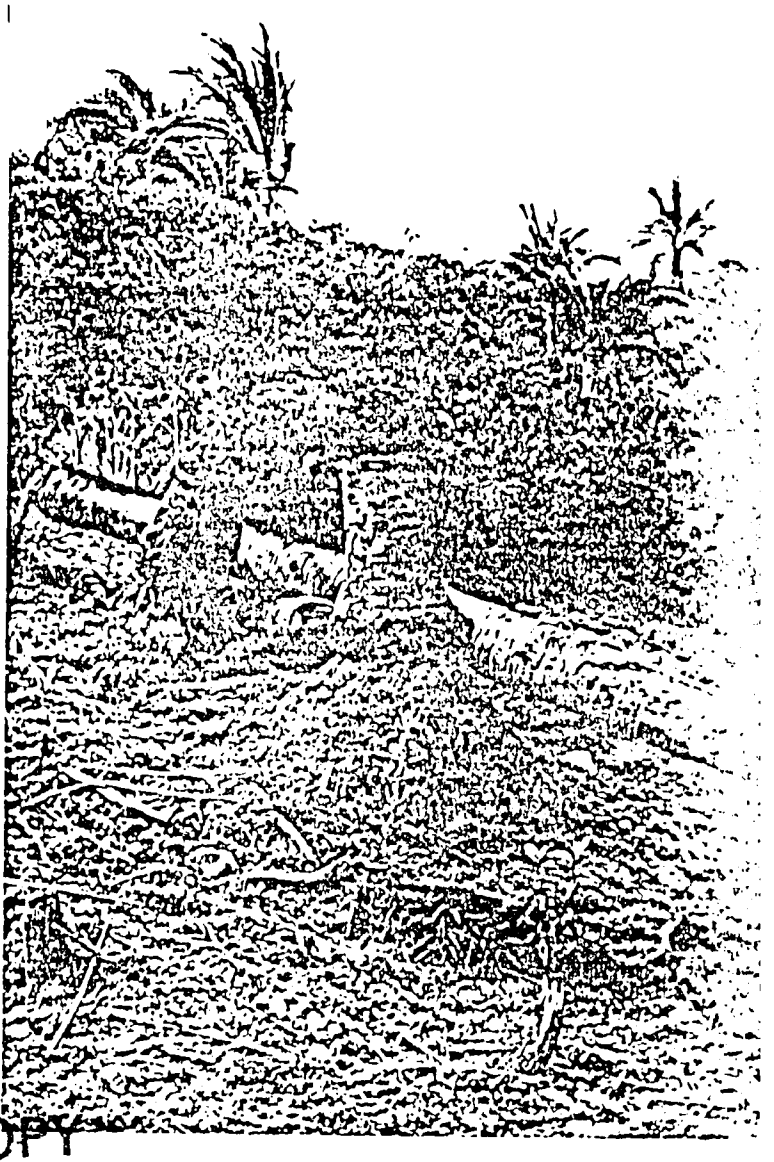


FOTO Nº 13.
Palmas altas (5 - 10 m),
son mucho más susceptibles
y caen con fuertes vientos,
la madera no es utilizada.
Loc. El Palmar - Collipa.

BEST AVAILABLE COPY

FOTO Nº 14
Algunas palmeras que se vuelcan o queman su corona, rebrotan y se recuperan lentamente. Loc. Las Chapas.

FOTO Nº 15
Esta planta se volcó años atrás y se recuperó bifurcándose, con excepciones con este detalle. Loc. El Palmar.

BEST AVAILABLE COPY

Appendix 5

Taxonomy and Natural History of Bolivian palms

Mónica Moraes R.

February 1994

Report submitted to the Faculty of Natural Sciences, University of Aarhus for del. A exam in the PhD program. Department of Systematic Botany, Institute of Biological Sciences, University of Aarhus, Universitetsparken Bygn. 137, DK-8000 Aarhus C, Denmark.

Table of Contents

Introduction	1
Study Subject	3
Previous Research on Palms	4
Results	8
Distribution	8
Life Forms	10
Root, Stem and Leaves	12
Inflorescence and Fruit	13
Biology	14
Taxonomy	14
Conclusions	24
Literature Cited	25

Appendices:

Appendix 1: M. Moraes R., G. Galeano, R. Bernal, H. Balslev & A. Henderson. (accepted). Tropical Andean Palms (Arecaceae). Mem. New York Bot. Gard. 00: 000-000.

Appendix 2: M. Moraes R. 1993. Allagoptera brevicalyx (Palmae), a new species from Bahia, Brazil. Brittonia 45: 21-24.

Appendix 3: M. Moraes R. & A. Henderson. 1990. The genus Parajubaea (Palmae). Brittonia 42: 92-99.

Appendix 4: M. Moraes R. 1990. Claves dicotómicas preliminares para las subfamilias y géneros de palmas nativos de Bolivia. Mus. Nac. Hist. Nat. (Bolivia Comunicación 10: 3-16.

Appendix 5: M. Moraes R. 1993. Palmae. Pages 612-628 in T. Killeen, E. García & S. Beck (Eds.), Guía de Arboles de Bolivia. Herbario Nacional de Bolivia/Missouri Botanical Garden, Edit. Quipus, La Paz.

Appendix 6: M. Moraes R. 1989. Ecología y formas de vida de las palmas bolivianas. Ecología en Bolivia 13: 33-45.

Appendix 7: M. Moraes R. 1991. Contribución al estudio del ciclo biológico de la palma Copernicia alba en una estancia ganadera (Espíritu, Depto. Beni, Bolivia). Ecología en Bolivia 18: 1-20.

Appendix 8: M. Moraes R. & J. Sarmiento. 1992. Contribución al estudio de biología reproductiva de una especie de Bactris (Palmae) en el bosque de galería (Depto. Beni, Bolivia). Bull. Inst. fr. études andines 21: 685-698.

Appendix 9: M. Moraes R. (draft). The genus Allagoptera Nees (Palmae). Fl. Neotrop. Monogr.

Introduction

Because of its position in the center of South America, Bolivia has a variety of physiographic and climatic factors that create diverse biogeographic and ecologic conditions (Beck, 1988; Ribera, 1992). Four main phytogeographic units are mixed and integrated in Bolivia: Amazonian, Andean, Cerrado, and Chaco (Beck et al., 1993; Moraes & Beck, 1992).

Two geologic events were particularly important for shaping the 10 geomorphologic units which are present in Bolivia: 1. Emplacement of the Brazilian shield (refill of intracratonian plain) and the associated Andean processes (Andean folding and uplifting, refilling of flat areas, subduction of the Nazca plate) which gave rise to the Amazonian alluvial area and the high Andean plain, and 2. The collision of the Andes and the Brazilian shield, which created a change in the orientation of the eastern cordillera (Ahlfeld, 1969).

One of the most important features, which determines the presence of high biodiversity areas in Bolivia, is the presence of pluvial centers with up to 7000 mm precipitation each year located in the perhumid sub-Andean sectors (Beck, 1988; Ribera, 1992).

The biological diversity in Bolivia occurs over wide altitudinal and latitudinal gradients in which different vegetation formations have developed. In Bolivia (1,078,000 km^2) close to 65% of the area is covered by various forest types. Pasture and shrub ecosystems cover 31%, and the remaining 4% are transitional dry and humid vegetation types (Brockmann, 1978). In a recent study it was reported that, at a scale of 1:1,500,000, fourty-four vegetation types occur in Bolivia on a vertical gradient between 140 m to 5000 m (Ribera et al., in press).

18

During the last 15 years - besides the establishment of research centers - several biological studies have been carried out in different parts of Bolivia. Most of these efforts were organized in order to compile and build up a scientific reference system of collections and publications that enhances the systematic knowledge of Bolivia's natural resources. Most of the available floristic information related to the vegetation types of Bolivia is still preliminar and several regions remain poorly known botanically (Moraes & Beck, 1992; Beck et al., 1993). It has been estimated that Bolivia has 18-20,000 vascular plant species (Solomon, 1989; Moraes & Beck, 1992) or 22% of the total Neotropical flora which is estimated at 90,000 plant species (Raven, 1976).

Information about the floristic diversity of Bolivian palms is still incomplete (Balslev & Moraes, 1989). Because of the limited knowledge of their potential benefits there are several palm species which are not used in Bolivia even if they are commercially exploited in neighbouring countries.

This research project aims at producing a reference for native Bolivian palms. First, it will compile all available information related to their taxonomy, natural history, and distribution. Second, it will gather botanical collections and other original data through fieldwork. It is part of a larger project, organized by the National Herbarium of Bolivia and funded by USAID, which deals with sustainable use, diversity, conservation status, and economic potential of Bolivian palms. A taxonomic treatment of palms that occur in Bolivia will also contribute to the Flora of Bolivia, which is organized by the National Herbarium of Bolivia in La Paz.

The results will be integrated in a taxonomic treatment carried out in four phases: 1. Search for available published knowledge of the Bolivian palm flora, 2. Spot

19

and solve taxonomic problems in taxonomically difficult genera, 3. Work out of keys, descriptions, and synonymy for all Bolivian palm species, and 4. Integrate all components into a comprehensive taxonomic treatment of Bolivian palms.

The results will be compiled in a manual, based on the traditional structure of botanical taxonomic treatments and it will be arranged phylogenetically. The treatment will include:

- A morphological description of the palm family in Bolivia, including summarized data on distribution, number of genera, and species;
- keys to the genera;
- morphological descriptions of the genera, keys to the species, and a brief description of each species, distribution, ecology, common names, uses;
- synonymy;
- index of exsiccatae, a numeric list of taxa, list of common names and specific names, and a general index.
- drawings, photographs, and tables.

In this first progress report two parts are included: 1. An introduction and a summary of the background for the study and a review of the research done so far on Bolivian palms, 2. A summary of research results which includes three chapters on distribution, morphology, biology, and taxonomy of Bolivian palms included with this report as appendices.

Study Subject

The palm family, the only member of the order Arecales, belongs to the monocotyledons and is usually characterized by a single meristem (Uhl & Dransfield, 1987). This feature makes palms especially vulnerable even if they have a tree habit. The palm family is distributed throughout the tropics and includes 200

20

genera and approximately 2800 species, of which 81 genera (40.5%) and 847 species (47%) are South American (Uhl & Dransfield, 1987).

The economical and cultural importance of palms has been recognized all over the world, although mostly in the tropical region (Moore, 1973a; Seibert, 1950; Uhl & Dransfield, 1987). Palms offer raw material for oil, fibers, and food. Ethnic groups have evolved cultural and social relationships using palm forests for subsistence and for magic purposes. Several palm products are used commercially with economic benefits at both the local and regional levels.

Palms have been used for physiognomic characterization of several vegetation formations, not only in climax vegetation, but also in ecological successions (Moore, 1973a). Bolivian palms occur in monotypic palm forests as well as in mixed vegetation types. In some cases palms are key elements for ecological indicators of soil types and incidence of hydrological dynamics in different vegetation units of Bolivia.

Due to human activities Bolivian palms are endangered. As in other countries, Bolivian ecosystems are being damaged through selective pressure when people search and extract palm products for construction and commerce of palm hearts. Other activities related to road construction, human settlements, and intensive erosive processes also affect palm populations.

Previous Research on Palms

Several studies were carried out by botanists during the past century in order to understand the taxonomy and biology of palms. Many of these studies included taxa which are present in Bolivia.

Depending on different concepts of species, two taxonomic schools have split or lumped species or groups of species. From the past century to recent times botanists contributed to the knowledge of Neotropical palms splitting several taxa - mainly in the form of descriptions of new species and monographs of palms. Among the most important authors who described new palm taxa from the neotropics were Burret (1928, 1929a, 1929b, 1929c, 1929d, 1930a, 1930b, 1931, 1932, 1933, 1934a, 1934b, 1934c, 1935, 1936a, 1936b, 1937a, 1937b, 1938, 1940, 1941), Glassman (1970, 1977a, 1977b, 1977c, 1987), and Martius (1823, 1847). Dahlgren and Glassman (1961) revised Copernicia, Pingitore (1978) worked on Trithrinax, and Wessels Boer (1968) treated Geonoma and allied groups.

Preliminar lists and contributions to palm floras were provided for some countries such as Argentina (Ragonese & Covas, 1942), Bolivia (Balslev & Moraes, 1989), Brazil (Barbosa Rodrigues, 1901, 1903; Henderson & Balick, 1987; Pinheiro & Balick, 1987; Raulino, 1974), Colombia (Dugand, 1940; Galeano, 1986, 1991, 1992; Galeano & Bernal, 1987), Ecuador (Balslev, 1987; Balslev & Barfod, 1987), Peru (Gentry, 1986; Kahn, 1990; Kahn et al., 1992; MacBride, 1960; Moussa et al., 1992), Suriname (Wessels Boer, 1965), and Venezuela (Braun, 1968; Braun & Delascio, 1987).

Descriptive works on distribution at a regional level were contributed for Neotropical palms by Glassman (1965) and Amazonian palms by Wallace (1843). Revised indices for synonymy and typification of Neotropical palms were published by Dahlgren (1936), Glassman (1972), and Moore (1963). General reviews were published with references to Bolivian palms by Meneces (1975) and to checklists by Foster (1958), by Glassman (1965), and by Uhl and Dransfield (1987). Some other information was given for Bolivian selected species with

22

economic importance by Antezana (1976), by Boom (1986), by Cárdenas (1970), and by Irmay (1947).

More recently started a period where most researchers considered an integrated system to classify palms based on phylogenetic characters (Moore, 1972, 1973a, 1973b, 1980; Uhl & Dransfield, 1987). This period coincided with increasing efforts for botanical collections of palms; several botanists lumped some palm taxa. A summary of Neotropical palms by Henderson (1990), includes a key to the genera. The Amazonian palms have been treated by Henderson (in press) who made several systematic rearrangements and added keys for genera and species.

Information on the taxonomy and distribution of palms in different parts of the Neotropics were published as monographs by several botanists (Table 1).

Table 1

Palm groups	Reference
Orbignya	Anderson & Balick (1988), Balick et al. (1987)
Mauritiella	Balick (1981a)
Jessenia, Oenocarpus	Balick (1981b, 1986)
Ammandra	Balslev & Henderson (1987a); Barfod (1991)
Ynesa colenda	Balslev & Henderson (1987b)
Phytelephantoideae	Barfod (1991)
Ecuadorean Attaleinae	Blicher (1989)
Aiphanes	Borchsenius & Balslev (1990); Borchsenius & Bernal (accepted)
Iriarteinae	Henderson (1990)
Chamaedorea	Hodel (1992)
Astrocaryum	Kahn & Millán (1992)
Allagoptera	Moraes (1989a, Appendix 9)
Hyospathe	Skov & Balslev (1989)

23

The morphology of rainforest palms was described by Dransfield (1978) and by Hallé and Oldeman (1970), regional ecology of Guianan palms by Granville (1978), 1992), and Amazonian palms by Kahn (1986, 1991), by Kahn and Granville (1992), and by Kahn and Mejía (1990, 1991). Comprehensive review were published on palm pollination by Henderson (1986) and dispersion by Zona and Henderson (1989). Results of these reviews indicate that palms are insect pollinated and wind pollination is less common, and that zoochory is a common way of dispersion for palms.

Reproductive biology and pollination of certain palms were studied by some authors (Table 2).

Table 2

Palm groups	Reference
Bactridinae	Listabarth (1992)
Acrocomia aculeata	Scariot et al. (1991)
Astrocaryum mexicanum	Burquez et al. (1987)
Bactris	Essig (1971)
Bactris gasipaes	Mora Urpi & Solis (1980)
Bactris gasipaes & *B. porschiana*	Beach (1984)
Lepidocaryum tessmannii	Kahn & Mejía (1987)
Phytelephas microcarpa	Barfod et al. (1987)

Important collections of Bolivian palms were made by d'Orbigny in the period 1830-1833, and Martius (1847) described 32 new palm species based on these collections.

Glassman (1965) reported 48 Bolivian species in 23 genera out of a total of 1439 species and 82 genera of American palms. Therefore he considered that the Bolivian palm flora was relatively poor compared to

other countries with similar size such as Peru, Colombia, and Venezuela After a synoptical work based on Bolivian palm collections, Balslev and Moraes (1989) reported a total of 90 native species in 29 genera; of these 35 species were new records for Bolivia.

The National Herbarium of Bolivia in La Paz started in 1986 to build up a scientific collection of Bolivian palms and to gather original information in the field, following traditional methods for botanical collections (e.g., Dransfield, 1986; Moraes, 1990b).

Results

Balslev and Moraes (1989) concluded that it was important to enhance the understanding on the richness of Bolivian palms and to promote botanical fieldwork in poorly known areas. To follow up these recomendations many studies were carried out and new records were gathered through fieldwork.

Distribution

Bolivian palms have conspicuous distribution patterns related to topographic levels, soil types, climatic gradients, and vegetation types. This plant group is one of the most useful floristic elements in physiognomic recognition and description of ecosystems in Bolivia (Moraes, 1989b; Appendix 6; Moraes, 1993b; Appendix 5). Their geographic area includes different kinds of forests and savannahs (Fig. 1). For example Geonoma is mostly found in sub-Andean forests and sandy soils; Mauritia is found in monospecific stands in poorly drained areas with black water; Copernicia is well represented in seasonally flooded savannahs; Bactris is mainly adapted to humid and rich soils of riparian forests; Attalea speciosa is dominant in mixed forests on Precambric soils (Moraes, 1989b; Appendix 6).

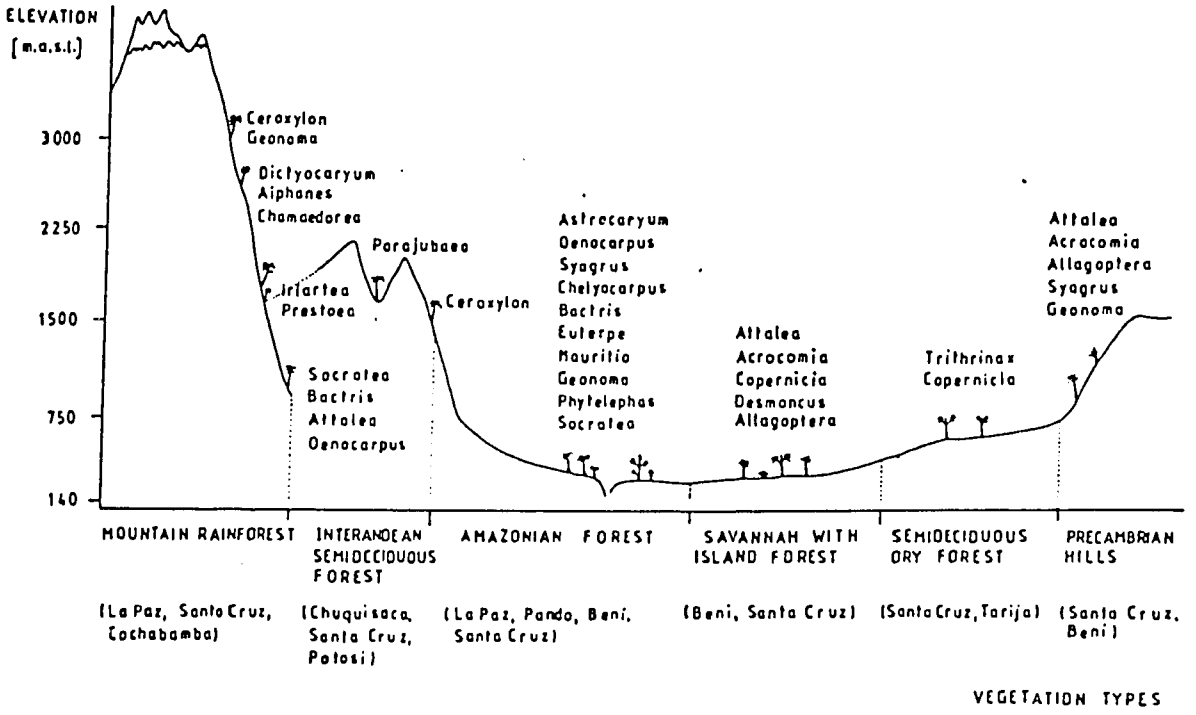


Fig. 1. Altitudinal distribution of Bolivian palms related to different types of vegetation.

Copernicia alba is a Chaco phytogeographical element; its distribution coincides with cattle ranches and it is found in open seasonally flooded areas from SW Brazil, central to S Bolivia, towards N Paraguay and NE Argentina (Moraes, 1991; Appendix 7). Bactris bidentula, an Amazonian species, is mostly found in gallery or riparian forests (Moraes & Sarmiento, 1992; Appendix 8).

The altitudinal range of distribution of Bolivian palms reaches from the lowlands at 150-1000 m in E Bolivia on Precambrian hills, up to 3200 towards the west on the Andean mountains (Balslev & Moraes, 1989; Moraes, 1989b; Appendix 6; Moraes, 1993b; Appendix 5). In one extreme between 2700 m and 3200 m occur species of Parajubaea, Geonoma, and Ceroxylon whereas Mauritia flexuosa, Astrocaryum, and Bactris are mainly found at 150-400 m (Fig. 1).

Although most Bolivian palms grow in humid areas, some species are adapted to dry conditions (Moraes, 1989b; Appendix 6). For example, Trithrinax is found in the Chaco forests where rain does not exceed 400 mm per year and Parajubaea torallyi is distributed in dry inter-Andean valleys.

Life Forms

In terms of architectural models, the unbranched polycarpic palms (Corner's model) is the most common among Bolivian palms whereas dichotomously branched (Schoute's model) is only found in Allagoptera.

Bolivian palms have the following habits (= growth forms, life forms): trees, shrubs, acaulescent, and climbers (Fig. 2) (Moraes, 1989b; Appendix 6).

One of the most common palm habits in forests and open areas is the 'woody treelike' palm with solitary to

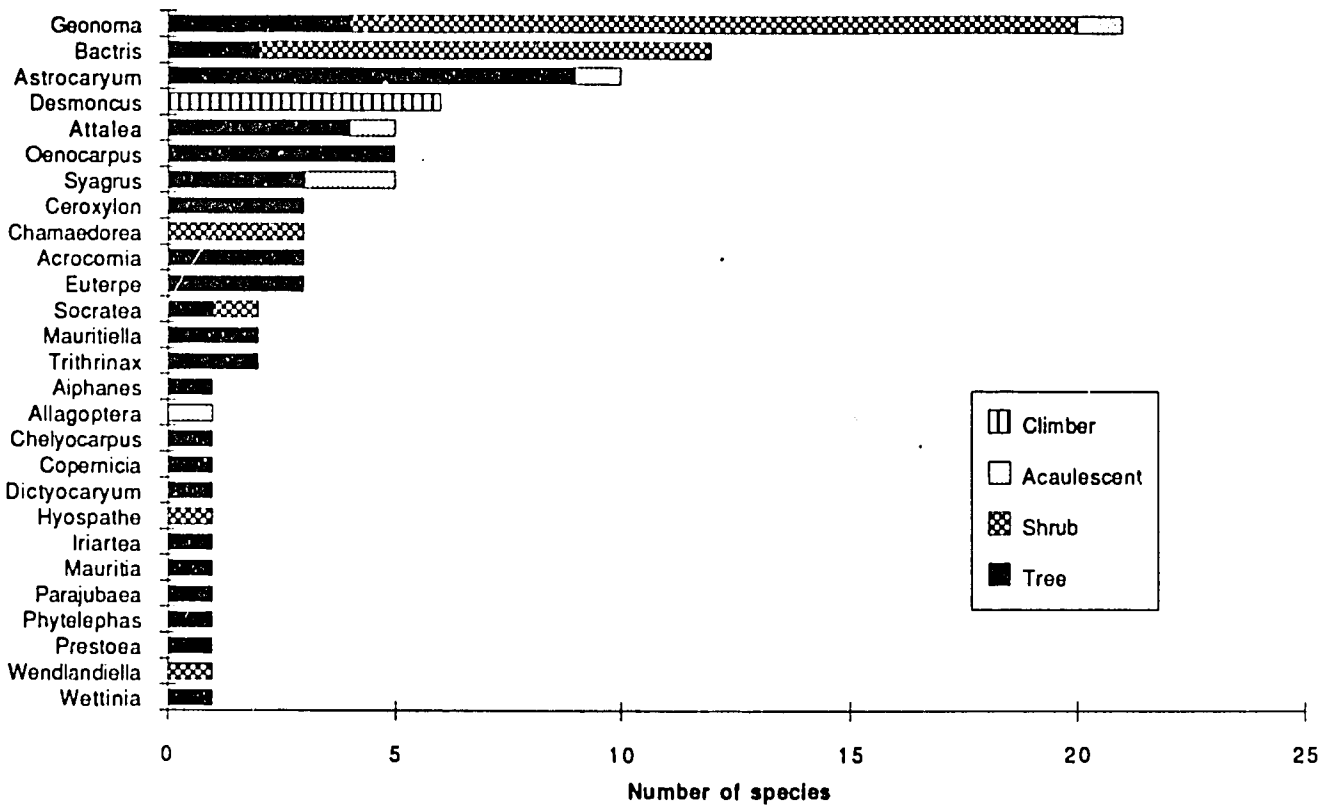


Fig. 2. Life forms of Bolivian palms.

clustered thick stems more than 10 cm in diameter. Bolivian tree palms include 40 species in 22 genera.

The 'shrubby' palms have slender stems, less than 10 cm in diameter. Chamaedorea, Wendlandiella, Hyospathe, and several species of Geonoma have the shrub habit. Some shrubby species have creeping stoloniferous growth such as Geonoma and Hyospathe.

Climbing palms are represented in Bolivia by the genus Desmoncus which has an extended leaf rachis with reflexed spines to adhere on branches or leaves of surrounding plants. Acaulescent palms have subterranean stems as found in Allagoptera, and some species of Syagrus, Astrocaryum, and Attalea.

Among Bolivian palms 54% have tree habit, 33% are shrubs, 6% are acaulescent, and 6% are climbers (Fig. 2). The most diverse genus in terms of habit types is Geonoma which includes three categories: trees, shrubs, and acaulescent. Bactris and Geonoma mainly have shrub habit found at 82% and 76% respectively.

The canopy level at 12-25 m is reached by several tree palm species such as Dictyocaryum lamarckianum, Syagrus sancona, Attalea speciosa, A. phalerata, and others. At the mid canopy level, which reaches 3-12 m, Astrocaryum spp., Ceroxylon spp., Acrocomia aculeata, Oenocarpus bataua, Aiphanes aculeata are found. Many shrub, acaulescent, and climber palms are present in the understory from 0.4-3 m such as Geonoma spp., Hyospathe, Allagoptera, Chamaedorea spp., and Desmoncus spp. (Moraes, 1989b; Appendix 6).

Root, Stem and Leaves

Most Bolivian palms have short adventitious roots near the soil surface. Wettinia, Socratea, Dictyocaryum, and Iriartea, however, have spiny stilt roots which reach

29

three m in length, and subtend a cylindrical stem (Moraes, 1989b; Appendix 6; Moraes, 1990a; Appendix 4).

Although several palm species have cylindrical stems, some genera such as Acrocomia, Dictyocaryum, and Iriartea have swollen stems. Individuals of most species of Bactris, Desmoncus, Attalea, and Astrocaryum have cespitose stems.

The stem surface of palms varies from smooth (Syagrus, Euterpe, Socratea, Ceroxylon), with remaining leafbases (Attalea, Parajubaea, Trithrinax), to spiny (Acrocomia, Bactris, Astrocaryum) (Moraes, 1990a; Appendix 4).

The leaves of palms are mainly grouped in a terminal crown, but sometimes they are arranged along the stem (Geonoma, Chamaedorea, Wendlandiella) (Moraes, 1989b; Appendix 6; Moraes, 1990a; Appendix 4). Most Bolivian palm species have a pinnate leaf blade which in a few cases is fused into an entire leaf or fewer leaflets (Geonoma, Chamaedorea, Bactris, Hyospathe). Copernicia, Trithrinax, Chelyocarpus, Mauritia, and Mauritiella have palmate leaves. Some species of Desmoncus, Chamaedorea, and Bactris have sigmoid pinnae. Distichous leaves are found in Oenocarpus distichus.

Inflorescence and Fruit

Most Bolivian palm species have interfoliar inflorescences (Moraes, 1990a; Appendix 4). Euterpe, Prestoea, Dictyocaryum, Socratea, Oenocarpus, Wettinia, Iriartea, and Hyospathe have intrafoliar inflorescences. There are no Bolivian palm species with suprafoliar inflorescences. Though branched inflorescences are most common among Bolivian palms, spicate ones are found in Allagoptera, Geonoma, and Chamaedorea. Hippuriform inflorescences occurs only in Oenocarpus.

The most common fruit type has a smooth epicarp; prickles are found in Bactris and Astrocaryum. Mauritia and Mauritiella have fruits covered by scales (Moraes, 1990a; Appendix 4).

Biology

Two palms were studied biologically in the Bolivian lowlands; Bactris bidentula (Moraes & Sarmiento, 1992; Appendix 8) and Copernicia alba (Moraes, 1991; Appendix 7).

Copernicia alba is a fast growing palm and reaches adult stage (3.5 m tall) in five years. In comparison Caribbean Copernicia species reach 6 m in 18 years even without being reproductive.

This palm species has two flowering peaks per year which coincide with rainy periods: August to October, and during March. Fruit dispersal of Copernicia alba (December to May) is affected by cattle and greater rhea (Rhea americana).

The population of Bactris bidentula, a monoecious, protandrous and cantaridophylous species, is adapted to dynamic hydrological conditions and its flowering stage coincides within start of the rainy season.

Taxonomy

A key to Bolivian native palm subfamilies and genera is based on diagnostic features for field and herbarium identification, and gives brief references to the distribution and number of species per genus (Moraes, 1990a; Appendix 4). This key reported two new genera for Bolivia, Wendlandiella and Wettinia. For a Bolivian Tree Guide, a taxonomic treatment of native tree palms represented in Bolivia was provided by Moraes (1993b; Appendix 5), including short descriptions for 25 genera,

keys for genera and brief references for 40 species. This contribution mentioned also some taxonomic references on non tree species. Due to further identifications and adjustements of the distribution range for some species Bolivian palms were reported to have 31 genera and 91 species (Moraes, 1990a; Appendix 4; Moraes 1993b; Appendix 5).

This report will consider systematic changes which were given for two groups: 1. Scheelea, Orbignya, Attalea, and Maximiliana which were synomizied under Attalea, and 2. Jessenia and Oenocarpus were united under Oenocarpus. Considering these adjustments there are 27 Bolivian palm genera which are arranged in five subfamilies, nine tribes, and six subtribes (Table 3).

Table 3

Subfam. Coryphoideae
- Tribe Corypheae
  - Subtribe Thrinacinae
    - 1. Trithrinax
    - 2. Chelyocarpus
  - Subtribe Livistoninae
    - 3. Copernicia

Subfam. Calamoideae
- Tribe Lepidocaryeae
  - 4. Mauritia
  - 5. Mauritiella

Subfam. Ceoxyloideae
- Tribe Ceroxyleae
  - 6. Ceroxylon
- Tribe Hyophorbeae
  - 7. Chamaedorea
  - 8. Wendlandiella

Subfam. Arecoideae
- Tribe Iriarteinae
  - 9. Dictyocaryum
  - 10. Iriartea
  - 11. Socratea
- Tribe Wettiniinae
  - 12. Wettinia
- Tribe Areceae
  - Subtribe Euterpeinae
    - 13. Euterpe
    - 14. Prestoea
    - 15. Oenocarpus
    - 16. Hyospathe
- Tribe Cocoeae
  - Subtribe Butiinae
    - 17. Syagrus
    - 18. Parajubaea
    - 19. Allagoptera
  - Subtribe Attaleinae
    - 20. Attalea
  - Subtribe Bactridinae
    - 21. Acrocomia
    - 22. Aiphanes
    - 23. Bactris
    - 24. Desmoncus
    - 25. Astrocaryum
- Tribe Geonomeae
  - 26. Geonoma

Subfam. Phytelephantoideae
- 27. Phytelephas

The most species rich genera are Geonoma (21 spp.), Bactris (12 spp.) and Astrocaryum (8 spp.) (Fig. 2). Another extreme includes 13 monospecific genera, while

intermediate genera have 2-6 species. Astrocaryum, Aiphanes (1 sp.), and Chamaedorea (3 spp.) were recently treated taxonomically by Kahn and Millán (1992), Borchsenius and Bernal (in press), and Hodel (1992).

1. Subfamily Coryphoideae. This subfamily has fan-shaped leaves and is considered primitive among palms. In Bolivia it includes three genera (Trithrinax, Chelyocarpus, Copernicia) which all belong to the tribe Corypheae. They are trees and are morphologically easily distinguished (Table 4). They grow in different vegetation types in the lowlands. Trithrinax is found in the thorny and xeric vegetation of the Chaco region, from E Santa Cruz to S Tarija. Chelyocarpus occurs in closed forests of the Amazonian region in Pando. Copernicia grows in seasonal savannahs of the Llanos de Mojos, reaching Paraguay and Argentina (Moraes, 1991; Appendix 7).

Table 4

	Trithrinax	[illegible]	Copernicia
Spp. in Bolivia	[illegible]	[illegible]	1
Height	[illegible]	[illegible]	[illegible] m
Stem	[illegible]	[illegible]	foliar bases
	[illegible]		up to 3 m
[illegible]	[illegible]	[illegible]	Curved spines
Leaves	[illegible]	[illegible]	Unsplit to
	[illegible]	[illegible]	rachis
Inflorescence	[illegible]	[illegible]	Straight,
	[illegible]	[illegible]	elongate to 1.3 m
Uses	[illegible]		[illegible]

We still lack good collections of Chelyocarpus chuco. The only material kept at the National Herbarium is

BEST AVAILABLE COPY

sterile. The two other genera are well represented in our collections, both in fruit and flower.

2. Subfamily Calamoideae. This subfamily is distinguished by closely overlapping scales on ovaries and fruits, and also mostly characterized by pinnate leaves although some are palmate. It includes two genera in Bolivia (Mauritia, Mauritiella) out of a total of 22 of which four are Neotropical. They have costa-palmate leaves and grow in swampy regions with poor acidic soils near the Andean foothills, in large lakes in open areas, and near low hills on the Precambrian shield.

Until now we have only poor information concerning habitat differences between the two genera, but apparently Mauritiella is more adapted to the banks of black-water rivers. Both genera have a single species in Bolivia. The morphological features which distinguish them are shown in Table 5.

There is an interesting region in the E Dept. of Santa Cruz from which both genera have been reported.

Table 5

BEST AVAILABLE COPY

	[illegible]	Mauritia
Spp. in Bolivia	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] m
Stem	[illegible]	solitary and unarmed
Pistillate flowers	[illegible]	[illegible] or on slightly [illegible] branches
	[illegible]	[illegible]
Staminate flowers	[illegible]	[illegible]

3. Subfamily Ceroxyloideae. In this subfamily all members are pinnately leaved. It includes 11 genera

which are mainly distributed in the Neotropics. They are dioecious and characterized by numerous peduncular bracts. In Bolivia the subfamily is represented by three genera: Ceroxylon, Chamaedorea, and Wendlandiella. These are well represented in the Andean forests and inter-Andean valleys on steep slopes and in wet ravines, and reach their southern distribution in Bolivia. While Ceroxylon species reach the canopy, Chamaedorea and Wendlandiella are found on the floor of umbrophilous forests. To compare features of these genera see Table 6.

Ceroxylon has three species in Bolivia. It is mainly distributed at high elevation of mountain forests on the eastern slopes of the Andes from the Department of La Paz southwards to the Department of Santa Cruz, reaching elevations up to 3150 m. Bolivian species of Ceroxylon may be distinguished by differences in height, their leaves being evenly spaced or clustered, and their red or purplish-black fruits. Ceroxylon needs more botanical collections to better understand the morphology of both male and female plants.

Table 6 BEST AVAILABLE COPY

	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]
Height	[illegible]	[illegible]	[illegible] m
Stem	[illegible]	[illegible]	clustered
Habit	[illegible]	[illegible]	shrub
Adaxial hastule	[illegible]	[illegible]	absent
Peduncl. bracts	[illegible]		[illegible]
Petals	[illegible]	[illegible]	basally fused
[illegible]	[illegible]	[illegible]	[illegible]
Endocarp	[illegible]	[illegible]	membranous

The genus Chamaedorea is represented with three species in Bolivia. The most useful characters to separate

Chamaedorea species is the shape of the pinnae (linear, sigmoid), the leaf division (divided, entire), and the inflorescence type (spicate, branched).

The understory dwarf palm Wendlandiella was recently found on the foothills of the Andes close to the border with Peru. It has only one species in Bolivia, W. simplicifrons.

4. Subfamily Arecoideae. This is the largest subfamily with 121 genera. It includes four tribes and 18 genera in Bolivia: Dictyocaryum, Iriartea, Socratea, Wettinia, Euterpe, Prestoea, Oenocarpus, Hyospathe, Syagrus, Parajubaea, Allagoptera, Attalea, Acrocomia, Aiphanes, Desmoncus, Bactris, Astrocaryum, and Geonoma. These genera show a wide range of life forms such as treelike, shrubby, acaulescent, and climbing. Some genera have spines (Acrocomia, Aiphanes, Desmoncus, Bactris, Astrocaryum). They occur in different types of vegetation in the lowlands and mountain forests.

Dictyocaryum, Iriartea, Socratea, Wettinia, Euterpe, Prestoea, and Aiphanes have Andean distribution centers but may be found as low as 250 m (Moraes et al., accepted; Appendix 1). The remaining genera are mostly centered in the lowlands, although some species such as Geonoma weberbauerii reach elevations up to 3200 m .

Dictyocaryum, Iriartea, and Socratea are treelike palms and have a crown of 3-7 arched leaves with fused groups of pinnae giving them a characteristic crisp-leaved appearance. They have stilt roots and infrafoliar inflorescences, both features are shared with the related genus, Wettinia (Table 7).

Wettinia was only recently found in Bolivia. Wettinia augusta is medium sized and grows in forests on the E flanks of the high Andean mountains where it reaches

down to 400 m in a small area close to the border with Peru. For this species flowering and fruiting herbarium material from Bolivia is still lacking.

Table 7 BEST AVAILABLE COPY

	Dictyocaryum	Iriartea	Socratea	Wettinia
Spp. in Bolivia	1	1	2	1
Height	20-25 m	18-25 m	10-20 m	3-5 m
Stem	swollen	swollen	not swollen	not swollen
Stilt roots	150, dense	100, dense	25, spaced	fused
spines	short, obtuse	2 cm sharp	2 cm sharp	short sharp
Leaves	3-6	4-7	7	4-5
Pinnae	fused	fused	fused	free
Infloresc./nude	one	one and	one	various
Bud infloresc.	erect	erect	curved	erect
Pedunc. bract.	[illegible]	[illegible]	4-5	4-5
Stamens	[illegible]	[illegible]	[illegible]	8-10

Euterpe, Prestoea, and Oenocarpus have a regular arrangement of the pinnae and a treelike life form, but differ in many features (Table 8). Both Euterpe and Prestoea have infrafoliar inflorescences, a crown of gracefully arched leaves, and a smooth stem. They are mostly distributed in wet to flooded Andean forests down to the foothills (Euterpe and Prestoea) and lowland rainforests (Euterpe precatoria). In contrast to Euterpe, Prestoea has a longer petiole and prophyll and its peduncular bracts are of unequal length and the flowers are not born in pits. There is a lack of fertile herbarium material - both flowers and fruits - of Prestoea globosa.

Oenocarpus has interfoliar, hippuriform inflorescences and a stem with remnant foliar bases. It is found in Andean mountain forests as well as in Amazonian forests.

Table 8

	Euterpe	Prestoea	Hyospathe	Oenocarpus
Spp. in Bolivia	3	1	1	5
Height	10-14 m	3-4 m	2-4 m	6-12 m
Stem	solitary	solitary	creeping	solitary to clustered
Habit	treelike	treelike	shrub	treelike
Leaves	pendule	pendule	erect or	erect or arched
Pinnae	even spaced	even spaced	threefolded	even spaced
Inflorescence	branched	branched	branched	hippuriform

Some species have solitary stems and erect leaves whereas others have clustered stems and arched leaves (Table 8). We still need both flowering and fruiting herbarium material from Bolivia of Oenocarpus distichus.

Hyospathe is monotypic and occupies the understory. Sometimes it has a creeping habit (Table 8). It is frequently confused with Geonoma due to its three-pinnate leaves.

Syagrus, Parajubaea and Allagoptera belong to the subtribe Butiinae, but they are morphologically easily distinguished (Table 9). Although Syagrus reaches mountain forests up to 1000 m of elevation, both Syagrus and Allagoptera are mostly distributed in the lowlands. Parajubaea on the contrary is restricted to wet ravines in the inter-Andean dry valleys of Santa Cruz, Chuquisaca, and Potosí.

Syagrus has five species in Bolivia which are acaulescent or treelike.

Parajubaea has two species (P. cocoides, P. torallyi), both of which are Andean (Moraes & Henderson, 1990; Appendix 3). Parajubaea torallyi, an endemic species,

has a massive stem densely covered with fibrous foliar bases.

Table 9 BEST AVAILABLE COPY

	Syagrus	Allagoptera	Parajubaea	Attalea
Spp. in Bolivia	5	1	1	5
Height	2-18 m	1.5-3 m	6-8 m	8-18 m
Habit	treelike & acaulescent	acaulescent	treelike	treelike
Inflorescence	branched & spicate	spicate	branched	branched & spicate
Stamens	6	12	15-18	6-28

Allagoptera is represented in Bolivia with one species, which is widely distributed in well drained savannahs and on the top of hills E Bolivia. This genus is a biogeographical element of the Cerrado, and is widespread in central Brazil, E and central Bolivia, N Argentina, and N Paraguay (Moraes, draft; Appendix 9).

The genus Attalea has five species in Bolivia (Table 9). Three of them are well known and have wide distributions. Most species are treelike. Attalea phalerata and A. butyracea are frequently confused because of their similarities in size and appearence. For Attalea butyracea, A. eichleri, and A. maripa flowering herbarium material from Bolivia is still lacking.

Acrocomia, Aiphanes, Desmoncus, Bactris and Astrocaryum include mostly armed species (Table 10). Acrocomia and Desmoncus are found in secondary vegetation in open areas as well as in low thorn forests and island forests. The six species of Desmoncus are easily

differentiated by their leaf shape, curved or straight spines, and the color of their fruits.

Table 10

	Acrocomia	Aiphanes	Desmoncus	Bactris
Spp. in Bolivia	3	1	6	12
Height	4-8 m	3-6 m	3-8 m *	2-10 m
Stem	solitary	solitary	clustered	solitary & clustered
Habit	treelike,	treelike,	climbing	shrub to treelike
Pinnae	elongated	fishtailed	sigmoid	elongated, sigmoid to fused
Inflorescence	branched	branched	branched	branched
Rachillae	+ 10	+ 10	+ 10	± 10

* depending on the length of cirrus

Aiphanes, represented in Bolivia with one species, is mostly restricted to Andean forests. This genus is easily recognized by having 'fishtail'-pinnae. Astrocaryum and Bactris have diversified in the Andean foothills forests up to 1000 m and in the Amazonian rainforests.

Bactris is very diverse and represented in Bolivia with 12 species. Important features to differentiate species are solitary or clustered habit, pinnate or fused leaves, and orange or purple fruits. Most species are well adapted to seasonal and permanent humid soils.

Astrocaryum, has ten species in Bolivia. They are acaulescent or treelike (Table 11). The most useful feature to distinguish between species is the number of pistillate flowers on the base of the rachillae, solitary or cespitose habits, and the arrangement of pinnae.

46

Geonoma has 21 species in Bolivia, but this number may be an overestimate since some currently accepted names may need to be synonymized. This genus has a wide range of leaf forms (Table 10). Several names cited for Bolivia need further taxonomic work.

Table 11 BEST AVAILABLE COPY

	Astrocaryum	Geonoma
Spp. in Bolivia	10	21
Height	[illegible] m	[illegible] m
Stem	solitary or clustered	solitary or clustered
Habit	treelike and acaulescent	shrub to treelike
Pinnae	elongated	elongated, sigmoid to fused
Inflorescence	branched	spicate to branched
Rachillae	< 10	> 10

5. Subfamily Phytelephantoideae. This is one of the most advanced 'pinnate-leaves' dioecious palm groups. It includes one genus in Bolivia, Phytelephas, which has only one species, P. macrocarpa. This genus has a treelike life form with a short stem. It is widely distributed in the Andean forests towards the Amazonian rainforests, but restricted to the W and NW of Bolivia.

Conclusions

1. The richness of Bolivian native palms is not only expressed in number of species, but also in the diversity of habits, and in a wide range of distribution patterns in altitudinal levels and vegetational units.

2. Although some Bolivian taxa, 27 genera and 94 species, have been rearranged systematically through many treatments of palms, much work remains to be done in order to solve the identity and synonymy of several

species names. Geonoma, Bactris, Astrocaryum, Acrocomia, Desmoncus, Ceroxylon, Mauritella, Syagrus, and Trithrinax require further taxonomic studies.

3. It is expected that further fieldwork and search for palms in poorly known areas will provide relevant information about the occurrence and distribution of Bolivian palms.

Literature Cited

Ahlfeld, F. E. 1969. Geología de Bolivia. Ed. Los Amigos del Libro, La Paz/Cochabamba.

Anderson, A. B. & M. J. Balick. 1988. Taxonomy of the babassu complex (Orbignya spp.: Palmae). Syst. Bot. 13: 32-50.

Antezana, L. 1976. Palmeras nativas de Bolivia de valor económico. Pages 87-97 in Simposio Internacional sobre Plantas de Interés Económico de la Flora Amazónica. IICA, Turrialba.

Balick, M. J. 1981a. Mauritiella (Palmae) reconsidered. Brittonia 33: 459-460.

_____. 1981b. Jessenia bataua and Oenocarpus species; native Amazonian palms as new sources of edible oil. Pages 141-155 in E. H. Pryde, L. H. Princen & K. D. Mukherjee (Eds.), New Sources of Fats and Oil. American Oil Chemists' Society, Champaign.

_____. 1986. Systematics and economic botany of the Oenocarpus-Jessenia (Palmae) complex. Adv. Econ. Bot. 3: 1-140.

_____, C. U. B. Pinheiro & A. B. Anderson. 1987. Hybridization in the babassu palm complex: I. Orbignya phalerata x O. eichleri. Am. J. Botany 74: 1013-1032.

Balslev, H. 1987. Palmas nativas de la Amazonia ecuatoriana. Colibrí 3: 64-73.

_____ & A. Barfod. 1987. Ecuadorean palms - an overview. Opera Bot. 92: 17-35.

_____ & A. Henderson. 1987a. A new Ammandra (Palmae) from Ecuador. Syst. Bot. 12: 501-504.

_____ & _____. 1987b. The identity of Ynesa colenda O. F. Cook (Palmae). Brittonia 39: 1-6.

_____ & M. Moraes. 1989. Sinopsis de las palmeras de Bolivia. AAU Reports 10: 1-107.

Barbosa Rodrigues, J. 1901. Ordo Palmae. Contr. Jard. Bot. Rio de Janeiro 1: 7-17.

Barbosa Rodrigues, J. 1903. Sertum Palmarum Brasiliensium. Veuve Monnom, Brussels.

Barfod, A. S. 1991. A monographic study of the subfamily Phytelephantoideae (Arecaceae). Opera Bot. 105: 1-73.

_____, A. Henderson & H. Balslev. 1987. A note on the pollination of Phytelephas microcarpa (Palmae). Biotropica 19: 191-192.

Beach, J. H. 1984. The reproductive biology of the peach or "pejibayé" palm (Bactris gasipaes) and a wild congener (Bactris porschiana) in the Atlantic lowlands of Costa Rica. Principes 28: 107-119.

Beck, S. 1988. Las regiones ecológicas y las unidades fitgeográficas de Bolivia. Pages 233-271 in C. B. Morales (Ed.), Manual de Ecología. Instituto de Ecología, UMSA, La Paz.

Beck, S., T. J. Killeen & E. García. 1993. Vegetación de Bolivia. Pages 6-24 in T. J. Killeen, S. Beck & E. García E. (Eds.), Guía de Arboles de Bolivia. Herbario Nacional de Bolivia-Missouri Botanical Garden, Edit. Quipus, La Paz.

Blicher-Mathiesen, U. 1989. The subtribe Attaleinae (Palmae) in Ecuador. Cand. scient. Thesis, Botanical Institute, University of Aarhus, Denmark.

Boom, B. M. 1986. The Chacobo indians and their palms. Principes 30: 63-70.

4/

Borchsenius, F. & H. Balslev. 1990. Three new species of Aiphanes and notes on the genus in Ecuador. Nord. J. Bot. 9: 383-393.

_____ & R. Bernal. (accepted). The genus Aiphanes (Palmae). Fl. Neotrop. Monogr.

Braun, A. 1968. Cultivated palms of Venezuela. Principes 12: 39-103; 111-136.

_____ & F. Delascio C. 1987. Palmas Autóctonas de Venezuela y de los Países Adyacentes. LITORCA, Co., Caracas.

Brockmann, C. E. 1978. Mapa de Cobertura y Uso Actual de la Tierra en Bolivia. Programa ERTS, Serie Sonsores Remotos 2, GEOBOL, La Paz.

Burquez, A., K. Sarukhan & A. L. Pedroza. 1987. Floral biology of a primary rain forest palm, Astrocaryum mexicanum Liebm. Bot. J. Linn. Soc. 94: 407-419.

Burret, M. 1928. Die Palmengattungen Chelyocarpus Dammer und Tessmanniophoenix Burret nov. gen. Notizbl. Bot. Gart. Berlin-Dahlem 10: 394-401.

_____. 1929a. Die Palmengattung Orbignya, Attalea, Scheelea und Maximiliana. Notizbl. Bot. Gart. Berlin-Dahlem 10: 493-701.

_____. 1929b. Die Gattung Ceroxylon Humb. et Bonpl. Notizbl. Bot. Gart. Berlin-Dahlem 10: 841-854.

_____. 1929c. Die Gattung Hyospathe Mart. Notizbl. Bot. Gart. Berlin-Dahlem 10: 854-859.

_____. 1929d. Die Gattung Euterpe Gaertn. Bot. Jahrb. Syst. 63: 49-76.

_____. 1930a. Iriarteae. Notizbl. Bot. Gart. Berlin-Dahlem 10: 918-942.

_____. 1930b. Eine neue Palmengattung aus Südamerika. Notizbl. Bot. Gart. Berlin-Dahlem 11: 48-51.

_____. 1931. Palmae Hoppianae novae vel criticae. Notizbl. Bot. Gart. Berlin-Dahlem 11: 231-236.

_____. 1932. Die Palmengattungen Martinezia und Aiphanes. Notizbl. Bot. Gart. Berlin-Dahlem 11: 557-577.

44

_____. 1933. Chamaedorea Willd. und verwandte Palmengattungen. Notizbl. Bot. Gart. Berlin-Dahlem 11: 724-768.

_____. 1934a. Bactris und verwandte Palmengattungen. Repert. Spec. Nov. Regni. Veg. 34: 185-253.

_____. 1934b. Die Palmengattung Astrocaryum G. F. Meyer. Repert. Spec. Nov. Regni. Veg. 35: 114-158.

_____. 1934c. Die Palmengattung Desmoncus Mart. Repert. Spec. Nov. Regni. Veg. 36: 197-221.

_____. 1935. Die Palmengattungen Mauritia L.f. und Mauritiella Burret nov. gen. Notizbl. Bot. Gart. Berlin-Dahlem 12: 605-611.

_____. 1936a. Die Palmengattung Morenia R. and P. Notizbl. Bot. Gart. Berlin-Dahlem 13: 332-339.

_____. 1936b. Palmae neogeae X. Notizbl. Bot. Gart. Berlin-Dahlem 13: 339-347.

_____. 1937a. Palmae neogeae XI. Notizbl. Bot. Gart. Berlin-Dahlem 13: 478-481.

_____. 1937b. Die Palmengattung Syagrus Mart. Notizbl. Bot. Gart. Berlin-Dahlem 13: 677-696.

_____. 1938. Palmae Kuhlmannianae Amazonicae. Notizbl. Bot. Gart. Berlin-Dahlem 14: 261-268.

_____. 1940. Palmae neogeae XII. Notizbl. Bot. Gart. Berlin-Dahlem 15: 99-108.

_____. 1941. Die Palmengattung Tessmaniodoxa nov. gen. Notizbl. Bot. Gart. Berlin-Dahlem 15: 336-338.

Cárdenas, M. 1970. Palm forests of the Bolivian high Andes. Principes 14: 50-54.

Dahlgren, B. E. 1936. Index of American palms. Field Mus. Nat. Hist., Bot. Ser. 14: 1-456.

_____ & S. F. Glassman. 1961. A revision of the genus Copernicia. Gentes Herb. 9: 3-40.

Dransfield, J. 1978. Growth forms in rain forest palms. Pages 247-268 in P. B. Tomlinson & M. H.

45

Zimmermann (Eds.), Tropical Trees as Living Systems. Cambridge University Press, Cambridge.

_____. 1986. A guide to collecting palms. Ann. Missouri Bot. Gard. 73: 166-176.

Dugand, A. 1940. Palmas de Colombia: clave diagnóstica de los géneros y nómina de las especies conocidas. Caldasia 1: 20-84.

Ellengerg, H. 1981. Mapa simplificado de las ecoregiones de Bolivia. Ecología en Bolivia 1.

Essig, B. F. 1971. Observations on pollination in Bactris. Principes 15: 20-24, 35.

Foster, C. R. 1958. A catalogue of the ferns and flowering plants of Bolivia. Contr. Gray Herb. 184: 1-223..

Galeano, G. 1986. Primer registro de dos géneros de palmas para la flora colombiana. Mutisia 66: 1-4.

_____. 1991. Las palmas de la región de Araracuara. Estudios en la Amazonia Colombiana, Vol. 1. Tropenbos Colombia, Bogotá.

_____. 1992. Patterns of palm distribution in Colombia. Bull. Inst. fr. études andines 21: 599-608.

_____ & R. Bernal. 1987. Palmas del Departamento de Antioquia. Región Occidental. Universidad Nacional de Colombia, Bogotá.

Gentry, A. H. 1986. Notes on Peruvian palms. Ann. Missouri Bot. Gard. 73: 158-165.

Glassman, S. F. 1965. Geographic distribution of new world palms. Principes 9: 132-134.

_____. 1970. A synopsis of the palm genus Syagrus Mart. Fieldiana Bot. 32: 215-241.

_____. 1972. A revision of B. E. Dahlgren's index of American palms. Phanerogamarum Monographiae, Tomus VI. Cramer, Lehre.

_____. 1977a. Preliminary taxonomic studies in the palm genus Orbignya Mart. Phytologia 36: 89-115.

46

_____. 1977b. Preliminary taxonomic studies in the palm genus Scheelea Karsten. Phytologia 37: 219-250.

_____. 1977c. Preliminary taxonomic studies in the palm genus Attalea H.B.K. Fieldiana, Bot. 38: 31-61.

_____. 1987. Revisions of the palm genus Syagrus Mart. and other selected genera in the Cocos alliance. Illinois Biol. Mon. 56: 1-230.

Granville, J.- J. de. 1978. Notes biologiques sur quelques palmiers guayanais. Cah. ORSTOM, sér. Biol. 12: 347-353.

_____. 1992. Life forms and growth strategies of Guianan palms as related to their ecology. Bull. Inst. fr. études andines 21: 533-548.

Hallé, F. & R. A. A. 1970. Essai sur l'Architecture et la Dynamique de Croissance des Arbres Tropicaux. Masson, Paris.

Henderson, A. 1986. A review of pollination studies in the Palmae. Bot. Rev. 52: 221-259.

_____. 1990. Arecaceae. Part I. Introduction and the Iriarteinae. Fl. Neotrop. Monogr. 53: 1-100.

_____ & M. J. Balick. 1987. Notes on the palms of Amazônia Legal. Principes 31: 116-122.

Hodel, D. R. 1992. Chamaedorea Palms. The Species and Their Cultivation. Allen Press, Kansas.

Irmay, H. de. 1947. La palmera "cusi" y el aceite de "babassu". Un gran recurso forestal de Bolivia: Orbignya phalerata Mart. Rev. Agr. UMSS Cochabamba 6: 29-41.

Kahn, F. 1986. Life forms of Amazonian palms in relation to forest structure and dynamics. Biotropica 18: 214-218.

_____. 1990. Las palmeras del Arboretum Jenaro Herrera (Provincia de Requena, Departamento de Loreto, Perú). Candollea 45: 341-362.

47

_____. 1991. Palms as key swamp forest resources in Amazonia. For. Ecol. Manage. 38: 133-142.

_____ & J. - J. de Granville. 1992. Palms in forest ecosystems of Amazonia. Springer, Berlin/ Heidelberg.

_____ & K. Mejía. 1987. Notes on the biology, ecology and use of a small Amazonian palm: Lepidocaryum tessmannii. Principes 31: 14-19.

_____ & _____. 1990. Palm communities in wetland forest ecosystems of Peruvian Amazonia. For. Ecol. Manage. 33/44: 169-179.

_____ & _____. 1991. The palm communities of two "terra firme" forests in Peruvian Amazonia. Principes 35: 22-26.

_____, A. Henderson, L. Braho, M. Hoff & F. Moussa. 1992. Updating Peruvian palm flora - first step: collecting intensity and collection richness. Bull. Inst. fr. études andines 21: 549-564.

_____ & B. Millán. 1992. Astrocaryum (Palmae) in Amazonia. A preliminary treatment. Bull. Inst. fr. études andines 21: 459-532.

Listabarth, C. 1992. A survey of pollination strategies in the Bactridinae (Palmae). Bull. Inst. fr. études andines 21: 699-714.

MacBride, J. F. 1960. Palmae. Flora of Peru. Field Mus. Nat. Hist., Bot. Ser. 13: 321-418.

Martius, C. F. P. von. 1823. Historia naturalis palmarum. 2: 23. T. O. Weigel, Leipzig.

_____. 1847. Palmetum Orbignianum. Descriptio Palmarum in Paraguaria et Bolivia crescentium. P. Bertrand, Paris.

Meneces, E. 1975. Bibliografía de las palmeras de Bolivia. Rev. Soc. Boliviana Hist. Nat. 2: 14-21.

Moore, H. E. Jr. 1963. The types and lectotypes of some palm genera. Gentes Herb. 9: 245-274.

_____. 1972. Chelyocarpus and its allies Cryosophila and Itaya (Palmae). Principes 16: 67-88.

48

_____. 1973a. The major groups of palms and their distribution. Gentes Herb. 11: 27-141.

_____. 1973b. Palms in the tropical forest ecosystems of Africa and South America. Pages 63-88 in B. J. Meggers, E. S. Ayensu and W. D. Duckworth (Eds.), Tropical Forest Ecosystems in Africa and South America: A Comparative Review. Smithsonian Institution Press, Washington, DC.

_____. 1980. Four new species of Palme from South America. Gentes Herb. 12: 30-38.

Mora Urpi, J. & E. M. Solis. 1980. Polinización en Bactris gasipaes H.B.K. (Palmae). Rev. Biol. Trop. 28: 153-174.

Moraes R., M. 1989a. El género Allagoptera Nees (Palmae). Cand. scient. Thesis, Botanical Institute, University of Aarhus, Denmark.

_____. 1989b. Ecología y formas de vida de las palmas bolivianas. Ecología en Bolivia 13: 33-45.

_____. 1990a. Claves dicotómicas preliminares para las subfamilias y géneros de palmas nativos de Bolivia. Mus. Nac. Hist. Nat. (Bolivia) Comunicación 10: 3-18.

_____. 1990b. Ficha de colección para las Palmae bolivianas. Mus. Nac. Hist. Nat. (Bolivia) Comunicación 10: 23-31.

_____. 1991. Contribución al estudio del ciclo biológico de la palma Copernicia alba en una estancia ganadera (Espíritu, Depto. Beni, Bolivia). Ecología en Bolivia 18: 1-20.

_____. 1993a. Allagoptera brevicalyx (Palmae), a new species from Bahia, Brazil. Brittonia 45: 21-24.

_____. 1993b. Palmae. Pages 612-128 in T. Killeen, E. García & S. Beck (Eds.), Guía de Arboles de Bolivia. Herbario Nacional de Bolivia/ Missouri Botanical Garden, Edit. Quipus, La Paz.

_____ & S. Beck. 1992. Diversidad florística de Bolivia. Pages 73-111 in M. Marconi (Ed.),

49

Conservación de la Diversidad Biológica en Bolivia. CDC-Bolivia, La Paz.

_____, G. Galeano, R. Bernal, H. Balslev & A. Henderson. (accepted). Tropical Andean palms (Arecaceae). Mem. New York Bot. Gard. 00: 000-000.

_____, M. & A. Henderson. 1990. The genus Parajubaea (Palmae). Brittonia 42: 92-99.

_____. (draft). The genus Allagoptera (Palmae). Fl. Neotrop. Monogr.

Moussa, F., F. Kahn, A. Henderson, L. Brako & M. Hoff. 1992. Palms of the major river valleys of Peruvian Amazonia. Bull. Inst. fr. études andines 21: 565-598.

Pingitore, E. J. 1978. Revisión de las especies del género Trithrinax. Rev. Inst. Munic. Bot. 4: 95-109.

Pinheiro, C. U. B. & M. J. Balick. 1987. Brazilian palms. Notes on their uses and vernacular names, compiled and translated from Pio Corrêa's "Dictionário das Plantas Uteis do Brazil e das Exóticas Cultivadas", with updated nomenclature and added illustrations. Contr. New York Bot. Gard. 17: 1-63.

Ragonese, A. E. & G. Covas. 1942. Flora de la Provincia de Santa Fe. Las Palmeras. Darwiniana 4: 285-302.

Raulino R., P. 1974. Palmeiras. Flora Ilustrada Catarinense. Itajaí, Santa Catarina.

Raven, P. H. 1976. Ethics and attitudes. Pages 155-179 in J. Simmons, R. I. Beyer, P. E. Brandham, G. L. Lucas & V. F. da Silva (Eds.), Conservation of Threatened Plants. Plenum Press, New York/London.

Ribera, M. O. 1992. Regiones ecológicas. Pages 9-71 in M. Marconi (Ed.), Conservación de la Diversidad Biológica en Bolivia. CDC-Bolivia, La Paz.

_____, M. Libermann, S. Beck & M. Moraes. (in press). Mapa de Vegetación y de Grupos Indígenas de Bolivia. World Bank. CIMAR, Santa Cruz.

50

Scariot, A. I., E. Lleras & H. D. Hay. 1991. Reproductive biology of the palm Acrocomia aculeata in Central Brazil. Biotropica 23: 12-22.

Seibert, R. J. 1950. The importance of palms to Latin America; pejibaye as notable example. Ceiba 1: 65-74.

Skov, F. & H. Balslev. 1989. A revision of Hyospathe (Arecaceae). Nordic J. Bot. 9: 189-202.

Solomon, J. C. 1989. Bolivia. Pages 456-463 in D. G. Campbell & H. D. Hammond (Eds.), Floristic Inventory of Tropical Communities. The New York Botanical Garden, Missouri Botanical Garden/WWF, New York.

Uhl, N. W. & J. Dransfield. 1987. Genera Palmarum. A Classification Based on the Work of Harold E. Moore, Jr. Allen Press, Kansas.

Wallace, A. R. 1843. Palm Trees of the Amazon and Their Uses. John van Voorst, London.

Wessels Boer, J. G. 1965. The Indigenous Palms of Suriname. E. J. Brill., Leiden.

_____. 1968. The geonomoid palms. Verh. Kon Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect. 58: 1-[illegible].

Zona, S. & A. Henderson. 1989. A review of animal-mediated seed dispersal of palms. Selbyana 11: 6-21.

Title of project:

Sustainable use of *Geonoma deversa* (Palmae) in northwestern Bolivia

Objectives:

To propose harvesting techniques for a sustainable use of *Geonoma* spp. (Palmae) used by local people for thatching. These species are locally known as "jatata" and are distributed in the Bolivian Amazonia. This main objective will encomprise the following actions:

determining the species involved in thatching purposes,

determining current harvesting methods used by two ethnic groups (Tacanas and Chimane) in western Bolivia,

evaluating the effects of traditional use on the populations of species involved,

research of basic biological features of *Geonoma deversa* and related species used for thatching,

and searching resistance attributes of species used for thatching.

General background

In Bolivia the Amazonian forest is an important source of many products for subsistence economy (food, medicines, construction materials etc). Some of these could be included as economically rentable activities, at least at a local level. The use of non timber forest products has been largely proposed as an economically alternative against deforestation and conventional logging.

For a regional development of the Bolivian Amazonia the search of economically profitable activities is a primary goal. Recent evaluations have showed many restrictions on the use of natural resources. One of the most important recommendations is to promote the participation of local people in this process, mainly ethnic groups.

The "jatata" palm, mainly referred to *Geonoma deversa* but also includes other species of *Geonoma* is widespread used for thatching by many ethnic groups and rural settlements in Bolivian Amazonia.

The thatching-pieces assembled with jatata leaves have a high quality and last more than 15 years. They are highly required in many urban centers in the Bolivian Amazonia, and it could be considered as an economically important alternative at a local context, as a profitable activity for ethnic groups as the Chimane or Tacana people in western Bolivia. The economic importance of jatata was treated by Rioja (1992), who emphasized a growing demand of this product at the regional scale in Bolivia.

However, because this growing pressure the traditional use of jatata could not be considered sustainable. Local references and preliminary observations of many authors revealed a population declination in some areas. Then, with regard of the importance of the jatata in the economy of subsistence and as a potencial economic product, it is proritaire to improve its management towards a future sustainable use.

Methods

The study includes three key components:

1. Compilation of information related to ***Geonoma*** species and a brief review of species used for thatching in NW Bolivia. This will be carried out through local collections assisted by local harvesters, interviews with harvesters of ethnic groups and bibliographical reviews.

2. Evaluation of harvesting and uses of ***Geonoma*** species.

    2.1. Detailed description of local harvest applied by two ethnic groups, Tacana and Chimane. This description will include a selection of harvesting areas, selection of patches and individuals, and all the processes involved until assembling leaves of ***Geonoma*** for thatching
    2.2. Evaluation of harvest effects on individuals and populations of species involved
    2.3. Record of preliminary data on biological and demographic features
    2.4: Tests/proofs on experimental cutting to improve the long-term productivity of individuals and populations

3. Experimental tests of material quality in order to evaluate ***Geonoma***'s physical, heat, humidity, and organic decomposicion resistance.

In order to compare both harvested and untouched forests, representative forest sites were selected related to traditional settlements of Chimane and Tacana ethnic groups as well as in a pristine area of primary rain forest.

Both chosen areas are currently proposed as national parks under the Bolivian system of protected areas.

In each of these three areas will be stablished a 1-hectare plot where all the individuals of *Geonoma* spp. will be registered. For each 1-hectare plot a sample of 1/10 ha will be studied and a standard data series for all individuals of *Geonoma* species will be recorded such as phenology, growth, etc.

The stablished plots related to traditional settlements will be a study site for monitoring harvest techniques and their effects on populations and individuals. Whereas plots in pristine forests will serve as a comparison site. Information about traditional techniques on harvesting and treatments of the jatata leaves will be obtained trough interviews of Chimane and Tacana people.

For experimental cutting techniques, a sample of 1/10 ha will be tested for each sustainable use alternative proposed through this present project.

Plots will be visited at least three times per year. It is expected that chosing study plots in protected areas they will be kept as permanent monitoring sites.

Personnel and institutional affiliation

The present study will be carried out under the research project Sustainable Use, Diversity, Economic Potential, and Conservation Status of Bolivian Palms organized by the Bolivian Herbarium in La Paz and The New York Botanical Garden.