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**Peanuts and peanut farmers of the Rio Beni: Traditional crop  
genetic resource management in the Bolivian Amazon**

**Williams, David Edison, Ph.D.**

**City University of New York, 1991**

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PEANUTS AND PEANUT FARMERS OF THE RIO BENI:  
TRADITIONAL CROP GENETIC RESOURCE MANAGEMENT  
IN THE BOLIVIAN AMAZON

by

David Edison Williams

A dissertation submitted to the  
GRADUATE FACULTY IN BIOLOGY  
in partial fulfillment of  
the requirements for the degree of  
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1991

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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

PEANUTS AND PEANUT FARMERS OF THE RIO BENI:  
TRADITIONAL CROP GENETIC RESOURCE MANAGEMENT  
IN THE BOLIVIAN AMAZON

by

David Edison Williams

Adviser: Professor Ghilleen T. Prance

Although the peanut (Arachis hypogaea L.) has been the object of ample agronomic and taxonomic study, many basic questions remain regarding the peanut's origin and evolution in South America. A poorly known area of northern Bolivia was selected for exploration and study in an effort to shed light on the origin of the erect subspecies (ssp. fastigiata Waldron) and to understand the agricultural conditions under which it evolved and diversified. The chosen study site is located midway between recognized centers of peanut sub-specific diversity, where indigenous farmers cultivate numerous primitive peanut landraces using age-old agricultural methods. A community of Tacana Indian farmers living on the Beni River became the focus of the study. Conserving an ancient but little-studied cropping system, six

distinct landraces of peanuts, all belonging to the erect subspecies, are planted extensively on riverine sandbars exposed during the low-water season. A selected portion of the harvest is replanted in upland slash-and-burn gardens as a seed crop in order to insure a fresh supply for the following season's sandbar planting. This cropping system exerts a strong and continuous selection pressure on the peanut germplasm, maintaining characters specifically adapted to this agroecosystem. It is demonstrated that these adaptive morphological and physiological characters are precisely those which are taxonomically diagnostic of the erect subspecies, Arachis hypogaea ssp. fastigiata, suggesting that their ancient origin and evolution took place under similar agroecological conditions. Archeological, ethnographic, linguistic, and historical evidence, as well as the modern distribution and diversity of the erect landraces support the notion that this subspecies had its center of origin in the vicinity of the study area. At present, most of the traditional peanut landraces in the study area are in danger of becoming lost. The information recovered has important implications for in situ crop genetic resource conservation and local agricultural development projects, for which appropriate strategies are proposed.

## Resumen

El maní, o cacahuate, (Arachis hypogaea L.) es la leguminosa comestible más difundida y potencialmente la más importante del mundo. Aunque ha sido el objeto de amplios estudios agronómicos y taxonómicos, quedan por resolver muchas cuestiones básicas en cuanto al origen y evolución del maní en Sudamérica. Es imprescindible encontrar la respuesta a dichas cuestiones con el fin de desarrollar el máximo potencial del maní mediante el fitomejoramiento. Se eligió una zona escasamente conocida en el norte de Bolivia para la exploración y estudio del maní en un intento de vizlumbrar el origen de la subespecie erguida (ssp. fastigiata Waldron) y con el fin de conocer las condiciones agrícolas bajo las cuales evolucionó y se diversificó. La zona escogida está ubicada entre dos centros reconocidos de diversidad subespecífica de maní, al pie de los Andes orientales en un ambiente de bosque húmedo tropical donde agricultores indígenas cultivan numerosas razas primitivas de maní empleando prácticas agrícolas ancestrales. Cerca del área del estudio se encuentra varias especies silvestres de Arachis cercanamente emparentadas al maní cultivado. Se profundizó el estudio en una comunidad de agricultores indígenas Tacana, ubicada unos kilómetros al sur del pueblo

de Rurrenabaque sobre el Río Beni. A pesar de que muchos rasgos de su cultura e idioma se han perdido últimamente, conservan aun su sistema agrícola ancestral como base de su economía de subsistencia. El maní esta representado por seis razas distintas, todas pertenecientes a la subespecie fastigiata, y éstas forman un elemento importante en el sistema agrícola Tacana. Se levantan dos cosechas por año: una para semilla y la otra para producción. Conservando un sistema antiguo pero poco estudiado, se siembra el maní extensivamente sobre las playas arenosas de los ríos cuando éstas estan expuestas durante el tiempo de secas. El campo de cultivo requiere poca o ninguna preparación ni mantenimiento, haciendose el sembrío en la arena y cosechando antes que el río inunde las playas nuevamente en la época de lluvias. Una parte de la cosecha de la playa es seleccionada y sembrada en parcelas de roza, tumba y quema en las tierras altas con el fin de proveer semilla fresca para sembrar en la playa el año siguiente. Este sistema ejerce una fuerte y continua presión selectiva sobre el germoplasma del maní, manteniendo los caracteres específicamente adaptados a este agroecosistema. Se demuestra que los caracteres morfológicos y fisiológicos adaptados son precisamente aquellos que son diagnósticos de la subespecie erguida, Arachis hypogaea ssp. fastigiata. Esto sugiere que su antiguo origen y evolución

se llevó a cabo bajo condiciones agroecológicas similares a las actuales. Evidencias arqueológicas, históricas y lingüísticas, así como la distribución y diversificación moderna de la subespecie erguida, apoyan la hipótesis que ésta subespecie tuvo su centro de origen en la zona de estudio. Actualmente, la mayoría de las razas tradicionales se encuentran en peligro de perderse, y la costumbre de cultivar las playas del río está restringido a unos pocos agricultores indígenas a pesar de que existen tremendas extensiones de playas baldías que quedan olvidadas y desaprovechadas. Esta información tiene implicaciones importantes para la conservación in situ de recursos fitogenéticos y para el desarrollo agrícola de la zona, para los cuales se presentan estrategias apropiadas.

This dissertation is dedicated to my wife

SANDRA DICKINSON BISSELL

In me crediens vitae ipsae salvatrix.

## Acknowledgements

So many individuals have contributed to the conceptual and logistic processes in the development of this dissertation that it is difficult to acknowledge them all by name, yet without whose direct or indirect input, this project could not have come to fruition. To all those, named and unnamed, who have assisted me in my research, I express my sincere appreciation.

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I also thank my son, Natty Bumpo, for gamely rising to all of the challenges we put before him, and for his cheerful

companionship during much of the fieldwork. His inquisitive nature and unbridled enthusiasm are a constant source of joy and pride to his parents.

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## Introduction

Since the dawn of Homo sapiens, mankind has relied upon its plant surroundings for the satisfaction of its most basic needs. Yet, strangely, it was only relatively recently, after the retreat of the last glaciation some 10,000 years ago, that humans finally crossed the threshold from fortuitous gathering of wild plants to an ever-intensifying coevolutionary relationship that resulted in plant domestication, the development of agriculture and the rise of civilization. This fateful process, which for plants is known as crop evolution, is ongoing. Once a wild plant species is transformed to the point that it becomes a cultigen, the future course of its evolution is largely a response to the needs of its human caretakers. Over time, as the needs of the caretakers change, so do their selection priorities. This brings about diversifying changes in the cultigen. When cultigens spread from their centers of origin and come under the influence of different cultures and physical environments, further diversification is the result.

In the present century, the evolution of crop plants has undergone unprecedented changes in response to the correspondingly great changes in the size and technological

capabilities of the global human community. Crop improvement, although still largely adhering to the same biological principles unconsciously employed in neolithic times, is now deliberately achieved with the aid of modern scientific knowledge and technology. This has greatly accelerated the rate of evolution in many existing crops and, in a very few cases, brought about the domestication of new crops.

The exploitation of crop plants has been so successful that human population growth now threatens to outstrip the production capabilities of current agricultural systems and crop varieties. Because the available lands for agriculture are limited and in some areas decreasing, the necessary increases in crop production must largely come from improved agricultural practices combined with higher-yielding cultivars, cultivars adapted to marginal lands, and new or currently underexploited crop species.

Modern plant breeders strive to direct the course of crop evolution towards greater production, uniformity, disease and pest resistance, earliness, and other agronomically desirable traits, many of which are associated with mechanized harvesting or herbicide tolerance. While plant breeders rely upon genetically diverse primitive landraces and wild crop relatives to supply the suites of genes necessary for crop

improvement, a byproduct of their efforts is the reduction of the overall genetic base of the crop, often threatening or displacing unimproved sources of diversity that will be needed in future breeding efforts. This self-defeating trend is by no means a necessary evil and can be corrected and reversed by making pertinent changes in agricultural, conservation and development policies.

The shortcomings of modern, industrialized agriculture seem to lie in the built-in reliance upon a genetically narrow crop base and, at least in the underdeveloped nations, a failure to adequately address the social, cultural and economic needs of the local farmers. Traditional farmers in developing nations typically maintain a wide and often unique diversity of crops and crop varieties. Traditional landraces represent primary components of ancestral agricultural systems based upon centuries of accumulated empirical knowledge of climate, soils and the crop genetic resources that are highly adapted to local conditions. There is an unfortunate and unfounded tendency in the agricultural sciences to dismiss or discount traditional crop varieties and cropping systems as "primitive," of low productivity, or even as environmentally destructive. Yet attempts to wholly replace these locally specialized systems with imported crops and technology have usually met with limited success. A more logical approach would be to carefully study and evaluate the

merits of the native farming systems and find ways to enhance their productivity through the incorporation of appropriate technology to reduce existing limitations. Moreover, improving these native systems while conserving their basic integrity will provide a context for the continued maintenance, in situ, of the valuable crop genetic diversity particular to those systems and those cultures. In this way, the traditional guardians of crop genetic diversity during the past ten millennia can be incorporated into the international effort to improve agricultural production, rather than be subjugated and perhaps even defeated by it, having been rendered non-competitive.

## Chapter I

### The Problem

The peanut is the most widespread food legume in the world, being cultivated in the warmer areas on every continent except Antarctica. The peanut seed is rich in both oil (ca. 50%) and protein (ca. 30%) and consequently makes a substantial contribution to human nutrition worldwide. The most important peanut producing countries are India, China, the United States, Senegal, and Nigeria. All commercially cultivated peanuts belong to a single species, Arachis hypogaea L., of which there exist hundreds of landraces, cultivars, and breeding lines.

Yet despite the peanut's widespread distribution, nutritional merits and economic importance, it may still be regarded as an underexploited crop in light of its great unrealized potential. The primary obstacles standing in the way of realizing the peanut's full potential are the myriad pests and diseases that plague the crop worldwide, reducing yields and destroying harvests. This obstacle can be combated with pesticides and the development of resistant varieties through plant breeding. Resistant varieties not

only reduce the deleterious effects of pests and pathogens but also reduce or eliminate the need for applying costly and environmentally harmful chemical pesticides. Improved cultivars released by plant breeders between 1940 and 1980 contributed 25-30% of the peanut yield increases achieved during that time (Pattee & Young, 1982). Part of the crop's susceptibility to pests and pathogens is due to the narrow genetic base of the commercial varieties and a lack of good resistant varieties has forced the American peanut industry to rely on pesticides (NAS, 1972).

Peanut breeders are attempting to create improved varieties by introducing disease- and pest-resistant genes found in exotic primitive varieties (landraces) and their closely related wild species. The raw material for peanut improvement is obtained through plant exploration, primarily in the crop's center of origin where the crop's gene pool is most diverse. Some primitive landraces possess varying degrees of disease resistance which can be transferred to improved cultivars with relative ease using standard plant-breeding techniques. Wild species of Arachis, however, often demonstrate very high levels of disease and pest resistance that, by virtue of the fact that they pertain to distinct species, is far more difficult to transfer to the cultivated peanut genome because of hybridization barriers (Norden, 1980).

Although numerous peanut collecting expeditions have been made in South America in recent years (Valls et al., 1985), the critical area of northern Bolivia has remained largely unexplored, and has been assigned a high priority for future exploration by the peanut genetic resource community (Simpson, 1984; Valls et al., 1985). This region is not only the home of unusual primitive landraces, but is also believed to contain one or more still-uncollected and undescribed species of wild peanuts, possibly including the crop's elusive wild progenitors (Simpson, 1984; Smartt et al., 1978a, 1978b). The collection, description and conservation of this unique genetic material is of great importance for future peanut improvement.

Furthermore, basic questions regarding the origin and evolution of the cultivated peanut remain to be answered. The wild progenitor or progenitors of the crop have yet to be conclusively identified. The genus Arachis, entirely endemic to South America, has been divided by taxonomists into seven sections (Gregory et al., 1980). The cultivated peanut belongs to the section Arachis which includes numerous wild species from Bolivia, many of them recently discovered, and probably all of which will cross directly with the cultigen (Simpson, 1984). Gregory and Gregory (1976) postulate that A. hypogaea arose from the chromosome doubling of an intrasectional hybrid within the section Arachis, but the

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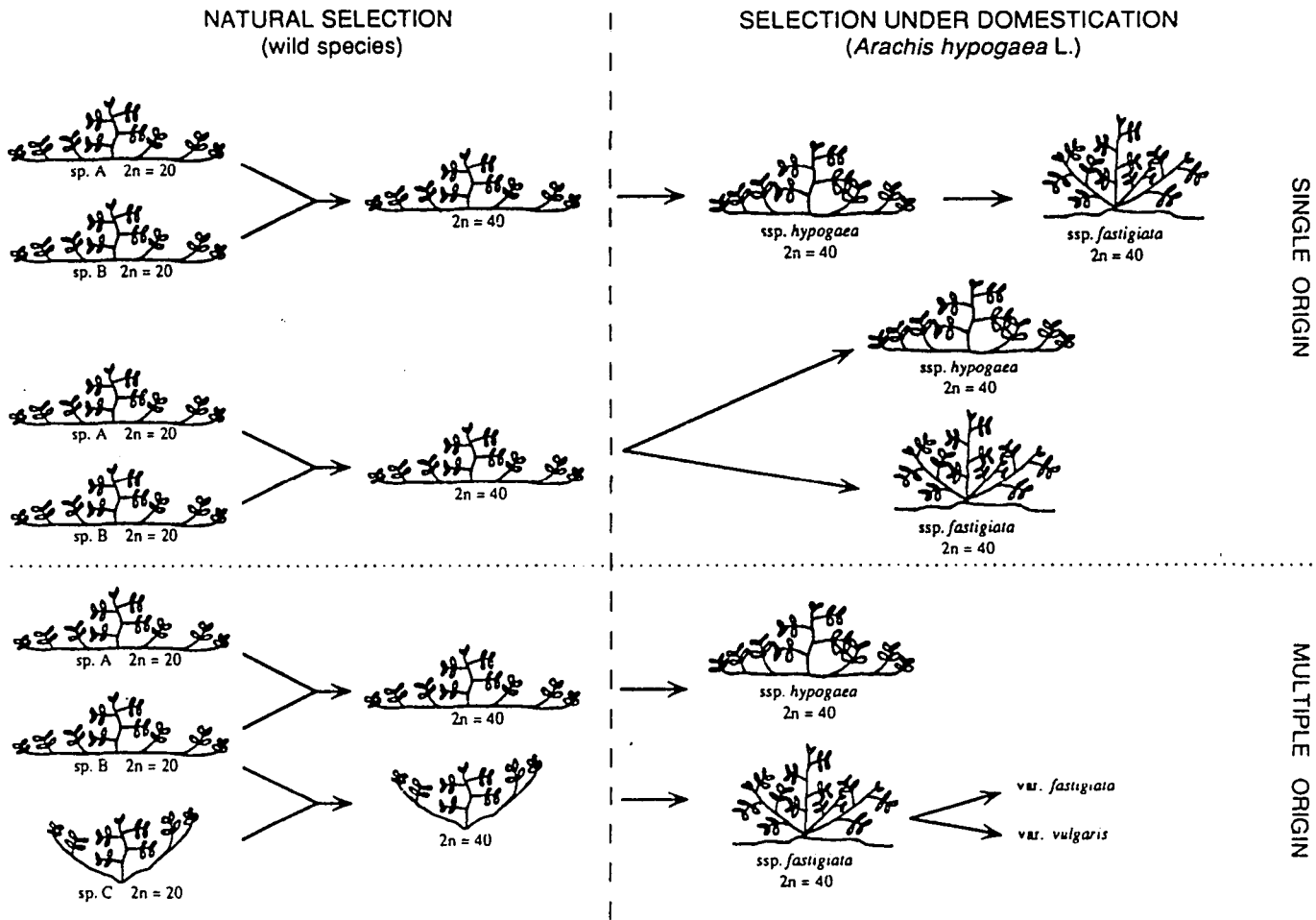
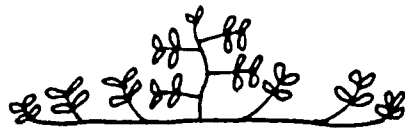


FIG. 1. Hypothetical evolutionary paths for the subspecific origin of cultivated peanuts.

wild progenitor species have not yet been conclusively identified (Smartt et al., 1978a). The discovery of the progenitor species will be of significant importance for peanut improvement and for the study of crop plant evolution (Fig. 1).

The separate origins of the different subspecies also need clarification. The two subspecies of Arachis hypogaea, ssp. hypogaea and ssp. fastigiata, are distinct entities that show divergence in physiological and genetic as well as morphological characters (Krapovickas, 1968; Stalker & Dalmacio, 1986). In crosses between the two subspecies the progeny have been observed with lethal characters or malformations that would indicate genetic divergence over a long period of separation in secondary centers (Gregory & Gregory, 1976; Krapovickas, 1968). Phylogenetically, the subspecies fastigiata can be considered to be more advanced than, or derived from, the comparatively more primitive subspecies hypogaea (Krapovickas, pers. comm.), primarily due to the fact that the latter (particularly its variety hypogaea) is the most similar to the closest related wild species (Krapovickas, 1973) pertaining to the section Arachis (Figs. 1, 2). The characters that distinguish the subspecies fastigiata appear to be largely the result of human selection under domestication. It is also possible that an extinct or still undiscovered wild species played a role in the origin of subspecies fastigiata.



Arachis spp. (wild)

perennial/annual

prostrate habit

seeds dormant

seeds 2

mainstem w/o flowers

alternate branching

ephemeral pegs



A. hypogaea hypogaea

long lived annual

prostrate habit

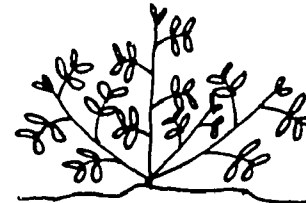
some seed dormancy

seeds 2-4

mainstem w/o flowers

alternate branching

weaker pegs



A. hypogaea fastigiata

short lived annual

erect habit

no seed dormancy

seeds 2, 4-6

mainstem with flowers

sequential branching

stronger pegs

FIG. 2. Comparison of characters among wild and cultivated peanuts.

These questions cannot be properly addressed until the wild and cultivated peanuts from northern Bolivia are known and studied. Moreover, the traditional uses and cropping systems employed by native peanut farmers in the crop's center of origin can provide useful information regarding the selective pressures guiding the evolution of the crop. Knowledge of the indigenous techniques for creating and maintaining peanut diversity will be important in modern efforts towards similar ends. No ethnobotanical study of peanuts has previously been undertaken in South America.

My preliminary studies showed that one of the native cropping systems, known as "playa agriculture" (because it exploits the seasonally exposed riverine sandbars or playas), is capable of producing sustained high yields with minimal labor expenditure, no clearing or burning of the forest, and virtually no decline in soil fertility year after year. Due partially to the demise of indigenous cultures and also to the lack of sufficient market, the extent of this age-old agricultural system has become greatly reduced, still being practiced primarily by indigenous farmers. Many thousands of hectares of sand and mud bars, perfectly suitable for playa agriculture, today lie unused along the shores of countless Amazonian headwater rivers and streams. As a first step towards bringing this vast, underexploited, high-yielding, thoroughly renewable agricultural resource back into

production, the native playa agricultural system, including its specially adapted crop varieties, needs to be carefully studied and understood.

Objectives: The primary objective of this research is to fill some of the gaps in basic information that have so far prevented a clear understanding of peanut origins and evolution. The timely recovery of this basic information and the corresponding genetic resources will also be valuable to local conservation and agricultural development projects. To achieve this overall goal, the following specific objectives were pursued:

- (1) conduct a systematic exploration of the poorly known Amazonian region of northern Bolivia to obtain germplasm and herbarium specimens representative of the area's peanut diversity, both wild and cultivated;
- (2) identify all material collected;
- (3) distribute subsamples of the germplasm collected to all major peanut seed banks in the Americas;

- (4) evaluate the conservation status of the peanut genetic resources in situ, identify factors that threaten or promote their existence, and design a practical strategy for monitoring and conserving endangered crop genetic resources in situ;
- (5) document the economic, nutritional, social and cultural role that peanuts and peanut farming play in the lives of contemporary indigenous peoples at the crop's center of origin; and
- (6) identify the selective pressures that the native culture and cropping system exert upon the peanuts.

## Chapter II

### Field Methods

The field study comprised two distinct phases: first a broad overland survey of the study region for what is known in the genetic resource community as "plant exploration," and then a more sedentary, in-depth ethnobotanical study of a native peanut farming system. Each of the two phases was accomplished according to accepted and distinct methodologies. Although there was a great deal of overlap, both phases contributed equally to the overall objective of the study.

The initial overland survey of the study region (SEP-DEC 1988) was carried out with the standard plant exploration procedures used by the United States Department of Agriculture (USDA) and the International Board for Plant Genetic Resources (IBPGR) as outlined in Simpson (1984) and Hawkes (1980). Because of the anticipated transportation difficulties and the numerous indigenous and remote peasant communities to be visited, I elected to travel alone to

minimize the problems that a larger team might present in those circumstances. The obvious disadvantages were offset by the enhanced travel flexibility and the reduced obtrusiveness when making contact with rural farmers and informants. Germplasm (seeds) and, whenever possible, herbarium vouchers were collected of wild and cultivated peanuts and of other crop plants.

Subsamples of the peanut germplasm were distributed to all gene banks in the Americas with major peanut collections: the Instituto Nacional de Tecnología Agropecuaria (INTA) in Manfredi, Argentina; the Centro Nacional de Recursos Genéticos (CENARGEN) in Brasília, Brazil; the Centro de Investigaciones Fitoecogenéticas de Pairumani (CIFP) in Cochabamba, Bolivia; and the USDA's Agricultural Research Service (USDA/ARS) in Beltsville, Maryland. Subsamples of other crop germplasm were divided between CIFP and USDA/ARS.

Based on this initial survey and the reports from earlier explorations, the area of Rurrenabaque was selected as the site for a more in-depth, long-term study because of its great ecological, ethnic, and crop genetic diversity.

By studying native peanut farmers in the crop's center of origin, I hoped to understand which aspects of the interrelationship between these people and this plant caused the peanut to change and diversify, and perhaps even get a

glimpse of the factors involved in the very origin of the cultigen itself. To accomplish this, I chose to do my study from an ethnobotanical perspective. Ethnobotany is defined here as the study of interactions and interrelationships between humans and plants over time. In the case of the intense coevolutionary processes of crop domestication and diversification, the ethnobotanical perspective seems particularly appropriate.

My first intention was to do a comparative study of peanut farming among the four native groups that have historically inhabited the study area: Tacana, Esse Ejja, Chimán and Masetén. I rented a house in the town of Rurrenabaque from where I had access to the various native communities via the Beni River, a dirt road, and foot trails. When I became aware that the four groups all cultivate the same landraces using essentially the same system, I decided to concentrate my research on the largest and most agriculturally oriented group, the Tacana. For this aspect of the research I followed the initial, non-experimental phases of the long-range methodology proposed by Hernández-X. and Ramos-R. (1981) for the study of agroecosystems with persistence of traditional agricultural technology. These include criteria for (a) selection of the study area, (b) introduction of the researcher to the area, (c) regionalization of the area, (d) ecological description, (e) recording the agricultural calendar and description of

the farming systems, (f) formulation of generalizations, and (g) formulation of a working hypothesis. Testing of the hypothesis and evaluation of the systems' productivity will be carried out at a future date.

The multidisciplinary methods of ethnobotanical research draw most heavily, but not exclusively, from the field techniques of botany and ethnography. Standard botanical collecting methods were used unchanged except that the plants collected are often found in anthropogenic environments and the collections themselves may be enriched with seeds or artifacts derived from the plants and with additional notes indicating economic, medicinal, supernatural or agricultural information.

The field methods of the ethnographer are also used by the ethnobotanist. Undoubtedly the most effective method for ethnographic work is that of the participant-observer, whereby the researcher engages to some extent in a society's activities as a means of gaining a better understanding and heightening rapport with the people he is studying (Winick, 1970). This technique calls for empathetic interaction, objective and penetrating observation, and accurate reporting (Hoebel, 1966). It is highly demanding of the researcher's time and stamina and for this reason is frequently shunned by researchers desiring quicker or easier results. Yet the quality of the information recovered through

participant-observation is far superior to any alternative method and is therefore almost mandatory for any in-depth ethnobotanical study. As pointed out by Hernández-X. (1971), a body of knowledge that has been accumulated over millenia will take some time to recompile.

Other specific ethnographic techniques, such as surveys and interviews, will depend upon the design of the study. In the present study, no formal surveys or interviews were conducted, these being regarded as awkward, intrusive, and invoking responses of uncertain veracity. Instead, interviews were conducted in a decidedly informal and casual manner, taking advantage of my rapport with the informant or a particular circumstance to enhance the reliability of the information recovered. I placed the highest confidence in unsolicited information that was usually exchanged between third parties or spontaneously offered directly to me as a result of my well-known interest in the subject. The unsolicited information was some of the most revealing data obtained, and is only available to the participant-observer. Unsolicited information is generally free of the kind of preconceived answers that are the unavoidable result of formal questionnaires, surveys and interviews.

Working for extended periods among peasant or tribal communities entails certain difficulties, challenges, and responsibilities. The very presence of the researcher

inevitably provokes some degree of change in the community, and the materials or information taken by the researcher may also have significant repercussions for the community. Regrettably, there have already been too many instances where contact from individuals or institutions associated with research, extension or development projects have been coercive, counterproductive or callously insulting to the very communities they sought to assist (Hernández-X. & Ramos-R., 1981). The ethnobotanical fieldworker must constantly be aware of and act according to the ethical responsibility that his or her activity brings with it. Not only should the researcher strive to make his presence as unobtrusive as possible and demonstrate respect for local customs and decorum, but should also seek ways in which the fruits of the research can be returned to benefit the community being studied.

For my field study I chose Carmen Florida, a small village of acculturated Indians located about seven kilometers upstream from Rurrenabaque on the right-hand bank of the Beni River. Beginning with my first trip to the area in 1988, I developed a friendly relationship with the family of dn. Wenceslao Cubo, a Tacana octogenarian who, with his wife dña. Rosa, had founded the village of Carmen Florida some 40 years earlier. I lived in the Cubo household for periods of one to four weeks at a time. Because they were elderly, maintained a relatively traditional lifestyle and were knowledgeable

peanut farmers, they became my primary informants throughout the 18 months between June 1989 and December 1990.

While my original intention was to map and quantify the agricultural production of all the swidden and sandbar plots in the village, I encountered difficulties in the mapping and in obtaining reliable harvest yield information. I soon realized that the multiple cropping system was far too complex for me to be able to document and quantify for the entire village, so I decided to limit myself to a case study of some representative plots belonging to the Cubo family. The mapping dilemma was resolved with the collaboration of a Bolivian cartographer, Máximo Liberman, using aerial photographs. Soil samples were taken from representative plots and analyzed at the INTA experiment station in Manfredi, Argentina. At different times, short trips were made to visit Chimán, Mosetén, Esse Ejja and Moxeño communities to collect their peanut landraces, and also to the savanna areas to search for wild peanut relatives. Besides making voucher specimens of the cultigens and cultivars themselves, herbarium specimens were also made of the vegetation surrounding and associated with the agricultural plots and dooryard gardens. Duplicate sets of herbarium specimens were deposited at the National Herbarium of Bolivia in La Paz (LPB), the "Noel Kempff Mercado" Museum of Natural History in Santa Cruz (MNKM), and The New York Botanical Garden (NY).

Research in Bolivia was carried out under cooperative agreements between The New York Botanical Garden, the Bolivian National Herbarium in La Paz, and the Museo de Historia Natural Noel Kempff Mercado in Santa Cruz. I worked in the field largely without a Bolivian collaborator only because no students or professionals with similar interests were available on a full-time basis. To compensate for this apparent lack of scientific interaction, I made a special effort to present lectures periodically on my work at the collaborating institutions in La Paz and Santa Cruz, and I served on the thesis committee of a Bolivian ethnobotany student at the National University. An article in Spanish describing my research results, coauthored by Máximo Liberman, is in preparation for publication in "Ecología en Bolivia," the official periodical of the Instituto de Ecología of the National University. Finally, together with another Bolivian colleague, Kitula Libermann, I helped organize and present a four-day seminar on Bolivian ethnobotany, Nov. 28-Dec. 1, 1990, which was the first seminar on this subject to be held in Bolivia.

### Chapter III

#### The Research Setting

The present research was concentrated in northwestern Bolivia. The study area is delimited by the Andean foothills to the south, the Peruvian frontier to the west, the Brazilian frontier to the north, and the Mamoré River to the east, corresponding roughly to the quadrant  $65^{\circ}$ - $70^{\circ}$ W,  $10^{\circ}$ - $15^{\circ}$ S. It includes the Province of Iturralde in the Department of La Paz, the western half of the Department of Beni, and the Department of Pando (Fig. 3).

Geology. The Andean front range that comprises the southernmost portion of the study area pertains to the Beu Formation of the Subandean Belt. The folded foothills are Ordovician, Devonian, Cretaceous and Tertiary in origin, comprised of hard, continental sandstones. The abrupt foothills, which do not exceed 1,500 m in elevation, occur in parallel chains with a NW-SE orientation and are known as the Serranias of Beu, Toregua, Charqui, Bala and Suse. They are

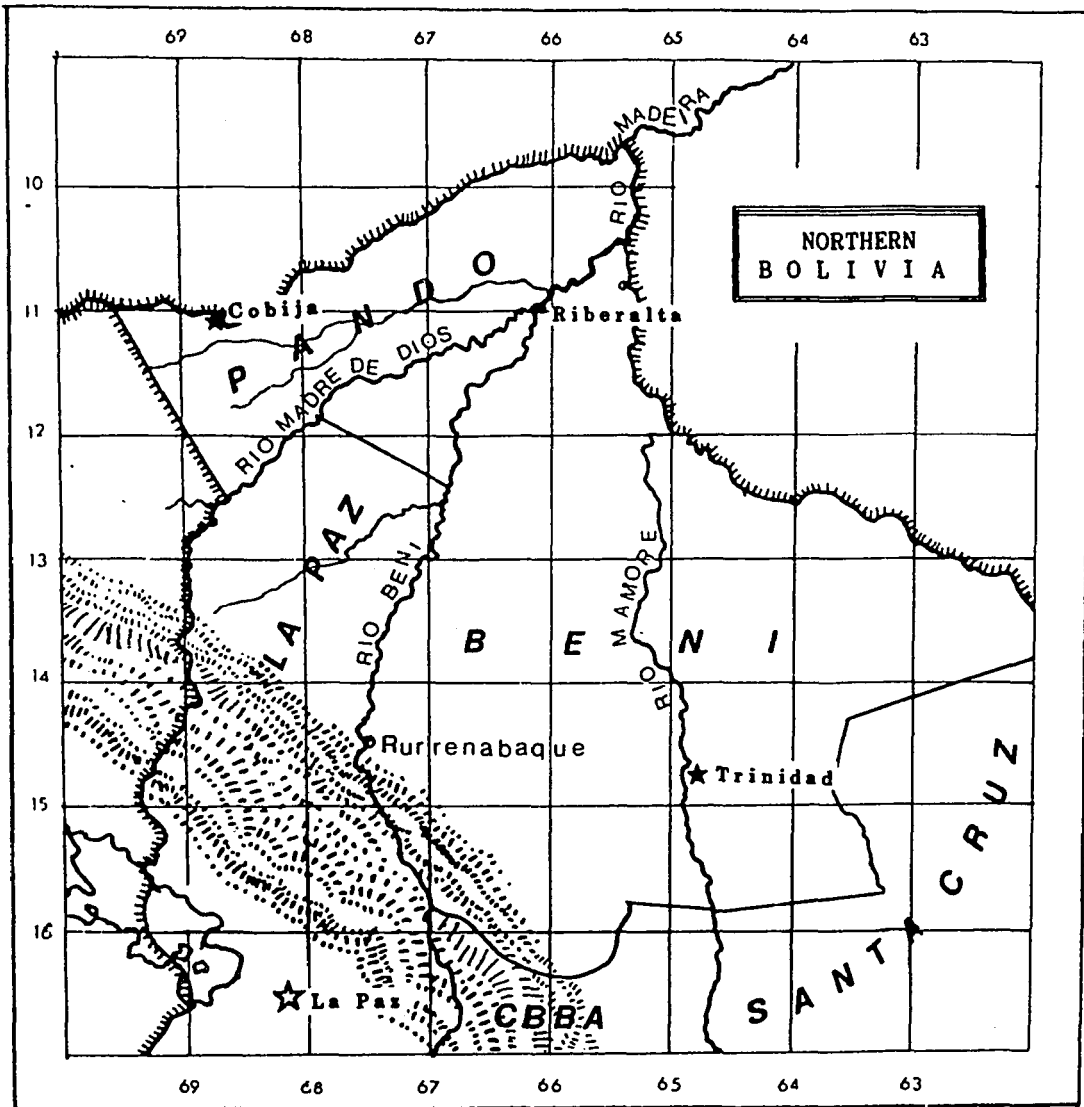


FIG. 3. Map of northern Bolivia.

transected by canyons cut by the Beni River as it flows northward. The flanks and valleys between the foothill chains are covered with Quaternary alluvial deposits (Ahlfeld, 1972; Montes de Oca, 1989).

The majority of the study area, north and east of the front range, is known as the Llanura Beniana. The Llanura Beniana is a vast plain with an elevation of less than 250 m whose only appreciable topographic features are the natural levees bordering the rivers (Campbell et al., 1985). It pertains to the Amazon Basin and is formed entirely of deep sedimentary deposits of Quaternary and Recent origin, comprised of clays, silt and sand. The deposits have been widely considered to be Pliocene to Pliestocene in age, but Campbell et al. (1985) argue that they may be much more recent, dating to the Holocene.

The northeastern extreme of the study area, in the vicinity of Guayaramerim, is located on the western tip of the Brazilian Shield. The Shield is formed of metamorphic, crystalline rock of Precambrian origin (Montes de Oca, 1989).

Hydrology. The study area includes the three largest rivers in Bolivia: the Mamoré, the Beni, and the Madre de Dios, each with numerous tributaries forming a web across the Llanura Beniana. The three rivers converge near the Brazilian frontier to form the Madeira River, the Amazon's largest

southern tributary.

Due to the extreme flatness of the Llanura Beniana, the rivers and their tributaries meander in the characteristic manner of Amazonian rivers. During the rainy season when the river levels rise as much as ten meters, the discharge from the eastern cordillera cannot be constrained to existing river channels, causing the lowlands to be regularly inundated by seasonal floods (Campbell et al., 1985). These are "white water" rivers that carry a heavy sediment load which is deposited annually throughout the rivers' floodplain. Upriver of the front range, the floodplain is restricted to islands and narrow bands along the inside bends of the rivers. Once free of the constraints of the front range, the rivers meander constantly, eroding their banks and leaving behind oxbow lakes, cutoff meanders, meander scars, and large islands (Campbell et al., 1985). The floodplains in the Llanura Beniana are extensive, forming one of the largest seasonally inundated areas in the Neotropics (Beck, 1984).

Climate. In broad terms, the climate of the study area is primarily tropical, corresponding to the Köppen classification type A, with the exception of the higher elevations of the Andean foothill ranges to the south which have a humid temperate climate corresponding to the Köppen classification type C (Montes de Oca, 1989). The median

annual rainfall for the region varies between 1,350 and 2,700 mm, with the wettest period occurring in the summer months of January and February, and a marked dry period during the winter months of June and July. Median annual temperatures for the region vary between 20° and 27°C. Winds are predominantly from the northwest, but in the winter months polar winds from the south occasionally cause temperatures to plummet abruptly to as low as 7°C (Montes de Oca, 1989; Wentzel, 1989). Due to topographic influence, places near to and particularly within the foothill ranges experience localized climatic conditions.

Vegetation. Thanks to its unique geographical position, Bolivia has one of the most diverse floras of all of South America (Solomon, 1989). Relatively few botanists, however, have collected plants in the area of the present study. H. H. Rusby explored the area in 1885-1887, and again in 1921-1922 with the Mulford Biological exploration of the Amazon Vally in which he was accompanied by O. E. White and M. Cárdenas (White, 1922). Miguel Bang collected in the area between 1883-1895, and R. S. Williams collected in the southern part of the study area between 1901-1903 (Funk & Mori, 1989). Recent botanical exploration has been carried out in northwestern Bolivia by Cárdenas (1953), Beck (1984), Boom (1987), D. E. Williams (1989), and the late David N. Smith from 1988 until his untimely death in 1991.

The study area encompasses the phytogeographic realms of Lowland Amazonian Forest, Seasonally Inundated Savanna, Yungas, and Cerrado. The majority of the study area is characterized by Lowland Amazonian Forest which covers the lower elevations of the front range, the northern plains of the Department of La Paz, the entire Department of Pando, and forms irregular extensions, islands, and gallery forests within the savanna areas. Solomon (1989) considers this formation to be the most species-rich in Bolivia. Nearly 40% of the Llanura Beniense is covered by Seasonally Inundated Savanna (Solomon, 1989), including over 100,000 km<sup>2</sup> in the Department of Beni alone and with smaller extensions occurring in the northern part of the Department of La Paz (Beck, 1984). The higher elevations of the front range in the study area are characterized by Yungas vegetation. Cerrado vegetation is found in the northeastern corner of the study area, on the Brazilian Shield, with elements extending into the savannas of the northern Llanura Beniense. There exists much intergradation of floristic elements between phytogeographic provinces.

Ethnic Groups. At least eight autochthonous ethnic groups, belonging to five linguistic families (Quechuamaran, Tacanan, Mosetenan, Arawakan, and Panoan), presently inhabit the study area (Fig. 4). Most groups are undergoing an accelerated acculturation and some have lost nearly all remnants of indigenous cultural identity. The Summer Institute of

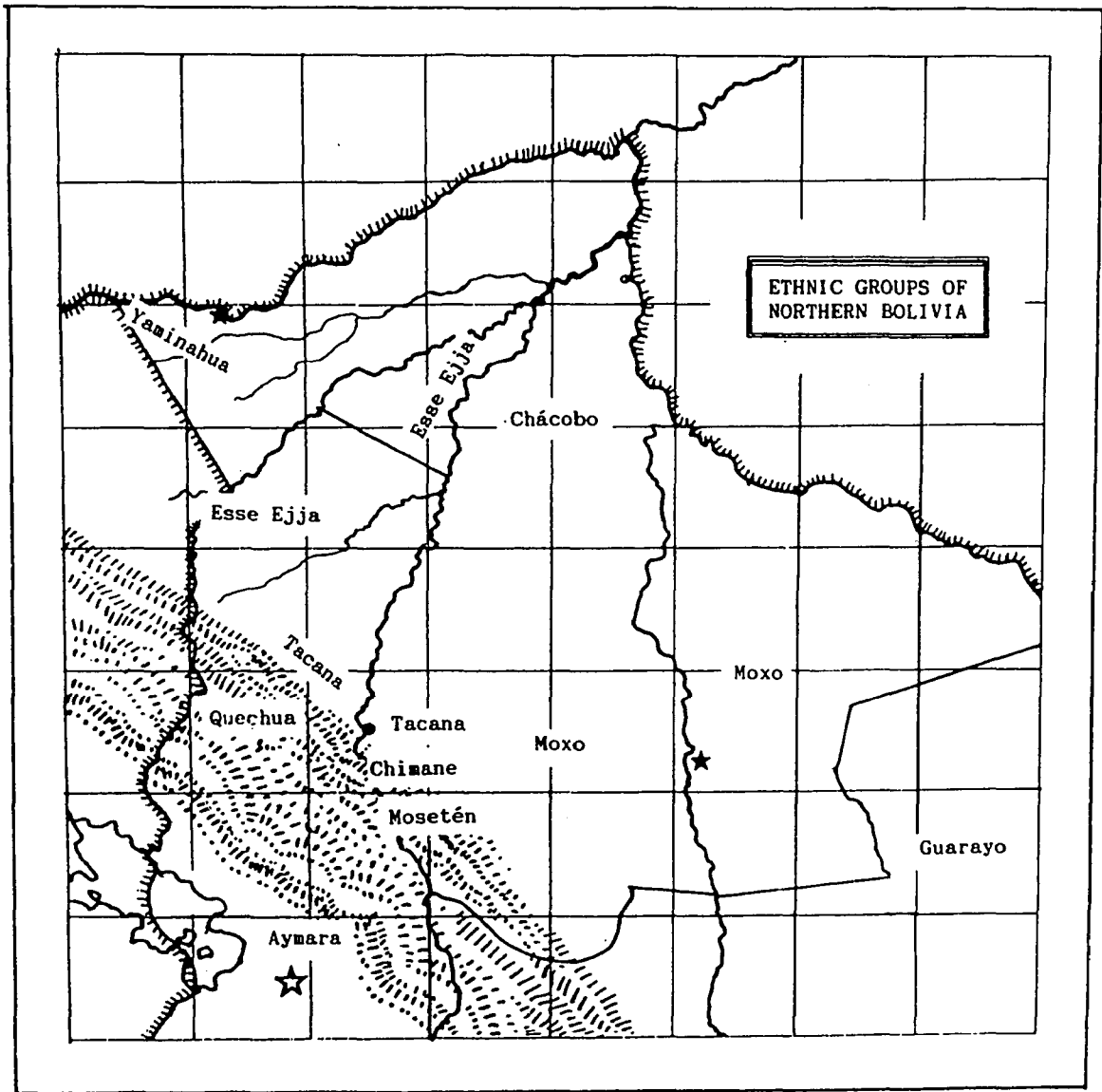


FIG. 4. Map of ethnic groups in northern Bolivia.

Linguistics (ILV, 1980) has carried out the bulk of ethnographic and linguistic research on these remote and largely unstudied groups.

Quechuamaran. Perhaps the largest group are the Quechua speakers of the mountain town of Apolo who, in recent years, have been migrating in increasing numbers to the lower elevations previously inhabited by Tacanas. Known as Apoleños, they now dominate the old Tacana town of San José de Uchupiamonas and have colonized numerous small settlements along the Beni River. The dialect of Quechua spoken by the approximately 11,500 Apoleños is distinct from that spoken by Quechuas in the rest of Bolivia and is more similar to the dialects spoken in southern Peru (Stark, 1985). The Apoleños are primarily farmers, cultivating swidden plots and, where available, riverine beaches.

Tacanan. The Tacanan language family is presently represented by two groups, the Tacana and the Esse Ejja. The more numerous of the two are the Tacana, who inhabit the piedmont towns of Ixiamas, Tumupasa, and San Buenaventura, as well as numerous small settlements and rubber camps scattered along the lower Beni River. Once a populous group with a rich cultural, religious, and artistic tradition, the Tacana were severely affected by early Catholic evangelization, disease, and the consequences of the Rubber Boom (Hissink & Hahn, 1984; Wentzel, 1989). The Summer Institute of

Linguistics estimates that the Tacana number now about 3,500 (ILV, 1980). The present-day Tacana are treated in more detail below.

The second Tacanan group are the Esse Ejja who number about 1,000 (ILV, 1980), and live in transient settlements along the rivers Beni and Madre de Dios. Of all the groups in the study area, the Esse Ejja are the least sedentary. They move their settlements, often comprised of only one or two families, on a seasonal basis. During the low-water season they live in makeshift shelters on the open beaches of the large rivers where they subsist primarily by fishing, gathering turtle eggs, and a minimal agriculture. During the high-water season the Esse Ejja retreat upriver to higher ground where they clear small swidden plots for maize, manioc, and plantains. The Esse Ejja are treated with disdain by other Indians and mestizos alike who commonly refer to them by the deprecatory name Chama or even bárbaro (savage). Armed attacks by Esse Ejja on the Tacana are still remembered by older residents of the towns of Ixiamas and Tumupasa. Attempts at evangelization by both Catholic and Protestant missionaries have met with only partial success. As a result, most Esse Ejja retain their language and, presumably, their religion although much of their material culture has been lost. Local reports of "wild" bands of Esse Ejja (also known as Guarayos or Toromonas) still living near the headwaters of the Heath and Madidi rivers and in the

northern savannas of Iturralde near the Peruvian frontier have not been recently confirmed.

Other Tacanan groups from the area, Cavineños, Reyesanos, and Araonas, have been largely absorbed into the national culture and have, for the most part, lost their ethnic identity.

Arawakan. Another numerous indigenous group in the study area is the Moxo (or Mojo) who are concentrated in the old Jesuit mission town of San Ignacio de Moxos and also live in scattered settlements throughout the savannas known as the Llanos de Moxos. Denevan (1966) estimates the pre-contact population of the Moxo to have been as high as 350,000. Numerous Arawakan groups that inhabited the Llanos de Moxos were amalgamated by the Jesuits in colonial times. Due to 200 years of intense Jesuit missionary activity, the Moxo were severely reduced in number, but conserve a remarkable degree of their cultural identity in syncretism with the Roman Catholic religion. The present population of the Moxo is more than 5,000 (Costales & Costales, 1983; ILV, 1980). They are primarily agriculturalists, farming the forest islands and gallery forests, while practicing fishing, hunting and cattle herding to a limited extent.

Mosetenan. The Mosetenans are comprised of the Chimán and the Mosetén. The Chimán are forest dwellers that inhabit

numerous villages along the lower and upper Manique River, the Apere, Chevejecure, and Matos rivers, and the upper Quiquibey River in the Department of Beni. They practice swidden and beach agriculture, and are prodigious hunters and fishermen. In recent times the Chimán have become important suppliers of jatata (Geonoma sp.) palm thatch which they gather in the forest, weave, and exchange to itinerant buyers for tools, supplies, and alcohol. The Chimán also frequently serve as a valued source of labor for the more affluent Tacanas and mestizos. The present day Chimán number about 4,500 (ILV, 1980).

The Masetén, speaking a language little differentiated from Chimán, inhabit the towns of Muchanes, Santa Ana, and Covendo along the Alto Beni River in the Department of La Paz, as well as a few small settlements on the lower Quiquibey River in the Department of Beni. At present they number less than 500. The Masetén have had more contact with outside influence and are more acculturated than their Chimán cousins. They continue to be primarily agriculturalists, with swidden and beach gardens, supplementing their diet with fishing and hunting. Some of the Masetén have become involved in commercial ventures and own trucks and outboard motors. Their acculturation has been concomitant to a marked loss of ethnic cultural identity.

Panoan. The Panoan groups in the study area are the Chácobo, the Pacaguara, and the Yaminahua. The Chácobo, numbering 260 (ILV, 1980), inhabit the headwaters of the Ivón and Yata rivers in the Department of Beni. Boom (1987), who published a detailed inventory of the plants used by the Chácobo, makes no report of peanuts being cultivated by the acculturated remnants of this group. The Pacaguara, who inhabit (or inhabited) the forests of the eastern portion of the Department of Pando, numbered only nine individuals ten years ago (ILV, 1980) and are now believed to be extinct.

The Bolivian Yaminahua live in a single village of 150 inhabitants in the extreme northwestern corner of the study area, near the military outpost of Bolpebra, located in the Department of Pando at the juncture of the Bolivian, Peruvian, and Brazilian frontiers. Other Yaminahua settlements exist in adjacent Peru and Brazil, with whom the Bolivian group is in occasional contact. The Yaminahua are a "typical" tropical forest group, relying on agriculture, hunting, and fishing for their subsistence. They practice a combination of swidden and beach agriculture. The Yaminahua share a cultural affinity with the other Panoan groups to the north, including the Marinahua, Sharanahua, Chandinahua, Mastanahua, and Cashinahua (Kensinger, 1985).

Rurrenabague and environs. The vicinity of Rurrenabague was chosen for the detailed study of native peanut farming because of its location in a center of combined geographic, floristic, ethnic, and crop genetic diversity (Fig. 5).

The town, whose elevation is a mere 227 m, is located on the right bank of the Beni River at the point where it emerges from the steep canyon it has cut through the last foothill range of the Andes. Downstream, to the north, lies the featureless Amazonian plain that extends to the Brazilian border and beyond. Immediately upstream, beginning at the south edge of town, looms the abrupt Andean front range with elevations topping 1,000 m. The mountain slopes and surrounding area are covered with a rich mantle of tropical rainforest vegetation.

The Beni River at this point is swift, some 500 m wide, and rises annually an average of six to eight meters during the rainy season, with infrequent floods of up to 12 m or more. During the flood season, the river carries a heavy silt load, becoming somewhat clearer during the dry season. Upstream of the town, and for several kilometers downstream, the river is characterized by dangerous rapids. Notwithstanding, the river is the primary avenue of local transportation which is accomplished with dugout canoes powered by poles, paddles or outboard motors, and balsa rafts known as cayapos.

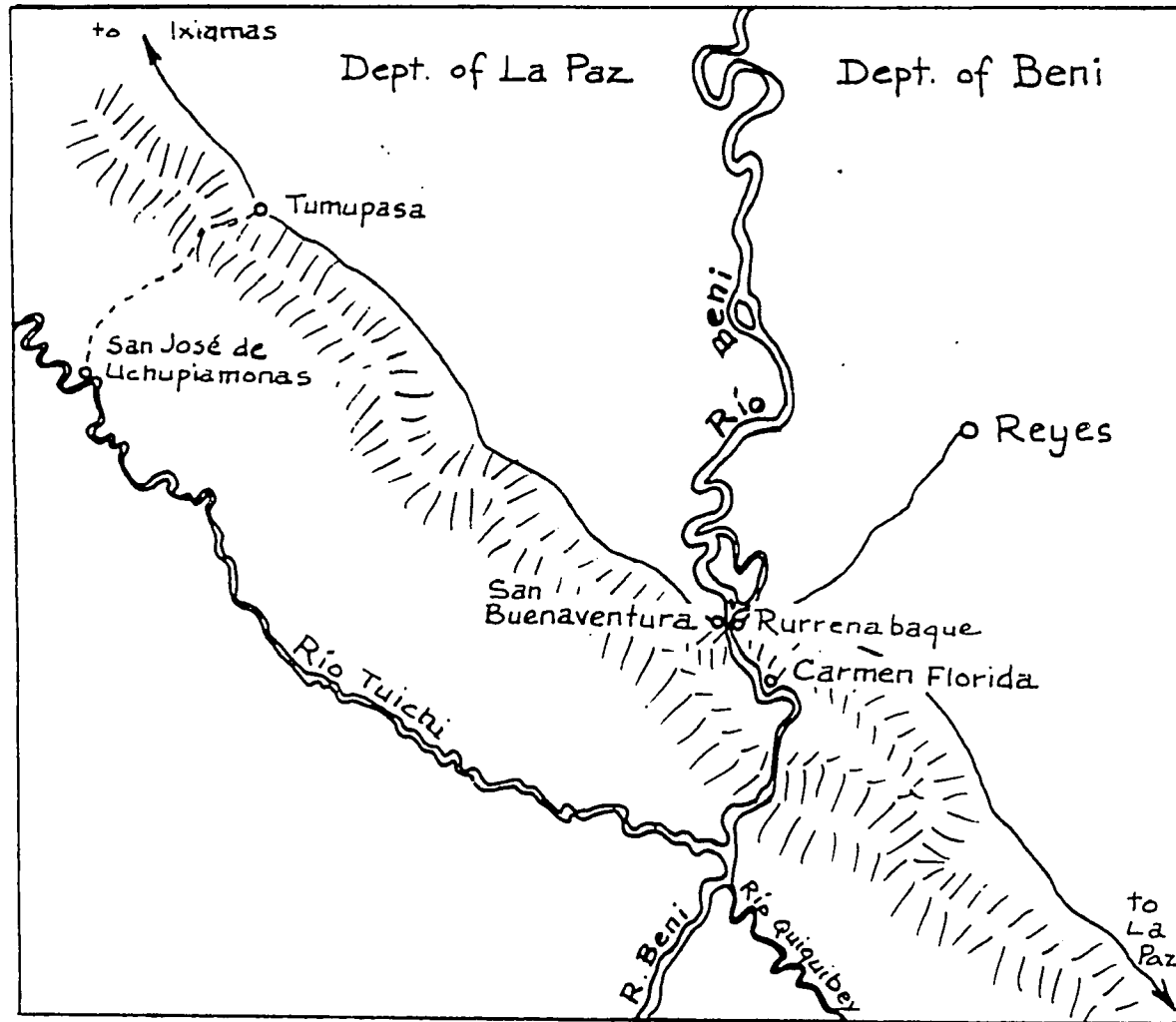


FIG. 5. Map of Rurrenabaque area.

Archeological evidence clearly indicates prehistoric inhabitation of the area, as well as contact with highland cultures. Although surface finds of prehistoric potsherds, stone axeheads, and even metal objects are not uncommon, formal archeological excavations in the area are scanty. A cache of metal bracelets, plaques, sling weights, and an Incaic gold-alloy pectoral was recently uncovered by a resident in San Buenaventura. Numerous petroglyphs of unknown age and origin are found on the rocks by the river in the canyon of Beu, and a large petroglyph depicting an undulating snake is carved on a rock in the canyon of Suse, just a few hundred meters upstream of Rurrenabaque. Portugal-Ortiz (1978) and Cordero-Miranda (1984) conducted archeological excavations around Rurrenabaque, although the paucity of thorough excavations in lowland Bolivia in general makes it difficult to place their finds in a proper cultural or chronological context, particularly due to the lack of radiocarbon dates. Portugal-Ortiz, based on ceramic analysis, distinguishes a Cultura Beni and concludes that the ancient inhabitants of the region were sedentary farmers who practiced spinning and weaving of cotton, and had a primitive but stratified society.

Rurrenabaque was founded in 1842 but apparently did not become a permanent settlement until the 1860s (Wentzel, 1989). Its primary initial function was as a port for the

nearby mission town of Reyes, and to this day the inhabitants of Rurrenabaque are known as porteños to distinguish themselves from the pampeños of Reyes and other savanna communities. The name Rurrenabaque is derived from the Tacana Suse-enabaqui (suse=duck, enabaqui=stream), meaning "River of Ducks;" and the name of the Beni River itself comes from the Tacana word beni, meaning wind (Van Wynen & Van Wynen, 1962).

Throughout most of its history, Rurrenabaque was accessible only with the greatest of difficulty, requiring a monumental foot journey over the Andes followed by a dangerous raft descent of the Beni River (see Rusby, 1922, 1933). For this reason, the town was not until recently much more than a village. The quinine trade, the Rubber Boom, and later the animal skin trade provided the town with short-lived periods of prosperity. More recently, oil exploration, gold mining, and logging have spurred further growth. Today the town boasts around 4,000 inhabitants and has overshadowed in importance both Reyes and San Buenaventura, the town directly across the river in the Department of La Paz which was once the provincial capital of Iturralde.

Rurrenabaque is now connected to La Paz, the nation's capital, by a tortuous dirt road which is undergoing improvement. Two bus companies recently established

passenger service to the capital, and a civil and a military airline each offer weekly flights. A satellite dish was installed at the town's military post in 1989, enabling residents to enjoy television for the first time. When I left Rurrenabaque in 1990 a satellite-linked telephone office was under construction. Previously, long-distance verbal communication was only possible by short-wave radio.

Several hotels operate in the town and cater to an increasing tourist trade. Aside from a sawmill, two brick factories, and a few rudimentary carpentry shops, there is no permanent industry. Electricity for the town is provided by a single diesel generator which operates only from sundown until midnight.

The improved road to La Paz has made the vast mahogany forests of Iturralde (Dept. of La Paz) accessible to logging interests. Numerous modern sawmills now operate in the vicinity of Ixiamas and are penetrating into the headwater regions of the Madidi River. Hundreds of trucks loaded with mahogany lumber pass through Rurrenabaque each year on their way to La Paz, bringing commercial goods from the capital on the return trip.

The recent improvements in transportation and communication with La Paz have provoked a rapid increase in the influx of merchants and colonists, the majority of which

are Aymaras from the highlands, commonly referred to as kollas. The kollas have dominated local business to such an extent that there is some resentment from the porteños, who identify themselves as cambas (lowland Bolivians). The cultural and social dichotomy of kollas and cambas is as evident in Rurrenabaque as it is everywhere else in the lowlands.

The Tacana are the ethnic group from which most of the porteños have descended, although many would be reluctant to admit it. Besides the Tacana and the Aymara (who are regarded as outsiders), the town is frequented by Chimanes, Apoleños, Esse Ejjas, Moxeños, and Mosetenes from the surrounding area. Some members of these groups have taken up residence in the town, but most come to sell their agricultural or extractive produce (e.g., firewood, forest fruits, turtle eggs) and to buy merchandise. Each Sunday an open-air market is held on the riverbank where buyers and sellers, some coming from a considerable distance, congregate to exchange goods.

The Tacana Today. A few kilometers upstream from Rurrenabaque are located three villages populated predominantly by Tacanas and their descendents: Villa Alcira and San Miguel on the left-hand bank in the Department of La Paz, and Carmen Florida on the right-hand bank in the Department of Beni. Traditional cropping of peanuts and

other crops on the river's beaches (playas) is practiced by members of all three communities. Because of the favorable contacts I had made there during my first visit to the area in 1988, I selected Carmen Florida as the locality for my in-depth study of Tacana peanut farming.

Carmen Florida was founded in the 1940s by Tacana settlers from San José de Uchupiamonas and Tumupasa, who were later joined by some Quechua settlers from Apolo. The village currently has 24 families totalling 114 people more or less evenly divided between Tacana and Quechua. Very little friction is evident between the two groups, and they frequently intermarry.

Carmen Florida is located on the floodplain in the bight of a large bend in the Beni River. The area covered by the village is checkered with swidden plots (chacos) and secondary fallow vegetation (barbechos), the result of sustained shifting agriculture over a long period. The land behind the village, to the north, rises abruptly to the peaks of the front range, bordering on Rurrenabaque (Fig. 6). The upland area, particularly at the higher elevations, is covered with intact rainforest, from which the villagers extract wild fruits, construction materials, and game animals. In the river in front of the village lies a large island over one kilometer long, that the villagers use during low water for planting peanuts and other playa crops. At the

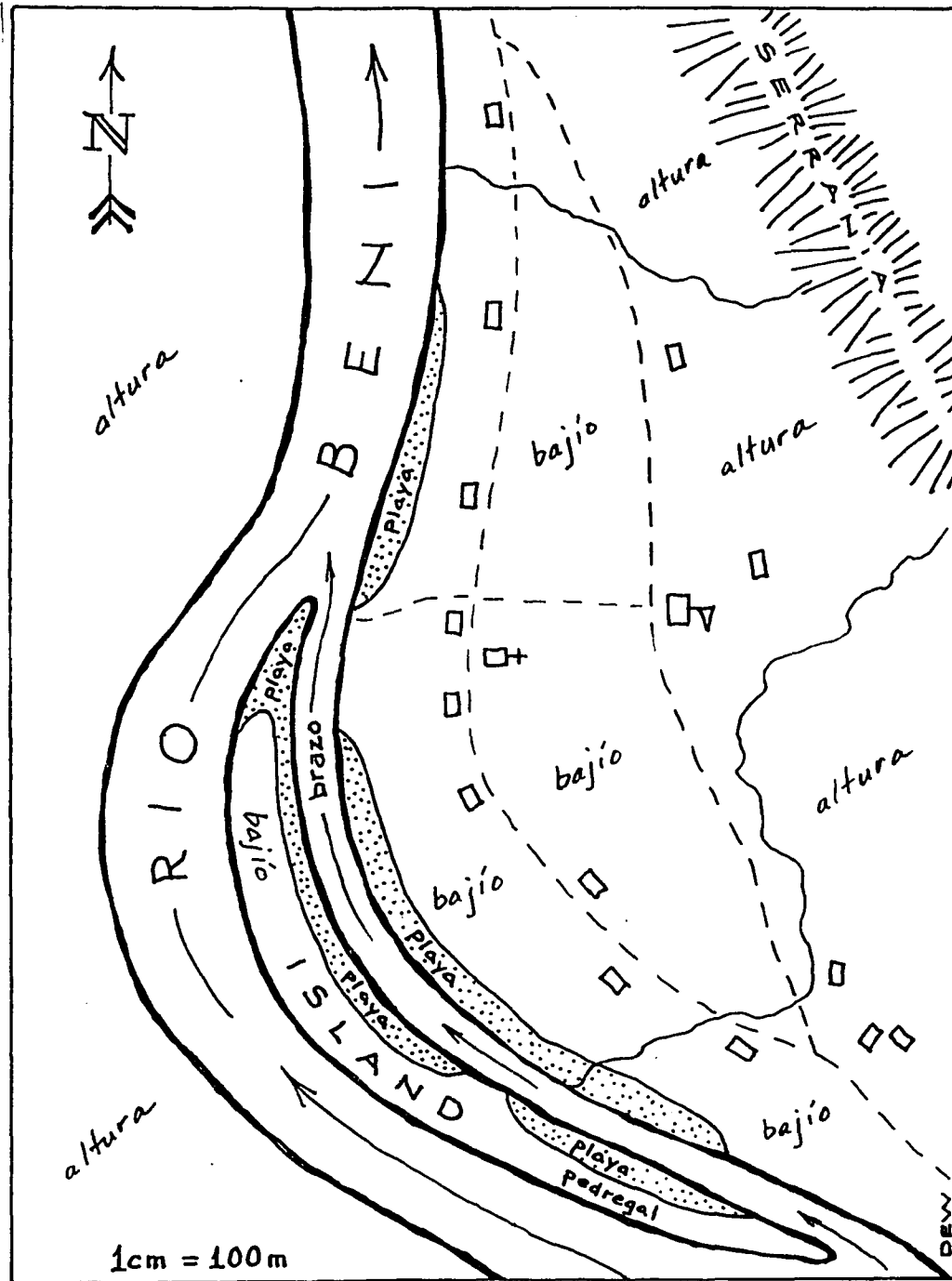


FIG. 6. Map of Carmen Florida.

foot of the island is a set of rapids (huarasta) that impedes the passage of river vessels larger than canoes. On the opposite bank, in the Department of La Paz, rises a steep cliff of 150 m, atop which is upland primary and secondary forest where some of the villagers have made swidden plots.

The Tacana today are primarily agriculturalists although hunting, fishing, and gathering continue to be important activities. The villagers are only marginally involved in the market economy and are remarkably self-sufficient in satisfying their day to day needs of food, fuel, household goods, and construction materials. Because of their proximity to the Rurrenabaque market, most households obtain a limited cash income from the sale of vegetables, plantains, firewood, fish, manioc, maize, rice, peanuts, forest fruits, and handicrafts. This income is usually entirely consumed in the purchase of clothing, tools, salt, cooking oil, ammunition, and western medicine. Trading of goods and services is common. Younger men occasionally leave the village to accept temporary employment in gold mines, oil exploration, and tourism.

Centuries of contact with outsiders has caused the Tacana, particularly those of Carmen Florida, to become marginally integrated into Bolivian society. They now consider themselves to be Bolivian first, and Tacana second, if at all. Spanish is the predominant language used in the

home; Tacana is now spoken only occasionally by the elderly. As a result of the early Franciscan missionization of the Tacana, those of Carmen Florida are all devout Catholics--a fact that they proudly assert, having resisted the recent inroads made in the area by evangelical Protestants. Catholic fiestas are rigorously observed. The traditional crafts of pottery making and basketry have been largely abandoned in favor of commercially produced containers. Agriculture, their primary subsistence activity, continues to be practiced in the traditional way, although many of the Tacana ceremonies associated with it appear to have been lost.

Despite the appearance of nearly total acculturation, the Tacana continue to be "invisible Indians," maintaining aspects of their native religion hidden from outsiders. Tacana shamans, known as yanaconas, still exist in Tumupasa and carry out secret rites related to agriculture and healing in cult houses hidden in the forest (Hissink & Hahn, 1985; Wentzel, 1989). The yanaconas are frequently sought out to heal illnesses of "magical" origin, divine the whereabouts of lost objects or people, resolve marital or romantic difficulties, and intervene in other matters of a supernatural nature. Yanaconas are sometimes called upon to treat illnesses that have not responded to Western medicine, when it is then presumed that the illness must be due to supernatural causes. The yanaconas are reported to derive

their healing and divining "powers" from sacred stones, and a hallucinogenic vine, ayahuasca (Banisteriopsis caapi (Spruce ex Griseb.) Morton), is also sometimes used.

The ethnographers Hissink and Hahn (1984) and Wentzel (1989) were aware that aspects of Tacana religion continued to persist, but were unable to gain access to the secret ceremonies or visit the cult houses. I encountered similar reluctance to discuss (if not outright denial of) the continuing existence of traditional Tacana religious practices. I was, however, able to contact a yanacona who had treated one of my informants' children for susto (an illness brought on by a sudden fright). This yanacona consented to reverse a "jinx" on my shotgun, and later to perform a healing ceremony on my young son. Although I was present for both ceremonies, held at night inside his house, I was unable to hear or understand all of the words spoken or see much of the ceremonial procedure. The ceremonies involved alcohol, coca, tobacco, small dolls, and many Christian elements.

The future of the Tacana as an ethnic entity is uncertain. Since the ethnographic studies carried out by Hissink and Hahn (1984) in the 1950s, it is apparent that the bulk of Tacana material culture has become lost. There seem, at present, to be few cohesive forces remaining to link the surviving Tacana and maintain their cultural identity.

Traditional subsistence and healing activities persist because Western alternatives are either inaccessible or inappropriate. The steady increase in outside influence in the area is likely to further accelerate the erosion of Tacana culture. On the other hand, recent assertions of indigenous territorial rights by the neighboring Moxo and Chimán may eventually influence the Tacana and reawaken a desire to preserve their cultural heritage in the face of inevitable modernization.

## Chapter IV

### Arachis Genetic Resources in Northern Bolivia

Of the 26 peanut explorations made in South America between 1958 and 1983, only six have included Bolivia in their itineraries (Valls et al., 1985). Of these, only two explorations (Gregory, 1979; Simpson, 1982) penetrated into northern Bolivia (north of 15°S), largely due to the relative inaccessability of the area, the extreme seasonability of the wild species, and the limited cultivation of the cultigen. Nevertheless, the explorations to this region yielded significant material and expanded our knowledge of wild and cultivated peanut diversity and distribution.

In response to the lack of comprehensive collections from northern Bolivia, I undertook two further explorations of the region in 1988 (Williams, unpubl.) and 1989-1990 (Williams, in prep. a.). The 1988 expedition was aimed at discovering the extent of cultivated and wild peanut diversity. The purpose of the 1989-1990 exploration was to obtain germplasm of cultivated and wild material missed during the 1988 trip. The materials collected during these two explorations are presented in Appendices 1 and 2.

As part of the present research, wild species of Arachis were collected in the northern portion of the Department of Santa Cruz, and in the Department of Beni near the cities of Guayaramerim and Trinidad. While the majority of these collections were made from known populations, some of those made near Trinidad appear to represent a previously unknown species. The determination of this material awaits the monograph of the genus being prepared by A. Krapovickas and W. C. Gregory. Fresh germplasm of A. monticola and A. duranensis nom. nud. were also collected in northern Argentina.

To date, no wild Arachis has been collected west of about 65°30'W. Reliable reports of wild Arachis populations were investigated in the savanna around San Ignacio de Moxos and west towards San Borja, in the Department of Beni, without luck. Discovery of wild Arachis here would expand the known range of the genus, and perhaps yield a new species. All wild Arachis in this part of Bolivia belong to sect. Arachis and are of potentially great value for the improvement of the crop. Unfortunately, efforts to collect these reported populations were thwarted by a prolonged drought in 1989-90. These populations will need to be collected during the short interval between the time when they begin to flower and fruit, shortly after the beginning of the rainy season, usually in November, but before the savanna becomes flooded,

usually by January. The remoteness of the area and the unpredictability of the rainy season have frustrated other explorations here in the past (Simpson, 1982).

A number of unusual cultivated landraces were also obtained or reports of their existence noted. While traveling by riverboat downstream on the Beni River from Rurrenabaque to Riberalta, I heard several reports that black-shelled peanuts were cultivated along this watercourse, some with red seeds, others with white. Although circumstances prevented me from obtaining specimens, I believe that this stretch of the river may yet yield the white-seeded variety of the black-shelled peanut. I was able to recover samples of the red-seeded black-shelled peanut during the 1989-1990 exploration. No peanut with any kind of pericarp pigmentation had ever been previously reported.

In the northern Department of Pando, with the assistance of the missionary John Skinner, I obtained germplasm of var. peruviana cultivated by the Yaminahua Indians living near Bolpebra, a small settlement on the Bolivian frontier with Peru and Brazil. This peanut has white seeds, and is the only other example of var. peruviana collected in Bolivia, aside from the purple-seeded accessions made around Rurrenabaque in 1981 and 1989. As is the case with the Rurrenabaque accessions, the white-seeded collection was obtained from Indians that have trade relationships with

their tribespeople in Peru and (in this case) Brazil, where var. peruviana is more common. Peanut landraces for the remainder of the Department of Pando remain largely uncollected.

In most of the larger towns, germplasm was obtained from Aymara- and Quechua-speaking merchants who sell the commonly encountered commercial varieties from Tarija, Chuquisaca, Santa Cruz, and Cochabamba, which are flown in from the markets of La Paz or Santa Cruz and rarely cultivated in the northern lowlands except by colonists. Locally produced peanuts were generally unavailable in the markets, these being grown in limited quantities for home consumption only.

The area of Rurrenabaque was where the greatest diversity of cultivated peanuts was encountered, with six distinct landraces cultivated by native farmers using traditional agricultural methods. These six landraces all pertain to the ssp. fastigiata, a taxon not well represented in Bolivia. No wild Arachis, however, was found in this immediate area.

In 1988, the predominant peanut landraces cultivated around Rurrenabaque were the white- and red-seeded races. Interviews with farmers and the technical report from an earlier peanut exploration (Simpson, 1982) made it evident that other races had existed here, but they were no longer available in the town. Besides the common red- and

white-seeded races, local farmers recalled having planted yellow-, black-, and purple-seeded races as well as some previously unheard of red- and white-seeded varieties with black shells. These races were said to have been quite common as recently as five to ten years ago. Subsequent trips to remote Tacana villages succeeded in recovering small samples of the reported yellow-, black-, and purple-seeded races and the red-seeded variety with the black shell. In each instance, the seed obtained was part of a very small supply possessed by a single farmer in a remote community. Clearly, these now-rare races were well on their way to becoming lost, being supplanted by the red- and white-seeded races. The black-seeded race has become extremely rare in the region. Despite considerable searching, the reported black-shelled peanut with white seeds has not yet been recovered and may have already fallen victim to genetic wipeout.

My principal informant, an elderly Tacana woman, related to me the interesting circumstances surrounding her first acquisition of the purple-seeded peanut. Fifteen to twenty years ago she noticed some Esse Ejja Indians planting an unusual purple peanut on a large playa of the Beni River above the mouth of the Tuichi River at a place called Iridia. She traded some black-seeded peanuts for a quantity of the Esse Ejjas' purple peanuts with their distinctively reticulated pods. My informant later learned to call the

purple variety "peruano" because she had been told that it was brought from Peru. In fact, the landrace does belong to the botanical variety peruviana which is common in lowland Peru but almost unknown from Bolivia. It is probable that this race was indeed introduced from Peru by the Esse Ejja during one of their migrations from the Peruvian headwaters of the Heath and Tambopata rivers to the shores of the Alto Beni described by Shoemaker et al. (1975). By the time of my arrival, however, the purple-seeded variety had been lost by my informant. I was able to recover a small sample of it from a Tacana farmer in the small village of Napashi, near Tumupasa, on the Enadere River.

By the end of 1990, with the willing cooperation of my informants in Carmen Florida, the seed of the rare landraces was greatly increased and became more generally available to area farmers.

With the exception of some Virginia-type (ssp. hypogaea var. hypogaea) peanuts that were introduced and cultivated by colonists from the departments of Tarija and Chuquisaca, all of the locally grown landraces currently pertain to the Valencia type (ssp. fastigiata var. fastigiata). I saw nothing to indicate that any improved peanut varieties had been introduced or were responsible for displacing the regional landraces. Nor did I observe that any of the native farmers had adopted the Virginia-type peanuts introduced by

the colonists.

Hissink and Hahn (1984), who made an ethnographic study of the Tacana in the 1950s, recorded that five varieties of peanuts were planted, having seed coats that were black, variegated, white, yellow, and red. They report that the red-seeded variety had a prostrate runner habit (i.e., ssp. hypogaea). The variegated peanut and the red-seeded runner are no longer known to be grown by the Tacana, and may have become lost. Their failure to report the purple-seeded var. peruviana supports the recent introduction of this race.

The noted genetic erosion of local landraces appears to be due primarily to factors endemic to the region. The abandoned landraces seem to be no more or less susceptible to pests or diseases than are the conserved races. While my informants were unable to provide me with any direct reasons for the progressive abandonment of the majority of the once numerous local races, it was suggested that the uniformity and market appeal of the white- and red-seeded races could be a factor. Nevertheless, it was observed that even in villages far removed from the market economy of San Buenaventura and Rurrenabaque, the red- and white-seeded races are now planted almost exclusively. However, nearly all of the farmers with whom I spoke lamented the loss of their ancestral varieties and eagerly accepted samples of these seeds when I was able to supply them.

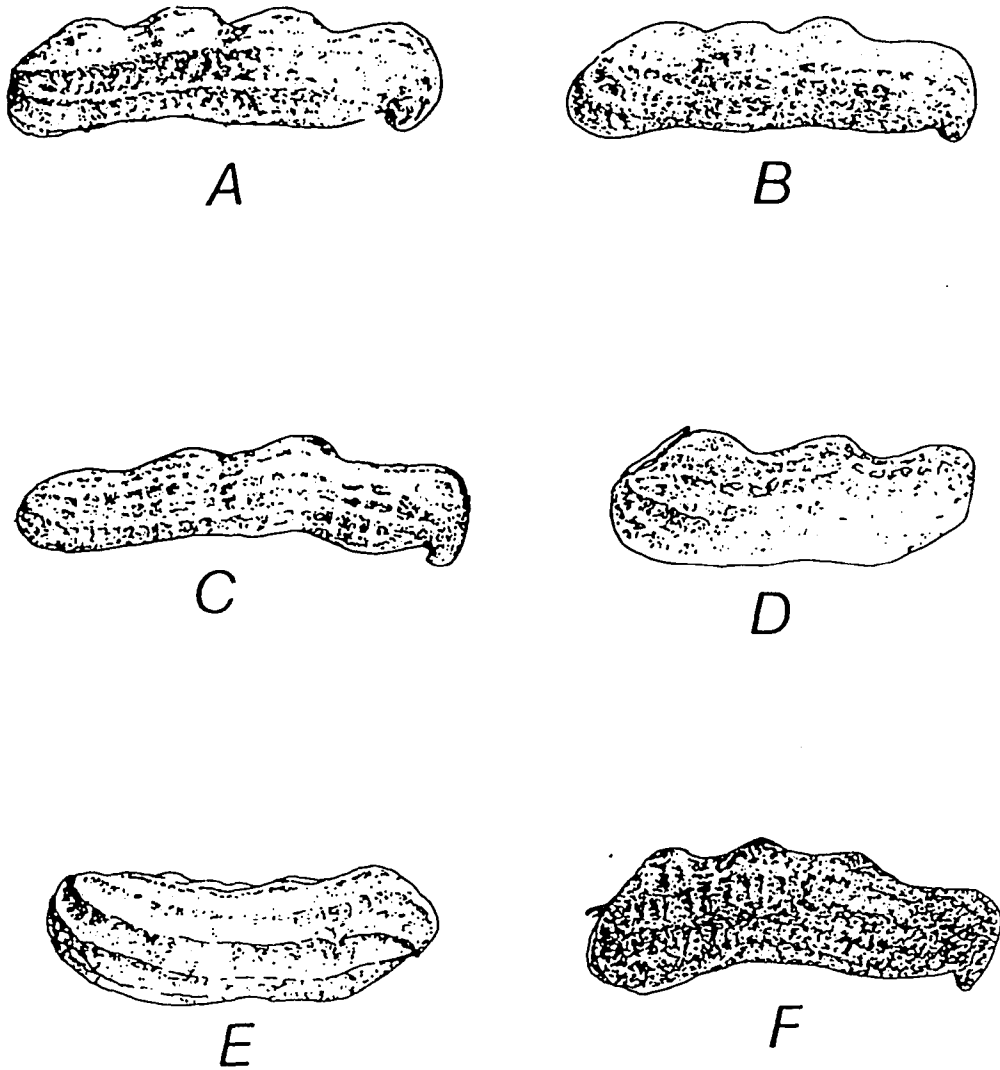


FIG. 7. Peanut landraces from Carmen Florida.  
A. Blanco (DEW 1146). B. Colorado (DEW 1170).  
C. Amarillo (DEW 1144). D. Negro (DEW 1148).  
E. Peruano (DEW 1145). F. Cáscara Negra (DEW 1143).  
Drawings by R. Rauh.

Description of the Rurrenabague landraces. The Spanish names given for the landraces are those used by the farmers who grow them. Introduced landraces cultivated by colonists from southern Bolivia are not considered here. A systematic treatment of Bolivian landraces, including those described here, is being prepared by A. Krapovickas and J. Pietrarelli (pers. comm., 1990) based on the comprehensive live collection of Bolivian material maintained at Manfredi, Argentina. The description of plants grown under homogenic experimental conditions is more valuable for comparative purposes but may differ from the descriptions offered below that were made in situ in Bolivia.

BLANCO:

Arachis hypogaea L. ssp. fastigiata Waldron var. fastigiata. Large, erect plants, 50-70 cm high; main axis well developed; primary branches decumbent, arching upwards, few secondary branches. Flowers bi-colored, produced on mainstem and lateral branches. Pegs purple. Fruits large, 5-6 cm long, bulky, thick shelled, fairly straight or curved, little or no constriction, pronounced humps, beak, some with keel, reticulation evident but subdued, containing 4 large creamy white seeds which turn pinkish with age (Fig. 7A).

COLORADO:

Arachis hypogaea L. ssp. fastigiata Waldron var. fastigiata.

Large, erect plants, 50-70 cm high, main axis well developed; primary branches decumbent, arching upwards, few secondary branches. Flowers orange, produced on mainstem and lateral branches, pegs purple. Fruits 3.5-5.5 cm long, fairly straight, little or no constriction, with humps and beak, reticulation shallow to almost smooth, containing 4 red seeds (Fig. 7B).

AMARILLO:

Arachis hypogaea L. ssp. fastigiata Waldron var. fastigiata.

Compact, erect plants, 30 cm tall, lateral branches ascending, stems green. Flowers bi-colored, produced on mainstem and lateral branches; pegs green. Fruits 4-6 cm long, straight, slender, thin shelled, little or no constriction, with humps, beak, keel, marked reticulation, containing 4 pale yellow seeds (Fig. 7C).

NEGRO:

Arachis hypogaea L. ssp. fastigiata Waldron var. fastigiata.

Plants not observed. Fruits appear very similar to the yellow-seeded race described above. Fruits 3.5-5.5 cm long, fairly straight, slender, thin shelled, little or no constriction, with slight humps and beak, reticulation

evident, containing 4 very dark purple, almost black seeds (Fig. 7D).

CASCARA NEGRA:

Arachis hypogaea L. ssp. fastigiata Waldron var. fastigiata.

Erect plants, 40 cm tall, lateral branches decumbent and ascending, stems tinged purple. Flowers orange, produced on mainstem and lateral branches; pegs purple. Fruits 4.5-5.5 cm long, fairly straight or curved, somewhat bulky, little or no constriction, with humps, slight beak, reticulation evident but not sharp, pericarp dark brown, containing 4 claret red seeds (Fig. 7F).

PERUANO:

Arachis hypogaea L. ssp. fastigiata Waldron var. peruviana.

Erect plants, 40 cm tall, well-developed main axis, little-branched, lateral branches usually 4, decumbent, arching up at tips, stems green. Flowers orange with purple lines on wings and standard, produced on mainstem and lateral branches, pegs purple. Fruits 4-4.5 cm long, fairly straight, little or no constriction, with humps, keel, slight beak, reticulation very sharp with longitudinal veins outstanding, containing 3-4 deep purple seeds (Fig. 7E).

Future exploration priorities. To complete our knowledge of the Arachis genetic resource diversity in northern Bolivia, the following areas are recommended for exploration. These are areas where uncollected genetic resources are believed to exist based on unconfirmed reports, frustrated previous collection efforts, insufficient or nonexistent previous exploration, appropriate ecological conditions, or a combination of two or more of the above.

Cultivated landraces:

- (1) Region of Apolo, Prov. Franz Tamayo, Dept. of La Paz
- (2) Region of the Alto Beni River, Dept. of La Paz
- (3) Region of the lower Beni River, Dept. of Beni
- (4) Region of Tahuamanu, Manuripi, and Orthon rivers, Dept. of Pando
- (5) Region of Puerto Maldonado, Madre de Dios, Peru
- (6) Region of Guajaramerín, Rondônia, Brazil

Wild Arachis species:

- (1) Llanos de Mojos between San Ignacio and San Borja, and around Santa Ana de Yacuma, Dept. of Beni
- (2) Pampas of Iturrealde, north of Ixiamas, Dept. of La Paz
- (3) Region to the south of Guayaramerín, Dept. of Beni

## Chapter V

### Traditional Peanut Genetic Resource Management

In recent years much deserved attention has been devoted to Amazonian indigenous farming systems. These ancestral systems have been shown to be complex interactions between the native farmers, a suite of diverse and highly adapted cultigens, and heterogenous natural environments. The native perception and differential exploitation of ecological zonation has been recognized as a key factor in the success of these systems (Denevan, 1984; Hiraoka, 1986), yet insufficient attention has been paid to the role played by selection and maintenance of the inter- and intraspecific diversity of the cultigens involved. The Tacana in the study area still practice genetically and ecologically diverse cropping systems typical of many tropical forest groups (Hissink & Hahn, 1984; Wentzel, 1989). After a brief overview, I will concentrate on the role of peanuts in those systems to evaluate the impact of the cropping systems on this cultigen and vice versa.

The study area of Carmen Florida includes both floodplain and upland environments in close proximity, all of which are exploited agriculturally on a seasonal or semipermanant basis (Fig. 6). The floodplain biotopes include annually exposed riverine sand and mud bars, annually flooded forests, and infrequently flooded forests. The upland biotopes include forested ancient river terraces and montane forests. Local folk taxonomy lumps the floodplain biotopes into the categories of playa (beach) and bajío (lowland), while the upland biotopes are simply known as altura. Forested areas are exploited using the traditional swidden-fallow system of shifting cultivation, known locally as a chaco. Practically all of the suitable floodplain and upland forested areas not presently under swidden cultivation are covered by secondary vegetation representing fallows of varying ages. A small area has been converted to pasture. The only remaining primary forest is found at some distance from the river and village houses, in ravines or on steep hillsides, and is used for hunting and the extraction of wild fruits, medicinal plants and construction materials.

The village population exerts a considerable pressure on the land available for farming. The floodplain is preferred for its fertile alluvial soils and most of the houses are located on the river levee, each surrounded by its respective dooryard garden, orchard, and nearby swidden plots. Yet the

available floodplain is rarely sufficient to supply the agricultural needs of a given household, most of which have one or more plantations in the more distant, less productive, and shorter-lived swidden plots in the upland forest. Most households also lay claim to the ever-variable expanses of alluvial sand and mud bars, as soon as they are left exposed by the ebbing river. The agriculturally suitable playas are staked out on a first-come-first-serve basis and some latecomers may be left without a playa in years after a low flood when alluvial deposits are less abundant.

In the chaco plots, traditional crops such as manioc, plantain, maize, peanut, squash, pineapple, tomato, pepper, and coca are planted, as well as more recently introduced crops such as rice, sugarcane, lettuce, cucumber and onion. The choice of crops planted on the playas is more reduced due to the temporal restrictions of the agroh habitat. Peanuts are the most important and most traditional playa crop, followed closely by introduced cowpea and yardlong bean (Vigna unguiculata cvs.), and watermelon. A list of cultivated plants and their corresponding agroh habitats is presented in Appendix 3. A generalized agricultural calendar for a typical year is summarized in Figure 8.

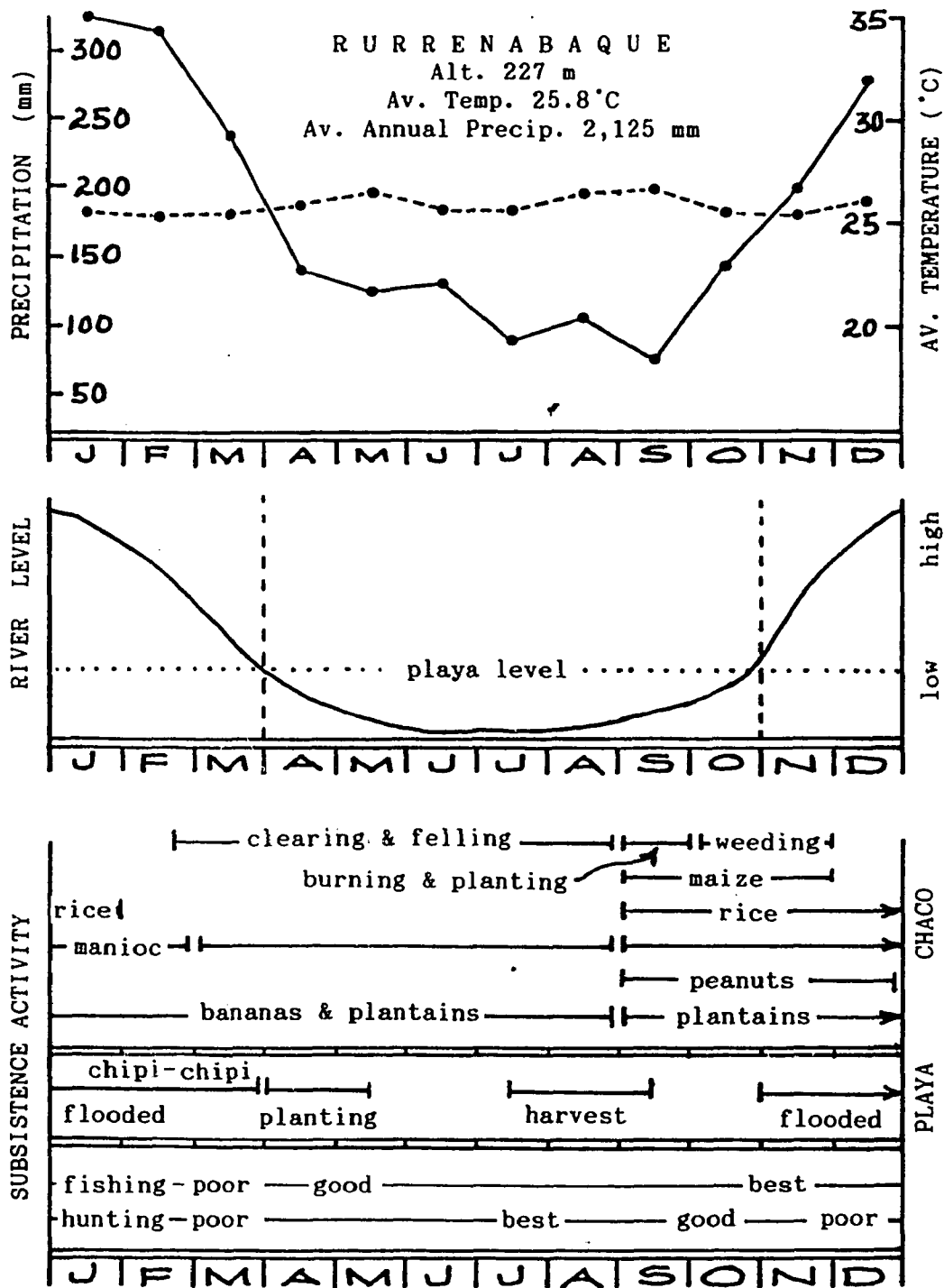


FIG. 8. Climate, river level, and subsistence calendar.

### The Chaco-Playa Cycle of Peanut Cropping

Although peanuts are traditionally planted in both upland and floodplain agroecosystems, the playa biotope is of primary importance for peanut production, while peanut cropping in floodplain or upland chacos is of a complementary yet vital nature.

The Playa Phase. In early March, when the rainy season is nearly over and the Beni River has begun to drop to its dry-season level, peanut farmers from Carmen Florida walk along the river's edge to scout out newly exposed sandbars suitable for planting peanuts. If the previous flood was exceptionally high, as it is every three to six years, the freshly deposited alluvial playas may be extensive and entirely free of colonizing vegetation. If the flood was not high, the playas will be smaller in size, generally in the same locations as they were the previous year, and somewhat invaded by persistent stands of cahuara (Tessaria integrifolia Ruiz & Pavón) and sauce (Salix humboldtiana Willd.). The farmers seek out playas that are, first of all, as high as possible above the river level to safeguard the crop against early or untimely floods. Secondly, they seek playas that have deep, large expanses of what appears to be pure, white, loose sand, ideally devoid of any vegetation. Playas that are close to the village are claimed first. At any rate, all the playas, by definition, are close to the

river and a canoe can be employed to transport the harvest should the playa lie some distance from the village.

Some farmers wade across a shallow place in an arm of the river to a large island opposite the village where they plant peanuts and cowpeas every year (Fig. 6). The location, shape and extent of the sandbars changes somewhat from year to year, but they are always present. Walking into the canebreak behind the playa, the farmers cut sturdy canes of the bamboo-like chuchío (Gynerium sagittatum (Aubl.) Beauv.) which they drive into the sand at the edges of the highest, sandiest part of the sandbar, delimiting plots from less than 1/4 ha. to 2 ha. or more in size. Having done this, the farmers plant cowpeas (V. unguiculata) along their plot boundaries. Poking shallow holes in the still moist sand every 30 cm with a machete or dibble stick, the farmers walk between their corner stakes, dropping two to three cowpea seeds into each hole which they cover up with their feet as they walk slowly ahead, poking and sowing. In a few days the cowpeas germinate, forming a recognized demarcation to the farmers' claims even after the corner poles have fallen, or are knocked or blown down. Each farmer marks off playas in response to their availability, soil quality, proximity to the village, and the supply of seed and labor. If first-rate playas are not abundant or if the farmer is adventurous, lower, smaller, or more distant playas may also be claimed.

Once the playas have been claimed it is still too early to plant peanuts; the risk of losing one's effort and seed to an unexpected late flood is still too great. Ordinarily, March 15 is regarded as the date after which serious risk of flooding has passed. The traditional indication that the river will remain low are the runs of chipi-chipi, tiny fish that migrate upriver in great schools. When the chipi-chipi run they can be caught by the thousands in baskets, and the danger of flooding has passed. By this time the borders of cowpeas have germinated around each parcel and the loose sand has dried to a gleaming white. Farmers wait until after a rain to sow peanuts on the well-drained soil to insure good germination. Phases of the moon are believed to be influential on planting and harvesting, and if the moon is new the farmers wait three to four days until it again becomes visible before planting.

When the decision to plant has been made, usually on a rainy day, the seed peanuts are taken from storage for shelling. The different varieties are usually stored separately or in the combinations in which they are traditionally sown. The seed peanuts are emptied into a pile in the middle of a large mat placed on the floor of the farmer's house or outside. A few adult members of the household sit around shelling the peanuts into a plastic washbasin or large hemispherical tutuma (Crescentia cujete L.) bowls. While the seed is being shelled it is also being

actively selected, peanut by peanut. Only the largest, most perfectly formed, disease-free peanuts are shelled for seed, all others are tossed into another pile destined for the kitchen. Occasionally a peanut will be found in which the basal seed is formed at a right angle to the other seeds in the pod, with a deep constriction between the seeds. Such peanuts are called cántaros or tinajas (lit. "water jugs") and are placed unshelled along with the shelled seed for planting at the corners of the playa plots in the belief that they will bring rain for the crop. Hissink & Hahn (1984) report that the cántaro peanuts are believed to represent the female gender (because of the vagina-like constriction), as well as a brook (i.e., water). Once all the seed has been shelled, the different varieties and mixtures are packed into bags and placed out of the reach of rats and children, to be sown the next day.

Planting is usually done in the morning, before the sun causes the beaches to become unbearably hot. If the playa is not already devoid of vegetation, some site preparation may be necessary. Smaller pieces of driftwood and flotsam are hauled to one side of the parcel, often piled in a windrow to make a division between neighboring parcels. Larger trunks and branches are left in place and the planting is done around them. Cahuara is a common sandbar-colonizing species on all but the newest playas, capable of forming dense stands. The soft stems of the young cahuara plants are

quickly cut off at ground level and then piled at the parcel's edge. Willows may also be present and, if small, are removed. Older willow trees with trunks too large to be easily felled with a machete are severely pruned so that they will not shade the crop. The pruned branches are added to the boundary windrow.

My informants confided some of the "secrets" that they adhere to when planting or harvesting to insure good peanut crops. Sowing and harvesting are avoided around a new moon. Children are prohibited from planting for it is believed that children, by carelessly putting their fingers in their noses or ears, will cause the peanut crop to be attacked by borers, pod rot, or produce fruits without seeds. Children are also prone to eat some of the peanut seed while planting and this will cause the plantation to be attacked by birds or rodents. The adult planters must likewise refrain from putting their fingers in their noses or ears, or eating the seed, for the same reasons. There are dietary taboos as well. The farmers must abstain from eating carancho, a small scaly fish with a hollow belly that lives in creeks. Eating carancho before planting peanuts will cause the fruits to be hollow. Nor can one eat stingray before planting because this could cause the peanut plants to die.

Hissink and Hahn (1984) report that the Tacana collect the seed peanuts' shells in a basket and strew them along the

path leading to the playa to insure a good harvest, but this practice was not observed in Carmen Florida.

Only two people are required for planting peanuts although three or four can make the work go much faster. The planting is usually done by women, but men may assist. Holes are punched in the moist sand with a dibble stick (punzón) (Fig. 9F) at intervals of 40-50 cm, in rows 60 cm apart. The holes are punched ca. 3 cm in diameter and 5-7 cm deep. The person with the dibble stick is followed by her assistant with the shelled seed in a calabash gourd bowl. (I was told that in earlier times, while planting, a hen's egg would be carried with the seeds to enhance their fertility.) She carefully drops two seeds in each hole and then covers over the hole with her foot so that the seeds will not be predated by birds or rodents. Varieties that are planted as mixed pairs are planted together indiscriminantly, i.e., two seeds of the same variety may be planted in the same hole or not, but the overall ratio in the field remains roughly 1:1. Varieties planted alone may be sown in the same parcel but not in the same row as another variety.

When the entire plot has been planted with peanuts, the special cántaro peanuts that were set aside are carefully planted at the corners of the plot, in their shell and in an upright or vertical position.

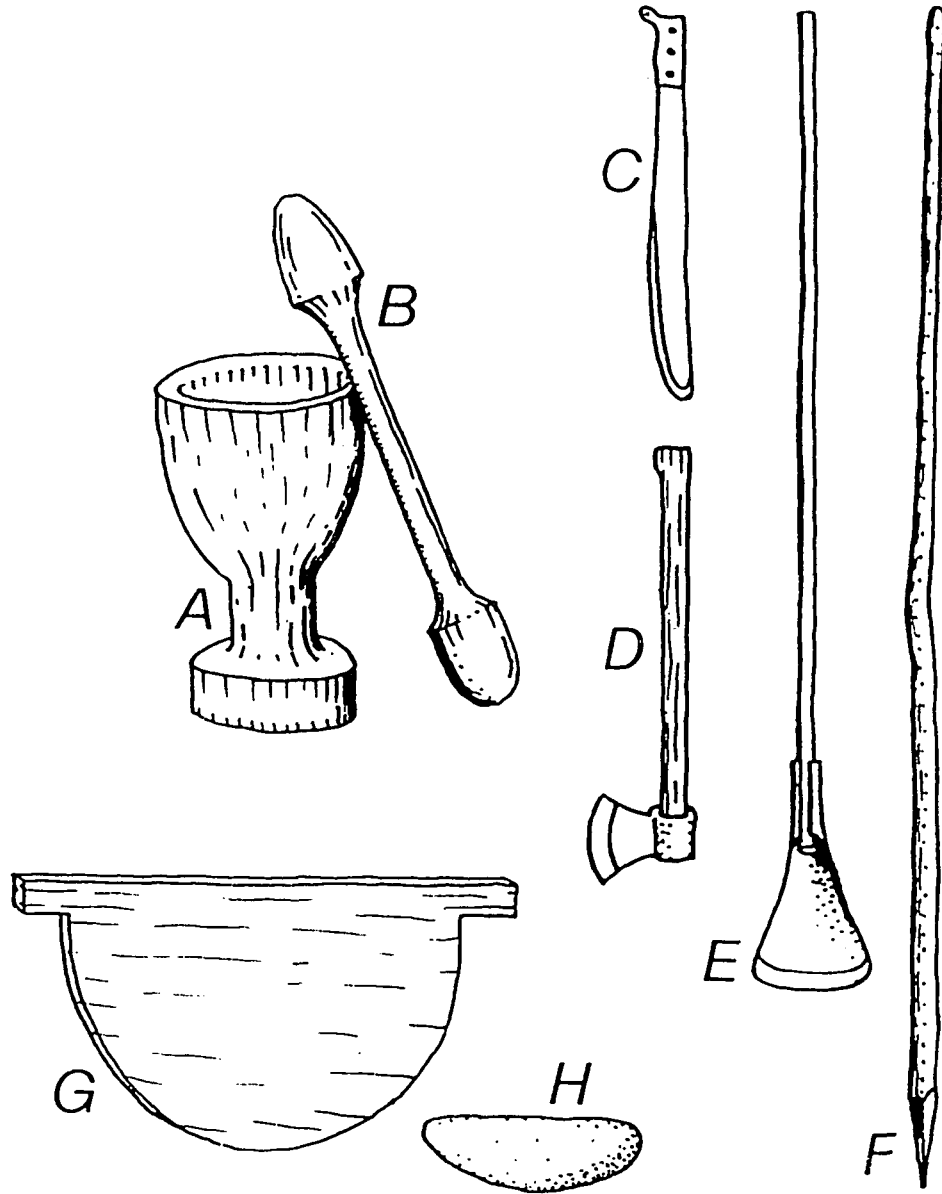


FIG. 9. Agricultural and food processing implements.

Finally, two to four rows of cowpeas are planted in the marginal soils around the perimeter of the peanut plot. This border of cowpeas serves a dual purpose: predator control and maximization of soil resources. The most serious predator of the peanut crop is the semi-aquatic capybara (Hydrochaerus capybara), the world's largest rodent that can weigh over 50 kg. Capybara herds tend to proliferate on playas where peanuts are cultivated. It is said that capybaras do not like to eat cowpea plants and a few rows around the perimeter can fool them into believing that the entire plot is planted to cowpeas, causing them to turn away in search of a peanut field. Perhaps more importantly, the cowpeas, whose fruits are produced above ground, can take good advantage of the heavier, shallower or rockier soil at the edges of the peanut plot where peanuts cannot be successfully grown or harvested.

On playas devoid of vegetation, no further attention is required until harvest. Within a week the seedlings have germinated and emerged. After about two weeks the parcels are revisited to check germination. If there are spots or areas where germination has failed or where there has been seed or seedling predation, replanting (rellenar) may be necessary. Parcels with established populations of Tessaria, Salix, or other weeds may require another weeding with the machete after a month or two.

The practice of heaping soil over the branches of the flowering plants, known as aporque, is common among native peanut farmers in some areas of Bolivia, such as the region of Ascención de Guarayos, where the Virginia-type peanut (ssp. hypogaea) is grown (Bojanic et al., 1986). This practice is not followed with the Valencia-type peanuts cultivated in the study area.

Generally there are few soil-borne pests or diseases of peanuts on the playas, since the soil itself is of very recent origin. Similarly, insect pests of the aerial portions of the plant are not a serious problem. In the town of San José de Uchupiamonas the farmers complained of petilla (a stinkbug) and leafcutter ants doing some damage. Leafspot disease (Cercospora sp.) is common. Besides the capybara, the jochi colorado (Agouti paca paca) also may cause considerable losses due to grazing of the branches and uprooting of the young plants. Mice (called tapiti) that dig up the developing fruits can also be a problem.

None of these pests or diseases is combatted in any way with the exception of the edible jochi colorado and the capybara which are sometimes shot. The capybara's meat is eschewed by most people and precious ammunition is generally used for shooting more palatable game. Around harvest time, due to the proximity of the playas to the water courses, there is frequent stealing of some portion of the peanut

harvest by nighttime fishermen and river travelers. The usual strategy used to offset these inevitable losses is to plant more than one expects to harvest. Given the relative ease of site preparation and planting, and an adequate supply of seed, it is not overly difficult to accomplish if there is enough available playa.

The peanuts mature in 100-110 days, the local wisdom calling for four months. As mentioned earlier, leaf fall, largely due to Cercospora infection, is regarded as a sign of fruit maturity--some plants are almost entirely denuded by harvest time. When this begins to occur, one plant is uprooted and a few peanut pods are opened to check for the appearance of the brown spots on the endocarp that are a direct indication of seed maturity. At harvest time the endocarp is so darkly spotted with brown as to be what North American commercial growers would reject as "overmature." The farmers intentionally wait as long as possible before harvesting so that more of the younger fruits on each plant can reach maturity. The farmers are also aware of the danger of waiting too long to harvest. It is not at all uncommon to see some of the new peanuts germinating from within their shells while still attached to the mother plant. This vivipary is due to the total absence of seed dormancy in this subspecies (ssp. fastigiata). If the peanuts are not harvested in time, the entire crop may be lost to premature germination. Cowpeas are harvested repeatedly as they mature

until the playa becomes inundated at the end of the dry season.

As with sowing, peanut harvesting is not done during a new moon. It is believed that to do so would cause the harvested peanuts to be attacked by insects.

The peanut harvest is the most labor-intensive phase of the process. No tools of any kind are required--the plants are simply pulled from the earth and the loose sand falls away from the roots and fruits, leaving them clean and free. The men work up and down the rows, pulling the plants, shaking off the sand, and piling the plants in mounds with the roots all facing the same direction. The piles are carried to where the women sit in the shade of a willow tree or makeshift lean-to where they methodically pick off the ripe peanuts by hand and toss them onto a large cloth. Here again, selection takes place. The women discard any damaged, diseased, malformed, small or immature fruits. The harvested plants are thrown aside and no further use is made of them. The peanuts are either wrapped up in the large cloth or transferred to a large sack for carrying back to the village. If the playa is far away a canoe may be employed since the wet, freshly harvested peanuts are heavy to carry.

The following morning, weather permitting, the green peanuts are spread out to dry in the sun. It is critical

that the peanuts are dried promptly and thoroughly to prevent them from molding or rotting. The peanuts are spread out on cloths or woven mats at a spot some distance from the house, such as a swidden clearing in the forest, to keep them away from children, chickens, free-ranging pigs, and even dogs, all of which are wont to eat fresh peanuts. If they are spread out to dry in the house clearing, they must be watched constantly. The various peanut varieties and mixtures are kept separate during the drying. To ensure even drying, the peanuts are stirred about with the hands or a broom every few hours. It takes about four full days of strong sun before the peanuts are completely dried and ready for storage. Each evening, or when rain threatens, the peanuts are gathered up in cloth sacks and baskets and taken indoors. The peanuts are dry when the seeds rattle freely inside the pods.

Once dried, the peanuts are stored. If there has been a surplus, it is sold at the Sunday market in Rurrenabaque. When packing up the peanuts for storage, a few kilograms of the best-looking fruits of each variety may be set aside for seed. The seed peanuts are stored separately so as not to be confused with the peanuts to be eaten or sold. The worst enemy of stored peanuts, aside from insect attack and mold caused by incomplete drying, are rats and mice, which abound. The preferred storage container for peanuts and other grains is a 55 gallon oil drum with the top removed. They are filled with loose peanuts of a single variety or

mixture, or with different peanut varieties and mixtures separated in cloth sacks. The drums are then covered with wooden boards and kept inside the house. If a farmer cannot afford to buy oil drums or if her harvest is more than her oil drums can accomodate, the peanuts are stored in cloth sacks suspended by a rope from the rafters. The rope passes through a tin can which serves as a foil to rats and mice that would otherwise climb down the rope and gnaw through the sack. If cloth sacks are not available, peanuts are stored in baskets lined with banana leaves. They are sometimes suspended from the roof inside the kitchen where smoke from the cooking fire helps discourage pests (Bojanic et al., 1986).

Stored peanuts can last six months without serious decrease in germination ability, or up to a year or more if the peanuts are redried in the sun every few months. However, peanuts are rarely kept longer than six months by which time they have usually been consumed, traded or sold. A conscientious effort is made to constantly maintain a source and supply of fresh seed which is achieved by planting a rainy season swidden or chaco peanut crop.

Other crops frequently planted on the playas are watermelons, rice, and sometimes maize. My older informants recall having also planted squashes, a particularly early variety of manioc called noventón ("ninety days"), sweet

potatoes, and even potatoes, although I have never seen any of these cultigens grown in recent times on the playas, perhaps due to the loss of those early varieties that were adapted to playa agriculture.

The Chaco Phase. While swidden gardens (chacos) are maintained and harvested all year round, new chacos are cleared during and burned at the end of the dry season. As previously mentioned, nearly all of the suitable agricultural land has been farmed at one time or another in recent times, and most is covered with secondary forest (barbecho) of different ages.

Floodplain barbechos are preferred to upland sites due to their greater soil fertility, flat terrain, and relative proximity to the village. The age and suitability of a barbecho for clearing and planting is usually determined by the size of the trees in the secondary vegetation. When the colonizing Cecropia and Ochroma trees have attained a girth of about 10 cm dbh, after five or six years, the land is considered to be bien descansado ("well rested") and will sustain good harvests as a swidden plot for two or three consecutive years before it must once again be fallowed.

During the relatively dry months between March and August, the menfolk work with axes and machetes clearing new

chacos. First the thick understory vegetation is cut down (rozar) while still in the shade of the larger trees. Then the larger trees are felled (tumbar) and the branches are cut up and spread around the clearing. Everything is then allowed to dry for 10-15 days before burning. There seem to be different personal styles in the way a chaco is cut and burned. Some men take pride in cutting up the brush and tree branches into small pieces that lie close to the ground when drying, causing a uniform, complete burn and leaving a relatively obstacle-free, clean-looking chaco.

Once the chaco is prepared it is, for the most part, turned over to the woman for planting, weeding and even harvesting. Sometimes a man will turn over the cut, dried, but unburned chaco to his wife, so that she can do this crucial operation to her own liking.

The timing of the final felling and drying is critical to successful planting. Ideally, it should be accomplished at the end of the dry season, just before the first rains of the wet season. At this time the cut vegetation dries and burns thoroughly, leaving more nutrient-rich ashes on the soil and fewer bothersome branches in the way; and then the first rains of the wet season permit good germination and continuing development of the crop. If the farmer burns too early there may not be enough rain for him to plant his crop before the weeds take over. If the farmer waits too long to

clear his swidden the first rains may prevent the slash from drying so that it cannot be burned before the weeds take over, producing an intractable tangle. As is the case for farmers the world over, the vagaries of climate and the unpredictability of weather are sources of much anxiety and diminished or even lost harvests.

Sowing takes place immediately after the first rain falls on the freshly burned chaco, which washes the ashes into the soil. Although chacos are occasionally monocropped with rice, maize, or even peanuts, they are most commonly planted with a broad inter- and intraspecific diversity of crops (Appendix 3). Peanuts are planted in the chaco much as they are on the playa, using a dibble stick and maintaining approximately the same planting densities. Peanuts are usually intercropped with other annuals such as maize but may also be planted in pure stands.

Peanuts are sometimes planted in the chaco on a comparatively large scale but most commonly the peanut crop in the chaco is a seed crop and not extensive. The main purpose is to produce fresh seed or to increase seed for planting on the playa the following year. The soil in the chacos is generally much heavier than it is on the playa (Table 1) and although the peanuts can still produce well in the heavy soil, their maintenance and harvest are much more laborious. Consequently, the areas of the chaco with the

sandiest soils are sought out for peanut planting.

Depending upon the age and composition of the surrounding vegetation, the chaco usually requires its first weeding about a month after planting. Weeding is accomplished by shaving a thin layer of soil from the ground surface with a lampa, a special long-handled shovel with a broad delta-shaped blade whose leading edge is sharpened (Fig. 9E) or with a machete by cutting all unwanted vegetation at or below ground level. To weed in this fashion is called carpir ("to scrape"). If this first essential weeding is neglected the entire crop will almost certainly be overtaken by weeds and will be lost. Weed invasion tends to be greater in floodplain chacos than in upland chacos, and greater in chacos made in young fallow than in old fallow. Chacos made in primary upland forest have the least problem with weeds. The most common reason for abandoning a chaco to fallow is not so much the loss of soil fertility as the insurmountable proliferation of weeds, a fact also observed by Denevan (1976).

Due to the heaviness of the chaco soils, it is not possible to harvest peanuts simply by pulling up the plants. To minimize the number of pods that break loose from the plant, it is necessary to carefully loosen the earth around each plant with a shovel or machete before it is uprooted. Even then the harvester must feel about in the earth where

the plant was growing to recover those pods that invariably remain in the ground. Peanuts harvested in the chaco tend to suffer from a greater incidence of soil-borne pests and diseases, and are often less perfectly formed than those grown on the playa. Chaco-grown peanuts are covered with soil when freshly dug up and must be washed with water before drying if they are to be marketable. Drying and storing of the chaco peanuts is the same as for those grown on the playa. The largest and most disease-free fruits of the harvest are selected for seed and stored separately.

Depending upon the particular needs of the farmer, chaco peanuts are sometimes replanted in the chaco at the time of harvesting. Using the freshly dug green peanuts as seed, they are sown in the loosened soil of the previous crop. This practice is possible only with fastigiata peanuts due to the total lack of seed dormancy in this subspecies (Krapovickas, 1968).

Cashinahua Peanut Farming. A useful comparison to the Tacana chaco-playa cycle of peanut cropping can be made with a similar system employed by the Cashinahua Indians as reported by Kensinger (1975). Practicing a traditional tropical forest type of agriculture, the Cashinahua cultivate swidden plots in upland and floodplain forests and also plant crops on the riverine sandbars. The Cashinahua are a Panoan-speaking group living in the remote headwater region

of the Juruá and Purús rivers in eastern Peru and western Brazil. The Panoan and Tacanan languages are believed to have derived from the Macro-Panoan language stock (Lathrap, 1970; Wise, 1985), indicating a probable prehistoric cultural affinity between the Tacana and Cashinahua peoples.

The Cashinahua sandbar plots are known as tama bai ("peanut garden") and, as their name indicates, are planted primarily to peanuts. However, a variety of other well-suited crops are also planted. A man stakes claim to a sandbar as soon as the flood recedes and clears it of vegetation if necessary, but the garden itself belongs to his wife. A family uses the same sandbar year after year. Peanuts are planted by the husband and wife, using a dibble stick. Along the edges of the peanut patch, watermelon and squash are planted. Manioc and maize are occasionally interplanted at the edges of the garden and may form a border between the gardens of different families. The peanuts mature after about four months and are harvested by the husband and wife together. After the plants are pulled from the ground they are tied into bundles and the vegetative branches are cut off, leaving the peanuts attached to the lower branches of the plant. The bunches are then stored inside the house where they are suspended from the rafters under the peak of the roof. Watermelon and squash are harvested as they mature until the sandbar is again inundated when the river rises.

To ensure a supply of fresh seed for the following year's sandbar garden, the Cashinahua frequently plant a small peanut patch in their upland plots during the high-water season. It is noted that the quantity and quality of the production in the seed-crop gardens is inferior to that of the sandbars.

Undoubtedly, the crop varieties planted by the Cashinahua on the sandbars are highly adapted to the particular edaphic and temporal restrictions of this agroecosystem. In his detailed treatment of manioc, Kensinger (1975) states that of the 22 varieties known to the Cashinahua, the four fastest maturing varieties (four to six months) are those planted on the sandbars. Propagation stock of these varieties is also maintained in the upland swiddens as a precaution against their total loss due to flooding on the sandbar plots.

Unfortunately, Kensinger makes no reference to the number or nature of the varieties of maize, squash, watermelon or peanuts planted on the tama bai. In recent conversations with a Brazilian Cashinahua who was visiting New York (Siã Kaxinawá, pers. comm. 1991), I learned that the Cashinahua plant at least five varieties of peanuts with white, black, yellow, purple, and variegated red-and-white seed coats. My informant stated that these peanuts are indeed cultivated on riverine sandbars and that they mature in three months. When I showed him some of my peanut collections from Bolivia he

immediately recognized the distinctively reticulated pods of A. hypogaea ssp. fastigiata var. peruviana as an "amendoim do Acre" ("peanut from Acre"), leading me to believe that the peanut landraces cultivated by the Cashinahua pertain to the botanical variety peruviana. This contention is supported by my collection nos. 631a and 632 from around Cruzeiro do Sul on the Juruá River, and no. 846 from the closely related and neighboring Yaminahua Indians of the Acre River, all of which belonged to variety peruviana.

In his treatment of Cashinahua agriculture, Kensinger (1975) notes that although the men of the village expend considerable time and effort in the creation and planting of agricultural plots, the ownership, tending and harvesting of the plots becomes the sole responsibility of the women. Kensinger found that while men have a good general knowledge of the production and uses of crop plants, the women possess a considerably fuller knowledge of these matters, particularly the identification and classification of crop varieties.

Uses and Relative Importance of Peanuts. The peanut is the most important grain legume in the local diet and, while not a staple, is an important complementary food. The only other cultivated grain legumes are the introduced cowpea (V. unguiculata), yard-long bean (V. unguiculata ssp.

sesquipedalis), pidgeon pea (Cajanus cajan), and hyacinth bean (Lablab purpureus). Only the cowpea is frequently cultivated--primarily for sale in Rurrenabaque as they are not commonly consumed by the farmers themselves. Neither common (Phaseolus) nor jack (Canavalia) beans are known to be traditionally cultivated.

While the carbohydrate requirements of the community are satisfied by agricultural production (plantains, rice, manioc, and maize), dietary protein comes primarily from fish, wild game, domestic fowl, and turtle eggs. This may account for the reduced importance of protein-rich grain legumes in the local subsistence economy. Nevertheless, the peanut is a favored ingredient in numerous dishes in the local cuisine to which it makes a savory, satisfying and nutritionally rich addition.

What follows is a list of some of the most common traditional dishes prepared with peanuts. It is by no means a complete list as a great deal of improvization in the local cuisine may result in the inclusion of peanuts in many dishes not mentioned here.

As a snack or travel food (known as tapeque), peanuts may be eaten raw, roasted, or boiled. Roasted peanuts (maní tostado) are prepared by stirring raw, shelled peanuts in a dry pot or frying pan over an open fire, or by placing the

unshelled peanuts into a hot adobe beehive-shaped bread oven, after the bread has been baked and removed, until roasted. Roasting is complete when the peanuts' papery seed coats are easily brushed away with the fingers. Roasted peanuts are often added to the locally made raw cane sugar just before it is poured into quadrangular molds where it hardens to form a candy called chancaca de maní. Boiled peanuts (maní sancochado) are made by boiling raw peanuts in the shell in heavily salted water until cooked.

Masaco is a popular dish prepared by pounding plantains together with dried meat (charque) in a large, upright wooden mortar (tacú) using a heavy wooden pestle (mano tacú) (Fig. 9, A & B). Roasted peanuts are often used in place of, or together with, the charque.

A peanut paste (masa de maní, pasta de maní), not unlike a very coarse, thick peanut butter, is prepared by pounding roasted peanuts in the tacú. The paste is often spiced with salt and ground hot peppers and is served as a side dish or alone. The paste may also be enclosed in bread dough which is then baked or deep fried to produce empanadas de maní. No evidence was found of whole, unripe peanuts being eaten as reported by Krapovickas (1968).

Two popular peanut beverages are prepared locally. The most common is chicha de maní. It is produced in many

regions of Bolivia, as described by Cutler and Cárdenas (1947). The Tacana around Rurrenabaque prepare it by boiling ground, toasted, floury maize together with ground, roasted peanuts. The resulting milky liquid is sweetened with sugar or honey, allowed to cool, and served as a nutritious and refreshing drink. I found no evidence that chicha de maní was ever allowed to ferment, although my informants said that it could be easily accomplished to make the mildly alcoholic drink reported amongst the Yuracarés by Weddell (1853). The other peanut beverage, called chocolate de maní, is prepared by toasting peanuts in a pan until they are quite dark then crushing them with a stone rocker (tumu) on a semicircular hardwood board (tada) (Fig. 9, H & G). The powder is then boiled in water and sweetened to produce a rich beverage that looks and tastes like hot chocolate.

Various savory sauces are made with peanuts. The sauces are prepared by shelling, peeling and grinding raw, blanched or roasted peanuts on a rocker mill together with peppers and other spices. A small amount of water is added to the sauce which is cooked slowly in a pot. It is served over chicken for pipián de maní and picante de maní, or over whole boiled potatoes for papa a la huancaína. Another popular dish is sopa de maní, peanut soup. It is made with raw, ground peanuts which cook along with other ingredients, including meat. The taste is quite unlike the flavor of roasted peanuts, but is rich and milky. Sopa de maní is

traditionally served throughout Bolivia on Saturdays and Sundays as well as on festive occasions.

Division of Labor. As mentioned earlier, the division of agricultural labor is fairly well marked but not exclusive. The largest portion of the work of planting, cultivating, harvesting and marketing falls to the women. Men are involved in activities that require the heaviest labor such as clearing and burning swidden plots, planting the large corms of bananas and plantains, weeding, harvesting and transporting the harvest. Women may participate in these activities also. When I attempted to interview men about agricultural practices, many frankly admitted ignorance to all but the most fundamental aspects of raising crops, referring me to or directly asking their wives for the answers to my questions. The different swidden plots or cultivated playas are usually named for the woman who tends them, e.g. "Maria's chaco" or "Eugenia's playa." Men are active year-round in the family farming effort, but it is the woman of the family who directs these efforts and makes the critical decisions as to when and where the men's work is required. Throughout the agricultural cycle it is the women who are most responsible for the upkeep of the gardens. All harvest surpluses and commercial produce are marketed by the women in Rurrenabaque. Food preparation, which includes hauling firewood and water, is done entirely by women.

Clearly, the most important aspects of the human-crop interrelationship lie in the women's domain. Women are also solely responsible for child-rearing, house cleaning, and the making, mending and washing of clothing. Female children begin assisting their mothers at an early age, while male children are not required to work until much later.

Purely male activities include fishing, hunting, forest clearing, extraction of building materials, house building, canoe construction, paddling and poling canoes, and communal labor service such as clearing village trails and common areas.

The suppositions and conclusions made by Hernández-X. (1988) regarding the preeminent role of women in the selection under domestication of crops in traditional agricultural systems in the Tropics appear to be born out by the Tacana of Carmen Florida.

Land Tenure. Land tenure in uninhabited areas of lowland Bolivia is based simply upon occupation of the land. A single family of Tacana settlers from San José de Uchupiamonas arrived at what is now Carmen Florida in 1949 when the land was under the domain of a patrón. The Tacanas were joined by a family of Quechua settlers from Apolo in 1952. By 1959 there were 14 families living on this bend in the Beni River, and a municipal surveyor delineated lots and

awarded land titles to the villagers. The lots consisted of a finite distance of frontage on the river, usually 100-200 m, and the same width extending as far back from the river into the forest as the owners cared to go. The same year the village was christened Carmen Florida. By 1990, Carmen Florida had grown to 24 families, many of which had no title to their land or were living on the land of relatives or friends with permission. Although no permanent markers separate proprietary land, boundary squabbles are rare and there still seems to be sufficient land for each family to support itself by shifting cultivation. Some enterprising families make swidden plots in unclaimed "wild" land at some distance from the village.

The land titles do not extend to the permanent island in front of the village nor to areas such as the playas that are flooded yearly by the river. Such land is freely available to anyone on a first-come-first-serve basis. Once claims to the untitled land have been made--generally by planting a crop--they are undisputed for the duration of the season. Families tend to return year after year to the same areas to seek out suitable playas. As with the higher lands, some families may plant on unoccupied playas as far as an entire day's travel by canoe from the village.

Soils. Soil classification by the Tacana of Tumupasa, reported by Wentzel (1989), is based on color, texture and

humidity. She notes that that formal classification is no longer familiar to many Tacanas, especially the younger generation whose site selection is based more on vegetational types than on soil. Nevertheless, the natives' familiarity with soil types continues to assist them in selecting appropriate crops for a given site.

Soil samples were taken from representative upland, floodplain and playa sites, the analyses of which are presented in Table 1.

Traditional Landrace Manipulation and Conservation. Tacana acculturation has brought with it the inevitable loss of some traditional agricultural practices (Wentzel, 1989). While younger generations of farmers tend to plant peanut landraces indiscriminately, older informants still adhere to traditional norms for the segregation and interplanting of specific landraces. The black-shelled and the large white-seeded landraces are traditionally planted in pure stands. (Note: some informants distinguish between large white-seeded and small white-seeded varieties. This distinction was somewhat tenuous by my observation. Agronomic, cytogenetic and/or enzymatic evaluation will be necessary to establish whether or not they are genetically distinct taxa.) Other landraces are customarily interplanted as companions or "pares." Red-seeded peanuts are nearly always interplanted with the small white-seeded race.

Table 1

Analysis of Agricultural Soils from Carmen Florida

<u>sample</u>	<u>organic material</u> %	<u>carbon</u> %	<u>nitrogen</u> %	<u>C/N ratio</u>	<u>pH</u>
upland <u>chaco</u> samples:					
A	1.27	0.74	0.093	8.0	6.60
B	1.22	0.71	0.098	7.2	4.97
C	1.25	0.73	0.090	8.1	5.13
L	3.76	2.18	0.216	10.1	7.53
lowland <u>chaco</u> samples:					
J	2.87	1.67	0.209	8.0	7.91
K	2.18	1.26	0.183	6.9	6.57
<u>playa</u> samples:					
D	0.13	0.08	0.032	2.5	6.62
E	0.13	0.08	0.029	2.8	6.70
F	2.54	1.47	0.167	8.8	7.00
G1	0.12	0.07	0.032	2.2	7.16
G2	1.34	0.80	0.112	7.1	7.25
H	0.10	0.06	0.027	2.2	7.67

Analysis done by Ing. Agr. Hector Pedro Salas, Departamento de Suelos, Estación Experimental Agropecuaria Manfredi, Manfredi, Argentina.

Black-seeded peanuts (or purple-seeded peanuts when the black-seeded ones are unavailable) are interplanted with the yellow-seeded race. Interplanted "pairs" are the preferred way of cropping but it is evidently not mandatory. Pure stands of only one variety of the ordinarily "paired" races are also seen, but this may have been due to the lack of seed of one of the counterpart races. I was unable to elicit any particular reason for deliberately interplanting races other than "Es nuestra costumbre" ("It's the way we do it").

Seed selection for all landraces is based solely on the criteria of size and healthy appearance of the pods, a process which typically takes place four times each year (at both planting and harvest times on the playa and in the chaco) for each variety.

Seed storage is a multifaceted endeavor. The availability of seed for planting is of critical importance to subsistence farmers, and the total loss of one's seed has serious consequences. To distribute and thereby minimize the risk of seed loss, two simultaneous and complementary strategies for seed storage are employed. The seed may simply be stored in the house as a part of the general harvest which is also used as a food supply and possible commercial resource, but as such is subject to the constant risk of being eaten or sold. Usually a portion of the harvest is specifically selected as seed and stored

separately in a protected location in the house. All seed, however, that is stored in the house may be attacked by rodents, insects, or mischievous children, or it may be required to feed the family in times of food shortage. Moreover, the farmers know that in the warm, humid, tropical environment, seed viability diminishes rapidly.

As a hedge against the recognized risks of seed storage, a second strategy is used to ensure an adequate supply of viable seed--the chaco seed-crop. Seed selected from the playa harvest is planted in an upland swidden. For four months this germplasm becomes unavailable for human consumption or sale, although it is subjected to all the risks ordinarily run by a standing field crop. If the chaco seed-crop is successful, fresh, highly viable seed becomes available shortly before it is time to plant on the playa, and the seed stored in the house may then be freely eaten or sold. If the chaco seed-crop should fail, the farmer can fall back upon the previous year's stored seed for planting the newly exposed playas.

When seed storage efforts are thwarted or neglected, seed may become lost. It is a surprisingly frequent occurrence, and steps are usually taken to recover lost seed of favored cultivars. It is often accomplished by requesting or purchasing seed from a relative, friend or acquaintance. If deemed necessary, a special trip is made to acquire the

seed. Sometimes a few seeds of a lost variety are discovered amongst the seed of another variety when shelled. Such inadvertent mixes are not uncommon. They may be the fortuitous result of a mutation or hybridization. These serendipitous seeds are carefully increased by planting them in favored, protected locations in the chaco or on the playa. A small palisade of sticks is sometimes made around such plants to protect them against predator attack.

There is surprisingly little differentiation made between the various landraces with regard to their agronomic traits or uses. For the most part, any landrace seems to produce as well as any other landrace in a given location, and all peanuts serve equally well for the preparation of peanut dishes.

## Chapter VI

### Evolution of the Valencia Peanut in Bolivia

Due to the peanut's economic and nutritional importance, the genus Arachis has become the object of increased scientific investigation in recent years. Intensive efforts, largely by plant breeders seeking to improve the crop, have been made since 1959 to collect wild and cultivated Arachis germplasm (Simpson, 1984). As with maize, another important native American cultigen, the elucidation of the peanut's evolution has proven difficult and, like maize, has resulted in a plethora of pertinent literature.

Though no recent monograph has been published for the genus, unprecedented progress has been made in furthering our knowledge of the number, distribution and systematic relationships of the species that comprise the genus, and a satisfactory system of infrageneric classification has been proposed (Gregory et al., 1973, 1980). A useful infraspecific classification system has likewise been developed and adopted for the cultivated peanut landraces

(Krapovickas, 1968). Catalogs of the landraces of Argentina (Rigoni et al., 1960), Venezuela (Mazzani & Cobo, 1957), and Africa (Gibbons et al., 1972) have been published and others are currently being prepared for Bolivia (Pietrarelli et al., 1988a), Peru (Pietrarelli et al., 1988b), and Ecuador (Pietrarelli, pers. comm. 1990). Because classification schemes strive to reflect phylogenetic affinities as much as possible, they represent important contributions to researchers in both plant systematics and plant breeding.

The genus Arachis is naturally endemic to South America and is characterized by geocarpy in all of its member species. Although 22 species have been validly described to date, it is likely that the total number of species is three or four times greater (Gregory et al., 1980). The genus has been provisionally subdivided into seven sections: Arachis nom. nud., Erectoides nom. nud., Caulorrhizae nom. nud., Rhizomatosae nom. nud., Extranervosae nom. nud., Ambinervosae nom. nud. and Triseminalae nom. nud. (Gregory et al., 1973).

The genus contributes only two species cultivated for their edible seeds, each of which was domesticated independently by prehistoric inhabitants of South America. Arachis hypogaea (sect. Arachis) is now widely cultivated in warm climates throughout the world. Arachis villosulicarpa Hoehne (sect. Extranervosae) is cultivated only by Nambycuara Indians in the present-day Brazilian state of Rondônia, where

the cultigen was discovered (Hoehne, 1944). Two other species, A. repens Handro (sect. Caulorrhizae) and A. glabrata Benth. (sect. Rhizomatosae) have recently been taken into cultivation as forage and ground cover (Krapovickas, 1973). Further discussion will be restricted to A. hypogaea, the only widely distributed cultigen in the genus.

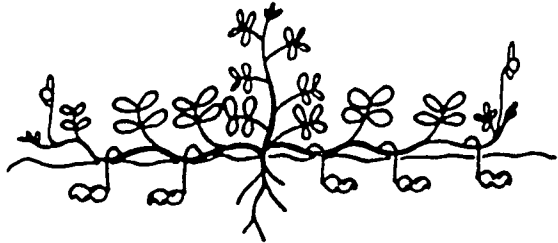
Arachis hypogaea pertains to the section Arachis which includes annual and perennial diploids ( $2n=2x=20$ ) and two annual allotetraploids ( $2n=4x=40$ ), the latter being the cultigen and the probably conspecific A. monticola Krap. et Rig. (Gregory & Gregory, 1976). In the evolution of the seven described sections in the genus, the section Arachis is believed to be of most recent origin due to geological considerations in its distribution and because genetic isolation is not marked between its member species. Fertile intra-sectional hybrids can be freely achieved (Gregory et al., 1980). Smartt (1985) believes that it is most likely that an intra-sectional, interspecific hybrid arose, producing a wild polyploid that was subsequently domesticated to become A. hypogaea. Yet the progenitor species have yet to be conclusively identified, despite extensive morphological, cytological and experimental crossing studies of known members of section Arachis (e.g., Smartt et al., 1978a; Stalker, 1980; Stalker & Moss, 1987; Gregory & Gregory, 1979; Gregory et al., 1973, 1980).

Smartt et al. (1978a) suggest that A. batizocoi Krap. et Greg. and A. cardenasii nom. nud. (both sect. Arachis) may be the progenitor species which hybridized in nature to form the wild allotetraploid species that was later domesticated to become A. hypogaea. These authors, however, recognize certain points that cast doubt upon their hypothesis and state that further plant exploration may turn up new taxa which more closely fit the genomic profile of a putative progenitor.

It is possible, if not probable, that one or more of the species that played key roles in the origin of A. hypogaea still exist unidentified in the wild (Stalker & Moss, 1987). Any undiscovered progenitor or progenitors must certainly belong to the section Arachis and are most likely to be found in the remote Bolivian lowlands where the genus has not been well collected (Gregory et al., 1980). Explorations made in this region as part of the present study yielded germplasm and herbarium specimens of wild Arachis sect. Arachis that appear to represent a new species (C. E. Simpson, pers. comm. 1991), as well as reliable reports of a disjunct Arachis population that possibly pertains to yet another undiscovered species.

However the wild allotetraploid progenitor first arose, the subsequent evolutionary course of A. hypogaea was guided by the self-serving hand of Homo sapiens. Evolution under

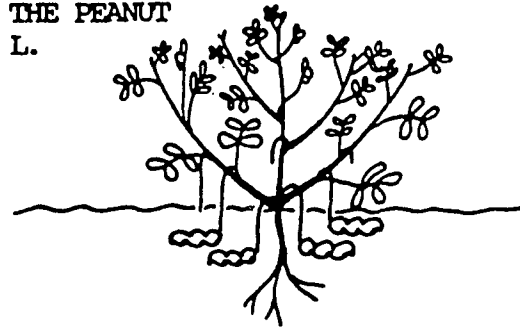
INFRASPECIFIC TAXONOMY OF THE PEANUT  
Arachis hypogaea L.



subspecies hypogaea  
 (prostrate plants)

variety hypogaea  
 "Virginia" type  
 - many races

variety hirsuta Kohler  
 "Peruvian Runner" type  
 - very few races



subspecies fastigiata Waldron  
 (erect plants)

variety fastigiata  
 "Valencia" type  
 - many races

variety vulgaris Harz  
 "Spanish" type  
 - many races

variety peruviana  
 - several races

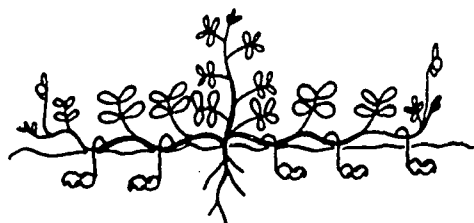
variety (from Ecuador)  
 - few races

FIG. 10. Intraspecific taxonomy of the peanut, Arachis hypogaea L.

domestication of the peanut proceeded over the course of several millennia in different agroecological and cultural contexts, resulting in a remarkable degree of infraspecific diversity.

Infraspecific classification of *A. hypogaea*. The currently accepted infraspecific classification of cultivated peanuts was first proposed by Krapovickas and Rigoni in 1960 (Fig. 10), based primarily on morphological and physiological characters (Fig. 11). There is evidence (Krapovickas, 1973) of genetic isolation existing between the subspecies, presumably the result of long separation in secondary centers where they evolved under different ecological and cultural conditions (Gregory & Gregory, 1976). Genetic isolation is evident in the progeny of intersubspecific crosses that frequently manifest lethal characters (albinism), malformations, or reduced fertility (Krapovickas, 1968; Wynne & Coffelt, 1982; Gregory et al., 1980). Karyotypic differences have been described among the subspecies and varieties of *A. hypogaea* by Stalker and Dalmacio (1986), although these authors do not propose a standard karyotype for the species as a whole because of the broad intraspecific chromosome variation observed. Little is known regarding the possible role of wild species in the infraspecific evolution of the cultigen (Pickersgill, 1986).

SOME AGRONOMIC DIFFERENCES BETWEEN THE TWO SUBSPECIES OF PEANUTS  
Arachis hypogaea L.



subspecies hypogaea

long cycle (120-160 days)

seed dormancy

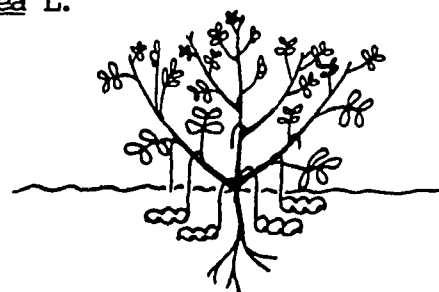
alternate branching

fruits scattered

weaker pegs

prostrate habit

sterile mainstem



subspecies fastigiata Wald.

short cycle (90-120 days)

no seed dormancy

sequential branching

fruits together

stronger pegs

erect habit

fertile mainstem

FIG. 11. Some agronomic differences between the two subspecies of peanut.

In his doctoral dissertation, R. A. Waldron (1919) recognized the fundamental difference between the groups of cultivated peanuts with prostrate and erect growth habits, and elevated these groups to subspecific rank, A. hypogaea ssp. procumbens and A. hypogaea ssp. fastigiata, respectively. Because he cited the type specimen of A. hypogaea L. in the description of his subspecies procumbens, the name of the prostrate subspecies was reverted to A. hypogaea ssp. hypogaea, in compliance with the International Code of Botanical Nomenclature (Krapovickas & Rigoni, 1960).

The original infraspecific taxonomic scheme of Krapovickas and Rigoni (1960) has been expanded upon in response to subsequent research and exploration that has shown relationships between infraspecific taxa and geographical regions (Krapovickas, 1968, 1973; Gregory & Gregory, 1976). Figures 10 and 12 show the most recent infraspecific classification for A. hypogaea, and a distribution map, respectively, adapted from Gregory and Gregory (1976). In the light of more recent discoveries, the proposed taxa and associated geographical regions no longer accurately reflect the known extent and distribution of peanut diversity in South America, and Gregory et al. (1980, p. 480) recognize an "obvious need for further clarification" in the area.

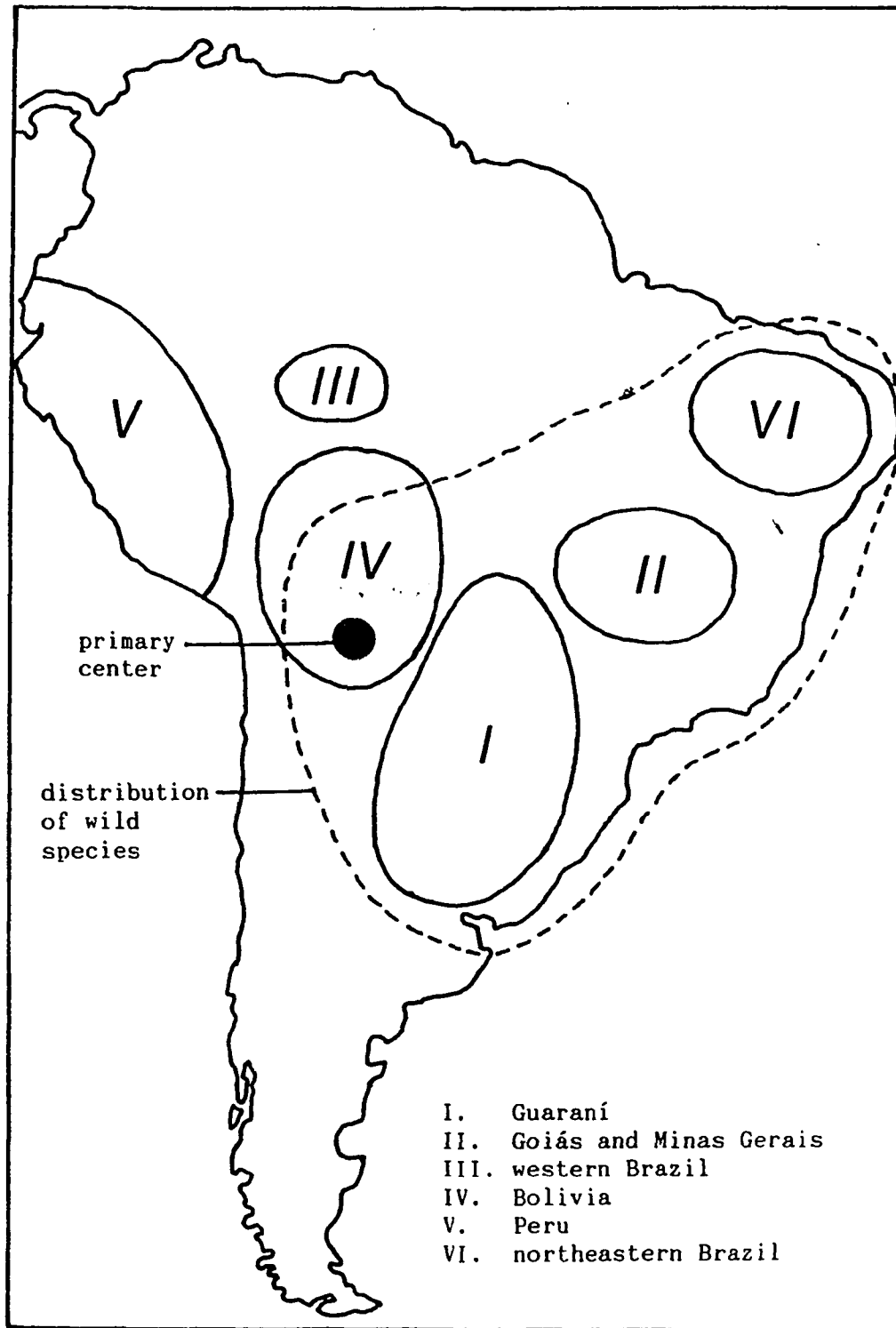


FIG. 12. Centers of origin and diversity of the peanut.  
(Redrawn from Gregory and Gregory, 1976.)

To date, most conclusions regarding the peanut's infraspecific diversification and diffusion have been based on the distribution of the still incomplete collections of existing diversity, and on genetic studies of an often unrepresentative portion of the collections. Only incidental attention has been paid to the human factor that, during the several millenia since the domestication of the cultigen, has been paramount in the evolution of the species. The present research offers additional information in an attempt to clarify some of the uncertainty and inaccuracy that exists concerning the distribution and evolution of the Valencia peanut, Arachis hypogaea L. subspecies fastigiata Waldron variety fastigiata, in lowland Bolivia.

Subspecies fastigiata is readily distinguished from subspecies hypogaea by several outstanding morphological and physiological characters. The characters are summarized in Figure 11. Subspecies hypogaea is generally accepted as the more primitive form, from which the subspecies fastigiata was derived as the result of evolution under domestication (A. Krapovickas, pers. comm. 1987). Some authors (Stalker & Dalmacio, 1986) have challenged this assumption based on studies of chromosome arm ratios using material that was, for the most part, not of direct or recent South American origin and therefore may have been subjected to a certain degree of introgression.

A reexamination of the distinguishing characters of subspecies fastigiata, in the light of observed human intervention in the crop's region of origin, is revealing. The interrelated subspecific characters to be discussed here are: growth habit, mainstem fertility, branching pattern, earliness, autogamy, leaf color, disease resistance, fruit morphology, seed dormancy, peg strength, and geographic distribution. Pertinent linguistic, archeological, and ethnographic evidence is also discussed.

Growth habit. The manifest dichotomy in the growth habits of cultivated peanuts has long been recognized and formed the basis for the first subspecific classification scheme (Waldron, 1919). Virtually all varieties of the ssp. fastigiata have an erect or ascending growth habit. The ssp. hypogaea, on the other hand, is generally characterized by prostrate growth, with some semi-erect "bunch" types that may have arisen as the result of intersubspecific introgression (Krapovickas, 1968).

The growth form of wild species of the section Arachis is uniformly prostrate. Typically, an erect main axis develops 10-25 cm in length and four main horizontally growing branches develop from the axils of the cotyledons and first pair of leaves. The same form of prostrate growth is found in the ssp. hypogaea (Smartt, 1985). Because ssp. fastigiata

departs from the wild-type growth habit, it can be supposed that it represents a derived form which has arisen as a result of human selection (Smartt, 1978).

The erect growth habit offers distinct advantages to a farmer utilizing lands such as the riverine playas that are subject to extemporaneous flooding and silting. Flash floods, or turbiones, are not uncommon in Amazonian headwater streams, particularly at the end and towards the onset of the high-water season, and sometimes interfere with peanut planting and harvesting. The turbiones are usually brief and, while the temporary submersion of the crop may not in itself kill the plants, the accompanying deposition of five to ten cm of river-borne silt can cause serious damage to or loss of the crop. A crop with a prostrate habit would be particularly susceptible to damage by silting, while a strongly erect plant would be much more likely to survive.

I once observed a man harvesting peanuts from a low playa upon which a turbión earlier in the season had deposited more than 10 cm of heavy silt on the sandbar on which his crop was planted. The upright branches of his Valencia-type peanuts emerged well above the silt deposit and continued to grow and flower. Although the farmer was no longer able to harvest his crop easily by uprooting the plants from the sand, by digging through the silt deposit he was still able to take in a respectable harvest. If the farmer had instead planted a

prostrate Virginia-type peanut he would have surely lost his entire crop. In a subsistence economy the difference between a diminished harvest and no harvest is truly great.

Mainstem fertility. The central axis, or mainstem, of both subspecies is erect. Yet in the subspecies hypogaea the mainstem is sterile, while in the subspecies fastigiata inflorescences are formed on the mainstem (Bunting & Elston, 1980). In an agricultural situation such as that described above, the erect mainstem of the prostrate ssp. hypogaea could survive a deposit of silt but its intrinsic sterility would preclude further flowering and fruiting.

Branching pattern and earliness. A mutually exclusive dichotomy in branching pattern exists between the subspecies and is the primary factor upon which the current taxonomic division of subspecies is based (Krapovickas & Rigoni, 1957). The subspecies hypogaea is characterized by an alternate branching pattern in which the primary vegetative branches produce secondary vegetative branches and reproductive branches in an alternating pattern of two vegetative nodes followed by two reproductive nodes. The subspecies fastigiata has a sequential branching pattern in which the initial nodes on the primary and secondary branches (as well as the mainstem) bear a sequence of inflorescences and the later nodes produce vegetative axes (Bunting & Elston, 1980).

The agronomic implications of the different branching patterns is significant. The alternately branched types (ssp. hypogaea) have an indeterminate flowering habit which prolongs the fruiting period. Sequentially branched types (ssp. fastigiata) have a defined fruiting period after which the plants become senescent and are ready for harvest a month or more before the alternately branched types. For this reason, the fastigiata types are more suited to agroecosystems with restricted growing seasons due to frost, limited rainfall, or flooding. The earliness of fastigiata types also permits double cropping in some areas (Krapovickas, 1968), which intensifies the human-plant interaction.

A shortening of life-span is frequently one of the changes that species undergo when they are domesticated (Schwanitz, 1966; Smartt, 1978). Closely related wild species in the section Arachis are either perennials or long-lived annuals. The report of both alternate and sequential types of branching in A. monticola (Gibbons, 1966) may be erroneous due to introgression from A. hypogaea in the material studied (Gregory et al., 1973). Longevity seems to be a character that ssp. hypogaea shares with its wild relatives, while the determinate growth of ssp. fastigiata appears to be the result of its evolution under domestication.

Autogamy. The peanut flower is essentially self-pollinating, but some degree of natural outcrossing occurs (Norden et al., 1982). Subspecies hypogaea is a more strict inbreeder than subspecies fastigiata (Culp et al., 1968; Gregory & Gregory, 1976). The occurrence of natural crosses was initially recognized as a problem by peanut breeders, making it difficult to maintain varietal purity in their breeding lines (Culp et al., 1968). More recently, natural crossing of lines with known pedigrees has been proposed as an economical technique for increasing the number of hybrids in peanut breeding programs (Coffelt, 1989).

The fact that subspecies fastigiata is more prone to outbreeding has useful implications for the indigenous peanut breeders. As described in an earlier chapter, Tacana peanut farmers habitually sow certain landraces in mixed plantings, often in the same hole. Whether or not it is a conscious effort to promote natural crosses is not clear, but it unquestionably creates optimal conditions for hybridization to occur. Any off-type progeny of such a cross would be quickly detected by a native farmer and, more than likely, would be carefully tended and propagated rather than rogued out. Interplanting landraces of the more freely outcrossing peanuts promotes heterogeneity in the farmer's seed stock, from which she may then select and propagate new or more productive types. This practice may explain the "unexpected"

diversity of Valencia peanuts discovered in the vicinity of Rurrenabaque (Krapovickas, pers. comm. 1990).

Evidence for such crosses is, so far, circumstantial. Off-type seeds are often found when shelling the harvest from a "pure" stand of a different landrace. As previously mentioned, the fortuitous discovery in a mix is sometimes the way that seed of a "lost" variety is recovered.

Interestingly, an electrophoretic study of 65 Bolivian landrace accessions (Grosso et al., 1988) showed that the five accessions from Rurrenabaque, all of which differed from one another in seed color, formed a distinct group unto themselves, suggesting a shared ancestry. While examining the fruits and seeds of those accessions produced during the 1989-1990 season at the Estación Experimental Agropecuaria in Manfredi, Argentina, in October 1990, we observed off-type seeds among the harvest. Although Antonio Krapovickas and José Pietrarelli suspected that the off-types were inadvertant mixes produced during the harvest, I had more faith in the capability of the carefully trained field workers at the experiment station who had years of experience maintaining the extensive peanut collection kept there. The off-types encountered were a yellow-seed fruit amongst the black; red-seeded fruits amongst the white; and white-seeded fruits amongst the red. Each mix represented landrace pairs that are customarily interplanted by the Tacana around

Rurrenabaque. Further investigation is required to determine whether the off-types found at Manfredi were the result of hybrid segregations or simply inadvertent artifacts of the harvest process.

During the course of his vast collecting experiences in the South American gene centers, Krapovickas (pers. comm.) observed that while mixes of different varieties are often encountered, they are almost always composed of varieties within one subspecies, rarely otherwise. He states (Krapovickas, 1968) that the great diversity in ssp. fastigiata encountered in the Guaraní region, for example, is most probably due to introgressive hybridization between var. fastigiata and var. vulgaris, resulting in a typical hybrid swarm.

Although the possible intervention of wild species in the origin of ssp. fastigiata has not yet been demonstrated, it has been determined that ssp. fastigiata cultivars produce hybrids with other Arachis species at a higher frequency than do varieties of ssp. hypogaea (Smartt & Gregory, 1967).

Leaf color. The two subspecies of A. hypogaea differ in leaf color. The subspecies hypogaea has dark green leaves while subspecies fastigiata has light green leaves (Wynne & Coffelt, 1982; Smartt, 1985). The wild species in the section Arachis have consistently dark green leaves.

Although light green leaf color may present no apparent advantage to native farmers, it does represent a departure from the wild type, indicating a more evolved form.

Disease resistance. Numerous diseases plague peanut crops worldwide and present a serious obstacle to commercial peanut production. Cercospora leafspot diseases--Cercospora arachidicola Hori and Cercosporidium personatum (Berk. et Curt.) Deighton--are the most widespread and destructive (Porter et al., 1982; Stalker & Moss, 1987). Improved disease resistance is one of the primary goals of peanut breeders (Norden, 1980). Members of the subspecies fastigiata generally show a marked susceptibility to Cercospora leafspot while those of the subspecies hypogaea are more resistant (Smartt et al., 1978b; Smartt, 1985). Near immunity or high resistance to many peanut diseases has been discovered in various wild Arachis species, making them the object of considerable interest to breeders seeking to transfer this resistance to the cultigen (Gregory et al., 1973). There appears to be a physiological trade-off between agronomically advantageous characters, such as earliness and yield, with disadvantageous characters such as disease susceptibility (A. J. Norden, pers. comm. 1990). The leafspot disease susceptibility of the subspecies fastigiata may be interpreted as the evolutionary price paid as a consequence of this group's advanced stage of domestication when compared with the relative leafspot disease resistance

that the subspecies hypogaea shares with its wild relatives.

Fruit morphology. One of the most consistent and characteristic changes that a species undergoes during domestication is the loss of its natural means of dissemination (Schwanitz, 1966). In wild species of Arachis seed dissemination is achieved by the typically horizontal elongation of the carpophore, or peg, which in some species may attain a length of as much as one meter (Krapovickas, 1968). Furthermore, the lomentiform fruit itself is biarticulated due to an intercalary meristem between the ovules which produces a filamentous isthmus that separates the two single-seeded compartments by as much as 20 cm (Krapovickas, 1968). Pods of geocarpic legumes are by nature indehiscent (Smartt, 1978); the fragile pegs and isthmi of wild Arachis serve to distance and detach the seeds from the mother plants.

In the domesticate, A. hypogaea, the pegs grow vertically, are much more robust and, once having penetrated the soil, begin fruit development immediately. The intercalary meristem is suppressed and the two (or more) ovules develop together in a non-articulated seed case. The pod constrictions found between seeds in some varieties may be interpreted as a last vestige of articulation (Smartt, 1978).

In A. hypogaea ssp. hypogaea var. hypogaea, the Virginia peanut, the fruits are characteristically two-seeded and bi-modal, that is, having a marked pod constriction between the seeds. The pegs of this variety have been reported to be weaker than those of ssp. fastigiata (Johnson-George et al., 1988). These may be seen as primitive traits. (The Peruvian Runner, A. hypogaea ssp. hypogaea var. hirsuta Kohler, whose distribution was originally confined to coastal Peru, has fruits that do not conform to the pattern of the rest of the subspecies. The fruits are generally four-seeded and have a deeply reticulated pod, both traits typical of the races of ssp. fastigiata found on the other side of the Andes in the Peruvian Amazon. Interestingly, archeologists suggest that it was precisely from this region that the cultigen was first introduced to the coast area, some 5,000 years ago or more (Towle, 1961; Lathrap, 1977).)

In A. hypogaea ssp. fastigiata var. fastigiata, the Valencia peanut, the fruits are generally four- or five-seeded without marked constrictions. Also, the pegs are reported to be comparatively stronger than those of ssp. hypogaea (Johnson-George et al., 1988). Such manifestations of fruit gigantism and loss of wild-type dispersal mechanisms are characteristic of evolution under domestication (Schwanitz, 1966; Smartt, 1985), and reflect the relatively more advanced phylogenetic position of this variety.

Clearly, selection for peg strength is a consequence of agricultural management, specifically harvest methods. Long-lived runner-type peanuts (ssp. hypogaea) were necessarily planted on heavier, upland soils where digging was required for harvest. Valencia and Spanish peanuts (both ssp. fastigiata), on the other hand, were cultivated on the sandier, more friable alluvial soils where harvesting could be accomplished by uprooting the plants (Gregory et al., 1973), a practice that would exert considerable selection pressure favoring stronger pegs. Johnson-George et al. (1988) conducted comparative tests of peg strength on vars. hypogaea, vulgaris, and fastigiata, as well as on A. monticola. They found that the wild A. monticola and the cultivated var. hypogaea had the lowest peg strengths, and vars. vulgaris and fastigiata had the highest peg strengths. The increasing progression of peg strength from wild to runner to erect peanuts suggests an evolutionary process guided by human selection.

It should be noted that the fruits of Spanish peanuts (ssp. fastigiata var. vulgaris Harz) retain the primitive-type bi-modal, two-seeded, somewhat lomentiform fruit. This and certain other departures from the typical Valencia form of the subspecies has caused some researchers to question the close affinity of Spanish and Valencia botanical varieties (A. Krapovickas, pers. comm. 1990).

Seed dormancy. Another characteristic modification brought about in nearly all domesticated plants is the loss of seed dormancy (Schwanitz, 1966; Smartt, 1978, 1985). A significant degree of seed dormancy is retained in the ssp. hypogaea, but it has been completely lost in the ssp. fastigiata. As pointed out by Smartt (1985), seed dormancy in a long-cycle, alternately fruiting, geocarpic crop (such as ssp. hypogaea) is advantageous: it prevents the germination of mature seeds while younger fruits are still forming. Yet, for a farmer exploiting a temporally restricted agroh habitat such as a riverine playa, a sequentially fruiting, early maturing crop without seed dormancy (i.e., ssp. fastigiata) would be equally advantageous and enable the farmer to produce a second crop on an upland site. The corresponding agroecosystems have been the deciding factors in the expressions of seed dormancy in the subspecies of A. hypogaea.

Based on the many characters they have in common, Krapovickas (1973) maintains that the Virginia-type peanut, A. hypogaea ssp. hypogaea var. hypogaea, is the most similar to the closely related wild species of the section Arachis. At the other end of the peanut evolutionary spectrum is the Valencia type, A. hypogaea ssp. fastigiata var. fastigiata. Smartt (1986, p.40), discussing general trends in the evolutionary progress of grain legumes under domestication, states: "In morphological terms the present peak of

evolutionary development is represented by grain legumes which are typically compact, erect, free-standing, annual herbs with determinate growth patterns, a concentrated flowering period and large pods with reduced dehiscence containing large seeds without long-term dormancy." This description of evolutionary advancement neatly encompasses the Valencia peanut.

Geographic distribution. Krapovickas (1968), in his seminal paper on the origin and spread of the cultivated peanut, was the first to identify a correlation between the taxonomic subdivisions of the cultigen and geographic regions. He also emphasized the importance of the relation between peanut genocenters and indigenous cultures. His conclusions, based on admittedly incomplete data, underlined the need for further exploration. Intense exploration in the past two decades has done much to enhance our knowledge of the nature and geographic distribution of peanut diversity in South America, but the picture is still far from complete. Large areas of eastern Peru, Ecuador, Central Amazonia, and the Guianas remain unexplored.

Discussion here will be limited, for the most part, to my observations on the distribution of the Valencia-type peanut. As a result of their ongoing study of the extensive landrace collection maintained in Manfredi, Krapovickas, Pietrarelli and collaborators have recognized distinct forms

from Peru and Ecuador that previously were included in the var. fastigiata but are now deemed to merit varietal rank: var. peruviana and var. aequatorialis, respectively (A. Krapovickas & J. Pietrarelli, pers. comm. 1990). My discussion deals with the var. fastigiata sensu lato (the Valencia type in the broadest sense), including the Peruvian and Ecuadorian varieties.

Krapovickas (1968, 1973) and Gregory and Gregory (1976) distinguish six genocenters of cultivated peanuts in South America (Fig. 12):

- I. Guaranitic region of Argentina, Paraguay, Uruguay and Brazil
- II. Goiás and Minas Gerais, Brazil
- III. Rondônia and northwestern Mato Grosso, Brazil
- IV. Eastern foothills of the Andes in Bolivia
- V. Peru
- VI. Northeastern Brazil

These authors state that Valencia peanuts are found primarily in centers I and II, with a special fastigiata form (i.e., var. peruviana) found in center V. Center I is identified as the primary center of diversity of Spanish (var. vulgaris Harz) and Valencia types.

Center III is distinguished by the presence of A. nambycuare Hoehne (now recognized as a landrace of var. hypogaea) and the distantly related species A. villosulicarpa. These taxa are not satisfactory evidence for the establishment of a genocenter in Rondônia and northwestern Mato Grosso. A number of erect peanuts with unusual yellow seedcoats were also collected there, probably pertaining to the ssp. fastigiata. The area is part of the Amazon Basin and the need for further exploration of the region is recognized (Krapovickas, 1968).

Center V needs to be separated into two distinct centers, one on the Pacific coast to include the extant diversity of ssp. hypogaea var. hirsuta, and another in the eastern lowlands to include the diversity of Valencia types. Based on recent collections, the center of Valencia diversity should be extended north into lowland Ecuador, east at least as far as the Brazilian state of Acre, and south into northern Bolivia.

Further exploration and study may show that Valencia peanuts are (or were) cultivated along the western rim of the Amazon Basin from Colombia to Rondônia and descend an appreciable distance into the center of the basin between the Brazilian Shield and the Guiana Highlands, where old alluvial deposits are transected by active flood plains.

Linguistic evidence. Based on the distribution of native languages in South America, Krapovickas (1968) suggested that Arawakan speakers may have been instrumental in the diffusion of the peanut from its center of origin to other parts of the continent. Lathrap (1970), drawing upon archeological evidence, offers a model explaining the dispersal and present distribution of the Arawakan peoples, beginning around 3,000 years B.C., from an assumed nucleus in the central Amazon basin near the mouth of the Río Negro. The Arawakan upstream migrations left divergent groups widespread along the foothills of the Andes, over to the Orinoco and eventually into the Antilles, where they displaced earlier inhabitants. Lathrap suggests that speakers of Proto-Tupi-Guaraní underwent a similar and contemporaneous expansion from the same nuclear region into southern Amazonia. The time and direction of the migrations is not consistent with the dispersal of the peanut from a sub-Andean center of origin, where the peanut was probably already being more or less widely cultivated by the time these groups arrived in the region around 2,000 years B.C.

More recent linguistic studies (synthesized in Greenberg, 1987) have brought to light evidence that the Panoan and Tacanan language families of the Peruvian and Bolivian foothills are closely related, comprising a Macro-Panoan stock, which also includes the Bolivian Mosestén. The common names for peanut in some of the languages in and near the

Table 2

Indigenous Names for Arachis hypogaea in the Study Area

<u>Language Group</u>	<u>Language Family</u>	<u>Language</u>	<u>Name</u>
Macro-Panoan.....	Tacanan.....	Tacana.....	<u>ianidhe</u>
		Esse Ejja....	( <u>maní</u> *)
	Mosetenan.....	Chimán.....	<u>dabáj</u>
		Mosetén.....	<u>dabá</u>
	Panoan.....	Yaminahua....	<u>taba</u>
		Cashinahua...	<u>tama</u>
Equatorial.....	Arawakan.....	Moxo.....	<u>curiquieré</u>
	Tupian.....	Guarayo.....	<u>mundubí</u>
Andean.....	Quechuamaran..	Quechua.....	<u>inchic</u>
		Aymara.....	<u>choccopa</u>

(\* The Esse Ejja interviewed currently use the Spanish word maní, having discontinued using the Esse Ejja term for the cultigen.)

study area are listed in Table 2. Greenberg (1987) demonstrates that Macro-Panoan has close affinities with and includes the Guaicuruan languages that are widespread in the Gran Chaco region and extend south to the region of Río de la Plata. The area encompassed by the Macro-Panoan stock today corresponds closely to the primary genocenters of peanut diversity (Fig. 13). Lathrap (1970) believes that the Macro-Panoan stock had its origin in eastern Bolivia, from where it spread north along the foothills of the Andes, and south into the Paraguay and Paraná river basins. From linguistic evidence he concludes that the northward spread of Macro-Panoan peoples into the Andean foothills took place rather recently, within the last several hundred years, displacing the Arawakan peoples who had previously established themselves there.

Although key data are still lacking, it would appear that the early speakers of the Macro-Panoan language stock may have played an important role in the evolution and dispersal of the cultivated peanut. Arawakan peoples, far from being discounted, were probably instrumental in the later dissemination of the cultigen, particularly into Venezuela and the Antilles. Much of the present uncertainty will be clarified when the archeological record becomes more complete.

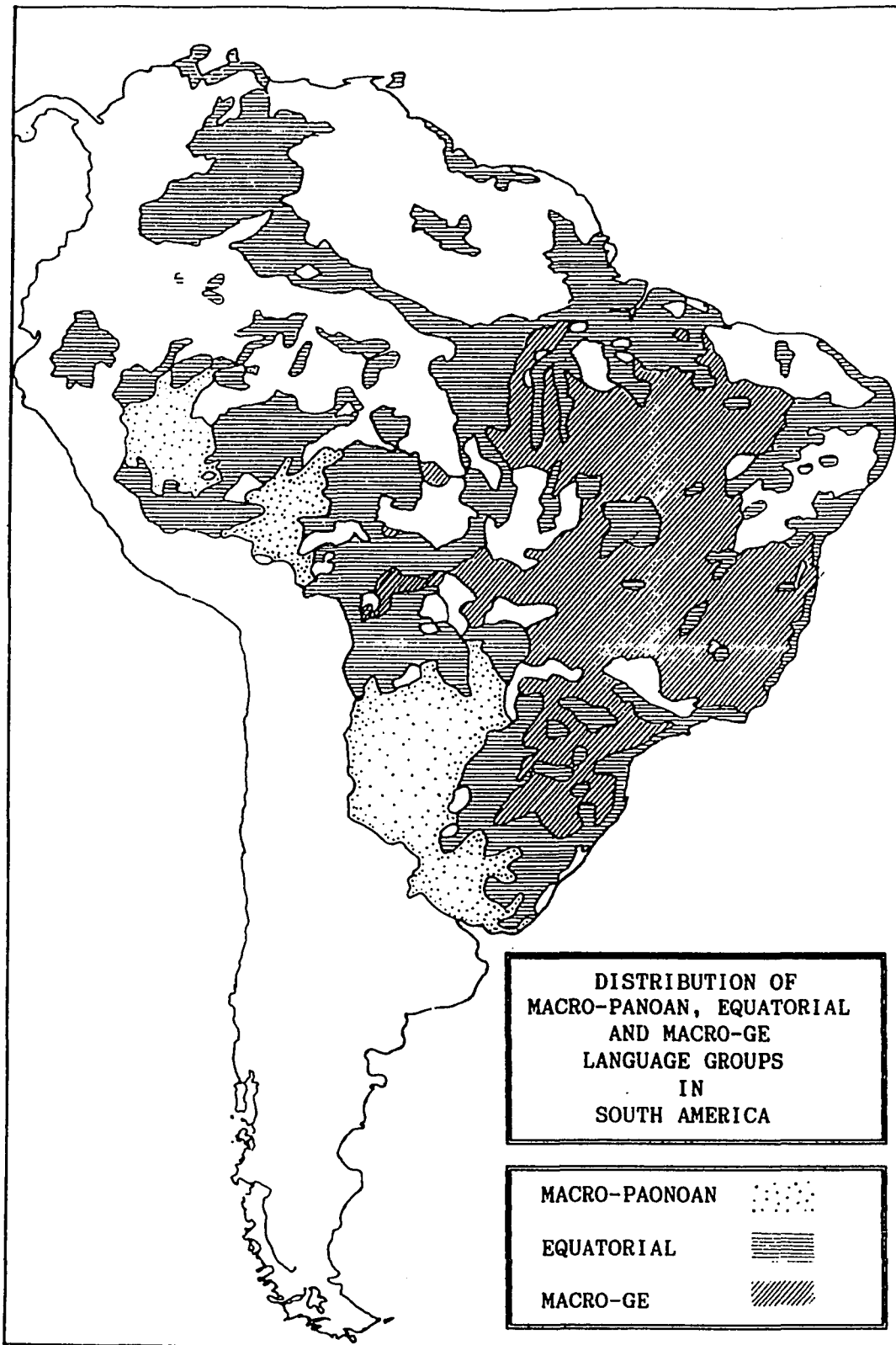


FIG. 13. Distribution of Macro-Panoan, Equatorial, and Macro-Ge languages. (Redrawn from Greenberg, 1987.)

Archeological evidence. Prehistoric peanut remains have been found as far away from the crop's center of origin as Tehuacán, Mexico, dating from as early as two thousand years ago (MacNeish, 1967). Peanuts were probably introduced to Mexico via the Antilles, where peanuts were encountered by the first European explorers (Hammons, 1973).

The earliest archeological remains of the cultigen comes from the Gaviota Complex in the Ancón-Chillón region of the Peruvian coast, dating from 3750-3900 years B.P. (Cohen, 1977). The abundant prehistoric peanut remains and ceramic representations from coastal Peru are identifiable as A. hypogaea ssp. hypogaea var. hirsuta Kohler, which is still cultivated in the region (Krapovickas, 1968). The pre-Columbian remains are those of a fully domesticated cultigen, probably introduced along with maize and other crops from the temperate valleys of the Amazon drainage by trading or migrating peoples (Towle, 1961).

A relative paucity of archeological excavations in Amazonia coupled with the generally poor condition of vegetal remains recovered in the humid, tropical environment has resulted in an archeological record that is, so far, blank with regard to the peanut. It is hoped that future excavations will remedy the situation.

Of particular interest will be the elucidation of the civilization responsible for the extensive agricultural raised fields spread over the Llanos de Mojos in eastern Bolivia, where only a modicum of archeological investigation has been undertaken to date. Neither the antiquity of the Mojos earthworks nor the ethnic identity of the builders is known. There is no conclusive evidence to support the commonly held notion that the Mojos earthworks were constructed by the forebears of the Arawakan people that now inhabit the region. Denevan (1963) believes that the earthworks were probably the product of several different linguistic groups over a long period of time. Preliminary radiocarbon dates from the lower levels of some recently excavated mounds are as early as 850 B.C. (C. Erickson, pers. comm. 1991). Basing his calculations on the aboriginal population at the time of contact and known rates of population decline, Denevan (1963, 1976) estimates a prehispanic population as great as one half million for the Llanos of Mojos. Tens of thousands of raised fields and hundreds of miles of causeways and canals is evidence for the existence of a large and locally dense population.

Peanuts were almost certainly one of the crops cultivated on the raised fields and, given the seasonal flooding characteristic of the region, it is likely that the peanuts grown were Valencia types. As discussed in Chapter IV, at least two and possibly more wild species in the section

Arachis are known to survive in the Llanos de Mojós and may have played a role in the evolution of the Valencia peanut, perhaps under the influence of the prehistoric farmers of the raised fields.

The antiquity of peanut cultivation in South America is not and may never be known with absolute certainty. Given the broad genetic diversity, widespread diffusion, and economic significance of the cultigen in aboriginal America, it is not unreasonable to suppose an age of five thousand years or more, in line with the domestication or introduction into the region of other crops with which the peanut formed an agricultural complex.

Ethnographic evidence. The peanut is an important element in the suite of crops that characterize the traditional Tropical Forest pattern of agriculture (Lathrap, 1970; Sauer, 1950). While the presence of the peanut is frequently mentioned in ethnographic monographs from the area, rarely, if ever, is the type or types of peanut cultivated by a particular group recorded by the ethnographer. Fortunately, ethnographers often comment on the ways or places in which peanuts are grown, sometimes giving an insight into the probable type of peanut used. Mention of peanuts grown on sandy beaches or river banks indicates the presence of a playa agricultural system, itself dictating the use of a Valencia-type cultivar.

Vouchered examples of Valencia peanut landraces cultivated by Panoan groups are limited to the Cashinahua (Williams 631a, 632) and Yaminahua (Williams 846). Vouchered Valencia landraces cultivated by Tacanan groups are Esse Ejja (Williams 851, 852) and Tacana (Williams 1143, 1144, 1145, 1146, 1170, 1171). Vouchered Valencia landraces cultivated by Mosetenan groups are Chimán (Williams 721, 723) and Masetén (Williams 1154). All of the above collections were being grown as part of a chaco-playa agricultural system, and no Virginia-type peanuts were being cultivated. Groups referred to in the literature as cultivating peanuts on riverine playas include the Amuesha (Salick & Lundberg, 1990), Mojo (Denevan, 1963), Movima (Métraux, 1948), rubber cutters (Yungjohann, 1989), Sharanahua (Siskind, 1973), and Shipibo (Bergman, 1974).

Virginia-type landraces cultivated by Arawakan speakers were collected from the Mojeños (Williams 705). Virginia-type peanuts were also collected from the Tupi-Guaraní-speaking Guarayos (Williams 700). Neither group presently cultivates peanuts on riverine playas.

Discussion. If we accept a southern Bolivian center of origin for *A. hypogaea* ssp. hypogaea, and the derived status of ssp. fastigiata, the question remains as to the place and circumstances for the divergence and dispersal of the latter. Obviously, the available data are still far from

complete, and any conclusions regarding the origin of Valencia peanuts must necessarily remain hypothetical.

It seems clear that the more important characters that distinguish Valencia peanuts are linked to the particular requirements and limitations of playa agriculture. I believe this link is neither coincidental nor fortuitous. Rather, I see the Valencia-type peanut enabling Amazonian farmers to more successfully exploit the easily worked and constantly replenished soils of the riverine playas, evolving to its present-day, highly modified state under these specific conditions. The adaptation of the cultigen to the playa agroecosystem is much more plausible than the creation a new agroecosystem to accommodate a spontaneous new cultivar.

This supposition may eventually be contradicted when more information becomes available regarding the agriculture practiced on the raised fields of Mojos. If Valencia peanuts were (as I suspect) an important element of the Mojos raised-field agroecosystem, they were most likely adopted from already existing playa systems. The decision to create a hydraulic agricultural system based on extensive earthworks was probably in response to population pressure arising when all the land along the major rivers became occupied. Subsequent meandering of the lowland rivers has probably destroyed most traces of the riverbank dwellers, while the inland sites of the Llanos de Mojos survive, creating the

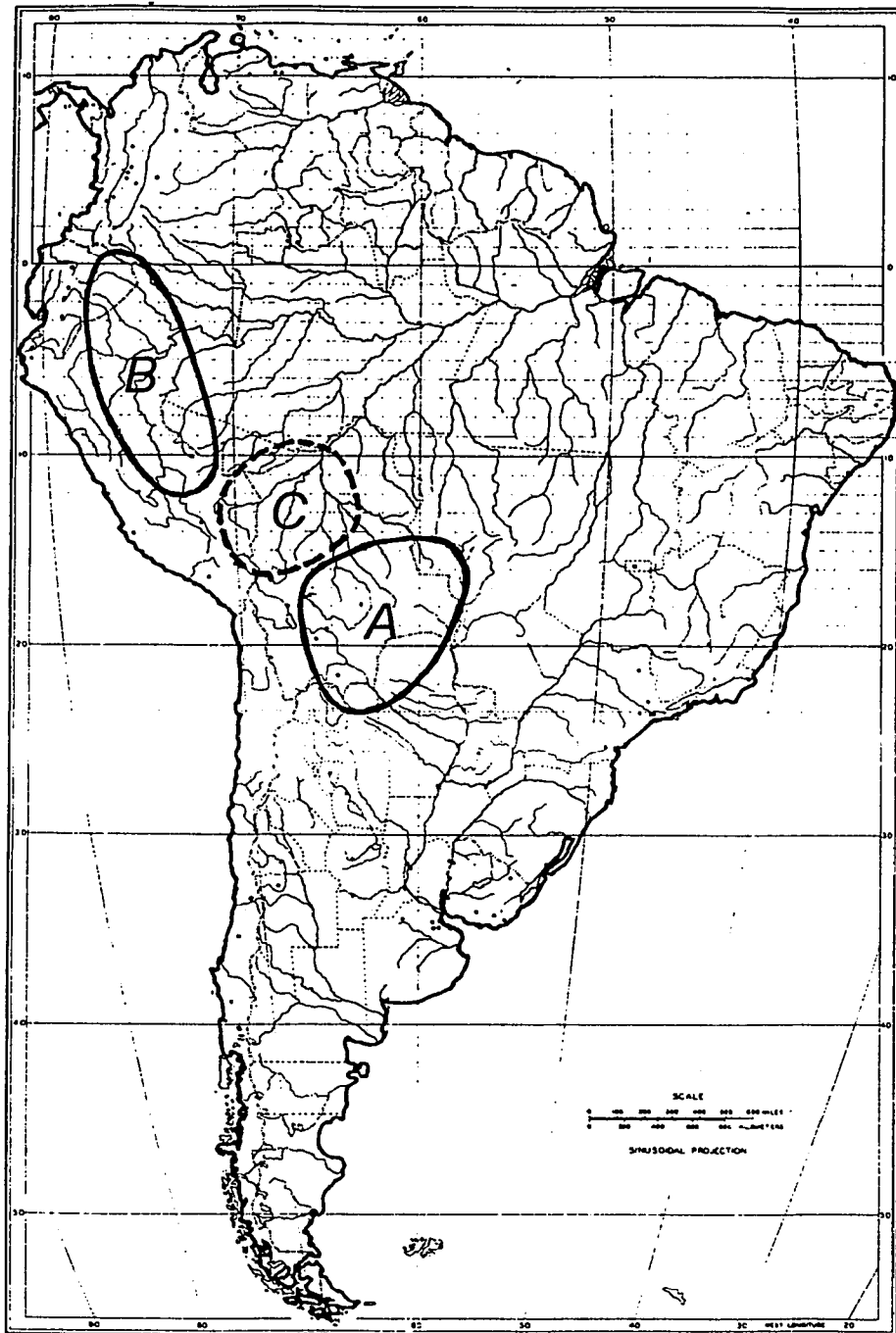


FIG. 14. Known and hypothetical centers of subspecific origin of Arachis hypogaea. A. Center of origin and diversity of A. hypogaea ssp. hypogaea. B. Western center of diversity of A. hypogaea ssp. fastigiata. C. Hypothetical center of origin of A. hypogaea ssp. fastigiata var. fastigiata.

illusion of only one populous prehistoric culture in the region.

Information is still lacking to establish the place of origin of the Valencia peanut. Based on the information currently available, I would like to draw attention to northern Bolivia as a possible locus where it could have occurred. The intermediate location between the important genocenters of Virginia and Valencia types (Fig. 14), its proximity to the natural range of undescribed wild species in the section Arachis, the existence of large-scale remains of a prehistoric agricultural civilization, the persistence of an aboriginal cropping system to which the variety is highly adapted, the unusually high landrace diversity, and the unique chemotaxonomic relationship of these landraces (Grosso et al., 1988) may be interpreted as evidence to support northern Bolivia as a hypothetical center of origin for the Valencia peanut.

Another persistent problem is the origin and differentiation of the Spanish peanut, A. hypogaea ssp. fastigiata var. vulgaris Harz. The Spanish peanut is consubspecific with the Valencia peanut but shows important and consistent differences with the latter in its morphology and distribution. The main morphological characters that distinguish the Spanish from the Valencia peanuts are the former's compact "bunch" habit and strictly two-seeded

fruits. Geographically, the diversity of Spanish peanuts is concentrated in the Guaranitic region and extends over into eastern Brazil (Gregory & Gregory, 1976; Krapovickas, 1968). Although Valencia peanuts are also widely cultivated in the Guaranitic and eastern Brazilian region, Spanish peanuts are not found growing in the riverine centers of Valencia diversity along the Andean foothills of Ecuador, Peru and Bolivia. I have encountered no evidence to indicate that Spanish peanuts are associated with playa agriculture or are traditionally grown in Amazonia. It may be that Valencia peanuts were suitable for native cultivation in the Spanish peanuts' area of origin, but not vice versa.

The answer to this problem may lie in independent origins for Spanish and Valencia peanuts, a case of convergent evolution, Vavilov's Law of Homologous Series. Stalker & Dalmacio (1986) provide evidence showing a large karyological distance between the Spanish and Valencia peanuts, and conclude that the Spanish peanut may be the most ancient of all peanut varieties. Krapovickas (pers. comm. 1990) has also contemplated the possibility of independent origins for Spanish and Valencia peanuts.

From existing information it is still impossible to ascertain the true origin of the Valencia peanut. For this to be accomplished, it will be necessary to:

- (1) complete the exploration of Amazonian regions of Peru, Ecuador, and Brazil for cultivated landraces, with due observation of the corresponding native cropping systems;
- (2) complete the exploration of lowland Bolivia for undiscovered wild species of the section Arachis;
- (3) conduct comparative studies at the cellular and molecular levels using carefully selected material representative of the various infra- and interspecific taxa (to avoid sampling error and introgressive contamination, the material should be well documented, fully identified, unimproved South American landraces and wild species, freshly obtained from the known genocenters and wild populations); and
- (4) establish a prehistoric cultural sequence for lowland Bolivia using modern archeological techniques.

A sound taxonomic foundation is basic to any study of plant evolution. The forthcoming monograph of the genus Arachis being prepared by Krapovickas and Gregory, and the systematic landrace treatments for Ecuador, Bolivia, and Peru being prepared by Krapovickas and Pietrarelli will undoubtedly resolve many of the problems addressed above, and pave the way for the resolution of the rest.

## Chapter VII

### The Challenge of In Situ Conservation of Cultivated Plants

The need to conserve crop genetic resources cannot be overestimated. In view of their indispensable and irreplaceable nature, and their imminently threatened and eroded present condition, it becomes imperative that an integrated strategy combining both ex situ and in situ conservation be developed to properly ensure their continued existence.

To date, the only widely employed strategy to conserve crop genetic resources has been ex situ, that is, in seed banks, clonal repositories, or in vitro cultures maintained far from the plants' natural environments. This strategy has marked advantages and disadvantages. The advantages of ex situ conservation include the ready accessibility of the genetic material to the plant breeders, and the relative protection that the material receives from environmental disasters, genetic erosion, and the threat of social or political upheaval in its country of origin. The disadvantages of ex situ conservation lie in its great financial costs, the potential of human error in record

keeping, seed increase, and maintaining the appropriate storage conditions and, most importantly, the drastic changes in the selection pressures exerted upon the material from the moment it is accessioned.

In situ conservation also presents marked, albeit different, advantages and disadvantages. In situ conservation is the intentional or fortuitous maintenance of crop genetic resources in their wild state or, in the case of cultivated plants, as a part of the traditional agricultural system under which they have evolved. The fundamental advantage of this strategy is the conservation of the genetic material within its dynamic, natural milieu where it continues to coevolve with those selective factors in its environment that guided its development to the evolutionary point at which we have found it. By maintaining the material in its natural (or traditional) evolutionary context, the ongoing vitality and currency of the material is assured. Other advantages of this strategy will be discussed later. The disadvantages of in situ conservation include the difficulty of preserving the often remote natural ecosystems where the wild species occur and, in the case of cultivated species, preserving native farming systems in such a way that the traditional varieties are not abandoned.

While in situ conservation of wild relatives of crop plants has been seriously considered and in some cases

implemented, the crop genetic resource community has generally regarded in situ conservation of cultivated species as untractably problematical and has been skeptical that a viable program towards this end could be devised.

Germplasm is not a static object which can be stored indefinitely without changing. It is, instead, living material that is constantly responding to its environment. Should the environment in which the material is stored suddenly change, the inevitable long-term result will be an inadvertent genetic change in the material. If the original environment is maintained, the germplasm will continue to keep pace with the selective forces, both natural and traditional, that characterize the native environment where that germplasm evolved.

The example of Bolivian peanut landraces illustrates the evolutionary differences between the two conservation strategies. When landrace material from the Beni is placed in gene bank cold storage, a conservative estimate for its continued viability is seven years, after which the material must be planted out to renew the seed. When planted out, those seeds which best tolerated the prolonged cold storage will germinate better and be more vigorous. Because of inevitable space constrictions, numerous different accessions are planted out in close proximity to one another, creating the possibility of cross-pollinations between accessions.

Furthermore, the climatic and pathological conditions, and thereby the natural selection pressures, of the gene bank's propagation plots differs markedly from the original collection site. When the plants mature and are harvested, the healthiest-looking fruits are selected by a technician, and the seeds of these are reintroduced into cold storage. Assuming that no errors have been made in the record keeping, harvesting, and storing of the accessions, these landraces will have undergone a single sexual generation in seven years. Any genetic changes in the material in the new generation will be in response to spontaneous mutation and recombination, genetic drift, contamination from other accessions, natural selection in the propagation plot, artificial selection by the bank technician, and resistance to long-term cold storage.

The same landrace material maintained in situ by native farmers in the Beni will have undergone 14 sexual generations in those same seven years. During that time the material will have been coevolving with natural pests and pathogens, been exposed to local climatic and edaphic conditions, and been selected approximately 28 times by observant native farmers for those characters which distinguish it as the particular landrace that it is.

Clearly, ex situ and in situ strategies each satisfy preservation and utilization requirements exclusive of each

another. Only by developing an integrated strategy whereby the two conservation techniques function in a reciprocal and complementary manner, can the genetic resources in question be truly safeguarded. Although the implementation of in situ peanut genetic resource conservation was not within the proposed scope of the dissertation, observations made during the course of the investigation permit the formulation of an appropriate strategy and initial steps were taken towards its implementation. Because the infrastructure for ex situ conservation is already in place, this aspect was accomplished by depositing the germplasm in existing gene repositories.

Wilkes (1988) reminds us that, one hundred years ago, all plant genetic resources were conserved in situ, either in the wild or in farmers' fields. Cultivated plant varieties were conserved as a part of the farmers' cultural heritage and subsistence economy without requiring outside incentive. Traditional varieties were maintained as an integral part of the cultures to which they corresponded. Now that both the cultural and economic aspects of native societies are changing, the needs and reasons for maintaining traditional varieties are also changing or being removed, often resulting in the abandonment of those varieties. Rather than attempt to impose a "top-down" policy that would oblige native farmers to maintain traditional varieties, a policy whose purpose is to reinforce and recognize native cultural values

would have a much more likely chance of successfully convincing farmers to retain these unique elements as part of their culture. Numerous researchers have recently recognized the important role of native agricultural systems in the conservation of crop genetic resources (e.g., Alcorn, 1984; Altieri & Merrick, 1987; Brush, 1986, 1991; Clawson, 1984; Oldfield & Alcorn, 1987; Wilkes, 1988).

The challenge of in situ conservation of crop genetic resources lies in designing a project that will successfully reinforce traditional cultural values to the degree that native farmers will conserve their traditional varieties because they want to, not because they are told to. Because peasant and native societies and economic conditions are each more or less unique, in situ conservation projects need to be individually designed to address the particular problems confronting each group.

In the case of the Tacana peanut farmers of the Beni, I suggest that the following steps would greatly promote the local conservation of endangered peanut landraces.

The first step, to recognize and reinforce traditional values, can be accomplished in many ways. Through sponsorship of an annual harvest-time agricultural fair, modest prizes can be awarded for producers displaying the greatest number of local crop varieties, as well as the usual

competitions for size and appearance of the produce. Workshops can be held to educate rural children on the disappearing cultural heritage of their forebears, and to revive traditional textile and ceramic production for sale to tourists and other outsiders. Exhibits of native culture can be prepared and displayed in local museums and public buildings. Easy-to-read booklets on sound indigenous natural resource management can be written and distributed. One such booklet on native seed storage and landrace conservation is currently being prepared (Williams, in prep.b).

It is interesting to note that my interest in local peanuts provoked a marked increase in the availability and utilization of endangered landraces in the study area. It seems that the simple recognition given to these landraces by an outsider was enough to cause some farmers to renew their desire to plant them.

A second step would be to promote development that incorporates and is based upon indigenous knowledge of natural resource management. In the study area, an obvious project would be to revive extensive agricultural exploitation of the vast amount of unexploited riverine sandbars. Drawing upon the traditional knowledge and extant cultivars adapted to the playa agroecosystem, agronomic trials could be carried out to determine ways in which playa agriculture can be exploited commercially on a larger scale.

The system has the advantages of low labor input, no forest clearing, and annually renewed soil fertility. In practice, the project would entail the renovation of a prehistoric cropping system to satisfy modern needs. A similar achievement was successfully accomplished in highland Peru (Erickson, 1988) and Bolivia (Straughan, 1991) by reconstructing the archeological raised fields around Lake Titicaca and putting them back into production. Trials are now underway to resurrect the agricultural exploitation of the ancient raised fields in the Llanos de Moxos (C. Erickson, pers. comm. 1991).

Playa agriculture, an important component of prehistoric Amazonian riverine subsistence, has long been known but is little studied. The importance of floodplain agriculture in Amazonia has received much attention in recent years (e.g., Barrow, 1985; Denevan, 1984; Hiraoka, 1985a, 1985b, 1985c, 1986; Padoch & Pinedo-Vasquez, 1991). Higbee (1945) presented the first scientific account of playa agriculture, yet he, like most recent authors, presents only a superficial description of the cropping system. To my knowledge, no experimental studies have been carried out to determine the actual and potential productivity of playa agriculture. Such studies will be required before development projects based on this agroecosystem can be implemented.

Traditional landraces as well as improved cultivars

should be assayed on the playas. It has been demonstrated that commercial crop varieties introduced into traditional agroecosystems need not entirely displace the local landraces, but can instead coexist with them to good advantage for the farmer (Brown, 1983; Brush, 1986; Bellon-Corrales, 1990).

Local farmers need to be involved in the agricultural trials to take advantage of the farmers' input and to facilitate their adoption of the findings. Agricultural extension workshops, attuned to local needs and restrictions, will further involve and prepare the farmers. Appropriate technological contributions, such as household or village-level oil presses and rice threshers, will enable the farmers to process their harvests locally and become less dependant upon purchased goods and services. Marketing assistance should also be provided.

For the proposed integrated strategy of crop genetic resource conservation to function, the national ex situ gene bank needs to become involved at the local level. Agreements must be established between the seed bank and the native farmers for reciprocal exchange of genetic material should this material become lost by either party. This reciprocal agreement provides the avenue through which scientists at the gene bank may monitor the in situ status of the material and take timely action to avert imminent losses of landraces, and

also to periodically replenish their holdings with fresh material. Ideally, the popular seed storage and maintenance manual now in preparation will include a self-addressed form with which the rural farmer can solicit lost seed from the gene bank, while also providing the bank with vital information regarding the status of his other cultivars and cultigens. In this way, the native farmer becomes an active participant in the national effort to monitor and conserve genetic resources. Integrating the farmer into the overall strategy is an implicit recognition of the importance of his efforts which will contribute to his awareness of the value of his traditional varieties.

For extant wild relatives of crop plants, a national survey of known populations needs to be carried out and their conservation status documented. The survey will undoubtedly involve further exploration for poorly known or insufficiently collected wild relatives of some crops. Local agronomists or extension agents working in the vicinity of the wild populations could be recruited to monitor and submit periodic reports on the populations' current status.

The cost of maintaining the reciprocal farmer-gene bank agreements, as well as the survey and monitoring of wild crop relatives, would fall to the gene bank itself, and serve to strengthen and amplify the bank's role in genetic resource conservation. A constantly updated database of in situ

genetic resources and their conservation status will be maintained at the gene bank. This database would be complementary to or integrated with the database of the bank's ex situ holdings. It is imperative that the gene bank and the in situ conservation efforts be combined if the proposed integrated strategy is to be effective. The national government and/or international organizations will need to make monies available to implement this worthwhile and cost effective program.

In an IBPGR report (Piedrabuena & Esquinas-Alcazar, 1983) on the current status of crop germplasm in the Andean countries, holdings of Arachis genetic resources were not even mentioned for Bolivia. Rea (1985), in his report on Bolivian crop genetic resources, states that the 174 accessions of native peanuts recorded in 1983 for the CIAT-Saavedra Experiment Station in Santa Cruz, where the county's most important peanut collection was housed, were lost in their entirety due to neglect. Peanuts collected in the course of the present study were deposited at the CIFP gene bank in Pairumani, Cochabamba where, although the institution did not work with or maintain a peanut collection, the director agreed to accept the material due to its inherent importance and potential value. Promotion of the integrated strategy would serve to strengthen not only the in situ but also the ex situ conservation capabilities of the national genetic resource institutions.

## Chapter VIII

### Conclusions

This dissertation has been an attempt to answer some of the basic questions regarding the complex problem of peanut evolution. It is the first study to describe in detail a native peanut cropping system in the cultigen's center of origin. In light of the coevolutionary role of humans in crop domestication and evolution, emphasis is placed on the human component of peanut evolution and this component is then compared with the morphological and physiological traits of the cultigen. As is often the case, the investigation has raised as many, if not more, questions than it sought to answer, but it is hoped that it will provide direction for future studies.

Plant exploration carried out as part of the present research filled a persistent gap in our knowledge of the distribution of Arachis hypogaea ssp. fastigiata and emphasized the existence of an unexpected amount of diversity of this subspecies in Bolivia. At least one new landrace was discovered, including Cáscara Negra which possesses a darkly pigmented pericarp previously unknown to peanut science.

Also, the existence of new populations and possibly a new species of wild Arachis was confirmed with herbarium specimens and germplasm. Exploration in this key region is still far from complete, and priority target areas for future exploration are indicated.

Using ethnobotanical research methods, a native peanut cropping system was documented and analyzed for its impact on peanut evolution. Native farmers in the study area were found to maintain an intensive interaction with their traditional peanut varieties, double-cropping the peanuts alternately on riverine playas and in forest swiddens. The physiological and agronomic characters which define ssp. fastigiata are precisely those required by this cropping system. Multidisciplinary evidence was presented that suggests that the playa agricultural system was instrumental in the evolution of the erect subspecies of peanut. The remarkable diversity of ssp. fastigiata, the intermediate location between two important centers of subspecific diversity, and the proximity to the known range of closely related wild Arachis, are reasons for proposing the study area as the center of origin for the Valencia peanut. Laboratory studies of the material collected will be necessary to confirm or reject these hypotheses.

The peanut landraces in the study area are presently in danger of becoming lost due to development, colonization and

neglect. A strategy for in situ conservation of peanut genetic resources in northern Bolivia is proposed that integrates ex situ conservation and community development. The strategy strives to reinforce the traditional cultural values, promote agricultural development based on native cropping systems, and establish a reciprocal agreement between farmers and gene banks for the exchange of lost seed. The need to involve native farmers in the overall strategy for effective crop genetic resource conservation is stressed.

Given the crop's high productivity and nutritional value, the peanut remains an underexploited plant. If the peanut's full potential is to be realized, important questions regarding the cultigen's origin and evolution in South America must be answered before the crop can be improved. This dissertation strives to provide some basic, descriptive information that may provide clues for resolving this persistent problem.

Appendix 1

Arachis hypogaea L. Collections from Northern Bolivia\*

<u>DEW #</u>	<u>subspecies</u>	<u>variety</u>	<u>seed color</u>	<u>Department</u>	<u>HERB</u>	<u>GP</u>
698	hypogaea	hypogaea	overo	Santa Cruz	O	X
700	hypogaea	hypogaea	overo	Santa Cruz	O	X
703	hypogaea	hypogaea	overo	Santa Cruz	O	X
705	hypogaea	hypogaea	brown	Beni	X	X
710	hypogaea	hypogaea	overo	Beni	O	X
715	hypogaea	hypogaea	white	Beni	X	X
737	hypogaea	hypogaea	mix	Beni	O	X
741	hypogaea	hypogaea	mix	Beni	O	X
743	hypogaea	hypogaea	overo	Beni	O	X
825	hypogaea	hypogaea	brown	Pando	O	X
835	hypogaea	hypogaea	overo	Pando	X	O
839	hypogaea	hypogaea	overo	Pando	X	O
841	hypogaea	hypogaea	overo	Pando	X	O
870	hypogaea	hypogaea	overo	Beni	O	X
931	hypogaea	hypogaea	tan	Beni	O	X
1148	hypogaea	hypogaea	brown	Beni	O	X
638	fastigiata	fastigiata	red	Santa Cruz	O	X
721	fastigiata	fastigiata	white	Beni	O	X
723	fastigiata	fastigiata	red	Beni	O	X
738	fastigiata	fastigiata	mix	Beni	O	X
739	fastigiata	fastigiata	mix	Beni	O	X
740	fastigiata	fastigiata	mix	Beni	O	X
746	fastigiata	fastigiata	red	Beni	O	X
747	fastigiata	fastigiata	white	Beni	O	X
753	fastigiata	fastigiata	red	La Paz	X	O
757	fastigiata	fastigiata	red	La Paz	O	X
763	fastigiata	fastigiata	white	La Paz	O	X
766	fastigiata	fastigiata	yellow	La Paz	O	X
767	fastigiata	fastigiata	red	La Paz	X	O
790	fastigiata	fastigiata	mix	La Paz	O	X
795	fastigiata	fastigiata	white	La Paz	O	X
798	fastigiata	fastigiata	mix	Beni	O	X
808	fastigiata	fastigiata	purple	Pando	O	X
831	fastigiata	fastigiata	mix	Pando	O	X
851	fastigiata	fastigiata	red	Pando	X	X
852	fastigiata	fastigiata	white	Pando	X	X
925	fastigiata	fastigiata	red	Santa Cruz	O	X
928	fastigiata	fastigiata	mix	Beni	O	X
929	fastigiata	fastigiata	white	Beni	O	X

Appendix 1  
continued

930	fastigiata	fastigiata	black	Beni	0	X
978	fastigiata	fastigiata	mix	Beni	0	X
1000	fastigiata	fastigiata	yellow	Beni	X	X
1010	fastigiata	fastigiata	red	Beni	X	X
1027	fastigiata	fastigiata	white	Beni	X	X
1028	fastigiata	fastigiata	yellow	Beni	X	X
1034	fastigiata	fastigiata	red	Beni	X	X
1055	fastigiata	fastigiata	mix	Beni	0	X
1143	fastigiata	fastigiata	red	Beni	X	X
1144	fastigiata	fastigiata	yellow	Beni	0	X
1146	fastigiata	fastigiata	white	Beni	0	X
1154	fastigiata	fastigiata	mix	La Paz	0	X
1170	fastigiata	fastigiata	red	Beni	0	X
1171	fastigiata	fastigiata	black	Beni	0	X
762	fastigiata	peruviana	purple	La Paz	0	X
846	fastigiata	peruviana	white	Pando	0	X
1001	fastigiata	peruviana	purple	Beni	X	X
1145	fastigiata	peruviana	purple	Beni	0	X
742	indet.		mix	Beni	0	X
824	indet.		red	Pando	0	X

\* HERB = herbarium specimen; GP = germplasm specimen; X = collection made; 0 = no collection made.

Herbarium specimens are deposited at The New York Botanical Garden (NY), The Herbario Nacional de Bolivia (LPB), the Museo de Historia Natural Noel Kempff Mercado (MNKM), and the Instituto de Botánica del Nordeste (CTES). Germplasm subsamples are deposited at the U.S. Department of Agriculture National Plant Germplasm System (NPGS), the Centro de Investigaciones Fitoecogenéticas de Pairumani (CIFP), the Estacion Experimental Manfredi (INTA-Manfredi), and the Centro Nacional de Recursos Genéticos (CENAREN).

Appendix 2

Wild Arachis Species Collections from Northern Bolivia\*

<u>DEW #</u>	<u>ID</u>	<u>location</u>	<u>HERB</u>	<u>GP</u>
639	sp. 1	45 km E of Buenavista, Sta.Cruz	X	O
691	sp. 2	Santa Cruz city park, Sta.Cruz	X	O
697	sp. 3	2 km N of Surucusí, Sta.Cruz	X	X
699	sp. 3	2 km N of Ascención, Sta.Cruz	X	X
860	sp. 4	Guayaramerim airport, Beni	X	X
861	sp. 4	Guayaramerim airport, Beni	X	X
866	sp. 4	UTB Trinidad campus, Beni	X	O
1117	sp. 4	UTB Trinidad campus, Beni	X	X
867	sp. 5	near UTB campus, Beni	X	O
1118	sp. 5	UTB Trinidad campus, Beni	X	X
1120	sp. 5	near UTB campus, Beni	X	X
809	<u>A. repens</u> Handro	Cobija city plaza, Pando	X	O

\* HERB = herbarium specimen; GP = germplasm specimen; X = collection made; O = no collection made.

Herbarium specimens are deposited at The New York Botanical Garden (NY), The Herbario Nacional de Bolivia (LPB), the Museo de Historia Natural Noel Kempff Mercado (MNKM), and the Instituto de Botánica del Nordeste (CTES). Germplasm subsamples are deposited at the U.S. Department of Agriculture National Plant Germplasm System (NPGS), and the Estacion Experimental Agrícola Manfredi (INTA-Manfredi).

Appendix 3

Cultigens of the Tacana Chaco-Playa System\*

<u>Cultigen</u>	<u>English</u>	<u>Tacana</u>	<u>Chaco</u>	<u>Playa</u>
<u>Abelmoschus</u> sp.	okra	-----	X	-
<u>Allium cepa</u> L.	onion	<u>cihuela</u>	X	-
<u>Ananas comosus</u> (L.) Merr.	pineapple	<u>tsayu</u>	X	-
<u>Annona cherimola</u> Mill.	chirimoya	<u>tsinima</u>	X	-
<u>Arachis hypogaea</u> L.	peanut	<u>janidhe</u>	X	X
<u>Artocarpus communis</u> Forst.	breadfruit	-----	X	-
<u>Averrhoa carambola</u> L.	star fruit	-----	X	-
<u>Bactris gasipaes</u> H.B.K.	peachpalm	<u>mue</u>	X	-
<u>Bixa orellana</u> L.	annatto	<u>matse</u>	X	-
<u>Brassica oleraceae</u> L.	cabbage	-----	X	-
<u>Cajanus cajan</u> (L.) Druce	pigeon pea	-----	X	-
<u>Canna edulis</u> Ker-Gawl.	canna	<u>dhijuidni</u>	X	-
<u>Capsicum</u> spp.	pepper	<u>bidú</u>	X	-
<u>Carica papaya</u> L.	papaya	-----	X	-
<u>Citrullus lanatus</u> (Thunb.) Mansf.	watermelon	<u>sandilia</u>	-	X
<u>Citrus</u> spp.	citrus	-----	X	-
<u>Cocos nucifera</u> L.	coconut	-----	X	-
<u>Coffea arabica</u> L.	coffee	<u>cape</u>	X	-
<u>Coix lachryma-jobi</u> L.	job's tears	-----	X	-
<u>Colocasia esculenta</u> (L.) Schott.	taro	-----	X	-
<u>Crescentia cujete</u> L.	calabash	<u>pararata</u>	X	-
<u>Cucumis sativus</u> L.	cucumber	-----	X	-
<u>Cucurbita moschata</u> (Duch.) Poir.	squash	<u>jemi</u>	X	0
<u>Cyclanthera pedata</u> Schrad.	cyclanthera	-----	X	-
<u>Cymbopogon citratus</u> (DC.) Stapf.	lemongrass	-----	X	-
<u>Cyperus</u> cf. <u>corymbosus</u>	sedge	<u>cahuasha</u>	X	-
<u>Dioscorea</u> sp.	yam	<u>batri</u>	X	-
<u>Erythroxylum coca</u> Lam.	coca	<u>dha'adhi</u>	X	-
<u>Euterpe oleracea</u> Mart.	asai	<u>evid'a</u>	X	-
<u>Genipa americana</u> L.	genipa	<u>aguid'u</u>	X	-
<u>Gossypium barbadense</u> L.	cotton	<u>huapese</u>	X	-
<u>Helianthus annuus</u> L.	sunflower	-----	X	-
<u>Inga</u> spp.	inga	<u>nasaturu</u>	X	-
<u>Ipomoea batatas</u> Poir.	sweet potato	<u>jariri</u>	X	0
<u>Lablab purpureus</u> (L.) Sweet	lablab	<u>chilpi</u>	X	-
<u>Lactuca sativa</u> L.	lettuce	-----	X	-
<u>Lagenaria siceraria</u> Standl.	bottle gourd	<u>mumo</u>	X	-
<u>Lycianthes asarifolia</u> (K.&B.)Bitt.	motojobobo	-----	X	-
<u>Lycopersicon esculentum</u> Mill.	tomato	-----	X	-
<u>Mangifera indica</u> L.	mango	-----	X	-
<u>Manihot esculenta</u> Crantz	manioc	<u>cuave</u>	X	0
<u>Maranta arundinacea</u> L.	arrowroot	<u>iajiru</u>	X	-
<u>Momordica charantia</u> L.	balsam pear	<u>etibeini</u>	X	-

Appendix 3  
continued

<u>Musa paradisiaca</u> L.	plantain	<u>nasa</u>	X	-
<u>Musa sapientum</u> L.	banana	<u>cashi</u>	X	-
<u>Nicotiana tabacum</u> L.	tobacco	<u>umasa</u>	X	-
<u>Oryza sativa</u> L.	rice	<u>arusu</u>	X	X
<u>Pachyrrhizus ahipa</u> (Wedd.) Par.	yam bean	-----	X	-
<u>Passiflora</u> sp.	passionfruit	<u>pidhenunu</u>	X	-
<u>Passiflora quadrangularis</u> L.	barbadine	-----	X	-
<u>Persea americana</u> Mill.	avocado	<u>palata</u>	X	-
<u>Psidium guajava</u> L.	guava	<u>buhue</u>	X	-
<u>Rheedia madruno</u> Pl. & Tr. (?)	camururo	<u>camururu</u>	X	-
<u>Rheedia achachairu</u> Rusby	achachairu	<u>jarao</u>	X	-
<u>Saccharum officinale</u> L.	sugar cane	<u>shita</u>	X	-
<u>Scheelea princeps</u> (Mart.) Karst.	motacu	<u>tumi</u>	X	-
<u>Solanum mammosum</u> L.	tittyfruit	-----	X	-
<u>Solanum</u> sp.	potato	-----	-	O
<u>Tamarindus indica</u> L.	tamarind	-----	X	-
<u>Tephrosia vogelii</u> J.D. Hooker f.	barbasco	<u>satre</u>	X	-
<u>Tephrosia toxicaria</u> (Sw.) Pers.	barbasco	<u>ada'ata</u>	X	-
<u>Theobroma cacao</u> L.	cacao	<u>cuase</u>	X	-
<u>Vigna unguiculata</u> (L.) Walp.	cowpea	-----	X	X
<u>V. unguiculata</u> ssp. <u>sesquipedalis</u>	yard-long bean	-----	X	X
<u>Xanthosoma sagittifolium</u> Schott.	yautia	<u>anu'ai</u>	X	-
<u>Zea mays</u> L.	maize	<u>ret'ije</u>	X	X

\* Information compiled from author's collections; Cárdenas (1989); Van Wynen & Van Wynen (1962); and Wentzel (1989). X = current utilization, O = reported past utilization, - = no name or utilization recorded or known.

Herbarium specimens are deposited at The New York Botanical Garden (NY), The Herbario Nacional de Bolivia (LPB), and the Museo de Historia Natural Noel Kempff Mercado (MNKM).

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