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A Descriptive Analysis of
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Dennis J. Bobilya

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A DESCRIPTIVE ANALYSIS OF TRADITIONAL SMALL SCALE SWINE PRODUCTION IN THE CAYO DISTRICT OF BELIZE

By

Dennis J. Bobilya

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ABSTRACT

A DESCRIPTIVE ANALYSIS OF
TRADITIONAL SMALL SCALE SWINE PRODUCTION
IN THE CAYO DISTRICT OF BELIZE

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Small scale swine producers were repeatedly interviewed during a 12 month period. Interaction with members of the farm families yielded an information base useful in further development of the swine industry. Prevailing management practices and production levels were detailed, as were potential improvements in the production system. Attention centered upon farmers' concerns regarding intensification of production and how alterations, such as alternative feeding programs, affect swine productivity and the rest of the farming system .

Swine fulfill a variety of cultural and economic functions on the small scale farm. Swine are a source of economic security and they stabilize grain consumption. Efforts to intensify production have frequently been contradictory to these roles. Indigenous pigs are raised with extensive use of forage and surplus crops. Production levels are low due primarily to malnutrition. Minimal financial investment is undertaken due to the riskiness of the enterprise.

dedicated to my parents

Donald A. and Velma E. Bobilya

Some of the research literature that is cited in this thesis was conducted in temperate climates with high performing swine. Conclusions made from this research may not excactly fit the genetic and environmental situation in Belize for which limited research has been conducted. Nevertheless, similar trends can be expected.

All monetary references in this thesis are presented in Belizean Dollars. One Belize Dollar is valued at approximately US$.50.

Measurements of distance and weight presented in this thesis are presented in both the metric and imperial systems to facilitate use of the information by those in Belize and elsewnere who are less familiar with the metric system.

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INTRODUCTION

According to the Belize Trade Report, 1983 (1984), the country of Belize imported BZ$4,254,000 worth of pork products in 1983. This is a considerable expenditure of foreign exchange and a drain upon the nation's economy. Consequently, it is the policy of the Government of Belize to promote increased swine production and processing within the country. Increased swine production would first contribute toward meeting domestic needs and reducing the demand for importation of swine products. Secondarily, exportation to markets in the Carribean and Central America might be explored and developed. The consequence would be increased farm income and employment in agriculturally related industries, as well as the reduction of foreign currency expenditures and eventually its generation.

In the past, pigs have been raised almost exclusively by small scale farmers. According to the 1980 Pig Census (1981), 68 percent of pig owners in Belize had 5 or fewer pigs. At the time of the census, only 1.7 percent of all owners had more than 25 pigs. In the Cayo District 82.4 percent of pig owners had 5 or fewer pigs. When passing through rural areas of Cayo District it appears to an observer as though nearly every farm has pigs.

The 1980 Swine Census (1981) also reports that there were 16,000 pigs in Belize, and there were 6500 pigs slaughtered in 1980. This represents an extraction rate (Pond, 1974, p. 14) of slightly greater than .40. This is a rough estimate since the size of the national herd was probably not static during this time, and the statistics may not accurately reflect those animals slaughtered outside official cognizance. Some farmers might not have reported the slaughter of pigs for home consumption or butchers might not have reported all the pigs they slaughtered in order to avoid taxes.

Swine is an important component of the small scale farming system, and thus it is preferable that increasing national swine production is accomplished by these farmers. Raun (1983) feels that agricultural development programs in tropical and subtropical ecosystems should focus on family-farm units with emphasis on mixed crop/livestock systems because greater numbers of livestock are found there than in any other livestock system. Increased swine production is best achieved by increasing animal productivity through well-planned integration of livestock with the existing farming system of grain and root production. Intensification of production, although on a subsistence scale, would most advantageously occur at the local farmer level (Oyenuga, 1973). This would also be in accordance with goals of minimizing the environmental impact and maximizing social justice (Jasiorowski, 1973).

Attempts have been made to improve and increase production of swine by small scale farmers, with limited success. One example is a group of small scale farmers in Frank's Eddie Village which purchased "improved" exotic breeding stock in 1984. The farmers sporadically fed commercial supplements and wormed the pigs, but otherwise continued raising them traditionally. The resultant production level was similar to that achieved with indigenous pigs without cash expenditures. Farmer expectations were not fulfilled and some of them have expressed their disillusionment with "improved" swine production. Some farmers which participated in the Belize Feeder Pig Project have also expressed their disillusionment with swine production. They are neglecting their management techniques and reducing their herds. There are also some noteworthy sucesses. A few farmers have expanded production.

Reasons for failure are numerous. Some organizational personnel are ineffective in communicating technical skills to farmers, or are inconsistent in doing so. The governments's emphasis on swine production in the past has varied from highly promotional to noninvolvement. Changes in policies related to swine production such as the establishment of fixed prices for pork and grains and restrictions on the movement of pigs and carcasses have increased the riskiness of investment in swine production. Farmers do not have convenient access to dependable markets for slaughter weight pigs. Nor is it convenient for them to acquire feedstuffs

which are not produced on the farm.

In addition to the institutional and economic restraints to intensification, there are cultural reasons why small scale farmers continue to raise swine traditionally. Pigs have several important roles on the small scale farm other than as a source of income and they bestow many benefits upon the farm family which might otherwise be unavailable. Two principal roles are regulation of stable grain production and consumption, and as a means of economic security.

Many farmers do not have the educational background or the serious interest required to raise pigs other than according to traditional production systems. There is uncertainty among swine production specialists, extension agents, and farmers as to which technological changes would be beneficial to small scale swine production. Some of the technological recommendations are incompatible with the prevailing farming system. In some cases farmer expectations are overly inflated, making them susceptible to disillusionment when problems arise.

This descriptive analysis looks closely at prevailing swine production practices on the small scale farm in Belize. Farming systems methodology as described by Dillon (1980) and Shaner (1982) is utilized in problem identification and development of a research base for the swine production component of the traditional farming system. Interactive informal survey methods were primarily employed. The

focus is upon how the farm family views swine production and upon the constraints against improvement. Alterations in the production systems of some farmers are also analyzed. Likely reasons for their success or failure are discussed. This information will allow better utilization of resources in the selection of appropriate technologies applicable to the improvement of swine production by small scale farmers. This will allow policy makers and extension agents to be more efficient in promoting an expanding swine industry.

There is a paucity of information dealing with small scale swine production in Belize. The variations and inconsistencies in the production practices of individual farmers on different small scale farms, and at different times preclude description of the "typical farm". Information presented is drawn from individual face-to-face interactions with members of small scale farm families involved in swine production.

The information presented here was gathered primarily within the Cayo district of Belize. One can be confident of the validity of the observations and conclusions presented only as they pertain to this district. Nevertheless, it is likely that there are similarities among the small scale swine farmers of the Cayo District and those in other districts of Belize and throughout the world.

METHODOLOGY

Strategy

The principal goal of this project was to obtain information about small farm swine production. Farmers (the term "farmer" is used to refer to any member of the farm family) tend to be suspicious of strangers asking questions, especially those affiliated with the government who carry clipboards and write down farmer responses. Confronted with such a situation, farmers are likely to respond in ways that hide information, or as they feel the interviewer desires them to respond (Dillon, 1980; Shaner, 1982). Additionally, many farmers are not accurately aware of some information concerning swine production, and their responses may only be biased estimates. To obtain accurate information, the researcher must keep records during repeated visits over an extended period of time. The method employed in this survey included participatory discussions and activities with the farm families, in an attempt to mimimize inaccuracies.

It was necessary to obtain the confidence of the farm family members so that they would speak with as little reservation as possible. This could only be accomplished through repeated visits during which familiarity developed. I dressed unimposingly, spoke in language common to the

farmers (as I became familiar with it), and spent time unhurriedly with them. Where appropriate, I ate and drank with farmers, and participated in their social functions. While it is likely that the farmers still retained some reservedness, these confidence building methods reduced this attitude considerably. Some farmers eventually spoke quite frankly.

Village and farm selection

Mr. Rene' Montero, the director of livestock research and development on the Central Farm Agricultural Station, initially introduced me to the farmers that had participated in the Feeder Pig Project of Cayo District. These farmers were already accustomed to working with government workers and foreigners. They were located in or near the villages of Cristo Rey, San Antonio, and Bullet Tree Falls. As participants in the Feeder Pig Project they had utilized some modern swine production methods on their farms. Mr. Rick August introduced me to a few farmers in and around Frank's Eddie Village and La Democracia.

Once introduced to these villages I began visiting other farms in the surrounding areas. Most of these operations were still raising pigs according to traditional methods. The actual selection of the farms followed no preset pattern. In general, I would receive a ride to the villages and then walk around visiting farms on foot. While walking about the neighborhood I would approach farms on

which swine were obviously present and begin engaging members of the farm family in conversation.

Some of the farmers were more responsive than others. Many farmers required two or three visits before they felt comfortable enough with me to converse in sentences which were more than short cautious statements. Some farmers were quite willing to "talk my ear off". Based upon the willingness of the people to "open up" to me, I selected from three to five farm families in each village on which to concentrate the majority of my efforts.

Numerous other persons involved in the swine industry were contacted in addition to farmers in these five villages. Visits were made to farms along the roads leading to these villages. Government personnel, butchers, traders, and retailers of pigs, pork, and swine production inputs were informally interviewed. Additionally, interviews and observations related to the swine industry were conducted throughout the country of Belize.

Frequency and duration of farm visits

Farms were repeatedly visited over a 12 month period and informal conversations were conducted with members of the farm family. Since new farms were added to the survey throughout the period, only a few farms were actually visited continually throughout the entire 12 months. Some were only visited a few times over a period of a couple months. Also, some farms which were visited in the

beginning were later dropped for one reason or another. Some farms ceased raising pigs, and some were totally disinterested in my presence or preferred not to be bothered.

During the 12 month period, Bullet Tree Falls was visited 35 times, Frank's Eddie was visited 14 times, Cristo Rey and San Antonio villages were visited 13 times each, and Santa Familia was visited 9 times. Bullet Tree Falls received the most visits because of the ease with which this village could be reached. I hitchhiked and walked there several times when other transport was unavailable. (The Ministry of Natural Resources was always cooperative and in general able to provide transportation.) Also, there were more farmers raising pigs and willing to cooperate with me in Bullet Tree Falls. I did not begin visiting farms in Santa Familia until the fourth month of the survey.

Swine production systems are dynamic. Several visits permitted tracking animals over time to gauge their long term performance and observe variations in performance and management practices due to seasonality. Some farmers would voice differing opinions regarding the same subject on different occasions, depending upon their mood. Frequent visits allowed farmers to express themselves under various circumstances.

There was considerable variation in the length of farm visits. Some farm visits lasted only five or ten minutes. Often, the principal farm family members were preoccupied with other activities or not at home. At other times they

would be willing to spend an hour or more of their time with me. Most farmers would politely visit with me as long as I remained on the farm.

Topics of discussion during farm visits

Only a few of the farmers were aware that the principal purpose of my visits was to gather information on their swine production methods and productivity. I presented myself as a member of the Central Farm agricultural research and extension team working primarily with swine. I often mentioned in conversation with farmers that we, at Central Farm, were interested in their attitudes and concerns regarding swine production so that we could improve aspects of government assistance in this field. However, I tried to minimize the "officialness" of my visits as much as possible to encourage candidness. Some small scale farmers are intimidated by official persons on official business. They may be fearful of appearing ignorant or backward (Shaner, 1982 p. 73).

I mostly asked questions and listened during the initial few visits to a farm. I tried to learn the ages of the pigs. Few farmers knew this information. Most commonly they would say one year old, which could mean that the pigs were anywhere from 10 to 20 months, or that they simply didn't know. I asked about where their pigs originated--whether they were born on the farm, or obtained elsewhere. I asked about farrowing practices, litter size, and

mortality, and how, to whom, and at what price pigs were marketed. Special attention was given to the feeding practices--how much of which foods were being fed. Some other questions that helped to develop discussions were: Are you content with your present level of swine production? Do you think pig production is profitable? What changes do you think might improve profitability? Are any swine inputs purchased? Who cares for the pigs? Where are the pigs at any particular time? Have any pigs died, been sick, or stolen? Do you have interest in purchasing feed for pigs? How do the pigs obtain water? Have extensionists or veterinarians been to the farm on swine-related business, or for any other reason? What breeding and castration practices do you employ? What are some of the alternative uses (opportunity costs) of resources being utilized by pigs? Additionally, observations were continually being made on materials used in construction of pens and facilities.

During later visits I began recommending certain alterations in swine production to select farmers. I then noted their oral response to the practice--concerns, doubts, and levels of acceptance. Then I noted if they actually did make the change, and what the results were. Information was learned concerning farmer acceptance of radically different production practices. Some conclusions could also be drawn regarding the utility of these practices, and their effect upon the farming system.

A portable scale was nearly always brought to the farm

to weigh pigs whenever practical. It was necessary to weigh pigs to accurately gauge their rates of growth. Most of the pigs that were weighed were those whose birth dates I was certain of. Most farmers were quite willing to have their pigs weighed if it could be done simply. Many were curious about their pigs' weights because knowing allowed them to approximate the pig's value if it was sold in the near future. It seemed that others allowed their pigs to be weighed just to humor me. Most recalled the previous weights of their pigs on succeeding weighings.

As a service to farmers, I carried simple veterinary supplies along on farm visits. These consisted of anthelmintics, injectable vitamins, antibiotics, and a knife for castration. Farmers were asked to pay to cover the replacement costs of the drugs. Otherwise, all services were performed free. These veterinary and extension services helped to develop my credibility with the farmers. They also helped to justify my visitation to farmers. Additionally, I was able to assist them by providing services which might otherwise be unavailable to them.

During informal conversations I interjected questions concerning the family structure and land holdings. I was curious about other crops and livestock that the farm produced. I asked about cropping patterns and the acquisition of livestock. We talked about other off-farm jobs that they held. An attempt was made to understand as many other aspects of the total farming system as possible.

The same questions were asked again to the same farmers on different farm visits to discover the consistency of their responses. On different days farmers might respond differently depending upon the prevailing circumstances. Farmers might also respond more openly after they became more comfortable with me. This also allowed for differences in their responses due to seasonality and other variations in environmental conditions on the farm. Different farm members might also respond differently depending upon their view of their relationship to the swine production system.

Keeping records of farm visits

Very few notes were written down during conversation with farmers. Note taking was kept to a minimum so as not to intimidate the farmer, or cause undue caution in their responses. Only essential information such as pig weights or ages were inconspicuously written down. Other brief notes were recorded out of sight of the farm family. Upon my return home, these notes helped me to write a description of activities and comments during the visit. Each farm has a file with dated entries for each visit. Each entry contains all the relevant information regarding the farm at that time.

A DESCRIPTION OF THE TRADITIONAL SYSTEMS OF SMALL SCALE SWINE PRODUCTION

Introduction

The overwhelming majority of rural households in the Cayo district have one or more pigs on the premises. Indeed, the households without pigs are rare. Among those farmers without pigs, many previously had pigs but have since sold them and have not as yet acquired others. In this case they will probably get another pig in the future. Like the dog and the chicken, the pig is a common feature of the rural household. Even within San Ignacio and Santa Elena Towns there are many households which boast a pig or two. In addition, many urban dwellers have ranches outside of town where they maintain some pigs. But, especially on the rural farming household, the pig is an important component of the farming system.

A minority of rural farm families are not interested in raising swine. For one reason or another they have decided that owning pigs is not best for them. Perhaps they do not have the facilities to properly care for a pig according to the way they feel it should be done. This concept of what proper care is will naturally vary considerably among individuals. Swine are a form of wealth and require certain

resources to obtain and maintain; a poorer household might not be able to afford one.

Some people feel that pigs are dirty animals that spread disease and are undesirable around the family household. Others might previously have had an unfortunate experience with pigs that soured their attitude toward these animals. For example, a pig may have injured someone they know or somehow damaged their property, facilities, or crops. Maybe they previously owned pigs, or know of someone who did, and the pigs died or were stolen; now they feel there is no sense in making any effort to raise pigs again. Then there are those households, particularly those new to farming, that simply know very little about pigs and have no interest in learning. Generally, those that do not have pigs are better able to tell you why they do not, than people who have pigs can tell you why they do.

Most farmers raise swine under a traditional system of management. People care for their pigs the same way their parents did, and this management system has continued from one generation to the next with few changes. The methods of daily care and management that are employed have evolved over the years to accommodate the perceived needs of the family under the prevailing conditions. The high prevalence of pigs being raised under this traditional system of management indicates how successfully it has been applied. Evidently, the benefits of this system have been sufficient to perpetuate it. Since the prevailing traditional system

of swine management is perceived as being adequately successful, any significant changes to this system of management are likely to be very critically appraised before they are accepted and inculcated into the farming system.

The raising of pigs is not a primary farming enterprise on most small scale farms. Rather, it is generally considered to be an activity of secondary importance, and consequently receives a secondary level of attention. In fact, many people, while having a pig or two on their farm, will respond negatively if asked whether or not they raise pigs. Sure, they have a pig, but they are not "raising pigs"; at least not according to the way they perceive an outsider might "raise pigs". "And anyway, they are only local pigs", a farmer is likely to conclude in an abject, unenthusiastic tone.

The traditional roles of swine

The direct benefits derivable from traditional swine production in the New Guinea Highlands is considerably less than the expenditures in time, energy, and resources. More energy was expended to raise food for pigs than was returned in the form of pork. Additionally, the pigs must be cared for, lost pigs must be searched for, and houses, crops, and gardens are damaged by pigs. Yet nearly all villagers raise pigs (Rappaport, 1968, p. 62). Evidently, the swine are fulfilling numerous other functions not directly attributable to pork or income. The same can be said of swine on

traditional small scale farms in the Cayo District of Belize.

Swine fulfill a variety of different roles while demanding relatively little in return. As will be described on succeeding pages, the traditional system of management is simple and inexpensive, demanding a minimal amount of land, labor, and financial resources. One important characteristic of this system is that the pig utilizes those resources which would otherwise be wasted or underutilized. The small piece of land upon which a pen is constructed is insignificant, and the pen itself is simply constructed of freely available materials. The labor involved in caring for the pigs consists of a few minutes in the morning when the pigs are fed and(or) let out of their pen to forage for food, and a few minutes in the evening when they are returned to their pen and fed. No money is expended in the purchase of anything for the pig.

While the pig is foraging about during the day it is eating food sources which might otherwise not be utilized. It is eating plants, primarily grasses and weeds growing about the farmyard. It is also eating grubs and other insects and worms which are of no other benefit to the farm, and may even be undesirable pests. What corn and other food the pig is given is either unfit for human consumption or in surplus of what the family can eat or sell. This includes crops which have been damaged by insects or microorganisms in the field or in storage. Bernsten (1977) reports one

random sample of 12 milpa farmers in the Cayo District found 5 percent of corn in storage under traditional methods for 9 months showed fungus damage; and 9 percent had been penetrated by weevils. The pig is a means of marketing this spoiled or surplus corn and other food crops. Additionally, kitchen scraps, human feces, and other garbage could conceivably pose a health hazard if not disposed of through the pig (Rappaport, 1968, p. 58).

Figure 1. Pigs foraging in farmyard.

The demands of this system of pig production are minimal, but the benefits are numerous. The more obvious benefit is the income received when the pig is sold. This income can be from the sale of young growing pigs to other farm families for fattening. Income is also derived from

the sale of slaughter size animals to a butcher or trader. The farmer might even slaughter the pig himself and sell the meat. Though less common, income is derived from the sale of mature breeding animals, or from services rendered by a boar. Income obtained through swine production is seen as clear profit by the farm family since they do not feel any cash production costs.

As the slow-growing pig gradually increases in size over time its value increases accordingly. In this way the pig is an accumulation of wealth--a savings account. A family which might not be able to discipline themselves to save a couple dollars each week can "save" this amount by feeding a pig so that it grows a kilogram each week. A pig is a relatively liquid asset which can be converted to cash when the need arises. In this same way, the raising of a pig is also an investment in an insurance policy which can be redeemed for cash should an emergency arise (McDowell, 1980). The actual expense of raising the pig may be more than the pig is worth, or as Rappaport (1968) describes it, "the service charges may be greater than the savings account." Nevertheless, a reserve is available which otherwise might not be.

Since the pig is such a valuable asset on the farm, and has a monetary value, the possession of several pigs is an indication of the wealth and status of the family. Their possession conveys a degree of prestige upon the owners (McDowell, 1980). In this same light, a pig can serve as a

proper gift on many occasions. The giving of a pig as a gift is quite common.

There are numerous occasions when family and friends gather together to celebrate or commemorate some occurrence, including weddings, christenings, wakes, and birthdays. Pork is a popular food to serve to the guests. The meat is frequently barbecued, or prepared in bollas, tamales, or some other dish. Many pigs are raised for the sole intention of being served at such a feast. Another important reason many people raise pigs is simply because they like pork, and want to have a pig ready for special occasions.

Some farmers have indicated that they have a pig because a farm family is not complete without one, and that a pig makes a sort of pet for the children. Caring for the pig is a way for the youngsters to begin participating in the operation of the farm.

Malynicz (1975) reports the use of manures is unknown in traditional agriculture, based on long-term bush fallow in New Guinea. A similar situation exists in the Cayo District. Farmers generally do not use swine manure as a fertilizer in crop production, nor do they use any other fertilizers. It might be that there is not enough land pressure to necessitate its use. Under the traditional management system, pigs roam freely during most of the day and there is not much manure in the pen for collection. Additionally, most crop fields are a mile or more from the homestead where the pigs are maintained. However, if

appropriate technology could be developed for fitting the use of swine manure into the farming system, it is a potentially valuable byproduct of swine production in the future. Swine manure contains on average .70 percent nitrogen, .68 percent phosphorus, and .70 percent potassium (Williamson, 1978, p. 541). These nutrients could be recycled back into crop production.

Vayda (1961) describes how pigs raised by Melanesian subsistence farmers serve as a nutritional reserve. Farmers plant crops in excess of what they need for subsistence. If there is a bountiful harvest then the surplus is used to feed pigs. If there is a harvest shortfall due to drought or other circumstances, then the lowered yield might still be nearly adequate, plus the pigs could be consumed or traded for other food. When yields are low, the pigs must subsist on what they can forage for themselves. Pigs fulfill a similar function on the subsistence farms of the Cayo District. This feast and famine situation is not entirely annual. There is also seasonal variation. During August and September, prior to the main harvest, pigs frequently subsist solely upon what they can forage for themselves.

Rappaport (1968) carries the discussion further than Vayda and notes that traditional swine production in New Guinea is so inefficient that people would serve themselves better by giving up pig husbandry, letting surplus crops rot in good years and in years of shortage eating the substandard crops which are edible even if undesirable. However,

this view neglects the other roles of swine for the farm family. He finally concludes that pigs are a "very expensive necessity."

Pigs are an important source of animal protein, essential fatty acids, vitamins, and minerals to the subsistence farm family (Pond, 1974, p. 31-36; Crawford, 1975). If this pork was not produced on the farm, or at least within the rural community, it is likely that less meat would be consumed. Refrigeration, transportation, and the distribution of fresh meat are not yet adequately developed to provide fresh meat for sale in many villages. Farm families might not have a sufficient cash flow to make such purchases if it was available.

These are some of the roles fulfilled by swine production on the small scale family farm. There are others, of course, which are perhaps more subtle than the ones mentioned above, but just as important to the farm family. The pig is an integral component of the farming system. Other linkages between this component and the rest of the system will be exposed in the following pages as the system is described. One critically important point to consider when analyzing a proposed change in the farming system is the impact of that change upon these roles fulfilled by swine production. A change which would increase the demands upon the farm family's resources without more than obviously compensating by providing greater benefits is unlikely to be implemented.

A description of the local pig

Malynicz (1970) describes the native pig of the New Guinea Highlands as "short, dark brown or black, with coarse hairs. It possesses heavy forequarters, light hind quarters and a fairly long snout. Tusks are not especially well developed, even in boars. When mature it lays down fat readily. The animal is intelligent and possesses a strong mothering instinct, readily attacking if provoked while with litter." Williamson (1978, p. 544) describes the Old English pig of the late eighteenth century as "large and heavy-boned, standing on long legs, possessing narrow and light hams and a highly arched and narrow back. It was usually sandy or reddish brown in colour and its hair was coarse. Its ears were large and floppy. It was very active in foraging but slow maturing." These descriptions are similar to the local pig presently found in the Cayo district.

The overwhelming majority of pigs which are raised on the small scale farms in the Cayo district are alike in their appearance. While there remains some natural variation among these pigs, there are also many similarities which indicate that they are interrelated and descended from common ancestors. These ancestors were brought to this area by the Spanish in the fifteenth century. They presumably were of the Neopolitan (Mediterranean) breed which is black and hairless (Williamson, 1978, p. 544). Occasionally, exotic pigs brought into the area contributed to the genetic

pool, but their contributions were not very significant. Their effect has been diluted through uncontrolled breeding practices. Similar pigs are still being raised on traditional small scale farms throughout Middle America.

The characteristics of this "local" pig dominate the line of pigs presently seen. On many farms, especially in the more remote regions, the pigs do not display characteristics of any breed except this "local breed" of pigs. Occasionally, though, pigs are found that have some markings which indicate that they have acquired some genes from other breeds of pigs. From the appearance of these pigs, the likely donors were Berkshire, Spotted Poland China, Hampshire, Duroc, Yorkshire, or a crossbred combination of these breeds. However, the effect of this crossbreeding has been diluted by the continuous back crossing of their offspring to the local pigs. Whatever genetic potential their ancestors may have possessed for rapid weight gains, high feed efficiencies, and large litters is not displayed by the local pigs under the traditional system of swine production on the small scale farms. Generally, all pigs with less than 50% of exotic blood are grouped together and referred to as local pigs.

Hutt (1958), Motulsky (1960), and Spooner (1982) present several examples of animals, including swine and man, that have developed genetic resistance to adverse environmental conditions such as infectious pathogens, climatic extremes, and malnutrition. How disease resistance may be

genetically controlled is presented by Cameron (1943) for swine brucellosis, by Przytulski (1976) for leptospirosis of pigs, and by Gibbons (1977) and Sellwood (1975, 1979) for neonatal E. coli diahrrea. Rothschild (1985) demonstrated breed differences in immune response to vaccination with Bordetella bronchiseptica. Presumably, susceptibility to other diseases is also genetically determined in swine. It appears that only a few genes are involved in each individual case, so resistance might develop after only a few generations under the stressful conditions. Rothschild (1985) recommends that "continuation of such research could provide useful information to ascertain the potential of selecting pigs more resistant to specific diseases."

Some veterinarians have suggested that these local pigs have a greater degree of resistance to some of the locally prevailing diseases (Stafford, 1984; Burns, 1985). It is probable that the relatively isolated and inbred indigenous local pigs have developed some resistance to the epizootic disease and other stresses of their environment. Perhaps they have genetically acquired some hormonal or metabolic alteration that provides them with a degree of naturally acquired immunity to these diseases. These animals could be a valuable genetic resource for the development of crossbred animals which are highly productive under the local conditions.

These local pigs have undergone generations of natural selection, which has acclimatized them physiologically and

behaviorally to their present environment. This environment is quite stressful and only the most resistant animals were able to survive and successfully reproduce. Natural selection was based upon such characteristics as adaptability, hardiness, foraging ability, drought and famine resistance, resistance to heat and excessive solar radiation, resistance to locally prevalent diseases, aggressiveness, longevity, and the ability to survive and reproduce on a low nutritional plane. In other words, an animal's individual survivability was of primary importance. These pigs developed into the most efficient producers of pork under the prevailing stressful conditions, regardless of how their rates of gain and feed efficiencies might compare to those of pigs raised under a controlled environment.

Most of the local pigs are all black in skin color, and they will commonly have relatively few long coarse black hairs covering their back and sides. A few pigs have white markings on their legs, or a white band or spots on their back. Other pigs are more reddish-brown in color, while a few others that are cream colored with brown, red, or black spots can be seen. Most of these latter pigs have a thicker coat of short hair. They are the result of the occasional introduction of a pig from one of the more recently developed exotic breeds used for crossbreeding with the original black pigs.

It is not surprising that these local pigs have darkly pigmented skin. This characteristic is a considerable asset

to the animal. Animals with pigmented skin are less susceptible to sun burning and skin cancers which can be provoked by heavy solar radiation like that common in Belize (Williamson, 1978, p. 12).

Figure 2. A typical indigenous pig.

The local pigs are relatively small in size, yet characterized by a large head and long, large ears that droop down. They will frequently have an appendage of skin which hangs down from either side of their chin, like earrings. Their legs are long and narrow, with very little ham muscling. These may not be characteristics which many butchers would like, but they appear to benefit the animal. The long legs and small narrow body increase the ratio of surface area to body size, and thereby facilitate heat loss

(Oyenuga, 1973). These pigs are well suited to withstand the effects of high temperatures and heavy solar radiation.

It has not been adequately documented, but this local type of pig seems to be able to resist periods of drought or famine much better than exotic pigs. These pigs can withstand days with virtually no food or water. When given the opportunity they are proficient foragers of food, and they appear to utilize well what they eat. Considering their very low nutritional plane, they are still able to grow, develop, and reproduce; albeit at low levels. An average daily gain of about .08 kilograms (.17 lb) is quite common. While litters as high as eleven are not unheard of, it is more common for five, six, or seven pigs to be farrowed. Even seven pigs can be a difficult load to carry and nurse for a sow on such a low nutritional plane. The piglets do not grow rapidly. Nevertheless it is noteworthy that a 35 kilograms (77 lb) sow can keep seven piglets alive under such a low level of nutrition.

When these pigs are provided with adequate amounts of a properly balanced ration their levels of growth and feed efficiency are not likely to be as good as that of the more recently developed crossbreed combinations of pigs which are the result of artificial selection for high rates of gain and feed efficiencies. It is Luke's (1982) opinion that raising indigenous pigs with commercial feeds in Cameroon is not economical since these pigs are reported to grow slowly, have low fecundity, and produce meat of poor quality.

However, this view is not supported by published research data. The actual growth rates and feed efficiencies of indigenous pigs under optimal conditions is unknown.

The local pigs are very cautious, selective eaters and often will not eat food that is provided for them. This behavior could be due to their particular environment, since they are exposed to numerous toxic substances. Changes in climate or poor health, including nutritional imbalances, may also cause this phenomenon. Additionally, dietary consumption is often reduced with nutritionally unbalanced rations (Pond, 1978, p. 92).

Many of the aforementioned characteristics of these local pigs appear to be positive. But the overriding negative characteristic of these pigs is their poor carcass composition under any nutritional plane. These animals do not produce hams, loins, or bellies which are of the size and composition preferred by meat processing plants (Pentak, 1985). The carcass that results under the typical nutritional level of the local pig on the small scale farm is very lean, with one or two centimeters of backfat. The carcass itself is very thin, with little meat around the bones. The loin eye is very narrow. The hams are flat and dry. Due to the age of the animal at slaughter the meat is generally tough and dry, and has a strong flavor. There is still a large market for this class of meat and some small scale butchers even prefer it for their clients. This is because many Belizeans dislike fat on their pork. However,

these are the small scale butchers operating by selling freshly killed meat in the marketplace and small butcher shops. The larger processors do not buy local pigs or pay less per kilogram for them.

The local pigs also have a lower percent carcass yield (roughly 62%) than the "improved" pigs (roughly 75%) (Pentak, 1985). This statistic is for pigs weighing roughly 90 kilograms (198 lb). The thin local pigs would yield an even lower percentage of retail cuts of meat since there would be a higher proportion of bone in the carcass. They therefore command a lower market price when sold for slaughter.

Even provided with improved nutrition the local pigs will not produce much better of a carcass. Farmers report the pigs become excessively fat, with as much as two inches of backfat, if fed for very long on a high energy ration after they are mature. This fat is used as cooking lard or fried for eating as "chicharones". This characteristic is desired in pigs raised for home consumption by small scale farmers.

The local pig is reasonably well suited to its environment. It is able to grow and proliferate under conditions of high temperatures, heavy solar radiation, drought, famine, and very unsanitary surroundings. It is a skilled forager. These are characteristics which are of limited importance on a well managed intensive swine production operation, but they are very beneficial characteristics if the pig is being raised under the traditional system of

swine management by a small scale farm family. These farmers are not prepared to provide more optimal conditions for their pigs. And until they are, it is ill-advised for them to try to raise pigs from one of the recently imported exotic breeds. They are only courting disaster since, as is discussed in the chapter on new breeds of pigs, the exotic animals are relatively delicate and suffer considerably under such stressful conditions.

General care and management

Nearly all farms on which pigs are raised have some building in which they are housed. The amount of time that the pigs are inside their enclosure varies somewhat from farm to farm. Most commonly, the pigs are released from their pen in the morning, usually around nine or ten. Sometimes this is done earlier in the morning, sometimes not until after noon. The pigs return to their pens at four or five in the afternoon and are shut in.

While the pigs are loose, they move freely around the neighborhood. They may stay near the farmyard or wander hundreds of yards in any direction, returning occasionally to the pen during the day until they eventually are closed in again by the owner. Frequently, the pigs will be given some corn or other additional food to entice them into the pen. This, in combination with someone calling them, will usually get all the pigs to go into their pens. Sometimes, however, a pig will not return and stays away all night, or

even for a couple days, before returning. For one reason or another, some never return at all, or return injured or sick. A few farmers intentionally allow their pigs to remain loose all the time for lack of facilities, but this is rare.

Figure 3. Pigs foraging in a communal field.

While the pigs are outside they eat whatever is available in the way of forage, pasture, or other food sources. This is also when they seek out a nearby creek or pond to drink water. They are rarely provided with water inside the pen, and then only if they are not allowed outside for some reason. They particularly enjoy wallowing in the water and mud during warm weather. When the ground is wet the pigs dig more, and can also cause greater damage to the property

of neighbors. While occasionally seen as a nuisance, this wallowing in the mud is considered by many farmers to be essential to the well being of pigs. It is considered to be a significant reason for allowing the pigs to leave their pens. Ingram (1965) reports that the evaporative cooling effect of mud is superior to that of water. By virtue of this behavior, the pig has a potentially high heat tolerance.

Pigs are unaware of property lines and therefore will invariably enter the farmyards of neighbors. In doing so they can, and do, cause damage to neighbor's property. The pigs tend to enter the farm family's household, especially the kitchen, and make a nuisance of themselves. Crops and other valuable plants are eaten. The pigs may destroy other farm facilities as they root about. Some people feel that it is a pig's right to move about freely. Their attitude is, "It is only natural. You shouldn't let that bother you." They feel that it is the responsibility of the neighbors to fence in their own property if they want to keep the pigs out. Other people will do the extreme of striking any trespassing pig with a club, or chopping it with a machete. In some cases this is done as an act of vengeance during family feuds. If the unfortunate pig escapes with only an injury, it must then cope with this injury on its own. The veterinarian is not likely to be called. If, on the other hand, the pig is killed, then the neighbor has acquired a fresh piece of pork. In some cases people feel that this is

fair compensation for the pig's crime. He certainly will not return it to the original owner. Many pigs suffer this fate. This can be a considerable loss to the owner. It certainly is cause for a lot of mistrust and animosity among neighbors, some of which are family members. This same problem is also referred to by Rappaport (1968, p. 160) in his discussions of traditional swine production in the New Guinea Highlands. It is most severe when the swine density in a community is high.

Some farmers take a more understanding approach toward tresspassing swine. In such cases the property owner is concerned only when serious damage is done. Then the owner of the pig is obliged to pay for the damage. The more common situation that occurs is when a pig eats a neighbor's chicken. The pig's owner is then obliged to reimburse the neighbor for the chicken. This can be rather costly to the owner of the pig, especially if the offending pig repeats its crime. Once the neighbors know that this pig eats chickens it may become the scapegoat for the reason behind any missing chickens in the neighborhood. A dishonest neighbor might even claim that the pig ate a chicken which never existed. Such a pig is then incarcerated in a pen and not allowed out until it has forgotten this bad habit. If the pig is deemed incorrigible, it will probably be sold or slaughtered. Several pigs are reported to have been broken of this habit by locking them in their pen, or tying them to a tree when outside the pen, for several weeks.

Not all pigs are allowed to forage freely all day. Some people only let their pigs out for an hour or two each day so they can drink water, get some exercise, and forage for a little food. They are then penned back up. They are less likely to cause damage or be injured or stolen this way. Other people will not allow certain of their pigs out of the pen at all, especially if the pig is a valuable one or is known to be problematic. If a pig has a history of wandering far away and not returning, or eats chickens or causes other damage, it will not be allowed out. Frequently, a sow or gilt that is near to her farrowing time is not released since she might wander off to a secluded spot in the bush to make a nest and give birth to her young there. This can be a problem since the young might be drowned in the rains, or killed and eaten by wild animals. A nursing sow might be allowed out only briefly in order to keep her near her young. A pig might also be kept in its pen so that it is available when a buyer passes through the area.

It is a common practice to restrain a pig with a rope tied to a tree. A simple harness is made by looping the rope around the pig's back, in front of and immediately behind the pig's forelegs. Some people tie their pig up like this and keep it tied up all the time, without ever using a pen. But this is also one way that a pig could be allowed outside of its pen so that it might eat some pasture and wallow in the mud without wandering off.

In some of the more densely populated village areas

there is some public support for a village ordinance which would require that pigs be penned up at all time. This is of course the case within the city limits of San Ignacio, Santa Elena, Benque Viejo del Carmen, and Belmopan. Presently, in these urban areas, if neighbors complain about a pig, then the pig must be removed. While there are still pigs in these areas, they are mostly penned or tied up. The smaller village of Santa Familia officially prohibits the free movement of pigs. Yet, they are still commonly seen running loose. The village councils of Bullet Tree Falls and San Antonio are also debating this idea. As areas which were recently rural gradually become urban, pigs will no longer be allowed to roam freely. This trend will alter the system considerably.

According to Malynicz (1970) and Purdy (1971), in the New Guinea Highlands all pigs are owned by the men despite the fact that women perform all the work associated with husbandry. In the Cayo district of Belize there is not such a clear cut delineation of roles. Instead, as with many farming enterprises, there is not any one particular individual family member who is responsible for caring for the pigs. The family members share the responsibilities among themselves. If the family is a married couple without teenage children, the couple share the responsibility of caring for the pigs. Generally, it is the woman who gives the kitchen scraps to the pigs after each meal. She may also give them some corn or other food. Usually it is the

man who lets out the pigs to forage before he goes to work, or when he returns after noon. He will also close them back in the pen in the evening. But this is not necessarily true all the time. Many women release the pigs and many men will give food to the pigs on any particular day. Who does what is determined primarily by which is most convenient or expedient. There are no mandatory roles. Teenage children will often assist their parents in these duties. In the case of extended families living together on the same farm, the pigs may be owned by one or more members exclusively. In this situation these members will retain greater responsibility, but the others on the farm will assist when they are needed.

It often appears to visitors that the women and young children are responsible for the care of the animals. This is only partially true. It happens that when most visitors arrive on farms, during the middle of the day the men and older children are generally away working in the fields or elsewhere. They may even be away for weeks working on the citrus or sugarcane plantations. During these times the women and children will care for the pigs, but no major decision regarding their care is likely to be taken by a family without the man's approval.

Generally speaking, management responsibilities for these pigs demand little. Caring for the pigs under the traditional system is very simple and consists of only a few simple tasks requiring only a few minutes each and every

day. The pigs are let out. Then later they are enclosed again and fed. During the day some food scraps might be thrown into the yard for the pigs to eat. Pig pens are not cleaned. If the pigs are not allowed outside of their pen, they must be fed more frequently and also provided with water, a breeding program has to be established, and the pens need to be cleaned regularly--reasons why intensive swine production has not been readily adopted.

Housing and facilities

Most families have some type of structure where the pigs can be enclosed, at least during the night. The structures in which pigs are housed, while varying from community to community, and among farms within each community, are of a generally similar rustic construction. The commonest characteristic on all farms is that few, if any, materials or outside labor are purchased in the construction of the swine housing unit. This is in accordance with the farmer's limited cash flow and vast knowledge of the utility of naturally available resources. Variation in the types of housing employed by different communities results from different local traditions and the nature and abundance of locally available building materials. Variation in the design and construction utilized on different farms within any one community is likely to be due to the size and complexity of the swine enterprise combined with farmers' personal preferences and perceptions of their animals' needs.

The walls of the structure are nearly always constructed from wooden sticks and poles. These are straight and narrow trees which were cut in the bush (jungle) nearby. Sometimes it is necessary to go some distance into the bush to find good quality poles. They are a very common building material and therefore in great demand. They are used in construction of most buildings and other structures.

Many farmers feel that it is best to cut poles during the full moon, meaning from three days prior to the full moon until three days afterward. They feel that the wood is drier at this time due to some effect of the moon, and that therefore, the wood is less susceptible to infestation by worms. These worms burrow into the wood lessening their strength and durability. The poles are not painted or treated in any way. Structures built with these poles can last as long as 15 years or more.

The pens are nearly always rectangular. Many buildings are nearly square, with each wall being from 1.0 to 2.0 meters (3.3 to 6.6 ft) in length. Other pens have one side being two or three times this length with the width still about 2.0 meters (6.6 ft). These larger buildings would likely be partitioned into two or three separate rooms of approximately equal size. This allows for the separation of a sow from her previous litter, or from another sow. The interior walls which partition the building into separate pens are constructed similarly to the exterior walls, described below.

The stocking densities within pens vary according to the number of pigs on the farm. A sow will frequently have one square meter (11 sq ft) of space, with or without a litter of piglets. The same square meter might otherwise have 3 or 4 growing pigs.

Four relatively thick poles serve as cornerposts for the building. These are frequently from 5 to 18 centimeters (2.0 to 7.0 in) in diameter, depending upon the size of the structure as well as the building's desired strength and durability. These poles are usually from 1.5 to 2.5 meters (4.9 to 8.2 ft) in length, depending upon the intended height of the roof. The size of poles available to be cut is also a contributing factor in the size of cornerposts that are used. As more and more trees are cut down, farmers must either journey farther to find good strong poles or settle for less desirable ones.

The cornerposts are set approximately 20 centimeters (7.9 in) into the ground. If the length of the building so warrants, other vertical posts are placed at intervals of from 1.0 to 2.0 meters (3.3 to 6.6 ft) along the walls for additional support. These are usually not as thick as the cornerposts, nor are they set as deeply into the ground. The cornerposts are the principal support of the roof as well as the walls.

Narrow poles are usually used to form the walls. Some farmers prefer to set the poles vertically forming a stockadelike structure similar to the one in Figure 4. These

poles are often placed into the ground from about 1 to 5 centimeters (.4 to 2.0 in). Sometimes a small space is left between the poles; at other times they are placed closely together. Most commonly, a vine, referred to as bejuco, is used to lace these poles together. Another method is to fasten the vertical poles to a horizontal pole extending between the cornerposts, using wire or nails. If this design is used, the vertical poles forming the walls are rarely more than 3 centimeters (1.2 in) thick and are usually 1.2 meters (3.9 ft) long, giving the building's walls a height of slightly less than this. This method requires more poles than the method described in the following paragraph, but the individual poles do not need to be as thick.

Figure 4. Typical pigpen of stockadelike construction.

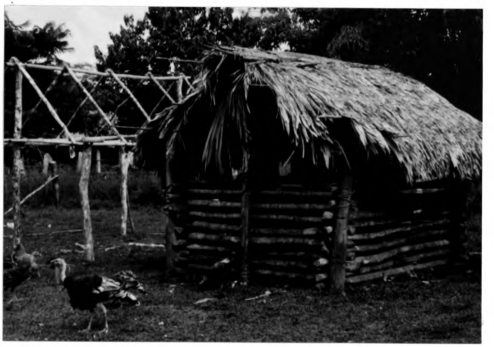

Figure 5. Typical pigpen of logcabinlike construction.

Additionally, there are no spaces wide enough to allow small animals to enter or leave the pen.

Another common way to build the walls is to attach several poles horizontally between the cornerposts. These poles are attached by nails or tied on with bejuco vines or wire. The poles are typically 5 centimeters (2.0 in) in diameter and five or six of them are used to form the wall of about 1.2 meters (3.9 ft) in height. This leaves about 20 centimeters (7.9 in) of space between the individual horizontal poles. This allows for considerable beneficial ventilation. It also allows small animals such as young piglets, chickens, and dogs to enter and leave at will.

Some farmers allow the horizontal poles to extend 5 to 10 centimeters (2.0 to 4.0 in) beyond the cornerposts, and then use this extension as a support for the horizontal poles of the adjacent walls. This log cabin-like structure requires more poles and decreases the space between the poles. Sometimes farmers will notch the upper sides of the extending ends of the poles so that poles of the adjacent wall set into them, providing additional strength and reducing further the space between poles.

An opening to allow the pigs to enter and leave the pen is usually built into one of the walls. A simple door like the one seen in Figure 6 is made possible by placing from eight to twelve thin vertical poles in an opening, thereby closing it. Two poles are placed horizontally along the top of the wall, and the vertical poles are placed so they fit between them. This is often done by extending a pole between two cornerposts on the inside of the wall, and another pole on the outside of the wall at the same height. Two other poles are likewise placed at the ground level, one between the cornerposts on the inside, and one on the outside. In this way a slot is formed into which the several thin poles can be vertically inserted to form the door. The door is commonly about .5 meters (1.6 ft) wide when open. This is the most common door used in swine pens. Occasionally, no door is built into a traditional pen. In this case the farmer lifts the pig over the wall, into or out of the pen.

Figure 6. Yorkshire pigs in traditional pigpen.

The same type of poles are used to form the supporting infrastructure of the roof. These poles are lashed together by vines, ropes, or wire to form a framework upon which the roofing material can be attached. The roof is nearly always the Gable or Hip type (Midwest Plan Service, 1983, p. 304.1) with two sides sloping upward to a ridge in the center. The roof is usually about 2.5 meters (8.2 ft) high at the ridge and 1.6 to 2.0 meters (5.3 to 6.6 ft) high at the eaves on the two sides. The two ends of the roof may (in the case of the Hip type roof), or may not (in the case of the Gable type roof), have any roofing material. The four sides of the roof usually extend from .3 to .5 meters (1.0 to 1.6 ft) beyond the walls. A space is usually left between the top of the walls and the eaves. This space varies in height

from zero to .7 meters (2.3 ft). This opening is important in providing ventilation and permitting observation of the pigs in the pen.

The roof is always thatched with either cohune branches or bay leaves. The cohune branches are usually between 1.5 to 4.0 meters (4.9 to 13.1 ft) in length. They are tied tightly to the rafters lengthwise (horizontally) with wire or vines. The roof is constructed from bottom to top so that the higher branches overlap the lower ones shinglelike. A well constructed roof will be five or six branches thick in any one spot. The roof will last from three to ten years depending upon the care and materials used in constructing it. Tying the branches tightly together and using wire increases its lifetime. Bay leaves are used in a manner similar to the use of cohune branches. They are tied to the roof supports in a shinglelike fashion. Whether cohune branches or bay leaves are used depends primarily upon availability and personal preference, but one does not appear to be much better than the other.

The floor of the pig pen is almost always the natural dirt surface upon which the building was constructed. In a few rare cases it has been hardened by the addition of some limestone. Whenever possible the building is constructed on well drained land, but often this is not enough to provide adequate drainage. Sometimes a shallow trench is dug surrounding the pen to divert water away. In some places, where the floor tends to be very muddy, loose materials have

been placed to provide some dry spot upon which the pig can lie. Old pieces of galvanized zinc roofing material, old boards or sticks, and rocks are sometimes used, but with little effect. The pigs generally just root them up. Leaves, weeds, and branches are also thrown in to help provide some bedding on the floor. Corn cobs, husks, and other trash also accumulate within.

Pens with muddy floors like the one in Figure 6 often go unattended even when the pig may be standing in mud and manure up to its shoulders. These unsanitary conditions tend to increase stress upon the animals, and probably depress performance and increase health problems.

On some farms, an area adjacent to the housing unit is fenced in to provide the pigs with an enclosed grazing area. This is particularly common in areas where pigs cannot be allowed to forage freely about the neighborhood for fear that they will damage the valuable crops planted nearby. This "run" allows the pigs to leave the covered house at will to exercise and forage. It thereby reduces the burden of keeping the pen dry and clean without allowing the pigs to wander unrestrained. When properly maintained it can be an excellent source of fresh pasture, though generally the "run" becomes overcrowded and rapidly becomes a barren strip of dirt and mud due to overgrazing by the hungry pigs. Forage crops are not planted.

The enclosed area may vary in size from one square meter to a couple hundred square meters. A wide variety of

fencing materials are used. Sometimes the fence is made similarly to the walls of the covered pig pen described above. Some farmers have hung barbed wire or chicken wire fencing to wooden poles with success. The strands of barbed wire must be strung relatively close together to prevent the pigs from passing through them. Most traditional farms, however, do not have the resources for these fences.

Most farms have troughs for feeding and watering the pigs; however, not very many use them. Generally, the pigs are released to drink water from a nearby creek or pond, and food is thrown loosely onto the dirt floor. Occasionally, however, a trough is useful, particularly when a pig is tied or enclosed all day and therefore cannot wander freely about for its water. A wide variety of old bowls, buckets, and tires serve this purpose adequately. Sometimes a log is dug out to form a basin or canoelike container for holding water that is 8 to 10 centimeters (3.1 to 3.9 in) deep. These also double as feeders. Sometimes a feed trough has been built from old boards nailed together to form a box, open at the top. They are not water tight, but they can hold corn or other food.

On most of the small scale traditional farms the pigpen can be readily identified by its characteristic size and construction. Rare and relatively incomplete is the farmyard without one. Building the pen generally costs nothing more than the time and effort expended in gathering the materials and building it. Once built, it often lasts for

10 to 15 years.

Traditional feeding systems

Rappaport (1968) reports that the traditional swine feeding system in the Highlands of Papua New Guinea is based upon the pigs foraging in abandoned gardens and surrounding fields. Each pig is also fed a nightly ration of about 4 ounces of garbage and substandard sweet potatoes. This ration is a small part of the pig's diet, most of which is provided through foraging, but it is sufficient to induce most pigs to return home each evening and thus remain attached to the household. This system is similar to that employed by the traditional small scale farmers of the Cayo District.

The small scale farm family does not make any special effort to provide a balanced diet for their pigs. The farmer is not aware of the importance, or value, of doing so. The pigs receive whatever foods are presently available, regardless of the nutritional composition of the diet. The quantity of food which the pig receives varies considerably depending upon the available resources. When plenty of surplus food is available the pigs receive a relatively large amount. At other times, when there is a shortage, the pigs receive very little to eat. The farmer is particularly loath to purchase any food for the pigs. Consequently, the pig's nutritional condition is directly related to the productivity of the rest of the farming system.

The foraging diet. The food that is eaten by the pigs while they are foraging varies considerably depending upon the prevailing local vegetation and the season of the year. The pigs primarily eat the naturally occurring leafy vegetation. They readily consume the succulent young leaves from grasses, weeds, bushes, and trees. They eat many different kinds of plants, but particularly like eating the chichibe plant. Costa's analysis (1981) of one sample of Chichibe leaf meal found it to contain 23.2 percent crude protein. The percent crude protein was found to be 22.0 for hog bush, 18.2 for pumpkin leaf, 16.5 for peanut leaf, 14.0 for trumpet leaf, and 12.5 for plum leaf meals. Pigs eat what is available and no effort is made to cultivate any forage crops for them. When there is insufficient forageable food available nearby they may wander several hundred meters searching for something to eat. Most farmyards have been severely overgrazed, especially since cattle, horses, and sheep also frequently occupy these fields.

The availability of edible plants varies with the season of the year. Their nutritional quality also varies with the season and the stage of maturity of the plant. The best pasture is available in June and July, shortly after the rainy season begins, when the plants are growing well but are not fully mature. The pasture is poorest during the drier months from January until May.

Most of the plants available to the pig are high in moisture. They are also principally composed of cellulose,

hemicellulose and lignins. These latter nutrients are relatively undigestible by the pig, a nonruminant animal. These forages are low in digestible energy. However, older pigs are able to adapt their digestive systems to the digestion of cellulose by increasing the populations of microorganisms in their hind gut (Whittemore, 1976). Varel (1984) reports that pigs on a high fiber diet (35.0% alfalfa meal) had a greater number of cellulolytic bacteria and greater cellulase activity (determined from fecal samples) than did pigs on a low fiber diet. There was considerable animal-to-animal variation, but a trend toward greater cellulolytic activity occurring after time on the high fiber ration was observed, suggesting progressive adaptation with prolonged feeding of alfalfa meal. The protein, vitamins, and minerals in such high fiber forages constitute an important part of the pig's diet (Loon, 1978).

Seasonality will also determine the availability of fruits and nuts to the foraging pig. If the fruits and nuts ripen on the tree without being harvested, they fall to the ground and the pigs eat them. In season, the pigs eat pineapples, grapefruit, oranges, limes, mangos, plums, crabbos, acorns, and berries. Throughout the year they eat coconuts, cohune nuts, bananas, and plantains as they are available. Most of the latter fruits eaten by the pigs are given to them in their pen. During certain seasons of the year the pigs will eat a considerable amount of the many fruits and nuts that grow in the area.

The pigs dig up edible roots and tubers and eat them. They will also consume whatever insect, worm, or small animal they can catch. By eating insects, grubs, caterpillars, and rodents they control the population of these pests which are generally undesirable on the farm. However, they also tend to eat beneficial insects and worms as well as an occasional chicken. These are valuable sources of quality nutrients for the pig, but, in the case of the chickens, a very expensive and undesirable source as well. Generally, the pigs are discouraged from entering areas where vegetables or other crops are growing. These cropping areas are either fenced in or distant from the pig's domain. Occasionally though, they will be allowed to forage through a recently harvested area to eat the crop residues. Even less frequently, pigs are sometimes permitted to forage among a crop such as potatoes or coco yams. They dig up the tubers themselves. The farmer will still harvest the crop but some of it is intended for the pigs anyway, and they are not permitted to forage extensively. At harvest time, crops such as corn or peanuts are spread over galvanized zinc roofing sheets to dry in the sun. The pigs are sometimes permitted to nibble on these foods.

While loose, the pigs are running about and exercising. They fight, and are chased by dogs. On many days the pigs will expend more calories foraging than they will consume in the process. But they are getting variety in their diet and obtaining a combination of essential amino acids, vitamins,

and minerals from the many different things they eat. This is particularly important since the pigs are not regularly provided with foods that have a balanced complement of these nutrients while in their pens. While foraging the pigs are balancing their diets through free choice consumption of whatever is available. They are, however, limited by the availability of food.

Hand feeding. Most farmers when queried about their feeding practices will respond that they feed "lone corn", implying that they only feed corn to their pigs. While corn is traditionally the major feedstuff given to pigs, this statement is an oversimplification of the situation. Along with the food eaten while foraging, the pig is given a variety of feedstuffs in its pen. The type and quantity of these feedstuffs varies from community to community, and among farms within each community.

What is fed depends upon what is grown on the farm. Corn is the principle crop grown on nearly all farms in the Cayo district. Not surprisingly then, it is the principal feedstuff for swine. On many farms, particularly those east of Santa Elena Town, coco yams, cassava and potatoes are also grown. In some wet areas, like Frank's Eddie Village, rice is grown. In the better drained soils near Cristo Rey and San Antonio villages, peanuts are grown. All of these crops are fed, to some degree, to pigs. However, most of them command a relatively high market price which precludes their use as a swine feed if markets are available.

The amount of whatever feedstuff is given depends upon several factors. Since the food that is given is surplus to the family needs, they must consider how much food they have presently stored, when more will be available from the next harvest, and whether there is expected to be a surplus. This is an inexact measurement. Generally more corn is fed during and shortly after a good harvest when there is a more obvious excess. Also, at harvest time any old corn from the previous harvest is removed from storage to make room for the new. This might be fed to the pigs along with any corn that has been damaged by insects or birds. When the supply is lower and there is concern over whether or not the next harvest will be bountiful, more use is made of other feedstuffs such as cohune nuts. Concern about natural problems such as high winds, heavy rains, or pests such as insects, birds, and mammals which could lower the crop yield are considered in predicting the yield of an upcoming harvest. Naturally, some farmers are more cautious than others in their appraisal of the situation.

Different people have different perceptions about how much food is enough for a pig. Some farmers feel that a few handfulls of food is enough. None of the traditional producers feed their pigs as much as they could eat. The rationale behind full feeding is not well understood, and probably not even very beneficial when the pig is receiving an unbalanced diet. However, if the feed is available, the farmer will sometimes give the pig relatively large amounts

of food in hopes that it will fatten more quickly.

The pigs prefer eating the old corn rather than the new corn which was recently harvested. This situation occurs whenever you abruptly change the diet of pigs. Fresh corn, which may still be green and high in moisture, is quite different from the 6 or 12 month old dry corn in storage.

In the morning, before the pigs are released to forage during the day, they are fed any scraps from the breakfast meal. These might be left over tortillas or corn husks, corn cobs, banana or plantain peelings, or other fruits. Generally it is not very much. Occasionally, a small amount of shelled corn or corn still on the cob is fed as well, or instead of any other food. In general, not much is fed to the pig prior to its release so that it is hungry enough to forage enthusiastically for food. Those pigs which are not let out, or are only let out for an hour or two after noon, would likely receive more food in the morning.

During the day, often around the midday meal, some food is frequently thrown into the yard. This might be a little corn, for which the pigs compete with the chickens. Any kitchen scraps or leftovers such as extra tortillas or potato peelings are thrown into the surrounding farmyard for them to eat. The leftovers of any snacks, such as sugar cane shavings, or peelings of bananas or other fruits eaten during the day are also thrown into the yard.

In the evening, the pigs are once again returned to their pens and then fed their main meal. They are given

their principal feedstuff then, whether it be corn, rice, cassava, or another food crop. Depending upon the size of the pig and the other factors mentioned above, each pig is given some food. For a pig weighing 15 kilograms (33 lb), this seems to average approximately .5 kilograms (1.1 lb) of corn. A 30 kilograms (66 lb) pig might receive 1.0 or 1.5 kilograms (2.2 or 3.3 lb) of corn. A 50 kilograms (110 lb) pig might be given as much as 2.0 kilograms or more of corn. The actual amount given to the pigs varies depending upon whatever other food was fed to them during the day. Therefore, pigs that are kept in their pens all day usually receive more than those permitted to forage.

Frequently, three, four or even as many as ten pigs are penned together and consequently are fed together. Since the feed they receive is limited, they fight over it, and the larger or more aggressive pigs will command most of the food. Consequently, the smaller, weaker pigs eat little and remain runted.

The food which pigs have access to under the traditional system of management is limited, and does not come close to meeting their nutritional requirements. This is the main reason for their slow growth and poor reproductive performance. There is considerable potential for improvement in this area of swine management. A similar conclusion was drawn from observations of traditional swine production in Papua New Guinea (Malynicz, 1975).

Growth and efficiency

Performance is directly related to the nutritional state of the animal. Since the diet of pigs varies on different farms at different seasons there is considerable variation in performance by the local pigs. The genetic potential of the individual also plays an important role in its performance, as does its health. Nevertheless, there are certain observable trends in growth and efficiency of these pigs.

79 local pigs, whose dates of birth were known, were weighed at various stages of their lives to determine rates of growth under the traditional system of production. The ages and weights of dozens of other pigs were also estimated and recorded. The esimated values did not contradict results obtained through measured data. Though farmers never measure or record the amounts of food that the pigs eat, they were able to provide some rough estimates of the amounts of corn being fed. Following are some of the conclusions of this survey.

Growth. The growth rate of the local pig under the traditional system of management is between zero and .20 kilograms (.44 lb) per day throughout the animal's life. Figure 7 presents ADG as a function of age for some pigs raised traditionally. The average daily gain (ADG) is .076 kilograms (.164 lb) per day for those pigs measured in the survey. During the first four months of age, ADG ranged from -.016 to .130 kilograms (-.036 to .286 lb), though most

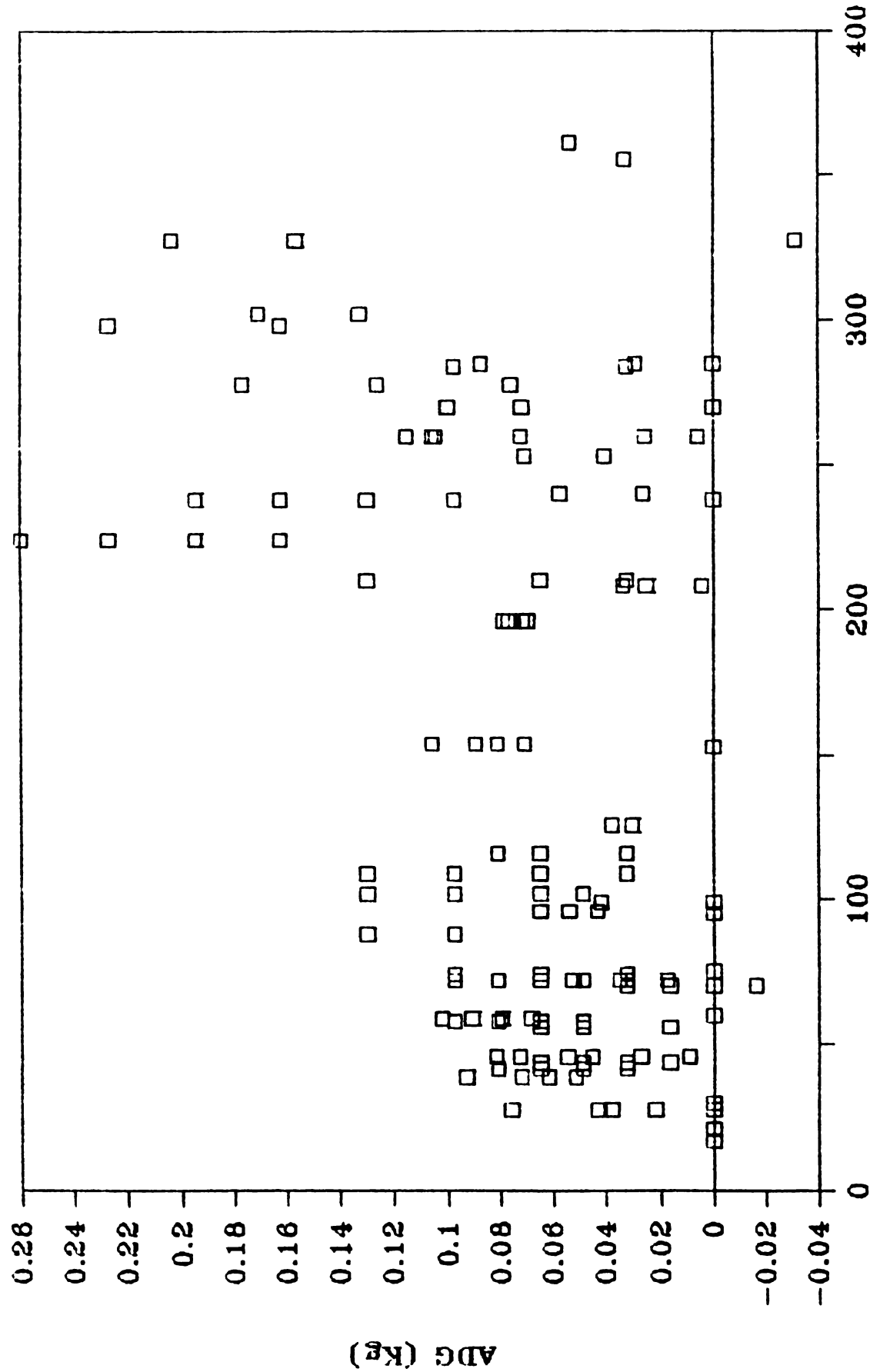

Figure 7. The relationship between ADG and age for several pigs raised traditionally.

values were between zero and .10 kilograms (.22 lb). The average was .059 kilograms (.130 lb) per day. After four months of age, the rates of gain varied more widely and ranged between -.031 and .260 kilograms (-.068 to .571 lb) per day. Most of this variation was between farms. Variation due to season of the year was also noted, due to the differing availabilities of food at different times of the year.

Figure 8 demonstrates the relationship between weight and age for several pigs raised traditionally. A one year old pig will generally weigh 20 to 30 kilograms (44 to 66 lb). However, some pigs may weigh only 15 kilograms (33 lb) at this age; others may weigh as much as 60 kilograms (132 lb). Generally, a pig will reach a market weight of about 60 kilograms (132 lb) in 18 to 24 months. Only rarely will pigs exceed this weight. Some pigs do not achieve even 35 kilograms (77 lb) of weight after two years. Butchers will buy pigs weighing as few as 20 kilograms (44 lb), though the price per kilogram will be low.

Similar rates of growth have been observed in indigenous pigs elsewhere. Malynicz (1970) notes that local pigs raised by subsistence farmers in the New Guinea Highlands would probably not weigh more than 23 kilograms (50 lb) when one year old. He refers to research recording a mean growth rate of 28 grams (one oz) daily over a period of two months for 26 village pigs weighing from 2.3 to 16.4 kilograms (5 to 36 lb). Under "careful management" these pigs were able

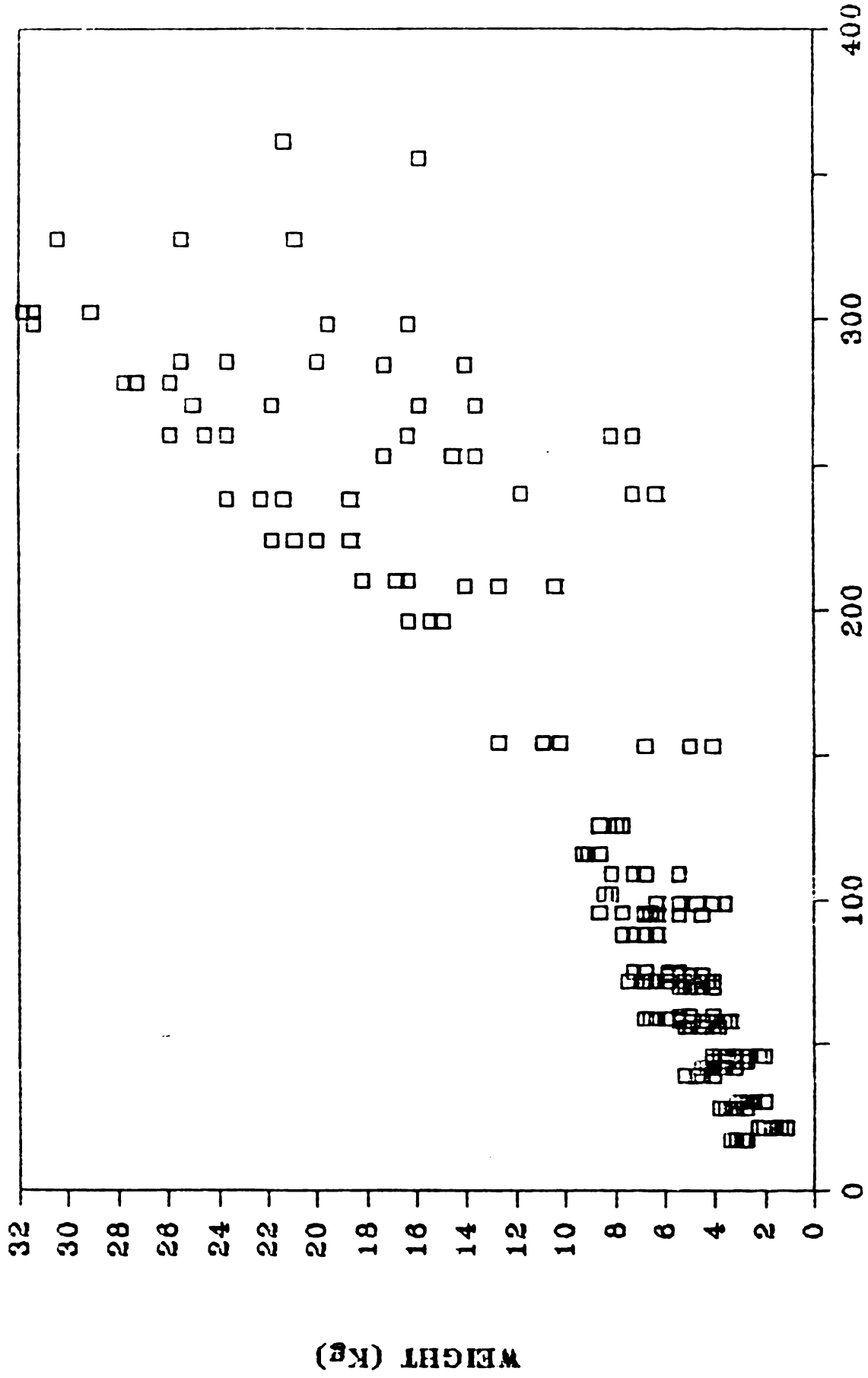

Figure 8. The relationship between weight and age for several pigs raised traditionally.

to acheive weights of 54.5 kilograms (120 lb) when one year old. Rappaport (1968) estimates a mean growth rate of 20.7 kilograms (60 lb) per annum for these native New Guinea pigs. Purdy (1971) estimates growth rates to be 27 kilograms (59.4 lb) per year.

In Belize, more food, especially corn, is available for feeding to pigs during the harvest periods. This is primarily during October and November, and to a lesser extent during the dry season harvest in April. During these months the pigs may gain as much as .15 kilograms (.33 lb) per day. However, prior to the harvest season there is frequently not enough corn to feed to pigs. Consequently, during July and August pigs may even lose weight. At different times of the year, a pig might grow .20 kilograms (.44 lb) per day, or .05 kilograms (11 lb) per day, or none at all, depending upon the food it receives. Since the pigs usually are not fed as much as they could eat, and are not fed a complete diet, they generally do not grow very much faster when they are larger. Only a few large pigs eating relatively large amounts of corn grow more than .10 kilograms (.22 lb) per day.

Efficiency. As was mentioned in the preceding section, pigs eat a variety of foods around the farm. They also receive some corn on most days. The amount of corn they receive generally varies from .1 to 2.5 kilograms (.22 to 5.5 lb) per day. Each pig might consume anywhere from 100 to 400 kilograms of corn per year. This indicates that the

traditionally raised pigs commonly consume from 6 to 15 kilograms of corn for each kilogram of live weight they gain.

This poor rate of feed efficiency is due to several reasons. The daily maintenance requirements for nutrients is relatively high since the pigs are traditionally loose during the day, and they run about, fight, and are chased by dogs. It is likely that on many days they eat just enough food to barely satisfy their maintenance needs with no nutrients left to support growth. Growth and productivity are adversely affected by deficiencies and imbalances of energy (Seerley, 1983), amino acids (Baker, 1983), and minerals and vitamins (Miller, 1983). It is difficult to measure the actual consumption of these nutrients by swine on an unrestricted foraging diet. However, it is likely that some imbalances exist. Their exposure to an unsanitary, stressful environment results in a further decline in productivity (Stott, 1981).

The farmers are not aware of their pig's feed efficiencies. They do not measure their food, nor do they record the ages and weights of the pigs. Since they grow the corn themselves they do not feel the cost of its use. If they did, it might be apparent that feeding their corn to pigs under the traditional system of management is a poor utilization of this resource. To better understand the costs of production, farmers should be encouraged to keep simple records recording the birth date of pigs, the amount of feed

consumed and their weight at slaughter.

The market price for corn varies from 35 to 48 cents per kilogram (16 to 22 cents per lb) and is commonly 44 cents per kilograms (20 cents per lb). On-farm corn value is considered to be 35 cents per kilograms (16 cents per lb) (Rai, 1985). If the farmer is fortunate enough to market his pigs at $2.00 per kilograms liveweight, he can afford a feed conversion of no greater than approximately 5.7 kilograms of 35 cent corn per kilogram gained. This is assuming that corn is the only production ingredient with a significant opportunity cost; and does not include the cost of maintaining the reproducing females. Apparently, traditional small scale swine production is fequently not economically efficient.

Reproduction

Swine are very prolific under the proper conditions. This ability to produce a relatively high number of offspring contributes significantly to the value derived from raising pigs on the small scale farm. Consequently, many farms maintain one or two reproducing females.

The actual productivity of the reproducing female will vary considerably between farms. The animal's genetic potential, environmental situation, health, and nutrition all play roles in determining her reproductive performance. Most of the traditionally raised gilts and sows are in a state of malnutrition throughout their lives. This probably

has a negative effect upon their productivity. The degree to which performance is affected depends upon the severity and length of the malnourishment. Hovell (1977) found that sows limited to half the ARC recommended amounts of protein and energy during pregnancy and lactation through three parities produced litters which were lighter in weight, though not significantly smaller in number, than the sows on the standard diet. The sows lost considerable weight. These "thin sows" had lowered milk production and they tended to abort and cease their reproductive activity after the second or third pregnancy. "The extent to which the thin sows penalized themselves in order to provide foetal requirements during pregnancy, or milk synthesis during lactation, was remarkable." Nevertheless, they were unable to sustain this indefinitely. Some sows were better able to withstand the nutritional deficiency than others, but they all became anestrus by the third pregnancy.

Svagar (1972) subjected gilts to a 2 percent crude protein diet during gestation and 5 percent during lactation and found that reproductive performance was significantly impaired. The percentage of sows exhibiting estrus and the average ovulation rate and uterine weights were significantly lower, while the average number of days from weaning to estrus was higher, than for sows on a control diet.

The general conclusion drawn from research of the effects of malnutrition on reproductive performance is that the dam is able to withstand some degree of malnourishment

without her reproductive performance suffering severely, but, under severe and prolonged malnutrition reproductive performance declines and eventually ceases.

Breeding system. While the pigs are foraging, they wander where they please. They may wander hundreds of yards away. This practice facilitates the free range breeding of these animals based upon the prevailing principles of natural selection. Any available boars which are in the vicinity and loose will compete for breeding privileges. The female may be serviced by more than one boar. Naturally, this service is free. However, in some neighborhoods there are no available boars of breeding size running loose. The boar which sires a particular litter of offspring is rarely known. Occasionally, some member of the family might see the animal being bred, but this does not happen often. It is even more rare for the sire to be selected. Few farmers are familiar with the signs of estrus. This makes controlled breeding especially difficult.

When there is no available boar running loose nearby, or the owner of the female prefers using a boar of known quality, a boar is brought from another farm and penned together with the female or females. The sow or gilt might also be taken to a farm with a boar. In either case they are penned together. If the farmer knows when a female is in estrus, this simplifies breeding, and they may remain together for only a day or two. Otherwise the boar might remain together with the females for a few weeks. If there

is a size difference between the animals, as is occassionally the case, servicing may be difficult. This has also resulted in injuries. The fee for this breeding service is generally one pig from the litter at about 10 to 12 weeks of age. The owner of the female usually selects the piglet. Otherwise, a fee of between ten and twenty dollars is assessed, though this is less common. Often the owner of the female will be given the choice of paying ten dollars at breeding time, or a piglet later. In situations where only one person in the area owns a boar rates as high as one piglet plus 15 dollars are charged.

Figure 9. Typical indigenous boar.

Castration of boars. Rappaport (1968, p. 70) reports that in the New Guinea Highlands traditional farmers

castrate all males at 3 months of age. Farmers there feel that this practice produces a larger and more docile animal. It also means that all matings are done by wild native boars while the females are foraging in the bush. Traditional swine farmers in the Cayo district also castrate most boars, but at an older age.

On different farms boars are castrated at different times for different reasons. Many boars are castrated when they reach puberty to lessen their inclination to wander far in search of females in estrus. Barrows are also more docile to manage. Consequently, in some areas, the only intact boars which are foraging freely are relatively young and small. These would be unable to service large sows and are likely to be of questionable fertility.

Most farmers feel that a barrow will fatten more quickly, though they feel that a boar should not be castrated until its testicles are fully developed and the animal is "fat". Research cited by Thornton (1973, p. 213) contradicts this. Apparently, young boars tend to have improved feed conversion and growth rates as well as leaner carcasses. Boar odor is negligible in young boars, but may be more significant in older boars.

One reason frequently cited by farmers in defense of not castrating before maturity is that the animal will not develop properly, and not learn how to wallow in the mud. Castration at this older age is more difficult, however. The animal is more difficut to restrain and stress is

greater (Pond, 1974, p. 498). How this attitude originated is uncertain; perhaps, under the prevailing low sanitation and nutritional plane, a larger animal can better survive this surgery than a smaller animal. Also, very few people are knowledgeable enough to surgically remove the testicles from the abdominal cavity, before they descend into the scrotum.

Most boars are castrated when they weigh between 15 and 30 kilograms (33 and 66 lb). They are rarely younger than seven months, and often are eight or nine months old. If the pig is growing more slowly he may be well over one year old. Butchers will buy boars, and they often do. However, many farmers feel that as an intact boar, the animal will not get very fat. Therefore, they will eventually castrate most of them, and then fatten them up for slaughter. The intact boars that are marketed are not large enough to be a nuisance yet, or were kept for breeding purposes. Often, even breeding boars are castrated and fattened prior to their marketing.

Size and age of gilt at first farrowing. Age at first farrowing is used as a reproductive parameter rather than age at puberty since estrus is a relatively indistinguishable occurrence under the traditional system. First farrowing indicates when the first successful ovulation and fertilization occurred. Under natural mating conditions this is often an indication of the first estrus. The prevalence of swine brucellosis and leptospirosis in the area (Stafford,

1984) could have a confusing effect upon this parameter. Brucellosis can cause abortion early in pregnancy, which may go unnoticed, and also temporary or permanent sterility (Merck, 1979, p. 371). Leptospirosis may also cause abortion, but late in pregnancy (Merck, 1979, p. 384).

The size and age of a local gilt raised under the traditional system of production will depend primarily upon her level of nutrition during development. Haines (1959) found that gilts on a low energy diet were older and lighter at puberty. Apparently, severe restriction will slow growth and delay puberty (Seerley, 1983).

Generally, a gilt will farrow at 14 to 18 months of age. Weight immediately after farrowing generally ranges between 35 and 60 kilograms (77 and 132 lb), and commonly is about 45 kilograms (99 lb). Sows weighing as little as 20 kilograms (44 lb) were also observed.

Litter size. During this last year 42 litters of local pigs were observed soon after farrowing. The number of pigs born per litter ranged between 2 and 11. The average was 7.3. Though accurate data are unavailable, it appeared that larger, better fed sows tended to have larger litters of greater individual birthweights. They were also better able to support moderate growth in the nursing piglets.

Malnutrition does not seem to have a significant effect upon litter size. Clawson (1952) and Haines (1959) demonstrated that ovulation rates were diminished by low energy consumption. This did not have an effect upon litter size

though, since embryonic mortality was also lower. Clawson (1963) and Pond (1973) observed no significant effect upon litter size and individual birthweight due to lowered protein and energy consumption. However, prolonged severe malnutrition can produce abortion and death of the sow (Howell, 1977).

Sharna (1974) found that feeding naturally moldy corn in Ohio did not affect the estrous cycle or rates of ovulation or fertilization in gilts, but did increase the rate of embryonal and fetal mortality resulting in fewer live pigs being born. Fusarium moniliforme and F. roseum were the most abundant molds naturally affecting the corn in this study. Pigs in Belize are often fed moldy corn that is unfit for human consumption.

Weaning. Most pigs that are born alive survive through weaning. Those deaths that do occur usually take place during the first days after farrowing. During the period of the survey, one mummified fetus was reported born in all the litters investigated. In about one fifth of the litters, a pig or two was reported to be born dead. However, since it is very rare for someone to be present during farrowing, these pigs could have suffocated or been crushed soon after birth. Rarely, a gilt or sow was reported to have eaten her young or not let down her milk. However, there are few farrowing problems with the local pigs.

This survival rate under traditional management systems appears exceptionally good. Rappaport (1968, p. 71) reports

that an average of only two pigs per litter survive infancy in the Highlands of New Guinea.

Generally, the pigs nurse for as long as the sow permits. Therefore, they will nurse for three or four months. Some pigs will still be nursing at five months of age. Occasionally, a farmer will wean his pigs by separating them from the sow, but this is rare. Separation is difficult since all the pigs run loose together during the day and are penned up together at night. Separating them requires additional facilities.

Figure 10. Indigenous sow foraging with her four piglets.

Three months is considered early weaning. Most people do not even wean, because they are afraid the piglets will die if they are denied the sow's milk. They wait until the

piglets are "fat", or until the sow prevents their nursing of her own volition.

While they are nursing, the pigs are foraging and eating along with their dam. By the time the sow weans her pigs she has lost 10 to 15 kilograms (22 to 33 lb) of weight. At weaning, the pigs will weigh 5 to 10 kilograms (11 to 22 lb) each.

Libal (1975) found that restricting energy consumption in lactating sows did not effect litter weight up to 3 weeks after the birth, but reports that one would expect a difference on pig weight if they were allowed to nurse to 6 weeks of age. The restricted sows lost considerable weight. The average weight of these sows was 216 kilograms (475 lb). The local sow commonly weighs 45 kilograms (99 lb) after farrowing and is unable to sustain high lactation on a restricted diet.

The farmer usually will give away or sell all but about three of the piglets soon after weaning. Small farm resources are rarely adequate to maintain any more than this. This is an opportunity to pay off any debt or earn some income or social prestige.

Interval between farrowings. Not all sows are bred again. Some animals that are deemed troublesome are sold or butchered. However, a good sow is often retained. The time interval between farrowings depends considerably upon the age of her piglets at weaning, and upon her condition and nutritional level. A sow receiving continually poor nutri-

tion that has lost much weight while nursing will be in a state of anestrus and may need to recover for a few weeks or even months before she will return to estrus (Hovell, 1977).

This interval between farrowings ranges between six and 12 months. The shorter interval occurs for an animal whose piglets were weaned at 10 weeks of age who returns to estrus within 10 days for rebreeding. However, this is very rare. Generally, the interval is 7 to 11 months.

A gilt or sow might be sold or butchered any time before she appears pregnant. After she becomes noticeably pregnant she will be kept until her piglets have been weaned and she has regained some weight.

Breeding season. Pigs are polyestrus and there does not appear to be any conscious effort on the part of the farmer to breed at a particular time of the year. Therefore, it is expected that pigs will be born at all times of the year.

Nevertheless, this year there were disproportionately large numbers of farrowings between the middle of January and the middle of March. These sows and gilts were primarily bred under free range conditions. Apparently, they were serviced between September and early November. This time of the year coincides with the principal corn harvesting period, when more corn is being fed to pigs, and their nutritional state is at its annual highest. It also follows the "mawga" season of July and August when the least amount of corn is available for feeding to pigs.

At harvest time any old corn previously in storage is removed to make room for the new. This corn, along with any spoiled corn, is fed to pigs. Also, the moist corn is cut from the freshly harvested green ears and is used to make the sweet tamalitos that are enjoyed during harvest season. The resulting cobs with corn fragments, and the husks, are then fed to the pigs.

It is likely that there is a significant improvement of the nutritional state and, consequently, the health and reproductive performance of the pigs at this time. Most females are probably in a state of nutritionally induced anestrus during July and August. I am not aware of any local pigs born to sows under the traditional system of management during the months of November and December. Once they are on a more nutritive diet, higher in protein and digestible energy, they would begin to cycle again, and are serviced. Hovell (1977) rebred all "thin sows" whithin 4 weeks on a repletion diet.

This breeding period also coincides with the onset of cooler temperatures in October. It is possible that the high temperatures which commonly occur from April through August could cause reproductive failure in swine. Wetteman (1976) demonstrated that heat stressed boars had reduced spermatogenesis, sperm motility, conception rate, and embryo survival. Teague (1968) demonstrated that an elevation in dry bulb temperature [to 33.3 degrees centigrade] increased the incidence of anestrus and the number of gilts which

returned to estrus after breeding. High temperatures and humidity seem to contribute to failures of estrus and provoke early embryonic mortality.

Summarizing, on the small scale farms of Cayo district it is not unusual for a gilt to be raised under such low levels of energy, protein, vitamins, and minerals that she weighs 25 kilograms (55 lb) and is 11 months old at puberty. She is relatively unprepared for the burden of pregnancy because of continuing malnutrition. She farrows seven one kilogram piglets. Her small body size and malnutrition allow only limited lactation. The piglets in turn are undernourished and grow slowly. They nurse for three or four months. The sow is then anestrus for two or three months. This low level of reproductive performance is one potential opportunity for considerable improvement. Improving the nutritional status of the gilt sow, especially energy consumption in the lactating sow, would likely increase the growth rate of nursing pigs. This might encourage early weaning and more rapid postweaning return to estrus.

Traditional marketing methods

The local pigs which are raised under the traditional system of management are not marketed according to any one particular method. Rather, the pigs are utilized in a variety of ways ranging from home consumption of pork products to the sale of live slaughter animals. The particular

method used depends upon the farmer's available options and the benefits perceived to be derived from each option. The marketing channels are relatively disorganized and undependable. Nevertheless, there are observable marketing trends. Traditional marketing methods complement the traditional roles fulfilled by local pigs raised under the traditional management system.

Since the pigs themselves take so long to reach marketable weight, there are few pigs sold by any one farm. This means that the individual farmer probably has little swine marketing experience or influence upon the market. The way in which the pig is marketed determines whether or not any benefit is derived from its production. It appears that in more than a few cases the financial benefits are actually less than they are perceived to be by the farm family.

Sale to itinerant traders. There are no accurate figures available on how many pigs are sold to itinerant traders, but this study found that between 40 and 60 percent of all the pigs raised to slaughter size on the small scale farms of the Cayo district are marketed this way; most of the remaining pigs are killed for use within the community. The buyers from outside the community are often butchers, or their purchasing agents, from the larger towns such as Santa Elena or San Ignacio. They may also be middle men who buy pigs and sell them to butchers in these towns or even as far away as Belize City, Corozal, and Orange Walk.

Usually, there are no previous arrangements made

between the farmer and the purchaser concerning the sale. The buyer drives through a community and makes queries as to who might wish to sell pigs. Also, community members are usually aware that a purchaser is in the neighborhood and they may approach the buyer with the intention to sell pigs. The buyer then looks at the pigs and offers the farmer a price. The farmer either accepts or rejects this offer. He might ask for more, and the buyer might agree; usually, however, the buyer has the advantage in such bargaining because of the market conditions that prevail in the area. There are a limited number of individuals who buy pigs, and only two or three principal buyers, in the Cayo district, so it is difficult for farmers to get another offer. Often, the farmer wants to sell the pig for a certain reason: the money is needed or the farm's resources can no longer support the pig. Only occasionally are pigs sold because they have reached slaughter weight. The buyer is aware of these facts and can afford to be intransigent in any offer. There simply is not much competition for the purchase of lightweight local pigs.

The traders will purchase a pig of nearly any size but the price will vary according to the appearance of the animal. The price also varies a little among buyers. Generally, buyers report that pigs under 25 kilograms (55 lb) bring about $1.25 per kilogram ($.57 per lb) of live weight. Pigs weighing from 25 to 40 kilograms (55 to 88 lb) bring about $1.50 per kilogram ($.70 per lb). Pigs weighing from

40 to 60 kilograms (88 to 132 lb) bring about $2.00 per kilogram ($.91 per lb). Pigs weighing over 60 kilograms (132 lb) might bring as much as $2.20 or $2.30 per kilogram ($1.00 or $1.05 per lb). Some farmers are less exact and will tell you that the price is $1.98 per kilogram ($.90 per lb) for animals under 45.5 kilograms (100 lb), and $2.20 per kilogram ($1.00 per lb) for animals over this. However, actual pricing is not as exact as these numbers indicate. The buyer establishes the price. Occasionally, he will weigh the pig and pay by the pound. But often he will estimate the value of the pig by sight and make an offer. The farmer's only options are to accept or reject this offer. The buyer's attitude is "take it or leave it."

The family member who owns the pig decides when the pig will be sold. This may be any member of the family but is most frequently the male head of the household. However, he might not be present when the buyer arrives; in this case, another family member, such as the wife or mother, would complete the transaction.

Marketing of pigs within the community. Frequently, young pigs are given, traded, or sold to neighbors, friends, or relatives. These are most commonly pigs which have recently been weaned. They usually are three or four months old and weigh 5 to 15 kilograms (11 to 32 lb), though occasionally they are larger or older. A farmer might even receive a 45 kilogram (99 lb) gilt to use for breeding or further fattening, though this is relatively rare.

The arrangements for the transfer of a pig's ownership are as numerous and varied as there are farms and reasons for making the transfer. The arrangements are usually informal since the participants know each other and are often friends. Often, pigs are given to someone as a gift, as payment of a debt, or in return for a favor received. At other times pigs are traded; for example, it might be convenient for a farmer to trade one larger pig for two smaller pigs. If the pigs are sold outright the price is generally $2.20 per estimated kilogram of live weight ($1.00 per lb), regardless of size. However, in dealings between friends and relatives arrangements are often made that would be considered excellent bargains.

These transfers most commonly take place within the community but also might include friends or relatives in other communities, or even strangers who are not actually traders but merely desire pigs for their own use, whether this be for raising or barbecuing.

Sometimes the farmer feels that it would be preferable to slaughter the animal himself and either sell the carcass to a retail meat shop or sell the meat by the pound within the community himself. Some stores will pay between $2.75 and $3.30 per kilogram ($1.25 and $1.50 per lb) for the carcass. These retailers then sell the meat at prices ranging from $4.40 to $5.50 per kilogram ($2.00 to $2.50 per lb). Some farmers have killed their pigs and sold the meat for $3.85 or $4.49 per kilogram ($1.75 or $2.00 per lb)

within the community. While this requires some rudimentary hog slaughtering ability, and a market for the meat, it is probably the most profitable means of marketing a hog.

Home consumption. A considerable number of pigs, about 15 to 20 percent, are killed on the farm for use on some occasion when guests are invited to the household. The pork is used in the preparation of tamales or bollas. It might also be barbecued or cooked as pipil. It is a favorite food to serve at birthdays, christenings, confirmations, graduations, farewells, weddings, funerals, or whatever holiday or holy day is considered important. In fact, one of the major reasons for raising a hog is to have one available for some particular upcoming occasion.

Traditional health concerns

The traditional system of management exposes pigs to an unsanitary environment where infectious diseases and parasites are endemic. Nevertheless, health concerns of traditional small scale swine farmers are minor. Their reluctance to purchase anything for their pigs extends to reluctance to pay for medicines and veterinary services. Therefore, it is rare that pigs will receive any medical attention.

The majority of local pigs have some degree of morbidity, due to either the effects of malnutrition or infection. Soon after recovering from one insult, they are likely to be afflicted with another. Some diseases, such as

parasites and malnutrition, may plague them throughout their life. When a pig becomes ill, it must recover on its own. Depending upon the animal's prior condition, resistance, and immunity, it may slowly effect a recovery or it may waste away and die. Some farmers attempt traditional remedies. They will not call upon the veterinarian, unless, perhaps, one happens to be passing through the neighborhood.

In one case 14 of 16 eight month old pigs which weighed approximately 15 kilograms (33 lb) became ill and wasted away over a two week period before dying. They had diarrhea and were vomitting severely yet the family never called upon the veterinarian. When the veterinarian (Dr. Burns) heard the symptoms, he felt the pigs could have been saved if he had been consulted.

Small scale farmers raise only a few pigs at a time. Even though most farms have pigs, the swine population density is low. There is a correspondingly low likelihood of a build-up of large populations of pathogens. Therefore, when a pathological infection occurs, it is minor. The pig's immunological system has time to produce sufficient antibodies for its defense.

Because pigs raised under the traditional system roam freely about the community and mingle with all other pigs in the area, it is likely that every pig is exposed to all the locally prevailing diseases early in life. The immunity imparted to the piglet passively by the dam gradually declines, but is concurrently replaced by the pig's own

naturally developing immune system. Consequently, there is a high level of morbidity, but very little mortality due to disease.

Swine are not vaccinated against any disease by traditional small scale farmers. It would not be useful. It has been suggested that the indigenous local pigs have developed some natural resistance to the locally prevailing pathogens (discussed in the "Description of the Local Pig" section). Exotic pigs may be less resistant than the indigenous pigs to local pathogens. However, the introduction of an alien disease such as hog cholera could result in high mortality to all pigs in the area affected.

The most common symptoms of poor health mentioned by farmers are that the pig will not eat or grow. These are two symptoms common to nearly all infectious and nutritional diseases. Frequently, no other information is available to assist in diagnosis of a health problem since the animal's movement and activities are uncontrolled and unknown, and its age and history uncertain. If there is no elevated temperature, internal parasites and poor nutrition are generally assumed to be the principal problems (Burns, 1985).

Internal parasites. While the pigs are foraging and rooting in the soil for food they are swallowing the eggs of internal parasites. It can safely be stated that every pig raised under the traditional system of management has some internal parasites (Burns, 1985). Most pigs have a heavy parasite load. Ascarids, lungworm (Metastrongylus

elongatus), kidneyworm (Stephanurus dentatus), Trichenella spiralis, and Strongyloides suis are all present in swine in the Cayo District (Arnold, 1959; Gamble, 1982).

Dunne (1975, p. 780) indicates that swine severely infected with nematodes can weigh only 7 kilograms (15 lb) at 3 or 4 months of age. Such low weights at these ages are frequently the case in the Cayo district. However, it appears that for many of the local pigs, the internal parasites are not a handicap significant enough to warrant regular dewormings. Research indicates that pigs dewormed regularly perform no better than pigs which are not dewormed (Rai, 1983). Deworming appears to be justifiable only when the pig is visibly suffering from a very severe infestation. Otherwise, malnutrition is the first limiting aspect of swine production. The principal deleterious effect of the endoparasites is a diminished ability to withstand malnutrition (Henry, 1970). It is possible that the local pigs have developed a genetic ability to withstand high levels of endoparasites.

Most farmers feel that worms are a problem in their pigs, but they are unfamiliar with the mode of infestation or how to control these pests. Adult worms are found in the feces of some pigs. Many farmers believe that pigs get worms by eating pumpkins or squashes.

If someone visits the farm and offers to worm the pigs inexpensively or for free, farmers will consider having it done. Otherwise, they are unlikely to make the effort

themselves.

External parasites. As with internal parasites, nearly all pigs are exposed to external parasites while they are foraging and have some degree of parasitic infestation. Parasites attacks are worst during the drier months, from January until May.

The sarcoptic mange mite is a problem which causes severe itching and stress on the pigs. Severe cases of mange have been reported by farmers as the cause of mortality in pigs. It appears to affect the pigs without skin pigmentation more severely than the black skinned pigs. This could be due to further aggravation from sunburning or photosensitization (Howard, 1981, p. 773). It might also indicate some resistance to the mites by the local, black pigs which the light colored exotics and exotic crosses do not possess. The traditional treatment for mange is to bathe the animals in burnt engine oil, which can be effective.

Ticks will attack pigs but are generally not a significant concern. Considering the large quantity of ticks to which they are exposed, relatively few attach themselves to pigs. Perhaps the local pigs have some level of tick resistance that makes them a less desirable host.

Abscesses. Jowl abscesses appear occasionally in pigs. The streptococcal organisms producing this condition thrive in unsanitary conditions (Merk, 1979, p. 354) prevalent under the traditional small scale swine production system.

Infection could be introduced into the lymph nodes when the animals graze on sharp objects such as thorns as is believed to be the case with actinomycosis (Howard, 1981, p. 668). Abscesses also develop on the shoulders or hams, frequently after an injury to the area.

The abscesses concern the farmer, but ignorance of their cause or treatment, combined with his reluctance to request assistance or purchase medicines, precludes any remedial action. Most pigs stop eating and gradually lose strength until they die. This may take a couple months.

Bats. Vampire bats will frequently molest pigs. They weaken the animal by drawing blood. They usually bite pigs around the neck, shoulders, or ears. The wound is a potential source of infection by screwworms. Rarely is anything done to control them. Some farmers occasionally place lanterns within the hog pen in an effort to ward off the bats. One farmer reported having success swinging a 7 m (23 ft) pole back and forth in the air to attract the bats, and then striking them down. Others have reported success in controlling bat problems by painting a poisonous arsenic based solution on the neck areas where bats frequently bite.

Beefworm. This parasite can be a considerable nuisance, especially in areas like Frank's Eddie Village that are still closely surrounded by jungle. All warm blooded mammals, including swine and man, are affected. The "worms" are larvae of the botfly, Dermatobia hominis. According to chandler (1961, p. 786), when the adult female fly is ready

to oviposit, she captures an insect, usually a large mosquito but occassionally other flies or ticks, and glues her eggs to the underside of the abdomen of her captive. After several days incubation, the maggots emerge when the carrier insect alights upon the skin of a warm blooded animal, and they penetrate the skin. The larvae mature in the host's skin in 5 to 10 weeks. They ultimately reach a length of 18 to 24 milimeters.

As the larva develops, a boil-like cyst forms about it which opens to the surface of the skin by a little pore used by the larva for obtaining air. At intervals these boils cause excruciating pain. When farmers observe a boil on an animal they try to pinch the larva out through the pore in the skin. When the larva is allowed to develop to maturity it exits through the pore and drops to the ground to pupate. These wounds are a potential location for infection or screwworm infestation.

Screwworm. This parasite is found throughout the area. The "worms" are larvae of the screwworm fly, Callitroga hominivorax. The adult female fly oviposits her eggs in open wounds. After several hours the white larvae begin eating away at flesh and bone. They grow to a length of 12 to 15 milimeters in 5 or 6 days, then drop from the animal to pupate in the loose earth. There is usually an abundant discharge of pus, blood, and scraps of tissue from the site of infestation, accompanied by intense pain. Death from tissue destruction and toxemia is frequently the end result

(Chandler, 1961, p. 775). Farmers treat the worms with burnt engine oil, with some success.

Any other diseases which affect the pigs are less common and often go undetected. Occasionally, a pig may get sick, fail to recover, and die. This can be a relatively large loss for the farmer, but he will accept it stoically, as if it were meant to be.

RECENT INNOVATIONS IN SWINE PRODUCTION

Introduction

The following pages contain a discussion of the recent innovations which have been attempted by swine farmers. Few of them have been successfully adopted by the small scale farmer and reasons for their apparent unacceptability are also discussed herein. Perhaps the benefits of altering certain aspects of swine management have not been demonstrated effectively. An even more likely reason is that for many small scale farmers certain proposed changes are not compatible with their goals and rationale behind raising swine. In many cases the disadvantages of these changes upon the small scale farming system are more significant than the benefits.

The costs and benefits of intensifying small scale swine production must be viewed culturally and monetarily. The security and stability provided to the farm family through traditional swine production cannot be overlooked in the development of methods of intensifying production. Economic returns must be sufficient to justify investment of limited financial resources in such a risky venture as livestock production rather than in some other activity. The sudden failure of a market outlet or the invasion of a

serious disease into the herd would have disastrous consequences.

Changes which have been proposed include the use of imported breeds of pigs, controlling swine movement by enclosing them in sanitary housing, and feeding the pigs a properly balanced diet. These practices are being adopted on some of the larger scale farms where swine production is considered one of the principal farming enterprises. Some medium scale farmers have also had some success adopting these practices. On the small scale farms, where swine production is not a principal enterprise warranting significant attention, very few farmers have successfully adopted any of these changes.

Malynicz (1970) reports that in 1966 indigenous people of the New Guinea Highlands were encouraged to buy British bred pigs, and many pig enterprises were begun. However, by 1968 the project had all but collapsed. The failure was attributed to technical and economic factors including lack of protein supplements, poor management, and over-capitalization on housing. Very few people were prepared tp produce home grown feeds. These are some of the same reasons for the failure of many farmers in the Cayo district who have attempted to intensify their swine production.

The following analysis is an attempt to better understand why certain changes in the system of swine production are perceived as unacceptable by the small scale farmer, why some changes are likely to fail or succeed, which changes

might be most beneficial, and how their benefits could best be demonstrated to the farmer.

Farmer's general attitude regarding adoption of recent innovations in swine management on the small scale farm.

There is no perfectly typical attitude that farmers have toward the adoption of new technologies. No two farmers are alike in their views or their goals. Nevertheless, there are certain characteristic positions which are commonly exhibited by the small scale farmer. Understanding these attitudes can be helpful in the development and extension of new ideas to the farmer. The goal of extension is not to trick the farmer into trying a new technology, but rather to present it in such a way that the farmer's concerns and doubts regarding the technology are adequately answered.

A common characteristic of the small scale farmer is polite humility. An extensionist visiting the farm is politely received and listened to. It would be rare for the farmer to disagree or argue with the visitor, or to ask any difficult questions concerning the presentation of a new technology. This would be considered rather rude behavior. Thus, the farmer might appear to be in agreement when in fact he has considerable doubts regarding the subject. Consequently, it is the duty of the extensionist to anticipate any questions the farmer might be expected to have, and answer them in the presentation. Naturally, there are many exceptions to this generalization. Some farmers are very

inquisitive and talkative, even argumentative.

Farmers in the Cayo District of Belize tend to only believe a fraction of what they hear. They know that talk is cheap. They are accustomed to people talking confidently about a subject as if they were quite knowledgeable about it, when in fact they are not. Therefore, it is necessary for them to actually see something with their own eyes before they seriously consider whether to believe it, especially in the case of something that is new and unusual to them, and carries some risk.

Most farmers would enthusiastically adopt changes beneficial to themselves. However, since most proposed changes of technologies involve some risk or uncertainty relative to the traditional practices, the farmers must be cautious in their acceptance of them. Most small scale farmers possess limited resources and survive just above the subsistence level. They are reluctant to take any unjustifiable risks, a trait often mistaken for innate conservatism (Moris, 1981, p. 57).

Many technological improvements of the traditional farming system require some capital expenditure. Small scale farmers have a very limited cash flow situation. They generally are subsistence farmers who primarily consume what is produced on the farm. Only occasionally will they be able to sell some farm produce or work for another farmer or employer where they receive cash income. And when they do, this money is often intended for another purpose of higher

priority. Therefore, the return on investment must be high enough to warrant the allocation of limited financial resources for swine production rather than some other use.

Many small scale farmers are limited in their ability to read, write and perform mathematical calculations beyond addition and subtraction. Consequently, they are limited in their ability to analyze the profitability of a particular production activity and successfully adopt the proposed changes in technology (Malynicz, 1975). Exceptions to this are some of the younger farmers. It is frequently necessary for the extensionist to perform calculations along with the farmer so that the economic advantages or disadvantages of a technological improvement are understood.

Farmers generally do not keep records of production. They are not accurately aware of the costs of production, nor the returns. This is particularly the situation with the traditional system of swine production. Farmers rarely record the birth dates of their pigs and therefore have a poor idea of how old they are. They do not generally have access to a scale to weigh their pigs and measure growth progress. Nor do they measure or record the amounts of corn or other food that the pigs eat. This information has traditionally not been important. If they ever did keep these records and made the calculations, they might realize that their pigs were eating large amounts of corn and growing very slowly. They do not perceive the opportunity lost by not using their corn more efficiently. Most farmers are

satisfied with weight gains of less than one-half kilogram per week. Pigs are considered to be doing well as long as they do not appear sickly and continue gaining weight steadily, albeit slowly.

New breeds of pigs

The government of Belize has imported exotic breeding stock for the purpose of upgrading the genetic potential of the nation's swine. Five modern breeds of exotic swine are identifiable. Berkshire boars were introduced in 1950 (Arnold, 1950). Poland China seedstock was later introduced. Presently, the Ministry of Natural Resources maintains Yorkshire (Large White), Duroc, and Hampshire breeding animals at the agricultural stations. Purebred and crossbred animals are available for purchase by farmers at these stations. These are usually sold as weaner pigs, but some older pigs are also sold. The price is $4.40 per kilogram ($2.00 per lb) for purebred animals, and $3.30 per kilogram ($1.50 per lb) for crossbred animals .

Several farmers have purchased exotic pigs from the government. Their production results are mixed. Those farmers who adopted the appropriate technologies for the management of these high performance animals were generally successful. Those farmers who did not were generally unsuccessful. The latter are primarily the traditional small scale farmers.

A study conducted by Rai (1983) indicates that

"improved" weaner pigs from Central Farm gained weight faster than local pigs. All pigs on the trial were given a measured amount of commercial protein supplement each day and allowed to forage for themselves throughout the day. The "improved" pigs consumed less supplement per kilogram of live weight gained than did the local pigs.

Malynicz (1973) describes problems associated with the consideration of genotype in isolation from other factors operating in the management system. He notes that distribution of improved pigs into traditional management systems of swine production did not significantly increase productivity due to the environmental influences of nutrition and parasitic diseases. An example of this in Belize occured in the village of Frank's Eddie where several farmers acquired a few Yorkshire gilts but continued raising them under traditional management systems. These animals have productivities equal to or lower than the local pigs. They appear to suffer more from various afflictions than the local pigs do. The loss is greater if one of these exotic pigs dies since they are more expensive. Other similar examples can be found throughout the district. According to Purdy (1971), introducing exotic breeds of pigs to improve the village herd's genetic composition must be considered as an integral part of any broad program to increase productivity, but it cannot be considered as an end in itself, apart from improvements in the environment.

Spooner (1982) recommends consideration of genetic

resistance in developing breeding programs. He states that, "under extensive and subsistence management systems the use of vaccines and chemotherapeutics can be very difficult and certainly not cost effective. Genetic resistance presents perhaps the only possibility for maintaining animal production systems in such environments." It is conceivable that, in Belize, indigenous pigs that have been selected for their genetic resistance to locally prevalent diseases could serve as genetic seedstock for a crossbreeding program with exotic pigs to produce animals which are highly productive under local conditions.

Breeding populations raised under improved conditions which include vaccination, medication, and isolation from diseases could show reduced expression of genetic resistance. Breeding animals would be selected for their production traits without regard to disease resistance. It is possible that a negative correlation exists between the genetic potential for some production traits and genetic resistance to certain diseases (Gavora, 1983). The offspring of such a breeding program may not be expected to perform well when exposed to disease. (The same principle may apply with regard to offspring of animals selected for production traits while all nutritional needs are met. When they are fed an inadequate diet, they may have severely impaired productivity.) This may explain why exotic pigs raised traditionally perform poorly.

Freeden (1983) comments that "the old models [earlier

breeds of pigs] were low producing and equally modest in their environmental requirements. In contrast, the high performance models of the most advanced production units cannot produce unless their nutrition and management match their produtive potential." When managed properly, these exotic pigs are more profitable to raise than the local pigs. This is due in part to their higher market price. However, only a few farmers have the interest and ability to raise these pigs properly, i.e., intensively. Most are unwilling to make the necessary changes. Pig production has traditionally been a relatively simple activity requiring no capital investment. Intensive pig management necessitates more time and some financial investment, which many farmers are reluctant or unable to provide.

Luke (1982) cautions against the introduction of exotic breeds on subsistence farms since this would disrupt the functions of swine on these farms. Instead of a regulator of feedstuff supplies for man, the exotic pig becomes a competitor for food. The raising of exotic pigs demands an investment of cash income in commercial feedstuffs and other supplies. This requires a regular source of cash income. The exotic pigs should be marketed at an optimal slaughter weight to be profitable. This means that the exotic pig is no longer a liquid asset or viable cash reserve. Exotic pigs are rarely used for home consumption so, rather than improving the nutritional well-being of subsistence farmers, increased production of exotic swine has the opposite

effect. The pork of these pigs is usually sold to middle and upper class persons in urban centers. However, the increased income which is likely to result from successful production and marketing of exotic swine may minimize these negative effects.

One complaint mentioned by farmers who have attempted to raise exotic pigs is that they tend to eat chickens. Apparently, it is less common for local pigs to eat chickens. Yorkshire pigs are the most frequently mentioned culprits. Duroc and Hampshire pigs are accused less frequently. Naturally, this can be a considerable cost to the farm family. Under the traditional system, the pigs and chickens must coexist together. Local pigs eat with and are often housed together with chickens without problems. However, exotic pigs are frequently reported to have eaten chickens. Consequently, many farmers have arrived at the conclusion that "if you raise `improved' pigs, you cannot have chickens".

One possible explanation for this phenomenon of a greater tendency toward chicken eating is that it is precipitated by a higher protein requirement of the more productive exotic pigs. (It has never been established that the exotic breeds of pigs have a different protein requirement.) A more likely explanation is that chicken eating is a behavior which can be learned by any pig. Whatever the reason, many farmers believe that the exotic pigs have a greater tendency to eat chickens, and these pigs are therefore a

potential liability on the farm.

Another complaint is that exotic pigs eat their newborn piglets. This has frequently occurred. This behavior is often attributed to nervous excitement by the dam, especially in gilts, and is not likely to be breed dependent (Thulen, 1985). Nevertheless, traditional farmers mention this as one reason for being prejudiced against exotic pigs. They view these pigs as being delicate, troublesome, and unprofitable.

On one farm in Santa Familia a Yorkshire gilt was raised traditionally except that the diet was supplemented with a daily amount of commercial supplement. It eventually weighed over 125 kilograms (275 lb). The family intended to use her for breeding, but she never became pregnant. Perhaps there was a physical defect, or maybe she was too large to be successfully bred by the relatively small and immature boars in the area. This family is disillusioned with exotic pigs now.

Improvements in the management of swine housing and facilities

Some farmers are realizing the benefits of restricting the movement of their pigs and feeding them a properly balanced diet. They are constructing pens suitable for holding the pigs throughout their growing and finishing phases. While the number of farmers who are actually doing this is still relatively small, there is a trend in this

direction. Until recently, this was only done on larger farms. Now a few farmers with only one litter of pigs are also keeping them penned up.

Wooden pole buildings with thatch roofs are well suited for all sizes of swine production units. Thatch roofs are cooler than metal ones and properly constructed wooden pole walls allow plenty of ventilation, important to the pig's well-being.

Many larger producers install concrete floors. These are simple to clean and help to control parasites. As small scale farmers begin to put more emphasis into swine production they want to cement the pig pen floor. However, as long as a dirt floor can be kept relatively clean and dry, the expense of cementing it is probably not justified. A dirt floor is usually adequate if the pen is located on well drained land and is well ventilated. Pigs will often defecate in one area of the pen. This waste could be removed periodically. Placing sand or wood shavings on the floor might further improve drainage and sanitation within the pen. However, in poorly drained wet areas a concrete floor is recommended for intensive swine production. A slotted wooden floor is not durable under very humid conditions, but can improve sanitation in drier areas.

Large scale producers use self-feeders and automatic watering nipples. Small scale producers usually continue to use troughs to provide their pigs with food and water. Some medium sized farms have automatic nipples connected to water

containers. They fill the container periodically. This system reduces the labor requirement and ensures that the pigs have continuous access to clean water. It also removes one source of humidity--spilled water troughs--from pens with dirt floors. Self-feeders are found on a few small scale farms. Their proper use prevents the pigs being without food, but an attentive manager can do the same with a simple wooden feed trough.

Farrowing crates that are properly constructed to provide plenty of ventilation can help minimize the crushing of baby piglets. Sturdy wooden poles that prevent the sow from flopping onto her side should be adequate in most cases. Only the larger scale producers are presently using farrowing crates.

Many of the medium scale and larger producers employ a young boy or older man who has the responsibility of cleaning the pens and caring for the pigs. Some of the traditional swine farmers have seen this and arrived at the conclusion that to raise pigs intensively requires employing someone. This is of course only true for large operations. Small and medium scale producers can function quite well with a minimum amount of family labor.

Modern swine feeding systems

Malynicz (1975) describes an experiment in which exotic "improved" pigs and native New Guinea pigs were subjected to two extremes of nutrition and housing. Results showed that

nutrition accounted for four times as much of the variance in growth rate as did breed. Housing was only of minor importance. The contribution that improved nutrition can make toward improving productivity is considerable. Raun (1983) refers to inadequate nutrition as the most important factor limiting growth and reproduction rate. He feels that malnutrition also aggravates and/or predisposes the animal to disease problems.

Improved swine nutrition generally implies increased use of concentrated feeds and supplements. Tasiorowski (1973) demonstrated the clear relationship that exists between the amount of concentrates fed and increased animal productivity. It is likely that these trends are applicable to the swine farms of the Cayo District. The greatest improvements in swine productivity can be expected by increasing the quality and quantity of swine feeds.

Increasing swine production is limited by the availability of inexpensive feedstuffs. Small scale farmers are unlikely to have the resources to purchase livestock feeds. Bernsten (1977) indicates that a farm's crop production is limited by the available labor for land clearing. Therefore, increased crop production requires the development and application of labor enhancing technology, i.e. mechanization; yield enhancing technology, i.e. genetically superior seedstock; or improved planting, cultivating, fertilizing, harvesting, and/or storage techniques. Increased crop yields that are not directly marketed may be marketed

indirectly through livestock such as swine. However, the profitability of this also relies upon improvements in the utilization of these crops by swine through the application of efficient feeding and management systems.

The traditional feeding system has the advantage of essentially not requiring any capital investment. Very little labor is expended, and the swine feed is all produced on the farm. If very little or no perceived cost is attributed to these resources, then costs of production are low and swine production appears profitable, or at least useful. On the traditional small scale farm this has been the case. Nevertheless, this is not the optimal allocation of these resources. Due to the poor nutritional composition of the diet and the energy expended by the animal during extensive foraging, there is inefficient conversion of the food resources to swine production.

There are three basic alterations of the traditional swine feeding system that contribute to the development of a modern feeding system. First, the movement of the pigs is restricted. Second, they are fed a nutritionally balanced ration that supports optimal growth and production. And third, they are fed ad libitum or close to it.

Farmers that have tried to improve their feeding system by adopting only one or two or these changes--restricting their pig's movement, feeding a balanced diet, or feeding them ad libitum-- have encountered problems. It is necessary for all three changes in the system to be made

concurrently to achieve their full benefit. These practices contradict the way pigs have traditionally been fed, but if the resources are available substantial improvements in production, efficiency, and farm income could be realized by adopting them.

Restricting the movement of pigs. When the pigs forage for food they usually expend more nutrients, especially the energy component, than they consume. While they are loose, the pigs are running about, sometimes several hundred meters from their pen, fighting, and being chased by dogs. These activities significantly increase the animal's maintenance energy requirement. The areas where the pigs forage are generally already severely overgrazed. The available plants are usually of low nutritional value. Consequently, foraging frequently has a net negative energy effect. It is likely that the pigs would not grow at all if they did not receive energy in the form of corn and other food fed to the them inside their pen.

There is always the possibility that the pigs will be poisoned, injured, killed, or stolen while they are loose. They are exposed to parasites and other infectious pathogens. They are capable of damaging property or injuring young children. It seems logical, therefore, that the pigs should be penned up for their own well-being, and that of the farm family.

However, small scale farmers are not keeping their pigs penned up, even in the villages where there are laws

forbidding the loosening of pigs. Allowing pigs to forage freely for food is essential to the traditional system of swine production. Remove this crucial component and the system breaks down. Unless other significant changes are made in the system of production, the pigs are likely to be less healthy and productive than they were when they were foraging.

Even though the area where the pigs forage is usually overgrazed, it still contains food resources which might otherwise go unutilized or are undesirable if not consumed by the pigs. Some examples are weeds, insects, and garbage. The food which pigs are traditionally fed within their pen is deficient in certain nutrients which are obtained while they are foraging. The pigs eat a variety of plants, soils, insects, and small animals to supplement their diet. These are especially important sources of vitamins and minerals. They might also contain some essential amino acids deficient in the "pen diet".

Farmers are aware that pigs which are kept penned up do not perform well. They may not know the scientific explanation for this poor performance, but they are very reluctant to keep their pigs penned up. They have expressed the opinion that pigs need to eat "bush" (pasture and jungle vegetation), and wallow in mud to be healthy. Overcoming this attitude is difficult, and is undesirable unless the animal's pen is adequately maintained and a nutritionally adequate diet is provided.

Feeding a nutritionally balanced diet. Hardly any farmers understand the concept behind the feeding of a nutritionally balanced diet. They are not aware that pigs require minimum dietary levels of certain nutrients to perform optimally. Neither are they aware that different food sources have different levels of these essential nutrients, or that by carefully combining different foods together a least cost, nutritionally balanced diet can be prepared which will support optimal performance in the pig. This makes it considerably more difficult to explain to farmers the rationale behind balancing rations. Of course, it is not necessary that they be able to identify all these nutrients, but some understanding of basic nutrition principles would be helpful. The small scale farmer's perception of a balanced diet is that the pigs eat a variety of foods whenever possible, along with lots of corn. This does not include feeding anything that is purchased or that has other value to the family. This feeding system has been relatively successful in supporting mediocre growth and production.

Farmers are able to discern when their pigs are performing well, and when they are not--at least relative to their own expectations of pig performance. However, the effects of proper nutrition, or malnutrition, are often not obvious unless measurements of production are taken, and records kept for comparison purposes. This complicates any efforts to demonstrate the value of proper nutrition to farmers. Improvements must be significant and obvious.

Balancing, mixing, and feeding a nutritionally balanced diet can be a complicated procedure for any farmer, but is especially so for the small and medium scale farmers with limited education and resources. The government provides extension bulletins with ration formulation recommendations. Some medium and large scale producers utilize these, but small scale farmers do so very rarely. This information is apparently not being adequately explained to farmers by extension agents. Perhaps the extension agents are not sufficiently knowledgeable in swine production, or have not been informed of the results of studies done on swine feeding at Central Farm.

Farmers often fail to accurately follow feeding recommendations. Some are not aware, or don't believe, that the recommended mixing levels are optimal, or that omitting even a single ingredient can significantly lower the nutritional value of the ration. They may try to cut costs by diluting the feed with less nutritious dietary components or neglecting to add an ingredient. This may be due to ignorance, or because they were unable to afford or obtain the proper ingredients. The consequence is that performance is lowered, and the farmer then concludes that the initial recommendations (which he did not follow accurately) are not beneficial.

The principal reason that nutritionally balanced rations are not fed by people who are aware of the need to do so is that some ingredients in the ration are costly or

unavailable. One such ingredient may be corn, but usually is a protein, vitamin, and mineral supplement. This is the situation with many producers, but especially the small and medium scale ones who have limited financial resources and perhaps are not sufficiently convinced of the benefits of a proper diet. For farmers to be able to feed their pigs a balanced diet, they must be able to acquire the necessary ingredients in an easy to use form. Since most farmers produce the energy component for their pig's diet, a supplement high in protein, vitamins, and minerals would be useful. Presently, there are such products available commercially. Unfortunately, they are imported, expensive, and relatively difficult for the small scale farmer to obtain, and the recommendations for their usage are often misunderstood by farmers. The small scale farmer does not feel that there will be a sufficient improvement in production to justify the expenditure of limited financial resources, especially since the pig might die, be stolen, or be difficult to market. In such a case, the farmer has lost cash; without this investment, only the family's time and effort would be wasted, not their money.

Some farmers purchase commercially available food for their pigs that is nutritionally balanced. It is primarily the medium scale or "progressive" small scale producers that do this. Some producers feed their pigs ad libitum with this purchased mixed feed. However, this livestock feed is relatively expensive. In nearly every case the farmer would

benefit from producing an energy source on the farm, such as corn, and mixing this with a commercial supplement. The cost of on-farm crop production is minimal and not "felt" by the farm family. Limited cash flow and limited transportation resources make the real price of purchased feeds beyond the reach of most small scale farmers. Sometimes (rarely), a small scale farmer will buy a few kilograms, or maybe even a 22.7 kilogram (50 lb) sack, of commercial mixed feed and give small amounts to the pigs. It is likely the farmer heard that feeding this food increased the health and growth rate of pigs. The pigs would probably be fed small amounts occasionally, and this may even have some beneficial effect upon them. A small scale farmer would never feed pigs purchased feed ad libitum.

Feeding pigs ad libitum. Most pigs on small scale farms are fed a very limited diet. Many of them are fortunate if they are able to meet their nutritional maintenance needs. Seldom is there enough to support high levels of production. Farmers are not aware of the rationale behind ad libitum feeding. They do not eat this way and do not comprehend why pigs should. Additionally, pigs are fed what is available; not what they might need. Farmers expect their pigs to be with them for more than a year and they need enough food for the entire time. They are stretching their food over a longer time by feeding smaller amounts each day. Benjamin Franklin might call this being "penny wise and pound foolish" since each animal ends up consuming

much more food during its lifetime. Most of the food goes toward maintenance, with very little left to be used for production. This is apparently an uneconomical use of food resources. However, one must remember that the farmers are not feeding a balanced diet to the pigs. Additional amounts of a nutritionally unbalanced ration may be of only limited benefit to the pig. Often, when the ration is deficient in some nutrients, the pigs will not even have an appetite for more food (Pond, 1978).

The "progressive" farmers that have tried feeding pigs ad libitum are often amazed at the large amounts of a balanced ration that pigs are capable of eating. The most common reason for not feeding ad libitum is that there is not enough food to do so. Some farmers underestimate their feed requirements and then run out of food. Perhaps they had difficulty selling their pigs when they had intendedto do so, and more food was needed; or the farmer may have had difficulty harvesting or transporting food for the pigs. Often there is no means to acquire feed without scarce cash or credit. In this case the pigs may go hungry, or the farmer may be forced to sell them early, at a low price. This can be very frustrating, and financially ruinous, for a farmer trying to expand and improve his level of swine production.

Current status of feedstuffs for swine in Belize

Successful feeding systems of most swine producers are

based on feeding a nutritionally balanced ration, mixed from more than one ingredient, and fed to the animals ad libitum. The growing and finishing pigs are kept in total confinement; often, though not necessarily, they are kept on concrete floors. Forage crops are another potential feedstuff for some innovative farmers, especially for feeding to the breeding herd.

The best assistance extensionists can provide to farmers interested in profitable swine production is information on nutritious least-cost swine rations. Swine rations should be based upon feedstuffs produced on the farm. In most cases this means corn will serve as the main energy component of the diet, though other feedstuffs such as cassava, potatoes, rice, or sorghum could also fulfill this role on some farms. Generally, supplemental sources of protein, vitamins, and minerals need to be purchased for inclusion in the ration, though some creative on-farm crop production could minimize this.

In this section the usefulness in swine diets of each of the major feed ingredients is examined. The current availability and cost of each feedstuff is described, as is other pertinent information regarding its use as an ingredient in swine rations.

Corn. Corn is the most common crop grown in the Cayo District. Its principal use is as human food. Secondary uses are as a source of cash income or livestock feed. Extra corn is fed to the chickens and pigs on the small

scale farms.

Bernsten (1977) reported that sixty percent of respondents to a farm survey in the Cayo District marketed corn in 1972. The Government of Belize Marketing Board purchases corn at their offices in San Ignacio and Belmopan, in the Cayo district. They generally will pay the established market price. Some farmers complain that the Marketing Board often will not purchase their corn; that "previous arrangements" are necessary for the Marketing Board to purchase from them. This is understandable since the government's need, and the Marketing Board's storage facilities, are not unlimited. However, some farmers do not feel they have a dependable market here (the intended role of the Marketing Board) and that favoritism might be exhibited in the granting of purchasing agreements.

The two principal livestock feed stores in Spanish Lookout, Farmer's Feed Supply and Reimer's Feed Shop, also purchase corn for use in their mixed livestock feeds. They pay the established market price. Actually, their volume is so large that they are major participants in the "free market" establishment of the market price. Most of their corn goes into poultry feed. Swine and dairy feeds are secondary. Most of the poultry feed is used within the Spanish Lookout community. Sometimes, when they have adequate supplies, the feed stores are not interested in purchasing corn. Therefore, previous arrangements should be made, usually necessitating another visit to the feed mill.

Preference is given to the Mennonite farmers. A minimum of 12 percent moisture is acceptable in the corn they purchase. An even more important obstacle to small scale farmers' use of this market outlet is that they generally do not produce sufficient quantities to warrant transporting the corn to Spanish Lookout.

The price paid for corn by these feed stores in recent years varied from $.352 to $.528 per kilogram ($.16 to $.24 per lb), but during the 12 month period of this survey the price varied from a high of $.484 per kilogram ($.22 per lb) in August, 1984 to a low of $.396 per kilogram ($.18 per lb) in November, 1984. By February, 1985 the price was back up to $.44 per kilogram ($.20 per lb).

Prices at the village level ranged between $.25 and $.40 per quart container of corn. The quart container is a common measuring device on small scale farms and holds approximately .68 kilograms (1.5 lb) of whole kernel corn. The corresponding price ranged between $.37 and $.59 per kilogram ($.17 and $.27 per lb). The higher price was the most common price throughout the year; the $.25 price occurred only during October and November. Small scale farmers rarely buy or sell corn. When they are forced to buy, they usually end up doing so from one of the nearby larger scale farmers.

The cost of production of corn on farms which utilize some mechanization and fertilization practices is reported by farmers to range from $.26 to $.35 per kilogram ($.12 to

$.16 per lb), depending upon the efficiency and productivity of the farm and the weather. The cost of corn production by small scale farmers utilizing their own labor and seed corn and no fertilizer is minimal. The opportunity costs of these resources in traditional subsistence agriculture are negligible. Labor for weeding and planting sets the upper limit on farm size (Bernsten, 1977) and consequently on the quantity of corn that a farm can produce.

The grinding of corn for use in mixed swine feeds while not necessary, is useful. It allows for more even mixture of the ration ingredients. Hoefer (1956) compared free choice feeding of shelled corn and ground corn along with a supplement and found no difference in rate of gain. However, cost of gain was cheaper on the shelled corn, primarily due to the savings in grinding cost and less wastage of feed. The feed mills at Spanish lookout charge $.0011 per kilogram ($.005 per lb) to grind corn. Small grinders are found on some medium and large scale farms. They charge $.0011 to $.0022 per kilogram ($.005 to $.010 per lb) to grind.

The majority of corn raised on small scale farms is from locally developed seedstock, but many innovative farmers also plant a section of their fields with imported hybrid seed corn (Bernsten, 1977). Farmers prefer the yellow corn over the white corn. They believe the white corn is less nutritious than the yellow. Costa (1981) found the yellow grain corn to have 88.7% dry matter and 8.2% crude

protein, while the white corn had 87.6% dry matter and 9.5% crude protein.

The cost of purchasing and transporting corn to the farm for inclusion in swine rations makes it prohibitively expensive for most farmers. On-farm production is preferable. Likewise, the transportation costs of moving corn to market often cuts deeply into any profit the farmer might receive from the sale of corn.

Rice Bran. This by-product of the rice (Oryza sativa, L.) milling industry can be purchased from the Big Falls Ranch Mill for $.286 per kilogram ($.13 per lb) in 23 kilogram (50 lb) sacks. Costa (1981) studied several combinations of feed ingredients available in Belize for inclusion in swine rations and found that replacing sorghum with 20% rice bran and polishings resulted in the lowest feed costs of gain during the growing and finishing phases.

Swine feeding trials were conducted at Central Farm by Sapkota (1980) to evaluate the feeding value of rice bran which has been heated to reduce the free fatty acid rise that occurs during storage and reduce the effect of a trypsin inhibitor factor in untreated rice bran. Pigs gained significantly more, and did so with improved efficiency, when fed heat treated rice mill feed diets than when fed untreated diets. Sapkota also described methods by which farmers could heat the rice bran. Pigs on wet heated rice bran diets (88.5% rice mill feed) gained more and had lower average feed requirements per unit of gain than the pigs on

diets based on dry heated rice bran.

Analysis performed at Central Farm July 5, 1984 on dry heated rice bran from Big Falls Ranch showed 93.6% dry matter, 11.4% crude protein, and 13.9% crude fat. Depending upon availability and cost, heated rice bran is a potentially valuable purchased feed ingredient in mixed swine rations.

Farmers are feeding untreated rice bran to swine. A few farmers that grow rice for home consumption feed excess rice and rice hulls to swine.

Cassava. Manihot esculenta, commonly referred to as cassava or yuca in Belize, is a potential feedstuff for swine. It is grown throughout the Cayo District, but is most common in the east. Analysis performed at Central Farm indicates locally produced cassava to have 32.2% dry matter and 0.8% crude protein (Costa, 1981). Pond (1974) reports an average of 30.84% nitrogen free extract for 15 Columbian cassava varieties. Its usefulness in swine diets is primarily as a source of carbohydrates.

The Marketing Board purchases cassava wholesale for $.44 per kilogram ($.20 per lb). The price is usually $.55 per kilogram ($.25 per lb) in the marketplaces. Consequently, it is frequently not an economical swine feed. Farmers generally do not feed the large cassava tubers to swine. However, they do feed the leaves, short tubers, and roots. Farmers who inexpensively produce quantities in excess of what they can consume or market could successfully feed

cassava to swine.

The presence in cassava of a toxic factor (hydrocyanic acid) necessitates its being fed immediately upon harvesting or its being processed by drying or boiling (Pond, 1981). The high moisture content limits dry matter intake so that inclusion of a more concentrated energy feed such as corn, sorghum, or rice bran in the ration is recommended. Since cassava is practically devoid of protein, considerable supplementation is necessary to sustain optimal production.

Small scale farmers might best utilize their cassava waste by feeding it ad libitum along with a balanced ration.

Coco yam. This root crop (Dioscorea sp.) is grown throughout the district. Like cassava, it is generally too expensive to be used as a livestock feed. The market price ranges from $.55 to $1.10 per kilogram ($.25 to $.50 per lb), but is usually $.77 to $.88 per kilogram ($.35 to $.40 per lb). It is also high in moisture (65 to 70 percent) and low in crude protein (1 to 2 percent on a fresh basis) (Pond, 1974). Farmers feed the leaves, roots, and spoiled tubers to swine.

Sweet potato. Some farmers have had success growing sweet potatoes (Ipomoea batatas). Costa (1981) indicated that sweet potatoes have 30.2% dry matter and 1.0% crude protein. Sweet potatoes are generally used for human consumption and are too expensive to feed to swine. Farmers feed the leaves and spoiled potatoes to swine and sometimes allow the pigs to root about in the garden for potatoes.

Utilization of foods high in starch such as cassava, coco yam, and sweet potato is improved by cooking (Pond, 1978, p. 299).

Cohune nut meal. Many small scale farmers extract cooking oil from cohune nuts. They crush the nuts and then boil off the oil. The remaining residue is called "sheesh" and is fed to swine and poultry. Costa (1981) found this village-produced cohune nut meal to contain 9.0% crude protein and 53.8% ether extract.

Farmers also feed the whole cohune nut to swine, especially during the "mawga" season, July and August. After the nuts have dried in the sun the pigs can break the shell and eat the kernel. Costa (1981) found the kernel to have 90.5% dry matter, 8.1% crude protein, and 58.6% ether extract.

Meat and bone meal. This slaughterhouse byproduct is being produced by Belize Meats Limited. Analysis performed at Central Farm by Costa (1981) indicates it to have 93% dry matter, 36% crude protein, 10% calcium, and 4% phosphorus. Costa (1981) conducted feeding trials at Central Farm in which 0, 50, and 100% of the protein supplement was replaced with meat and bone meal (MBM). At the 100% level, feed consumption and ADG were significantly depressed; feed cost of gain was increased. Diets containing MBM as 50% of the protein supplement were the most economical in the study, based on 1983 prices. Unpalatability and an unbalanced amino acid composition makes MBM a poor sole protein source

in swine rations (Pond, 1974). It is preferable to combine MBM with another concentrated protein source such as bean meal or fish meal for use in feeding swine.

The MBM is sold at the slaughterhouse in Ladyville at $.88 per kilogram ($.40 per lb). This is not competitive with imported commercial supplements available in the Cayo District. Additionally, the commercial supplememt is likely to have a superior amino acid composition and adequate levels of vitamins and minerals.

Poultry offal. Montero (1984) reports that growing and finishing swine fed poultry offal free choice along with ground corn or rice bran performed similarly to a control group on a commercial mixed feed. The poultry offal was boiled and salted prior to feeding. The product had 34.0% dry matter, 46.0% crude protein, and 17.2% crude fat. The poultry offal is obtained free from poultry slaughterhouses in Spanish Lookout and Red Creek, both in the Cayo District. Farmers able to transport the offal to their farm might benefit from its use in a swine ration.

Fish meal. Fish meal is a potentially viable protein supplement for swine rations in Belize. Hall (1981) developed a method for solar drying fish meal on the island of San Pedro. However, fish meal is no longer being produced there. The previous operators indicated that they prefer to use boat space for more valuable fish, and toss the less desirable fish and fish parts overboard while at sea.

The fish meal produced by Hall (1981) ranged in crude

protein content from 54.0% to 69.6% depending upon the type of fish or fish parts included. Hall (1985) estimated the cost of producing solar dried fish meal to be $1.10 per kilogram ($.50 per lb). Depending upon the protein level in the fish meal, it could be priced as high as $1.40 per kilogram (.64 per lb) and still be competitive with other protein supplements (Table 1). This would be the value of $2.00 per kilogram of crude protein in a 70 percent crude protein fish meal. Fish meal would be best utilized in combination with MBM and other protein, vitamin, and concentrates in a commercial supplement produced locally.

Commercial supplements. Farmer's Feed Supply and Reimer's Feed Shop in Spanish Lookout import concentrated livestock feeds from the United States for distribution in the Cayo District. Farmers travel to Spanish Lookout to buy these products. Agricultural supply stores elsewhere in the district also purchase these products for resale, raising the price accordingly. Table 1 shows prices on Feb. 28, 1985 for some commercial supplements which are potential sources of protein, vitamins, and minerals for swine rations. Purina Fateena and the broiler concentrates are the most economical sources of protein.

Complete mixed feeds. Farmers that have the resources to obtain various feed ingredients and combine them into a balanced least cost ration for swine in some cases benefit from doing so. Farmers may also find it profitable to purchase mixed feeds for swine feeding. Presently, Farmer's

Feed Supply Store and Reimer's Feed shop in Spanish Lookout sell complete mixed swine feeds. They mix imported commercial supplements with an energy source (usually corn, but occasionally some sorghum or rice bran) to produce mixed feeds. Table 2 shows prices of some mixed feeds on Feb. 28, 1985.

Table 1. Prices of Commercial Supplements.

	$/kg	$/lb	CP[1] $/kg	CP[1] $/lb
Pillsbury Hog Concentrate (40% CP)[2]	.84	.38	2.09	.95
Pillsbury Broiler Concentrate (48% CP)[2]	.95	.43	1.97	.90
Pillsbury Breeder Layer Conc. (40% CP)[2]	.83	.38	2.08	.95
Purina Farm Blend Hog Chow (36% CP)[3]	1.10	.50	3.04	1.38
Purina Farm Blend Sow Chow (32% CP)[3]	1.00	.45	3.11	1.42
Purina Broiler Chowder (48% CP)[3]	.94	.43	1.97	.89
Purina Pro-Lay Chowder (40% CP)[3]	.81	.37	2.02	.92
Purina Fateena (Guatemala) (32% CP)[3]	.61	.28	1.91	.87
Meat and Bone Meal[4]	.77	.35	2.14	.97

1. crude protein
2. Farmer's Feed Supply Store
3. Reimer's Feed Shop
4. Belize Meats Limited

Table 2. Prices of Mixed Swine Feeds.

Swine Feed	$/kg	$/lb
(Reimer's) Pig Starter (18% CP)	.8316	.3780
(Reimer's) Pig Grower (14% CP)	.5940	.2700
(Reimer's) Pig Finisher (12% CP)	.5489	.2495
(Farmer's) Pig Feed (14% CP)	.5632	.2560
(Farmer's) Pig Feed (12% CP)	.5390	.2450
(Reimer's) Chick Starter Mash (18% CP)	.6193	.2815
(Reimer's) Chick Growing Mash (15% CP)	.5599	.2545

Research was conducted at Central Farm and on some private farms in Cayo District during the Belize Livestock Feeds Project. The updated Belize Livestock Feeds Project Report (1983) lists 49 different feedstuff combinations whose use in growing and finishing swine rations was studied. The feed ingredients which were included in various combinations in the rations, based upon their availability in Belize and their likelihood of supporting economical production, were corn, sorghum, rice mill by-products, wheat bran and middlings, molasses, commercial supplement, soybean meal, meat and bone meal, bone meal, blood meal, cohune meal, local limestone, defluorinated rock phosphate, synthetic lysine, salt, zinc sulfate, trace mineral premix, and vitamin premix.

The results of the feedstuffs research have been used

to develop a computer program at Michigan State University which estimates the feed cost of gain for each ration (Belize Feedstuffs Project Report, 1983). This information is valuable for any complete mixed feed producer, and should be important to the development of a mixed livestock feed industry. (Broiler and layer rations were also studied in the Belize Livestock Feeds Project.) The diet with the lowest feed cost of gain based upon 1983 prices consisted of a grower ration of 63.5% corn, 20% rice mill by-products, 9.9% MBM, 5.0% SBM, .1% synthetic lysine and .5% each of a vitamin premix, trace mineral premix, and salt, in combination with a finisher ration of 65.1% sorghum, 20% rice mill by-products, 3.3% wheat bran and middlings, 10.0% MBM, .05% synthetic lysine, and .5% each of a vitamin premix, mineral premix, and salt.

Potential small farm swine feeding systems.

Adopting improved feeding programs intended to improve the nutritional status, and thereby the productivity and profitability of swine, requires that the farm family elevate swine production from the secondary status it now exists at on many small scale farms to a farming enterprise of primary importance. This is necessary since optimal benefits derivable through improved management and nutrition can only be achieved through their consistent application. This requires greater care in management of swine and their facilities, implying a greater time commitment on the part

of the farm family. It usually requires the purchase of some feedstuffs and veterinary supplies. The resultant income of this improved swine production must more than compensate for the incurred costs.

Intensive use of supplements. Many small scale farmers produce corn for use in swine production. They frequently have access to a means for grinding this corn. Mixing this ground corn with appropriate amounts of purchased commercial supplements for feeding ad libitum to swine kept in pens may be the most applicable swine feeding system for many farmers. They frequently do not have the resources or skills to produce or purchase a variety of feedstuffs for inclusion in rations. However, if they have access to an inexpensive supplement, and are provided with clear information on its usage, they can improve the quality of their pig's diet rather simply. Some cash expenditure would be necessary, but only for this one dietary component, constituting a small fraction (10 to 20 percent) of most swine diets. Considerable care should be used in properly mixing the feed. Farmers could continue to throw all kitchen scraps and other swine food into the pen. Farmers should not overcapitalize by constructing elaborate facilities or purchase mixed feeds. Adequate available corn is necessary. Local swine are suited for this system. Small scale farmers with limited resources may want to feed only three or four animals at a time.

Hoefer (1956) indicates that it is not necessary to mix

the supplement with corn. Corn, shelled or ground, can be provided in one feed trough and the supplement in another. When provided with this free choice, swine consume appropriate amounts of each ingredient to balance their diet. Their ADG in Hoefer's study was similar to that of pigs on the complete mixed ration. Feed efficiency and feed cost of gain was slightly improved on the free choice shelled corn and supplement diet. This feeding system is likely to be the most practical and economical one for many small scale farmers.

The development and local production of an inexpensive concentrated protein supplement would have a significant effect upon feed cost of production. Rarely is a least cost concentrated protein commercial supplement for swine produced from only one ingredient. Presently, only meat and bone meal (MBM) is being produced in Belize by Belize Meats Limited. However, it is preferable not to feed MBM as the sole protein source in swine rations (Pond, 1974, p. 304). Atkinson (1970) found MBM to be first limiting in lysine, followed by methionine and threonine (equally second). Tryptophan is first limiting when fed in a corn based ration. Fishmeal is another concentrated source which can be economically produced in Belize (Hall, 1981). Fishmeal is relatively high in lysine, methionine, threonine, and tryptophan (National Research Council, 1979), and is therefore an excellent ingredient for combining with MBM in a concentrate.

The production of poultry offal meal, or inclusion of the raw offal into meat and bone scraps prior to meal production is another potential protein source that is available locally. At times it may be economical to import soybean meal for inclusion in a supplement. If vitamins, minerals, and perhaps synthetic amino acids are combined with these meals a valuable product is available for use by farmers. Manufactured and marketed economically, along with clear recommendations for its use in swine rations, this product could reduce the nation's reliance upon expensive imported supplements and reduce feed costs, thereby stimulating expansion of swine production by farmers.

Modified Lehman system of pig feeding. An uncomplicated, low-capital system is needed whereby the traditional diet can be supplemented with protein. Under the Lehman system, pigs are fed about 220 grams of crude protein daily from a fairly concentrated protein source, and as much of a low protein staple as can be consumed. Because energy requirements rise more rapidly than protein requirements, the animal balances its own nutritional requirements with increasing age (Malynicz, 1975). Malynicz reported results of a Lehman feeding experiment in which different levels of commercial supplement were fed daily along with ad libitum access to sweet potatoes. Feeding the standard amount of 220 grams of crude protein daily supported the highest ADG and feed efficiency, but either feeding 110 grams or 55 grams produced more economical gains. The research also

demonstrated the importance of adding salt to the diet.

Rai (1983) conducted an experiment in the Cayo District of Belize whereby farmers fed a measured amount of a commercial supplement (Purina Broiler Chowder, 48% crude protein) to pigs daily. Each pig was fed 120 grams of supplement for each 10 kilograms of live weight. Additionally, the pigs were fed some corn and allowed to forage under the traditional management system. "Indescript" and "Razor Back" (local) pigs which were wormed and fed the supplement had ADG of .119 kilograms (.263 lb); those which were wormed only had ADG of .078 kilograms (.172); those which were not treated at all had ADG of .069 kilograms (.151 lb). "Improved" pigs consumed .646 kilograms of supplement per kilogram of live weight gained. The local pigs consumed 1.264 kilograms of supplement per kilogram of live weight gained.

I supervised a similar experiment in the Cayo District during March and April, 1985 in which measured amounts of meat and bone meal (MBM) from Belize Meats Limited were fed daily to pigs under the traditional system of management. Analysis performed at Central Farm found the MBM to have 93.1% dry matter, 35.8% crude protein, 27.8% ash, 10.0% calcium, and 3.9% phosphorus.

The crude protein concentration of the pig's diet under the traditional system of management is estimated to be 8%. National Research Council (1979) estimates that a 5 to 10 kilogram pig consumes 500 g of air dry feed and recommends a

20% crude protein fortified grain-soybean diet be fed for optimal performance. Based upon these assumptions, an estimate can be made of the additional supplemental crude protein needed in the diet (500 g X (20 - 8) = 60 g). Moderate economical gains are preferable to maximum growth, so one-third of this amount was supplemented (20 g). 20 grams CP X 35.8% CP in MBM = 56 g. Therefore, approximately 56 grams of MBM were fed to each pig each day. Similar calculations yielded amounts of 93 grams of MBM supplementation for 10 to 25 kilogram pigs, 112 grams for 25 to 60 kilogram pigs, and 140 grams for pigs over 60 kilograms. Farmers measured the MBM with a plastic cup provided by the experimenter.

The price of MBM to the farmer is $.88 per kg. Therefore, $.05 worth of MBM is fed daily to 5 to 10 kilogram pigs, $.082 of MBM to 10 to 25 kilogram pigs, $.10 of MBM to 25 to 60 kilogram pigs, and $.125 of MBM to pigs over 60 kg.

A litter of pigs on each farm was divided so that approximately half the pigs were randomly selected to receive the MBM while the rest did not. The treatment pigs on the farm were penned up together for 15 to 30 minutes each day, during which time they were fed the MBM. Otherwise, all pigs on each farm were commonly fed and housed according to the traditional management system. All pigs foraged freely during the day.

Pigs on farm A were approximately 260 days old when the trial began. The two treatment pigs together were fed 224 grams of MBM each day throughout the 42 day experiment.

These two pigs consumed 9.408 kilograms of MBM and gained a total of 12.7 kilograms, or .74 kilograms of MBM per kilogram of live weight gained. They had an average gain of 6.36 kilogram each, whereas the control pigs gained an average of 5.45 kilograms each. It cost $4.14 (4.704 kg X $.88/kg) to achieve this additional .91 kilograms of gain ($4.55 per kg) per pig.

Pigs on farm B were 196 days old when the trial began. The three treatment pigs together were fed 279 grams each day for the 42 days. These three pigs consumed 11.718 kilograms MBM and gained a total of 21.8 kilograms, or .54 kilograms of MBM per kilogram of live weight gained. They had an average gain of 7.27 kilograms each, whereas the control pigs gained and average of 4.09 kilograms each. It cost $3.44 (3.906 kg X $.88/kg) to achieve this additional 3.18 kilograms of gain ($1.08/kg) each.

Pigs on farm C and D were 28 days old when the trial began. On each farm the four treatment pigs together were fed 112 grams of MBM per day for the first 14 days and 224 grams each day for the next 28 days. The 4 pigs on farm C consumed 7.840 kilograms of MBM and gained a total of 12.7 kilograms, or .62 kilograms of MBM per kilogram of live weight gained. They had an average gain of 3.18 kilograms each, whereas the control pigs averaged 2.05 kilograms each. It cost $1.72 (1.960 kg X $.88/kg) to achieve this additional 1.13 kilograms of average gain ($1.52/kg) per pig. The 4 pigs on farm D consumed 7.840 kilograms of MBM and

gained a total of 6.6 kilograms, or 1.19 kilograms of MBM per kilogram of live weight gained. They had an average gain of 1.65 kilograms each, whereas the control pigs averaged 1.42 kilograms each. It cost $1.72 (1.960 kg X $.88 /kg) to achieve this additional .23 kilograms of average gain ($7.40 per kg) per pig.

Pigs on farm E were 95 days old when the trial began. The two treatment pigs together were fed 112 grams each day for 14 days. Shortly thereafter they refused to eat the MBM. They consumed a total of 1.568 kilograms of MBM and gained 3.2 kilograms, or .49 kilograms of MBM per kilogram of live weight gained. They had an average gain of 1.59 kilograms each, whereas the control pigs averaged .68 kilograms each. It cost $.69 (.784 kg X $.88/kg) to achieve this additional .91 kilograms of average gain ($.76 per kg) per pig.

Table 3 presents the growth of individual pigs in the trial. Pigs fed the MBM had significantly higher ($P<.01$) ADG on farm C, and significantly higher ($P<.05$) ADG on farms B and D. ADG was not significantly different on farms A and E.

Farmers consider their pigs to be worth $2.20 per kilogram of live weight, though they may not receive this much when they sell them. A profitable simple rate of return (SRR) on investment in MBM occurred only on farms B, C, and E. SRR was 204% on farm B, 145% on farm C, and 289% on farm E. This rate of return may not be adequate to

Table 3. Results of Modified Lehmann Swine Feeding Trial with MBM.

Farm		Initial Wt.(kg)	Final Wt.(kg)	ADG
A	*	25.9	31.4	.130
A	*	24.5	31.8	.173
A		23.6	29.1	.130
B	*	16.4	23.6	.173
B	*	16.4	23.6	.173
B	*	15.0	22.3	.173
B		16.4	21.4	.119
B		15.5	18.6	.069
C	*	2.5	5.2	.065
C	*	3.2	6.6	.081
C	*	3.0	5.9	.069
C	*	3.2	6.8	.086
C		2.0	4.1	.050
C		2.7	4.3	.039
C		3.2	5.9	.065
C		2.7	4.5	.044
D	*	2.7	4.5	.044
D	*	2.7	4.5	.044
D	*	3.6	5.2	.038
D	*	3.6	5.0	.033
D		3.9	5.5	.037
D		3.2	4.5	.037
D		3.4	4.8	.033
D		2.7	4.1	.033
E	*	6.4	8.2	.129
E	*	5.5	6.8	.093
E		6.8	7.3	.036
E		4.5	5.5	.071

* indicates a treatment pig (fed MBM).

stimulate investment in this technology under the prevailing uncertain conditions for continuing production and marketing. This increased production must be converted into increased cash income, and that is uncertain. Additionally, it must be noted that increased production did not adequately cover the investment costs on farms A and D.

Some farmers were not interested in feeding MBM to their pigs. They felt that the pigs would develop a taste for meat and begin eating chickens. Incidentally, one chicken was reportedly eaten by a pig which was being fed MBM. On another farm, the pigs would not eat the MBM.

The government of Belize felt that those farmers who participated in the experiment had to purchase the MBM. Consequently, few farmers were interested in experimenting with this new technology.

This experiment does not clearly demonstrate that MBM fed at these levels is advisable, but it does indicate that some modification of the Lehmann system of pig feeding can be beneficial. Meat and bone meal should not serve as the only protein source in the diet (Pond, 1974). A better dietary supplement could be studied. Locally produced MBM could be combined with fish meal or a bean meal. Vitamins, minerals, and synthetically manufactured amino acids could be added. Alternately, commercially available imported supplements might be used.

Research should be conducted to ascertain optimal feeding levels of supplements in a modified Lehmann feeding

system that fits into the traditional system of swine management. A label might be applied to retail packages of the supplement that provides feeding recommendations.

Modern Marketing Concerns

Markets which provide an assured outlet for slaughter animals and adequate returns to the farmer are essential if both production and productivity are to be improved (Kesteven, 1975). Without them farmers become disillusioned and lose their initiative to increase production. Farmers risk considerable losses if they expand production without adequate markets. They must be confident of an adequate return on the cash, labor, and land they invest in modern facilities, exotic breed of pigs, and commercial feeds.

Small scale farmers traditionally raise pigs without a fixed marketing schedule. As they intensify production they lose the luxury of this flexibility. To achieve maximum returns swine are marketed at an optimal slaughter weight. Processors prefer that slaughter hogs weigh over 90 kilograms (200 lb) (Pentak, 1985). Field (1961) conducted a survey of processors, retailers, and consumers in the United States and found that processors preferred hogs weighing 90 to 102 kilograms (200 to 225 lb). The processors estimated that processing costs were 20% greater per unit weight for hogs weighing under 80 kilograms (175 lb) because (a)"it takes practically the same time and facilities to dress, chill, and cut the light weight hog as it does a hog which

yields twice as much pork", (b)"lesser value of the thin bellies from light hogs," and (c)"the yield of the lighter hogs is less." (Incidentally, retailers preferred lighter cuts of pork since they are easier and more profitable to sell. Consumers found no difference in tenderness or flavor but objected to the greater amount of fat in the cuts from heavier hogs.) As pigs approach market weight, their daily gains tend to plateau, but their daily feed intake continues to increase while efficiency of feed utilization declines (Pond, 1974, p. 505). Unexpected delays in marketing the pigs can be costly and feed resources might be limited.

Small scale farmers who continue to raise indigenous pigs traditionally may find themselves in a predicament in the future. Processors prefer to slaughter exotic pigs which weigh over 90 kilograms (200 lb) because they yield better carcasses for ham and bacon production. The government would like to promote the increased production of this type of hog for processing to reduce the need for importation of hams and bacon into the country. Small scale farmers are unprepared to produce this type of market hog. The type of pig they produce is retailed almost exclusively as fresh pork. But the slaughter of heavy exotic pigs also yields fresh pork. Therefore, increased production of exotic pigs will compete for markets with pigs raised by small scale farmers. The likely result would be decreased demand and decreased prices for local pigs. Eventually, local pigs might be utilized solely within the local community, without

their being purchased by itinerant traders and butchers. This will have a negative impact upon the small scale farm families which rely upon swine as a source of income, economic security, and stability. Governmental policies regarding the subsidization of large scale producers of exotic swine should be studied for their impact upon these farmers.

Generally, intensively raised pigs are not consumed on the farm, or even in the village. They are marketed through butchers catering to urban customers (Luke, 1982). Within the Cayo District there are several such butchers. In 1984 they slaughtered 486 pigs (BLPA, 1985). Other pigs are transported to Belize City and the Northern Districts for slaughter.

The importance of efficient transportation to marketing is emphasized by Mellor (1966, p. 340). Many small scale farmers are restricted in their marketing options by their lack of available transportation. They must rely upon butchers or itinerant traders to pick their pig up from the farm. This reduces the farmer's income and flexibility. Yet, without these traders most small scale farmers would be unable to market their pigs.

Abbot (1967, p. 385) outlines the contribution that improved roads into rural areas can make upon marketing efficiency. The USAID Rural Access and Feeder Roads Project appears to be having such an effect upon swine marketing in the Cayo District. More purchasers are willing and able to travel to rural villages on improved roads. More vehicles

are available for hire at lower rates to transport animals. More farmers are acquiring vehicles. Less time in transit on smoother roads reduces losses due to shrinkage, injuries, and death (Dowell, 1941, p. 385). This improved marketing efficiency permits a better return to producers and savings to the consumer (Abbot, 1967).

Cooperative marketing and shipping associations are often proposed as a means of increasing operational efficiency and social justice (Mellor, 1966, p. 341). They result from a belief that the local dealers are taking advantage of the farmer and making huge profits. The cooperative association intends to increase returns to the farmer (Dowell, 1941, p. 164; Mellor, 1966, p. 341). Farmers in the Cayo District have expressed similar opinions. They have mentioned that sometimes they cannot sell their pigs, or are only able to sell them at a low price.

The Belize Livestock Producers Association functions as a cooperative shipping association, but handles primarily cattle and horses for export. The association presently does not market hogs. It did construct a livestock holding facility in San Ignacio that can be used by swine farmers that have brought animals to town and need a temporary place to keep them.

Most butchers in Cayo only buy one or two pigs at a time. The only exception is the Running W processing plant at mile 68 on the Western Highway, which processes 6 or 7 on one day each week. They anticipate increasing this number.

This processor only buys animals of exotic breeds weighing over 90 kilograms (200 lb). This kind of pig is not produced on most small scale farms. The only practical destination for cooperatively shipped pigs is the Belize Beef Ltd. slaughterhouse in Ladyville, near Belize City, which slaughtered 3602 pigs in 1984. Many of the pigs handled there are of the local type. In 1984, they had an average liveweight of 51 kilograms (113 lb) (BLPA, 1985). One independent trader purchases most of the hogs in the Cayo District that go to the Belize Beef Limited packing plant. It will be a challenge for a cooperative venture to be as efficient and flexible as the independent trader (Mellor, 1966, p. 342).

DISCUSSION

Traditional swine production is viewed by small scale farmers in the Cayo District of Belize as beneficial and profitable. Nevertheless, it is a farming enterprise of secondary importance. An increase in the utilization of on-farm resources for swine production can be achieved through the application of appropriate technology. Successful intensification of production can only occur through management consistency. Therefore, improvement is likely only on those family farms that genuinely elevate the significance of swine production. These farmers should be identified and provided with adequate technical information. The remainder of the small scale farm families should be permitted to continue swine production unencumbered by inappropriate improvement schemes.

Under the traditional system of swine production, swine growth is likely to average .076 kilograms per day. A 12 month old pig commonly weighs 24 to 30 kilograms. In addition to foraging and eating kitchen waste, swine will likely consume anywhere from 6 to 15 kilograms of corn for each kilogram of weight gained.

Most boars are castrated when they weigh between 15 and 30 kilograms. Breeding occurs under natural range

conditions. Most gilts farrow at 14 to 16 months of age and commonly weigh approximately 45 kilograms immediately afterward. Average litter size is approximately 7.3 piglets. Most pigs born alive survive through weaning. Few farmers wean their pigs. Most pigs are naturally weaned at 3 or 4 months of age. Sows which are rebred commonly have a farrowing interval of 7 to 11 months. There was an increase in the number of farrowings around the month of February, indicating a "natural" breeding season around the post-harvest month of October, when the nutritional level is likely to be at its highest point of the year.

Traditional small scale farmers market 40 to 60 percent of their pigs to itinerant traders. The remainder are slaughtered on the farm for home consumption or sale to other families within the community and to retail outlets of fresh pork. Pigs and pork are also commonly traded or given as gifts. Increased production of heavy weight market hogs by large scale producers will reduce the farmers' ability to market the local pigs outside community. This will likely have a negative impact upon their well-being.

The local swine do not appear to be significantly affected by major health problems. Internal and external parasites, abscesses, bats, beefworms, and screwworms are the principal health concerns.

The local swine are better suited to traditional small scale swine production than are the exotics. Farmers should only incorporate exotic animals into their herds following,

or in conjunction with, the adoption of improved, relatively intensive management practices. Careful research should be conducted to ascertain whether the local swine possess genetic characteristics beneficial to extensive and/or intensive swine production locally, or elsewhere in the world. Their growth rate, feed efficiency, and carcass characteristics which result from the feeding of a ration which meets their nutritional needs should be measured. They are a potentially valuable genetic resource.

Intensification of swine production should not include over-capitalization on housing and facilities. Small scale swine producers are able to successfully intensify swine production with local swine in properly managed wood pole and thatch roof structures on well drained dirt floors. Wood shavings or sand on the floor might improve conditions. Concrete floors may be beneficial in poorly drained areas.

The principal constraint to improved production is nutritional; the secondary constraint is managerial. The third limitation to be addressed is genetics. Note that genetic improvements cannot be promoted without first addressing the nutritional and managerial shortcomings. Ideally, nutritional and managerial improvements would result in significant increases in productivity, which would stimulate interest in improving the genetic quality of the animals on the farm and thereby generate another increase in productivity.

Farmers are reluctant to invest their limited resources

in the intensification of production due to the riskiness of the enterprise. Uncertain governmental support, political policies, feed prices, and market outlets are some concerns expressed by farmers.

Increasing the profitability of swine production is limited by the availability of inexpensive feedstuffs. Research into the development and application of labor and yield enhancing technologies which are applicable to small farm crop production should be conducted. Emphasis should be placed upon the development and local production of an inexpensive, concentrated, high-quality protein, vitamin, and mineral supplement for inclusion in swine rations. This might be produced from solar-dried fish meal, meat and bone meal, synthetic amino acids, minerals, and vitamins. The possibility of the addition of dried poultry offal meal should also be explored.

Swine feeding systems that efficiently utilize on-farm feedstuffs and require a minimum of capital expenditure are available. Concentrated protein, vitamin, and mineral supplements can be combined with farm produced feeds in mixed feed or free choice rations, or in a modified Lehman feeding system. Further research should be conducted to develop feeding recommendations for small scale farmers based upon the principle of diminishing returns. Caution should be exercised to ensure that only as many swine are raised as on-farm resources can efficiently support. Purchasing ration components other than a concentrated supplement is

unlikely to be economical for the small scale farmer.

There should be improved cooperation between swine researchers and extension personnel, so that appropriate research is conducted and the results extended to farmers.

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