Nutritional Self-Sufficiency at Jama-Coaque Reserve:

An Initial Assessment

By Jason Hernandez

Jama-Coaque Ecological Reserve is a forest reserve located in the western lowlands of Ecuador, at elevation ranging from 280 to 330 m in the foothills of the Jama-Coaque Mountains, at 0° 7' south latitude, 10 km inland from the Pacific Ocean. It lies on a climatic transition zone between the wet Chocó region to the north, extending from coastal Colombia into the Ecuadorean province of Esmeraldas, and the dry coastal zone extending from southern Manabí into Peru. In the heart of the Reserve was an area of about one hectare of deforested and degraded land, and this was chosen as a zone of food production, using permaculture techniques.

The majority of the production zone is planted in assorted tropical fruit trees, including banana, breadfruit, avocado, papaya, citrus, and many others. Coffee and cacao are also present in the production zone, as these will form an understory of shrubs beneath the fruit trees. Near the main dwelling house, called Bamboo House, are terraced areas available for annual vegetable crops, totaling approximately 220 m^2. Bamboo House itself also has a series of window boxes where leafy green vegetables can be grown, in three rows each 10 feet long. One purpose of the production zone is to demonstrate sustainable food production on small scales that reduce pressure on dwindling tropical forests. This is especially important in the Jama-Coaque region, since the forests of coastal Ecuador have been reduced to only a tiny fraction of their aboriginal extent.[1]

One of the challenges faced in food production at this site is regional climate change due to deforestation. Under the original extent of forest cover, the wet season was eight months, the dry season four, but today that ratio is reversed. Currently, the most labor-intensive part of production at Jama-Coaque is watering the gardens and orchards. Interns at Jama-Coaque spend many man-hours every week ensuring each tree receives adequate water. All water is piped in by a gravity-fed system from the headwaters of the Rio Chila. Due to the nature of gravity-fed systems, coordination among interns is necessary to ensure adequate water pressure for all tasks, e.g. downhill tasks will tend to steal water pressure from uphill tasks.

Another challenge to food production is the soil. Most soils on the Reserve are heavy and clayey. Efforts are being made to mimic the natural tropical forest nutrient cycling, in which a constant flux of organic matter sustains plant life despite poor soils. Ongoing projects in this area include composting of all plant-based food waste, vermiculture to produce worm castings, and the use of a composting toilet to generate humanure. Weeds cut down are left in place as natural mulch. Lastly, for certain applications, such as seed germination in the nursery, *tierra del monte* is brought in from the forest. *Tierra del monte* is the term for accumulations of rich organic topsoil in pockets under especially favorable conditions, such as beneath trees producing heavy litterfall. However, its use is necessarily limited due to its dispersed nature, the difficulty of locating and transporting it, and the unsustainablity of doing so on a large scale.

METHODS

Existing plantings at Jama-Coaque were investigated, and a list made of fruit and nut trees currently established. Nutritional analyses for these species were taken from *Fruits of Warm Climates*, by Julia Frances Morton (Florida Flair Books). Foods commonly eaten at Bamboo House were determined by several weeks' stay there, monitoring the kinds and amounts of purchased foods brought in. Analyses of vegetables and non-packaged foods commonly eaten at Bamboo House were obtained from netrition.com and nutritiondata.self.com. In some cases, no exact match was found on the database for a common food at Bamboo House, and in these cases, the food judged to be the nearest equivalent was used; for example, the common cheese of Ecuador, *queso fresco*, was not found in the database, so Mexican *queso asadero* was used as an approximation. Packaged foods found in the Bamboo House kitchen were examined, and nutrition data taken from the labels.

Since different sources used different quantities of foods, some conversions were necessary for accurate comparisons, e.g. Morton standardized all analyses for 100 g edible portion of fruits and nuts, whereas netrition.com and nutritiondata.self.com used USDA recommended serving sizes, which differ in number of grams according to different kinds of food. Also, vitamin A was in some cases given in mg, other cases in international units (I.U.), and in still others, as a percentage of the recommended daily value.

HUMAN NUTRITIONAL REQUIREMENTS

In generalizing about human nutritional needs, it is necessary to bear in mind that each individual is slightly different. Some people have higher or lower caloric needs than the average, and the average itself differs for men and women. On nutrition labels, percent daily values are usually given in terms of a 2000 calorie diet; however, this is actually slightly less than most people's caloric needs. The percent daily value of for example, vitamin A in a given portion will be higher than the label indicates if a person needs fewer than 2000 calories, lower if a person needs more than 2000 calories. Also, differing levels of physical activity will change caloric needs, with any given individual requiring more calories on a day of higher physical activity than one of lower physical activity. Trace nutrient requirements, too, can be affected by different kinds of activity, e.g. salt is lost through perspiration, so a person is likely to require a higher than usual intake of salt after strenuous activity or on hotter days.

As an example, a 30-year-old male, 5'9", 150lbs, living an active lifestyle, requires 2917 calories; a female of the same statistics requires 2578 calories. As a general rule, men require more calories than women of comparable age, size, and level of activity.

Nutrients are divided into two categories based on their functions in the body. Macronutrients are used for building and maintaining body structures and as energy sources, and consist of fats, proteins, and carbohydrates (including sugars). All these together add up to total caloric intake. Micronutrients function in various bodily processes necessary to maintaining good health, and consist of various vitamins and minerals. Whereas requirements for macronutrients are measured in grams, micronutrients are needed in quantities measured in milligrams (mg) or micrograms (mcg).

Average daily values for the nutrients of concern are as follows:

Calories	2500 (men) 2000 (women)
Protein	50 g
Fat	65 g
Carbohydrate	300 g
Fiber	38 g (men) 25 g (women)
Calcium	1000mg
Phosphorus	1000 mg
Iron	18 mg
Potassium	3500 mg
Vitamin A	5000 I.U.
Vitamin B_1 (Thiamine)	1.5 mg
Vitamin B_2 (Riboflavin)	1.7 mg
Vitamin B_3 (Niacin)	20 mg
Vitamin B_6 (Pyroxidine)	2 mg
Vitamin B_{12}	6 mcg
Vitamin C (Ascorbic Acid)	60 mg
Vitamin D	400 I.U.
Vitamin E	30 I.U.
Iodine	150 mcg
Biotin	300 mcg
Folate	400 mcg
Magnesium	400 mg

Among the macronutrients, proteins and carbohydrates are equally energy-dense, both providing 4 calories per gram. Fat is more energy-dense, providing 9 calories per gram. All three of these macronutrients occur in both plant- and animal-based foods.

There is a persistent misconception that a vegetarian diet is protein deficient. With proper planning, this need not be true. A vegetarian diet is not simply cutting out meats; it involves replacing meats with plant-based protein sources, i.e. legumes and nuts.[2] In fact, all vegetables contain some of all three macronutrients; for example: ½ cup of cucumber contains 0.3g protein, 0.1g fat, and 1.9g carbohydrate. Of course, these amounts are insufficient as sources of macronutrients. Conversely, pulses (i.e. legumes) have higher levels of protein than other plant-based food sources: 1 cup boiled lentils provides 17.9g protein, 0.8g fat, and 39.9g carbohydrate. On a vegetarian diet, the full daily value of protein can be obtained from <1 cup peanut butter, 1.3 cups peanuts, 3.4 cups cooked lentils, or <100g cooked green plantain. Compare this with the protein content of animal-based foods, in which obtaining the full daily value requires almost 2 cups eggs, 168g tuna, or 228g shrimp.

Carbohydrates come in several types, including sugars, starches, and dietary fiber. Sugars are simple in molecular structure, and break down quickly into energy, but cannot sustain the body for very long. Complex carbohydrates are better for long-term, sustained energy because they break down more slowly. Generally, one of the most important components of a successful weight-loss diet is replacing sugars and processed white flour with complex carbohydrates, as this increases the metabolism and helps burn off accumulated fat reserves.

Dietary fiber is a special category of carbohydrates, and as such is listed on nutrition labels as a distinct line item. Fiber is needed to maintain proper digestion and thus enable the body to use other nutrients efficiently. Fiber is almost wholly absent from animal-based foods – eggs and cheese each have zero fiber, and 59g of chicken breast provide only 0.1g fiber – and thus a strictly or nearly-carnivorous diet is unsuitable for humans in the long term. This is reflected in human dentition: the human canine teeth are the smallest teeth in the mouth, and highly unsuited to tearing into large prey in the same way that these teeth function in the Carnivora.

Fat, despite its bad reputation, is also essential to human nutrition, as certain micronutrients are fat-soluble and thus can only be used by the body with the mediation of fat. It will be noted that the daily value for fat is actually higher than that for protein: 65g fat to only 50g protein. The dichotomy in the popular mind that animal fats are saturated and plant fats (i.e. oils) unsaturated holds as a general rule, but there are exceptions. Palm oil, for example, although plant-based, is a saturated fat and carries the same health risks as animal fats. Contemplating this while riding the bus past the many acres of *palma Africana* in Esmeraldas is unnerving.

Some micronutrients are found in abundance in most foodstuffs, and a deficiency of these is unlikely in a person eating a calorically adequate and reasonably balanced diet. Phosphorus is the most abundant of these. In this analysis, phosphorus was abundant in banana, avocado, grapefruit, *hobo*, passion fruit (*maracuya*), and *tomate de arbol*, all of which can supply 40mg or more per 100g edible portion. Potassium is also an abundant micronutrient; although bananas have a reputation as a rich source of potassium, several other fruits are also rich in this nutrient, including oranges with 190-200mg per 100g, grapefruit juice with 162mg per 100g, and passion fruit with 348mg per 100g. Baked potato with the skin provides a whopping 1600mg potassium per large potato; 1 cup boiled beet greens provides 1309mg; and 1 cup peanuts, 1029mg .

The majority of fruits, and many vegetables, are rich in vitamin C, and scurvy, a disease caused by vitamin C deficiency, indicates a severely unbalanced diet. Any given kind of fruit shows a wide variation in vitamin C content. Pineapple, for example, ranges from 27 to 165mg, whereas the orange, one of the most famous sources of vitamin C, can range from 45 to 61mg, and the mango shows the widest variation of all, from 7.8 to 172mg. Surprisingly, the highest vitamin C content is found in the *marañon*, that is, the “fruit” attached to the cashew nut, which ranges from 146.6 to 372mg per 100g.

Vitamin A is also available in many different fruits and vegetables: passion fruit contains 700 I.U., *tomate de arbol* 540 I.U., jackfruit also 540 I.U., and *naranjilla* 600 I.U. per 100g. Grapefruit varies by type, i.e. red grapefruits contain 440 I.U. vitamin A, but white grapefruits only 10. The greatest sources of vitamin A, however, are sweet potato baked in skin, with 38,433 I.U. per 200g; carrot, with 21,383 I.U. per cup; and boiled mustard greens, with 8853 I.U. per cup.

Conversely, dried fruits are often completely lacking in these vitamins; the label on a box of raisins, for example, lists zero percent daily value of both vitamin A and vitamin C, even though fresh grapes contain 99.7 I.U. vitamin A and 16.3mg vitamin C per cup. The same is true of jams and jellies, which are high in simple carbohydrates (i.e. sugars), but low or lacking in vitamins.

THE PROBLEM OF B12

A few words need to be said about one micronutrient in particular, B_{12}. B_{12} is required in amounts of only a few micrograms, but in a vegetarian diet, those few micrograms require careful forethought and planning. Although some plant-based foods do contain inactive analogues which were once thought to be B_{12}, research has shown that true B_{12} occurs only in animal-based foods[3]. The richest sources of B_{12} are various meats, but it occurs also in acceptable amounts in eggs and dairy-based foods.

In developed nations such as the United States, most ready-to-eat breakfast cereals are fortified with B_{12} and can serve as an easy source of the body’s whole daily requirement. Vegan diets can work in countries where such supplementation is available. In Ecuador, however, fortified, ready-to-eat breakfast cereals are not common. In this situation, a vegan diet is probably not adequate, and would need to be supplemented with eggs or dairy products. Of the foods commonly eaten at Bamboo House, the sources of B_{12} are, in descending order: dry milk (4.2mcg per cup); canned tuna (3.2mcg per 146g) eggs (1.7mcg per cup); cheese(1.3mcg per cup); yogurt (1.2mcg per cup). If the planned shrimp aquaculture is successfully developed, the shrimp would provide 1.3mcg per 85g, comparable to the existing sources. By comparison, 59g of chicken breast – about the amount that would be obtained from a 1lb chicken – contains only 0.2mcg B_{12}, making this a far less efficient source.

BRAND NAMES MATTER

In packaged foods, not all brands are equally nutritious. A prime example at Bamboo House is granola. Of two brands examined there, Granola Crocante was found to contain 5g protein, 6g fiber, and 23g calcium; but Gustamas contained only 2g protein, 1g fiber, and no calcium. Clearly, then, Granola Crocante is the more nutritious of the two.

Within the same brand, different flavors and varieties can also differ markedly in nutritional value. In bread, for instance, "Miel y Granola" provides, per slice, no fiber, no vitamin B_1, 10% daily value of B_2, 30% daily value of B_3, and 100% daily value of folate; whereas "Siete Cereales," of the same brand, provides 1g fiber, 20% daily value vitamin B_1, 60% daily value of B_2, 40% daily value of B_3, but only 90% daily value of folate.

ACTUAL SITUATION AND RECOMMENDATIONS

The existing fruit orchards at Jama-Coaque Reserve will probably be sufficient to supply most micronutrients other than B_{12}, once they come into full production. Papaya is already in production, with many fruits going to waste since people at the Reserve cannot keep up with eating the number of fruits produced. Papaya is a calcium-rich fruit (13-41mg per 100g), and compares favorably with citrus in vitamin C. Assuming the range of fruits planted has been sufficiently well planned to ensure a rotation of production season s throughout the year, the Reserve should be self-sufficient in fruit.

One potential challenge in this area is the unfamiliarity of many interns from North America and Europe with some of the fruits being grown. Many people are reluctant to change their accustomed diet to include unfamiliar foods. A case in point is the *hobo* fruit, which was coming into season at the time I was at the Reserve, in August and September. Many ripe *hobo* fruits could be found along the road from Camarones to the Reserve, but no one thought to gather them up and bring them to Bamboo House to be eaten. *Hobo* is rich in vitamin C and phosphorus and would have been a valuable fruit to use. Another such case was the mamey. Jesse brought some mamey from the market on one shopping trip. No one liked it, and no one was sufficiently familiar with mamey to know whether the particular fruits he brought were rotten, or if that was really the way mamey tastes.

With intensive gardening techniques, it is probable that sufficient vegetables could also be grown in the existing garden areas. The balcony planter boxes alone can grow a total of 30 feet of row of leafy greens – three rows of 10 feet each. Since greens were not consumed every day, and many greens-producing plants can be managed for an extended season, it may well be possible to produce sufficient leafy greens using just the balcony boxes. For other crops, intercropping will likely be needed to make maximum use of available space. The “three sisters” tradition developed by indigenous peoples of North America might be used to advantage here: corn requires a lot of space, especially since it needs to be planted in blocks rather than rows for proper pollination, but climbing crops such as pole beans can use the corn stalks for support, and low-growing, large-leaved crops such as squash have been employed to suppress weeds beneath other crops.

It will not be possible to become self-sufficient in flour grains. Wheat is unsuited to tropical climates, and the wheat flour and wheat breads used in this part of Ecuador are imported from elsewhere. Corn should do well, but flour corn needs to be planted well away from sweet corn to avoid cross-contamination of pollen. We do not have data on how much corn masa could be produced from the area available for growing corn. Quinoa is a highland grain in Ecuador, but it may be worth investigating whether there are varieties adaptable to Jama-Coaque’s lowland tropical climate. Quinoa would be a valuable addition to Jama-Coaque’s complement of crops if growing it is found to feasible, as it contains the full spectrum of amino acids and is thus considered a complete protein.

Among starchy roots, there is a better prospect for self-sufficiency. Potatoes are also primarily a highland crop in Ecuador; however, the climate here is suitable for manioc (*yuca* – note correct spelling with only one “c;” yucca with two c’s is an unrelated plant). Several extensive patches of manioc are already established at Jama-Coaque, and roots may be harvested over an extended period without killing the plants. The manioc present at Jama-Coaque appears to be a “sweet” cultivar in that ordinary cooking is sufficient to render it edible, unlike the “bitter” cultivars common in the Amazon, which must be processed to remove the toxin.

Another starchy root, not yet present at Jama-Coaque but with potential, is taro. Some published sources give its local name as *papa china*[4]. Like manioc, taro must be properly prepared to be edible, but the process is simple boiling and discarding the water. Taro does not seem to figure in the diet of largely-*mestizo* Manabí, but is grown in abundance in the Afro-Ecuadorian village of San Miguel in Esmeraldas. Taro compares nutritionally with manioc thus:

	Manioc (1 cup)	**Taro (1 cup)**

Calories	330	187
Protein	2.8g	0.7g
Carbohydrate	78.4g	45.7g
Fiber	3.7g	6.7g
Fat	0.6g	0.1g
Vitamin A	26.8 I.U	111 I.U.
Vitamin C	33mg	6.6mg
Vitamin E	0.4mg	3.9mg
Calcium	33mg	23.8mg
Potassium	558mg	639mg
Iron	0.6mg	1mg
Folate	55.6mcg	25.1mcg

Other root and tuber crops are known in the Ecuadorian Andes: *mashua*, *ulluco* and *oca* are ancient Andean crops[5] now in danger of disappearing due to industrial agriculture. Although they come from cool highland climates, their endangered status makes them a worthwhile subject of experiment to see if their cultivation can be expanded. *Oca* is high in protein, with a good amino acid balance, and also high in fiber and antioxidants; *ulluco* produces edible leaves in addition to tubers, with a high calcium, vitamin A, and protein content; and *mashua* thrives in poor soils and helps repel insects.[6]

There are currently two breadfruit trees on the Reserve, not yet in production. However, when these begin producing, they will become an additional source of bread-like carbohydrates, being rich in starches as well as vitamins. Breadfruit is actually better classified in the breads and cereals food group rather than the fruits group due to its unique nutritional profile; it was the chief staple of Polynesia where grains were lacking.

One particularly suitable root vegetable for our climate is the sweet potato, which is already well-established at Jama-Coaque. The challenge here is to improve production of suitable-sized tubers, as the current ones tend to be rather too small. Sweet potato is rich in both vitamins A and C, and in other ways compares favorably with the regular potato, having the same amount of fiber, higher calcium, and similar levels of the B vitamins.

Protein sources need much more development at the Reserve, but it may be possible to achieve at least near self-sufficiency in these. The leading protein sources at the Reserve are peanuts, beans, and green plantains. If the shrimp aquaculture can be developed, this will add another protein source; however, shrimp trails behind, say, tuna in protein content, and is high in cholesterol. On the other hand, these sources of protein compare very favorably with, say, chicken: tuna contains 43g protein per 146g; shrimp, 18g protein per 85g; and chicken, 18.8g protein per 59g. Given the difficulty of raising chickens on the site due to uneven terrain and the lack of available space, this is encouraging – it is actually better to focus on more feasible protein sources than to try to establish chickens.

Given that cattle raising is excluded from consideration, the Reserve will never produce its own dairy products. Thus, either dairy products will continue to need to be purchased, or the nutritional requirement currently met by dairy will need to be fulfilled in other ways. Dairy products supply primarily protein, fat, and, to a lesser degree, calcium, all of which are available from other sources: protein from pulses, fat from vegetable oils, and calcium from dark-green, leafy vegetables, especially turnip greens, kale, and broccoli.

Oil crops are so far largely lacking in Jama-Coaque's cropping scheme. They are currently not required, as fat is supplied by purchased vegetable oil, canned tuna, eggs, and dairy products, and also the fat-rich avocado. However, as the Reserve tries to move toward greater self-sufficiency, oil crops will need to be considered, especially if dairy and tuna are phased out. There are several coconut seedlings planted around the periphery of the production zone, but the site is at or near the upper altitude limit for coconuts, which are originally native to seacoasts. Corn and peanuts have both been grown successfully on the site, and are potential sources of fat. Macadamia nuts and cashews are also rich in fat, and are established in small numbers on the site. *Palma Africana* is not recommended, as its oil is a saturated fat and carries health risks which other plant-based fats do not.

CONCLUSION

Jama-Coaque Ecological Reserve has the potential to become self-sufficient in some, but not all, nutritional requirements, assuming its current level of staffing. Most vitamins and minerals can be supplied once the current plantings come into full production. B_{12} may not be able to be produced onsite in sufficient amounts. Macronutrients will require the most planning and management, but sufficient protein can likely be achieved, complex carbohydrates likewise, and fats may present a challenge. It will be important to manage the crop rotations in such a way as to keep perishable foodstuffs in production year-round, which will require additional data on the production seasons of the various crops.

NOTES:
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