# SOCIO-ECONOMIC CORRELATES OF RURAL WOMEN'S NUTRITION: THE SPECIAL CASE OF RE-INTRODUCING QUINOA IN ECUADOR

by

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May, 1999

"A thesis submitted to the Faculty of Graduate Studies and Research

in partial fulfillment of the requirements of the degree of

Doctor of Philosophy"

0-612-50214-7

**SUGGESTED SHORT TITLE**

**Quinoa production and rural women's nutrition**

# ABSTRACT

A cross-sectional study with repeated measures was conducted in the Ecuadorian Highlands to determine whether quinoa (*Chenopodium quinoa*) production was associated with improved nutrition among women. Agricultural production systems, income, socio-economic status, morbidity, diet and protein-energy status were compared between a group of quinoa-producers and a randomly sampled quasi-control group of non-quinoa-producers (total n=90 households) over four study rounds (pre- and post-quinoa-harvest).

Seasonal and age-related variability in nutrient intakes as well as anthropometric status provided evidence of nutritional vulnerability in this population. Post-menopausal women (50+ years of age) consumed less energy (300 calories), less protein (11 g) and maintained a lower mean body weight (3.66 kg) compared to their younger counterparts. Seasonal changes in dietary quality and anthropometric status were apparent for women of all ages with less protein and micronutrients consumed post-harvest and mean arm circumference 6 cm smaller. Marked prevalences of inadequate intakes of many of these same nutrients (including iron, niacin, and vitamin $B_{12}$) were demonstrated with the Probability Method.

Correlates of diet quantity (energy), quality (animal protein adjusted for energy) and anthropometric status were established. By means of a Principal Components analysis, socio-economic status was shown to be comprised of two unique constructs: modern lifestyle and farming wealth. Both factors were related to diet quality but neither was related to diet quantity. Diet quality, in turn, was significantly related to anthropometric status in multivariate models.

Women in quinoa-producing households consumed higher amounts of most nutrients and maintained larger arm protein-energy stores than those in non-quinoa-producing families. Trends were similar in children with no evidence of a difference in anthropometric status. However, quinoa-producers scored higher on both scales of socio-economic status, demonstrating self-selection bias. In multivariate models, quinoa production was related to increased intakes of energy, iron, zinc and folate but effects on animal protein intake and anthropometric status were confounded by the socio-economic effects. Therefore, while quinoa production was associated with positive nutritional impacts, the most impoverished households were left virtually untouched by this agricultural opportunity.

# ABRÉGÉ

Une étude transversale comprenant des prises de mesures répétées a été menée dans les hautes terres de l'Équateur pour déterminer si la production de quinoa (*Chenopodium quinoa*) était associée à une amélioration de l'alimentation chez les femmes. Six variables, soit les systèmes de production agricole, les revenus, les statuts socio-économiques, la morbidité, le régime alimentaire et les réserves d'énergie de source protéique, ont fait l'objet de comparaison entre un groupe de fermiers producteurs de quinoa et un groupe quasi-témoin de fermiers non-producteurs de quinoa. Ces fermiers ont été choisis au hasard (n$^{bre}$ total de foyers : 90) au cours de quatre séances d'enquête tenues avant et après la récolte de quinoa.

Les écarts constatés entre les saisons et entre les différentes tranches d'âge quant à l'apport de nutriments et les mesures anthropométriques ont fait ressortir la vulnérabilité de la population en matière d'alimentation. Les femmes ménopausées (50 ans et plus) consomment moins d'énergie (300 calories) et moins de protéines (11 g) que les femmes non ménopausées, et leur poids moyen, est moins élevé (3,66 kg) que celui de ces dernières. Des changements saisonniers dans la qualité de l'alimentation et dans les mesures anthropométriques ont été observés chez les femmes de tous âges; ainsi, la consommation de protéines et de micronutrients est moins élevée après les récoltes et la circonférence moyenne des bras diminue de 6 cm. L'analyse des probabilités a mis en évidence une forte prévalence d'une carence en nutriments, notamment en fer, en niacine et en vitamine $B_{12}$.

Des corrélations ont été établies entre la quantité (énergie) de nourriture et la qualité (protéines d'origine animale corrigées pour l'énergie) de l'alimentation et les mesures anthropométriques. L'analyse des composantes principales a révélé que le statut socio-économique reposait sur deux éléments, soit le mode de vie moderne et la richesse des entreprises agricoles. Ces éléments sont liés à la qualité de l'alimentation, mais ni l'un ni l'autre n'est lié à la quantité de nourriture. Dans les modèles à plusieurs variables, la qualité de l'alimentation est, pour sa part, fortement liée aux mesures anthropométriques.

Les femmes vivant dans des foyers producteurs de quinoa consomment plus de la plupart des nutriments et présentent de plus grandes réserves d'énergie de source protéique dans les bras que celles vivant dans des foyers non producteurs de quinoa. Des tendances semblables ont été observées chez les enfants, sans différence de mesures anthropométriques. Cependant, les producteurs de quinoa ont présenté des résultats plus élevés en ce qui concerne les deux composantes du statut socio-économique, d'où une autosélection biaisée. Dans les modèles à plusieurs variables, la production de quinoa a été liée à un apport plus élevé d'énergie, de fer, de zinc et d'acide folique, mais les effets sur la consommation de protéines d'origine animale et les mesures anthropométriques ont été confondus avec les effets socio-économiques. La production de quinoa a donc été associée à une incidence favorable sur l'alimentation, mais les foyers les plus pauvres n'ont pratiquement retiré aucun avantage de ce type de culture.

# ACKNOWLEDGEMENTS

I am deeply indebted to a number of institutions and individuals who provided technical support and friendship during the conduct of this work.

The School of Dietetics and Human Nutrition (McGill University), the Centro Internacional de la Papa (CIP), the Instituto Nacional de Investigaciones Agropecuarias (INIAP), the Fundación para el Desarrollo Agropecuario (FUNDAGRO) and the Unión de Comunidades Indígenas de Guamote (UCIG) provided office space and logistical support during the course of this research.

Several individuals went well beyond the call of duty in offering valuable technical direction. Primary among these at McGill University are my present and past committee members: Dr. Katherine Gray-Donald, Dr. Olivier Receveur, Dr. Laurel Bossen, Dr. Randall Westgren and Dr. Steven Esrey. I am especially grateful to my supervisor, Dr. Timothy Johns for his advice and support. Dr. Peter Berti, Dr. Adelheid Onyango, and Dr. Abdulaziz Adish, time and again, provided words both of guidance and encouragement.

In Ecuador, this work simply would not have been possible without the active participation of Ing. Carlos Vimos and Eliseo Guzñay who constantly helped me bridge the Canadian-Ecuadorian cultural gap and re-orient my work to the Andean setting. Similarly, the research team of Ing. Sandra Espinoza, Vicenta Caiza, Nancy Muñoz, Laura Cunduri, and Custodia Lema was instrumental in every step of data collection from pre-testing of questionnaires to organizing community nutrition courses. A special thanks is offered for their expert guidance in both potato-peeling and Andean slope rapid descent! Ing. Carlos Nieto, Ing. Bolivar Navas, and Dr. Gregory Scott all facilitated the work in their own special way.

I am deeply thankful to the communities for their participation and for welcoming the research team into their households. More than 100 families provided information for up to four study rounds and the donation of their valuable time and energy is gratefully acknowledged.

Undertaking a Ph.D., especially one that involves uprooting your life for over 14 months, places unique strains on friends and colleagues which are fully recognized by the author. The patience and support of the following individuals merits special note: Fabian Muñoz, Robert Koep, Caroline Crawford, Christina Calciu, Tarik Kassaye, Dr. Beverley Watts, Dr. Dennis Fitzpatrick, Dr. William Edwardson, Anna Congacha, Diego Vimos, Betty Vimos, Mirian Congacha, Elena Dueñas, Luis Dueñas, Dr. Ernest Loevinsohn, Dr. Yves Bergevin, and Archana Dwivedi.

Finally, as always, the love of my family is an enduring source of inspiration. Gratitude is extended to Donald and Patricia Macdonald; Donald, Catherine and Julia Macdonald.

Susan, Mildred and Joe, this is for you.

# THESIS REGULATIONS

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# STATEMENT OF ORIGINALITY

Despite the growing recognition that women's nutritional status is critical for the long-term development of rural societies, few studies have documented the social and economic conditions under which women receive optimal nourishment. This bias is particularly puzzling given that women produce 80% of food in some developing regions (Quisumbing et al., 1995), are among the most vulnerable members of households due to gender bias, and are often subjected to excessive labour demand and reproductive stress. This study provides new information on the adequacy of women's nutritional status and its relationship to an agricultural programme.

Congruent to the focus on children in nutritional research, there is a paucity of information documenting the status of post-reproductive households. Along with women, adults of advanced age may be considered a vulnerable group as there may exist biases towards nourishment of younger, more economically productive family members. The present focus of this study on women, including the elderly, makes this research highly relevant for improved understanding of the extent of nutritional stress within communities.

This study also produces new information with respect to the nutritional impacts of agricultural projects and policies. Firstly, in the past this type of inquiry has often limited the outcome of interest to children's growth. Secondly, dietary analyses have focused on energy intakes (*quantity*) despite the importance of micronutrients for health and the real possibility that economic improvements may produce shifts in the sources of energy rather than the total amount of calories consumed. Thirdly, although a copious literature exists which documents the effects of cash-crops such as tobacco or sugar, few studies have looked at the effects of production and commercialization of a nutritious food, particularly the effects of the re-introduction of an indigenous crop. Fourthly, although knowledge of the nutrient composition of quinoa exists, no study has ever examined the linkages between production of this grain and its fit with the broader food and nutrition system for Andean dwellers. Therefore, this study is unique both for the crop studied and its focus on women and their access to a *high-quality*, balanced diet.

In addition to the contribution made to the agriculture-nutrition literature, this study also advances knowledge in the area of Andean nutrition. Again, women's nutrition, especially in terms of their micronutrient status has been seriously under-studied. New data are provided showing a high prevalence of inadequate intakes of nutrients associated with anemia (iron and vitamin $B_{12}$) and marked age and seasonal variability in intakes. Furthermore, important information is provided regarding the *inapplicability* of current WHO (1995) BMI cut-off points for this population. These insights should help to re-orient and accurately target nutritional interventions in this region.

Finally, an important analytical finding is presented which should clarify the measurement of socio-economic status as a confounder of nutrition relationships. A Principal Components analysis demonstrated that commonly applied proxies for socio-economic status actually measure two distinct constructs (modern lifestyle and farming wealth) and are therefore, not interchangeable. Both of these factors were related to diet quality and the "intervention" (quinoa production). Therefore, adjusting for some of these indicators and not others leaves the confounding effect of socio-economic status only partially controlled. This analytical approach should aid in reaching valid conclusions from future evaluations of development projects and policies.

# STATEMENT OF AUTHORS' CONTRIBUTIONS

The primary author, Barbara Macdonald, was responsible for the review of literature, formulation of research hypotheses and objectives, development of the research design and methodology, all aspects of data collection including field supervision, all aspects of data input, data analysis and interpretation, and manuscript preparation. The primary author sought advice from the contributing authors, Timothy Johns, Katherine Gray-Donald and Oliver Receveur in the formulation of appropriate objectives, appropriate design and methods, data analysis and presentation of results. In particular, Johns provided counsel on overall scientific conceptualization/method and clear presentation. Gray-Donald and Receveur provided valuable feedback regarding the correct application of statistical methods, and the interpretation and presentation of results.

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# CHAPTER 1

# INTRODUCTION

Optimal nutritional status is widely recognized as an essential input to the physical and intellectual development of individuals, and therefore the social and economic development of societies (Schultz, 1993; UNICEF, 1998). Adequate intakes of both macro and micronutrients are required throughout the life cycle for growth, development and maintenance of tissues, optimal functioning of the immune system and learning and work capacity. Evidence suggests, however, that a large proportion of the world's population is chronically malnourished. Approximately 841 million individuals lack sufficient food (FAO, 1996), 100 million lack sufficient vitamin A in the diet and 2 billion women and children are anemic (UNICEF, 1998). The consequences at a population level are devastating and include increased rates of maternal and child mortality, increased incidence and severity of illness, intellectual impairment, and physical disabilities such as blindness.

Women form one of the groups most vulnerable to malnutrition. This is because women's multiple productive and reproductive roles place an enormous strain on nutrient stores, a situation compounded by the gender biases in intra-household food distribution and access to health services witnessed in some cultures. Statistics indicate that women's nutritional status is seriously compromised in many parts of the developing world. James et al. (1994) reported that the prevalence of Chronic Energy Deficiency (CED) (Body Mass Index [BMI] < 18.5) was approximately 35% in Ethiopia and Somalia and as high as 66% in parts of India.

Globally over 51% of pregnant women and 35% of non–pregnant women are estimated to suffer from iron deficiency anemia (Gillespie, 1998). These nutritional problems seriously threaten the survival of both women and their offspring. Over 20% of maternal deaths are estimated to be associated with anemia (Gillespie, 1998) and malnourishment among women is associated with increased rates of low birth-weight and perinatal mortality.

Despite the evidence demonstrating the importance of women's health and nutrition for developing country societies and the widespread nature of nutritional deficits among this group, research and programming has largely failed to address these concerns. This information gap includes limited knowledge of the socio-economic determinants of optimal nutrition for women and their families. While the causative model of malnutrition developed by UNICEF in 1990 recognizes that the distal determinant of poor nutrition is a lack of political and economic resources (UNICEF, 1998), scientific operationalization of this part of the framework has been weak. Specifically, while variables such as caring capacity, education, and socio-economic status are increasingly recognized as important determinants of nutrition, there remain questions as to the role of varying livelihood strategies and programmes to improve nutrition both in the urban and rural sectors.

In Ecuador, an agricultural project (International Development Research Centre, Project 3-P-90-0160, Ottawa) provided an ideal context not only to better understand the nutritional status of women and its socio-economic correlates but to determine the capacity of agricultural programmes to improve the status quo. The project was located in the Highlands (3100 to 4000 m.a.s.l. [metres above sea level]); a fragile ecosystem characterized by drought, freezing temperatures, soil erosion and extreme poverty. These difficult conditions are accompanied by severe malnourishment. Among children, 52% of those under 5 are stunted and approximately 25% suffer from riboflavin and iron deficiencies (Freire et al., 1992; Freire et al., 1988). Similar information for women is not readily available but Berti et al. (1997) observed marked prevalences of inadequate intakes of vitamin A, riboflavin, vitamin $B_{12}$ and folate in one Highland community.

A search for options to improve agricultural productivity and alleviate income and food insecurity has led the Ecuadorian government to support agricultural production and post-production research on Andean crops. These crops, which include quinoa *(Chenopodium quinoa)*, amaranth (*Amaranthus caudatus*), mashua (*Tropaeolum tuberosum*), and lupins (*Lupinus mutabilis*), constitute a significant source of locally produced protein, carbohydrates, and micronutrients in an environment characterized by resource degradation. These crops are well-adapted to mountainous climates, may be cultivated on marginal soils and are drought and frost-resistant, thereby providing protection against food insecurity when traditional market crops such as barley and potatoes produce insufficient yields.

One of the most promising alternatives among these crops is quinoa. This pseudo-cereal was a staple in the Incan diet but was marginalized and replaced by barley and wheat following the Spanish conquest. Rich in a number of nutrients including protein, vitamin E, vitamin C, thiamin, riboflavin, folic acid, phosphorus, magnesium, iron, zinc, and copper (Ruales Nájera, 1992; Koziol, 1990), urban demand for quinoa has recently increased in both domestic and international markets.

In terms of both production and marketing potential then, increased cultivation of quinoa among rural Ecuadorian dwellers appears to provide a favourable agricultural option. Consumption of quinoa both by adults and children has the potential to play an important role in the delivery of a variety of nutrients. Furthermore, income derived from quinoa commercialization may be used for the purchase of additional foods to diversify the household diet.

The sustainability of the re-introduction of quinoa, however, is contingent upon the achievement of these nutritional impacts, which in no way can be assumed *a priori*. In fact, similar research in other parts of the developing world suggests that projects designed to increase agricultural cash incomes may have limited impact in terms of rural dwellers' nutrition (Kennedy and Cogill, 1987; Bouis and Haddad, 1990). The research presented in this thesis drew on the fields of anthropology, agricultural economics and nutrition to understand if the production and commercialization of quinoa did in fact contribute to women's and children's nutrition in this fragile ecosystem.

The study was completed under the auspices of a research project conducted by the Instituto Nacional de Investigación Agropecuaria (INIAP). The project assessed the feasibility of production, processing and commercialization of quinoa and other traditional grains through a community-based pilot plant. Production was financed through a revolving credit fund and was accompanied by agricultural extension services provided by project staff. Processing performed by the plant included the removal of bitter-tasting saponins from quinoa and milling.

The fundamental **research question** addressed by this thesis was:

Is quinoa production associated with improved nutritional status (diet and anthropometry) among rural Ecuadorian women?

In order to answer this question comprehensively, a series of specific objectives were devised and addressed in the three manuscripts which comprise this thesis. The first set of objectives (Manuscript A) included an assessment of women's energy status over the agricultural year and identification of the most responsive anthropometric indicators to be used in the remainder of the analyses. The underlying purpose was to determine whether intakes of energy (diet *quantity*) were of sufficient variation to identify associations with differing food production patterns. The second set of objectives (Manuscript B) examined the adequacy of women's diets in terms of micronutrient intakes (diet *quality*) and the socio-economic co-variates of both diet and anthropometric status. The goal was to better understand the economic processes associated with optimal nutrition and to identify the variables likely to confound an analysis of the nutritional impacts of quinoa production. The third set of objectives (Manuscript C) sought to identify the nutritional impacts of the quinoa project adjusted for the confounding variables identified in Manuscript B.

These objectives are detailed below:

**Manuscript A**:

1) to determine whether differences in anthropometric status exist across the life cycle and across seasons in women residing in rural Ecuador;
2) to determine whether differences, if they exist, are reflected in energy and protein intakes and reported illness patterns; and
3) to determine the utility of BMI as an indicator of energy stress in this population.

**Manuscript B**:

4) to describe Ecuadorian Andean women's diet quality and establish its adequacy;
5) to describe the household socio-economic resource base in three Ecuadorian communities; and
6) applying multivariate analyses, to determine the strength of associations between household socio-economic variables and diet quantity (energy), diet quality (animal protein intake adjusted for energy), and the anthropometric status (BMI, mid-upper-arm circumference [MUAC] and arm fat area [AFA]) of rural Ecuadorian women.

**Manuscript C**:

7) to compare the household resource base and income between quinoa-producing families and a randomly selected group of non-quinoa-producing families from the same communities;
8) to compare dietary intake and anthropometric status of the female head of household and one index child between these same groups, and

9) if differences exist between these groups, to control for potential confounding by applying multivariate analyses including known predictors of diet and anthropometric status in this population.

# CHAPTER 2

# REVIEW OF LITERATURE

## 2.1 General Description of the Quinoa Plant:

Quinoa is an annual plant, well adapted to mountainous regions (2000 to 4000 m.a.s.l.) characterized by frost and drought resistance (Ruales Nájera, 1992; Galwey et al., 1990; Varriano-Marston and DeFrancisco, 1984). Alvarez et al. (1990) report that the plant is able to withstand frost temperatures of -5 degrees C and may also survive annual precipitation levels as low as 400 mm. Growing to a height between 0.7 and 3.0 m (Galwey et al., 1990), quinoa yields both edible seeds and leaves. The grain itself exists in a variety of shapes (disc, conical or cylindrical), colours (yellow, cream, brown, white or translucent), and sizes (1.5 to 3.0 mm) (Ruales and Nair 1992; Galwey et al., 1990; Alvarez et al., 1990). It is cultivated mainly in the Andean countries of South America including Peru, Bolivia, Ecuador, Chile and Colombia although limited cultivation has also taken place on both a commercial and experimental basis in the United States of America, the United Kingdom, Finland, Holland, Germany, Denmark and Canada (Alvarez et al., 1990; Galwey et al., 1990).

## 2.2 Nutritional Composition of Quinoa

Quinoa is a source of a wide range of nutrients essential for the human diet. The chemical composition of this pseudo-cereal has been the subject of intense interest and has been detailed by several authors over the past 40 years (White et al., 1955; de Bruin, 1964; Mahoney et al., 1975; Cardozo and Tapia, 1979; Gross et al., 1989; Koziol, 1990; Chauhan et al., 1992, Ruales Nájera, 1992). The energy content is similar to that of other cereals, and has been reported as 399 kcal/100g dried weight by Koziol (1990). Proximate composition, vitamin and mineral as well as anti-nutrient content have all been studied but results show a large degree of variability due to such factors as the cultivar of quinoa studied, environmental conditions, and methods of analysis (Galwey et al., 1990). In order to increase the relevance of the results presented, only analyses conducted during the past 10 years will be reviewed. Analyses conducted on Ecuadorian varieties will be emphasized.

2.2.1 Proximate Composition:

A summary of proximate analyses conducted on quinoa in recent years is found in Table 1. Protein content is the nutritional property emphasized most often by authors and ranges from 13.7 to 16.5% in the most recent studies (Chauhan et al., 1992; Rubio and Espin, 1988). Differences in protein content may be the result of varietal differences or may be an artifact from the use of different nitrogen conversion factors (N x 5.7 versus N x 6.25). Studies of the nutrient content of quinoa cultivated in Ecuador show protein contents between 14.1% and 16.5% (Koziol, 1990; Rubio and Espin, 1988; Ruales and Nair, 1992). Even at the lowest value of 14%, however, quinoa has a higher protein content on a dried basis than many comparable cereals including whole wheat flour (10%), barley flour (9.2%), parboiled rice (7.7%), and corn (10.2%) (Ruales and Nair, 1992; Koziol, 1990). On the other hand, the protein content is significantly below that of common legumes including beans (*Phaseolus vulgaris*) at 28% and soybeans at 36.1% (Koziol, 1990). Analysis of amino acid patterns show quinoa to be high in lysine, which is commonly an amino acid of limited supply in plant proteins including wheat (Galwey et al., 1990; Ruales and Nair, 1992). Analysis of the amino acid pattern of an Ecuadorian variety conducted by Ruales and Nair (1992) indicated that quinoa provided threonine, valine, leucine, lysine, histidine and tryptophan at levels higher than those outlined as the FAO reference protein pattern. Tyrosine and phenylalanine were identified as the limiting amino acids. Other authors, however, have reported that methionine, leucine, threonine and valine may be present at levels below those of the FAO reference pattern (Mahoney et al., 1975; Koziol, 1990). These differences in the reported amino acid composition may be due to environmental, agronomic, and genetic variation as well as differing analytical procedures (Galwey et al., 1990). Regardless, the fact that quinoa is deficient in some essential amino acids demonstrates that it needs to be consumed in combination with other protein sources such as legumes or animal products to provide complete protein.

Less research has focused on the carbohydrate and fat contributions of quinoa. Total carbohydrate content has been estimated to range from 61.2% to 72.5% (Chauhan et al., 1992; Ruales Nájera, 1992). Crude fibre content has also been studied and has been determined to range from 2.16 to 13.4% (Chauhan et al., 1992; Ruales Nájera, 1992). The major constituent of the carbohydrate fraction is starch which has been reported to range from 54% to 65.2% (Ruales Nájera, 1992).

Table 1: Proximate Composition (%) of Quinoa

| | North American cultivar[a] | Peruvian cultivar[b] | Ecuadorian cultivar[c] | Ecuadorian cultivar[d] | Ecuadorian cultivar[e] |
|---|---|---|---|---|---|
| Moisture | 12.00 | 9.50 | 9.61 | N/A | N/A |
| Protein | 13.70 | 15.50 | 15.72 | 16.46 | 14.10 |
| Fat | 6.80 | 8.20 | 7.16 | 8.52 | 9.70 |
| Carbohydrate | 61.20 | 66.30 | 61.70 | N/A | 72.50 |
| Fibre | 2.16 | 6.50 | 2.91 | 5.60 | N/A |
| Ash | 2.82 | 3.50 | 3.29 | 3.45 | 3.40 |

[a]Chauhan et al. (1992); [b]Gross et al. (1989); [c]Koziol (1990); [d]Rubio and Espin (1988); [e]Ruales and Nair (1992)

In terms of crude fat content, figures range from 6.03% to 9.70% (Reichert et al., 1986; Ruales Nájera, 1992). The higher fat content was reported for an Ecuadorian variety, while the lower fat content was reported for Peruvian and North American varieties. Fatty acid profiles revealed high levels of oleic acid (24.1%), and linoleic acid (52.3%) for an Ecuadorian variety (Ruales Nájera, 1992). It was also reported that the PS ratio (polyunsaturated fatty acids to saturated fatty acids) is 4.9 which is higher than that of many of the common dietary oils including soybean oil (3.92) and corn oil (4.65) (Ruales Nájera, 1992). Koziol (1990) reported that the oil present in quinoa is remarkably stable despite the high content of unsaturated fatty acids.

### 2.2.2 Vitamin and Mineral Composition

Quinoa contains a significant amount of many micronutrients including vitamin E, vitamin C, thiamin, riboflavin, folic acid, phosphorus, magnesium, iron, zinc and copper (Ruales Nájera, 1992; Koziol, 1990). Ruales Nájera (1992) calculated nutrient density ratios for children 1 to 3 years of age (ratio between the nutrients present in the amount of quinoa which provides 1300 kcal and the amount of nutrients recommended for children 1 to 3 years) and reported that quinoa provided nutrient levels in excess of recommended amounts for the nutrients listed above, except for riboflavin for which the nutrient density was calculated to be 0.9. It has been reported that levels of riboflavin, folic acid, alpha-tocopherol and iron found in quinoa outstrip those found in wheat, barley, rice and corn (Ruales Nájera, 1992; Koziol, 1990).

The bioavailability of iron in quinoa, however, requires further investigation. Employing a rat model, Allred et al. (1976) reported the availability to be equivalent to that of $FeSO_4$ and that quinoa was a superior source of iron compared to wheat flour for hemoglobin regeneration in anemic rats. More recently, however, radioiron absorption studies in adult human subjects showed that less than 1% of iron was absorbed from quinoa flour and that the increase in availability due to an addition of vitamin C (increased from 0.93% to 1.61%) was less than that observed with maize, rice or wheat (Cook et al., 1997). The reduced bioavailability in quinoa is likely due to its high content of phytic acid as is described below.

2.2.3 Presence of Antinutrients

Most varieties of quinoa contain a significant amount of saponins which impart a bitter taste to the grain. The saponins must be removed prior to human consumption which customarily consists of washing and scrubbing of the seeds at the household level and either washing or dehulling of quinoa at the industrial level. Saponins are triterpane glucosides which consist of an aglycone linked to one or more sugar chains (Ruales Nájera, 1992; Price et al., 1987). In addition to the bitter taste, many saponins are characterized as foaming in water, lysing cells (including hemolysis) and as having a hypocholesterolemic effect (Price et al., 1987; Galwey et al., 1990). As can be expected, intravenous administration of hemolytic saponins is highly toxic to mammals. Oral administration however, results in decreased toxicity as saponins are largely incapable of crossing the gut and because hemolysis is not as severe in the presence of plasma (Price et al., 1987). The lethal dose for rodents ranges from 1.9 to 6000 mg total saponins per kg body weight (George, 1965 as cited in Koziol, 1990).

There is large variation in the data reported for the saponin content of quinoa varieties partly due to genetic variation and partly due to the fact that saponins are notoriously difficult to quantify. It has been reported that gravimetric methods and the foam method of estimating saponins may overestimate content (Reichert et al., 1986). Ruales Nájera (1992) assayed the saponins in an Ecuadorian variety of quinoa and found that two main types of saponins existed; saponin "A" which was present at a level of 0.7% (dried weight) and saponin "B" which was present at a level of 0.2%. Koziol (1991) reported saponin levels between 0.85% and 1.12% for four Ecuadorian varieties.

In quinoa, the saponins are mainly located in the outer layers of the seed and as a result, can be removed by either washing or dehulling as outlined above (Chauhan et al., 1992; Reichert et al., 1986). It should be noted, however, that the processing required to remove saponins may also remove some of the vitamins and minerals located in the outer layers of the quinoa seeds. Ruales Nájera (1992) reported that washing reduced thiamin content from 0.4 to 0.3 mg/100g (dried weight), alpha-tocopherol content from 2.6 to 2.4 mg/100g and folic acid from 78.1 to 66.3 μgrams/100g. There were also losses of potassium (1201 to 571 mg/100g), iron (81 mg/kg to 59 mg/kg), manganese (33 to 25 mg/kg) and magnesium (2620 mg/kg to 2463 mg/kg). Chauhan et al. (1992) reported that manual dehulling of quinoa reduced the calcium content from 110 to 70 mg/100g and manganese content from 42.7 to 34.3 mg/100g. Protein, fat and carbohydrate content remains relatively unchanged after washing and/or dehulling (Chauhan et al., 1992; Ruales and Nair, 1992; Reichert et al., 1986).

The antinutrient phytic acid has also been found in quinoa and its content has been determined to remain high after washing (Ruales Nájera, 1992). Ruales Nájera (1992) reported the phytate content of Ecuadorian varieties at 8 mg/g quinoa flour or 0.80%; a figure in line with the 0.76% to 0.88% range reported by Cook et al. (1997). Chauhan et al. (1992) reported that the North American variety of quinoa analyzed in their laboratory contained 174.4 mg/100g phytates. As was alluded to previously, high levels of phytic acid are a cause for concern as they are capable of binding with multivalent minerals such as iron, zinc, calcium and magnesium, thereby reducing the bioavailability of these nutrients. As for other antinutrients, trypsin inhibitor activity is negligible and tannins were not detected in an Ecuadorian variety (Chauhan et al., 1992; Ruales Nájera, 1992).

## 2.3 Nutritional Quality of Quinoa

Both animal and human studies have been conducted to evaluate the nutritional quality of quinoa seeds. In particular, the quality of quinoa protein has been the subject of investigation. The evidence suggests that the quality of quinoa protein is on a par with that of other cereals.

2.3.1 Animal Models:

Employing a rat model, White et al. (1955) reported that after completion of a 28 day depletion-repletion study, rats fed quinoa gained an average of 48.9g versus a gain of 37.7g for rats fed casein. Mahoney et al. (1975) randomly allocated weanling male Sprague-Dawley rats to 6 diets with different protein sources (10% protein) including 100% quinoa flour, 100% cooked quinoa, 20% quinoa flour/80% wheat flour, bread made with 20% quinoa flour/80% wheat flour, 100% casein and 100% wheat flour. Rats assigned to the cooked quinoa diet gained 87g compared to those assigned to the casein diet (57g). Cooking appeared to affect protein quality as rats assigned to the uncooked quinoa diet gained only 43g. Diet quality was further assessed by NEG or nitrogen efficiency for growth. Uncooked quinoa flour and casein were observed to have a similar NEG (29.6 and 32.3 respectively). Again, cooking was reported to have a positive effect and improved NEG by 40% (NEG = 41.6). PER values were observed to be similar for cooked quinoa and casein (2.71 and 2.67 respectively).

A review of more recent work leads to similar conclusions. Gross et al. (1989) reported that the PER of quinoa and casein were equivalent at approximately 3.10.

Apparent digestibility was also similar for the 2 protein sources at 84.1% for quinoa and 87.5% for casein. Ruales and Nair (1992), examining an Ecuadorian variety of quinoa, observed that quinoa had a lower net protein utilization (NPU), biological value (BV) and true digestibility (TD) than casein. To maintain perspective however, with the exception of the TD for rice, the NPU (73.95), BV (80.79) and TD (91.55) of washed quinoa are higher than those reported for corn, rice and wheat, common cereal components of the Andean diet. No significant differences were found for NPU, BV and TD of washed versus unwashed quinoa indicating that saponins in this variety did not interfere with digestibility and nitrogen utilization.

2.3.2 Human Studies:

Studies examining the quality of quinoa for the human diet are scant. Two studies completed by López de Romaña et al. in 1978 and 1981 investigated the appropriateness of washed quinoa combined with oats as a protein source for 8 Peruvian infants (4-29 months) recovering from malnutrition. The quinoa diet was compared with 5 other diets where milk, fish, eggs, beans and a commercial product each supplied 10% of protein. Although the quinoa diet was well tolerated, nitrogen absorption (67%) was lower from the quinoa diet compared to the other diets (78.8 - 82.4%) ($p<0.05$) (López de Romaña et al., 1978). A similar study conducted with 6 malnourished children compared protein quality of diets based on whole quinoa seeds, quinoa flour, and casein (López de Romaña et al., 1981). In this study, nitrogen absorption of both milled and whole quinoa (69.8% and 66.6% respectively) were lower than that of the casein diet (83%). It should be noted however, that similar to the findings reported with the animal models, the biological value (BV) for the quinoa flour diet (50.7%) was higher than that of the casein diet (45.8%) (López de Romaña et al., 1981). More recently, Ruales Nájera (1992) fed a drum-dried infant food based on quinoa to 40 boys aged 50 to 65 months in Quito, Ecuador for 15 days. After feeding, the level of insulin-like growth factor-1 (IGF-1) was reported to increase significantly in undernourished children (<10th percentile for weight-for-age), but did not change among the control group of children (Ruales Nájera, 1992). As might be expected, anthropometric indicators showed no change after such a short supplementation period. Protein quality of the supplement in terms of digestibility or biological value was not studied with the human subjects. These indicators were studied with a rat model and showed that the digestibility of the quinoa supplement was 95.3%, the net protein utilization (NPU) was 67.7%, and the biological value (BV) was 71.1%.

## 2.4 Utilization of Quinoa in the Human Diet

Following the de-bittering of quinoa, the grains are consumed in a number of ways. Traditionally, quinoa grains are either left intact or ground into a flour for use in gruels and soups; methods which are still common among rural dwellers in Ecuador (Ruales Nájera, 1992; Galwey et al., 1990; Macdonald, 1992). Traditional preparations also include fermentation to produce a type of beer (Galwey et al., 1990; National Research Council, 1989). In addition, quinoa flour may be used as a partial replacement for wheat and corn flours in the production of baked goods (Koziol, 1990). The small size of the starch granules and the low amylose content appear to limit substitution to levels of 10-15%, although pasta products have been produced at levels as high as 60% (Bacigalupo, 1973 as cited in Koziol, 1990). Product development studies carried out in the United States demonstrated that quinoa, when added to corn grits at levels up to 30% and extruded, yielded an acceptable product and increased lysine content by up to 50% over products derived from 100% corn grits (Coulter and Lorenz, 1991). Commercial production of quinoa-based products is on the rise in Peru, Bolivia, Ecuador and North America and include quinoa flours, quinoa flakes (similar to oatmeal), puffed grains and extruded snack products (National Research Council, 1989; Macdonald, 1992).

**2.5 Food Patterns in the Andean Diet including the Role of Quinoa**

Despite growing demand for processed quinoa products among upper-income urban consumers, consumption of traditional Andean grains among rural dwellers appears to be low. Recent studies which detail rural Andean food patterns have been mainly conducted in Peru and Ecuador with a smaller literature providing similar information for Bolivia. These studies will be examined together although it should be noted that there may be variation in patterns given differences in altitude, climate, socio-economic status and market accessibility among the communities studied.

Rural dwellers in the Andes rely on both subsistence agriculture and market foods for their dietary intake. In a study of the nutritional status of the inhabitants of the Ecuadorian Sierra, subsistence agriculture was reported to account for over 50% of energy intake (Leonard et al., 1993) while in Bolivia, local foods comprised 37% of intake (Kim et al., 1991). The traditional diet is comprised primarily of vegetable matter with approximately 80-85% of calories derived from carbohydrate, 10% from protein and 5-15% from fat (Picón-Reátegui, 1976; Berti and Leonard, 1998). Animal products are less commonly consumed and contribute just 7.7% of energy in Ecuador and 4.1% of energy in Bolivia (Berti and Leonard, 1998; Kim et al., 1991). Potatoes and other tubers (*Ullucus tuberosa*, *Oxalis tuberosa*) are staples commonly associated with the Andes (Tripp, 1982; DeWalt and Uquillas, 1989; Leonard and Thomas, 1988) but grains (wheat, barley, rice, bread and pasta) have often been shown to contribute higher percentages of energy. Berti and Leonard (1998) in a recent study of 50 Ecuadorian Andean households (n=227) observed that tubers contributed 25% of energy and grains 34%. Similarly, in Bolivia, Kim et al. (1991) demonstrated with a 7 day weighed record of 21 households that wheat contributed 40% of calories.

There have been significant changes over time in the intake of quinoa that partly reflect increased availability of market foods. Leonard and Thomas (1988) in a study of 33 households in Nunoa, Peru showed lower levels of intake compared to dietary data collected in the same community 20 years earlier. Quinoa's energy contribution to the diet was reported to have decreased from an average of 238 calories per day to 22 calories. Similar patterns of low levels of quinoa consumption have been documented in Bolivia and Ecuador (Kim et al., 1991; Tripp, 1982). In Bolivia, quinoa contributed an average of 28 calories per day (Kim et al., 1991) and in a study of 3 Andean communities (n=89 individuals), Tripp (1982) reported that quinoa was reported to be a constituent of only 5% of the meals in a 24 hour period, compared to maize at 63%, potatoes at 45%, and barley at 15%. In the current study area of Guamote, at the time this project was first proposed, rural dwellers stated in informal group interviews that quinoa was neither grown nor consumed (Macdonald, 1992). The main constraint to increased consumption mentioned was the lengthy de-bittering process traditionally required at the household level (Macdonald, 1992).

## 2.6 The Nutritional Status of Andean Dwellers

### 2.6.1 Adequacy of the Andean Diet

Nine studies have been conducted which analyze the Andean diet in Peru, Bolivia and Ecuador. Most studies have focused on the provision of macronutrients with scant information available for micronutrient intake, especially for adult women.

There is some inconsistency in the literature regarding the adequacy of energy intake. In order to accurately determine adequacy, energy requirements must first be established via studies of energy expenditure. Expenditure has been measured with the heart-rate monitoring and doubly-labelled water methods in Bolivia (Kim et al., 1991; Kashiwazaki et al., 1995) and with the heart-rate monitoring method in Ecuador (Leonard et al., 1995a). In both countries, total energy expenditure was observed to equal approximately two times the basal metabolic rate; expenditure levels consistent with very heavy activity patterns (physical activity level or PAL=2.0) (Kim et al., 1991; Leonard et al., 1995a; Kashiwazaki et al., 1995). Energy intakes were measured both in Bolivia and Ecuador. Energy intakes for adult women were equal to 2165 calories in Ecuador and 2320 calories in Bolivia (Leonard et al., 1995a; Kim et al., 1991). Bolivian women consumed adequate amounts of energy in relation to requirements (2338 kcal) (Kim et al., 1991) while Ecuadorian women were found to consume only 88% of required calories (Leonard et al., 1995a). It should be noted, however, that Leonard's study was completed during the potato harvest; a period of intense agricultural labour (Leonard et al., 1995a). Similarly, other investigators have reported Andean energy intakes to range from 80 to over 100% of requirements (Berti et al., 1997; Leonard 1989a; Marquis and Kolasa, 1986).

Several studies show strong influences of both socio-economic status and season on energy intake and/or energy sources. Berti and Leonard (1998) and Leonard et al. (1993) both observed associations between land ownership and diet in Ecuador. For the Peruvian community of Nunoa, estimates of energy intake range from a low of 1,150 kcal/day for lower socio-economic groups (adequacy of 0.90 when compared to estimated total energy expenditure) to 1,632 kcal/day for upper socio-economic groups in the post-harvest season (adequacy of 1.26) (Leonard, 1989a; Leonard, 1989b). In addition to consuming more calories, individuals of upper socio-economic status (as measured by the occupation of the head of household) were shown to have less seasonality in the diet (Leonard and Thomas, 1988) while those of the lower stratum consumed 29% fewer calories pre-harvest.

There appears to be some protection of children against pre-harvest caloric shortages as their diet shows a decrease of only 10-15% of calories during this season compared to adults who suffer a decrease of 30% (Leonard, 1989b). Nevertheless, the intake of children is likely to be marginal as Marquis and Kolasa (1986) reported that children under 36 months consumed just 85% of FAO recommended levels. Similarly, Berti et al. (1997) reported that intakes were approximately 80-85% of requirements and added that low intakes were probably not attributable to food shortages but rather to the high bulk of the diet combined with low nutrient density.

With the exception of one study, inadequate intake of protein does not appear to be a concern among Andean populations owing to the high consumption of tubers and a mix of different grains (Leonard et al., 1993; Kim et al., 1991; Freire et al., 1988, contra Berti et al., 1997). Protein consumption has been estimated to equal 164% of FAO recommended levels for children under 3 years at Pacobamba, Peru and 207% of predicted needs in the Ecuadorian Sierra (Marquis and Kolasa, 1986; Leonard et al., 1993). While the quantity of protein appears to be adequate, analysis of protein quality does not appear in the literature, possibly due to insufficient documentation of the amino acid composition of Andean foods.

Unlike macronutrient intakes, with the exception of anemias, little analysis exists regarding potential micronutrient deficiencies in the Andes. National and sub-national surveys conducted in Bolivia, Peru and Ecuador have all demonstrated a marked prevalence of anemia in women and children. Anemia rates among pregnant women are estimated to range from 40% in Ecuador (Rodriguez et al., 1997 as cited in Mora and Mora, 1998) to 57% in Highland Bolivia (Ministerio de Desarrollo Humano, Bolivia, 1994 as cited in Mora and Mora, 1998). In Ecuador, Cañizares et al. (1988) reported an anemia rate of 28% (men, women and children) in the Highlands north of Quito; 26% of which was identified as iron-deficiency anemia.

In terms of broader analyses of micronutrient intakes and status, Marquis and Kolasa (1986) reported that in Peru, mean calcium and niacin intakes of children were

76% and 85% of FAO recommended levels, respectively. Kim et al. (1991) reported that both calcium and vitamin A intakes were considerably below those recommended in Bolivia. In an Ecuadorian national survey of children under 5 years of age, Freire et al. (1988) presented biochemical data with vitamin A, zinc, riboflavin, and iron deficiencies evident. In terms of dietary intake, only protein and vitamin C were observed to be consumed at levels above those recommended. The most detailed analysis of micronutrient intakes was completed recently by Berti et al. (1997) and employed the Probability Method of dietary assessment (National Research Council, 1986). Low intakes of zinc, vitamin A, vitamin $B_{12}$, riboflavin and folate were reported. Berti et al. (1997) observed a higher prevalence of low zinc, vitamin A and vitamin $B_{12}$ intakes in children and demonstrated that the Andean diet was insufficiently micronutrient dense relative to energy to meet the high needs of the youngest age groups.

With regards to infant feeding practices, Peruvian children breast-feed until a mean age of 18.3 months with the introduction of complementary feeding between 4 and 6 months (Marquis and Kolasa, 1986). Special weaning foods are not reported to exist with children consuming the typical household diet (Marquis and Kolasa, 1986). Vitzthum (1992) reported similar results in a qualitative study undertaken in Nunoa, Peru but was able to provide evidence of socio-economic differences in duration of breast-feeding (low SES = 23.6 months, upper SES = 16.6 months, $p<0.005$). Brüssow et al. (1993) reported that Ecuadorian infants are exclusively breast-fed until approximately 7 months of age.

Methodological weaknesses and information gaps can be identified in the Andean dietary literature. In terms of methodological improvements, a general problem exists of sampling a number of individuals from the same household and then treating these data points as independent. This practice violates the assumption of independence required for many multivariate statistical analyses. Only Berti and Leonard (1998) have addressed this issue by employing a fixed effects statistical model. Furthermore, most studies, again with the exception of Berti and Leonard (1998), have only collected one day of dietary information and fail to consider intra-individual variation in intake. This practice tends to over-estimate the numbers of individuals falling within the tails of the normal distribution of intake and may compromise multivariate analyses as well as analysis of numbers of individuals falling below required intakes. Berti and Leonard (1998) corroborate this concern as the authors showed that in Ecuador, intra-individual variation in intake is high relative to inter-individual intake, suggesting that several days of dietary data are required to estimate individual intakes. In terms of information gaps, the evidence remains inconclusive with respect to adequacy of energy and micronutrient intakes among adult women. Also, the impact of seasonality on diet has not been explored in Ecuador and multivariate analyses of social and economic predictors may be improved upon in terms of breadth of variables investigated and study design.

2.6.2 Anthropometric Status of Andean Dwellers:

Anthropometry has been the method of choice for assessing protein and energy status. Several studies have been published which document Andean nutritional status, some of which move beyond purely descriptive purposes and attempt to correlate deficits with environmental, economic and dietary factors. Data have been collected in Peru, Bolivia and Ecuador with several patterns emerging. Firstly, Andean dwellers appear to suffer widely from stunting (low height attained for age). Height-for-age has usually been compared against NCHS standards with children's mean z-scores ranging from -3 to -1.10 (DeMeer et al., 1993, Stinson, 1980; Wolff et al., 1985; Leonard et al., 1993; Berti et al., 1998; Freire et al., 1988; Obert et al., 1994). In the Ecuadorian Sierra, the range in reported prevalence of stunting is 57 to 67% (Leonard et al., 1993; Freire et al., 1988). Stunting is indicative of chronic undernutrition. Conversely, acute malnutrition, as assessed by weight-for-height, does not appear to be a widespread problem, especially for children beyond 24 months of age. Compared to international standards, mean weight-for-height z-scores range from -0.25 to 0.58 (DeMeer et al, 1993; Wolff et al, 1985; Leonard et al, 1993; Freire et al., 1988). Freire et al. (1988) reported that acute malnutrition was uncommon and was concentrated among children aged 12 to 23 months where the prevalence ranged from 13.9 to 25.5%. Fatness has also been measured by some investigators at various skinfold sites and has been found to fall approximately between the 5th and 25th percentiles compared to international references (Stinson, 1980; Marquis and Kolasa, 1986; Berti, 1996). The overall pattern that emerges is a stunted, but not necessarily wasted population.

The status of adult women has been under-studied. Leonard et al. (1995a) reported that their sample of Andean Ecuadorian women maintained a mean Body

Mass Index (BMI) of 25.6 but Bolivian women have been observed to have a much lower BMI averaging 20.5 (Kashiwazaki, et al., 1995). Berti (1996) chose not to calculate BMI as there was a correlation between BMI and height in his study population. Nevertheless, for comparison purposes, his anthropometric observations are equivalent to a BMI of approximately 26 for women aged 30 to 50 years. It should be noted that Leonard et al.'s (1995a) study and Berti's (1996) study were conducted in the same area and the authors suspect that households were of a higher socio-economic status than those in surrounding communities (Berti et al., 1998).

Several studies have attempted to differentiate the effects of hypoxia, ethnicity and compromised socio-economic status as possible determinants of the near-universal stunting encountered in the Andes. These studies share the design of observing the growth of children either of similar ethnicity and/or similar socio-economic status at different altitudes. The cross-sectional nature of most of these data, however, as well as difficulties in accurately identifying ethnicity and measuring and isolating the effect of socio-economic status make hard and fast conclusions regarding the relative importance of determinants elusive. Nevertheless, the weight of the data points to a strong effect of socio-economic status (synergistic effect of diet and infection) (Berti et al., 1998) with the effect of hypoxia/altitude/ethnicity minimal (Greksa et al., 1985; Leonard, 1989a; Obert et al., 1994; Berti et al., 1998; Leonard et al., 1993). Leonard et al. (1995b) in a comparison of Coastal and Highland Ecuadorian children observed that the effect of hypoxia was less important than socio-economic status and mainly manifested itself through lower birth weights. The effect of low birth weight was also demonstrated by Haas et al (1982) in a longitudinal comparison of growth between Highland and Lowland healthy Bolivian children during the first year of life. The authors demonstrated that birth weight was significantly lower in the Highland infants and that during the first year these children showed reduced linear growth and increased adiposity compared to Lowland children.

It is likely that socio-economic effects are at least partly mediated via diet as inadequate intakes of protein, zinc, and vitamin A have been reported in children under 10 years of age by Berti et al. (1998) and height-for-age was observed to be associated with animal product intake in a cross-sectional study by Leonard et al. (1994). Furthermore, height was found to increase with zinc supplementation (randomized trial) in rural Ecuador (Dirren et al. 1994). In addition, as in most developing countries, socio-economic status may exert its effect via higher rates of infectious disease. In a cross-sectional study in Ecuador, weight-for-age was inversely associated with diarrhea (Brüssow, et al. 1993).

In addition to socio-economic status, as can be expected, overall statistics mask differences that exist among sub-populations classified by ethnic group, age, sex, and remoteness. DeMeer et al. (1993) observed that in Southern Peru, Aymara children possess higher weight-for-height than Quechua children. This difference may be the result of higher infant mortality rates (surviving children fare better) or the use of protected water supplies in the Aymara communities. Age has been shown to be highly correlated with nutritional status indicators. DeMeer et al. (1993) reported that height-for-age z-scores declined after the first year (-1.10 to -1.73) but weight-for-height scores increased over the same time period (0.18 to 0.58). Wolff et al. (1985) reported in a Peruvian point prevalence study that there existed a negative trend in all z-scores from 12-18 months followed by an increase from 18 to 36 months. Height-for-age z-scores were found to level off at approximately -2.0 and weight-for-height scores at 0.0 to 0.5 after 3 years of age. In Ecuador, an effect of age has also been shown for weight-for-age and weight-for-height with older children demonstrating improved nutritional status (Freire et al., 1988; Leonard et al., 1993). There has also been a sex effect observed with female children scoring higher than male children for weight-for-height, height-for-age, weight-for-age and skinfolds (Stinson, 1980; Wolff et al, 1985; Marquis and Kolasa, 1986). Conversely, Freire et al. (1988) observed no sex effect among Ecuadorian children under 5 years of age. Explanatory mechanisms for this effect where it exists have not been tested but may include differences in nutrient requirements or differences in child-care behaviours including feeding (Wolff, et al., 1985). Other variables which have been successfully correlated with anthropometric measures include family size (negative), protected water supply (positive), altitude and remoteness (negative), population size of centre of residence (positive), land ownership (positive), land in cultivation (positive), education (positive), and caloric adequacy (positive) (Stinson, 1980; Freire et al., 1988; DeMeer et al., 1993; Wolff et al, 1985; Leonard et al., 1993, Berti, 1996).

Like the literature for nutrient intake, the anthropometric data may be improved upon. Again, one of the main problems is the sampling of children from the same household and subsequent treatment of these data as independent. Furthermore, while the data serve a descriptive purpose, there is a need for increased understanding of the relationship between nutritional status and social and economic factors. As an example, household economic variables such as women's education and control of income have been shown to influence nutritional status but have yet to be incorporated in the analysis for this population. Finally, good data on the adequacy of adult women's energy stores is lacking.

**2.7 The Complexity of Linkages Between Agricultural Commercialization and Nutrition**:

The majority of the literature examining the nutritional impacts of agricultural commercialization has focused on cash-crops such as sugar and tobacco and has shown both positive and negative effects. Positive effects are to be expected through an increase in household income thereby decreasing poverty, the root cause of malnutrition. It has been reported, however, that negative effects may arise due to factors such as a loss of income control by women, changes to women's time allocation, and a loss of dietary diversity from home produced foods (Dewey, 1979; Longhurst, 1988; Bouis and Haddad, 1990). All the studies that comprise this literature are observational. As a result they all suffer from the problem of a self-selected population and therefore, potential self-selection bias as well as limited external validity. Furthermore, the research is complicated by the influence of a variety of social, cultural, economic and political factors which impinge on the relationship between commercialization and nutrition. A short review of the most recent literature reporting both positive and negative effects of agricultural commercialization follows. Some of the strongest studies have been published by the International Food Policy Research Institute (IFPRI) which embarked on 5 case studies comparing income, consumption, and nutritional parameters in semi-subsistence and cash-cropping populations in 5 different countries (The Gambia, Rwanda, Kenya, The Philippines and Guatemala) (Bouis and Haddad, 1990).

A summary of case-studies is presented in Table 2. Most studies have demonstrated higher incomes among households producing cash-crops but these differences have not always been accompanied by higher intakes of energy or greater anthropometric scores. The research demonstrating positive effects include evaluations of modern rice irrigation in the Gambia (von Braun, 1988), production of export vegetables in Guatemala (von Braun et al., 1989), tea/potato production in Rwanda (von Braun et al., 1991) and a rubber resettlement project in Papua New Guinea (Shack et al., 1990).

The studies completed by Von Braun et al. were carefully designed (large random sample, repeated surveying, extensive pre-testing of questionnaires, repeated recalls for food consumption, and measurement and control of confounding variables). In Central Gambia, caloric consumption per adult equivalent was positively associated with income and women's seasonal weight fluctuations were negatively related to a household's access to land in the rice scheme. In the Western Highlands of Guatemala, membership in an export-vegetable cooperative was associated with higher height-for-age and weight-for-age z-scores among children, although energy intakes were not significantly different. In this study, as in those described later in this section, the relationship between income and anthropometric status was positive but weak. This is because cooperative members spent substantially more on housing and land, and income was related to the purchase of more expensive calories (meat, eggs and fish) rather than increased calories *per se*. Social and medical programs were also offered to the cooperative members in Guatemala, and it is likely that this improved health care was linked to the greater anthropometric scores. In Rwanda (Giciye Commune), it was reported that income increased with decreasing subsistence orientation with households with the lowest subsistence orientation earning 3 times as much as those with the highest subsistence orientation. In turn, higher incomes were associated both with higher caloric intake (difference of 1271 calories/person/day between the highest and lowest income quartiles) and a lower prevalence of stunting (difference of 11% between the highest and lowest income quartiles). It should be noted, however, that like Guatemala, measures of morbidity and sanitation had a stronger effect on nutritional status than did energy intake. Higher income groups (those commercializing agricultural products) were found to spend more on housing and health care than lower income groups. It appears therefore that the positive effects of agricultural commercialization on child morbidity may be primary in improving nutritional status with caloric intake having a secondary effect.

Shack et al. (1990) also showed positive effects of commercialization on income in lowland Papua New Guinea. Again, this income was shown to be associated with nutritional status. The amount of income from cash crops was the most consistent predictor of anthropometric status (height-for-age, weight-for-age, and arm circumference) as well as energy intake for children. Morbidity was also found to be a strong predictor as occurrence of diarrheal disease in the previous 2 weeks was negatively correlated with weight-for-age and weight-for-height. Mason et al. (1985), in north Haiti, also demonstrated a positive link between income and mean household height-for-age. However, the authors did not report the numbers of subsistence versus commercializing versus wage-earning farmers that fell within different income groups. Therefore, the reader cannot compare anthropometric measures among families with different cropping patterns. Also, anthropometric measures were presented as household means which may mask differing effects of income on nutrition for children of different ages.

DeWalt et al. (1990) presented an interesting case which demonstrated that in Mexico while adoption of sorghum had no effect on children's anthropometry, total income (regardless of crop) was positively correlated with weight-for-age. Weight-for-age was also negatively correlated with the amount of hectares planted as maize indicating that the families with a greater subsistence orientation were worse off. The authors concluded that access to basic resources such as land was far more important than crop choice as a determinant of nutritional status.

Table 2: Summary of Studies of Impacts of Agricultural Commercialization on Nutrition

| AUTHORS | SITE/SAMPLE SIZE | CROP | DIET EFFECT | ANTHRO-POMETRY |
|---|---|---|---|---|
| Dewey (1981) | Mexico - 149 households | cash crops/cattle production | none | none |
| Mason et al. (1985) | Haiti - 462 households | rural development project | N/A | associated with income |
| Kennedy and Cogill (1987) | Kenya -504 households | sugar vs. maize | positive effect | none |
| von Braun (1988) | the Gambia, 200 households | modern rice irrigation | positive effect | positive effect |
| von Braun et al. (1989) | Guatemala, 399 households | export vegetables | none | positive effect |
| Kurth (1989) | Malawi, 1732 children | rural development project | N/A | lower number of deaths of children under 5 yrs, no difference in anthropometry |
| DeWalt et al. (1990) | Mexico, 163 households | sorghum production | N/A | no effect of crop choice; positive effect of commercialization |
| Shack et al. (1990) | Papua New Guinea, 56 households | rubber resettlement project | positive effect | positive effect |
| Bouis and Haddad (1990) | Philippines, 500 households | sugar | negative effect | negative effect |
| von Braun et al. (1991) | Rwanda, 200 households | tea, commercial potato production | positive effect | positive effect |

Three studies show no effects associated with agricultural commercialization (Dewey, 1981; Kennedy and Cogill, 1987; Kurth, 1989) and one study demonstrated negative impacts (Bouis and Haddad, 1990). Two of the studies completed by IFPRI fall under this classification (Kenya and the Philippines) and were comprehensive in terms of the information collected. In South Nyanza, Kenya, Kennedy and Cogill (1987) examined the nutritional impacts of semi-subsistence maize production versus sugar production. The authors reported that although household income was higher in the cash-cropping households, there were no differences in length-for-age, weight-for-age, nor weight-for-length z-scores between pre-school children in the different cropping groups. The lack of difference may be partly explained by the findings that 1) increased income in sugar producers was not expended on food but rather on housing and education 2) energy consumption figures per adult equivalent did not differ among the cropping groups 3) energy intake was higher among pre-school children in sugar households but there was no significant difference in morbidity between the cropping groups. Regression models again demonstrated that morbidity (mainly the occurrence of diarrhea) was a stronger predictor of nutritional status than energy intake.

Bouis and Haddad (1990) also reported negative effects of contract sugar production compared to maize production in the Philippines (Bukidnon Province). Again, the authors observed that sugar households had higher incomes than the corn households but similar to the Kenyan case, these differences in income were not translated into improvements in the nutritional status of pre-school children. There was an interaction effect present between age and income in their relationship with nutritional status. Specifically, while a positive relationship existed between income and height-for-age z-scores before the age of 1 year, z-scores decreased with age in both income groups after the 1st year with the decline more extreme in higher income groups. This decrease is reflected in the figures for the third age tercile which show the mean height-for-age z-scores in sugar households to be -2.32 compared to -2.07 in maize households. The authors speculated that the discrepancy may have been related to the time allocation of women. Women in sugar-producing households had a lower agricultural labour burden (2.7 days/hectare compared to 12.4 days/hectare in maize households). As a result, after the first year following childbirth (roughly coincides with the end of breast-feeding), women from sugar households were less tied to their farms/households and spent less of their time on child care activities. This discrepancy in time allocated to child care may have been responsible for the higher prevalence of illness observed among children from sugar households, which could not be attributed to differences in housing or sanitation.

Finally, Kurth (1989) and Dewey (1981) failed to show any positive nutritional effects stemming from agricultural commercialization in Malawi (Lilongwe District) and Mexico (Tabasco), respectively. Although incomes were again found to be higher in cash-cropping households, there were no differences in prevalence of acute and chronic malnutrition between households with different degrees of subsistence orientation.

In addition to studies which compare nutrition in households grouped according to production and commercialization patterns, several studies have tested for associations between sources of income and nutrition across households. Kaiser and Dewey (1991a) note that this type of analysis recognizes that individual households may adopt a variety of economic strategies rather than being classified as "subsistence" or "cash-cropping" households. In a study of 178 Mexican (Guanajuato) households, Kaiser and Dewey (1991a) observed that subsistence income was associated with children's energy, protein, and sufficiency of micronutrient intake but there was no relationship between maternal nutrient intake and source of income once adjusted for the absolute amount of income. Similarly, there was no relationship between the proportion of income derived from cash-cropping and children's anthropometric status (Kaiser and Dewey, 1991b). In an earlier study completed in Mexico (Temascalcingo), DeWalt (1983) observed a relationship between modern lifestyle (cash income) and increased intakes of meat and eggs. The author commented that while a substitution of market foods for subsistence/locally-produced foods in Mexico did not produce a nutritionally inferior diet *per se*, reliance on non-local foods placed communities at risk. Studies in Highland (Leonard et al., 1993) and Coastal (Mack, 1993) Ecuador have demonstrated a positive association between subsistence incomes and energy availability. Mack (1993) in a study of 108 Coastal households determined that it was the level of in-kind income and not total income that was best associated with energy and protein intakes as well as dietary diversity.

The complex nature of the linkages between agricultural commercialization and nutritional status has yet to be fully elucidated. Studies examining this issue continue to produce conflicting results. Clearly, while income appears to increase almost universally in families commercializing agriculture, this income may not be expended on improved diet quality or quantity. Furthermore, maternal human capital variables require more careful study to ascertain their influence. Chief among these variables are the effects of maternal education and maternal time and income allocation. These variables have been shown to be a significant predictor of children's nutritional status in rural households in both the Philippines and Panama (Bouis and Haddad, 1990; Franklin and Harrell, 1985). Several of the studies comprising the agricultural commercialization/nutrition literature have neglected careful study of these household economic variables and some studies have shown that maternal income may actually be associated with lower nutrient intakes (Mack, 1993) perhaps because women may need to generate cash income in poorer households.

In terms of dietary data collection, several authors rely on single 24-hour recalls which fail to account for intra-individual variation and compromise regression analyses. Furthermore, with a few exceptions (Kaiser and Dewey, 1991a; Kennedy and Cogill, 1987; Shack et al., 1990) impacts of agricultural commercialization on women's status have been under-studied as have impacts on micronutrient intakes. As many investigators have reported that intake of animal products increases with income, increased consumption of highly bioavailable vitamins and minerals such as vitamin A, calcium, iron and zinc is possible and not yet well-documented. Finally, although the commercialization of nutritious food crops can simultaneously contribute to both diet and household incomes, these foods, such as quinoa, have rarely been the subject of case-studies.

# CHAPTER 3

# DESCRIPTION OF THE STUDY LOCALE

## 3.1 Description of Ecuador

Ecuador is a small nation both in terms of its population and geographical reach. Its area extends just 283,561 $km^2$ and its inhabitants number just 10,747,956 according to recent census figures (Ministerio de Asuntos Sociales de España and FLACSO, 1995; INEC, 1996). Along with Bolivia, Peru, Guatemala and Mexico, Ecuador is one of the Latin American countries with a significant Indigenous population at 38% or 4,000,000 individuals (Ministerio de Asuntos Sociales de España and FLACSO, 1995) concentrated in the rural areas of the tropical rainforest (The Orient) and the mountainous Highlands (the Sierra).

Considered by the United Nations to have a medium level of development, Ecuador reported a per capita gross domestic product (GDP) of 1,393 USD in 1992 (Ministerio de Asuntos Sociales de España and FLACSO, 1995). Like many Latin American nations, development in Ecuador staggered under the burden of the foreign debt crisis throughout the 1980's, and in 1990 9.1% of the GDP was allocated to foreign debt service compared to 2.3% in 1975. Growth was stagnant throughout the 1980's and early 1990's but international trade has increased and exports accounted for 39.8% of the GDP in 1992 (Ministerio de Asuntos Sociales de España and FLACSO, 1995). Key export commodities for the country are crude oil (46.4% of total exports in 1990), bananas (17.4%), crustaceans and mollusks (12.6%) (Ministerio de Asuntos Sociales de España and FLACSO, 1995).

Quality of life indicators show that life expectancy has improved dramatically and now stands at 71.4 years for females up from 60.5 years in 1970 (Ministerio de Asuntos Sociales de España and FLACSO, 1995). Similar figures for males are 66.4 years and 57.4 years, respectively (Ministerio de Asuntos Sociales de España and FLACSO, 1995). Unfortunately, under five and infant mortality rates are still notable at 40 and 31 respectively (per 1000 live births) and the rate of low weight births is 13% (UNICEF, 1998) probably due to a combination of malnutrition and poor ante-natal and professional care during delivery. Education statistics indicate that 11.4% of the population were illiterate in 1990, 43.1% had some primary schooling, 32.5% had some secondary schooling and 12.3% had advanced education (Ministerio de Asuntos Sociales de España and FLACSO, 1995).

**3.2 Rural Ecuador**

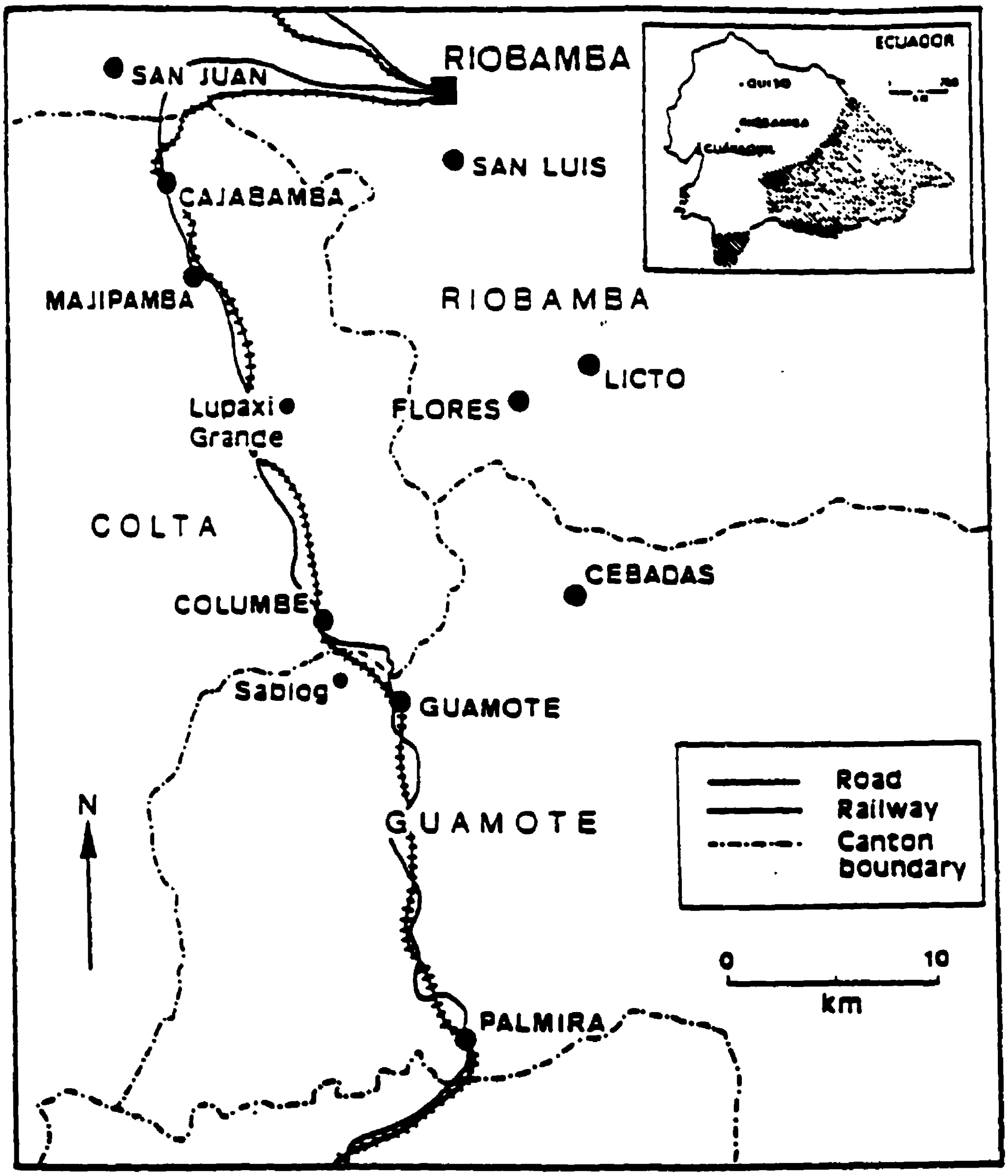
In many developing countries national statistics mask the poverty gripping the rural sector and Ecuador is no exception. This study was undertaken in one of the most impoverished provinces of Ecuador, Chimborazo, located in the Highlands south of Quito (see Figure 1). Chimborazo has a sluggish economy based on agricultural production and the rural sector of this province has not experienced the same advances in basic service delivery witnessed in urban centres. As might be expected, level of education attained is far lower in the rural Highlands than the national average; for male household heads, 20% have received no education and 95.2% have completed primary school or less (INEC, 1996). Similar figures for females are 26.2% with no education and 93.6% reporting no higher than primary school (INEC, 1996). Living conditions are poor with 41.9% of inhabitants lacking access to human waste removal services (including latrines), and 26.5% without a piped water supply (adapted from INEC, 1996). It was reported in 1988 that 79.5% of households left waste out in the open as their primary method of garbage disposal and 85.8% had no method of waste water disposal (Freire et al., 1988).

The poor level of environmental sanitation reflected in the figures above coupled with inadequate delivery of medical services (79% of inhabitants have no medical insurance, INEC [1996]) has resulted in a high prevalence of morbidity. Children under 5 suffer especially and prevalences of diarrheal disease and acute respiratory infection were 24.2% (mean incidence 4.4 episodes/year) and 36.9%, respectively in 1988 (Freire et al., 1988). The mortality rate in children under 5 years is the highest in the country at 126 per 1000 live births between 1982 and 1986 (Freire et al., 1988); a figure approximately triple the national average.

### 3.3 The Study Communities

The study was undertaken in the canton of Guamote, located 220 km south of Quito between 150' and 214' south latitude and between 7833' and 7851' west longitude (Nieto Cabrera and Vimos Naranjo, 1995). With a population of 30,426 (Nieto Cabrera and Vimos Naranjo, 1995), Guamote is still predominantly rural and the majority of the population depends on small-scale agriculture and animal production as the base of the household economy. This lifestyle, however, is becoming increasingly endangered as the natural resource base is poor and facing rapid degradation. Soils commonly have a sandy texture lacking in water-holding capacity and are eroded as a result of demographic pressure, decreasing fallow periods and high winds (Bebbington, 1990; Nieto Cabrera and Vimos Naranjo, 1995). The mean ambient temperature is 12.9 degrees C and mean annual precipitation is 488.8 mm (Nieto Cabrera and Vimos Naranjo, 1995). Precipitation varies throughout the year and in typical years there is a dry season from mid-May to August and a wet season from February to April (Bebbington, 1990). The climate is harsh and frost, hailstorms, drought and high winds are all frequent occurrences. These factors, which are intensified with high altitude (3,100 to 4,000 m.a.s.l.), make agriculture risky and crop productivity is notoriously low.

This research was conducted in 3 Indigenous communities; 2 in the parish of Guamote and 1 in the parish of Cebadas (see Figure 1). These communities formed part of haciendas as recently as the 1950's and 1960's. Originating in the 18th century (CESA, 1991), the hacienda system was essentially feudal where the Indigenous peasantry received between 1.5 to 2.0 hectares of land from Mestizo landowners in return for their labour on the balance of the hacienda (Bebbington, 1990). On these small pieces of land, the family's food was produced with little opportunity to accumulate wealth, except for those individuals who were able to enter share-cropping arrangements with the landowner. Wage labour relations have only recently evolved with the Agrarian Reform Laws of 1964 and 1973 and the accompanying demise of the hacienda system (Bebbington, 1990; Weismantel, 1992). At least 64,332 hectares of land were transferred (Nieto Cabrera and Vimos Naranjo, 1995) and the predominant form of social organization is now the "community".




(Bebbington, 1990)

Figure 1: Map of the Study Region

Communities are legally recognized groupings of families with adjacent farms. They may be comprised of any number of families but a community typically embraces about 30 families.

The poor delivery of basic services described above for rural Ecuador is epitomized by Guamote's Indigenous communities. Only 63% of communities have piped water, 70% have electricity, 30% of the population are illiterate and child mortality rates have been reported to be as high as 28% (Nieto Cabrera and Vimos Naranjo, 1995). On a more positive note, most communities now possess a small store, road access and a primary school.

A comparison of key characteristics of each of the study communities is found in Table 1. The altitude of communities is stated as a range as the land encompassed is often on sloped mountainsides with individual farms located at different elevations. Communities often have shared access to the land above 4000 m.a.s.l. referred to locally as the "paramo". The paramo, poorly suited for agriculture, is characterized by natural vegetation and used primarily for pasturing livestock and gathering grasses and wood for fuel.

Table 1: Comparison of Key Characteristics for the Three Study Communities:

| CHARACTERISTIC | COMMUNITY 1 | COMMUNITY 2 | COMMUNITY 3 |
|---|---|---|---|
| altitude (m.a.s.l.*) | 3400-4000 | 3300-4000 | 3500-4000 |
| number of families | 30 | 110 | 32 |
| electricity | yes | yes | yes |
| road access | yes | yes | yes |
| primary school | yes | yes | yes |
| local store | yes | yes | no |
| health clinic | yes | no | no |
| health promoter | yes | yes | yes |

(CESA, 1991; interview; personal observation)
* metres above sea level

The economy in these communities, as it is in the balance of the province, is still heavily based on agricultural production. All family members participate in agricultural activities (mainly manual labour), with the cropping system typically comprised of potatoes, fava beans and barley, rotated in that order on a given field (CESA, 1991). As potatoes require a high level of agricultural inputs, they lead the rotation so that the crops following may benefit from residual fertilizers in the soil. Additional crops commonly cultivated include corn, peas, lentils, lupins, wheat, rye, alfalfa, oats, and the Andean crops of quinoa, oca, mashua and melloco. Systems also increasingly include market-destined horticultural crops such as onion, carrots, and garlic (Bebbington, 1990). The agricultural cycle may begin any time from September to November with land preparation and planting activities and ends any time between May and August depending on such factors as the crop, altitude of the field, climatic conditions and market prices (CESA, 1991; Bebbington, 1990; personal observation). During the growing cycle, crops are maintained with manual weedings and ridging, and with the application of fertilizers and pesticides. Post-harvest activities are limited to threshing and classification of potatoes, bagging and commercialization.

Livestock are a crucial component of the farming system in this region. Large animals such as cattle, sheep and horses are found on wealthier farms, while the smaller species of pigs, poultry and guinea pigs are ubiquitous. Livestock is often purchased with cash from crop sales and act as a saving mechanism to be consumed by the household or sold during times of stress. These animals further contribute to the household economy through the sales of milk and eggs, production of fibre for weavings, and maintenance of soil fertility through manure.

Temporary migration, part-time local employment, and sales of weavings are all supplementary income-generating activities. Migration, in particular, is a common component of the household economy as family farms are often too small to absorb family labour throughout the year (CESA, 1991; Bebbington, 1990). Migration is a predominantly male activity and usually involves travel to haciendas or urban centres on the Coast or in the Highlands to seek temporary employment as agricultural labourers, and factory or construction workers. Men generally return to the community during peak agricultural labour periods such as planting, spraying and harvesting. The significant absence of males during the year affects leadership and development in the communities, shifts much of agricultural labour to women and children, and exposes migrants to urban culture (CESA, 1991; Bebbington, 1990). As a result, migration exercises a significant effect on cultural, political and economic relations within the community.

Life in these communities is undergoing significant transition as increased market access and migratory labour provide both the opportunity to witness "mestizo/urban" lifestyle and the ready cash to emulate it. These cultural shifts are articulated in the communities through a mix of traditional and urban dress, brick houses viewed alongside adobe and straw huts, cropping strategies incorporating agrochemicals and market crops, the inclusion of purchased foods such as rice and instant coffee in the diet and the combination of Spanish and Quechua used by the Indigenous people. It is these same shifts in cultural, economical, and political relations coupled with Guamote's precarious health and nutrition situation which makes the present study timely.

# CHAPTER 4

# MANUSCRIPT A

## ENERGY STRESS IN HIGHLAND ECUADOR: ARE ELDERLY WOMEN BUFFERING THE SHORTFALLS?

**Macdonald, B., Johns, T., Gray-Donald, K., & Receveur, O.**

## ABSTRACT

**Objectives:** The primary objective was to determine whether differences in protein-energy status exist across the life cycle and across seasons in Ecuadorian Andean women. A secondary objective was to determine the utility of body mass index (BMI) and current cut-off values as indicators of energy stress in this population.

**Design:** The protein-energy status of Andean women (n=91) of reproductive and post-reproductive age was studied over the 1995-1996 agricultural year. Anthropometric measures (height, weight, mid-upper-arm circumference (MUAC), triceps skinfold), dietary intake (24-hour recalls) and morbidity data (recall) were collected over four study rounds.

**Results:** Cross-sectional analyses indicate that post-menopausal women (50+ years) weighed approximately 3.66 kg less than younger women. This difference was supported by dietary trends; and age was positively associated with respiratory morbidity. Seasonal nutritional stress was apparent among women of all ages as body weights ($\Delta$=1.30 kg), mid-upper-arm circumference ($\Delta$=6 cm) and protein and micronutrient intakes were all lower 4 months post-harvest. While anthropometric measurements (including BMI) were negatively associated with morbidity, the current WHO (1995) BMI cut-off of 18.5 did not identify the majority of women at risk in this population.

**Conclusions:** Energy stress may be under-estimated when evaluations are limited to study of women of reproductive age or to one season. BMI appeared to be a valid tool for within sample comparisons but the cut-off for Grade I thinness would be better set at

20 rather than 18.5 for nutritional assessment in some populations.

## INTRODUCTION

The harsh environmental and economic conditions faced by small-scale farming households in developing countries often leads to marked food insecurity and malnutrition. Impacts for children have been well-documented with inadequate nutrient intake, high rates of infant morbidity and mortality, and compromised linear growth among the outcomes reported (Calloway et al., 1992; Allen et al., 1992; Berti et al., 1998). What has been less well-studied is the nutritional status of adults and energy stress that may occur across the life cycle. The nutritional status and health of women in particular, may act as excellent markers for community well-being as their multiple productive and reproductive roles all exact a heavy physical toll (Calloway et al., 1992). As the household members normally responsible for food procurement, transformation, distribution and care giving, women are in a position to exert control over intra-household food distribution and may limit their own intake when food systems are stressed. So, while a focus on younger household members in research and programming is warranted given limited economic resources and the importance of reaching children during critical periods of physical and mental development, valuable insights with regards to the true extent of food insecurity and coping mechanisms may be gained by broadening the focus to older age groups.

In recognition of the importance of adult nutritional status in maintaining the economic and physical reproduction of the household, the concept of chronic energy deficiency (CED) was developed and body mass index (BMI) proposed as a convenient tool for its measurement (James et al., 1988; Ferro-Luzzi et al., 1994). However, the utility of BMI as a marker for Latin American populations has been questioned (Immink et al., 1992; Berti, 1996) and data are still required to determine the applicability of BMI and its associated cut-off points (18.5 for Grade I thinness) across populations, especially in relation to increased morbidity and/or mortality (James et al., 1994; WHO, 1995).

A baseline study examining the nutritional impact of an agricultural project in the Ecuadorian Andes provided opportunities for comparing women's nutritional status both across age groups and across two seasons. The utility of BMI as a marker for energy stress in Andean rural communities was also evaluated.

The objectives of the present paper are :

1) to determine whether differences in anthropometric status exist across the life cycle and across seasons in women residing in a rural, non-industrialized setting;
2) to determine whether age-related and seasonal differences in anthropometric status, if they exist, are reflected in dietary intakes and reported illness patterns; and
3) to determine the utility of BMI as an indicator of protein-energy stress in this population.

## MATERIALS AND METHODS

### i) Study Design, Sampling and Research Team:

Data were collected in 1995 and 1996 as part of a larger study investigating associations between the re-introduction of an Indigenous crop (quinoa) to the farming system and women's nutrition in Highland Ecuador. Anthropometry, repeated 24 hour dietary recalls and agricultural and socio-economic surveys were conducted in the province of Chimborazo (2400-4000 metres above sea level [m.a.s.l.]) over 4 study rounds timed to cover the pre- and post-quinoa-harvest seasons. The objective of the larger study was to compare the nutritional status of participants in the quinoa project with a randomly selected sample of non-participants. Due to the small size of communities, however, sampling resulted in a near-census of households. The non-response rate was 14% and the final sample consisted of 104 households. Of those 104, 90 provided dietary data over both seasons (13.5% lost to follow-up), 63 provided anthropometric data pre-harvest and 22 provided both pre- and post-harvest data. Participation was reduced for anthropometry as the measurements were made in a central location and not in households. Only the focal female from each household was studied to avoid violating the assumption of independent data points required for most statistical tests. Household characteristics were compared between the women who completed the study and those lost to follow-up. There were no differences in level of education or socio-economic status (data not shown).

Pre-quinoa-harvest data (2 rounds) were collected from May-July 1995 followed by the collection of the post-harvest data (2 rounds) from November 1995 to January 1996. Data collected during the first visit consisted of gender-disaggregated (men and women interviewed separately) agricultural, socio-economic and health questionnaires and a 24 hour recall of food intake for women. The second pre-harvest visit comprised a second dietary recall and anthropometric measurements (height, weight, mid-upper arm circumference and triceps skinfold). Data rounds were repeated with the same order of measurements post-harvest.

The research team consisted of 4 Indigenous women from the region, a local university-trained nutritionist and the senior author. All assistants were literate, bilingual (Spanish and Quichua) and possessed at least primary level education. All recalls were conducted by the Indigenous women in Quichua, who then translated and transcribed responses in Spanish.

The research assistants were trained over a 6 week period from February-March (1995) by the nutritionist and the senior author. Standardized protocols were designed for the 24 hour dietary recall, the anthropometric measurements, and for the completion of questionnaires. Once training was completed, the research assistants pre-tested the questionnaires and recall method with 5 families each. During these sessions in the field, the research assistants were supervised by the senior author to ensure adherence to the protocols. The anthropometric methods were pre-tested with approximately 20 women and 10 children from a community not participating in the study. Research assistants participated in a one week re-training session prior to the post-harvest data collection rounds.

ii. Anthropometric Methods:

Anthropometric measurements included height, weight, mid-upper-arm circumference (MUAC) and triceps skinfold. Although it is preferable to include both a limb and trunk skinfold measure to account for varying patterns in subcutaneous fat distribution (Gibson, 1990), subjects did not consent to trunk measures during organizational meetings. The equipment used were Shorr height measuring boards (Shorr Corporation, Olney, Md) for height, a Seca electronic balance (Seca Corporation, Columbia MD) for weight, non-stretchable plastic measuring tapes for arm circumference and Lange calipers (Cambridge Scientific, Cambridge, MD) for triceps skinfold. The balance and calipers were calibrated in the field. All measurements (in triplicate) were made in accordance with standardized methods (Lohman et al., 1991; Gibson, 1990). Measurements were conducted in a central location in the community (health clinic or meeting house) to ensure a hard, flat surface and minimal movement of the balance.

Height, weight and MUAC measures were taken by the Indigenous research assistants working in pairs and supervised either by the senior author or the trained nutritionist. Triceps skinfold measures were taken by the senior author or the nutritionist. Height and weight measurements were taken without shoes and hats and subjects were asked to remove the majority of their clothing. The subjects did not feel comfortable removing their skirts, a light shirt and plastic necklaces. Therefore, clothing worn by subjects, including number of necklaces, shirts, and bracelets were marked on the anthropometric data sheet and sample items representing jewellery and clothing were later weighed and subtracted from measures.

iii Dietary Assessment:

Dietary intake was assessed with the 24 hour recall method. Two non-consecutive days were assessed per season for a total of 4 days per research subject. The female head of household was interviewed by the Indigenous research assistants in Quichua and asked to recall all foods and beverages (including snacks and meals eaten away from home) that were consumed during the previous day. Common-pot eating predominates in this region, so research assistants obtained full ingredient lists including portion sizes from subjects. If a composite dish was recalled, interviewers asked subjects to estimate the number of servings resulting from the preparation using standard sized dishes, cups and spoons. Subjects were then requested to recall the number of servings they consumed. For meals purchased on market days or consumed away from home (i.e. not prepared by the interviewee), subjects were asked to recall as many ingredients as possible and the number of servings consumed, and standardized recipes obtained from the nutritionist and the Indigenous research assistants were applied. All foods observed in the recalls were weighed locally to improve estimation of portion sizes. The senior author accompanied the research assistants to the field and reviewed all data collected for completeness at the end of each day.

iv. Morbidity Recall:

As part of the socio-economic and health questionnaire, all women were asked to recall the occurrence, severity and duration of 5 symptoms characteristic of either gastro-intestinal and/or respiratory illness during the previous 2 weeks. These symptoms included diarrhea, fever, vomiting, cough and difficulty breathing. The questionnaire was administered by the trained research assistants, following strict protocols both pre- and post-harvest.

v. Data Entry:

The questionnaire and anthropometric data were entered into the EPI INFO 6 program, Version 6.02 (CDC/WHO, 1994) and reviewed twice to ensure that data had been keyed correctly. To minimize coding errors, all dietary recalls were entered by the senior author using the Worldfood Dietary Assessment System, Version 2 (University of California at Berkeley, 1996). Worldfood is a menu-driven program with food composition data covering 1800 foods from 6 developing countries (Kenya, Mexico, Egypt, India, Senegal, and Indonesia). Worldfood calculates nutrient totals by cross-referencing foods to an International Minilist, a database detailing the nutrient values for 195 foods commonly consumed in the developing world. The minilist was validated at the University of California, Berkeley with the United States Department of Agriculture (USDA) and developing country food composition tables. It is based on the premise that a single food may be used to represent a class of foods with similar nutrient composition (Calloway et al., 1994). Cooking losses for vitamins are taken into account. Intake totals for 52 dietary constituents are calculated and stored in dBASE files. All data files were exported to SAS Version 6.12 (SAS Institute Inc., 1996) for statistical analyses.

vi. Development of the Ecuadorian Food Database:

An Ecuadorian food database was compiled and entered into Worldfood for analyzing dietary recalls. Food composition data were gathered from the Ecuadorian food composition table (Ministerio de Salud Pública del Ecuador, 1988), scientific literature on the composition of Andean crops (Koziol, 1990; Ruales Nájera, 1992; Galwey et al., 1990; Gross et al., 1989) and the Worldfood Mexican database. Values from the Ecuadorian food composition table were compared with similar foods from the Worldfood database to assess accuracy. Good agreement was found for most items although iron values were higher and dietary fibre values lower than those reported for similar foods in the Berkeley database. Iron values are thought to be high in many developing country databases due to environmental contamination (Calloway et al., 1994). Therefore, iron values from the Berkeley list (USDA values) were used preferentially. If there was a good match between the Ecuadorian food values and the minilist for key nutrients, the Ecuadorian values were retained. As the Ecuadorian tables include only 11 nutrients and Worldfood databases 52, missing nutrient values for the Ecuadorian foods were taken from similar foods in Worldfood.

vii Statistical Analysis

All data analyses were conducted with the SAS Statistical Program (Version 6.12) (SAS Institute Inc., 1996). Arm fat area (AFA) and arm muscle area (AMA) were calculated according to formulae in Frisancho (1990) and basal metabolic rate from FAO/WHO/UNU (1985) sex, age and weight specific equations, the validity of which have been established for similar populations in Bolivia and Colombia (Kashiwazaki et al., 1995; Spurr et al., 1994). All variables were tested for normality with SAS univariate and normality probability plot procedures. All anthropometric measures (including BMI) were normally distributed as was macronutrient intake. With respect to micronutrients, intakes of vitamins A, C, $B_{12}$ and folate were non-normally distributed. A log transform was completed and the distributions for vitamin C and folate were normalized. Vitamins A and $B_{12}$ were treated with non-parametric methods.

Analysis of Variance (Tukey's test) was used to test for age group differences in anthropometry and the Student's t-test (parametric) and Wilcoxon's Rank Sum test (non-parametric) were used to test for age group differences in dietary intake. Seasonal differences in anthropometry and diet were tested with paired t-tests (parametric) or Wilcoxon's Signed Rank test (non-parametric) (for dietary data, two recalls were averaged per season).

viii Ethical Considerations

Research and consent protocols were in accordance with Canada's national research councils' (NSERC, MRC and SSHRC) guidelines and were approved by the Ethics Review Committee at McGill University. Written informed consent was obtained at the community level following meetings where the study objectives, methods, anonymity, consent, and diffusion of results were explained. Individual families gave oral consent or refused participation at the time of the first interview. Benefits promised during these meetings were delivered to communities and included hiring and training of local Indigenous people as research assistants, preparation and delivery of a written report describing preliminary results and donation of all anthropometric and food weighing equipment to a microenterprise jointly owned by the communities. Identities of communities and individual informants were protected during all stages of data collection, analysis, and reporting.

## RESULTS

### Anthropometric Status

Mean height, weight and body mass index are presented by age category in

Table 1. Six women were determined to be either pregnant and/or lactating and were excluded from the anthropometric analysis, resulting in a final sample size of 57 with a mean age of 41.5 years.

Table 1: Height, Weight and Body Mass Index of Chimborazo Women (Pre-harvest)

| Age Category | n | Height (m) | Weight (kg) | BMI (kg/m²) |
|---|---|---|---|---|
| Total | 57 | 1.47 | 48.7 | 22.5 |
| 20-30 | 10 | 1.48 | 49.4[a] | 22.6[ab] |
| 30-40 | 18 | 1.48 | 50.8[a] | 23.1[b] |
| 40-50 | 11 | 1.44 | 49.4[a] | 23.6[b] |
| >50 | 18 | 1.46 | 45.7[b]* | 21.2[a]* |

*means with different letters are significantly different ($p \leq 0.05$)

At first glance these values reflect the typical short Andean physique (Frisancho et al., 1975; Mueller et al., 1980; Leonard et al., 1995a; Berti, 1996). The mean heights for all age categories are below 150 cm. but at an average of 22.52, the BMIs for these women indicate that they maintain a "normal" weight for that height. Caution should be exercised in interpretation, however, as South American populations possess short legs relative to body length and may have higher BMIs for weight than European and Indo-Mediterranean populations (WHO, 1995). The lack of correlation between BMI and height ($r=0.05$, $p=0.71$) and non-significant regression slopes of height$^2$ and height$^3$, however, suggest that no linear nor curvilinear relationship exists between height and BMI. That is, BMI is, as it is designed to be, independent of height in this population.

When BMI was classified according to WHO (1995) criteria, the distribution showed little evidence of protein/energy stress with 80% of the sample falling between the "normal" range of 18.5-25. Only 1 woman (age=55 years) out of 57 (1.8%) may be described as "thin" according to these criteria (<18.5). For a healthy population 3-5%

can be expected to fall below 18.5 (WHO, 1995). Even if a more conservative cut-off is chosen at 20 (sometimes applied as a cut-off for industrialized populations [Gibson, 1990]), only 12.3% of the population would be considered underweight. A larger proportion of the sample actually falls within the "grade 1 overweight" category. However, because no BMI was higher than 30 (maximum = 27.3) morbidity due to excess weight is unlikely in this population.

A closer examination of these data revealed that older women (50+ years) weighed less than younger women. Table 1 indicates that BMI is highest in the 30-50 age group at approximately 23 and lowest in the >50 age group at approximately 21. This difference in protein/energy status is clear from the raw height and weight measures. From the 40-50 age category to the 50+ group, mean weight is 3.7 kg (8 lbs) lower.

While BMI allows an estimation of the overall adequacy of protein and energy status, it does not indicate whether the observed post-menopausal difference in weight is comprised of variations in the fat-free (including bone density) and/or fat compartments. MUAC, triceps skinfold, and the calculated indices of AFA and AMA (Frisancho, 1990) are presented in Table 2 and aid in pinpointing the source of weight differences observed among age groups. While the data provided may not be extrapolated to account for the composition of the entire body, these measures do indicate that arm fat stores are lower in the post-menopausal women (Table 2). As with BMI, MUAC, arm fatness and muscle mass are largest in the 30-40 year age group and smallest in those over the age of 50. The large weight difference (3.7 kg) observed in Table 1, however, appears to be comprised primarily of energy stores as both triceps skinfolds and AFA showed age-related effects while arm muscle area was constant.

Table 2: Mid-Upper-Arm Measures and Related Indices (mean ± s.d.) for Chimborazo Women

| Age Category | n[1] | Triceps (mm) | Mid-Upper-Arm Circumference (cm) | Arm Muscle Area ($cm^2$) | Arm Fat Area ($cm^2$) |
|---|---|---|---|---|---|
| Total | 53 | 10.6±3.4 | 25.4±2.3 | 32.4±6.6 | 12.7±4.3 |
| 20-30 | 9 | 10.1±2.2[a] | 25.7±1.2[a] | 34.0±4.8 | 12.1±2.5[a] |
| 30-40 | 17 | 12.4±3.1[b] | 26.4±2.1[a] | 34.2±7.0 | 15.3±4.0[b] |
| 40-50 | 10 | 11.5±3.4[ab] | 25.0±2.5[ab] | 30.2±7.6 | 13.5±4.4[ab] |
| >50 | 17 | 8.4±3.0[c]** | 24.3±2.4[b]* | 31.2±6.1 | 9.9±3.8[c]** |

[1] sample size reduced from 57 to 53 as 4 women refused arm measurements
means with different letters are significantly different (*$p \leq 0.05$, **$p \leq 0.01$)

Further evidence of energy stress among these women is provided by the seasonal drops in anthropometric status observed 4 months post-harvest (Table 3). Although the sample size available for post-harvest measures was limited, weight dropped by 1.30 kg and arm circumference by 6 cm suggesting that energy shortfalls occurred during the year. The average age of those showing a decline in anthropometric status (n=14) was 39.2 years, that is, the decrease was experienced by all age groups and was not restricted to the elderly.

Table 3: Seasonal Differences in Anthropometric Status

| Variable | n | Mean Difference (Post-harvest - Pre-harvest) | Standard Error | Probability Value |
|---|---|---|---|---|
| Weight (kg) | 22 | -1.29 | 0.74 | 0.09 |
| BMI ($kg/m^2$) | 22 | -0.84 | 0.57 | 0.15 |
| MUAC (cm) | 21 | -5.95 | 2.34 | 0.02* |
| Triceps Skinfold (mm) | 21 | -0.67 | 1.13 | 0.56 |
| AMA ($cm^2$) | 21 | -0.47 | 4.87 | 0.92 |
| AFA ($cm^2$) | 21 | -0.93 | 1.31 | 0.49 |

*=$p \leq 0.05$

**Dietary Intake**

To determine whether age-related differences in anthropometric status at baseline were reflected in the diet, mean energy and protein intakes for women below and above 50 years of age were calculated and are presented in Table 4. Differences in micronutrient intake are presented in Table 5. Pregnant and lactating women were removed from the analysis.

Table 4: Energy and Protein Intakes (mean ± s.d.) and Estimated Basal Metabolic Rates for Chimborazo Women

| | Total Sample (n=91) | Women <50 years (n=65) | Women >50 years (n=26) |
|---|---|---|---|
| Energy Intake (Kcal/day) | 2656 (656) | 2741 (668) | 2441 (583)* |
| Estimated BMR | 1235 (65) | 1252 (51) | 1192 (75)*** |
| Intake: BMR | 2.15 (0.52) | 2.19 (0.54) | 2.04 (0.47) |
| Protein Intake (g/day) | 72.1 (22.0) | 75.4 (22.1) | 64.0 (19.7)* |
| FAO/WHO Safe Level of Protein Intake (g/day) | 36.5 | 37.4 | 34.3 |

*=p≤0.05, **=p≤0.01, ***=p≤0.001

The ratio of energy intake:basal metabolic rate (physical activity level or PAL) may be used to estimate energy adequacy and to determine the extent of under and/or over-reporting in dietary intake data (FAO/WHO/UNU, 1985; Goldberg et al., 1991). Basal metabolic rate was calculated for each woman applying age and weight-specific equations presented in FAO/WHO/UNU (1985). Where women's actual weights were unavailable, weight was estimated by taking the average weight of women of the same age. The average energy intake for the group was 2656 kcal/day which when divided by these women's estimated basal metabolic rate yields a physical activity ratio of 2.15. Energy intake appears to be adequate for this group, and reported intakes appear to be valid as the mean PAL is approximately 5-10% above that calculated by Leonard et al. (1995a) employing heart-rate monitoring in Ecuador (PAL=1.96) and Kashiwazaki et al (1995) employing doubly-labelled water in Bolivia (PAL=2.04). Similarly, protein intakes are well above recommended values. Like the anthropometric measures, however, estimated energy and protein intakes do differ between the two age groups, with the younger women consuming approximately 300 kcal per day more than the older women. The older women maintain an acceptable PAL at this lower intake (2.04) but only because their weight was lower. Lower weight implies a lower BMR and thus, a lower intake of energy required to meet needs.

Table 5: Micronutrient Intakes (mean ± s.d.) for Chimborazo Women

| Nutrient | Total Sample (n=91) | Women <50 years (n=65) | Women >50 years (n=26) | FAO/WHO Reference Values |
|---|---|---|---|---|
| niacin (mg) | 19.2 (6.0) | 19.6 (6.4) | 18.3 (5.0) | 17.3 |
| riboflavin (mg) | 1.0 (0.3) | 1.0 (0.3) | 0.9 (0.3)* | 1.44 |
| thiamin (mg) | 1.8 (0.6) | 1.9 (0.6) | 1.7 (0.5) | 1.04 |
| folate (μg) | 253 (102) | 254 (99) | 248 (112) | 151 |
| vitamin $B_{12}$ (μg) | 1.3 (1.0) | 1.4 (1.0) | 1.0 (0.9)* | 1.0 |
| vitamin C (mg) | 126 (45) | 128 (47) | 121 (42) | 30 |
| vitamin A (RE) | 737 (621) | 752 (625) | 699 (621) | 500 |
| calcium (mg) | 329 (137) | 346 (138) | 288 (126) | 450 |
| iron (mg) | 14.2 (4.4) | 14.6 (4.4) | 12.9 (4.1) | 12.5 |
| zinc (mg) | 11.1 (3.3) | 11.6 (3.3) | 9.9 (3.0)* | N/A |
| bioavailable zinc (mg) | 1.7 (0.5) | 1.7 (0.5) | 1.5 (0.5)* | 0.9 |

*=p≤0.05, **=p≤0.01

In line with energy/protein results, absolute intakes of riboflavin, vitamin $B_{12}$ and zinc are lower in the older women with a similar trend apparent for calcium (p=0.07) (Table 5). This is of concern, particularly for riboflavin and calcium, as mean intakes for these micronutrients are well below FAO/WHO values. Analysis of degree of inadequacy is reported in Macdonald et al. (1999b) with high prevalences confirmed for these micronutrients as well as iron. Age group tests were repeated for micronutrient intakes adjusted for energy and were not significant indicating that older women eat less food but not different foods than their younger counterparts.

Table 6: Seasonal Differences in Nutrient Intakes among Chimborazo Women (n=79)

| Nutrient | Post-Quinoa-Harvest | Pre-Quinoa-Harvest | Mean Difference (Post-harvest - Pre-harvest) | Probability Value |
|---|---|---|---|---|
| energy (kcal) | 2561 (667) | 2718 (868) | -156 | 0.14 |
| protein (g) | 66.9 (23.2) | 76.1 (26.3) | -9.2 | <0.01** |
| niacin (mg) | 17.4 (6.4) | 19.9 (6.5) | -2.5 | <0.01** |
| riboflavin (mg) | 0.9 (0.4) | 1.0 (0.4) | -0.1 | 0.08 |
| thiamin (mg) | 1.7 (0.6) | 1.9 (0.6) | -0.2 | <0.01** |
| folate (μg) | 245.2 (124.2) | 262.5 (140.1) | -17.3 | 0.40 |
| vitamin $B_{12}$ (μg) | 1.1 (0.8) | 1.4 (1.2) | -0.3 | 0.02* |
| vitamin C (mg) | 123 (58) | 125 (53) | -2 | 0.81 |
| vitamin A (RE) | 906 (727) | 668 (867) | 237 | 0.03* |
| calcium (mg) | 315 (154) | 346 (177) | -31 | 0.15 |
| iron (mg) | 13.2 (5.0) | 14.7 (5.8) | -1.5 | 0.07 |
| zinc (mg) | 10.3 (3.8) | 11.7 (4.0) | -1.4 | 0.01* |

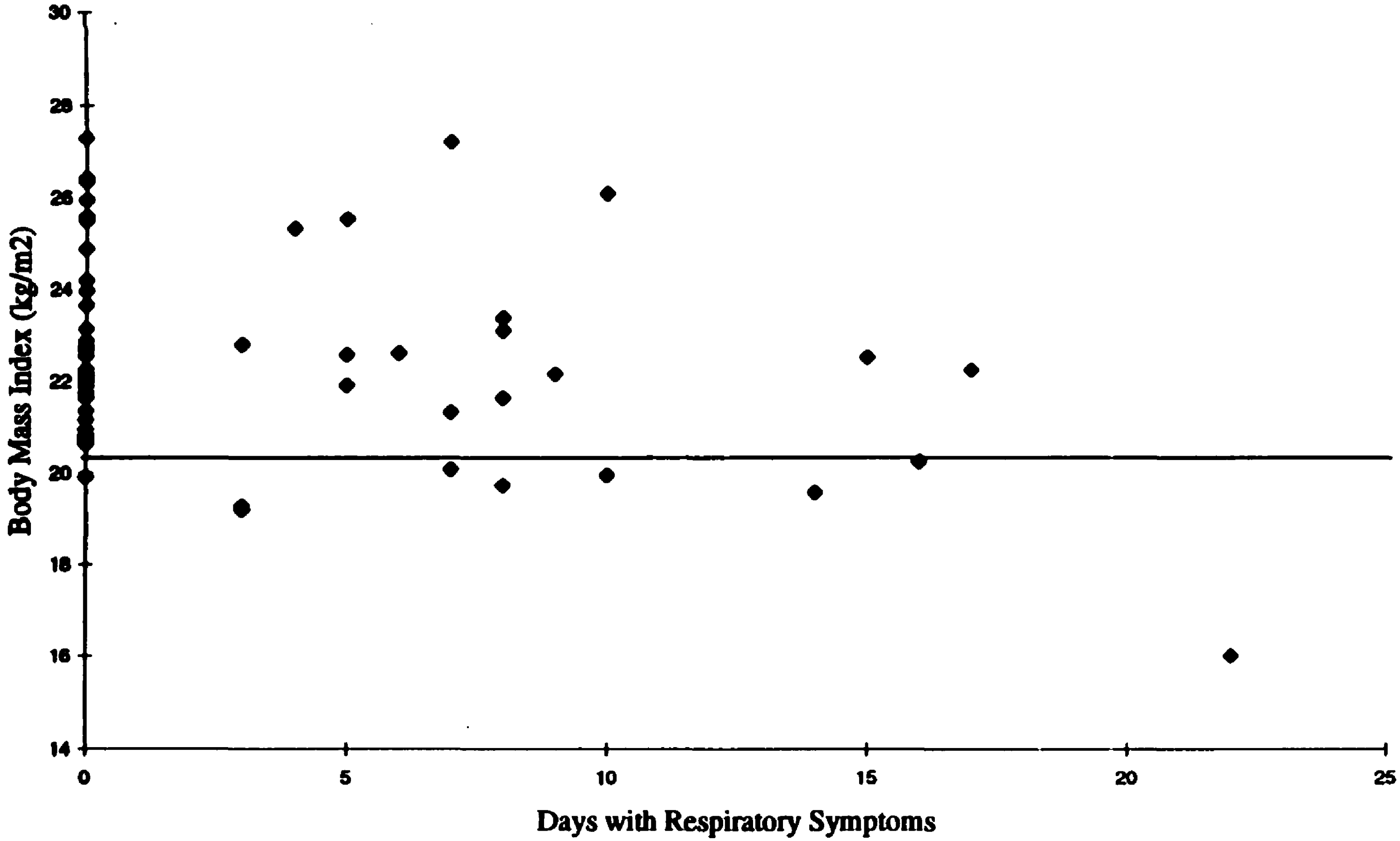
*=p≤0.05, **=p≤0.01

Conversely, Table 6 indicates that diet quality did differ by season, if not by age group. Like the anthropometric indices, diet was of a higher quality pre-quinoa-harvest rather than post-harvest. That is, although there was a modest drop in energy intake post-harvest (156 kcal, p=0.14), decreased intakes of protein and micronutrients were readily apparent. Protein intake dropped by 9.2 g (p=<0.01) accompanied by lower intakes of zinc (Δ=1.4 mg, p=0.01), vitamin $B_{12}$ (Δ=0.3 μg, p=0.02), iron (Δ=1.5 mg, p=0.07), niacin (Δ=2.5 mg, p=<0.01), thiamin (Δ=0.2 mg, p=<0.01) and riboflavin (Δ=0.1 mg, p=0.08), all suggestive of a lower intake of animal products post-harvest. Interestingly, vitamin A intake showed a reverse trend and was higher post-harvest. This finding is most likely due to an increased intake of carrots post-harvest, one of the main sources of vitamin A in the diet. On average, women consumed 15.2 g more carrots post-harvest (p<0.001), and 43 women reported consuming carrots post-harvest compared to 22 women pre-harvest. When adjusted for energy, all seasonal differences remained statistically significant.

**Utility of BMI Cut-off Values**

Evidence establishing the validity of body mass index and its associated cut-off values as an assessment tool for adult energy status is required (WHO, 1995). As increased morbidity is cited as a meaningful indicator of compromised anthropometric status in adults (WHO, 1995), the correlations between BMI and days ill with gastro-intestinal and respiratory symptoms were tested and compared to the associations observed with MUAC and AFA. There were no correlations observed between vomiting or diarrhea with any of the anthropometric indicators. Days ill with respiratory symptoms, however, were reported by close to one-half of the women studied and Spearman correlations showed a trend towards negative associations with BMI (-0.22, p=0.10), MUAC (-0.27, p=0.05) and AFA (-0.21, p=0.13) indicating that these measures are valid for within sample comparisons. What seems to be at issue given the fact that only one woman was classified as thin according to the WHO (1995) criteria is the cut-off for BMI set at 18.5. Figure 1 illustrates the relationship between respiratory days ill and BMI. On the scatterplot a cut-off (horizontal line) is depicted below which only one woman was free from illness. This cut-off is at approximately 20 ($kg/m^2$). Seven women with BMIs falling below 20, but above the currently accepted cut-off of 18.5, presented with respiratory symptoms, confirming evidence that a cut-off of 18.5 may be too low for Latin American populations (Immink et al., 1992). Notably, 6 of those 7 were over the age of 50 and Spearman

**Figure 1: Relationship Between Body Mass Index and Respiratory Days Ill**



correlations indicated a positive association between age and days ill with respiratory symptoms (r=0.36, p=0.01).

## DISCUSSION

Despite the multiple physical demands faced by women in developing countries, their nutritional status and their potential to act as markers for energy sufficiency within rural communities has been under-studied. This is especially true for women past their reproductive years who are often missed by sampling protocols designed to select children as the primary units of analysis. Establishing whether protein-energy stress existed among women living in Ecuadorian Highland communities was a useful first step in analyzing the nutritional impact of an agricultural project.

A basic contradiction in the data was immediately apparent as the mean BMI of the sample fell well above the WHO's (1995) cut-off for Grade I thinness, yet the observed age- and seasonally-related differences in energy stores provided evidence that mild energy stress may occur. Further evidence of this stress is provided when these findings are compared with similar Andean populations as the values for BMI and triceps skinfold are closer to results published for Peru and Bolivia 15 to 20 years ago (BMI range 22.81-23.7, triceps=9.8) than for recently reported data from the Ecuadorian Andes (BMI range 25.6 - 26.11; triceps=17.30) (Frisancho et al., 1975; Mueller et al., 1980; Leonard et al., 1995a; Berti, 1996). Further evidence of heterogeneity in nutrition among Andean households is presented in Macdonald

(1999b) and Macdonald (1999c) where diet and anthropometry were found to vary with family size, socio-economic status, and cropping pattern. There is significant variation in economic and livelihood strategies in these communities (Macdonald, 1999b; Macdonald 1999c) and these factors may far outweigh the physical environment or genetics in determining nutritional status.

**Age Effects**

In the present data set, the sample mean clearly masked trends occurring among vulnerable sub-groups and over time. The age-associated differences in anthropometric measures deserve further consideration, especially as limited information exists regarding optimal energy stores for the elderly. Similar age-related trends to those observed here have been reported in Papua New Guinea, India, Ethiopia, Zimbabwe, Brazil and the Congo (Norgan, 1990; Allain et al. 1997; de Vasconcellos, 1994; Delpeuch et al., 1994). In the Collaborative Research Support Program on Nutrition and Human Function (NCRSP) studies, age was positively associated with BMI in Mexican and Egyptian women, but was not associated with BMI in Kenyan women (Calloway et al., 1992). In North America, this stage of the life cycle (50 years - 65 years) is associated with an increase in fat stores and a decrease in lean body mass and bone density; body composition changes that are associated with such health problems as osteoporosis and sarcopenia. So, while age seems to be linked to body composition, the changes depend very much on locale and lifestyle. This idea is corroborated by Delpeuch et al. (1994) and de Vasconcellos (1994) both of whom observed that age-related decreases in BMI were more marked in lower socio-economic groups and/or in rural areas. What seems important then, is that significant variation exists among populations with regards to age-related differences in body composition, while little information exists to guide the interpretation of 'adequate stores'.

The etiology of the lower stores in the Andean post-reproductive women remains unclear as these data are cross-sectional. It is possible that respiratory symptoms resulted in anorexia and thinness; a plausible argument given the existence of tuberculosis in these communities and/or the practice of cooking over smoky fires. However, energy intake:expenditure imbalance is also a tenable explanation. Energy expenditure may still be high at this age as these women are still responsible for farm and domestic chores, the cost of which may be compounded by the absence of child labour in post-reproductive households. Andean children have been estimated to account for up to 30% of economic activity and it has been theorized that during times of stress, they may perform labour in place of adults due to the lower energy costs associated with smaller body sizes (Tucker, 1987 as cited in Leonard and Thomas, 1989). Similarly, it is possible that a subtle accommodation is taking place where older household members are limiting their intake until they reach a new energy equilibrium. Regardless, age, decreased stores and increased morbidity are interrelated and further study of age-related coping strategies and/or activation of disease is warranted. The debate is not merely academic, as the negative repercussions arising from an increased disease load in households include decreased economic productivity and increased probability of transmission of infections such as tuberculosis to younger family members (Bwibo, 1985).

**Seasonal Effects**

In addition to age-related differences in anthropometry, seasonal variation was observed both in protein-energy status and diet. Women were 1.3 kg lighter four months post-harvest, had arm circumferences that were 6 cm smaller and were consuming inferior diets. These findings further make the case for mild nutritional stress among these women and were similar in magnitude to changes reported in other developing country populations. In an EEC multi-country seasonality research project, body weights were found to vary between 0.5 kg in India to 1.6 kg in Ethiopia while energy intakes were found to differ only by 6-8%, a range comparable to that presently reported (6%) (Durnin et al., 1990; Shultink et al., 1990; Ferro-Luzzi et al., 1990; Ferro-Luzzi, 1990).

The issue of seasonality in the high Andes, however, draws further debate. Leonard (1989b) reported a 1.2 kg pre-harvest drop in weight and 30% decrease in energy intake among adults in Highland Peru but Leonard et al. (1993) and Berti (1996) argue that there is limited seasonality in the Ecuadorian Highlands due to Ecuador's proximity to the equator. In the present study communities, as well as those studied by Weismantel (1992) and Bebbington (1990), an agricultural cycle did exist. An Ecuadorian agronomist working in the region notes that the farming system is timed to avoid the wet season (Vimos, 1996, personal communication) but also reported that the harvest is long (June - Sept.) and the year may include 2 harvests for some crops. It is important to note that quinoa is one of the last crops to be harvested. Although agricultural questionnaires indicated that few crops had come in, it is possible that produce other than quinoa such as potatoes and fava beans were already harvested by some families which allowed them to improve their diet.

Novel findings regarding seasonality were the decline in dietary quality (protein and micronutrients) compared to diet quantity (energy) and the observation that the decline occurred just four months post-harvest. Previous attempts to quantify seasonal trends in food consumption have focused on energy intake although it can be hypothesized that one of the first responses to food stock or income stress would be a switch to the consumption of less-preferred foods (Thomas and Leatherman, 1990). This shift in eating patterns seems to be plausible given the results presented here, that is, a limited change in energy but discernible differences in the intake of vitamins and minerals. The reverse trend in seasonal variation is also logical when one considers that the "post-harvest" data rounds were not immediately post-harvest but rather four months later. Highland families must make their stocks last throughout the year, and therefore, a logical strategy would be to eat according to requirements during the year and then consume at, or above requirements during the early harvest knowing that during the main harvest period, energy expenditure will be high, time will be limited for cooking meals, and food stocks will soon be replenished. What is important to note is that just 4 months post-harvest, energy stores were lower compared to the early harvest state and that seasonal declines were not confined to the elderly but rather were experienced by women of all ages.

**Utility of BMI**

While the value of measuring adult energy status has been established, the need for simple, cost-effective, non-invasive tools remains. The WHO (1995) has called for further evidence regarding the validity of BMI for assessment, and more specifically has voiced the need for: a) investigation of the appropriateness of BMI in populations with varying body shapes with corroboration of the validity of the cut-off values and, b) investigation of the value of mid-upper arm circumference in identifying the malnourished. This study serves these purposes, especially as evidence linking the various anthropometric measures and morbidity in developing country adults is rare (WHO, 1995).

The present data indicate that both BMI and the more direct measures of body composition correlate with morbidity, but that the BMI cut-off of 18.5 to delineate Grade I thinness was too low to identify Andean women at risk. Setting universal cut-off values for BMI may prove to be difficult as constant levels of BMI may represent differing proportions of fat and fat-free mass across ethnic groups (James, 1994; Immink et al., 1992; Wang et al., 1994). For example, differences in body shape as measured by the Cormic Index (sitting height/height) have been reported to account for across population variation in BMI of up to 5 $kg/m^2$ with weight and body composition held constant (Norgan, 1994). Biacromial diameter (shoulder width) may also affect the relationship between BMI and body composition (Norgan, 1994). Similar to results reported here, Immink et al. (1992) in a study of Guatemalan subjects indicated that while BMI was associated with fat and fat-free mass, it was poorly associated with these body composition measures at low levels of BMI.

Because of their more direct relation to peripheral tissue protein and energy stores, MUAC, triceps skinfold and the associated indices of arm fat and muscle areas have been proposed as alternative measures to BMI or as measures to improve the sensitivity of BMI in identifying chronic energy deficiency (CED) (James et al., 1994). In the present study, replacing BMI with MUAC would have resulted in much lower costs and maximal participation as the requirement to present at a clinic would have been dropped. BMI was found to be highly correlated with MUAC ($r=0.78$, $p<0.001$) in this study at a strength similar to that reported for 8 different countries by James et al. (1994) ($r=0.79$) but slightly weaker than that reported for adult women in the NCRSP studies ($r=0.89$) (Calloway et al., 1992) suggesting that MUAC could replace BMI under field conditions, especially for within sample evaluations. Calloway et al. (1992) observed that the ability of MUAC to predict BMI <20 improved significantly when used within a sample with similar risks and somatypes but produced a high rate of false negatives when applying an inter-country model incorporating data from Mexico, Kenya and Egypt. Unlike BMI, however, cut-off values for MUAC have yet to be established and because of its smaller coefficient of variation this measure may have decreased sensitivity for discriminating intermediate stages of CED (James et al., 1994).

As is the case with many anthropometric measures, the validity of the tool seems to depend on the purpose of the evaluation. Both BMI and MUAC seemed to have limitations for general assessment but were meaningful measures for within sample applications. The strength of BMI and MUAC lie in their simplicity and concomitant low measurement error, making them excellent methods for longitudinal studies. MUAC, in particular, was an important inclusion in the present study as seasonal changes in energy status were more easily observed (mean difference of 5.95 cm, p=0.02) versus the accompanying drop in weight (1.29 kg) (p=0.09).

## CONCLUSIONS

To accurately assess the energy status of a community, programme planners and investigators must decide who to measure, when and how. The present study demonstrates the potential to underestimate energy stress within communities when vulnerable sub-groups, such as the elderly, or critical periods of the year are excluded from the evaluation. The age-related differences in body mass index and energy stores among these Andean women suggested the existence of subtle energy stress that may be missed when only younger family members are studied. Although identification of the causative links is difficult, older women also consumed less food and reported more days ill with respiratory symptoms. The post-harvest decline in energy stores experienced by women of all ages further suggests energy stress and makes the important point that shortfalls are not restricted to the elderly.

Research is still required, however, on the most cost-effective methods for identifying the malnourished among adults and for investigating the causes of compromised stores when they exist. This is true both for developing and developed countries where age-related changes in body composition such as osteoporosis and sarcopenia are an increasing public health concern. Currently, reference cut-off values only exist for body mass index, although as demonstrated here, this measure may have limited validity for general assessment across populations. The cut-off values for BMI and a cost-benefit analysis of replacing BMI with MUAC and related arm composition indices all warrant further study.

# EPILOGUE TO MANUSCRIPT A

As a first step in identifying the nutritional impacts of the re-introduction of quinoa, it was important to establish whether protein-energy malnutrition existed in this population of women. Specifically, the question of interest was whether diets were of insufficient quantity to the extent that women could be expected to consume more protein and/or energy should economic or physical access to food increase in these households.

Manuscript A presented data indicating mild energy stress among these women. Cross-sectionally, older women consumed less energy and maintained lower BMI and arm energy stores than their younger counterparts, a situation that was associated with higher reported morbidity. There was also evidence of seasonal changes in anthropometric status for women of all ages, suggesting effects of either heightened energy expenditure or food shortages during the year. Seasonal differences were also apparent with regards to micronutrient intake.

Therefore, there is reason to believe that mild food insecurity did exist in this population. Interventions, such as quinoa production, which increase either the household's ability to produce food or generate income to purchase food *throughout the year* can therefore be expected to be associated with increased nutrient intakes and the maintenance of larger energy stores.

The remaining manuscripts examine whether quinoa production was, in fact, linked to nutritional status among these women. Because of its cross-sectional non-randomized design, the thesis must incorporate an analysis of self-selection bias as certain characteristics may pre-dispose households both to produce quinoa and maintain better nutrition. That is, there is a high potential for confounding of associations. Manuscript B, identifies these variables including an in-depth analysis of socio-economic status, one of the most difficult confounding variables found in observational nutrition research. Manuscript C, tests for nutrition-related differences between quinoa producers and non-producers and then lays out multivariate models where these effects are adjusted for the confounding variables identified in Manuscript B.

# CHAPTER 5

# MANUSCRIPT B

# SOCIO-ECONOMIC CORRELATES OF ECUADORIAN WOMEN'S NUTRITIONAL STATUS

**Macdonald, B., Johns, T., Gray-Donald, K., & Receveur, O.**

## ABSTRACT

**Objectives** - A cross-sectional study with repeated measures was conducted in the Ecuadorian Highlands to establish the adequacy of Andean women's diet and determine the strength of associations between socio-economic variables and nutrition in this population (diet and anthropometric status).

**Methods** - Dietary, anthropometric and socio-economic variables were measured over four study rounds (two seasons) in 90 households during the 1995-1996 agricultural year. Estimated prevalences of inadequate nutrient intakes were determined by the Probability Method, and socio-economic and nutrition associations were established with Principal Components and Regression analyses.

**Results** - Ecuadorian women consumed inadequate amounts of calcium, iron, riboflavin and vitamin $B_{12}$. The phytate-zinc ratio was observed to be 21: a level expected to reduce zinc availability to 15%. Two distinct constructs representing socio-economic status were identified: modern lifestyle and farming wealth. These variables were more strongly associated with diet quality (animal protein adjusted for energy) than with diet quantity (energy). Anthropometric status was most significantly associated with age (negative) and the amount of animal protein in the diet (positive) with no independent effect of either socio-economic marker.

**Conclusions** - Ecuadorian Andean women were at high risk of micronutrient deficiencies due to low intakes of animal products coupled with high intakes of phytates. Women living in households characterized by either having a modern lifestyle and/or possession of farming capital consumed higher amounts of animal

protein, but these socio-economic markers had no effect on anthropometric indicators independent of diet.

## INTRODUCTION:

Women are recognized as the key actors in food and nutrition systems world-wide (Quisumbing et al., 1995). Via their roles in food production and preparation, income-generation, reproduction and family care-taking, women support the nutrition and health of the remainder of the household (McGuire and Popkin, 1991). It is these same demands, however, that may lead to serious depletion of nutrient stores and compromise women's productive and caring-capacity. Clearly, optimizing the nutritional status of women is crucial not only for their quality of life but for that of all family members.

One of the main threats to rural women's nutritional status is a lack of household economic resources including housing, land, water/sanitation systems, and the time, education and health of family members. Household economic theory contends that families accumulate and combine these resources to satisfy needs and wants including providing a safe and healthy environment for children's growth and development (Becker, 1965). Specifically from a nutritional perspective, this human and physical capital permits a household to either produce food and/or generate income to procure and prepare food in a hygienic manner, thereby improving food security and ameliorating the household's burden of illness. In developing countries, female human capital, especially education, has been shown to be positively associated with increased food expenditures, farm output, and the nutritional status of children (Franklin and Harrell, 1985).

Despite recognizing the importance of these variables on a theoretical level, nutrition researchers have yet to fully capture the complex nature of socio-economic status in their analyses. The variables are difficult to measure and multivariate methods such as Principal Components analysis and Multiple Linear Regression are particularly important for reducing statistical collinearities and confounding. Clarifying the relationships is a particularly important issue for nutritionists who aim to separate out the effect of diet from other factors which may positively impact nutritional status including improved housing, education, or access to health and sanitation services (Kennedy and Cogill, 1987; von Braun et al., 1991).

These issues were studied as part of an evaluation of the nutritional impacts of an agricultural project in Highland Ecuador.

The specific objectives of this study are:

1) to describe Ecuadorian Andean women's diet and establish its adequacy;

2) to describe the household socio-economic resource base in three Andean communities; and

3) applying multivariate analyses, to determine the strength of associations between household socio-economic variables and diet quantity (energy), diet quality (animal protein intake adjusted for energy) and the anthropometric status (body mass index [BMI], mid-upper-arm circumference [MUAC] and arm fat area [AFA]) of Ecuadorian Andean women.

## MATERIALS AND METHODS

i) Study Design, Sampling and Research Team:

The study design, sampling methods and research team have been described previously (Macdonald, 1999a). Briefly, the study was conducted in Highland Ecuador, province of Chimborazo (2400 to 4000 m.a.s.l.) as part of an evaluation of the nutritional impacts of an agricultural project. Household composition, socio-economic status, farming system components, diet and anthropometry were compared between two groups of small-scale farming families: a self-selected group engaged in an agricultural project versus a randomly sampled quasi-control group from the same communities. In order to participate in the study, households had to maintain their principal residence in the community and own less than 10 hectares of land. Women were the focal research subjects and therefore, presence of children in the household were not part of the eligibility criteria. Four survey rounds were completed over the 1995-1996 agricultural year. The total number of households that entered the sample at baseline was 104, 90 of which completed the study. The research team consisted of four local Indigenous women trained for a period of six weeks prior to data collection. All data were collected in the local language, Quichua, then transcribed to Spanish.

ii) Dietary and Anthropometric Variables

Measurement of dietary and anthropometric variables are described in Macdonald (1999a). Dietary intake was assessed with four 24-hour recalls conducted over two seasons. Recall interviews were conducted by the Indigenous research assistants with the female head of household. Serving sizes were estimated with standard-sized cups, bowls and spoons, and local foods were weighed to improve precision of estimates. Anthropometric measurements included height, weight, MUAC and triceps skinfold and were conducted in accordance with standardized methods (Lohman et al., 1991; Gibson, 1990). AFA was calculated with the formula presented in Frisancho (1990). The equipment was calibrated in the field and measurements were made in a central location in the community (health clinic or meeting house).

iii) Household Socio-economic and Health Variables

Household socio-economic and health variables were measured with gender-disaggregated questionnaires (male and female heads of household interviewed separately) and direct observation of assets both at baseline (pre-harvest) and post-harvest. The questionnaires were developed with the aid of local collaborating institutions (Centro Internacional de la Papa; Fundación para el Desarrollo Agropecuario; Instituto Nacional Autónomo de Investigaciones Agropecuarias). Survey tools were pre-tested with 20 families not participating in the study to ensure adherence to the protocols designed to standardize questionnaire administration and observation. Questionnaires were revised following the pre-test to remove inappropriate questions and improve response categories. The following variables were measured with the male head of household as respondent: age, sex, formal and informal education of household members, occupation, water supply, human waste and garbage disposal, ownership of durable goods, land holdings and land in cultivation. The female head of household confirmed information regarding household composition and human waste disposal and provided details on her occupation, morbidity and household use of health services.

Housing characteristics, latrine ownership and water supply were measured by direct observation.

iv) Data Entry:

Questionnaire and anthropometric data were entered by a single clerk into the EPI INFO 6 program, Version 6.02 (CDC/WHO, 1994). All data were reviewed twice to ensure correct coding. Details of dietary recall data entry are provided in Macdonald (1999a). Recall data were entered by a single clerk using an Ecuadorian food composition database created with the Worldfood Dietary Assessment System, Version 2 (University of California at Berkeley, 1996). Food composition data were gathered from Ecuadorian (Ministerio de Salud Pública del Ecuador; 1988) and Mexican (University of California at Berkeley, 1996) tables and from the scientific literature for Andean crop nutrient composition (Koziol, 1990; Ruales Nájera, 1992; Galwey et al., 1990; Gross et al., 1989). dBASE files created in Worldfood were exported to the SAS statistical program (Version 6.12) (SAS Institute Inc., 1996) for analysis.

v) Data Analysis:

Variables were tested for normality with SAS univariate and normal probability plot procedures. Means, medians and frequencies were generated for all data as appropriate given the distribution.

Dietary adequacy was tested with the Probability Method where appropriate (National Research Council, 1986). With this approach, the probability that an individual's mean nutrient intake is below her own (unknown) requirement is computed (Murphy et al., 1992). Individual probabilities are then averaged over the sample and this value represents the predicted prevalence of inadequate intakes (Murphy et al., 1992). This method assumes that data are available on usual intakes, that requirement curves are symmetrical and that there is no relationship between requirements and intake. Given these assumptions, probability analysis is normally not performed on energy, and will not be performed on vitamin A in this study as only four days of dietary data were available. Calcium and vitamin C are also not normally analyzed with this method as international mean requirements and their variance have not been established (Berti, 1996). In the present study, probability analysis was performed for protein, zinc, iron, vitamin $B_{12}$, folate, niacin, riboflavin and thiamin.

Pearson and Spearman correlations tested bivariate associations among predictor variables and between independent and dependent variables. Principal Components analysis, conducted with PROC FACTOR (principal axis), aided in understanding the underlying structure of the data and reduced the multiple economic measures to a few meaningful, independent factors (Kleinbaum et al., 1988).

Principal components were included as predictors in multivariate analyses with diet quantity (energy), and diet quality (animal protein intake adjusted for energy) as dependent variables. Animal protein was chosen as the diet quality marker because it was highly associated with women's anthropometry, and because Ecuadorian women were shown to consume diets characterized by low intakes of micronutrients (especially riboflavin, vitamin $B_{12}$, calcium and iron) which are in their most bioavailable form in animal products. Spearman correlations were calculated between animal protein (g) and these micronutrients and were highly significant for vitamin A (r=0.45, p<0.01), vitamin $B_{12}$ (r=0.96, p<0.01), iron (r=0.66, p=0.01), riboflavin (r=0.62, p<0.01), and calcium (r=0.60, p<0.01). Models were also developed for women's anthropometry (BMI, MUAC and AFA). Multivariate analyses were conducted with PROC REG in SAS.

## RESULTS:

### Dietary Intake

Nutrient intakes for *non-pregnant, non-lactating* Ecuadorian women, averaged over four days, are presented in Table 1. In terms of macronutrient composition, the proportion of energy derived from carbohydrates was very high (76%). Protein accounted for 11% and fat 13% of energy. Energy and protein intakes were sufficient (Macdonald, 1999a), but diet quality in terms of micronutrient intakes was compromised. For those nutrients where the Probability Approach was applied, more than 10% of women had insufficient intakes of riboflavin, vitamin $B_{12}$, iron and niacin reflecting their low consumption of animal products. These women consumed a high amount of phytates, which considerably reduced the bioavailability of zinc and iron in their diets. The phytate-zinc molar ratio (g phytate/660 molecular weight divided by mg zinc/65.4 atomic weight) was calculated to be 21, a level which is expected to reduce the availability of zinc to 15% (Murphy et al., 1992). Although the Probability Approach could not be applied, mean calcium intake was below the recommended allowance. Folate, thiamin, and vitamin C intakes were largely sufficient.

Table 1: Dietary Intake of Chimborazo Women (mean 4 days ± s.d.) and Probability of Inadequacy (n=79)

| Nutrient | Mean ± s.d. | FAO/WHO Reference Values | Predicted Prevalence of Inadequate Intakes (%) |
|---|---|---|---|
| energy (kcal) | 2613 (574) | 2465 | N/A |
| fat (g) | 38.3 (13.3) | N/A | N/A |
| protein (g) | 71.0 (19.4) | 36.5 | 1 |
| % energy as carbohydrate | 76.0 (4.5) | N/A | N/A |
| % energy as fat | 13.2 (3.3) | N/A | N/A |
| % energy as protein | 10.8 (1.4) | N/A | N/A |
| % energy as animal products | 6.4 (3.9) | N/A | N/A |
| niacin (mg) | 18.9 (5.0) | 17.3 | 11 |
| riboflavin (mg) | 0.9 (0.3) | 1.44 | 89 |
| thiamin (mg) | 1.8 (0.5) | 1.04 | 1 |
| folate (μg) | 251 (94) | 151[a] | 4 |
| vitamin $B_{12}$ (μg) | 1.3 (0.8) | 1.0 | 28 |
| vitamin C (mg) | 123 (44) | 30 | N/A |
| vitamin A (RE) | 772 (622) | 500[a] | N/A |
| calcium (mg) | 327 (128) | 450 | N/A |
| iron (mg) | 13.8 (4.0) | 12.5/9.5[b] | 58 |
| zinc (mg) | 10.9 (3.0) | N/A | N/A |
| bioavailable zinc | 1.6 (0.5) | 0.87[c] | 6 |
| phytate (mg) | 2370 (608) | N/A | N/A |

a=safe level; b=basal requirement for menstruating women (12.5) for post-menopausal women (9.5); c=normative requirement

## Household Socio-economic Resource Base

Household composition and access to what may be described as the key household resources of education and land are detailed in Table 2.

Table 2: Household Composition and Land Resources (n=89)*

| Variable | Mean (±s.d.) | Range |
|---|---|---|
| Household Size | 4.86 (1.78) | 1-9 |
| Number of Children <6yrs | 1.01 (1.10) | 0-4 |
| Male Head's Age (years) | 42.42 (13.26) | 21-66 |
| Male Head's Formal Education (years) | 3.67 (3.68) | 0-17 |
| Female Head's Age (years) | 39.75 (13.36) | 13-66 |
| Female Head's Formal Education (years) | 2.10 (2.73) | 0-6 |
| Land Owned (hectares) | 2.65 (1.80) | 0-10 |
| Land in Cultivation (hectares) | 2.22 (1.50) | 1-9 |

* n decreased by 1 due to missing data

The typical household consisted of 5 members, normally comprised of the nuclear family but encompassing alternative forms such as children living with their grandparents, or eldest daughters as the female head of household following a maternal death. Four households were headed by women. An important number (40%) of households reported no children <6 years, while 50% reported only 1 or 2 preschoolers. This variability in household composition is further reflected in the wide age range of subjects, which extends from 13 to 66 years. Mean level of education was low with a strong negative correlation between age and years of formal education attained (r=-0.680). This trend reflects improved community access to primary schools in the past 10 years (Nieto Cabrera and Vimos Naranjo, 1995). The illiteracy rate in the study sample was high and there existed a gender bias in educational attainment with 58% of females illiterate compared to 38% of males.

The majority of males (96.2%) reported agriculture as their primary occupation making land a key economic resource. As expected, the farmers studied were small-scale with 82% of respondents possessing < 5 hectares of land. The average holding was 2.65 hectares, 84% of which was in cultivation during the 1995-1996 agricultural year.

The survey of basic services revealed that 100% of households had access to piped water, 94% reported latrines as their primary method of human waste disposal (latrine ownership confirmed by observation), and 84% had electricity. Due to a lack of variation in the sample, these variables were dropped from further analysis.

**Socio-economic Status**

Socio-economic status is a difficult variable to measure with a standardized instrument especially given the sensitive nature of this information. What is common research practice then, is to observe a variety of household characteristics such as ownership of durable goods, land and livestock, which are believed *a priori* to be markers of wealth. Principal Components analysis may then be used to determine the relationships between the measures to see if they do, indeed, co-vary in the expected fashion. Principal Components analysis was conducted as part of the present analysis and the results are summarized in Table 3.

In the analysis, the criteria of eigenvalues greater than 1, scree plots, and interpretability were applied in the selection of factors to be retained. Scree plots identify a "break" between components with large eigenvalues and those with low eigenvalues. Although four factors had eigenvalues greater than 1 and jointly explained 66% of the variance, the scree appeared to begin after the second factor and the third and fourth factors were difficult to interpret. Based on these considerations, only the first two factors were retained and they jointly explained 50% of the variance in the original variables. Due to the interpretability of the unrotated factors, rotation was not performed.

In performing the Principal Components analysis, some variables originally measured were dropped because they did not load on the retained factors or they loaded on both factors. These include work migration patterns, and ownership of radios, vehicles, back-pack sprayers, sheep, swine, horses, and mules. Variables that do not load clearly on components are often removed from an analysis because they are not pure measures of the retained constructs (Hatcher and Stepanski, 1994).

Table 3: Principal Components Analysis of Socio-economic Markers in the Ecuadorian Andes (n=89)

| Variable | Factor 1 | Factor 2 |
|---|---|---|
| roof material (straw, zinc, eternit) | 39* | -18 |
| floor material (earth, wood, cement) | 66* | -14 |
| wall material (adobe, cement/brick) | 48* | -30 |
| stoves (number) | 70* | 9 |
| furniture (number) | 80* | 10 |
| bicycles (number) | 63* | 24 |
| stereos (number) | 65* | -9 |
| televisions (number) | 67* | -3 |
| blenders (number) | 80* | 0 |
| land (hectares owned) | -15 | 78* |
| land in cultivation (hectares) ℘ (1995-1996) | -4 | 85* |
| fowl (number owned) | 26 | 52* |
| guinea pigs (number owned) | 17 | 59* |
| Eigenvalue | 3.985 | 2.161 |
| Cumulative Variance Explained | 0.306 | 0.473 |

℘ 1995-1996

As can be seen in Table 3, the series of variables measured as socio-economic proxies actually represent two different constructs. Nine of the twelve variables loaded on Factor 1 which accounted for 30.6% of the variance. These variables include possession of small durable goods and improved housing materials and the factor may therefore be described as "modern lifestyle". Factor 2 represents the construct of "farming wealth" and accounted for 16.7% of the variance in the original variables. Variables loading on this factor included land ownership, land in cultivation during the study year and small livestock. Large livestock did not load clearly on this factor.

The correlation matrix for all the predictors of nutritional outcomes is presented in Table 4. As can be seen, the potential for confounding/collinearity is substantial. In particular, there is a web of interrelationships among education, age and the modern lifestyle factor. Specifically, age is negatively associated both with education and modern lifestyle, while education and modern lifestyle are positively related, an association that may be confounded by age. Furthermore, since individuals of similar age and education tend to marry, characteristics of male and female heads of household were associated so that relationships between women's characteristics and nutritional outcomes may to some extent capture or incorporate characteristics of her spouse and vice-versa.

Table 4: Correlation Matrix [r (p-value)] for Socio-economic Variables (n=89)

| | men's education | women's education | women's age | modern factor | farming factor |
|---|---|---|---|---|---|
| men's age | -0.680 (<0.001) | -0.575 (<0.001) | 0.774 (<0.001) | -0.441 (<0.001) | 0.152 (0.156) |
| men's education | | 0.499 (<0.001) | -0.491 (<0.001) | 0.550 (<0.001) | -0.055 (0.608) |
| women's education | | | -0.559 (<0.001) | 0.186 (0.094) | -0.036 (0.751) |
| women's age | | | | -0.290 (0.006) | 0.187 (0.081) |
| modern factor | | | | | -0.004 (0.972) |

Multivariate models demonstrating the relationships between these predictors and women's diet (energy intake, animal protein intake adjusted for energy) as well as anthropometric status are presented in Tables 5 and 6. For the models, to reduce collinearity among the independent variables, women's characteristics were retained in place of those of men and modern lifestyle was retained in lieu of education since education reflected secular trend to a certain extent in these communities (Nieto Cabrera and Vimos Naranjo, 1995). It should be remembered, however, that effects attributed to women's characteristics also capture men's traits and that modern lifestyle incorporates education.

In Table 5, what is immediately apparent is that the socio-economic variables were more significantly associated with the variable representing diet quality (animal protein intake adjusted for energy) than with overall diet quantity (energy). In fact, the overall probability value for the energy model was insignificant and therefore individual predictors will not be interpreted. For diet quality, intake of animal protein was significantly associated with farming wealth (positive). The model indicates that every unit increase in farming wealth was accompanied by an additional 2.6 grams of animal protein per 1000 kcal in the diet (adjusted for age and modern lifestyle). There was evidence of a similar tendency towards increased intake with modern lifestyle. Therefore, both markers of socio-economic status were associated with improved diet quality. Moreover, there was an additive effect where the degree to which a household invested in both types of assets, animal protein increasingly appeared in the diet.

Table 6 demonstrates that unlike diet quality, the associations between the socio-economic variables and anthropometric status were largely insignificant, perhaps because they are more distal on the causative chain (SES → animal protein → anthropometric status). In fact, the only significant model is arm fat area, with a trend towards larger fat stores with modern lifestyle.

Table 5: Multivariate Models of Chimborazo Women's Dietary Intake

| | Energy (kcal) (n=85[ρ]) | | Animal Protein (g/1000 kcal) (n=85) | |
|---|---|---|---|---|
| | ß-coefficient | Prob>T | ß-coefficient | Prob>T |
| intercept | 2914.96 | <0.01 | 7.59 | <0.01 |
| women's age (years) | -8.20 | 0.09 | -0.11 | 0.10 |
| modern factor (standardized) | 27.70 | 0.70 | 1.99 | 0.11 |
| farming factor (standardized) | 33.97 | 0.59 | 2.62 | 0.01 |
| Probability Value | 0.30 | | <0.01 | |
| $R^2$ | 0.04 | | 0.14 | |

[ρ] = sample size reduced as 4 households did not have an adult female

Table 6: Multivariate Models of Chimborazo Women's Anthropometric Status

| | BMI ($kg/m^2$) (n=51) | | MUAC (cm) (n=47) | | AFA ($mm^2$) (n=47) | |
|---|---|---|---|---|---|---|
| | β-coefficient | Prob>T | β-coefficient | Prob>T | β-coefficient | Prob>T |
| intercept | 24.04 | <0.01 | 26.00 | <0.01 | 1557.29 | <0.01 |
| women's age (years) | -0.04 | 0.12 | -0.02 | 0.49 | -7.53 | 0.11 |
| modern factor (standardized) | 0.29 | 0.47 | 0.56 | 0.19 | 137.30 | 0.07 |
| farming factor (standardized) | 0.29 | 0.37 | 0.40 | 0.24 | 45.59 | 0.45 |
| Probability Value | 0.21 | | 0.23 | | 0.04 | |
| $R^2$ | 0.10 | | 0.10 | | 0.17 | |

The question remains whether the socio-economic effects on diet quality resulted in improved anthropometric status. Multivariate models are presented in Table 7 which demonstrate that animal protein (adjusted for energy) was indeed a significant predictor of BMI, MUAC and AFA. Adjusted for age, each additional gram of animal protein was associated with a 0.19 $kg/m^2$ increase in BMI, a 0.25 cm increase in MUAC and a 35.8 $mm^2$ increase in AFA. In addition, of particular interest to nutritionists, when the socio-economic factors were included in these models the effect of animal protein remained significant, while the factors did not (data not shown). Therefore, it is clear that animal protein intake is not merely acting as a proxy for socio-economic status but more likely is an intermediate variable between socio-economic status and anthropometrics.

Table 7: Multivariate Models Demonstrating the Effect of Diet Quality on Chimborazo Women's Anthropometric Status

| | BMI ($kg/m^2$) (n=51) | | MUAC (cm) (n=47) | | AFA ($mm^2$) (n=47) | |
|---|---|---|---|---|---|---|
| | β-coefficient | Prob>T | β-coefficient | Prob>T | β-coefficient | Prob>T |
| intercept | 22.94 | <0.01 | 24.68 | <0.01 | 1409.47 | <0.01 |
| women's age (years) | -0.04 | 0.09 | -0.02 | 0.39 | -8.86 | 0.05 |
| animal protein (g/1000 kcal) | 0.19 | 0.03 | 0.25 | 0.01 | 35.79 | 0.04 |
| Probability Value | 0.02 | | 0.02 | | 0.01 | |
| $R^2$ | 0.16 | | 0.17 | | 0.18 | |

**DISCUSSION:**

Despite the pivotal role played by women in household production and reproduction, their nutritional status has been largely neglected as a serious topic of study. The high probabilities of inadequate micronutrient intakes among rural Ecuadorian women reported here illustrate the situation facing women and children worldwide. Micronutrient deficiencies place women at high-risk of anemias, compromised immunocompetence and for those women of child-bearing age, of maternal mortality (Gillespie, 1998). Of course, high rates of micronutrient deficiencies among women also places infants at risk both pre- and post-partum and the lethargy associated with anemias and mild energy insufficiency may compromise maternal caring capacity and worker productivity. Finally, women's nutritional status may act as a marker of diet inadequacies experienced by the entire household (Calloway, et al. 1992).

Although there is now a broad literature detailing inadequate micronutrient intakes among Latin American children including Ecuador (Freire et al, 1988; Berti et al., 1997; Kim et al., 1991; Brown, 1991; Marquis and Kolasa, 1986; Calloway et al., 1992), similar high quality data describing women's intake is limited. In fact, only Kim et al. (1991) and Berti et al. (1997) provide information for Bolivia and Ecuador, respectively. Kim et al. (1991) observed low intakes of calcium and vitamin A relative to Bolivian recommended intakes. Similar to the findings presented here, Berti et al. (1997) reported inadequate intakes of calcium, vitamin A, riboflavin and vitamin $B_{12}$. Discrepancies between Berti et al.'s (1997) observations and the present data mainly manifest themselves in probabilities of deficient intakes of iron and folate. Berti et al. (1997) reported low intakes of folate while low intakes of iron were documented in the present study. While these two studies were both conducted in Highland Ecuador with similar methodologies, there were important departures in the food composition tables employed and assumptions made regarding iron bioavailability. Furthermore, the studies were conducted in different provinces in the Highlands and Berti et al. (1998) reported that their study population may have been of a higher socio-economic status than surrounding communities. In terms of folate status, an important distinction between the two studies was the presence of the agricultural project in the present sample. The nutritional impacts of the project are reported in Macdonald (1999c) and the crop re-introduced, quinoa, contains a significant amount of folate compared to staples commonly consumed in the region.

A number of the micronutrients found to be lacking in the diet (riboflavin, iron, calcium, and vitamin $B_{12}$) are those found in the highest supply and most bioavailable form in animal products. The relatively low intake of these foods among this population at approximately 6% of energy confirms other observations from Ecuador where the contribution of this food group to energy intake has been reported to range from 5 to 7.7% (Leonard et al., 1993; Berti, 1996). Animal product intake has been shown to be a significant predictor of child size in Ecuador and Mexico (Leonard et al., 1994; Allen et al., 1992). Allen et al. (1992), in a longitudinal study, demonstrated that the association between maternal size and child size was modified by animal energy intake and that coordinated length and weight gain also depends on this dietary variable. The links between animal product intake and anthropometric status in children have excellent biological plausibility via increased intakes of high quality, bioavailable protein, zinc, iron and vitamin A. These nutrients have been shown to directly impact appetite, cellular differentiation, growth and severity of infection (Beaton et al., 1993; Brown, 1991; Golden and Golden, 1991; Dirren et al., 1994). The novel contribution of the present study is the demonstrated association between animal protein intake (adjusted for energy) and improved anthropometric status in adult women. Similar to children, the high protein quality and micronutrient bioavailability associated with animal products can be expected to lower infection rates. Furthermore, rather than merely acting as a proxy for socio-economic status, the relationship with diet was significant when adjusted for both modern lifestyle and farming wealth. It should be noted, however, that animal product intake is normally accompanied by decreased unrefined grains in the diet (Calloway et al., 1992) which complicates interpretation due to the concomitant decrease in phytates.

Measuring socio-economic status either as a predictor or a confounder is of prime importance in international nutrition research. The present Principal Components analysis demonstrated that indicators which are often used interchangeably to denote socio-economic status may in fact, measure two distinct constructs: modern lifestyle and farming wealth. The distinction between these markers has also been identified by Onyango (1990), Weismantel (1992) and DeWalt et al. (1990). The important implication is that both these constructs must be measured and included in models to fully understand the role of socio-economic status. In addition, the complex web of inter-relationships among economic predictors demonstrated here raises questions as to whether often cited relationships between economic predictors (e.g. women's education) and nutritional status have been adequately adjusted for potential confounders such as women's age (negatively associated with education), men's education (positively associated with women's education), and both types of socio-economic markers. Similar co-variation in predictors has been reported by Mack (1993), Calloway et al. (1992) and Weismantel (1992). The strong negative relationship between education and age also support Behrman's (1995) contention that women's schooling is not randomly distributed in populations but rather is systematically associated certainly with secular trend and modern life-style and also possibly with motivation, savvy, better family background and other unmeasured variables which may account for the education-nutrition associations commonly reported. In the present study, an attempt was made to measure this type of motivation by measuring women's participation in informal courses and extension activities but insufficient variation was present in the data to merit inclusion in statistical models.

In the past, the impacts of economic variables have mainly been studied in relation to the nutritional status of children. The positive effects of education/literacy on children's diet and growth are frequently reported (Mack, 1993; Franklin and Harrell, 1985; Leonard et al., 1994; Allen et al., 1992) and have also been found to co-vary with adult females' anthropometric status in Kenya and Mexico (Calloway et al., 1992). The effects of socio-economic status, depending on the indicators employed, are less clear-cut. Authors employing indicators similar to the modern lifestyle factor generated here (durable goods and/or housing or occupation) have found conflicting results. Leonard et al. (1993) found no association between modern lifestyle and children's growth (height and weight) in Ecuador. Conversely, Freire et al. (1988), Vitzthum (1992), DeWalt (1983) and Calloway et al. (1992) have all reported positive associations either with diet or nutritional status in Latin America. The present study demonstrated a marginal association between diet quality and modern lifestyle but the relationship with farming wealth was statistically significant. As noted by Weismantel (1992), the variables associated with modern lifestyle may be markers of acculturation rather than wealth. Cash spent on goods such as televisions, blenders, and tin roofs, may represent foregone investments in the more expensive capital of cattle or land. Fewer authors have specifically chosen farming wealth as their socio-economic indicator but those who have chosen to do so have shown a positive effect on diet (Berti and Leonard, 1998; Leonard et al., 1993) and children's nutritional status (Leonard et al., 1993; DeWalt et al., 1990).

## CONCLUSIONS

The present study highlighted variation in access to a high-quality diet by women living in rural communities. In the Ecuadorian highlands, despite consuming a diet largely adequate in energy and protein, there was a marked prevalence of inadequate intake of many micronutrients. These intakes, in addition to women's anthropometric status, were related to a complex web of economic and demographic variables including age, education, housing and ownership of durable goods, land and livestock. The potential for confounding and/or collinearity was high when delineating the effects of these predictors and Principal Components analysis was an invaluable tool both for understanding the structure of the data and for reducing the number of variables. Interestingly, typical markers of socio-economic status clustered to form two distinct factors: modern lifestyle versus farming wealth both of which were more highly associated with diet quality than diet quantity. These data suggest that Ecuadorian Highland families chose to consume more animal products as opposed to more calories as socio-economic status increased. This is particularly interesting in light of the negative association between energy intake and women's age demonstrated by Macdonald (1999a) which pointed to mild energy stress in this population. Clearly, the relationships between socio-economic status and nutrition are complex and a number of variables (modern lifestyle, farming wealth, diet quantity, diet quality, and anthropometry) must be addressed to fully understand the nutritional impacts of policies and interventions.

# EPILOGUE TO MANUSCRIPT B

Andean nutrition literature has demonstrated socio-economic variation in dietary intakes (Leonard, 1989a; Leonard et al., 1993; Berti and Leonard, 1998). In detailing the impacts of quinoa production, these socio-economic correlates present an analytical problem as they may confound associations. Carefully measuring these culturally sensitive variables in the present population and their association with the nutritional outcomes of interest formed the crux of Manuscript B.

The Principal Components analysis demonstrated that variables which are often used interchangeably to denote socio-economic status actually measure two different constructs: modern lifestyle versus farming wealth. Furthermore, these variables were shown to be highly correlated with other characteristics linked to nutritional status including women's age and education. These associations pointed to a high probability of collinearity and confounding of the quinoa-nutrition relationship, and Manuscript B lays out justification for variable inclusion and exclusion decisions related to multivariate models presented in Manuscript C. Specifically, evidence is provided that diet quality and quantity are distinct both from each other and from anthropometric status and that all three should be measured in terms of identifying the impacts of quinoa production. Furthermore, the case is made that education should be dropped from models as it was highly collinear with both age and modern lifestyle, and in addition, was related to secular trend in the communities.

Manuscript C presents an example of an agricultural intervention to improve nutrition with effects adjusted for these socio-economic effects, where appropriate.

# CHAPTER 6

# MANUSCRIPT C

## CONTRIBUTION OF QUINOA PRODUCTION TO IMPROVED NUTRITIONAL STATUS IN THE ECUADORIAN HIGHLANDS

**Macdonald, B., Johns, T., Gray-Donald, K., & Receveur, O.**

## ABSTRACT

**Objectives** - A study was conducted in the Ecuadorian Highlands to document the nutritional impacts associated with the re-introduction of quinoa (*Chenopodium quinoa*) to the agricultural production system. The objectives of the study were to compare dietary intake and anthropometric status between quinoa-producing households and a randomly sampled group of non-quinoa-producing households.

**Methods** - Gender-disaggregated socio-economic surveys, repeated 24-hour recalls and anthropometry were conducted over two seasons (pre- and post-harvest) covering 90 families in three communities. Group differences in nutrient intakes and anthropometry were tested with the Student's t-test and Multiple Linear Regression analyses were applied to adjust for confounding effects.

**Results** - Quinoa-producers owned more land and generated more cash income from crop sales than non-producers. Women in quinoa-producing households consumed higher amounts of energy and most micronutrients and also maintained larger mid-upper-arm circumference (MUAC) and arm fat area (AFA). Trends in children were similar but of a smaller magnitude with no evidence of differences in anthropometric status. Quinoa group differences in energy, iron and zinc remained significant when adjusted for confounding variables although differences in animal protein, protein and calcium intakes as well as anthropometric indices appeared to be confounded by socio-economic status.

**Conclusions** - Quinoa production was associated with nutritional status in these communities. The impacts varied between women and children and were apparent in

both macro- and micronutrient intakes suggesting that policy evaluations restricted to an evaluation of children's caloric intakes and growth status may under-estimate effects.

## INTRODUCTION

Although international agricultural projects often explicitly or implicitly set improved nutritional status of rural dwellers as their goal, micro-level analyses indicate that impacts have been sub-optimal (Dewey, 1979; Bouis and Haddad, 1990). Specifically, while adoption of novel cropping practices is often accompanied by increased incomes, there may be no concomitant improvement in energy intakes or the nutritional status of individuals (Kennedy and Cogill, 1987; Bouis and Haddad, 1990). This is because the determinants of dietary intake and nutritional status are complex and include a number of social and economic factors which must be fully understood in order to maximize outcomes.

Despite the extensive amount of research documenting agriculture-nutrition linkages, several issues are outstanding. For example, a few exceptions notwithstanding (Kennedy and Cogill, 1987; Kaiser and Dewey, 1991a), there is a notable paucity of information regarding the impact of agricultural projects on micronutrient intakes and/or the nutritional status of women. Furthermore, limited research is available documenting the effects of the production of food-based crops compared to non-nutritious cash crops such as sugar, tobacco and tea. Finally, there remains insufficient understanding of the complex shifts in the household economy resulting from agricultural changes and the accompanying effects on nutrition.

A case study examining the relationships between Andean crop production and nutrition was conducted in Highland Ecuador (province of Chimborazo) to address these questions. There is evidence of marked malnutrition among both women and children in this region, with 52% of children under 5 years of age stunted, and high prevalences of micronutrient deficiencies including iron, riboflavin, zinc and vitamin $B_{12}$ (Freire et al., 1992; Freire et al., 1988; Berti et al., 1997; Macdonald, 1999b).

A search for options to improve food security has led the Ecuadorian government to re-introduce native Andean crops such as the highly nutritious pseudo-cereal, quinoa (*Chenopodium quinoa*) to the production and consumption system. Formerly a staple of the Incan diet, quinoa was marginalized and replaced primarily by barley as a subsistence crop following the Spanish Conquest. Urban demand for the crop, however, has recently increased partly due to quinoa's rich nutrient profile which includes high-quality protein, vitamin E, vitamin C, thiamin, riboflavin, folic acid, phosphorus, magnesium, iron, zinc, and copper (Ruales Nájera, 1992; Koziol, 1990).

The focus of the present study was to determine whether nutritional improvements occurred in three Indigenous communities following a re-introduction of quinoa.

The objectives of the present study are as follows:

1) to compare the household resource base, production systems, and income between quinoa-producing families and a randomly selected group of non-quinoa-producing families from the same communities;
2) to compare dietary intake and anthropometric status of the female head of household and one index child between these same groups, and
3) if differences existed between these groups, to control for potential confounding by applying multivariate analyses including known predictors of diet and anthropometric status in this population (Macdonald, 1999b).

## MATERIALS AND METHODS

i) Study Design, Sampling and Research Team:

The design employed was cross-sectional with repeated measures. A group of quinoa-producers residing in three communities was compared to a group of non-quinoa-producers in the same communities over two seasons (pre-harvest and post-harvest). The research compared household composition, socio-economic status, farming system characteristics, income, health practices, morbidity, diet and anthropometric status between the groups over four study rounds.

The study was conducted in the Indigenous communities surrounding the town of Guamote, Province of Chimborazo, Ecuador. The research universe was comprised of households with access to a quinoa credit and technological package offered through a rural microenterprise. During the research year, the majority of producers were clustered in four communities, the leaders of which were approached with regards to study participation. Community meetings were held to explain the objectives of the research, methods to be employed (including confidentiality), benefits, and a chronogram of activities. Following these meetings, three communities agreed to participate and community leaders provided written informed consent. Each family sampled for the study gave oral consent at the time of the first interview. The protocol was approved by an Ethics Review Board at McGill University.

Because the number of quinoa-producers was lower than initially anticipated, all producers were selected in place of random sampling. As community of residence is expected to exert an influence on nutritional status (access to health and social services, distance from markets, environmental conditions), the comparison group of non-quinoa-producers was randomly selected from a population census of the same communities. Inclusion criteria included maintaining primary residence within the community and possession of less than 10 hectares of land. The non-response rate was 14% and the final sample consisted of 104 households and 181 research subjects (the focal female and one child from approximately 2/3 of households). The index child was identified as the youngest child in the household not currently breast-fed and under 10 years of age. Only one child was studied per household to avoid violation of the independence assumption required for most statistical tests. The sample was balanced in terms of quinoa-producers and non-producers.

Between the pre-and post-harvest rounds of data collection, 14 families dropped out of the study and 1 had missing data, leaving a final sample size of 89 (44 quinoa-producers and 45 non-quinoa-producers) with complete information. Statistical analyses produced no evidence of differences in key characteristics such as age, education, family size and socio-economic status between those who completed the study and those lost to follow-up (data not shown).

The research team, their training and pre-testing of methods have been described previously (Macdonald, 1999a; Macdonald, 1999b). The team was comprised of four Indigenous women from the study communities who were bilingual (Spanish and Quichua), literate, and possessed at least primary-level education. The team was responsible for the administration of questionnaires, 24-hour recalls of dietary intake and anthropometric measurements. They were trained in the application of standardized research protocols for six weeks prior to data collection by the primary author and again for one week prior to the post-harvest rounds. All methods were pre-tested with approximately 20 families not participating in the study. Interviews were conducted in the local language, Quichua, and responses were transcribed in Spanish.

ii) Household Socio-economic, Farming System and Health Variables:

Household composition, socio-economic and health variables were measured with gender-disaggregated questionnaires (male and female heads of household interviewed separately) and observation as detailed in Macdonald (1999b). Pre-harvest questionnaires focused on household composition, dwelling characteristics, sanitation, the farming system, income streams and spending patterns, morbidity and reproduction. Post-harvest questionnaires sought information regarding yields, fate of yields (subsistence versus commercialization), animal production, and morbidity patterns.

Land holdings and the farming system were reported by the male head of household and cross-checked with recall of the area of crops produced. Incomes were reported by source and then validated by multiplying an individual's occupation by local wage rates and by multiplying crops/livestock sold by market prices (monitored bi-weekly). Incomes were also validated with expenditures. Female and male incomes were reported separately in their respective questionnaires. Socio-economic status was estimated via Principal Components analysis of a number of wealth markers including land, livestock, housing and durable goods. This analysis is presented in Macdonald (1999b) and resulted in two distinct concepts of socio-economic status: farming wealth and modern lifestyle. The farming wealth component was comprised of land and small livestock ownership, as well as land-in-cultivation during the study year; the modern lifestyle component captured aspects of durable goods ownership and housing characteristics (Macdonald, 1999b). Morbidity was measured by recall; women reported the occurrence, severity and duration of five symptoms characteristic of either gastro-intestinal and/or respiratory illness during the previous two weeks. These symptoms included diarrhea, fever, vomiting, cough and difficulty breathing. Illness for both the index child and the woman was recalled, measured both pre- and post-quinoa-harvest.

iii) Dietary and Anthropometric Variables:

The measurement of dietary and anthropometric variables are described in Macdonald (1999a) and Macdonald (1999b). Food intake over the previous 24 hours was reported by the female head of household according to standardized protocols. Children's intakes were recalled by their mothers. Four days of intake were recorded for both women and children over the agricultural year; two pre-quinoa-harvest and two post-harvest. Anthropometric measurements (height, weight, mid-upper arm circumference or MUAC and triceps skinfold) were made in accordance with standardized methods (Lohman et al., 1991; Gibson, 1990) and were conducted in a central location in each community.

iv) Data Entry and Analysis:

Data entry was conducted by a single clerk to eliminate inter-clerk coding errors. Questionnaire and anthropometric data were entered with the EPI INFO 6 program, Version 6.02 (CDC/WHO, 1994) and dietary data with the Worldfood Dietary Assessment System, Version 2 (University of California at Berkeley, 1996). Children's heights and weights were converted to standard deviation scores relative to the NCHS/WHO growth reference with EPI INFO 6. The nutrient content of diets was calculated with the Worldfood system applying Ecuadorian and Mexican food composition data (Ministerio de Salud Pública del Ecuador, 1988; University of California at Berkeley, 1996; Koziol, 1990; Ruales Nájera, 1992; Galwey et al., 1990; Gross et al., 1989). All data were exported to the SAS statistical system for analysis (Version 6.12) (SAS Institute Inc., 1996).

Data analysis for the household socio-economic, dietary and anthropometric variables is discussed in Macdonald (1999a) and Macdonald (1999b). Dietary intake data were averaged over the four days to estimate usual intakes of foods, food groups and nutrients. Anthropometric indices of body mass index (BMI) and arm fat area (AFA) were calculated according to standard formulae (Frisancho, 1990).

All variables were tested for normality with SAS univariate and normal probability plot procedures. For group comparisons (quinoa versus non-quinoa producers), either the Student's t-test (parametric) or Wilcoxon's Rank Sum Test (non-parametric) was performed depending on the distribution. For multivariate analyses, the effect of quinoa production was tested in a model with other demographic and socio-economic measures (Macdonald, 1999b) to predict nutrient intakes (energy, animal protein adjusted for energy, micronutrients) and anthropometric status (women's MUAC and AFA). Multivariate analyses were performed with PROC REG in SAS.

**RESULTS**:

**Household Economy**:

Household composition and economic resources among the quinoa-producing and non-producing groups are presented in Table 1. Comparing these characteristics between the groups is essential as the study design is observational and therefore subject to a self-selection bias with regards to membership in the quinoa-producing group. Statistical analyses confirmed that quinoa-producing households had more members, more land, more land-in-cultivation, greater cropping diversity during the study year, and pursued a modern lifestyle to a greater extent than non-producers. The age and education of the household heads as well as the number of small children did not differ between the groups.

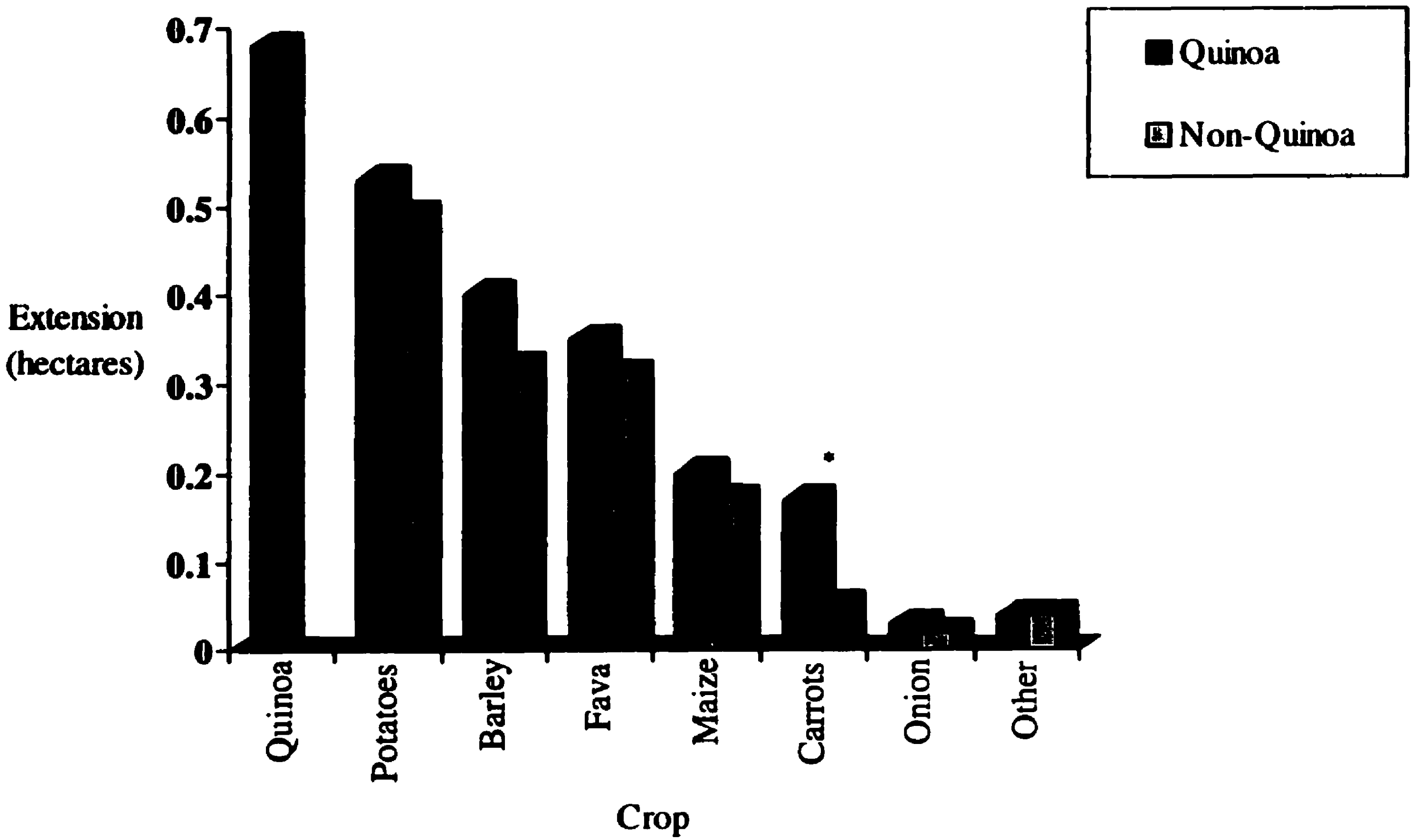
Table 1: Household Profile of Quinoa-Producing and Non-producing Groups (mean±s.d.)

| VARIABLE | QUINOA PRODUCERS (n=44) | NON-QUINOA PRODUCERS (n=45) |
|---|---|---|
| household size[1] | 5.20 (1.67) | 4.51 (1.84)* |
| number of children <6 years[2] | 1.07 (1.23) | 0.95 (0.95) |
| index child's age (months)[1] | 62.92 (28.06) | 58.53 (27.98) |
| male head's age (years)[1] | 42.15 (12.07) | 42.70 (14.54) |
| male head's education (years)[2] | 3.82 (3.79) | 3.51 (3.61) |
| female head's age (years)[1] | 40.70 (11.91) | 38.70 (14.88) |
| female head's education (years)[2] | 1.88 (2.60) | 2.16 (2.87) |
| land owned (hectares)[1] | 3.16 (2.04) | 2.10 (1.31)*** |
| land in cultivation (hectares)[1] | 2.68 (1.63) | 1.73 (1.19)*** |
| number of crops[1] | 4.73 (1.89) | 3.77 (2.50)** |
| farming wealth factor (standardized)[1] | 0.12 (0.85) | -0.03 (0.96)*** |
| modern lifestyle factor (standardized)[1] | 0.27 (0.98) | -0.35 (0.78)*** |

[1]=Student's T-test [2]=Wilcoxon's Rank Sum Test
Significance: *=p≤0.10, **=p≤0.05, ***= p≤0.01

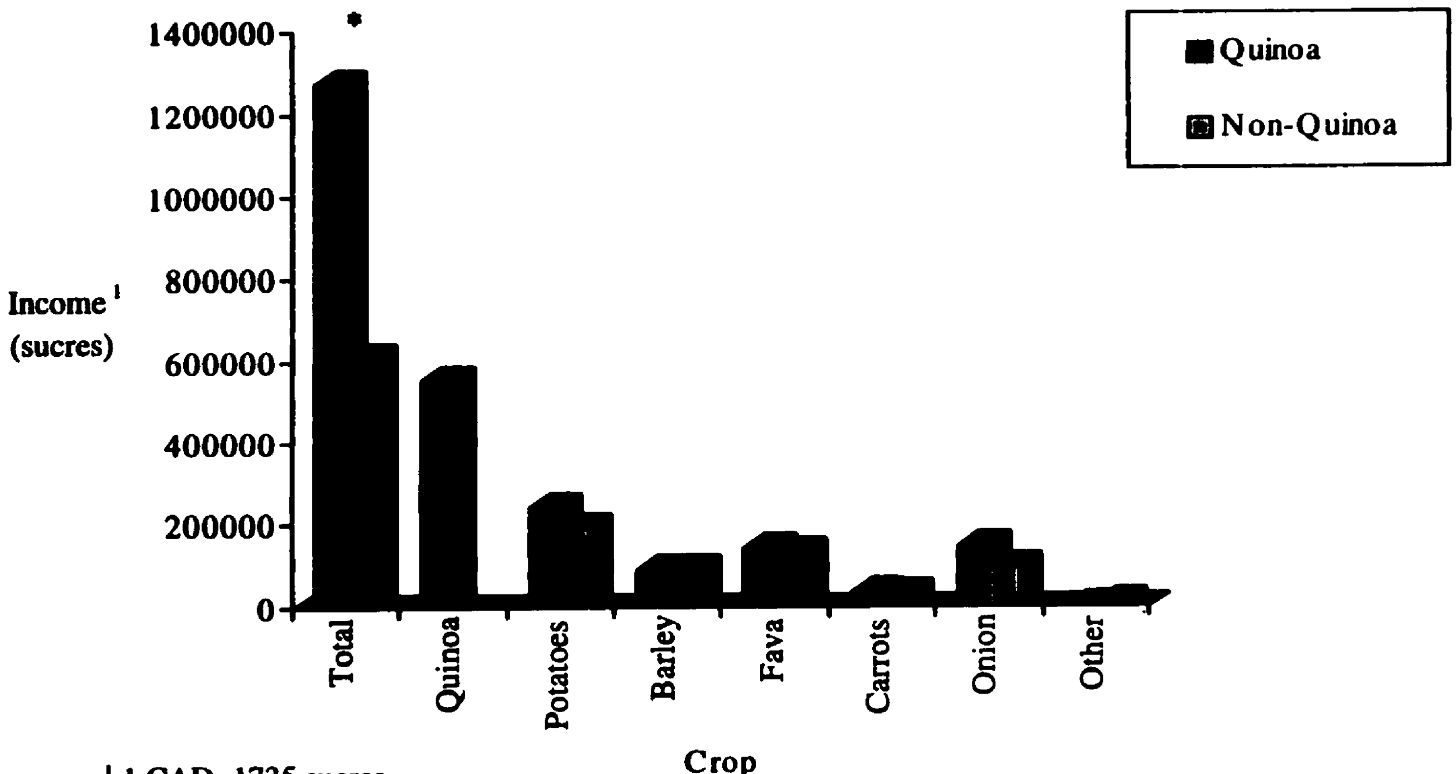
Figures 1 and 2 contrast cropping patterns and income between the two groups. In terms of the agricultural system, both groups produced a wide variety of crops with potatoes, barley and fava beans prominently featured. Interestingly, quinoa-producers and non-producers maintained an identical cropping portfolio with quinoa the sole exception. That is, quinoa producers, because they owned more land, were able to maintain the traditional system but were also in a position to *add* quinoa to the cropping strategy, making it the largest parcel in their system. They were also able to dedicate more land to carrot production. Both quinoa and carrots are considered *cash* rather than *subsistence* crops (mean % of harvests sold were 70% and 80%, respectively) as

Figure 1: Agricultural Production Systems In Quinoa-Producing and Non-producing Groups




Significance: *=p<0.05

Figure 2: Crop Cash Income Generated by Quinoa-Producing and Non-producing Groups




[1] 1 CAD=1735 sucres

Significance: *=p<0.05

compared to barley (25% sold). Therefore, quinoa-producers appear to be more market-oriented than non-producers.

This market orientation is reflected in the finding that quinoa-producers generated higher agricultural cash incomes than non-producers (Figure 2). Notably, quinoa production itself was responsible for the difference in crop income, as cash generated from the remaining crops was identical between quinoa-producing and non-producing households.

There were no group differences in salaried or women's incomes (data not shown). The women's income result is not surprising as income was reported to be largely pooled between men and women. In the present study, only 15% of women reported separate incomes.

**Nutritional Status**

Tables 2 and 3 show the nutrient intakes of adult women and children in quinoa-producing and non-producing groups. For women, intakes in the quinoa-producing group were significantly higher for a host of nutrients including energy, protein, folate, riboflavin, vitamins A and E, calcium, iron and zinc. However, the quinoa women's diets were also significantly higher in phytates. The phytate-zinc molar ratio was calculated for the quinoa-producers' and non-producers' diets, and were found to be 21.05 and 22.07, respectively. Therefore, while the phytate content was increased in the quinoa-producing diet, the higher zinc level played a compensatory role, leading to a similar phytate-zinc ratio in the two diets.

As might be expected, quinoa-producing women consumed more quinoa than non-producers and quinoa itself appeared to be one of the key sources of a number of micronutrients. Quinoa's contribution to macro and micronutrient intakes relative to its contribution to energy intake was calculated for the days when it was consumed. On those days, quinoa contributed more protein (25.3%), vitamin E (56.3%), iron (42.2%), zinc (38.0%), calcium (35.2%), riboflavin (31.0%), and folate (30.3%) compared to its contribution to energy (18.3%), indicating that it is a relatively important source of these nutrients. In addition to consuming more quinoa, quinoa-producers also consumed more animal protein which also contributed to the observed higher intakes of micronutrients.

A similar analysis for children was completed (Table 3). It should be noted, however, that the sample size is small due to the absence of children in some households. For the children's diets, although some of the same trends were apparent, the differences were not as striking as those observed among women. For energy intake, the quinoa-producing children consumed approximately 100 kcal more per day which translated to a 10% difference in magnitude compared to a 20% difference among women. This difference in energy intake was not sufficient to be statistically significant given the sample size. In terms of diet quality, quinoa-producing children did have statistically higher intakes of folate, iron, zinc and phytates.

Table 2: Dietary Intake of the Female Head of Household in Quinoa-Producing and Non-Quinoa-Producing Groups (mean±s.d.)

| NUTRIENT | QUINOA PRODUCERS (n=42[P]) | NON-QUINOA PRODUCERS (n=43) |
|---|---|---|
| energy (kcal)[1] | 2767 (575) | 2432 (523)** |
| fat (g)[1] | 38.6 (13.8) | 35.1 (12.0) |
| protein (g)[1] | 76.5 (19.8) | 63.5 (16.6)** |
| folate (μg)[2] | 275 (93) | 221 (84)** |
| riboflavin (mg)[1] | 1.0 (0.3) | 0.8 (0.3)** |
| vitamin B12 (μg)[2] | 1.4 (0.9) | 1.0 (0.6) |
| vitamin A (RE)[2] | 918 (668) | 671 (619)* |
| vitamin E (TE)[2] | 2.5 (1.7) | 1.7 (1.2)** |
| calcium (mg)[1] | 357 (136) | 297 (112)* |
| iron (mg)[1] | 15.2 (4.1) | 12.4 (3.5)** |
| zinc (mg)[1] | 11.9 (3.1) | 9.7 (2.6)*** |
| phytic acid (mg)[1] | 2514 (630) | 2186 (556)* |
| quinoa/person/day (g)[2] | 36.3 (35.6) | 15.0 (27.5)*** |
| animal protein intake/person/day (g) | 17.7 (12.0) | 13.0 (8.0)* |
| animal product intake (% of kcal) | 6.9 (4.4) | 5.9 (3.4) |

[1]=Student's T-test [2]=Wilcoxon's Rank Sum Test

[P] = sample size reduced as 4 households did not have an adult female

Significance: *=p≤0.05, **=p≤0.01, ***= p≤0.001

Table 3: Dietary Intake of Children in Quinoa-Producing and Non-Quinoa-Producing Groups (mean±s.d.)

| NUTRIENT | QUINOA PRODUCERS (n=30) | NON-QUINOA PRODUCERS (n=36) |
|---|---|---|
| energy (kcal)[1] | 1541 (416) | 1438 (417) |
| fat (g)[2] | 20.6 (8.1) | 20.9 (12.5) |
| protein (g)[1] | 41.0 (12.9) | 36.1 (12.0) |
| folate (µg)[1] | 144 (54) | 113.7 (41.1)* |
| riboflavin (mg)[1] | 0.6 (0.2) | 0.5 (0.2) |
| vitamin B12 (µg)[2] | 0.8 (0.6) | 0.7 (0.5) |
| vitamin A (RE)[2] | 402 (267) | 370 (339) |
| vitamin E (TE)[2] | 1.0 (0.8) | 0.7 (0.8) |
| calcium (mg)[2] | 210 (92) | 190 (83) |
| iron (mg)[1] | 8.5 (2.5) | 6.9 (2.0)** |
| zinc (mg)[2] | 6.5 (2.0) | 5.5 (1.7)* |
| phytic acid (mg)[1] | 1380 (419) | 1188 (346)* |
| quinoa/person/day (g)[2] | 19.8 (19.2) | 7.4 (11.8)*** |

[1]=Student's T-test [2]=Wilcoxon's Rank Sum Test
Significance *=p≤0.05, **=p≤0.01, ***= p≤0.001

A comparison of the women's and children's anthropometric status between the two groups is presented in Table 4. Quinoa-producing women had greater energy stores as measured by MUAC and AFA but not BMI. Similar to their macronutrient intake data, the anthropometric status of the two groups of children could not be distinguished. The mean height-for-age z-scores were low (< -2.00) reflecting the severe stunting commonly observed in Andean children (Leonard et al., 1993; Berti et al., 1998).

Table 4: Anthropometric Status of Quinoa-Producing and Non-Quinoa-Producing Groups

| VARIABLE | QUINOA PRODUCERS (n=25 for women; 26 for children) | NON-QUINOA PRODUCERS (n=28 for women; 25 for children) |
|---|---|---|
| women's BMI (kg/m$^2$) | 22.62 (2.31) | 22.44 (2.23) |
| women's triceps skinfold (mm) | 11.45 (3.35) | 9.80 (3.24) |
| women's MUAC (cm) | 26.01 (1.86) | 24.79 (2.48)* |
| women's AMA (cm$^2$) | 33.70 (6.54) | 31.29 (6.53) |
| women's AFA (mm$^2$) | 1388.89 (418.00) | 1159.31 (423.26)* |
| child HAZ | -2.56 (1.44) | -2.08 (1.48) |
| child WHZ | 0.18 (0.95) | 0.05 (0.61) |
| child WAZ | -1.42 (1.23) | -1.32 (0.82) |

Significance: *=$p \leq 0.05$

**Morbidity**

Wilcoxon's Rank Sum Test was conducted to test for group differences both pre- and post-harvest in the number of days ill with vomiting, diarrhea, fever, cough or difficulty breathing. No significant differences were observed in women or children (data not shown).

**Multivariate Models**

As was demonstrated in Table 1, several variables including family size, land ownership and modern lifestyle appeared to pre-dispose households to adopt quinoa production. These same variables have been previously observed to predict dietary and/or anthropometric variables in this sample (Macdonald, 1999b). Multivariate models are presented in Tables 5 and 6 which test the effect of quinoa production adjusted for these potentially confounding variables. As effects were more demonstrable among adults, these models were analyzed for women's diet and anthropometric status.

Table 5: Multivariate Models for Women's Diet Quantity and Quality (n=85)

| | Energy (kcal) | | Animal Protein Intake (g/1000 kcal) | | Iron Intake (mg/1000 kcal) | | Zinc Intake (mg/1000 kcal) | |
|---|---|---|---|---|---|---|---|---|
| | β-coefficient | Prob>T | β-coefficient | Prob>T | β-coefficient | Prob>T | β-coefficient | Prob>T |
| intercept | 2555.94 | <0.01 | 5.50 | <0.01 | 4.41 | <0.01 | 3.85 | 0.01 |
| quinoa production (0=no; 1=yes) | 228.41 | 0.06 | 0.62 | 0.43 | 0.52 | 0.05 | 0.27 | 0.06 |
| modern lifestyle factor (standardized) | N/A | N/A | 0.95 | 0.02 | -0.32 | 0.03 | -0.10 | 0.21 |
| farming factor (standardized) | N/A | N/A | 0.87 | 0.04 | 0.05 | 0.72 | 0.11 | 0.16 |
| family size (number) | -60.98 | 0.08 | -0.16 | 0.46 | 0.03 | 0.72 | -0.03 | 0.46 |
| Probability Value | 0.06 | | 0.02 | | 0.05 | | 0.04 | |
| $R^2$ | 0.06 | | 0.13 | | 0.10 | | 0.11 | |

Table 6: Multivariate Models Predicting Women's Anthropometric Status (n=45)

| | MUAC (cm) | | AFA (mm²) | |
|---|---|---|---|---|
| | ß-coefficient | Prob>T | ß-coefficient | Prob>T |
| intercept | 23.82 | <0.01 | 886.68 | <0.01 |
| quinoa production (0=no;1=yes) | 1.16 | 0.12 | 148.45 | 0.26 |
| modern lifestyle factor | 0.49 | 0.27 | 126.09 | 0.12 |
| family size (number) | -0.06 | 0.79 | 26.20 | 0.51 |
| Probability Value | 0.17 | | 0.07 | |
| $R^2$ | 0.11 | | 0.15 | |

Table 5 presents models for some of the nutrients where group differences were demonstrated in bivariate analyses. Quinoa production is presented as the first independent variable, allowing for a comparison of the effect of the agricultural production variable adjusted for potential confounders. It has been shown previously that modern lifestyle and farming wealth are not correlated with energy intake and farming wealth is not correlated with anthropometry in this data set (Macdonald et al., 1999b). Therefore, these variables are not included in those models.

What is immediately apparent is that for energy, iron and zinc, quinoa production remained a significant predictor when controlling for self-selection bias (modern lifestyle, farming wealth and family size). Similar models were tested for all the micronutrients where group differences were observed with borderline quinoa effects ($p<0.15$) apparent for folate, riboflavin and vitamin E. Conversely, the model generated for animal protein intake (adjusted for energy) (Table 5) showed no effect of quinoa production when adjusted for modern lifestyle, farming wealth and family size suggesting that the group difference reported in Table 2 was confounded by these variables. Similarly, when protein and calcium were modeled there was no quinoa effect.

In terms of the non-agricultural variables, for energy, there is a negative association with family size. Furthermore, for iron intake, it is noteworthy that a strong negative association was observed with modern lifestyle. This result is somewhat puzzling but Weismantel (1992) reported that those pursuing a modern lifestyle are more likely to consume processed grains such as white rice and bread in lieu of subsistence crops such as barley. Spearman correlations between modern lifestyle and intakes of these foods were generated and found to be significant for bread (0.27, p=0.01), noodles (0.24, p=0.03) and barley (-0.28, p=0.01). Therefore, the higher intakes of unrefined grains among those with a more traditional lifestyle may increase their intakes of iron.

Women's MUAC and AFA were also modeled (Table 6). Once adjusted for self-selection bias, there was no clear quinoa effect on anthropometric status, indicating that the bivariate relationship may have been confounded.

## DISCUSSION

With a few notable exceptions (Kaiser and Dewey, 1991a; Kennedy and Cogill, 1987), nutritional evaluations of agricultural projects have excluded women as research subjects and have limited the outcomes of interest to energy intakes and children's anthropometric status. The present study is unique both in its focus on women's nutrition as the main variables of interest and in the crop production strategy analyzed.

Quinoa has been the object of considerable attention from health food consumers and food system researchers alike due to its nutritional properties, adaptability to difficult growing conditions and the essential place accorded this pseudo-cereal in the Incan diet. In fact, it is this mix of properties that makes quinoa production such a promising agricultural alternative from a food security perspective. The agronomic traits allow for high yields while the nutritional profile and the romanticism associated with the "ancient grains" optimize marketability. As a result, the present research demonstrated that in comparison to non-adopting families, households that produced quinoa during the study year had higher incomes derived from crop production but also possessed an average of 1.90 kg of quinoa per week for household consumption (data not shown). Furthermore, quinoa-producing women consumed significantly higher amounts of most nutrients compared to non-quinoa-producing women. The increased intakes of energy, zinc, iron and folate were particularly striking and the effect of quinoa remained significant when adjusted for confounding variables in multivariate models. Children between the age of 2 and 10 years also appeared to be at a nutritional advantage over their non-quinoa-producing peers as they consumed higher levels of these same micronutrients. It should be noted that compromised micronutrient intakes and status have been reported among both women and children in Ecuador (Berti et al., 1997; Macdonald, 1999b; Freire et al.,

1988) making the observed dietary impacts of high relevance to nutrition in the region.

The increased energy intake (approximately 350 kcal) among the quinoa-producing women warrants further comment. What is unclear is whether quinoa production via its income and food effects increased food security or whether quinoa producers worked harder and therefore consumed more calories. As is discussed later, quinoa production does require a heavier labour input than barley, but these inputs were reported to be covered off by neighbouring families as part of food-labour exchanges. The energy expenditure issue and the lack of difference in weight between the groups requires further study.

There exists an extensive body of literature examining the nutritional outcomes of cash-cropping policies. For the most part, studies have indicated that incomes almost invariably rise but that there is significant leakage of effects to the point where discernible improvements in children's nutritional status have rarely been observed (Kennedy and Cogill, 1987, Dewey, 1981; Bouis and Haddad, 1990). The factors most often cited as those responsible for the dilution of nutritional effect include low income elasticity of energy intake and a lack of improvement in health and sanitation systems (Kennedy and Cogill, 1987; von Braun et al., 1989; Bouis and Haddad, 1990). Two additional possibilities may be added to the list in light of the present results: 1) that some agricultural schemes may be related to women's nutritional status but not to that of children and, b) micronutrient intakes were higher among project participants but unmeasured.

Like the present results, studies that have included women as research subjects have demonstrated a divergence in effects between adults and children (Kaiser and Dewey, 1991a; Kennedy and Cogill, 1987). In this study, the lesser magnitude of impacts observed among children for most nutrients may be attributed to the small sample of children studied and the large degree of error normally associated with consumption data. Power calculations were performed for the children's data and showed that the power to declare the observed difference in energy intake as significant was just 17%. Conversely, 88% power existed for declaring the difference in women's energy intake as significant. It should be noted, however, that the magnitude in group energy differences did vary between women (20%) and children (10%). What is possible, therefore, is that some of the difference in effects is real, perhaps related to variation in the gastric capacity of different family members. Berti et al (1997) reported that the low nutrient density of the Andean diet coupled with children's limited gastric capacity as well as their increased nutrient requirements yielded higher prevalences of deficient intakes in this age group compared to adults.

This study clearly showed that the linkages between agriculture and nutrition are complex, and fraught with analytical difficulties including self-selection bias in technology adoption, intricate household economic strategies, and the multi-factorial etiology of malnutrition. Certain characteristics were shared by those farmers who chose to include quinoa in their production strategies compared to a random sample of non-producers. Those traits included a larger household size and ownership of approximately 1 more hectare of land. In fact, reflecting the risk-aversion strategy commonly observed among developing country populations (von Braun, 1995), possession of enough land to maintain the traditional cropping pattern appeared to be a pre-condition of quinoa adoption. In their study of the nutritional impacts of sorghum production in Mexico, DeWalt et al. (1990) observed that variables such as land ownership and total income were more important correlates of children's weight-for-age than crop choice. Therefore, for research purposes, establishing the directionality of associations is of prime importance and attributing effects is difficult, if not impossible, especially since baseline data were unavailable.

A weakness of the present study was the lack of time allocation data. These data were part of the original protocol but participants denied consent due to intrusiveness. An evaluation of the quinoa project conducted in 1994 (Macdonald, 1994), however, included qualitative interviews which addressed this issue. In terms of preparation time, the variety of quinoa produced is "sweet" (low-saponin content) requiring only 10 minutes of washing time compared to 30-60 minutes for high-saponin varieties. In terms of agricultural labour demand, it was reported that quinoa production does require more days of labour compared to the subsistence cereal, barley. In particular, additional hilling and weeding is required, labour traditionally supplied by women and children (Bebbington, 1990). An estimated 4-5 days of extra labour per hectare is required (Macdonald, 1994). This labour, however, appeared to be covered by non-quinoa-producing families in the community, who then received a portion of the harvest in return. As a result, the non-quinoa-producers consumed 15g of quinoa/person/day. Harvest-sharing with the more vulnerable families in the community and reinforcement of non-monetized food-labour exchanges may be viewed as positive impacts of quinoa production (Bebbington, 1990). Regardless, it is unlikely that the increase in labour demand associated with quinoa significantly reduced the time available for breast-feeding or child care among the producing families.

Finally, this micro-level analysis indicated that at least in the short-run, positive nutritional outcomes were associated with quinoa production. While it is impossible to definitively untangle cause and effect relationships with these cross-sectional data, it can be said that no negative impacts appear to have occurred. Phytate intake was increased in quinoa-producing households but was accompanied by increased intakes of minerals to compensate for reduced bioavailability. What cannot be determined, however, from short-run surveys are the long term impacts of quinoa's re-introduction, including the sustainability of the positive impacts observed (Dewey, 1989; von Braun, 1995). For example, the current income effects associated with quinoa production may be diminished as supply increases or if domestic and international demand is unstable or short-lived. Furthermore, it appears that the wealthier farmers in this region are the "experimenters" or first wave adopters of new technology. It is difficult to predict the outcomes for smaller producers over the long-run, especially if quinoa substituted for another crop in the subsistence system.

# CONCLUSIONS

This study provides evidence that the nutritional impacts of agricultural projects and policies may be seriously under-estimated when the analysis is restricted to effects related to energy intake and children's nutritional status. It was also demonstrated that production and commercialization of food-based rather than cash crops allow for a win-win situation in that farmers both generate income and maintain nutritious foods for home consumption. Although the cause and effects relationships could not be definitely established, these data indicated that women in quinoa-producing households consumed higher amounts of energy and some micronutrients than similar women in non-quinoa-producing households. Most of the dietary effects remained significant when adjusted for confounding variables.

Quinoa-producers, however, were also wealthier farmers in that they had greater access to agricultural assets and therefore were better able to manage risk. This wealth allowed these households to consume more animal products and for women to maintain larger arm energy stores. Therefore, in terms of an intervention to improve food security, the quinoa production strategy did not reach the most vulnerable groups within communities. The inability of the most marginalized groups to take advantage of technological innovation must be kept in mind as agronomists, nutritionists and other development specialists strive to improve the nutritional status of the malnourished.

# EPILOGUE TO MANUSCRIPT C

Manuscript C addressed the fundamental research question of the thesis: Do women in households producing quinoa have increased intakes of nutrients and larger protein-energy stores compared to women in non-quinoa-producing households? Simple bivariate statistics demonstrated that indeed, these households generated more cash income from crop sales, that a sizeable amount of quinoa was available for household consumption, that women's diets were superior in terms of quantity and quality, and that they maintained larger arm energy stores. Manuscripts A and B were essential for identifying key nutritional problems in the communities and therefore, the relevance of the impacts observed, as well as improving the analytical framework to enhance the credibility of the conclusions reached.

Once these associations were adjusted for the confounding effects identified in Manuscript B, however, a different picture emerged. While quinoa production was still associated with energy and some micronutrient intakes, associations with animal protein intake and anthropometric status were spurious. Quinoa producers owned more land and led a modern lifestyle to a greater extent than non-quinoa producers and it was these characteristics which were more highly linked with some of the nutritional outcomes. What was apparent then, is that quinoa production as an intervention, reached those of a higher socio-economic status in communities, leaving those most vulnerable relatively untouched. Nutrition and agriculture planners must take these biases into account and realize that poverty, the root cause of malnutrition, also precludes participation in programs aimed at its alleviation.

# CHAPTER 7

## GENERAL DISCUSSION AND CONCLUSIONS

In developing country societies, food production, processing, marketing, acquisition and distribution are often counted among women's responsibilities. In addition, women are normally charged with ensuring the social and physical reproduction of the household and their complement of human capital (education, health and nutritional status) is essential for success. Despite women's pivotal role in household systems, evidence documenting the economic processes and livelihood patterns that are best associated with their nutrition is sparse. Given that a lack of physical and economic resources is recognized as the distal determinant of malnutrition (UNICEF, 1998), provision of this information is of paramount importance.

The central purpose of this research was to determine whether an agricultural project which hoped to improve nutrition among rural women in Highland Ecuador achieved that goal. The purpose was broken down into three questions that were answered sequentially: a) did energy stress exist among these women b) were diets sufficient in quality and what socio-economic processes were best associated with women's diet and anthropometric status; and c) was the agricultural project positively associated with women's nutritional status when adjusted for these socio-economic processes.

The first study provided evidence of subtle energy stress among these women and demonstrated that BMI may be of insufficient sensitivity to detect these effects.

Women past their reproductive years weighed 3.66 kg less and had lower arm energy stores than their younger counterparts. They consumed approximately 300 calories less per day and they reported more days ill with respiratory symptoms. Seasonal differences in anthropometric status and food intake were also reported for women of all ages with lower intakes of most micronutrients evident just four months post-harvest.

The seasonal drop in vitamin and mineral intake was particularly noteworthy given that intakes of several of these nutrients were shown to be inadequate in the second study. These shortfalls existed for calcium, iron, riboflavin, as well as vitamin $B_{12}$. Socio-economic variation in dietary quality was also documented in the second manuscript. Commonly measured proxies for socio-economic status were subjected to Principal Components analysis and two different constructs were identified: modern lifestyle and farming wealth. Both socio-economic indicators were associated with diet quality as measured by animal protein intake (adjusted for energy) but were not associated with energy intake. Accurately measuring socio-economic status is therefore critical for correctly attributing effects to interventions in international nutrition research.

The attribution issue was underscored in the third study which sought to identify the nutritional impacts of the re-introduction of quinoa to the agricultural production system. Bivariate statistics demonstrated that women from quinoa-producing households consumed more calories, more micronutrients and possessed larger arm energy stores when compared to a quasi-control group of non-quinoa-producers. However, households that adopted quinoa production also had larger families, possessed more land, produced a broader portfolio of crops, and pursued a more modern lifestyle. Controlling observed nutrition-related group differences for these sources of bias was essential in reaching valid conclusions. These analyses indicated that quinoa production was related to energy, zinc, folate, riboflavin and iron intakes but that animal protein and anthropometric effects were spurious.

Unfortunately, the cross-sectional design of this study ruled out definitely identifying cause and effect relationships in the data. The randomized clinical trial is considered to be the "gold standard" in attributing effects but inappropriate in this setting as it is not feasible to "randomly" select households to adopt technology. A random design would also be in direct opposition to the spirit of the research which was to observe in as natural setting as possible the real-life nutritional impacts of agricultural opportunities. For example, randomization of the "intervention" would have precluded the important findings regarding which farmers could adopt this technology and which could not bear the risk. It is just this type of research, that is studies which characterize the socio-economic and physical environment in which nutrition occurs, which is lacking in the literature.

Methodological lessons were learned that may aid in the future conduct of this type of research. Firstly, this study would have been strengthened considerably with true baseline (pre-intervention) data. Baseline data would have provided important information regarding the prior use of the land destined for quinoa production and the previous diet of the quinoa producers. Unfortunately, the project started two years prior to this research. Secondly, several of the key variables examined are notoriously difficult to quantify. Incomes, possession of land and goods, as well as diet, are all subject to intentional or unintentional response bias. In this case building the trust of the study participants and careful training and standardization of the research assistants was critical. The study benefited greatly from the good will of community leaders and built on the agricultural project which had already been in place for two years. The research project attempted to return that good faith by hiring local research assistants, training the assistants as nutrition promoters, donating equipment to the quinoa microenterprise and making a small gift to improve community centres. The Indigenous assistants aided in the collection of excellent data as they conducted all the research in Quichua and were able to assess accuracy post-hoc. It is suggested that collecting such high-quality, sensitive data without building up relationships of trust would have been impossible.

The collection of anthropometric data was also invaluable in validating the indirectly observed data. Weights and ages allowed calculation of basal metabolic rates which when compared to caloric intakes helped to gauge the plausibility of recalled dietary data. Arm energy stores were associated both with animal protein intakes and with variables measured by questionnaire. Trends were always in the expected direction, that is, those with better diets or more assets were better off in terms of anthropometric stores. Importantly, the arm energy measures were as good as, if not better than, BMI for evaluating impacts across the sample and over time. Exclusive reliance on arm measures would have increased participation in the anthropometric section of the study as these data could have been collected in households and not in a central location requiring travel on behalf of the subjects. It is suggested that further validation work be conducted, including the establishment of valid cut-off points, to determine whether arm energy stores can replace BMI in field settings.

This research provided illustrative evidence of how agricultural initiatives can be positively associated with women's nutritional status. Given the importance of gender control of income, women's education, women's labour demand/energy expenditure and breast-feeding to both women's and children's nutrition, international nutritionists should forge stronger alliances with gender specialists, anthropologists and economists to advocate for increased participation of women in development projects and programmes. This should not only be in the form of special women's projects and programmes but as an overall mainstreaming of women and nutrition in projects that directly impact or have the potential to impact women's lives and help them fulfill their multiple roles. Of course, the already heavy demands on women's time and energy should always be kept in mind in the design of such projects. The crux of the issue is that with a clearer understanding of the means by which women interact with their socio-economic, cultural and physical environment, nutritionists can help to identify and then reinforce those processes associated with positive nutritional returns.

Although quinoa production was associated with some nutritional impacts, the benefits were somewhat modest in that micronutrient intakes remained suboptimal for most of the sample and differences in anthropometric status directly attributable to the project were not apparent. The research indicated that in order to really address the nutritional problems in these communities, increased economic and/or physical access to micronutrient dense foods will be required (Berti et al., 1997). It is possible that the income generated from quinoa sales may contribute to this diversification in the diet over the long-run although the effects were not apparent in the short-run. Furthermore, given the high rates of stunting and morbidity observed among children and women, as well as the low level of sanitation in the communities, it can be speculated that substantial advancements in nutrition may be difficult to achieve in the absence of improvements in basic services.

Finally, the economic disparities among those who participated in the agricultural project and those who did not were striking. This research illustrated how development opportunities may exclude those most vulnerable. This is the reality of new technology adoption among the impoverished. A certain economic safety-net or threshold must exist in order for the food and income insecure to manage risk and make changes to their livelihood strategies. Planners need to take these "pre-conditions of adoption" into account when designing development projects. The positive message is that investments in nutrition will improve health, learning capacity, and work productivity, thus better arming populations to take advantage of opportunities in the future.

# CHAPTER 8

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# APPENDIX 1

## COMMUNITY CONSENT FORM

# APPENDIX 2

# QUESTIONNAIRES

**ESTUDIO SOBRE IMPACTOS NUTRICIONALES DEL PROYECTO "ICU"**
**RECORDACION DEL CONSUMO DE ALIMENTOS DEL DIA PASADO**

**INFORMACION REFERENCIAL:**
Código de la Encuestadora:______________________________
Fecha de la Entrevista (día/mes/año):______________________________
Nombre de la Encuestada:______________________________
Código____________ Comunidad______________________________

Por favor, trate de recordar todos los alimentos y bebidas que consumió ayer desde el tiempo que despertó. Primero, podría decirme todos los alimentos que consumió y después podríamos revisar la lista y podría decirme como preparó los alimentos, su origen y las cantidades que comió. Para ayudarle describir las cantidades, tengo una taza, un tazón, y cucharas. Comenzamos con el primer alimento del día. Qué fue el primer alimento que comió ayer después de se despertó? Qué comió después?.......

| COMIDA | ALIMENTO | FORMA DE PREPARACION/ INGREDIENTES/ORIGEN (H=producido por la familia; C=comprado; R=regalado; P=pago por trabajo u otros alimentos) | CANTIDAD |
|---|---|---|---|
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1. **Ud. Tomó algún tipo de suplemento de nutrientes ayer (ej. vitaminas?)**
   **1.______si 2.______no En el caso de "si", que tipo? ____________**
2. **Diría si su consumo de alimentos ayer fue un día típico?**
   **1.______si 2.______no En el caso de "no", porque?______________**

______________________________________________

## ESTUDIO SOBRE IMPACTOS NUTRICIONALES DEL PROYECTO "ICU"
## ENCUESTA DE JEFE DE FAMILIA

**INFORMACION REFERENCIAL:**

Código de la Encuestadora:________________________________________

Fecha de la Entrevista (día/mes/año):__________________________________

Nombre de la Encuestada:__________________________________________

Código____________ Comunidad__________________________________

### 1. CARACTERISTICAS DE LA FAMILIA:

1.1 Cuántas personas viven con Usted? (misma casa) ____________

| NOMBRES (incluya información sobre el jefe de familia) | PARENTESCO (a jefe de familia) | SEXO | EDAD | FECHA DE NACIMIENTO | ANOS DE ESCOLARI-DAD |
|---|---|---|---|---|---|
| el jefe de familia: | | | | | |
| | | | | | |
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Códigos:

Sexo: 1. Masculino 2. Feminino

Fecha de Nacimiento: día/mes/año

1.2 Cúal es su principal ocupación?

1._____ agricultura (ganadería) por su propia cuenta
2._____ agricultura (ganadería) como un jornalero
3._____ obrero en una fábrica
4._____ construcción
5._____ comerciante (en un local estable)
6._____ empleado de gobierno
7._____ maestro de escuela
8._____ artesanía por su propia cuenta
9._____ artesanía como un obrero
10.____ transportista
11.____ servicios (empleado, jardinero, guardian)

____________________________
(especifique)

12.____ otro ____________________________
(especifique)

1.3 Cúal es su ocupación secundaria?

1._____ no tiene
2._____ agricultura (ganadería) por su propia cuenta
3._____ agricultura (ganadería) como un jornalero
4._____ obrero en una fábrica
5._____ construcción
6._____ comerciante (en un local estable)
7._____ empleado de gobierno
8._____ maestro de escuela
9._____ artesanía por su propia cuenta
10._____ artesanía como una obrera
11._____ transportista
12.____ servicios (empleado, jardinero, guardian)

____________________________
(especifique)

13.____ otro ____________________________
(especifique)

1.4 Ha permanecido fuera de la comunidad con el objeto de trabajar por más de 2 semanas en los últimos 6 meses?

1.______ si 2._____ no (en el caso de "no", pase a la pregunta 2.1)

1.5 Cuántas semanas trabajó fuera de la comunidad en los últimos 6 meses?

______________________

1.6 En que trabajaba (ocupación)? 1. ____________________
2. ____________________
3. ____________________

**2. VIVIENDA:**

2.1 Materiales predominantes en la vivienda (verifique con observación)

a) techo o cubierto

1._____ loza de hormigon
2._____ eternit
3._____ zinc
4._____ paja
5._____ teja
6._____ otros materiales ______________________
(especifique)

b) paredes exteriores

1._____ hormigon, ladrillo, bloque
2._____ adobe
3._____ madera
4._____ otros materiales ______________________
(especifique)

c) piso

1._____ entablado
2._____ ladrillo o cemento
3._____ tierra
4._____ otros materiales ______________________
(especifique)

2.2 Tiene su casa servicio de luz eléctrica? (verifique con observación)

1.______si 2.______no

2.3 Como se abastece de agua? (marque la alternative más usada)

1._____ lluvia
2._____ río
3._____ acequia
4._____ pozo
5._____ vertiente
6._____ entubada fuera de la vivienda
7._____ entubada dentro de la vivienda
8._____ potable fuera de la vivienda
4._____ potable dentro de la vivienda
5._____ cisterna o ajibe

6._____ otro ______________________________ (especifique)

2.4 El servicio higiénico que usted dispone es: (marque la alternativa más usada)

1._____ excusado de uso exclusivo (verifique posesion de un excusado ______ si _______ no)

2._____ excusado de uso comun

3._____ letrina (verifique posesion de una letrina _____si ______no)

4._____ campo abierto

2.5 Como elimina la basura? (marque la alternativa más usada)

1._____ entierro

2._____ incineración (quemar)

3._____ aire libre

4._____ recolector público

5._____ otro ____________________________ (especifique)

2.6 Cuales de los siguientes artículos poseen Uds. y en que cantidad? (marque todos los que tengan incluyendo la cantidad, verifique con observación si es posible)

| | |
|---|---|
| 1._____ bicicleta | 6.______ carro/camioneta |
| 2._____ radio | 7.______ televisión |
| 3._____ cocineta | 8.______ refrigerador |
| 4._____ muebles (camas) (mesas, sillas) | 9.______ licuadora |
| 5._____ equipo de sonido | 10.______ bomba de fumigar |

## 3. TENENCIA DE LA TIERRA:

3.1 Qué cantidad de tierras tiene Ud. en propiedad? (Anote la cantidad y el nombre de la unidad de medida que le de el agricultor) ______________________

3.2 Qué cantidad de tierras toma en arriendo Ud.? (Anote la cantidad y el nombre de la unidad de medida) ______________________

3.3 Qué superficie cultiva Ud. este año? (Anote la cantidad y el nombre de la unidad de medida) ______________________

## 4. AGRICULTURA / GANADERIA

4.1 CULTIVOS (Complete el siguiente cuadro con el agricultor usando estas preguntas)
Cuales cultivos sembró Ud. este año y en que cantidad? Ha cosechado algunos cultivos? Cuales fueron los rendimientos? Trate de estimar que parte vendió Ud. y que parte quedó con Ud. para el autoconsumo.

| CULTIVO | CANTIDAD SEMBRADA (la medida que le de el agricultor) | RENDIMIENTOS OBTENIDOS (incluya la medida) | CANTIDAD VENDIDA (incluya la medida) | CANTIDAD PARA AUTO-CONSUMO (incluya la medida) |
|---|---|---|---|---|
| papa | | | | |
| cebada | | | | |
| haba | | | | |
| chocho | | | | |
| centeno | | | | |
| quinoa | | | | |
| arveja | | | | |
| lenteja | | | | |
| maiz | | | | |
| melloco | | | | |
| oca | | | | |
| ajo | | | | |
| cebolla colorada | | | | |
| cebolla blanca | | | | |
| trigo | | | | |
| zanahoria | | | | |
| | | | | |
| | | | | |

4.1 PRODUCCION PECUARIA (Complete el siguiente cuadro con el agricultor usando estas preguntas)
Que tipos de animales tienen en la finca y en que cantidad? Ha vendido algunos animales en el mes pasado? Ha consumido la familia algunos animales en el mes pasado?

| ESPECIE DE ANIMAL | CANTIDAD QUE POSEEN ACTUALMENTE | CANTIDAD VENDIDA (mes pasado) | CANTIDAD DE CONSUMO FAMILIAR (mes pasado |
|---|---|---|---|
| bovinos (vacas, toros) | | | |
| ovinos (borregos, ovejas) | | | |
| aves de corral | | | |
| cuyes | | | |
| chanchos | | | |
| caballos | | | |
| burros | | | |
| | | | |
| | | | |

4.3 Pertenece a alguna organización de productores / organización campesina?
1._______si 2._____ no (en el caso de "no" pase a la pregunta 4.5)

4.4 Que tipos de organizaciones? (marque todas las alternativas mencionadas)
1._____ cooperativa de producción
2._____ cooperativa de comercialización
3._____ cooperativa de ahorro y crédito
4._____ organización política
5._____ organización de segundo grado
6 _____ otra_____________________ (especifique)

4.5 Ha tenido la visita de algun técnico en los últimos 6 meses?
1._______si 2._____ no
Si es "si", de quien?________________________________________
____________________________________________________________
____________________________________________________________
____________________________________________________________

4.6 Ha asistido a reuniones (cursos, talleres, etc.) de capacitación en los últimos 6 meses?
1._______si 2._____ no

Si es "si", a que eventos?________________________________________
________________________________________
________________________________________
________________________________________

**5. FUENTES DE INGRESOS:**

5.1 Que fuentes de ingresos ha tenido Ud. en el último mes? (solo el jefe de familia sin los ingresos de la esposa)

| FUENTES | CANTIDAD (sucres) |
|---|---|
| 1. venta de cultivos | ________ |
| 2. venta de animales | ________ |
| 3. venta de productos de animales (huevos, leche, abono, etc.) | ________ |
| 4. arrienda tierra | ________ |
| 5. arrienda pastos | ________ |
| 6. artesanía | ________ |
| 7. jornales (local)<br>-tipo de trabajo ________ (especifique)<br>- cuántos dias ________ | ________ |
| 8. salario fijo<br>-tipo de trabajo ________ (especifique)<br>- cuántos dias ________ | ________ |
| 9. jornales de trabajo migratorio<br>-tipo de trabajo ________ (especifique)<br>- cuántos dias ________ | ________ |
| 10. trabajo de sus hijos | ________ |
| 11.ahorros | ________ |
| 12 otros (especifique) | ________ |

| | |
|---|---|
| 1.________________ | __________ |
| 2.________________ | __________ |
| 3.________________ | __________ |
| 4.________________ | __________ |

**6. GASTOS:**

6.1 Cuánto gastó Ud. sobre los siguientes artículos en la **semana** pasada?
(solo el jefe de familia sin los gastos de la esposa)

| ARTICULO | CANTIDAD (sucres) |
|---|---|
| alimentos para la familia | __________ |
| alimentos para animales | __________ |
| combustible | __________ |
| transportación (por ejemplo bus) | __________ |

6.2 Cuánto gastó Ud. sobre los siguientes artículos en el **mes** pasado?
(solo el jefe de sin los gastos de la esposa)

| ARTICULO | CANTIDAD (sucres) |
|---|---|
| educación | __________ |
| servicios de salud | __________ |
| medicina | __________ |
| deudas | __________ |
| abono / químicos agrícolas | __________ |
| herramientos agrícolas | __________ |
| jornales | __________ |
| animales | __________ |
| ahorros | __________ |
| artículos para el hogar (especifique) | __________ |
| 1.________________________ | __________ |
| 2.________________________ | __________ |
| 3.________________________ | __________ |
| 4.________________________ | __________ |

**ESTUDIO SOBRE IMPACTOS NUTRICIONALES DEL PROYECTO "ICU"**
**ENCUESTA DE LA MUJER DE FAMILIA**

**INFORMACION REFERENCIAL:**
Código de la Encuestadora:______________________________
Fecha de la Entrevista (día/mes/año):______________________________
Nombre de la Encuestada:______________________________
Código____________ Comunidad______________________________

## 1. CARACTERISTICAS DE LA FAMILIA:

1.1 Pida a la mujer verificar la información su esposo dio sobre la edad, fecha de nacimiento y años de escolaridad de las personas en la familia.

1.2 Cúal es su principal ocupación?
1._____ agricultura (ganadería) por su propia cuenta
2._____ agricultura (ganadería) como un jornalero
3._____ obrera en una fábrica
4._____ construcción
5._____ comerciante (en un local estable)
6._____ empleada de gobierno
7._____ maestra de escuela
8._____ artesanía por su propia cuenta
9._____ artesanía como una obrera
10.____ lavado de ropa, servicio domestico
11.____ otro ______________________________
(especifique)

1.3 Cúal es su ocupación secundaria?
1._____ no tiene
2._____ agricultura (ganadería) por su propia cuenta
3._____ agricultura (ganadería) como un jornalero
4._____ obrera en una fábrica
5._____ construcción
6._____ comerciante (en un local estable)
7._____ empleada de gobierno
8._____ maestra de escuela
9._____ artesanía por su propia cuenta
10._____ artesanía como una obrera
11.____ lavado de ropa, servicio domestico
12.____ otro ______________________________
(especifique)

1.4 Si trabaja Ud. fuera de la comunidad, tiene una ausencia diaria de más de 4 horas?

1.______si  2._____ no  3._____ no trabaja fuera de la comunidad

1.5 Ha permanecido fuera de la comunidad con el objeto de trabajar por mas de 2 semanas en los últimos 6 meses?

1.______si  2._____ no  (en el caso de "no", pase a la pregunta 2.1)

1.6 Cuántas semanas trabajó fuera de la comunidad en los últimos 6 meses?

____________________

1.7 En que trabajaba (ocupación)?  1. ____________________
2. ____________________
3. ____________________

**2. PRACTICAS HIGIENICAS:**

2.1 El servicio higiénico que usted dispone es: (marque la alternativa más usada)

1._____ excusado de uso exclusivo (verifique posesion de un excusado _____ si _____ no)
2._____ excusado de uso comun
3._____ letrina (verifique posesion de una letrina _____si _____no)
4._____ campo abierto

2.2 El servicio higiénico que su niño/niña menor dispone es: (marque la alternativa más usada)

1._____ excusado de uso exclusivo
2._____ excusado de uso comun
3._____ letrina
4._____ campo abierto
5._____ pañales

**3. ORGANIZACION/CAPACITACION:**

3.1 Pertenece a alguna organización de productores / organización campesina?

1.______si  2._____ no  (en el caso de "no" pase a la pregunta 3.3)

3.2 Que tipos de organizaciones? (marque todas las alternativas mencionadas)

1._____ cooperativa de producción
2._____ cooperativa de comercialización
3._____ cooperativa de ahorro y crédito
4._____ organización política
5._____ organización de segundo grado
6._____ organización de mujeres

7 _____ otra_____________________ (especifique)

3.3 Ha tenido la visita de algun técnico en los últimos 6 meses?

1._______si 2._____ no

Si es "si", de quien?____________________________________________

_____________________________________________________________

_____________________________________________________________

_____________________________________________________________

3.4 Ha asistido a reuniones (cursos, talleres, etc.) de capacitación en los últimos 6 meses?

1._______si 2._____ no

Si es "si", a que eventos?________________________________________

_____________________________________________________________

_____________________________________________________________

_____________________________________________________________

## 4. FUENTES DE INGRESOS:

4.1 Que fuentes de ingresos ha tenido Ud. en el último mes? (solo la mujer sin los ingresos del esposo)

| FUENTES | CANTIDAD (sucres) |
|---|---|
| 1. venta de cultivos | __________ |
| 2. venta de animales | __________ |
| 3. venta de productos de animales (huevos, leche, abono, etc.) | __________ |
| 4. arrienda tierra | __________ |
| 5. arrienda pastos | __________ |
| 6. artesanía | __________ |
| 7. jornales (local)<br>-tipo de trabajo ___________ (especifique)<br>- cuántos dias ___________ | __________ |
| 8. salario fijo<br>-tipo de trabajo ___________ (especifique) | __________ |

- cuántos dias ___________

9. jornales de trabajo migratorio ___________
    -tipo de trabajo ___________
    (especifique)
    - cuántos dias ___________

10. trabajo de sus hijos ___________

11.ahorros ___________

12 otros (especifique)
    1.______________ ___________
    2.______________ ___________
    3.______________ ___________
    4.______________ ___________

**5. GASTOS:**

5.1 Cuánto gastó Ud. sobre los siguientes artículos en la **semana** pasada? (solo la mujer sin los gastos del esposo)

| ARTICULO | CANTIDAD (sucres) |
|---|---|
| alimentos para la familia | ___________ |
| alimentos para animales | ___________ |
| combustible | ___________ |
| transportación (por ejemplo bus) | ___________ |

5.2 Cuánto gastó Ud. sobre los siguientes artículos en el **mes** pasado? (solo la mujer sin los gastos del esposo)

| ARTICULO | CANTIDAD (sucres) |
|---|---|
| educación | ___________ |
| servicios de salud | ___________ |
| medicina | ___________ |
| deudas | ___________ |
| abono / químicos agrícolas | ___________ |
| herramientos agrícolas | ___________ |
| jornales | ___________ |
| animales | ___________ |
| ahorros | ___________ |
| artículos para el hogar (especifique) | ___________ |
| 1.______________ | ___________ |
| 2.______________ | ___________ |

3. ______________________ __________
4. ______________________ __________

**6. MATERNO / INFANTIL:**

6.1 Cuántas veces ha estado embarazada o en cinta (incluyendo todos los que terminaron como: abortos, nacidos vivos, nacidos muertos)?

______________

6.2 Cuántos hijos vivos en total tiene actualmente? ____________

6.3 Cuántos hijos se le han muerto después de nacidos (menor que 5 años)?

____________

LAS SIGUIENTES PREGUNTAS SE REFIEREN AL MENOR DE LOS NINOS QUIEN AL MOMENTO DE LA ENCUESTA NO ESTA LACTANDO

6.4 El niño lactó (mamó)?
1.______si
2.______nunca (pase a la pregunta 6.7)

6.5 Desde que nació, cuánto tiempo pasó hasta que le dio por primera vez el seno al niño?
1.____ en la primera hora
2.____ entre 1 y 6 horas
3.____ entre 6 y 24 horas
4.____ más de 24 horas

6.6 A que edad quitó el seno al niño? (incluyendo las noches; usa la medida de tiempo más apropiada)
______ meses ______ años

6.7 Cuales vacunas ha tenido el niño? (verifique con carnet de vacunaciones)

| VACUNACION | | SI | NO | NO SABE |
|---|---|---|---|---|
| BCG | | | | |
| DPT | 1a | | | |
| | 2a | | | |
| | 3a | | | |
| | R | | | |
| ANTIPOLIO | 1a | | | |
| | 2a | | | |
| | 3a | | | |
| | R | | | |
| SARAMPION | | | | |

6.8 En que lugar hace atender al niño cuando está enfermo?

1._____ servicio medico MSP (hospital)
2._____ subcentro de salud (auxiliar)
3._____ servicio medico IESS
4._____ servicio medico universitario
5._____ servicio medico privado (doctor)
6._____ curandero con medicina tradicional
7._____ ninguno
8._____ otro ______________________ (especifique)

6.9 Ha usado algún servicio de salud en el mes pasado?

1.______si 2.______no (en el caso de "no" pase a la pregunta 6.10)

Si es "si", indique el servicio, número de visitas en el mes pasado y la razón por la visita

| SERVICIO DE SALUD | NUMERO DE VISITAS EN EL MES PASADO | RAZONES POR LAS VISITAS |
|---|---|---|
| servicio medico MSP (hospital) | | |
| subcentro de salud (auxiliar) | | |
| servicio medico IESS | | |
| servicio medico universitario | | |
| servicio medico privado (doctor) | | |
| curandero con medicina tradicional | | |

6.10 Ha registrado su niño alguno de los siguientes síntomas y signos o dolencias durante las últimas dos semanas (en el caso de "si" pida a la madre su opinión de la gravedad del síntomas y la duración)

| SINTOMAS | 1. SI | 2. NO | 3. NO SABE | GRAVEDAD (1=muy poco; 2=moderada; 3=grave) | DURACION (DIAS) |
|---|---|---|---|---|---|
| diarrea | | | | | |
| fiebre (escalofrio; calentura) | | | | | |
| vomito | | | | | |
| sed intensa | | | | | |
| catarro o tos | | | | | |
| dificultad para respirar | | | | | |

6.11 Ha registrado Ud. alguno de los siguientes síntomas y signos o dolencias durante las últimas dos semanas (en el caso de "si" pida a la madre su opinión de la gravedad del síntomas y la duración)

| SINTOMAS | 1. SI | 2. NO | 3. NO SABE | GRAVEDAD (1=muy poco; 2=moderada; 3=grave) | DURACION (DIAS) |
|---|---|---|---|---|---|
| diarrea | | | | | |
| fiebre (escalofrio; calentura) | | | | | |
| vomito | | | | | |
| sed intensa | | | | | |
| catarro o tos | | | | | |
| dificultad para respirar | | | | | |

ESTUDIO SOBRE IMPACTOS NUTRICIONALES DEL PROYECTO "ICU"
GUAMOTE, CHIMBORAZO, ECUADOR
ENCUESTA DE JEFE DE FAMILIA

**INFORMACION REFERENCIAL:**

Código de la Encuestadora:______________________________
Fecha de la Entrevista: (día/mes/año)______________________
Nombre del Encuestado:________________________________
Código de la Familia: _______ Comunidad:_________________

**1. CARACTERISTICAS DE LA FAMILIA/VIVIENDA:**

1.1 Ha tenido un nino en los ultimos 5 meses? (desde mayo, 1995)

1.________ si 2.________ no (en el caso de "no", pase a la pregunta 1.2)

En el caso de "si", que es el sexo del nino?

1.________ masculino 2.________ feminino

Que es la fecha de nacimiento del nino? (dia/mes)

______________________________

1.2 Con que tipo de combustible cocina?

1.__________ lena
2.__________ gas
3.__________ electricidad
4.__________ carbon
5.__________ otro ______________________________
(especifique)

1.3 Ha comprado algunos de los siguientes articulos en los ultimos 3 meses (desde julio, 1995)?

(marque todos los que tengan incluyendo la cantidad)

1.__bicicleta
2.__radio
3.__cocineta
4.__muebles (camas, mesas, sillas)
5.__equipo de sonido
6.__carro/camioneta
7.__televisión
8.__refrigerador
9.__licuadora
10.__bomba de fumigar

## 2. AGRICULTURA/GANADERIA

2.1 CULTIVOS (Complete el siguiente cuadro con el agricultor usando estas preguntas)

Cuales cultivos sembró Ud. este año (94/95) y en que cantidad? Cuales fueron los rendimientos? Trate de estimar que parte vendió Ud. y que parte quedó con Ud. para el autoconsumo.(incluya parcelas perdidas)

| CULTIVO | CANTIDAD SEMBRADA (la medida que le de el agricultor) | RENDIMIENTOS OBTENIDOS (incluya la medida) | CANTIDAD VENDIDA (incluya la medida) | CANTIDAD PARA AUTO-CONSUMO (incluya la medida) |
|---|---|---|---|---|
| papa | | | | |
| cebada | | | | |
| haba | | | | |
| chocho | | | | |
| centeno | | | | |
| quinoa | | | | |
| arveja | | | | |
| lenteja | | | | |
| maiz | | | | |
| melloco | | | | |
| oca | | | | |
| ajo | | | | |
| cebolla colorada | | | | |
| cebolla blanca | | | | |
| trigo | | | | |
| zanahoria | | | | |
| | | | | |
| | | | | |

2.2 PRODUCCION PECUARIA: (Complete el siguiente cuadro con el agricultor usando
estas preguntas). Qué tipos de animales tienen en la finca y en que cantidad?
Ha vendido algunos animales en el mes pasado?
Ha consumido la familia algunos animales en el mes pasado?

| ESPECIE DE ANIMAL | CANTIDAD QUE POSEEN ACTUALMENTE | CANTIDAD VENDIDA (mes pasado) | CANTIDAD DE CONSUMO FAMILIAR (mes pasado) |
|---|---|---|---|
| bovinos (vacas, toros) | | | |
| ovinos (borregos, ovejas) | | | |
| aves de corral | | | |
| cuyes | | | |
| chanchos | | | |
| caballos | | | |
| burros | | | |
| | | | |
| | | | |

2.3 Ha tenido la visita de algun técnico en los ultimos 3 meses (desde julio, 1995)?

1.__si 2.__no

Si es SI, de quien?________________________________________

________________________________________

2.4 Ha asistido a reuniones (cursos, talleres, etc.) de capacitación en los últimos 3 meses (desde julio, 1995)?

1.__si 2.__no

Si es SI, a que eventos?________________________________________

________________________________________

________________________________________

ESTUDIO SOBRE IMPACTOS NUTRICIONALES DEL PROYECTO "ICU"

GUAMOTE, CHIMBORAZO, ECUADOR
ENCUESTA DE LA MUJER DE FAMILIA

**INFORMACION REFERENCIAL:**

Código de la Encuestadora:____________________
Fecha de la Entrevista: (día/mes/año) ____________________
Nombre de la Encuestada: ____________
Código de la Familia: _______ Comunidad: ____________

## 1. ORGANIZACION/CAPACITACION

1.1 Ha tenido la visita de algun técnico en los últimos 3 meses (desde julio, 1995)?

1.__si 2.__no

Si es SI, de quien?____________________
____________________
____________________
____________________

1.2 Ha asistido a reuniones (cursos, talleres, etc.) de capacitación en los últimos 3 meses (desde julio, 1995)?

1.__si 2.__no

Si es SI, a que eventos?____________________
____________________
____________________
____________________

## 2. MATERNO/SALUD

2.1 Esta embarazada actualmente? (en este momento)

1.__si 2.__no

2.2 Esta lactando a un nino actualmente? (en este momento)

1.__si 2.__no

2.3 Estaba embarazada durante los meses de mayo hasta julio de este ano (1995)?
1.__si 2.__no

2.4 Estaba lactando a un nino durante los meses de mayo hasta julio de este ano (1995)?
1.__si 2.__no

2.5 Ha usado algún servicio de salud en el mes pasado?
1.___si 2.___no (en el caso de "no", pase a la pregunta 2.6)

Si es SI, indique el servicio, número de visitas en el mes pasado y la razón por la visita.

| SERVICIO DE SALUD | NUMERO DE VISITAS EN EL MES PASADO | RAZONES POR LAS VISITAS |
|---|---|---|
| servicio medico MSP (hospital) | | |
| subcentro de salud (auxiliar) | | |
| servicio medico IESS | | |
| servicio medico universitario | | |
| servicio medico privado (doctor) | | |
| curandero con medicina tradicional | | |

2.6 Ha registrado Ud. alguno de los siguientes síntomas y signos o dolencias durante las últimas dos semanas? (En el caso de "si" pida a la madre su opinión de la gravedad del síntoma y la duración)

| SINTOMAS | 1. SI | 2. NO | 3.NO SABE | GRAVEDAD (1=MUY POCO, 2=MODERADA, 3=GRAVE) | DURACION (DIAS) |
|---|---|---|---|---|---|
| diarrea | | | | | |
| fiebre (escalofrio, calentura) | | | | | |
| vomito | | | | | |
| sed intensa | | | | | |
| catarro o tos | | | | | |
| dificultad para respirar | | | | | |