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THE ECOLOGY AND PROPAGATION OF VATOVAEA PSEUDOLABLAB: A WILD FOOD PLANT OF THE MAASAI IN KAJIADO DISTRICT, KENYA

BY

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February 1998

A Thesis

Submitted to the Faculty of Graduate Studies and Research

In Partial Fulfilment of the Requirements for the Degree of Master of Science

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ABSTRACT


The goal of this study was to further understanding of the ecology and propagation of an important wild food resource (*Vatovaea pseudolablab* (Harms.) Gillett) of the community of Loodokilani, Kajiado District, Kenya and by extension, contribute to its sustainable use.

*Vatovaea pseudolablab* is found in occasional, yet distinct patches in Loodokilani and these patches may be associated with a particular soil-water regime. The associated soils are moderately developed, dark brown (7.5YR 3/2, Munsell) clay-loams, with small (5.61 mm), angular blocky aggregates. The patches were moderately covered (30%) with medium-sized stones (9.5 cm).

Woody and leafy cuttings from wild stock were collected and rooted easily using a minimum of technological inputs. Rooting percentages were better under the hotter and drier conditions in Kilinito.

In conclusion, the data gathered for this study were analyzed within the framework developed by Arnold et al. (1985) for evaluating sustainable use strategies for indigenous plants. The low densities of *V. pseudolablab* found within the patches coupled with the high grazing pressure make it unlikely that wild resources could sustain higher usage.

This study highlights some of the greatest methodological problems facing ethnobotanical, and related, research in pastoral communities. More attention should be directed towards developing research methodologies to further our understanding of wild food plants in pastoral communities.
RESUME


Le but de cette étude était de mieux comprendre l'écologie et la propagation d'une ressource alimentaire sauvage importante (Vatovaea pseudolablab (Harms.) Gillett) de la communauté de Loodokilani, district de Kajiado, Kenya, et par là, contribuer à son utilisation renouvelable.

On trouve la V. pseudolablab dans des plants distincts de la région, bien qu'elle ne fût qu'occasionnelle. On associe ces plants avec des sols de texture moyenne (terraux argileux), d'une couleur brun foncé (7.5 YR 3/2) contenant une quantité moyenne de pierres de grandeur moyennes (9.5 cm). Les sols sont moyennement développés (73%), contenant des blocs d'agrégats angulaires.

Vatovaea pseudolablab se propage aisément à partir de boutures de feuilles et de tiges dans un propagateur sans vaporisation fabriqué localement. Les pourcentages d' enracinage pour les deux types de boutures étaient plus élevés dans les expériences de Kilinito.

Pour conclure, les données recueillies pour cette étude ont été analysées dans le cadre de l'évaluation des stratégies d'utilisation renouvelable pour les plantes indigènes développé par Arnold et al. (1985). Les faibles densités de V.pseudolablab trouvées dans les plants, plus la pression intensive de broutage, rendent improbable une plus grande utilisation des ressources sauvages.

Cette étude souligne quelques-uns des plus grands problèmes auxquels font face ceux les chercheurs ethnobotaniques de pastoralistes. Il faudrait accorder davantage d'attention au développement de méthodologies de recherche mieux adaptées aux besoins uniques de ces populations rurales.
ACKNOWLEDGMENTS

I wish to express my sincere appreciation to Dr. Tim Johns for his guidance throughout the course of this research project and for his constructive criticism in the preparation of this thesis. The other members of my committee, Drs. K. Stewart and A. Watson are acknowledged for their interest and contributions to this project.

I would like to extend my gratitude to M. de Vreede, Director of the Elangata Wuas Ecosystem Management Programme, and Dr. C.H.S. Kabuye, Director of the East African Herbarium of the National Museums of Kenya, who, in conjunction with my academic supervisor, made the undertaking of this project in Kenya possible. Thank you is extended to P. Muthoka and all the other staff of the Plant Propagation Unit for their invaluable help.

I am deeply indebted to the Canadian International Development Agency for their financial support through the CIDA Awards for Canadians Programme administered by the Canadian Bureau for International Education.

This thesis is dedicated to the people of Loodokilani, and in particular to my friends and colleagues in Kilinito and at Base Camp, whose expertise and patience made this project possible. To my family (Zoë, Edwin, Mom and Don) thank you for your unwavering support.
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CHAPTER 1 INTRODUCTION

This research project focuses on the ecology and propagation of an important wild food plant (*Vatovaea pseudolablab* (Harms) Gillett: Papilionaceae) of a Maasai community in Loodokilani, Kajiado District, Kenya. *Vatovaea pseudolablab* is a tuberous liana that is widely used and distributed in the arid and semi-arid regions of East Africa. The raw tubers of *V. pseudolablab* are eaten as a source of food and water, or they can be boiled or roasted. Seedling roots, immature pods, flowers and leaves are eaten as a vegetable, or added to soups and sauces. Human and animal populations. The new shoots are also palatable to domestic livestock and wild ungulates. It is the first detailed ecological study of this species in the region, and complements informal propagation studies that other workers in the area have done.

Data were collected between November 1994 and August 1995, while I was a visiting researcher with the Elangata Wuas Ecosystem Management Programme (herein referred to as the 'Programme'). The ecological study covered the period between November 1994 and April 1995. Three separate propagation experiments were conducted between December 1994 and July 1995.

The issues confronting Loodokilani are common to many other pastoral communities in the South. The people of Loodokilani face major upheavals in their traditional subsistence patterns; as a consequence, gathered, cultivated and purchased foods are gaining in importance (Holland 1989). As the process of dismantling large

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1. The Elangata Wuas Ecosystem Programme is based in Loodokilani but is administered through the National Museums of Kenya in Nairobi. It will be referred to as the 'Programme' throughout the text.
communal grazing areas into individual land titles begins, new concerns about the vulnerability of Loodokilani to food insecurity are raised. It is generally agreed that these holdings (< 100 hectares) will be insufficient to support the livestock numbers needed to meet household subsistence (GTZ 1993). Livestock, and their products, are provide the main source of subsistence in the region, and there is a growing awareness that a concerted effort must be undertaken to expand the range of subsistence choices for the local population.

The 'Programme' was created to undertake practical research geared to expanding the range of livelihood choices available to the people in Loodokilani. It is an approach that recognizes the primary decision-making role of local communities in long-term, sustainable resource use. Thus, research programmes must be problem-oriented and deliver improved scientific information, in an appropriate form, to local inhabitants.

On a more global scale, my work adds to the increasing number of participatory research projects exploring how indigenous knowledge contributes to community food security and sustainable resource management. Embodied in this approach is an acknowledgment of the value of western scientific methodology, yet a recognition that in today's world, research must be cognizant of the cultural, socio-economic, and technological climate in which it operates, and attempt to use the best of each.

Chapter 1 (Introduction) provides a brief overview to my research project, outlining the objectives and major modifications to the original design. It also includes background information on the study area and an overview of the information available on the study species. Chapter 2 (Literature Review) outlines the significance of indigenous plants in development and stresses the role of local communities in ensuring current and future availability of these important natural resources. The state
of ecological research in the arid and semi-arid regions of eastern Africa is reviewed, with a particular emphasis on the importance of spatial heterogeneity in these ecosystems. The limited information available on vegetative propagation of indigenous plant species is surveyed. Chapter 3 (Ecology) provides the methodologies and results of an exploratory study of *V. pseudoloblab* *in situ*. This study has two distinct, though not unrelated, components. The first part includes a general site description and quantifies edaphic heterogeneity. The second part is a study of individual plants, and includes determinations of patch densities, along with results of measurements made on some important growth parameters. Chapter 4 (Propagation) provides the methodology and results of propagation trials with *V. pseudoloblab* vine cuttings. Chapter 5 (Conclusion) draws all three studies together, providing a general picture of the ecology of the species and, more importantly, raising research questions for the future.

The focus and methodologies of this project limit the generalizability of the research results, yet I believe this project can be of practical and theoretical value to other programs. By using 'low-tech', yet scientifically rigorous methods, this project offers a contribution to bridging the gap between local and western scientific knowledge systems, in the recognition of the mutual benefits offered to each. Overall, it advances a better understanding of the ecological adaption of semi-arid lianas and contributes to the very limited information available on propagating plant species indigenous to Africa. More importantly, by outlining the benefits and constraints of conducting research in environments which are rarely studied, I hope to contribute to a better understanding of what is relevant, community-based research.
1.1 Objectives

The objective of this research project was to provide ecological and propagation information on a locally important wild food plant (*V. pseudolablab*), with the long-term goal of promoting its sustainable use. This species had been identified as an important resource by a nation-wide ethnobotanical study\(^2\), and was targeted by the East African Herbarium for further research.

The specific aims of my research were four-fold:

- To identify 'patches' of *V. pseudolablab* in the Loodokiiani region and determine patch densities. This would provide the first information on the distribution of this resource in the area;
- To identify some important growth characteristics of *V. pseudolablab*.
- To determine the degree of habitat specificity of *V. pseudolablab*.
- To develop a low-cost, technically appropriate methodology for the rooting of *V..pseudolablab* stem cuttings.

1.2 The Study Region

Kenya is part of the Inter-Tropical Convergence Zone, and is described as steppe and savannah (Jansen et al. 1987). About 75% of Kenya is arid or semi-arid. In recent years, some noticeable progress has been made in raising the standard of

\(^2\) The Indigenous Food Plants Programme (1989-1992) identified the important wild food plants in the arid and semi-arid regions in Kenya. It was a joint project of the National Museums of Kenya, Worldview International Foundation and Kenya Freedom from Hunger Council.
living of many Kenyans. However, seasonality of food supplies remains a serious problem, compounded by the limited resources and capacity of the Kenyan government to meet the basic needs of the whole population. With limited arable land, the goals of national food self-sufficiency as outlined in the Kenyan National Food Policy (1984) remain out of reach.

It is within this context that ethnobotanical research has emerged as a vibrant science in Kenya, with both national and international organizations working diligently to preserve a rapidly disappearing national resource and to explore various ways that indigenous botanical knowledge can contribute to local, national and international development efforts. FAO (1988b) provides a good overview and inventory of the most important wild and domestic indigenous plant species in eastern Africa. General inventories of important indigenous plants in Kenya can be found in Gura (1986), Pope (1986) and Kiambi and Opole (1992). Arid and semi-arid regions in East Africa are covered in general in Heine and Brensinger (1988), while Kabuye (1985) and Maundu et al. (nd) limit their inquiry to Kenya. Glover et al. (1986), Ichikawa (1980), Morgan (1981), Arum (1989) and Becker (1984), document the ethnobotany of specific ethnic groups in Kenya, while lists that focus on the use of specific plant parts, such as leafy greens, are found in Yazawa (1988), Kokoworo (1990), Johns and Kokoworo (1991) and Mwajumwa et al. (1991).

1.2.1 Kajiado District, Kenya

Kajiado District, south-west of Nairobi (1°S, 34° E), is a semi-arid region within the Great African Rift Valley system (Figure 1). Altitude ranges from 1000-1500 meters.
Annual rainfall is between 400-800 mm year⁻¹, with precipitation levels positively correlated with altitude. Rainfall is bimodally distributed, with the 'long' rains falling between March and May and the 'short rains' from mid-October to early December. However, precipitation varies greatly in intensity and distribution, both within and between years.

Geologically, quaternary sediments dominate in Kajiado, with isolated patches of Quaternary and Tertiary Volcanics (Survey of Kenya 1970). The dominant soils of the step-faulted floor of the Rift Valley in southern Kenya are well-drained, deep, Cambisols with many stones and boulders, interspersed with long, narrow strips of imperfectly drained, undifferentiated Vertisols and Solonchaks which are prone to cracking under mesic conditions (Kenya Soil Survey 1982). The population of Kajiado (1991 census) is 267 300, with densities ranging between 1-4 people per square kilometer. The physiognomic classification is Somali-Maasai (Lind and Morisson 1974), and the vegetation type is Acacia-Commiphora bush and scrub (White 1983). The economy is primarily pastoral, reflecting the traditional economic activity practice by the Maasai, the dominant ethnic group in the District.

Several important factors have and will continue to affect the modern-day settlement and economic patterns of the District. Large tracts of important dry season grazing areas for the Maasai cattle have been converted to national reserves to support the wild game populations on which Kenya's tourist industry is based, making them susceptible to food shortage during the dry season. More recently, immigrants from land-poor areas of Kenya are settling in the wetter regions of Kajiado, a pattern common throughout Kenya (Maundu et al. nd). While the process of land adjudication has begun, few alternatives to meet family subsistence needs are available for most of
Figure 1: Kajiado District, Kenya
people in the region. 'Development' in areas dominated by pastoral economies such as Kajiado, has traditionally emphasized the enhancement of domestic livestock resources, often with the ultimate goal of promoting commercial ranching (Campbell 1984). While the general failure of these approaches is well documented (cf. Campbell 1986; Holland 1989), few alternatives have emerged to address the increasing marginalization of pastoral communities around the world. In Kenya, an innovative approach to this issue culminated in the Indigenous Food Plants Programme (IFFP), a nationwide ethnobotanical survey of arid and semi-arid lands with a decidedly practical bent. In documenting the rich botanical knowledge contained within these communities, the authors of the IFFP hoped to raise the profile of indigenous plant resources and generate ideas how they could contribute to local and national development efforts.

Nestel (1989) identifies strong seasonal, gender and age differences in dietary patterns in the District. Protein intakes always exceed the World Health Organization's (1985) recommended daily intake levels (RDI), while energy supplies fall between 65-80% RDI based on body weight. The major deficiencies identified are carbohydrates, vitamins and minerals (Maundu et al. nd). Consumption of vegetables is very low (Nestel 1989) due to high costs, low availability (Maundu et al. nd) and cultural preferences (pers. obs.). This low consumption pattern has generated particular interest in promoting wild vegetable species, like V. pseudolablab, as part of a nutritional intervention in the region.

1.3 Vatovaea pseudolablab (Harms.) Gillett

Vatovaea pseudolablab is a woody climber (liana), 1-3 m. tall from a woody
tuber. Old growth is woody, pale reddish-brown, new growth greenish-purple. Leaflets usually three, (ob)ovate, 1-5.7 cm. long, 0.8-5.3 wide. Inflorescences 7-45 cm. long, many flowered, above a peduncle. Flowers green and purple to blueish. Fruit flattened, curved, 4.5-6.0 cm. Usually 4-6 seeded. Seeds brown, sub-globose or squarish. Basic botanical descriptions are found in Agnew (1974); FTEA (various) and Beentje (1995). A detailed description is provided in Appendix 1.

1.3.1 Ethnobotany

Various studies document the ethnic groups which exploit *V. pseudolabilab* (Table 1) and provide evidence of its widespread use and distribution in the semi-arid and arid regions of Kenya, Ethiopia, Somalia and Tanzania (Glover et al. 1966; Morgan 1981; Hiene and Brenzinger 1988; Kabuye 1985; Vincent 1985; Stiles and Kassam 1986; Maundu et al. nd).

Table 2 summarizes the different ways *V. pseudolabilab* is used throughout eastern Africa. The edible tubers are swellings along lateral shoots that branch off the central rootstock (Vincent 1984). They are sweet and easily peeled. The tubers are eaten raw by the Turkana, Pokot, Samburu, Rendille, Borana, Maasai and Hadza, both as food and source of water, either in the field or back at the homestead. The fibrous pith is discarded. They are roasted or boiled by the Turkana, Pokot and Hadza. Morgan (1981) noted that the Turkana chopped and ground the tuber to make flour, which in combination with sorghum, was used to prepare a stiff porridge used as an emergency food.

Seedling roots are eaten as a vegetable in Kajiado (pers. obs; Maundu et al.)
and) in the early rainy season. Samburu eat the raw seeds or the Akamba cook them. Both uses of seeds have been documented for the Turkana and Pokot. The use of

Table 1: Ethnobotany of *V. pseudolablub*: Ethnic groups and common names

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<th>COMMON NAME</th>
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<td>KELOWO, KELA</td>
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<td>HIMADI, HENADI, HINAADI</td>
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<td>SAMBURU</td>
<td>INANYO, NANYOINJASI</td>
<td>3, 5, 6</td>
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<tr>
<td>TURKANA</td>
<td>EGILAE, EGLAE</td>
<td>2, 3, 4, 5, 6</td>
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From: Arum, 1989¹; Beenste, 1994²; Glover et al., 1966³; Heine and Brezinger, 1988⁴; Kabuye, 1986⁵; Maudu et al., nd⁶; Stiles and Kassam, 1986⁷; Vincent, 1985⁶.
immature pods, flowers and leaves cooked and eaten as vegetable have been observed for the Maasai, Akamba, Pokot, Samburu, and Turkana, while the Maasai in Kajiado add these plant parts to sauces and soups (Maundu et al. nd; pers. obs.).

The new shoots and pods are palatable to livestock (cattle, camel, donkeys, sheep and goats) and wild ungulates (pers. obs.). Other ancillary uses are noted by Morgan (1981) and Maundu et al.(nd). Root fibers have been used for making ropes by the Maasai, Rendille and Turkana, or used for making hats and flywhisks by the Maasai.

<table>
<thead>
<tr>
<th>Table 2: Uses of <em>V. pseudolablab</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Root</td>
</tr>
<tr>
<td>Shoot</td>
</tr>
<tr>
<td>Fodder</td>
</tr>
<tr>
<td>Misc</td>
</tr>
</tbody>
</table>
Although various authors have reported that the Maasai eat tubers (Glover et al. 1966; Heine and Brensinger 1988), in Loodokilani, only two local men questioned reported digging tubers, and only when they were children. Local women gathered seedlings available at the start of the rains, and gave them to the family either raw or cooked. Leaves and pods were used in the same way and were also important as fodder for domestic animals.

1.3.2 Ecology

While no formal ecological study of *V. pseudolabiab* in Kajiado exists, local people have maintained a rich store of knowledge about the species. In addition, East African floras (Agnew 1974; Beentje 1995; FTEA various) and ethnobotanical studies (Table 1) provide some ecological information in botanical notes. Maundu et al. (nd) report that it is found occasionally throughout Kajiado and is rarely common. Figure 2 shows its distribution in many arid and semi-arid regions in Kenya (Turkana, Baringo, Samburu, Marsabit and Kajiado). The Flora of Tropical East Africa notes that it is most often found on soils with impeded drainage and Agnew (1974) records its location along dry (seasonal) watercourses. It is also found in the dry areas of Uganda, Tanzania, Sudan, Ethiopia and Somalia (Vincent 1985; Heine and Brensinger 1988).

Only one study in northern Tanzania (Vincent 1985) provides quantitative information on the distribution and availability of *V. pseudolabiab*. In the Mangola region, it occurs in patches that range from 0.8 hectares to 15 hectares in size, with a mean density of $1840 \pm 1041$ plants hectare$^{-1}$. Vincent (1985) provides qualitative descriptions of the major ecological and topographical features associated with these 'patches'. They are found in hillside deposits of weathered lava and in the basement
From: Beenjte (1994).

Figure 2: Distribution of *V. pseudolabioides* in Kenya
hills to the south of a major seasonal river (Barai) that transects the Mangola region.

One source (Maundu et al. nd) provides some details on the phenology of V. pseudolablab. The species flowers during the late dry and early rains (March, April, October, November) often before the appearance of leaves in the rainy season. Fruiting occurs toward the end of the rainy season (April, May, November, December).

1.3.3 Propagation

To the best of my knowledge, no formal experiments have been conducted with V. pseudolablab. Mr. E. Roimen, Kilinito site manager, has propagated V. pseudolablab from seed, as part of a larger indigenous plant demonstration garden. The seed exhibits a physical dormancy, imposed through a hard seed coat, but this is easily overcome through soaking. (Roimen, pers. comm; pers. obs.). Shoots emerge in approximately seven days, and seedlings are easily transplanted. Maundu et al. (nd) mention both seed and root propagation, although their source was not recorded. Conversations with a few older community members revealed that, historically, V. pseudolablab may have been semi-cultivated around some homesteads, either by seed and/or seedling transplant, but this information could not be confirmed firsthand.

1.4 Summary

Vatovaeae pseudolablab is an important wild food resource of the Maasai community in Loodokilani, Kajiado District, Kenya. Like many pastoral communities around the world, the Maasai face major upheavals in their traditional subsistence
patterns that threaten their ability to meet basic household food and nutritional needs.

An important goal of this research was to make a practical contribution to local, ongoing efforts to expand the range of subsistence activities available to the community of Loodokilani. Through a consultative process, several modifications to the original design were introduced which enabled me to meet the stringent requirements of western scientific methods while responding to the more immediate needs of the community.

*Vatovaea pseudolablab* is used widely in the mesic regions of eastern Africa, yet only one detailed study from Tanzania is available (Vincent 1985). While no such study has been carried out in Loodokilani, the species is well-known locally. This research offers contribution to information on the ecology and propagation of *V. pseudolablab*, and more generally contributes to a better understanding of semi-arid ecology and the propagation of important plant species indigenous to Africa.
CHAPTER 2 LITERATURE REVIEW

In the Bruntland report (WCED 1987) and again at the United Nations Conference on Environment and Development (1992), the international community underscored the links between food security, poverty and environmental degradation. Environmental destruction must be perceived as part of a process that has at its core the problems of the vulnerability of rural communities to food insecurity.

In spite of these historic conferences, 'development' in Africa is in crisis. Food insecurity, as well as absolute poverty, is increasing. In recognition of the failure of 'top-down' development programs to '... meet the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987) increasing emphasis is being placed on programs which draw upon indigenous knowledge and strengthen rural communities' capacities to manage their fragile resources (FAO 1988a, 1988b; Mooney 1992; Montecinos and Altieri 1992; Pellet 1991; Shiva and Dankelman 1992).

Ethnobotanists were among the first workers to recognize the vast wealth of indigenous knowledge in many communities in Africa. Historically, ethnobotanical research was geared to recording local plant use, usually as lists of important plants used and their methods of preparation. Today, many ethnobotanists are seeking to understand the role of traditional plants in community nutrition and economy and how this knowledge can make a practical contribution to the implementation of culturally, environmentally and technically-appropriate development (Okigbo 1977; FAO 1988b; Attire 1990; Cohen et al. 1991).

One of the greatest challenges for those interested in indigenous knowledge,
lies in bridging the gap between global (western) and local (indigenous) knowledge (Rennie and Singh 1996). By definition, indigenous knowledge is highly localized, varying widely within and between communities (Johns et al. 1990, Rennie and Singh 1996). Western scientific knowledge, while adopting a more global perspective, also has evolved within a particular cultural and technical framework. Although historically the two 'sets' of knowledge, local and global, have been poorly integrated (Rennie and Singh 1996), this synthesis may be at the core of raising the level of local community involvement in formal sustainable development programs.

2.1 Indigenous Botanical Knowledge and Development

2.1.1 Traditional Food Plants

Throughout history, rural communities have developed subsistence systems based on a knowledge and understanding of the surrounding environment. This tradition of indigenous knowledge has persisted in many rural communities in the South today. Local botanical expertise is one type of indigenous knowledge that has generated much attention in recent years. Traditional or indigenous food plants are ‘... cultivated or wild plant species accepted by rural communities through custom, habit and tradition as appropriate and desirable food.’ (FAO 1988b).

2.1.2 Indigenous Plants and Subsistence

Various authors have stressed the importance of wild food plants in rural food
security (Attere 1990; FAO 1988b; Okigbo 1977,1990). ‘Food security is ... the economic and physical access to food, for all people, at all times.’ (FAO 1990). In many parts of eastern Africa, seasonality of food supplies is acute. Indigenous plants are often best-suited to the rigors of marginal environments, tolerating drought, poor soil fertility, and local diseases and pests (Attere 1990) and serve as cheap and reliable food sources in times of scarcity (FAO 1988a;1988b).

Studies of the nutritional quality of indigenous vegetables show that their nutrient content is not only comparable to exotic species, but often exceeds them (Yang 1979; FAO 1988b; Attere 1990). Wild plants are often important sources of protein, vitamins and minerals, and make a significant contribution to the overall nutrition of the rural household (Yang 1979; Okigbo 1977,1990; FAO 1988a,1988b; Kokorowo 1990).

Access to cash is severely limited in most parts of rural Africa. Marketing surplus from cultivated or gathered sources of indigenous food plants provides many rural women with a source of discretionary income used to augment subsistence activities, such as the purchase of food, clothes and school supplies. (FAO 1988b; Gerson 1991; Okafor 1991).

2.1.3 Indigenous Plants and Genetic Diversity

Many international organizations recognize the importance of worldwide plant genetic resources and have mounted an international effort to halt or slow their decline (DEEP 1993). A major limitation of ex situ conservation methods is the inability to mimic the environmental conditions under which each landrace or traditional variety
evolves (Kiambi and Opole 1992; Montecinos and Alteri 1992; Mooney 1992). An alternative approach is to encourage in situ conservation by involving the communities that traditionally use these resources (Montecinos and Alteri 1992; Mooney 1992).

2.2 Research on Indigenous Plants

While the importance of indigenous plants for rural households is clear, what they mean for sustainable development is a source of debate. While various authors have argued that their use should be promoted, experience has shown how encouraging the use of wild food plants without a clear understanding of their ecology and sustainable harvesting rates can result in the depletion of wild populations (Lee 1973, 1979; Marshall 1976; Hallam 1979; Gott 1983; Gerson 1991; pers. obs.) with concomitant negative social and environmental impacts.

2.2.1 Utilization Strategy

Learning from lessons of the past, various authors have argued that maintaining the long-term viability of wild plant resources depends on developing sustainable 'utilization strategies' for their use (Okafor 1980; Bousquet 1982; Fox and Norwood-Young 1982; Grivetti 1987, Arnold et al. 1985; Dupriez and de Leener 1989; Cleveland and Soleri 1991; Juma 1989; Nerd et al. 1990; Biesele and Murray n.d. ). Yet there is little consensus as how to approach this issue. Arnold et al. (1985) provide a clear framework for evaluating in situ resources, offering a valuable contribution to systematizing a highly variable and often ad hoc field of research.
The system of Arnold et al. (1985) outlines the following set of criteria for assessing native plant significance in formulating sustainable management policy for each wild food plant.

1. **Nutritional composition:** number of chemical constituents with a value greater than 20% RDI (WHO 1985).
2. **Domestication potential:** time to first crop, ease of harvesting, accessibility of edible part, distribution (width of habitat), ease of propagation, handling and storage qualities.
3. **Relative Yield:** size of edible part and number edible parts per plant.
4. **Desirability:** reflects the desirability or potential acceptability of the plant part as a food, mainly based on palatability and nature of edible part.

While offering a valuable contribution to standardizing resource use strategies for wild food plants, Arnold et al. (1985) do not include a number of important criteria on their list.

The relative importance of many wild food plants differs depending on the season. In part this is due to seasonal fluctuations in availability. One category of wild food plants, 'famine foods' (Okigbo 1977) are much more important in times of scarcity, but may rarely be used otherwise. Clearly the desirability of one of these species would fluctuate depending on the food status in the community. In addition, a 'famine food's' contribution to basic energy requirements in times of shortage necessarily takes precedence over other nutritional needs.

Basing management decisions on a dichotomy between domestication and maximizing use of *in situ* populations may not be appropriate in the context of subsistence food production in Africa. It is more likely that management of a particular species would fall somewhere between the two poles, as a community responds to
temporal and spatial variations in local food needs.

Another limitation of the model developed by Arnold et al. (1985) is the use of evaluation criteria which stress western concerns with production and yield. Other factors which should be included are reliability of production; location of the plant in relation to where it is needed (i.e.- accessibility); and for many agro-pastoralists and pastoralists in Africa, fodder value.

While suffering from a number of shortcomings, these criteria provide a framework for standardizing applied research on useful indigenous plant species in Africa. Many such research projects have been conducted on an ad hoc basis; thus, interpretation and comparability are almost impossible. The approach advocated by Arnold et al. (1985) acknowledges the immediate needs and rights of rural populations to use these resources, yet recognizes that the maintenance of biodiversity is integrally tied to long-term survival of many of these communities.

2.2.1.1 Scale in Ecological Studies

It is axiomatic that sustainable use of wild plant resources requires a knowledge of their ecology and availability in situ (Bahuchet 1988; Peters and Hammond 1990). Anthropologists were among the first workers to quantify the use of wild plant species in the African diet (cf. Lee 1973), and showed clearly that the large number of plants identified in ethnobotanical studies do not reflect the smaller number of species that are regularly consumed (Lee and Devore 1979; Bahuchet 1988). One early reason offered to explain this observation was that low use of a species was due to low availability (Bahuchet et al. 1991). Seminal works in central African forests (Hladik et al. 1984) and
an east African savanna (Vincent 1985), have shown the unreliability of this paradigm. By quantifying wild food plants using standard ecological methods, both works clearly show that in situ abundance is much greater than would be inferred from actual community use. These results underline the importance of complementary sociological field work in indigenous knowledge research.

While these works have focused specifically on quantifying in situ resources, other works have focused on identifying the ecological factors associated with a particular wild plant species. Most ecological studies in this context are qualitative, with the most common method relying on correlation of species distributions to information contained in sources such as small-scale vegetation and soil maps (cf. Drechsel and Zech 1988; Harder et al. 1990; Maiga et al. 1991). However, the large-scale, general categories on thematic maps often inadequately explain the smaller-scale ecological processes that affect individual organisms (Rennie and Singh 1996).

Quantitative vegetation studies in Africa are for the most part limited to a single scale of measurement. This makes the research outcome highly scale-dependant (Greig-Smith 1983), and is an approach often not suited to exploratory studies where the spatial scale at which ecological factors vary is not known.

The importance of spatial heterogeneity in ecology lies in its ubiquity as a feature of ecosystems in general (Greig-Smith 1983; Dutilleul and Legendre 1993), and the East African landscape in particular (McNaughton 1983). While spatial variation is an intrinsic property in most natural systems, the scale at which spatial heterogeneity manifests itself varies widely (Dutilleul 1993). High environmental heterogeneity in the semi-arid grasslands of East Africa has been shown to influence grazing (Heady 1966; Harper 1969; McNaughton 1983; Holt 1984) and vegetative pattern (Belsky 1986).
addition, spatial heterogeneity may reduce the impact of inter-species competition (Sanders 1969; Danielson 1992), disease (Levin and Paine 1974) and seed predation (Dayton 1971) and subsequently allow higher species diversity to be maintained (Austin and Cook 1974; McNaughton 1983; Dempster and Pollard 1986). If a fundamental goal of ecology is the detection and explanation of spatial pattern (Greig-Smith 1983), then it is clear that distinguishing 'pattern' in nature rests squarely on paying adequate attention to scale and sampling technique in the research design (Greig-Smith and Chadwick 1965; Greig-Smith 1983; Schneider 1992).

Although spatial heterogeneity is a marked feature of vegetation in semi-arid East Africa (Milne 1935; Burtt 1942) very little is known of the underlying causes. Traditional vegetation ecology in east Africa has relied on qualitative observation and physiognomic classification (McNaughton 1983), often in relation to broad soil categories (cf. Anderson and Talbot 1965).

Water is the most important limiting factor for plant growth in semi-arid areas (Amon 1972; Park 1993). In areas that receive less than 750 mm rainfall year\(^1\), such as northern Sudan (Vetaas 1993) and the rangelands in East Africa (Pratt et al. 1966; McNaughton 1983), vegetation types and stature are broadly correlated with rain isohyets. Yet, meteorological patterns alone are obviously not sufficient to explain localized variations in vegetation. It is water available for plant growth, or soil water availability, that is crucial (Amon 1975). Spatial heterogeneity in East African vegetation has been linked to differing moisture regimes that operate at both macro and micro levels in semi-arid soils. Differences in soil water availability have been attributed most commonly to variability in physical soil characteristics (Greig-Smith and Comack 1965; Fitter 1983; McNaughton 1983), differences in vegetative cover (Belsky 1986; Belsky
micro topographic relief (Whittaker 1977), disturbance (McNaughton 1983; Lonsdale and Braithwaite 1991) and biological characteristics of the plant community itself (Belsky 1986; Belsky et al. 1993).

The influence of small-scale variations in soil physical characteristics on East African vegetation is alluded to in many works, but has been explicitly studied in few. Differences in vegetation are attributed to vague 'physical soil factors' when the other research parameters (i.e.- soil fertility) are discounted (cf. Greig-Smith and Chadwick 1965; Fitter 1982), or when differences in soil moisture are noted (Thorhallstottir 1990). Inherent in this approach is an assumption that these 'factors' vary at similar scales as the associated vegetation, although this is not explicitly studied.

Only a few works have precisely addressed the question of how the scale at which physical characteristics of soils vary spatially relates to vegetation distribution. In the Serengeti, McNaughton (1983) indexed vegetation communities to clay content of the soil. Handley et al. (1994) found that soil water supply (indexed as percentage of clay) influenced the distribution of associated vegetation, through it strong influence on the delta-15N signature of soils and plants. Belsky et al. (1989,1993) showed that under mesic conditions, woody cover had a profound influence on herbaceous undergrowth, primarily through a positive influence on soil water availability. One detailed study of Serengeti soils (de Wit 1978) found a clear link between the physical attributes of soils and vegetation types, with plant communities often changing as abruptly as the physical characteristics of the soils themselves.

2.2.1.2 Propagation

In Kenya, Maundu et al. (1993) and Kiambi and Opole (1992) document
widespread local interest in indigenous plants. However, lack of technical information and propagative material hinders their increased integration into subsistence economies. A valuable contribution to filling this need was made by the Kenyan Environmental and Energy Organization (KENGO), which has compiled a highly readable guidebook (Teel 1984) of the important indigenous tree species in the arid and semi-arid lands of Kenya, and how local communities could cultivate them. Other significant research in this vein is ongoing at the International Center for Research on Agroforestry (ICRAF) and Kenyan Agricultural Research Institute (KARI) and CARE-Kenya, to name but a few organizations that recognize the importance of indigenous plant species for current and future generations in Kenya.

While suitable propagation methods for indigenous tree species in some parts of Africa have been developed (e.g. Teel 1984; Leakey et al. 1990; Okafor 1991), little attention has been paid to the many other species regularly used by rural communities (Kiambi and Opole 1992). Until recently, many of these species were widely known and available in situ (FAO 1988b). Nevertheless, in one of the many unfortunate legacies of 'development' in Africa, some of these valuable resources are in danger of being lost. This threat can originate directly through physical means such as habitat destruction (Okigbo 1977; Okafor, 1991; DEEP 1993), or indirectly, such as through loss of local botanical knowledge within the community, as the social and cultural mechanisms for this transfer break down (Kiambi and Opole 1992; Mooney 1992). In either case, environmental degradation becomes intrinsically linked to a decrease in local capacity and self-reliance, which lies at the core of addressing food insecurity on the African continent.

Most of the agricultural and horticultural research in Africa still focuses on
exotics (M'Ribu et al. 1993). Increasingly, the potential of indigenous plants as alternative crop plants in rural subsistence (NAS 1971,1989; Carr 1985; Arnold et al. 1986; Mooney 1992) and environmental rehabilitation (Teel 1984; Leakey 1990) is being evaluated. Domestication is not a suitable approach for all threatened species. However, it is one way of increasing the availability of those varieties in short supply (Arnold et al. 1986; Dupriez and de Leener 1989; Gerson 1991; Kiambi and Opole 1992; Okafor 1991; Shiembo et al. 1996) and is an important consideration in developing a sustainable 'utilization strategy' for a particular species.

Vegetative propagation techniques have a particular role to play in this process, especially in species where seed production is low, or germination is a problem (Shiembo 1994). Of the several possible vegetative techniques available, one of the fastest, easiest and cheapest propagation methods uses stem cuttings (TeklehaImanot et al. 1996). While the scientific literature is scarce, a few studies do focus on the stem propagation of some locally important indigenous plants in Africa. While the wide variety of experimental materials and methodologies employed in these inquiries precludes direct comparisons, nonetheless, some surprisingly consistent patterns emerge. Many of these studies show that exogenous rooting compounds do not affect overall rooting percentages but positively affect the number of roots produced. This relationship has been shown for leafy cuttings of many tropical trees (Leakey et al. 1990; Okafor 1991) and lianas in West African forests (Caballé 1977,1980; Shiembo et al. 1996). Singh et al. (1990) achieved success rates ranging from 71-98.6 % for leafy cuttings taken from medicinal yam (Discorea floribunda Mart.& Gal.) using a variety of hormone concentrations and types. The highest success rate (98.6 %) was obtained with the widely available proprietary compound (Seridex<sub>2</sub> May and Baker, Ltd.). Other
reports include the successful rooting of the liana *Gnetum africanum* Welw (Teklehaimanot et al. 1996), of the dry forests of West Africa, and *Rhynchosia minima* (L.)DC (Naegelé 1977) a leguminous liana widely distributed throughout the arid and semi-arid rangelands of the Sahel.

2.3 Summary

Food insecurity is one of the most pressing issues facing many rural Africans today. Traditional food plants contribute significantly to household food security, nutrition and economy, yet are rarely targeted for research programs.

Increasingly, researchers are looking at how indigenous knowledge can make a significant contribution to the development of culturally- and technically-appropriate development programs. However, the general lack of technical information available for most species hinders this interest.

Over-exploitation, combined with habitat destruction, has placed many wild food plant species, and the communities that depend on them, at risk. Sound ecological information can help strengthen local management capacity and local community involvement in sustainable resource management.
CHAPTER 3 ECOLOGICAL STUDY

3.1 Introduction

While the importance of wild food plants to rural communities in eastern Africa is widely recognized (cf. FAO 1988a), few studies have addressed the question of their availability in the wild (Peters and Hammond 1990), and even fewer on their suitability as cultivated subsistence crops for agriculturally marginal areas (Thompson, 1985). The specific aims of this aspect of the research were to identify 'patches' of *V. pseudolablab* in the Loodokilani region and determine patch densities, to identify some important growth characteristics of *V. pseudolablab*, and to determine the degree of habitat specificity.

3.2 Methods

Ten 'patches' of *V. pseudolablab* (Sites 1-10) were chosen in consultation with staff of the 'Programme' and six community members (Figure 3). The general locations of sampled sites were predetermined by practical considerations of limited transportation and accommodations. As such, all stands within a 6-10 km radius that could be traversed on foot from the available accommodations at either of two 'Programme' camps, Kilinito and Base Camp, were sampled. Five stands were near Kilinito Camp (Sites 1-5) and five around Base Camp (Sites 6-10). Once the sites were chosen, the general dimensions were determined by walking with the informant who could easily identify the often cryptic relics (Vincent 1985) of the plants. The general boundaries of the patch were marked and the dimensions determined by pacing.
Figure 3: Study Site Locations

practice, the site dimensions were easily determined. The site usually existed as a relatively discreet entity, delineated by environmental factors such as thickets of *Acacia* ssp. and reduction of slope, or features associated with human settlement such as cattle paths or fencing. Some confusion existed over whether or not Sites 8 and 9 should be treated as distinct sites, due to the similar descriptions and proximity to each other. It was decided to treat the two sites as distinct entities for two reasons. The two sites were 0.75 km apart and were distinguished by very different management strategies (i.e. Site 8 is within a protected pasturage and Site 9 is within a communal grazing area).

3.2.1 Sampling

3.2.1.1 Soils

A stratified random sampling method (Grieg-Smith 1983) was employed by 'splitting' each SITE (Patch) into one hectare PLOTS, which were further subdivided into ten 50 X 20 m SUBPLOTS. Five variables: Color, Texture, Size, Stoniness, and Structure (see Appendix II for detailed discussion) commonly used by pedologists to classify the physical characteristics of soils were measured in the field.

The sampling units for Color and Texture were soil cores extracted with a 5 centimeter diameter auger to a depth of 21-42 centimeters, the actual depth depending on physical limitations imposed by local soil conditions (i.e. extremely rocky and/or compacted soils). Samples were taken at the intersection of randomly chosen X and Y coordinates along the axes of each SUBPLOT. The methodology employed to
measure 'Structure' was slightly different. A small hand shovel was used to loosen the soil around the soil core site and assessments made. In the case of Size and 'Stoniness', the sampling unit was the SUBPLOT itself.

3.2.1.2 Plant Study

In each site, I and at least one other person traversed the patch and every individual of the study species was identified. At the beginning of the study, I relied on my colleagues to identify the plants. However, as the project progressed, I became adept at identifying the species myself. Each woody stem that was seen to come from the ground was counted as one plant (Vincent 1985). Woody stems were chosen for two reasons. The woody part of the stem was visible year round, thus it was reasoned that the study period would not be restricted by seasonal variations in visibility of above-ground plant parts. Secondly, it was assumed that the existence of woody parts signified that a plant would be available throughout the late dry and early rains when it is most needed by the local community (Vincent 1986; pers. obs.). For each plant three variables were measured, circumference at the base of the longest woody stem, length of the longest woody vine and 'association' (i.e. whether the plants were growing alone or sprawling (passively climbing) on a tree or shrub).

3.2.2 Data Analysis

3.2.2.1 Soils

The levels of soil variables measured are summarized in Table 3. A brief
discussion of how the data were converted to semi-quantitative values follows, but the reader is directed to Appendix II for specific details of these operations.

Color was converted to the three components (Hue, Value, Chroma) which make up the Munsell Color chart system (McRae 1988; J. Fyles pers. comm.). The Soil samples taken in Kajiado produced four levels each for Hue and Chroma, and a single level for Value. Texture was divided into the relative percentage of Clay (five levels) and Sand (four levels). Values for both Size (three levels) and Percent (five levels) were obtained by taking the mid-point of each class. Structure was divided into three components: 'development' (two levels); Aggregate Size (two levels) and Aggregated Shape (one level).

3.1.2.2 Spatial Heterogeneity

A pure Model II nested Analysis of Variance with unequal sample sizes was carried out for each soil variable (Hue, Value, Chroma, Sand, Clay, Size, Percent and Aggsize) to assess whether each parameter (SITE, PLOT or SUB-PLOT) contributed a significant source of variation in relation to overall variability and the relative magnitude of that variation. This type of analysis is appropriate for exploratory studies in which the sources of variation in natural populations are of primary interest. (Sokal and Rholf 1969).
Table 3: Summary of Parameters and Levels Measured

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>VARIABLE</th>
<th>NUMBER OF LEVELS</th>
<th>VALUE OF LEVEL(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Hue</td>
<td>4</td>
<td>7.5, 12.5, 17.5, 25</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Chroma</td>
<td>4</td>
<td>1, 2, 3, 6</td>
</tr>
<tr>
<td>Texture</td>
<td>Clay (%)</td>
<td>5</td>
<td>7, 34, 35, 42, 50</td>
</tr>
<tr>
<td></td>
<td>Sand (%)</td>
<td>4</td>
<td>10, 32.5, 35, 52</td>
</tr>
<tr>
<td>Size</td>
<td>Size (cm)</td>
<td>3</td>
<td>0-10, 11-20, 21-30</td>
</tr>
<tr>
<td>Percent</td>
<td>Percent (%)</td>
<td>5</td>
<td>0-10, 11-20, 21-30, 31-40, 41-50</td>
</tr>
<tr>
<td>Structure</td>
<td>Development</td>
<td>2</td>
<td>Weakly developed</td>
</tr>
<tr>
<td></td>
<td>Aggregate Size</td>
<td>2</td>
<td>Moderately developed</td>
</tr>
<tr>
<td></td>
<td>(Aggsize)(mm)</td>
<td></td>
<td>0-9, 10-20</td>
</tr>
<tr>
<td></td>
<td>Aggregate Shape</td>
<td>1</td>
<td>Angular blocky</td>
</tr>
<tr>
<td></td>
<td>(Aggshape)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The model statement is:

\[ Y_{ik} = \mu + \text{SITE}_i + \text{PLOT}_{ij} + \epsilon_{ik} \]

where \( Y_{ik} \) is the \( k^{th} \) observation in the \( j^{th} \) plot of the \( i^{th} \) site. \( \mu \) is the parametric mean of the population. \( \text{SITE}_i \) is the random contribution for the \( i^{th} \) SITE. \( \text{PLOT}_{ij} \) is the random contribution for the \( j^{th} \) PLOT of the \( i^{th} \) SITE. \( \epsilon_{ik} \) is the combined contribution of the random error and the \( k^{th} \) SUBPLOT in the \( j^{th} \) PLOT of the \( i^{th} \) SITE.

The random, unbalanced design required the use of SAS General Linear Models (GLM) procedure for the statistical analysis. Satisfactory F-tests were carried out by synthesizing a new PLOT mean square using Satterthwaite's approximation (Sokal and Rholf 1969) and using this new value as the appropriate denominator to test the SITE mean squares.

The Variance Components (VARCOMP) procedure was used to determine the relative contribution of each parameter to overall variability.

Principal Components Analysis was used to evaluate how variables were interrelated. Due to the nature of the data (i.e. large, unequal sample sizes), a two step approach was used (Dutilleul per. comm.). The Principal Components (PRINCOMP) procedure generated the ordination axes. The Correlation (CORR) procedure measured the strength and direction of each variable's relationship to each ordination axis by generating Pearson's Product-Moment Correlation statistic (\( r_{12} \)).
Plant Study

Means and standard errors for circumference and length were determined for each SITE and their association analyzed through the calculation of Pearson's Product-Moment Correlation Coefficient ($r_{12}$).

The technique of Principal Axes and Confidence Ellipses as outlined in Sokal and Rholf (1969) was used to analyze the trend of the association between circumference and length (Dutilleul per. comm.). This technique linearly decomposes the association between the two variables and expresses the variability as a single axis through a bivariate scattergram of the two population means (Sokal and Rholf 1969). The confidence ellipses are essentially confidence regions around the bivariate sample mean ($y_1, y_2$) and are measures of the reliability of the trend. The technique of Principal Axes is analogous to Principal Component Analysis, in that the Principal Axis accounts for the greatest source of variation in the data and the Minor axis, the second.

Principal Axes and confidence ellipses were constructed for the data as whole, and for each major 'Association' (Alone, Shrub and Tree).

PROC MEANS was used to generate the necessary sums of squares for the calculations but the values used to construct the axes and confidence ellipses were derived using a hand calculator following the procedure outlined in Sokal and Rholf (1969).
3.3 Results

3.3.1 Site Descriptions

Reconnaissance visits showed that the distribution of *V. pseudolablab* is marked by a high degree of spatial heterogeneity (i.e., demonstrates a 'patchy' distribution), similar to Vincent's (1986) observations on the same species in northern Tanzania.

Figure 3 shows the location of the ten stands that were surveyed. Patches ranged in size from one hectare (Site 6) to 18 hectares (Site 9), with a mean patch size of $8.8 \pm 5.7$ standard deviations (std) hectares. Detailed descriptions and exact locations of each site are provided in Appendix III.

Most of the sites exhibit signs of extensive grazing, with the exceptions of Sites 2 and 9. These two sites are within 'privately-owned' dry-season pasturage, where the relatively abundant vegetation contrasts starkly with the meager vegetation in the other sites, all of which are within the communal grazing areas. On four different occasions, I observed wild ungulates (gerenuks) grazing on the new growth of *V. pseudolablab*, which is also palatable to domestic livestock.

3.2.2 Soils

Table 4 summarizes the means and standard deviations of the eight soil

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*Privately-owned* in this context is not to be confused with the idea of 'individual land-titles' that was discussed in Section 1.3.1. As trans-human pastoralists, the Maasai have traditionally 'protected' grazing lands in more humid areas for use during the dry season. Today, little of this traditional 'dry-season' pasturage is still available. Thus, these protected, dry-season grazing areas may be a local adaption of an indigenous livestock management practice.
Table 4: Means and Standard Deviation for Soil Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>17.5 ± 6.0</td>
</tr>
<tr>
<td>Value</td>
<td>3.0 ± 0</td>
</tr>
<tr>
<td>Chroma</td>
<td>1.7 ± 1.1</td>
</tr>
<tr>
<td>Sand</td>
<td>24.1 ± 18.9</td>
</tr>
<tr>
<td>Clay</td>
<td>37.0 ± 5.6</td>
</tr>
<tr>
<td>Percent</td>
<td>27.4 ± 8.0</td>
</tr>
<tr>
<td>Size</td>
<td>9.5 ± 6.3</td>
</tr>
<tr>
<td>Aggsize</td>
<td>5.7 ± 2.6</td>
</tr>
</tbody>
</table>

$n = 698$
characteristics that were measured. While the figures for Hue, Value and Chroma are reported separately, to interpret their meaning they were combined into a single composite value (Color). This synthesized value corresponds most closely with the 7.5YR 3/2 or Dark Brown color chip in the Munsell Chart.

Patch soils are generally medium textured clay loams. To evaluate the dominant soil texture, confidence intervals (Prob < 5%) were constructed for Clay (37.0 ± 0.01 standard error) and Sand (24.1 ± 0.02 standard error) and these were compared to a Textural Triangle (Agriculture Canada 1974).

The mean for stone size was 9.5 ± 6.3 cm, covering 27.35 ± 8.0% of the average SUBPLOT. Almost three-quarters (72%) of the soils were moderately developed, with angular blocky peds averaging 5.76 cm ± 2.61 cm in size.

3.3.2.1 Spatial Heterogeneity

Results of the variance component procedure are reported in Table 5. Overall, the variability within patches (PLOT) is always greater or equal to the variability among patches (SITE), and is always greater than the variability within subplots. Table 5 clearly shows that two distinct scales of spatial variation were identified using this procedure. In the first case, SITE and PLOT account for approximately the same amount of variation for Hue, Chroma and Size. In other words, within and between patch variability is roughly the same. In the second group, it is within-patch (PLOT) heterogeneity that accounts for most of the variation in Sand, Clay, Percent and Aggsizes.
The variability at the level of SITE and PLOT explains almost all the variation recorded in Hue (88%), Chroma (83%) and Size (89%), with each parameter accounting for roughly the same proportion of the overall variability (Hue 42%, 46%; Chroma 48%, 35%; and Size 45%, 44%). The effect of SUBPLOT is relatively minor for these variables.

In the second case, within-site heterogeneity (PLOT) accounts for the majority of the variation in Sand (64%), Clay (55%), Percent (56%) and Aggsize (59%). Between-site variability is much less important (Sand, 6%; Clay, 16%; Percent, 21%; Aggsize, 16%) than in the first category. Interestingly, small-scale variation (ERROR) is more important, accounting for roughly one-quarter of the total variability.

### Table 5: Variance Components expressed as a percentage of total variation

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>Site (%)</th>
<th>Plot (%)</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>41</td>
<td>46</td>
<td>12</td>
</tr>
<tr>
<td>Chroma</td>
<td>48</td>
<td>35</td>
<td>16</td>
</tr>
<tr>
<td>Sand</td>
<td>6</td>
<td>64</td>
<td>30</td>
</tr>
<tr>
<td>Clay</td>
<td>16</td>
<td>55</td>
<td>29</td>
</tr>
<tr>
<td>Size</td>
<td>45</td>
<td>44</td>
<td>11</td>
</tr>
<tr>
<td>Percent</td>
<td>21</td>
<td>56</td>
<td>23</td>
</tr>
<tr>
<td>Aggsize</td>
<td>16</td>
<td>59</td>
<td>25</td>
</tr>
</tbody>
</table>
Principal Component Analysis

Principal Component Analysis is a valuable tool for summarizing the large amounts of data collected in exploratory studies (Greig-Smith 1983) such as this one. In particular, graphing the ordination axes may help to generate testable hypotheses that could be addressed in further research.

Principal Component eigenvalues and their relative contribution to overall variability are reported in Table 6. No single principal component accounts for a majority of the overall variation. The first principal component accounts for 22% of the total variation, while the second and third axes account for 18% and 16%, respectively. Cumulatively, the first three principal components account for just more than 50 percent of the total variation. Table 7 shows the eigenvector loading for each variable relative to the first three principal components. The first principal component is most closely associated with soil texture (Clay, 0.61; Sand, 0.44) and 'stoniness' (Percent, 0.44). The variability in stone size (Size, -0.28) is also important, but has a negative value.

While drainage patterns may be most closely associated with the first principal component, the relationships of the variables along the second axis (PRIN 2) are unclear. Chroma is negatively associated with PRIN 2 (-0.61), while Aggsize and Size have high positive values (0.50, 0.34, respectively). Size has a similar loading on the second principal component, but the direction of this influence is now positive (0.34). Both Hue and Size are positively correlated to the third principal component (0.44; 0.42, respectively). Three variables (Aggsize, Percent and Chroma) have a significant negative correlation along this axis (-0.52; -0.36; -0.24, respectively).
Table 6: Eigenvalues of the Correlation Matrix

<table>
<thead>
<tr>
<th>Principal Component</th>
<th>Eigenvalue (λ)</th>
<th>Proportion (%)</th>
<th>Cumulative (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIN 1</td>
<td>1.74</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>PRIN 2</td>
<td>1.47</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>PRIN 3</td>
<td>1.25</td>
<td>16</td>
<td>56</td>
</tr>
<tr>
<td>PRIN 4</td>
<td>1.07</td>
<td>13</td>
<td>69</td>
</tr>
<tr>
<td>PRIN 5</td>
<td>0.99</td>
<td>12</td>
<td>82</td>
</tr>
<tr>
<td>PRIN 6</td>
<td>0.64</td>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>PRIN 7</td>
<td>0.56</td>
<td>7</td>
<td>97</td>
</tr>
<tr>
<td>PRIN 8</td>
<td>0.27</td>
<td>3</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 7: Eigenvectors of Soil Variables and the First Three Principal Components

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>Principal Component 1</th>
<th>Principal Component 2</th>
<th>Principal Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>-0.18</td>
<td>-0.01</td>
<td>0.44</td>
</tr>
<tr>
<td>Chroma</td>
<td>0.01</td>
<td>-0.64</td>
<td>-0.24</td>
</tr>
<tr>
<td>Sand</td>
<td>0.44</td>
<td>0.35</td>
<td>0.26</td>
</tr>
<tr>
<td>Clay</td>
<td>0.61</td>
<td>-0.18</td>
<td>0.29</td>
</tr>
<tr>
<td>Percent</td>
<td>0.45</td>
<td>0.16</td>
<td>-0.37</td>
</tr>
<tr>
<td>Size</td>
<td>-0.28</td>
<td>0.34</td>
<td>0.42</td>
</tr>
<tr>
<td>Aggsiz e</td>
<td>-0.16</td>
<td>0.50</td>
<td>-0.53</td>
</tr>
</tbody>
</table>
Principal component axes were plotted for comparison and are shown in Figure 4a. Figure 4a shows each variable relative to its position on the first and second principal components, and reveals two distinct groups with two outliers.

One group (Sand and Percent) is positively correlated to the first two principal components. Clay could be considered as part of this group, due to its low negative value along the second axis. The second group (Aggsize and Size) is positively correlated along the first Principal Component, but negatively correlated along the second. Hue and Chroma are both outliers. Hue is relatively unimportant along both axes. Chroma has a high negative correlation with the second Principal Component, but a low influence along the first.

Figure 4b locates each variables position on the first and third Principal Components and reveals three distinct groups. One group (Sand and Clay) is positively correlated on both axes. The second group (Size and Hue) is positively correlated with the third Principal Component, but negatively associated with the first. Chroma and Percent are positively correlated along the first Principal axis, but negatively correlated along the third. Aggsize is unique and is negatively correlated along both axes.

The variables along the second and third Principal Components are shown in Figure 4c. Size and Sand form a distinct group, with positive values along both axes. The second group (Aggsize and Percent) is positively correlated along the second principal component, and negatively associated with the third. Hue and Clay have positive $r^2$ values along the second axis, but are negatively correlated with the

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*The points on the graph represent the intersection of the $r^2$ values between each variable and the respective principal components that are reported in Table 7.*
Figure 4: Principal Components Analysis for Soil Variables
third. Chroma is distinct, and is negatively correlated along both axes.

3.3.2 Plant Study

The Plant Study results are summarized in Table 8. Average densities ranged from a high of 40.17 plants per hectare at Site 2 to a low of 12.5 plants per hectare at Site 3. The overall mean density was 22 plants per hectare.

Mean stem-base circumference was $6.5 \pm 2.96$ cm, with a high of $7.1 \pm 2.9$ cm measured at Site 9 and low of $5.4 \pm 2.2$ cm at Site 1.

The mean length of the longest woody vine was $74.2 \pm 49$ cm, with the greatest mean length of $88.5 \pm 51.1$ cm at Site 2 and a low of $50.9 \pm 48.8$ cm at Site 6.

Correlation Coefficients ($r_{12}$) for length by circumference were significant (P > 0.001) for all sites, with the exception of Site 1 ($r_{12} = 0.13$). Seventy percent of the sites had higher $r_{12}$ values than the mean ($r_{12} = 0.75$). The highest correlation coefficients were in Sites 9 and 10 ($r_{12} = 0.82$), and the lowest in Site 1 ($r_{12} = 0.13$).

3.2.3.1 Associations

Seventy-one percent of all vines were climbing on shrubs (59.5%), trees (12.0) or combination of the two (0.2%) (Table 9). Most of the plants observed were scrambling/climbing on low shrubs (< 1 meter). The number of plants in this category ranged from a high of 75.2 % at Site 4 to a low of 45.6 % at Site 2.

Few vines encountered grew in association with Trees (12%). Site 3 has the highest percentage (17.6%) and Site 7, the lowest (5.7%).
Table 8: Summary of Plant Study Data

<table>
<thead>
<tr>
<th>Site</th>
<th># Plants (plants/ha)</th>
<th>Density (plants/ha)</th>
<th>Circumference (cm)</th>
<th>Length (cm)</th>
<th>Pearson Correlation Coefficient ($r_{12}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>102</td>
<td>25.5</td>
<td>5.4 ± 2.2</td>
<td>61.1 ± 33.3</td>
<td>0.13 ns</td>
</tr>
<tr>
<td>2</td>
<td>241</td>
<td>40.2</td>
<td>6.1 ± 2.6</td>
<td>88.5 ± 51.1</td>
<td>0.63 **</td>
</tr>
<tr>
<td>3</td>
<td>125</td>
<td>12.5</td>
<td>6.4 ± 3.4</td>
<td>75.5 ± 60.4</td>
<td>0.81 **</td>
</tr>
<tr>
<td>4</td>
<td>347</td>
<td>21.7</td>
<td>6.7 ± 3.2</td>
<td>81.9 ± 50.5</td>
<td>0.82 **</td>
</tr>
<tr>
<td>5</td>
<td>192</td>
<td>21.3</td>
<td>6.2 ± 2.7</td>
<td>66.5 ± 47.5</td>
<td>0.73 **</td>
</tr>
<tr>
<td>6</td>
<td>27</td>
<td>27.0</td>
<td>6.1 ± 4.1</td>
<td>50.9 ± 48.8</td>
<td>0.89 **</td>
</tr>
<tr>
<td>7</td>
<td>35</td>
<td>17.5</td>
<td>5.7 ± 2.9</td>
<td>59.9 ± 40.1</td>
<td>0.79 **</td>
</tr>
<tr>
<td>8</td>
<td>169</td>
<td>18.8</td>
<td>6.6 ± 3.0</td>
<td>74.4 ± 47.3</td>
<td>0.78 **</td>
</tr>
<tr>
<td>9</td>
<td>416</td>
<td>23.0</td>
<td>7.1 ± 2.9</td>
<td>76.5 ± 48.4</td>
<td>0.82 **</td>
</tr>
<tr>
<td>10</td>
<td>284</td>
<td>21.8</td>
<td>6.4 ± 2.8</td>
<td>62.5 ± 42.5</td>
<td>0.82 **</td>
</tr>
<tr>
<td>All</td>
<td>1938</td>
<td>22.9</td>
<td>6.5 ± 2.9</td>
<td>74.2 ± 49.0</td>
<td>0.75 **</td>
</tr>
</tbody>
</table>

* significant 0.05;  ** significant 0.001  ns not significant
Table 9: 'Association' Type Expressed as a Percentage of Total Number of Plants

<table>
<thead>
<tr>
<th>Site</th>
<th>Alone</th>
<th>Shrub</th>
<th>Tree</th>
<th>Alone/Shrub</th>
<th>Shrub/Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30.4</td>
<td>56.9</td>
<td>12.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>39.8</td>
<td>45.6</td>
<td>13.3</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>33.6</td>
<td>48.8</td>
<td>17.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>16.0</td>
<td>75.2</td>
<td>7.8</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>32.8</td>
<td>54.7</td>
<td>11.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>40.7</td>
<td>48.1</td>
<td>7.4</td>
<td>3.7</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>37.1</td>
<td>57.1</td>
<td>5.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>26.0</td>
<td>58.0</td>
<td>14.2</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>9</td>
<td>24.8</td>
<td>59.4</td>
<td>15.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>28.5</td>
<td>63.0</td>
<td>8.1</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>All</td>
<td>27.9</td>
<td>59.5</td>
<td>12.0</td>
<td>0.4</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Over one-quarter (27.6%) of the plants surveyed exhibited a sprawling habit, i.e. did not require external mechanical support. Site 6 had the greatest percentage of vines growing 'alone' (40.7), and not surprisingly, also had the shortest mean vine length.

The principal and minor axes and the corresponding confidence ellipses for the 'association' data are reported in Figures 5 to 8. Ellipses do not appear to be orthogonal because the scales along the X and Y axis are different (Sokal and Rohlf 1967). The shape of the ellipse is a function of the correlation between the variables and the size (area) of the ellipse is a function of the confidence coefficient (1-α). In data that are highly correlated, the Principal Axis accounts for the majority of overall variance (λ₁ >> λ₂), and the ellipse is very narrow and elongated.

Both circumference and length tend to increase according to the height of the other woody vegetation that acts as a physical support for V. pseudolabilab vines. The variable 'Alone' (Figure 6), which measures the plants not passively climbing, had the smallest means for both circumference and length (5.2 ± 2.0 cm; 49.9 ± 26.4 cm, respectively), along with the lowest r₁² value (0.49). Plants found sprawled on associated species less than 1 meter in height (Shrubs) (Figure 7) had the second smallest means for circumference and length (6.3 ± 2.5; 69.1 ± 33.7 cm, respectively) but had the greatest r₁² value (0.70). Stems climbing up larger (>1 meter) woody species (Trees) (Figure 8) had the greatest mean circumference and length (10.4 ± 3.5, 155.3 ± 67.2, respectively) with an intermediate r₁² value of 0.64.
Figure 5: Principal Axes and Confidence Ellipses for Length and Circumference of Longest Woody Vine for Overall Plant Study Data
Figure 6: Principal Axes and Confidence Ellipses for Length and Circumference of Longest Woody Vine for 'Alone' Plant Data
Figure 7: Principal Axes and Confidence Ellipses for Length and Circumference of Longest Woody Vine for 'Shrubs' Plant Study Data
Figure 8: Principal Axes and Confidence Ellipses for Length and Circumference of Longest Woody Vine for 'Trees' Plant Study Data
3.4 Discussion

3.4.1 Soils

For comparison, the study sites were compared to the Exploratory Soil Map of Kenya (Kenya Soil Survey 1982). All of the sites are along the margins of the 'Bottomlands', which are long, narrow strips stretching from north to south in the southern region of the Kenyan Rift Valley. The Bottomland soils are deep, imperfectly drained clay loam to clay Vertisols, ranging in from dark brown to olive grey in color, with many boulders and stones. I never saw *V. pseudolabilab* on the Cambisols (‘red’ soils) which otherwise are the dominant soils in the region. This general observation, although not tested, was confirmed by local informants, and concurs with observations on the habitat of *V. pseudolabilab* in northern Tanzania (Vincent 1985).

3.4.1.1 Spatial Heterogeneity

Even to the casual observer, the spatially heterogenous nature of vegetation in semi-arid East Africa is immediately obvious; yet our understanding of the ecological mechanisms underlying these patterns is rudimentary. Historically, East African ecology has been based largely on qualitative observation and physiognomic classification (McNaughton 1983); more recent research has explicitly addressed spatial heterogeneity at scales likely to be relevant to community structure and individual organisms.
While the physical properties of soils within patches of *V. pseudolablab* were spatially heterogeneous, the scale at which this variation expressed itself varied for the different properties, and more importantly, the contribution of the individual parameters to overall variability differed. Indications are that the percentage of clay and sand in the soil (Texture), 'stoniness' (Percent), and aggregate development and size (Aggsize) are important ecological influences. It is within patch heterogeneity (PLOT) that accounts for most of the variation in Sand, Clay, Percent and Aggsize. Between site variability is much less important that in the first category. Drainage patterns are most closely associated with the first Principal component.

**Color**

While soil color was found to vary similarly between and within sites, it contribution to overall variation was small. Value, one component of Color, remained the same among all sites and was therefore not analyzed further. The contribution of the other two Color variables (Hue and Chroma) to overall variability was unimportant, as their low eigenvector loadings on the first ordination axis shows (Figure 4a).

Although no direct evidence exists in the Loodokilani regions to support these results, data from the Lake Naivasha region, 120 km north of Loodokilani, shows that soil color is relatively invariable at medium and small-scales. Ambrose and Sikes (1991) sampled 1000 meter transects, and found that variability in soil color was 'negligible'. Like Vincent (1985) in Tanzania, I only saw *V. pseudolablab* on 'dark brown soils'; never on the 'red', sandy soils which are conspicuous throughout the Mangola and Loodokilani regions. These observations were collaborated through extensive
questioning of local informants.

Texture

The percentage of Clay and Sand varied more within than between patches and both made an important contribution to overall variation on first two ordination axes (Figure 4a). These results suggest that a specific soil textural pattern may be associated with V. pseudolablab.

Again, no direct evidence is available from Loodokilani to support this hypothesis but related works point to the importance of soil texture in influencing soil moisture and nutrient patterns. In the Serengeti, de Wit (1978) clearly identified the close correlation between vegetation types and the physical characteristics of underlying soils; more precisely, spatial variations in plant communities closely follow edaphic heterogeneity. McNaughton (1983) more precisely showed that these vegetation communities could be closely correlated ($r_{12} = 0.65; \text{Prob} < 0.01$) with the clay content of associated soils.

Local variations in texture impact directly on differential distributions in soil moisture (Amon 1975; Bristow et al. 1984; Robertson and Gross 1994) and nutrient availability (Lechowicz and Bell 1991; Handley et al. 1994; Stark 1994). Nobel (1994) has shown that for three desert succulents (Agave deserti, Ferocactus acanthodes, and Opuntia ficus-indica) in sandy loam and Gossypium hirsutum in loamy sand, water loss from individual root systems during dry pulses is primary controlled by textural properties of the soil.
Percent and Size

While the variation in stone size was roughly the same between and within patches, the number of stones (Percent) was relatively constant across Sites. In addition, Percent had a high, positive association with the first principal component, while Size had a smaller, negative loading along this axis.

In the field, V. pseudolablab is clearly associated with areas containing many large rocks, yet the results of this study suggest that the size of the stones may be less important than the area these stones cover. Stark (1994) has hypothesized that high percentages of stones may increase patchiness in nutrient supply by segregating pockets of soil. In particular, this type of heterogeneity has been shown to favor plants with extensive (i.e.-shrubs) rather than intensive (i.e.-grasses) root systems (Walter 1979; Stark and Redente 1985). Large stones (> 20 cm) may negatively impact on species distribution, perhaps as large stones provide a mechanical hindrance to root penetration into the underlying soil.

3.4.2 Plant Study

3.4.2.1 Densities

The average density of V. pseudolablab in the Mangola area of Tanzania (Vincent 1985) was $1850 \pm 1041$ plants per hectare (based on 4 patches), while the
mean patch densities in this study were 22.9 ± 7.3 plants per hectare, although the
mean patch sizes were comparable (5 hectares and 8 hectares, respectively).

Why do densities of *V. pseudolablab* differ so dramatically between these two
studies, both carried out in regions with a similar climate and geography? Although the
two studies are not directly comparable, a close scrutiny of the two provides may
provide some clues to answer this question.

In Loodokilani, older community members often commented that numbers of *V.
pseudolablab*, along with many other 'useful' plant species, have decreased over the
years. They attribute this phenomena to a generalized environmental degradation in the
region, in part due to the historical reduction of their extensive grazing lands (see
Section 1.3.1). It is this reduction of grazing land, and the greater pressures thereby
placed on remaining resources, that lies at the core of 'overstocking' in many areas
inhabited by pastoralists around the world (Becker 1984; Bénéfice 1984; Campbell
1984; Arhem 1985; Fleuret, 1986; Sperling 1987; Bernus 1988; de Garine and Koppert

Further evidence of the relationship between grazing and low populations of
tuberous resources is found in the low density (45 plants per hectare) of *Vigna
frutescens*, a close botanical relative of *V. pseudolablab*, in one of Vincent's patches.
This density figure contrasts starkly to the much greater numbers found in all other
study sites. This particular patch, unlike others, was located in an area heavily grazed
by domestic livestock. Vincent (1985:84) notes that cattle had impacted severely on the
surrounding vegetation, reducing it to 'short (< 1.5 m), broken shrubs and bare ground'.
In my study, the lowest densities figures of *V. pseudolablab* were found at Site 3, which
is located in an area with a higher concentration of cattle than other sites (Appendix III). The importance of grazing on semi-arid vegetation in East Africa is well-documented (cf. McNaughton 1983; Belsky 1986) and it may be that grazing pressures exert an important control on the distribution and density of *V. pseudolablab*.

While anthropogenic factors may be partially responsible for the discrepancies in density figures between my and Vincent's study, differences in research design between the two studies raise some interesting questions. The limited applicability of many traditional ecological methods to the study of tropical vegetation, which is often highly aggregated, has long been recognized (Richards 1957; Prince 1986; Kent and Coker 1992). Vincent used quadrats to sample transects across her sites. However, quadrat size and placement, transect location and the percentage of each patch that was sampled varied widely from site to site. Close examination of the results show a trend for patch densities to decrease as sampling size increases. Traditional techniques in vegetation ecology, such as those used by Vincent, depend on the population of interest exhibiting a random distribution (Grieg-Smith 1983; McNaughton 1983), clearly not the case for species such as *V. pseudolablab*, whose distribution is marked by a high degree of spatial heterogeneity.

### 3.3.2.2 Associations

The density of vegetation within the patches of *V. pseudolablab* varied greatly. Common features were short, shrubby vegetation with few trees, and trees were often confined to the outer margins of the patch. This fact is reflected in the results of this
study which found most specimens sampled were clambering (passively climbing) over shrubs (woody species less than 1.5 m). No specialized climbing structures (i.e. tendrils, hooks) were observed.

While the majority of individual plants were encountered were associated with support structures, one quarter of established plants (i.e.- those with a lignified leader stem) were self-supporting. In lowland tropical forest in both Southeast Asia and Latin America, young plants of many scandent species, especially lianas, can typically achieve 30-40 cm of vertical growth before becoming 'unstable', with some species reaching heights of 1-2 meters before requiring mechanical support (Putz and Holbrook 1991). Although there is little data on semi-arid lianas, Rundel and Franklin (1991) note that in open mesic landscapes, many vines are trailing species, spreading widely over the ground surface, and/or clambering over rocks.

Availability of suitable supports is a major constraint on the height growth of forest vines (Putz 1984; Putz and Holbrook 1991), and the results of this study clearly show that height of the associated species is positively correlated with stem length in this species of woody liana.
CHAPTER 4  PROPAGATION

Many people in Kenya cite lack of technical information and suitable propagative material as the main reasons why indigenous plant species are not more widely cultivated (Kiambi and Opole 1992). The materials used in this study, in particular the propagator, were chosen to overcome the limitations of many standard technologies in rural Africa. Therefore, the aim of this research project is the development of a low-cost, technically appropriate method for rooting *V. pseudolabiab* stem cuttings.

A successful propagation method must have reliable stock material (Hartmann et al. 1990), besides being technically and economically feasible. Attempts to collect sufficient seed through two growing seasons were unsuccessful, due to low production. This phenomenon is common in many mesic plants (Amon 1975). Low seed production in cowpea has been related to water stress during flowering (Lush et al. 1980). Seed production is also related to the reproductive biology of the species itself. *Vatovaea pseudolabiab*, like many tropical lianas (Hegarty and Caballé 1991) may primarily reproduce clonally through root propagation (Sept 1984; Vincent 1985).

In addition, the collection of material must consider the owners of these resources and the surrounding environment. The roots of *V. pseudolabiab* are deeply buried in hard and rocky soils, making their excavation almost impossible with local technologies. In addition, it is extremely destructive to important grazing land and ultimately to the plant itself.

Thirdly, limited transportation restricts the collection area. In addition, many
modern nursery technologies (i.e. overhead mist, glasshouses) are not appropriate, due to high costs, lack of material and power sources and the need for high levels of technical expertise.

The research strategy consisted of three major steps; a preliminary study (Pretrial) from December 1994 to January 1995 in Kilinito, followed by formal experiments at Kilinito from March to May, 1995 and in Nairobi from June to July, 1995.

4.1 Experiment 1: Pretrial

The objectives of the pretrial were:

1) to provide initial information on the relative ease or difficulty of rooting cuttings and narrow down the number of treatments that would be tested in larger trials.

2) to establish a protocol for the larger experiments; including the development of collection and preparation methods suitable for local conditions (i.e. limited transport, power and water supplies) that would reduce physiological stress to propagative material.

3) to indicate an experimental 'timeline' to ensure that sufficient stem material was collected when available.

4.1.1 Methods

4.1.1.1 Sampling

Experimental material was sampled from Sites 2 and 3. At this early point in
the study period, Sites 1-3 had been identified, but only the first two contained enough material for the experiments. Whole woody and herbaceous vines were harvested from wild stock early in the morning of November 27, 1994. They were placed immediately into 'Ziploc' plastic bags to which a small amount of cool water was added and transported back to camp by motorcycle.

When we reached camp, the vines were placed under shade to keep them as cool as possible until early evening when they were prepared for sticking as described below.

4.1.1.2 Preparation

The cuttings were prepared under shade immediately next to the propagation facility, in the early evening of November 27, 1994. Throughout preparation, the material was sprayed often with a hand-held mister. Woody and herbaceous vines were separated, and twenty of each with six or more nodes were randomly selected.

Leafy cuttings

Herbaceous material was prepared first. Shoot tips were removed. Beginning at the basal end, three cuttings (single, double or triple nodes) were taken from each vine, in a random order. Cuttings were then grouped according to node number. For cuttings with two or more nodes, leaves from the bottom nodes were removed.

To test the effects of rooting powder, ten cuttings of each node size were
selected. Half of each group were dipped to a depth of 2-5 mm in Seridex 2 (0.3% IBA, May and Baker, Ltd.) a commercial rooting powder widely available in Kenya. Excess powder was removed by light tapping (Macdonald 1986). Cuttings were randomly placed into a 'non-mist' propagator (see Section 4.1.3.3), to a depth of half the cutting.

To test 'time to rooting', the remaining cuttings were placed in the propagator without any treatment.

**Woody Cuttings**

The general methods and the number of cuttings used were the same as for herbaceous cuttings, with a few modifications. A sloping cut was made just above the axillary bud and an internodal cut about 2.5-3.0 cm below the base of the leaf petiole (Macdonald 1986). Cuttings were not wounded.

### 4.1.1.3 Rooting Environment

The Plant Propagation Unit, a national research facility that operates as part of the National Museums of Kenya, has adopted the non-mist propagator (Leakey et al. 1990) for most of their research programs. Many common western technologies (i.e. overhead mist, glasshouses) are not financially or technically feasible in many developing countries.

The frame of the non-mist propagator is constructed from wood treated against termite damage. The base is enclosed in a double layer of polythene, ensuring it is
watertight (Leakey 1989) which eliminates daily watering. The base is then covered with a thin layer of sand. A 10-15 cm stratum of large stones (6-10cm) comes next. These are covered by successive layers of small stones (3-6 cm) and gravel (0.5-1 cm) to a total depth of 20 centimeters. The main function of the gravel is to act as a support for the fine sand (2-3 millimeters in diameter) used as a rooting medium.

A hollow plastic tube inserted into the layers is used to monitor the water level and to add water. The rest of the frame is covered tightly with a single piece of clear polythene. A closely-fitting lid in two sections (Leakey et al. 1990), also covered in polythene, is attached.

At Kilinito, a propagator had been built before I arrived, but the polythene covering, which generally only lasts for six months (Muthoka pers. comm.), needed to be replaced. The propagator layers were removed, separated, rinsed with treated (1% bleach) water, and set aside to dry. The bottom of the propagator was lined with new polythene and attached with small carpenter tacks. The original materials were replaced. Additional sand and gravel were obtained from a local quarry. Then the propagator was watered with rain runoff. To ease sticking of the cuttings, small holes were made in the rooting medium with a small twig (Macdonald 1986).

Throughout the year, photoperiod in Kajiado ranges between 11.5 and 12.5 hours daylight day\(^{-1}\) (Survey of Kenya, 1970). To reduce ambient temperatures within the propagator, it had been built under shade trees and I covered it with nylon mesh and burlap sacks during the day. To maintain high relative humidity, the cuttings were misted in early morning and late evening and the propagator was never opened in the heat of the day (Leakey et al. 1990).
4.1.1.4 Parameters

The three treatments were Habit (Woody and Herbaceous), Node (single, double or triple nodes) and Powder (the effect of the absence or presence of the rooting powder). The variable measured was Rooting Frequency (percentage of cuttings that rooted)(Leaky et al. 1990).

4.2 Propagation Experiments: Kilinito and Nairobi

4.2.1 Methods

The general collection and preparation methods follow the procedures outlined in Section 4.1.1. Samples from all ten sites (Figure 3) were included in the Kilinito trials but samples from Sites 6 and 7 could not be collected for the experiment in Nairobi, due to lack of material at these sites.

Vine collection for the Kilinito trials was carried out from March 21-28, 1995. Cuttings were collected, prepared and placed randomly into the propagator on the same day. Cuttings used in Nairobi were collected on June 2 and 3, 1995, stored in coolers and transported in a Landrover. They were prepared and placed randomly into the propagator in the evening of the 3rd and the morning and evening of the 4th.

Individual vines were not evaluated for node number, because the collection of enough similar-sized vines would have been impossible. Initially, herbaceous material was separated from woody growth. Both single and double node cuttings were taken from
each stem, alternating from the basal end to reduce any positional effects. The apical node was not used. Cuttings were then grouped according to the number of nodes and half of each group dipped in rooting powder as discussed in Section 4.1.1.

The three parameters measured were Habit (Woody and Herbaceous), Node (Single and Double nodes), and Rooting Powder. Rooting frequencies for each of these parameters were assessed.

4.2.2 Data Analysis

A $2^3$ factorial design was used in both experiments. The treatment hierarchy was 100 cuttings of each Habit (Woody and Herbaceous) with fifty of each node number (Single and Double nodes). Each node number was then further divided in half, with rooting powder applied to one group and compared against a control. This method was used for cuttings from each of the ten sites for the Kilimoto experiment and from eight sites for the Nairobi experiments.

The data was analyzed as an unbalanced Model II $2^3$ factorial model.

The model statement is:

$$Y_{ik} = \mu + \text{Habit}_i + \text{Node}_j + \text{Powder}_k + \text{Habit} \times \text{Node}_j + \text{Habit} \times \text{Powder}_k + \text{Habit} \times \text{Node} \times \text{Powder}_{ijk} + e_{ijk}$$

where $Y_{ik}$ is the number of roots of the $i_{th}$ Habit, the $j_{th}$ Node number and the $k_{th}$ Powder; $\mu$ = the parametric mean of the population; Habit = the random effect of woody or herbaceous habit; Node = the random effect of number of
nodes; Powder = the effect of the absence or presence of rooting powder; Habit Node = the random effect of the interaction between habit and node; Habit Powder = the effect of the interaction between Habit and Powder; Node Powder = the effect of the interaction between Node and Powder; Habit Node Powder = the random effect of the interaction between Habit, Node and Powder; and = the effect of the random error.

All data were analyzed using SAS General Linear Models procedure.

4.3 Results

4.3.1 Pretrial

Rooting had occurred in most herbaceous cuttings by Week 4, and in woody cuttings by Week 6. Leafy green cuttings rooted better than woody cuttings (73% vs. 63%). Differences due to node number were not large (Single, 65%; Double, 70%; Triple, 70%). More woody and herbaceous cuttings rooted without any rooting powder (59% versus 40% and 64% versus 36%, respectively).

4.3.2 Propagation Experiments

Rooting Frequencies

Rooting frequencies at Kilinito and Nairobi are compared in Table 10. Both
Table 10: Rooting frequencies of Woody and Leafy cuttings at Kilinito and Nairobi by site

<table>
<thead>
<tr>
<th>Site</th>
<th>Woody (%)</th>
<th>Leafy (%)</th>
<th>Woody (%)</th>
<th>Leafy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>86</td>
<td>66</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>79</td>
<td>36</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>73</td>
<td>90</td>
<td>34</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>82</td>
<td>83</td>
<td>46</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>59</td>
<td>30</td>
<td>46</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>33</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>7</td>
<td>67</td>
<td>62</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>8</td>
<td>78</td>
<td>81</td>
<td>36</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>79</td>
<td>85</td>
<td>37</td>
<td>45</td>
</tr>
<tr>
<td>10</td>
<td>76</td>
<td>84</td>
<td>63</td>
<td>6</td>
</tr>
<tr>
<td>All</td>
<td>75</td>
<td>65</td>
<td>39.5</td>
<td>23.5</td>
</tr>
</tbody>
</table>
types of cuttings (woody and herbaceous) rooted better in Kilinito than Nairobi (woody 75% versus 39.5%; leafy 65% versus 23.5%). For woody cuttings at Kilinito, rooting percentages ranged from 59%-86%, and for leafy cuttings, from 30%-90%. Of note are the low values for leafy cuttings from Sites 2 (36%); five (30%) and six (33%), which are more typical of those obtained in Nairobi.

Mean root number for woody and leafy cuttings at each location are reported in Table 11. At Kilinito, leafy cuttings developed more roots than woody cutting (12.3 ± 9.8 versus 8.1 ± 6.4), but this was reversed in Nairobi (5.4 ± 3.7 versus 14.3 ± 7.7).

Table 11: Number of roots and standard deviation by habit and location

<table>
<thead>
<tr>
<th>Location</th>
<th>Habit</th>
<th>Number of roots and standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilinito</td>
<td>Woody</td>
<td>8.1 ± 6.4</td>
</tr>
<tr>
<td></td>
<td>Leafy</td>
<td>12.3 ± 9.8</td>
</tr>
<tr>
<td>Nairobi</td>
<td>Woody</td>
<td>14.3 ± 7.7</td>
</tr>
<tr>
<td></td>
<td>Leafy</td>
<td>5.4 ± 3.7</td>
</tr>
</tbody>
</table>
The results from the Analysis of Variance are reported in Table 12 for Kilinito and in Table 13 for Nairobi. At Kilinito, all first order interactions were significant (P< 0.01). Main effects (Habit, Node, and Powder) were also significant, but cannot be separated from the confounding effects of significant interactions. Only the three-way interaction was not significant.

For the Nairobi data, only Habit was significant.

**Table 12: Analysis of Variance for Propagation Experiment in Kilinito** (n=1389)

<table>
<thead>
<tr>
<th>Source</th>
<th>Numerator</th>
<th>Denominator</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
<td>ms</td>
<td>df</td>
</tr>
<tr>
<td>Habit</td>
<td>1</td>
<td>51.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Powder</td>
<td>1</td>
<td>583</td>
<td>1.5</td>
</tr>
<tr>
<td>Habit*Powder</td>
<td>1</td>
<td>1.26</td>
<td>1.0</td>
</tr>
<tr>
<td>Node</td>
<td>1</td>
<td>0.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Habit*Node</td>
<td>1</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Node*Powder</td>
<td>1</td>
<td>4.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Habit<em>Node</em>Powder</td>
<td>1</td>
<td>0.001</td>
<td>1381</td>
</tr>
</tbody>
</table>

▼ synthesized values

+ Satterwaite's approximation

* significant 0.05  ** significant 0.01  ns not significant

✝Dependant variable: number of roots
Table 13: Analysis of Variance for Propagation Experiment in Nairobi† (n=506)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>ms</th>
<th>df</th>
<th>ms*</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit</td>
<td>1</td>
<td>231</td>
<td>1.4</td>
<td>2.9</td>
<td>79.4*</td>
</tr>
<tr>
<td>Powder</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>0.9</td>
<td>0.5 ns</td>
</tr>
<tr>
<td>Habit*Powder</td>
<td>1</td>
<td>1.1</td>
<td>1.0</td>
<td>0.4</td>
<td>2.7 ns</td>
</tr>
<tr>
<td>Node</td>
<td>1</td>
<td>23</td>
<td>0.8</td>
<td>1.9</td>
<td>12 ns</td>
</tr>
<tr>
<td>Habit*Node</td>
<td>1</td>
<td>2.2</td>
<td>1.0</td>
<td>0.4</td>
<td>5.5 ns</td>
</tr>
<tr>
<td>Node*Powder</td>
<td>1</td>
<td>0.2</td>
<td>1.0</td>
<td>0.4</td>
<td>0.4 ns</td>
</tr>
<tr>
<td>Habit<em>Node</em>Powder</td>
<td>1</td>
<td>0.4</td>
<td>498</td>
<td>0.9</td>
<td>0.5 ns</td>
</tr>
</tbody>
</table>

† synthesized values

+ Satterwaite's approximation

* significant 0.05  ** significant 0.01  ns not significant

†Dependant variable: number of roots
4.3 Discussion

Overall performance of cuttings was much better in Kilinito. Most of the losses of leafy cuttings in Nairobi were due to rotting. Susceptibility to rotting under high humidity is common in many semiarid species (Leakey et al. 1990). Kilinito is hotter and drier than Nairobi and better mimic conditions in situ. The ambient temperatures in the propagator were likely higher and the relative humidity lower.

Cuttings for the Nairobi experiments were collected over two days, during which they were left for long periods in the back of the Landrover. While unavoidable, it is likely that cuttings were severely physiologically stressed. This hypothesis is supported by two results in the research. First, Habit was the only significant effect in the Nairobi data. Woody cuttings are less prone to loss of turgidity during preparation and harvest (Macdonald 1986) and rooting was more successful for this habit. Further evidence is provided by rooting differences of leafy cuttings in Kilinto and Nairobi. However, due to the significant effects of all first-order interactions in Kilinito, this conclusion is speculative.

The performance of leafy cuttings from Sites 2 and 5 in the Kilinito experiments were much worse than woody cuttings from the same sites. What features do these sites have in common? Both are fairly far from the experimental site, and due to lack of transport, cuttings were transported on foot. This meant that cuttings were carried in a backpack for 2-3 hours in midday sun, which would exert physiological stress to herbaceous material.
The status of the 'stockplant' affects cutting performance (Macdonald 1986; Hartmann et al. 1993). Important stockplant factors are juvenility, and water and nutrient status. Experimental materials for the Nairobi trials were collected late in the rainy season (May 1995). The stockplants had likely been subjected to some water stress, which may have affected cutting performance.
CHAPTER 5: CONCLUSION

The goal of this study was to further understanding of the ecology and propagation of an important wild food resource of the community of Loodokilani, Kajiado District, Kenya and by extension, contribute to its sustainable use. As such, the study is intended to make a contribution to an on-going effort to redress the problems of domestic-food security and environmental degradation that plague the region. The conclusion to this research therefore examines the extent to which these objectives have been achieved. The results of this study and other related research are analysed within the model developed by Arnold et al. (1985) (Section 2.2.1). To repeat, their evaluation criteria are:

1) Nutritional Composition
2) Domestication Potential
3) Relative yield
4) Desirability
5) Contribution to local food security

4) Nutritional composition

The nutritional content of the tubers have been documented by several authors (Vincent 1985; Maundu et al. 1993). The tuber is mostly water (83%) and
the low protein level (6.3% on a dry weight basis (dwb)), is equivalent to those of yam, sweet potato, taro and cassava (Vincent 1985). In comparison with other plant foods, these tubers are good sources of carbohydrates (53.2% dwb), although it is not known what type of sugars and starches they contain (Vincent 1985). The nutrient and energy content of the tubers does not differ significantly between wet and dry seasons (Vincent 1985; Maundu et al. 1993). In regions such as Loodokilani, where people regularly experience seasonal shortages in food supply, these wild resources may serve as good, year-round source of carbohydrate and protein. Although I met few adults who regularly exploit these tubers, there are some indications they are important as a wild food source for Maasai youth. Many adolescents spend up to twelve hours each day herding cattle (Nestel 1989). Wild plants, collected 'on the go', are often the only foods available during these long periods away from the homestead (Nestel 1989). How do these wild foods affect the nutrition of children in pastoral communities? While some limited information is available for household consumption of wild food products in Kajiado District (cf. Nestel 1989; Maundu et al. 1993) to the best of my knowledge, and that of my Maasai colleagues, no research has studied consumption patterns of youths while in the field. Existing dietary studies focus on consumption habits within the homestead. Within the household, it is primarily the new leaves, pods and seedlings eaten by both humans and animals. However, to date, nutritional analyses for these plant parts are not available.
Domestication potential

Domestication potential, as outlined by Arnold et al. (1985) is a composite of time to first crop, ease of harvesting, accessibility of edible part, distribution (width of habitat), ease of propagation and handling and storage qualities.

Little is known about the physiology of wild legume tuber growth and reproduction. Pate and Dixon (1982) initiated some experiments and made some observations on these issues.

Most of the species described by Pate and Dixon flowered annually during the growing period. A small proportion (4%) exhibited the same pattern that I and Vincent have observed for V. pseudolablab, that is, flowering and seed production occurring before the new leaves were put out. In addition, seedlings emerge within a few weeks of the onset of the rains (pers. obs.). In addition, for some West Australian tuberous species, sexual reproduction was important for the first two years of a plant's life, after which vegetative reproduction assumed more importance (Pate and Dixon 1982).

The accessibility and ease of harvesting of the edible part depend on which plant part is exploited. The tubers of V. pseudolablab are deeply buried, often in hard, rocky soils. The Hadza in Tanzania collect only the tubers within the top 30-50 cm of soil. This strategy is suited to higher density patches, such as those in the Mangola region (Vincent 1985). In Loodokilani, where densities are much lower, it is primarily the easily-gathered leaves, pods and seedlings eaten within the household. However, new growth is also heavily grazed by the local animal.
population. In addition, seed production is limited, thus limiting the production of new seedlings.

In Loodokilani, *V. pseudoablabilab* is found in distinct patches found only occasionally throughout the region. The patches are associated with medium textured (clay-loam) soils, dark brown in color (7.5YR 3/2) with a moderate (30%) amount of medium sized stones (9.5 cm). The soils are mostly moderately developed (73%), with small (5.61), angular blocky aggregates. Most of the sites (70%) were associated with a slope.

Despite the less-than-ideal collection conditions and limited technology, rooting of both leafy and woody cuttings were successfully achieved both at Kilinito and in Nairobi. Rooting percentages for both types of cuttings were higher in the Kilinito experiments. It may be that cuttings are better adapted to the hotter and drier conditions in Kilinito. In addition, the proximity of stock plants to the propagators in Kilinito may have reduced the physiological stress suffered by transportation to Nairobi.

While softwood is the most common material used for vegetative propagation of tropical plant species (Hartmann et al. 1990; Macdonald 1986), the use of semi-ripe wood offers some unique advantages. Semi-ripe wood is less likely to suffer from loss of turgidity (Macdonald 1986), an issue important under the hot and dry collection conditions in many parts of Africa. In addition, woody cuttings could be rooted under nursery conditions during the late dry season, and 'planted out' at the onset of the rains. This would insure the longest period possible with the maximum amount of soil moisture to help the establishment of cuttings before the return of the
dry season. This is crucial in areas such as Loodokilani, with a pronounced wet/dry season and limited or no irrigation capacity. However, the effect of the dry season of stockplant health and subsequently successful rooting of cuttings, would have to be tested to optimize cutting collection time.

The research suggests that single node cuttings could be used, thus maximizing the number of cuttings per plant. It is still unclear whether rooting powder should be used. The Prelial results suggested that both types of cuttings (Woody and Leafy) rooted better without rooting powder. In the larger experiments (i.e. Kilinito and Nairobi) the effects of rooting powder were significant, but the results were confounded by the significant interaction between Habit and Powder. Further experiments are needed to speak definitively on this subject, but any positive effects of rooting compounds need to weighed against the often prohibitive cost of such items to low income communities.

In summary, there are a number of recommendations for rooting cuttings that can be drawn from this research. These are:

1) Woody cuttings should be collected in the dry season, and rooted in time for planting out at the onset of the rains.

2) Single node cuttings can be used, to maximize the number of cuttings per plant.

3) The research results are unclear as to whether or not rooting compounds contributed significantly to higher rooting frequencies.
The production of underground storage organs is a common adaptive strategy in many species of marginal environments, and offer some unique advantages for rural food security. Patches are close to those that exploit them and tubers can be left in the ground until needed. This factors is crucial to reducing the high losses often associated with storage and transportation of perishable foods in the tropics (FAO 1988b). Species such as V. pseudolabiab, which do not experience significant nutritional fluctuations between wet and dry seasons, may play a particularly significant role in this regard.

Another area of interest would be to develop methods for drying the leaves and pods of V. pseudolabiab. Related work has been undertaken by KENGO as part of the Indigenous Weaning Foods Programme in western Kenya. KENGO has developed low-technology methods for drying indigenous leafy green vegetables to develop nutritious and affordable weaning foods for local children.

While some of the technical issues surrounding the rooting of V. pseudolabiab cuttings have been addressed and general information on its ecology in situ, clearly the question of domestication of wild plant species must be addressed within the social and cultural milieu within which a particular plant is used. The community of Loodokilani, like all Maasai communities is primarily pastoral. Cattle, and animal by-products, are and will continue to remain, the preferred food source. In addition, there has been traditionally a 'taboo' against 'digging the soil' (i.e.- cultivating), although this is rapidly changing as the younger generation attend school, and agriculturalists continue to migrate to the region (see Section 1.3.1). Purchased maize meal, representing a 'modern' food, is widely eaten, but cannot be grown reliably through much of the Kajiado region. To cultivate V. pseudolabiab, in the western agricultural sense, would likely be doomed to failure. It would involve reversing years of cultural tradition, introducing models of land use and tenure which do not exist. Increasing the availability of V. pseudolabiab would depend on
developing locally-appropriate propagation and cultivation methods. Factors that would have to be taken into account are easy accessibility to the homestead, require no or little maintenance, and protection from wild and domestic animals. Clearly, the complex issues around improving food security in Loodokilani do not have a single solution, nor will their be a purely technical one.

3) Relative yield

Little information is available on the relative yield of in situ resources. Patch sizes are comparable to those measured by Vincent (1985), yet densities are much, much lower. In addition, I excavated four plants, yet no tubers were found, indicating that these populations may be relatively young. Low densities coupled with the high grazing pressure make it unlikely that wild resources could sustain higher usage.

4) Desirability

Although V. pseudolabiab is widely known in Loodokilani, whether or how it is used varies markedly different along gender, age and class lines. This is an important point for this project and other related research projects. For example, patches found by male informants were based on historical knowledge (i.e. they had exploited these patches in the past). The custom for young Maasai males to spend from 12-15 hours a day in the 'bush' herding livestock has been discussed previously. While Nestel (1989) argues that the contribution of these gathered sources is negligible to the Maasai diet, conversations with local men have led me to think otherwise and Johns, T. (per. comm.) working in
Ngorgoro District, Tanzania, confirms this. However, this is anecdotal evidence that needs to be confirmed more rigorously.

In contrast, female informants had personally utilized these patches within the past year. However, it is unknown how regularly women gather *V. pseudoablaba* either within or between years. It may be that the recent exploitation of these patches was a function of the severe drought that rocked the community just before my arrival.

In addition, my experience shows that how a plant is used differs between communities. In Loodokilani, it is primarily new growth used as a pot-herb, as well as fodder for domestic livestock.

5) Contribution to local food security

While this study has provided some new insights on the ecology and propagation of an important wild food resource of a community plagued by widespread food insecurity, it has also generated a host of pertinent topics which require research, so as to contribute to further comprehension of the complex issues relating to improving food security in the region. For instance, in light of the factors which impact on its role in community food security:

1) It is still unclear by whom and to what extent *V. pseudoablaba* is exploited within the community of Loodokilani, and more significantly, what are the factors which impact on when it is used. This information is critical to clearly identify its significance in food security for this community and by extension, assess the pressure on *in situ* resources.

2) A better understanding of the basic biology of the species, including
identifying the principal mode and rates of reproduction is needed. This issue is directly related to the first point.

3) The extent of all patches in the region and what are the ages of plants in these patches need to be identified.

4) Further studies need to be conducted to analyse the nutrient content of leaves and pods.

5) Studies of the physiological effect of sustained harvesting on leaf, tuber and seed production are needed.

Whatever the responses to these points, it is evident that a comprehensive understanding of the ecology and propagation of *V. pseudolabiab* is necessary to develop a strategy for its long-term sustainability. Critical to this understanding is cognizance of the diversity within habitats and the nature of interactions among their components. When these components are identified and clarified, they can form the basis for educated strategies for the sustainable utilization of these resources and the enhancement of domestic-food security. This study lays the groundwork for further research, which will further enhance comprehension of the interrelationships between small-scale subsistence activities and food security.

Although the generalizability of these research results are limited, they nonetheless provide a general insight into the ecological adaption of semi-arid lianas and the propagation of these species.

In addition, this study highlights some of the greatest methodological problems facing those interested in dietary patterns in pastoral communities. In order to better
understand the role of *V. pseudolablab*, and other wild plant species, in the Maasai diet, more attention should be directed towards developing research methodologies better suited to the unique needs of pastoral people.
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APPENDIX I  Vatovaea pseudolablab (Harms.) Gillett

Vatovaea Chiov.

Vatovaea is a monotypic genus, closely related to Vigna, belonging to the family Papilionaceae\(^5\). They are woody climbers with pinnately trifoliate stipellate leaves and axillary false racemes of purplish flowers; calyx 5-lobed, 2-lipped; corolla wings with long narrow spurs, stamens (9)+1; anthers uniform; ovary linear, 9-12 ovuled; style long, incurved, bearded within towards the apex and with a reflexed appendage above the oblique stigma, pod linear-oblong, dehiscent. (Agnew, 1974).

Vatovaea pseudolablab (Harms) Gillett.

Perennial trailing or twinning woody deciduous liana, 1-3 m. long from a long, thick vertical, rootstock 18 cm. long and 2-3 cm wide. Tubers are spherical shaped, like an potato or sweet potato, forming along lateral shoots that come off the central rootstock. Two or three tubers can form along these shoots, and these can grow up to a meter from the plant. The tubers have a thin papery skin which is peeled by hand or with a knife, and are juicy and fibrous.

Stems branched, old growth woody, pale reddish-brown; new growth greenish-purple, sometimes nodulous, glabrous to sparsely pubescent. Leaflets usually three, (ob)ovate 1.5-5.7 cm. long, 0.8-5.3 cm. wide, sometimes + 3-lobed, the laterals oblique, glabrous or with sparse hairs along the margins; petioles 0.6-6 cm. long; rachis 0.4-2 cm. long; petiolules 1-2 mm. long; stipules oblong, 3-5 mm. long, 1.5 wide, ribbed.

Inflorescences 7-45 cm. in length above a peduncle 6-21 cm long, 2-3-many-flowered; Flowers (sometimes present when leafless) green and purple to blueish. Calyx glabrous at base; tube 2.5 mm long; lobes 2.5 mm. long, with ciliolate margins. Standard dull purplish or brownish-claret with green base and green veins inside, greenish outside, 1-1.8 cm. long, 1.3-2.1 cm. wide, emarginate; wings magenta-purple to blue, green below; keel greenish flushed purple, or magenta-purple with apex greenish. Fruit flattened, curved, 4.5-6.0 cm. by 0.5-1 cm., pubescent by becoming glabrous usually four-six seeded. Seeds brown, sometimes densely speckled with black, subglobose or squarish, longest dimension 4.5-7 mm., shorter dimension 4.5-6.5 mm. thickness 2.5-3 mm.

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\(^5\) Taxonomy following Beentjee (1995)
Figure 9: Vatovaea pseudolabolab (Harms.) Gillett
Figure 10: Schematic drawing to show the formation of tubers of *V. pseudolabiata*.
APPENDIX II: DETAILED DESCRIPTION OF DATA MANIPULATIONS FOR SOIL VARIABLES

COLOR: A small portion of the soil sample was moistened and classified according to color 'chips' in the Munsell Color Chart.

Although a single measurement for COLOR was taken in the field, for the analysis, each COLOR value was divided into the three separate quantitative measures that make up the Munsell system: Hue, Value and Chroma. Hue refers to the basic 'spectrum' of color present. In the Munsell system, the colors in visible light are divided into ten equal ranges which are in turn further sub-divided into ten (McRae, 1988). The '10' point of each hue corresponds with the zero point of the next hue. Value is the 'darkness' or 'lightness' of the color on a scale of 0 to 10. All samples recorded a Value reading of 3. Chroma describes the 'strength' of color on a scale from 0 to 10, with ten representing the brightest available pigment, and with 0 considered neutral.

As an example, a 'color chip' reading of 7.5YR 3/1 would be assigned a value of 17.5 for Hue, 3 for Value and 1 for Chroma. Although the Munsell system is based on a quantitative scale, each category in the Color Chart essentially represents a class value. Therefore, for the analysis, the parameter estimates are considered semi-quantitative.

TEXTURE: Samples were analyzed using the 'finger assessment method', a commonly-used field method for soil surveys (McCrae, 1988). Small amounts of moistened soil taken from the soil cores were categorized into five TEXTURE classes (Canada Soil survey): Silty clay loam, sandy clay, silty clay, silty loam and clay loam. Two semi-quantitative values (SAND and CLAY) were calculated by taking the mid-point of each class on the Canadian Textural Triangle ( ), and reading the values along the respective axes.

SIZE: A visual assessment was used to group the diameter of the dominant stone size within SUBPLOTS into a four equal-sized, ordered classes. These class variables were converted to semi-quantitative values by assigning the mid-point of each class to the observation.

STONINESS: The percentage of the SUBPLOT covered by the dominant stone size was visually assessed. Five equal-size, ordered classes were identified. Semi-quantitative values for each observation were assigned according to the same method employed for SIZE.

STRUCTURE: Structure was assessed as a composite of two qualitative variables (Aggregate Development and Shape of Aggregates) and one quantitative class variable: Size (AGGSIZE). 'Development' is relatively subjective (McCrae, 1988). Samples consisting of less than 33% aggregates were considered weakly developed, from 33% to 66% aggregates were considered moderately developed and more than 66% aggregates were strongly developed. In all samples, the shape of aggregates were angular blocky. Four classes for aggregate size were found, and converted to semi-quantitative values as previously discussed.
APPENDIX III: SITE DESCRIPTIONS

SITE 1 is located north-west of Kilinito Camp, 3.2 km from the Kilinito-Main road junction, 170 m west off the main road. The area is bounded on the north side by a well-worn cattle path, while the south and east sides are bounded by a line of Acacia spp, while the west side slopes steeply down to the lower plains. The site is relatively flat, and not very stony. Vegetation is predominant scrub/brush.

Size of Patch: 4 hectares
Number of plants: 102
Density: 25.5 plants ha⁻¹
Mean circumference: 5.4 ± 2.2 cm
Mean length: 61.1 ± 33.3 cm

SITE 2 is found in a privately-owned pasture located down afoot/cattle path, 4 km west of the Kilinito-Main road junction. The patch is contained within a privately-owned dry-season pasturage. It is surrounded by a traditional thorn-fence on the south-east, south-west and north-west edges, while a thicket dominated by Acacia tortillis defines the north-east side. These barriers protect the area from unwanted grazing by domestic animals, although wild ungulates are able to enter by jumping the fences (pers. obs.). The site slopes steeply from north-east to south-west with V. pseudolabilab found only on the steepest parts of the slope. The slope is characterized by many large weathered lava rocks (+30cm), vegetation is dominated by Sansevaria ssp. ( <100cm) and Pancicum spp. (>50cm). The lower south-western edge gives way to a large flat plain with scattered clumps of grasses and sandy, light-brown soils. The north-eastern upper edge flattens out to a plateau with reddish sandy soils and a dense forest of A. tortillis and A. mellifera. A seasonal river is located 100 meters to the south-west of the thorn fence boundary.

Size of Patch: 6 hectares
Number of Plants: 241
Density: 40.2 plants ha⁻¹
Mean circumference: 6.1 ± 2.6 cm
Mean Length: 88.5 ± 51.1 cm

SITE 3 is located approximately 2.5 km west of Kilinito camp, just south of the access road. It is the only site in the Kilinito area that is located to the east of the main road. It is located within a densely populated area, in part due to the close proximity of year-round water supply to the north. The area is heavily grazed by domestic animals. Relatively flat, the site is criss-crossed by small foot and cattle paths. A homestead, whose owners regularly exploit this patch during the late dry and early rains, marks the south-western boundary and the north-east by a small plain of dense short grasses and heavy black cotton soils. The access road runs along the north-west side and the southeast is delineated by deep run-off gullies. The area has many small depressions (diameter 50m) that act as water catchment areas during the rainy season and which are associated with Acacia spp. Small shrubs dominate with almost total lack of grass.
APPENDIX III: SITE DESCRIPTIONS (contd.)

Size of Patch: 10 hectares  
Number of Plants: 125  
Density: 12.5 plants ha⁻¹  
Mean circumference: 6.4 ± 3.4 cm  
Mean Length: 75.5 ± 60.4 cm

SITE 4 is located 500 meters north of the Kilinito-main road junction, about 300 meters west of the main road. The north-west and north-east edges are bound by a dense forest of Acacia ssp. and large boulders of weathered lava rock. A large run-off gully / foot path defines the south-eastern border. The site is sloped from north-west to south-west, with the slope gradually decreasing to flatness on the south-western edge.

Size of Patch: 16 hectares  
Number of Plants: 347  
Density: 21.7 plants ha⁻¹  
Mean circumference: 6.7 ± 3.2 cm  
Mean Length: 81.9 ± 50.5 cm

SITE 5 is located 2.1 km south of the Kilinito-main road junction and 1 km west of the main road. The eastern edge is defined by a steep escarpment at the top of which is a plateau dominated by a dense forest of Acacia seyal. V. pseudolablab is found on the gentle slope that begins at the escarpment base. The western limit of the site ends at the flat end of a broad plain where large areas of bare soil are intermittently covered by clumps of short, heavily grazed grasses. Both the north and south side are bound by relatively large cattle paths (200 m). To the south is a large region called 'Næborkaware' (White night), a large flat plain of black cotton soils and containing several large open wells which are important seasonal water supplies.

Size of Patch: 9 hectares  
Number of Plants: 192  
Density: 21.3 plants ha⁻¹  
Mean circumference: 6.2 ± 2.7 cm  
Mean Length: 66.5 ± 47.5 cm

SITE 6 is the smallest site and is located 0.5 km south-west of Base Camp. The Escarpment defines the north-eastern edge. The main road acts as the south-western boundary. To the north-east lies a large cattle path, with a copse of A. tortillis and A. seyal demarcating the southeastern edge. Relatively flat, the site is characterized by bare soil broken by clumps of heavily grazed grasses.

Size of Patch: 1 hectare  
Number of Plants: 27  
Density: 27 plants ha⁻¹  
Mean circumference: 6.1 ± 4.1 cm  
Mean Length: 50.9 ± 48.8 cm
APPENDIX III: SITE DESCRIPTIONS (contd.)

SITE 7 is located near the village of Mile 46, 8 km north-west of Base Camp. It is at the western-most tip of a large area fenced as part of a small ruminant breeding project. The patch gradually slopes eastward from the upper western edge, giving way onto a broad open plain.

Size of Patch: 2 hectares
Number of Plants: 35
Density: 17.5 plants ha⁻¹
Mean circumference: 5.74 ± 2.9 cm
Mean Length: 59.9 ± 40.1 cm

SITE 8 is located 3.5 km west and 0.5 km south of the main road. The main difference lies in management practice, i.e. this area is communal land and is subject to year-round grazing. This patch has four homesteads within a 1 km radius.

Size of Patch: 9 hectares
Number of Plants: 169
Density: 18.8 plants ha⁻¹
Mean circumference: 6.6 ± 3.0 cm
Mean Length: 74.4 ± 47.3 cm

SITE 9 is 2.5 km southwest of Base Camp. This site is close to (0.75 km) and similar in description to Site 8. The species grows between the large weathered boulders of volcanic origin. These boulders dominate the steep slope that runs west to east. To the west (the higher area) are found the red, sandy soils associated with Acacia and Sansaveria spp. South and north are small thickets of A. tortillis. The site is very rocky with many bushes and tall grass. The area has been lightly grazed, as it is owned by a man with few cattle. The eastern edge is a plain dominated by Acacia bush and tall grass. In addition, homesteads are clustered around a nearby year-round water source.

Size of Patch: 18 hectares
Number of Plants: 416
Density: 23.0 plants ha⁻¹
Mean circumference: 7.1 ± 2.9 cm
Mean Length: 76.5 ± 48.4 cm

SITE 10 is located 4.5 km west of Base Camp, towards Mile 46 and 1.5 km east of the main road. The slope is from east to west. Endoynyu sinus (Mountains which are white) demarcate the eastern edge. There are many run-off gulleys to the north and south.

Size of Patch: 13 hectares
Number of Plants: 284
Density: 21.8 plants ha⁻¹
Mean circumference: 6.4 ± 2.8 cm
Mean Length: 62.5 ± 42.5 cm