ISLAND PERSPECTIVES

University of the Virgin Islands *Agricultural Experiment Station*

1988-1989 Vol. 3

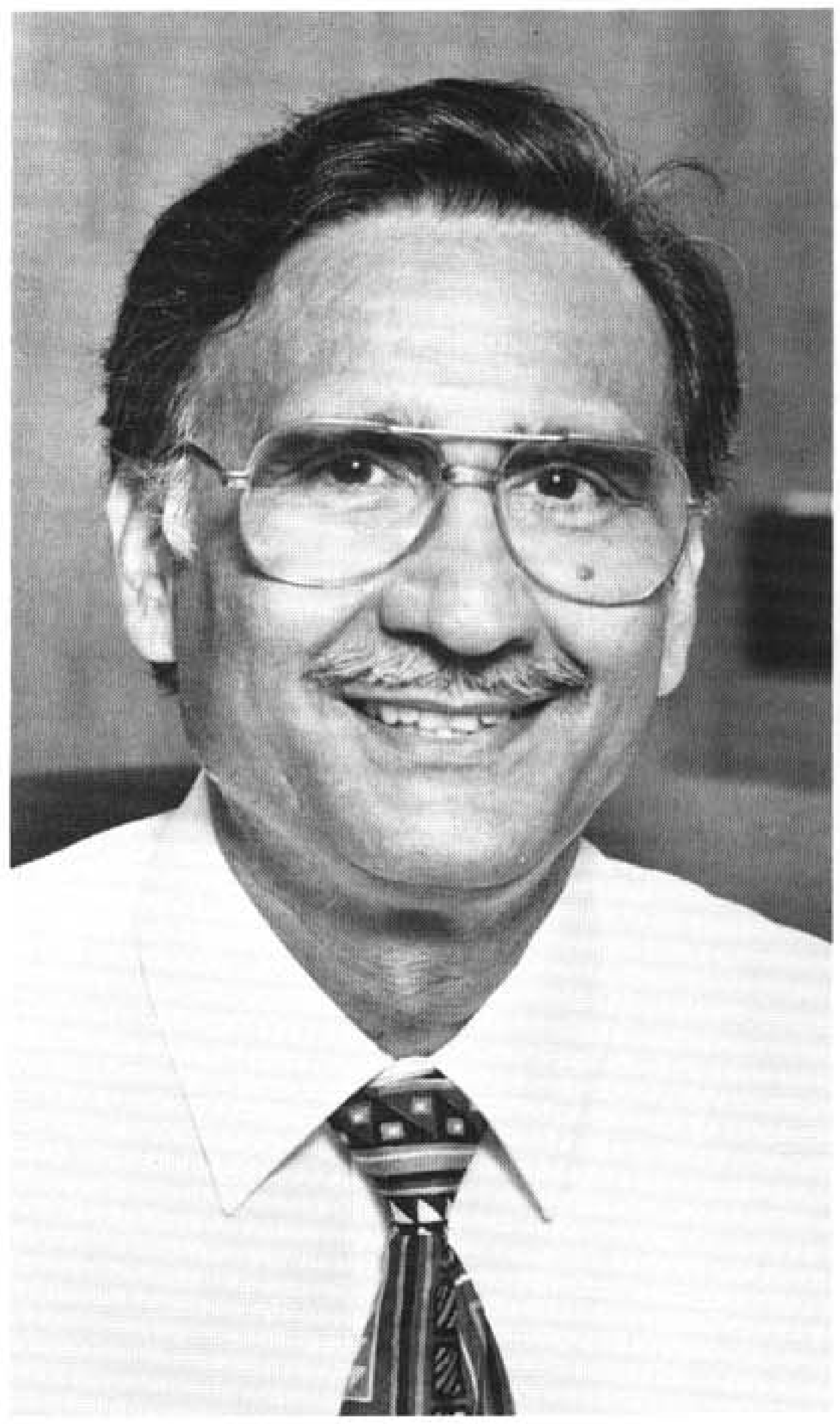
From The Director . . .

The eye of Hurricane Hugo passed directly over St. Croix just as the fourth issue of this publication was ready to go to press. The outcome was catastrophic. The University of the Virgin Islands Agricultural Experiment Station (AES) did not escape Hugo's devastation. Most of our research projects sustained extensive damage. In fact, very little remains of the aquaculture and plant science facilities. While the Animal Science and Forages Program suffered the loss of some animals and fences, their field facilities remained basically intact and they have been able to reestablish their research.

The hurricane did dramatically show us an overlooked advantage of root crops. Although the winds stripped away all of their vegetation, the tubers survived and quickly resprouted. The same cannot be said for vegetables, a total loss, and fruit trees. The trees that survived were badly damaged and will require years to recover.

While Hugo has dealt the Station a major setback, we *are* rebuilding. The Aquaculture Program is erecting new tanks and rebuilding fish stocks. New greenhouses will be added to the Plant Science Programs which have already sowed the seeds for new experiments. Although the research reported here is now history, we still feel it is important to document our past efforts as completely as possible as we continue the recovery.

During this period of change we would like to introduce our new format and new title—*Island Perspectives.* We hope the larger size will give you a better feeling—or quite literally—a better picture of the exciting work done here. With this issue, we have also opened the publication to the staff of all three research and extension divisions of the University of the Virgin Islands, in addition to the Agricultural Experiment Station. *Island Perspectives* will contain reports on the multi-faceted research and outreach activities at the Agricultural Experiment Station, Caribbean Research Institute and Cooperative Extension Service. We



think the inclusion of all three divisions will give our clientele a broader view of the many ways that researchers in the areas of agriculture, forestry, food and natural resources are working to develop and transfer new technologies to improve the quality of life in the territory and the region.

Research findings presented in this issue are immanently practical as well as geared toward long-term technological advances. For example, our horticulturist has found that ornamental plants do not grow well in the black plastic flower pots that are in common use here. The tropical sun raises the soil temperature over the plant's stress threshold and eventually hampers its growth. Light colored pots solved the problem. This is just one example of research that can be put to use on many levels—from a few potted plants on porches to the thousands of transplants destined for commercial use.

Our first story highlights an aspect of our nationally recognized aquaculture program which is developing technology for growing vegetables and fish in a closed system. This system harvests rainwater, conserves it through recycling, and recovers nutrients from the fish culture operation for vegetable production. At the same time, nutrient uptake by vegetables improves water quality and enhances fish growth. Although part of this facility was destroyed, the systems are being reestablished and new experiments are planned.

A report on research done at our sheep facility indicates that expensive short-term food supplementation of breeding sheep has very little effect on subsequent lambing performance. Although this type of feeding is a standard flock management practice in northern locations, our results suggest that it is unnecessary as well as unprofitable under St. Croix conditions.

We have also included some information on marketing which will be of interest to both farmers and consumers. And, as part of UVI's committment to maintaining the quality of the environment and the natural beauty of our islands, we have reported on an ongoing marine monitoring program which may help set up guidelines for keeping corals healthy throughout the Caribbean. The ability to evaluate Hugo's underwater impact is another unanticipated application for this project.

I would like to take this opportunity to encourage all Virgin Islands residents to look through this publication, make use of these findings, and feel free to contact us for more information. We look forward to our participation in rebuilding St. Croix and the Virgin Islands.

Darshan S. Padda
Vice President for Research
and Land-Grant Affairs

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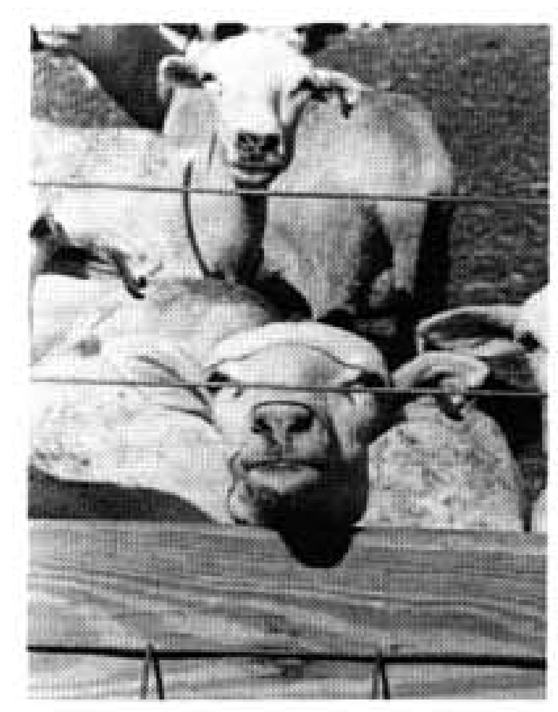

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Harvesting hydroponic lettuce involves separating the net basket from the peat cube. This removes most of the roots, but some remain and the plant can be sold as "living lettuce."

Hydroponic Lettuce Production in a Recirculating Fish Culture System

by James E. Rakocy

Innovative methods are required to expand food production on small Caribbean islands where resources are limited and most of the food supply is imported. The University of the Virgin Islands Agricultural Experiment Station (AES) is taking a new approach to growing more food by integrating vegetable hydroponics with fish culture in water reuse systems. These diverse agricultural enterprises are being combined to increase production while minimizing nutrient inputs and the consumption of water, the major limiting factor to agriculture in the U.S. Virgin Islands. Fish culture water provides most of the nutrients required by vegetables while nutrient uptake by vegetables improves water quality and may increase fish production. An experimental system has been established for studies on design, management, and production. This is a report on the results of two recent experiments involving the production of leaf lettuce and tilapia.

The integrated system at AES consists of a 12.3-m^3(3,300-gallon) fish rearing tank, a 1.9-m^3 500-gallon) settling tank (clarifier) for removal of solids, two, 2.1-m^3 (550-gallon) hydroponic tanks with a total plant growing area of 13.8 m^2 (148 square feet), and a 1.4-m^3 (370-gallon) reservoir (Figure 1). The total system volume during operation averages 17.8 m^3 (4,750 gallons). The hydroponic tanks, which are 6.10 m (20 feet) long, 1.22 m (4 feet) wide, and 0.2a8 m (0.92 feet) deep, are covered with floating sheets of polystyrene (3.8 cm thick; 1.5 inches) containing 5-cm (2-inch) holes for the support of lettuce plants in net baskets. Biofiltration (ammonia removal) is provided by a rotating biological contactor (RBC) with 92 m^2 (1,000 square feet) of surface area located in the rearing tank. The RBC is rotated by influent water striking a water wheel in the center of the RBC. Water is circulated by a submersible pump (1/6 hp) at an average rate of 57 liters/minute (15 gallons/minute), and aeration in the rearing tank is provided by an agitator (⅓ hp) and a diffused air line. High-quality water for the system is obtained by harvesting rainwater from a vinyl-lined catchment.

An experiment was conducted to determine the optimum ratio of lettuce plants to fish for maximum lettuce production. Six identical systems were

A harvest of tilapia cultured in a recirculating system.

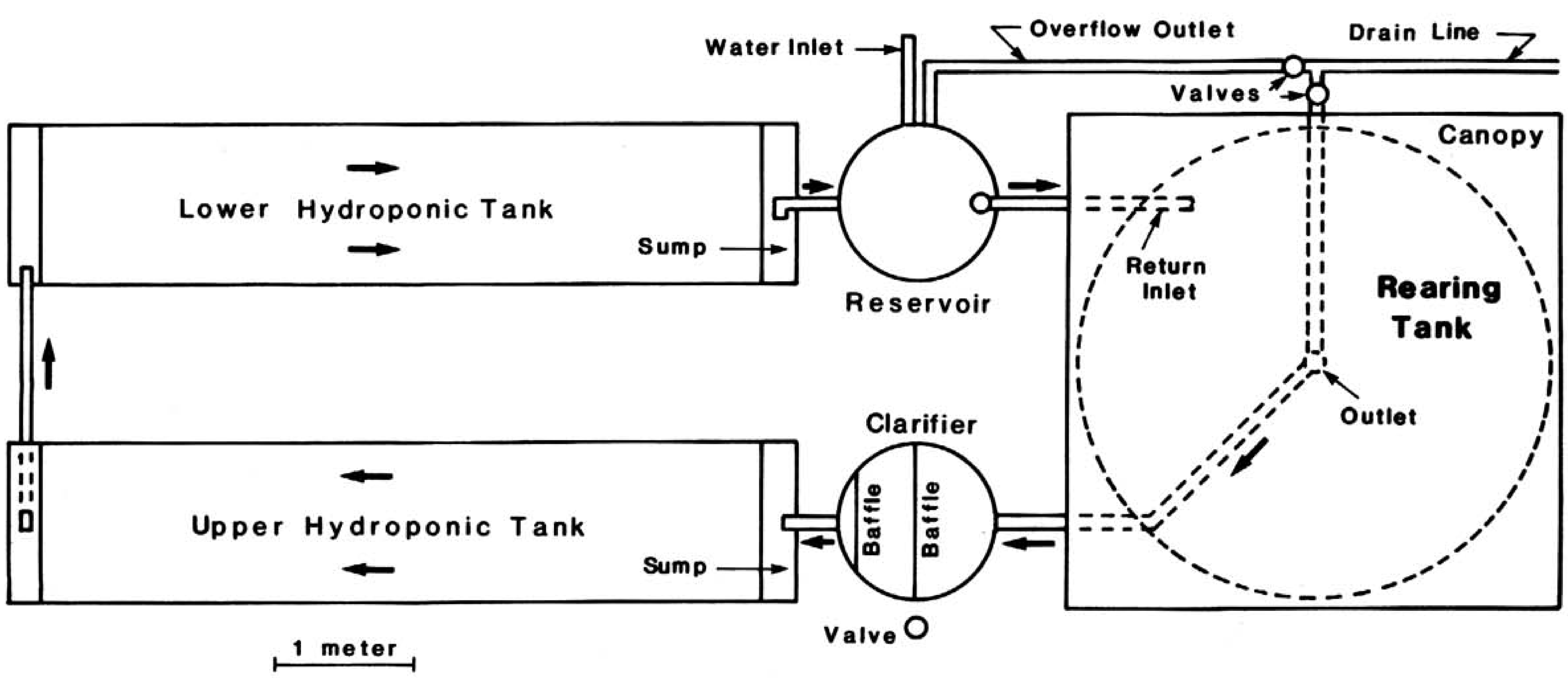


Figure 1. A closed recirculating system for integrating vegetable hydroponics with fish culture.

stocked with *Tilapia nilotica* at rates of 44, 88, 132, 176, 220, and 264 fish/system. The fish, which averaged 113 grams at stocking, were fed a complete diet for 21 weeks at a constant daily rate of 200, 400, 600, 800, 1000, and 1200 grams, respectively, which was equal to 4.5 grams/fish. The floating, pelleted food contained 36% protein plus vitamin and mineral supplements.

In each system, 330 leaf lettuce plants (var. Summer Bibb) were grown in 3-week, staggered production cycles. On Monday of each week, 110 plants from each system were harvested and individually weighed after root removal. An equal number of seedlings in peat pellets were then transplanted into the net baskets. The seedlings were grown for 3 weeks in flats prior to transplanting. Planting density was maintained at 23.9 plants/m^2 (2.2 plants/square foot) for a total of 18 crops.

Six ratios were obtained by holding the number of plants constant and varying the fish stocking rates. The ratios were 7.5, 3.8, 2.5, 1.9, 1.5 and 1.2 lettuce plants to 1 fish. The respective feeding rates were therefore equivalent to 0.6, 1.2, 1.8, 2.4, 3.0, and 3.6 grams/day/plant or 0.8, 1.6, 2.4, 3.2, 4..0, and 4.8 grams/day/m^3/m^2 in terms of system volume and plant growing surface area.

Since the bilfiltration process (nitrification) produces acid, pH was measured often. When the pH decreased to less than 6.5, a strong base (potassium hydroxide or calcium oxide) was added to the system to raise pH. These additions also supplemented the system with potassium and calcium, essential plant nutrients that do not accumulate in sufficient quantities in integrated systems. The system was also supplemented twice with chelated iron and once at the beginning of the experiment with phosphorus (as dipotassium phosphate).

The highest lettuce production (14.1 kg/week/system; 31 pounds) and the largest heads (131 grams; 0.29 pounds) were obtained from a ratio of 1.9 lettuce plants to 1 fish (Table 1). At this ratio the feeding rate was equivalent to 2.4 grams/day/plant. The plants obtained most of their nutrition indirectly from fish feed after it had been digested by the fish. Nutrients were excreted directly into the water by the fish or released to the water after waste products were broken down by bacteria. Lettuce production and head size decreased at both higher and lower ratios. At the higher ratios there was less fish feed available to plants as a source of nutrients, which led to nutritional deficiencies and diminished growth. Plants at the highest ratio even exhibited chlorosis, yellowing of the leaves. There was more fish feed available per plant at the lower ratios, resulting in an accumulation of nutrients that possibly inhibited plant growth (Figure 2).

Weekly lettuce yields were variable, and only with the ratio of 1.9 plants to 1 fish was there a pattern of gradually increasing yields (Figure 3). Yields did not increase as nutrients accumulated at the highest ratio (7.5) nor were initial yields substantially higher before possible inhibitory effects occurred at the lowest ratio (1.2). The nutrient dynamics of integrated systems therefore appear to be very complex and warrant further investigation.

There was a direct correlation between the stocking ratio (feeding rate) and the accumulation of total dissolved solids (mainly nutrient salts). Concentrations of dissolved salts increased (Figure 2) with an increase in the feeding rate. Most of the salt came from the addition of bases (potassium hydroxide, calcium oxide and dipotassium phosphate) to neutralize the acid produced by nitrification. Acid production increased with higher feeding rates, and therefore more base was added to these systems. The other major component of total dissolved solids was generated from fish feed and consisted of nitrate, phosphate and sulfate ions. The initial sharp

Table 1. Fish *(Tilapia nilotica)* stocking rates, feeding rates and mean lettuce (Summer Bibb) and fish production during 21 weeks in integrated recirculating systems stocked at six ratios of plants to fish.

	Stocking ratio (plants:fish)					
Variable	**7.5**	**3.8**	**2.5**	**1.9**	**1.5**	**1.2**
Stocking rate						
(fish/system)	44	88	132	176	220	264
Feeding rate						
(kg/day/system)	0.2	0.4	0.6	0.8	1.0	1.2
(g/day/plant)	0.6	1.2	1.8	2.4	3.0	3.6
(g/day/m^3/m^2)[a]	0.8	1.6	2.4	3.2	4.0	4.8
Lettuce production						
(kg/week/system)	10.5 ± 0.4	11.8 ± 0.7	12.3 ± 0.7	14.1 ± 0.9	13.1 ± 0.9	11.2 ± 0.8
(kg/m^2/crop)[b]	2.3	2.6	2.7	3.1	2.8	2.4
(g/head)[c]	98 ± 4z	109 ± 6yz	117 ± 6xyz	131 ± 8x	124 ± 8xy	106 ± 7yz
Net fish production						
(kg/system)	20.5	41.3	56.8	83.1	95.6	112.2

[a]Based on a system volume of 17.8 m^3 and a plant growing area of 13.8 m^2 with 23.9 plants/m^2.

[b]Each crop was produced in 21 days from transplanting. Using staggered production, one crop was harvested weekly for a total of 18 crops.

[c]Means followed by the same letter are not significantly (P >0.05) different.

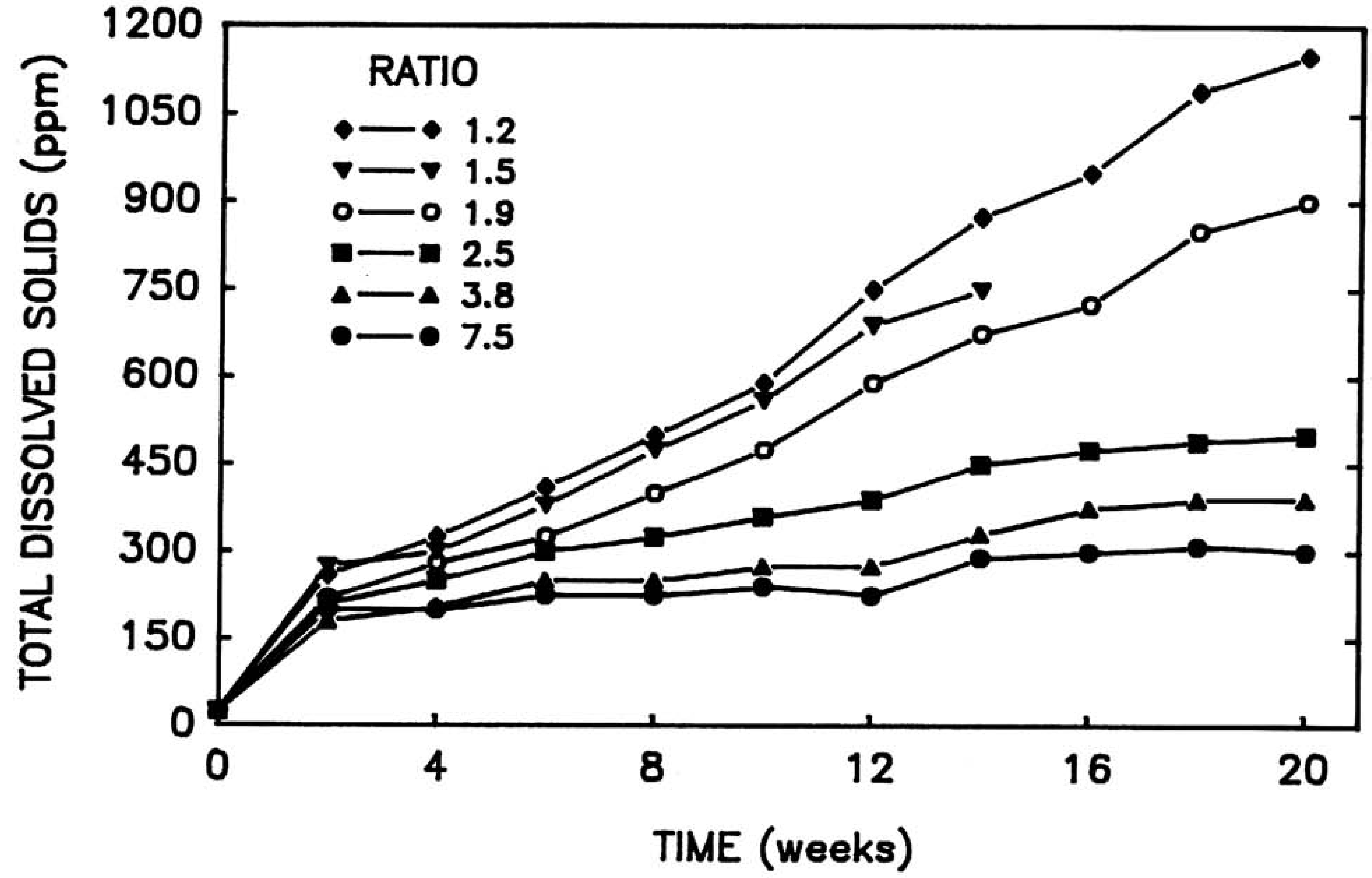


Figure 2. Accumulation of total dissolved solids during 20 weeks in 17.8-m^3 integrated recirculating systems stocked at six ratios of plants to fish.

increase in total dissolved solids was due mainly to the addition of bases and nutrient supplements during a period when three staggered groups of lettuce were being established. Afterwards, salts increased at a relatively low rate at 7.5, 3.8, and 2.5 plants:fish, indicating that a large portion of nutrient salts were being used for plant production. The rate of salt accumulation was substantially higher at 1.9 plants:fish, which suggests that the nutritional needs of the plants had been met and exceeded. Total dissolved solids reached 900 mg/liter in 20 weeks and increased at an average rate of 135 g/kg of feed at 1.9 plants:fish, which gave the highest lettuce yields. Ratios of plants:fish that are intermediate between 1.9 and 2.5 should be examined to determine if comparable yields can be obtained while lowering the rate of salt accumulation. High accumulation rates will shorten production cycles or necessitate more frequent water exchanges or dilutions.

The ratio of plants to fish and the equivalent feeding rate per plant are inadequate terms for quantifying the relationship between plants and fish in integrated systems because they do not consider volume. The system volume is an important factor in determining nutrient concentrations, which in turn affects plant production. The relationship is expressed more clearly by relating feeding rate (grams/day) to system volume (m^3) and plant growing area (m^2) or, specifically, grams/day/m^3/m^2 for designated plant growing densities, which in this case was 23.9 plants/m^2. The optimum feeding rate was 3.2 g/day/m^3/m^2 in this experiment. This feeding rate can be used as a design ratio in determining optimal fish feeding and stocking rates for a given level of lettuce production or the optimum lettuce growing area for a desired level of fish production.

Integrating vegetable hydroponics with fish culture has been promoted as a means of obtaining greater profitability by reducing water and nutrient costs. Vegetables are viewed as a by-product of the fish culture operation that would generate additional income. But these are unproven assumptions. Therefore, an experiment was conducted to compare chemical and water use in a integrated system for tilapia and lettuce production with a lettuce hydroponic system utilizing synthetic nutrient salts. Tilapia production in the integrated system was also compared to tilapia production in a recirculating system without lettuce hydroponics. The overall objective of the experiment was to quantify the likely advantages of integrated systems over traditionally separate production systems where tilapia and lettuce are grown independently.

Three of the systems used in the first experiment were modified by creating separate hydroponic and fish culture systems. The hydroponic system, known as a deep flowing system, consisted of a reservoir and two hydroponic tanks. Water was continuously pumped from the reservoir to one of the hydroponic tanks from which it flowed by gravity through the second hydroponic tank to the reservoir. The fish culture system consisted of a clarifier and fish rearing tank containing an RBC. Water was continuously pumped from the clarifier to the rearing tank and returned by gravity to the clarifier. The water volumes of the integrated, hydroponic and fish culture systems were 17.8, 4.8, and 13.5 m^3 (4,700, 1,270, and 3,570 gallons), respectively. Each system was replicated three times.

There was no significant difference in lettuce production or survival between the integrated and hydroponic systems.

Table 2. Mean tilapia *(Tilapia nilotica)* and lettuce (Summer Bibb) production, and water and chemical use in an integrated fish culture/vegetable hydroponic system, a vegetable hydroponic system, and a fish culture system after 14 weeks.

	System				
Variable	**Integrated fish culture/vegetable hydroponic**		**Vegetable hydroponic**		**Fish culture**
Tilapia production					
Net production (kg)	46.8		—		41.6
Mean final weight (g)	1008		—		968
Feed conversion ratio	1.68		—		1.89
Survival (%)	99.5		—		99.5
Lettuce production					
Total weight (kg)	385.1		380.1		—
Mean weight (kg)	115.4		114.6		—
Total number	3337		3318		—
Survival (%)[a]	88.2	(94.3)	87.7	(93.2)	—
Water use					
Quantity (m^3)	24.1		13.7		19.3
Cost ($)[b]	255.04		144.88		71.57
Chemical use					
Quantity (kg)[c]	9.56		21.99		10.10
Cost ($)	43.30		47.37		35.15

[a]The number in parenthesis is survival excluding the crop destroyed by Hurricane Gilbert.
[b]Delivered desalinated water for hydroponic plant production costs $40/1000 gallons. Piped government water (a blend of well and desalinated water) for fish production costs $14/1000 gallons.
[c]Potassium hydroxide, calcium oxide, dipotassium phosphate, and iron chelate were added to the integrated system. Potassium hydroxide was added to the fish culture system. Potassium hydroxide, calcium nitrate, magnesium nitrate and 8-15-36 (N-K-P) were added to the hydroponic system.

Over a 14-week period, twelve crops of leaf lettuce (var. Summer Bibb) were cultured on 3-week staggered production cycles in the integrated and hydroponic systems. Each crop consisted of 110 plants per system with the exception of the first three crops when fewer transplants were available.

A commercial nutrient formulation for lettuce was used in the hydroponic system. It consisted of 8-15-36 (N-P-K) with trace elements, calcium nitrate (both applied at a rate of 0.5 lbs/100 gallons), magnesium sulfate (applied at 0.31 lbs/100 gallons), and potassium hydroxide (applied as needed to raise pH). The hydroponic solutions were discarded after weeks 4 and 10 and replaced with fresh solutions to maintain a proper nutrient balance. Fish feed was the main nutrient source in the integrated system, although the system was supplemented with potassium hydroxide, dipotassium phosphate, calcium oxide, and chelated iron. Potassium hydroxide was the only chemical addition to the fish culture system. In the integrated and fish culture systems, pH was measured often and maintained at 6.5-7.0 by adding base.

The integrated and fish culture systems were stocked with *Tilapia nilotica* at a rate of 138 fish per system. The fish had been used in the first experiment and averaged 663 grams at stocking. The fish in each system were fed at a constant rate of 800 grams/day (5.8 grams/fish) for 98 days. The feeding rate in the integrated system was 3.26 $g/day/m^3/m^2$, which was found to be the best feeding ratio from the previous experiment for maximum plant production.

There was no significant difference in lettuce production or survival between the integrated and hydroponic systems (Table 2). Total production was 385.1 and 380.1 kg (847 and 836 pounds) in the integrated and hydroponic systems, respectively. Lettuce growth was the same with synthetic nutrients or nutrients mainly from fish feed.

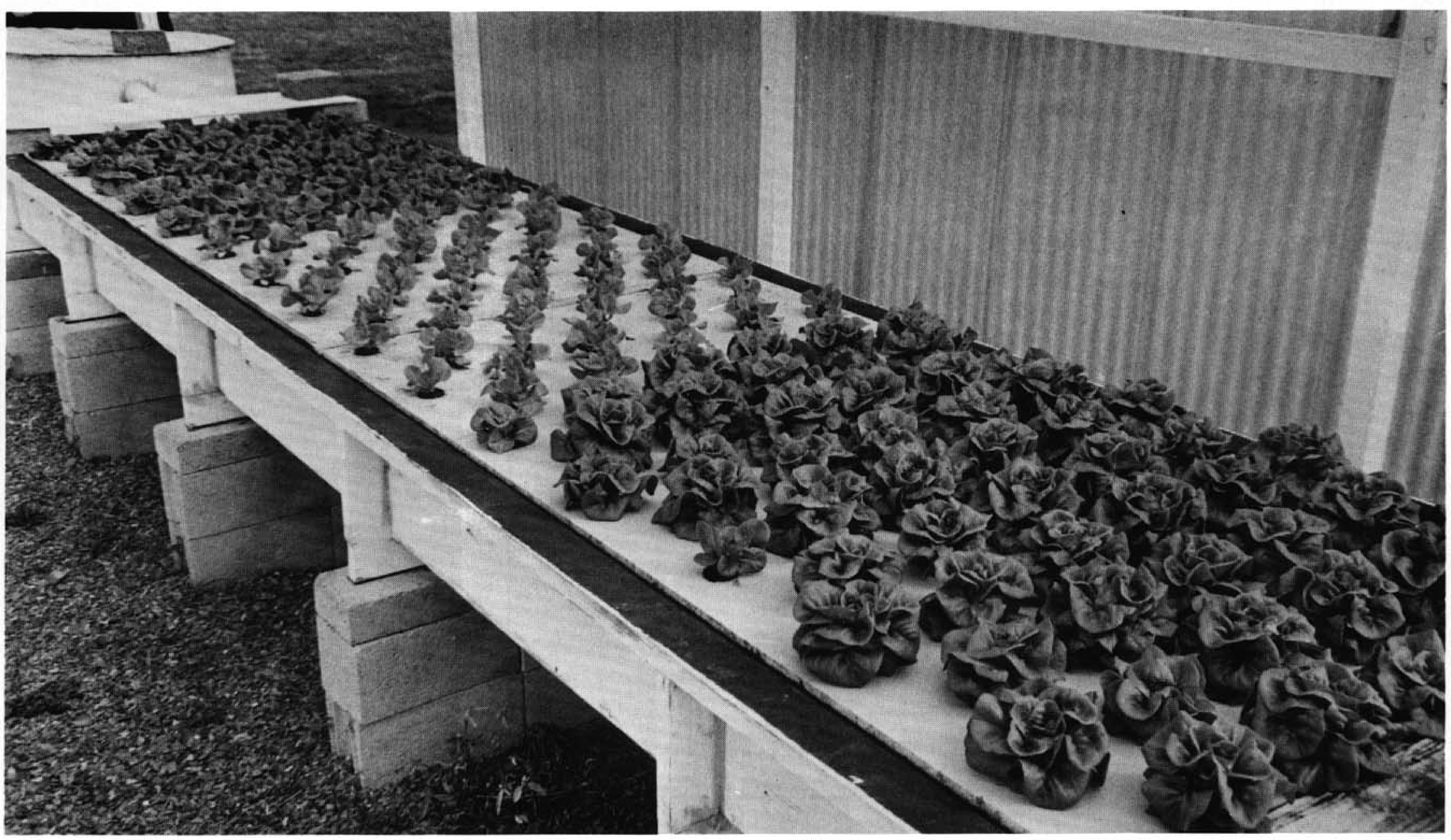
The integrated system produced 12.5% more tilapia than the fish culture system alone (Table 2). Net tilapia production and final mean weight were 46.8 kg (103 pounds) and 1008 grams (2.2 pounds) in the integrated system and 41.6 kg (92 pounds) and 968 grams (2.1 pounds) in the fish culture system. Significantly greater production in the integrated system resulted from more efficient feed conversion (1.68 vs. 1.89). The lettuce plants helped create a stable environment by inhibiting phytoplankton growth, reducing suspended solids, and absorbing toxic metabolites, which thereby improved feed conversion and fish growth.

The results clearly demonstrate the quantitative advantages of integration (Table 2). The amount of chemicals (21.99 kg; 48.3 pounds) applied to the hydroponic system was more than twice of that (9.56 kg; 21.0 pounds) used by the integrated system, although the costs were similar due primarily to the expense of iron chelate in the integrated system. The advantage of the integrated system is illustrated dramatically by combining the chemical requirements and costs of the hydroponic and fish production systems. The combined cost and chemical requirement of the separate production systems ($82.52; 32.09 kg or 70.6 pounds) are approximately two and three times greater, respectively, than that of the integrated system ($43.30; 9.56 kg of 21.0 pounds) to produce the same amount of lettuce and slightly less fish.

The integrated system utilized more water (24.1 m^3; 6,370 gallons) than the hydroponic (13.7 m^3; 3,620 gallons) or fish culture (19.3 m^3; 5,100 gallons) systems, but the combined water use (33.0 m^3; 8,720 gallons) of the separate production systems was 37% higher than that of the integrated system (Table 2). The water cost ($255.04) for the integrated system was higher than the combined water cost ($216.45) for the separate production systems because the fish culture system used less expensive water ($3.70/$m^3$ or $14.00/1,000 gallons for piped government water, a blend of well and desalinated water). The integrated and hydroponic systems require either desalinated water at a cost of $10.57/$m^3$ ($40.00/1,000 gallons) or rainwater. Groundwater is generally unsuitable for hydroponics in the Virgin Islands due to high levels of dissolved salts. The cost of desalinated water was used for comparison, but less expensive water can be obtained by rainwater harvesting.

The frequency of nutrient solution exchange was a key factor in determining nutrient and water costs in the hydroponic system. In recirculating hydroponic systems it is common practice to replace nutrient solutions every four weeks to ensure proper nutrient balance. Different batches of the nutrient solution were used for the first 4 weeks, the next 6 weeks, and the final 4 weeks of this experiment. There was no clear trend of declining production during the 4-week or 6-week periods. If nutrient solutions could be used for longer periods without a decrease in production, nutrient and water costs would decline, and the comparative economics of the integrated and separate production systems would change slightly. Nevertheless, integrated systems would still compare favorably with separate production systems.

The concept of growing vegetables in fish culture water has been envisioned for many years, but there have been few quantitative experiments. The ratio



An experimental recirculating system integrating vegetable hydroponics with fish culture. Lettuce production is staggered in 3-week cycles.

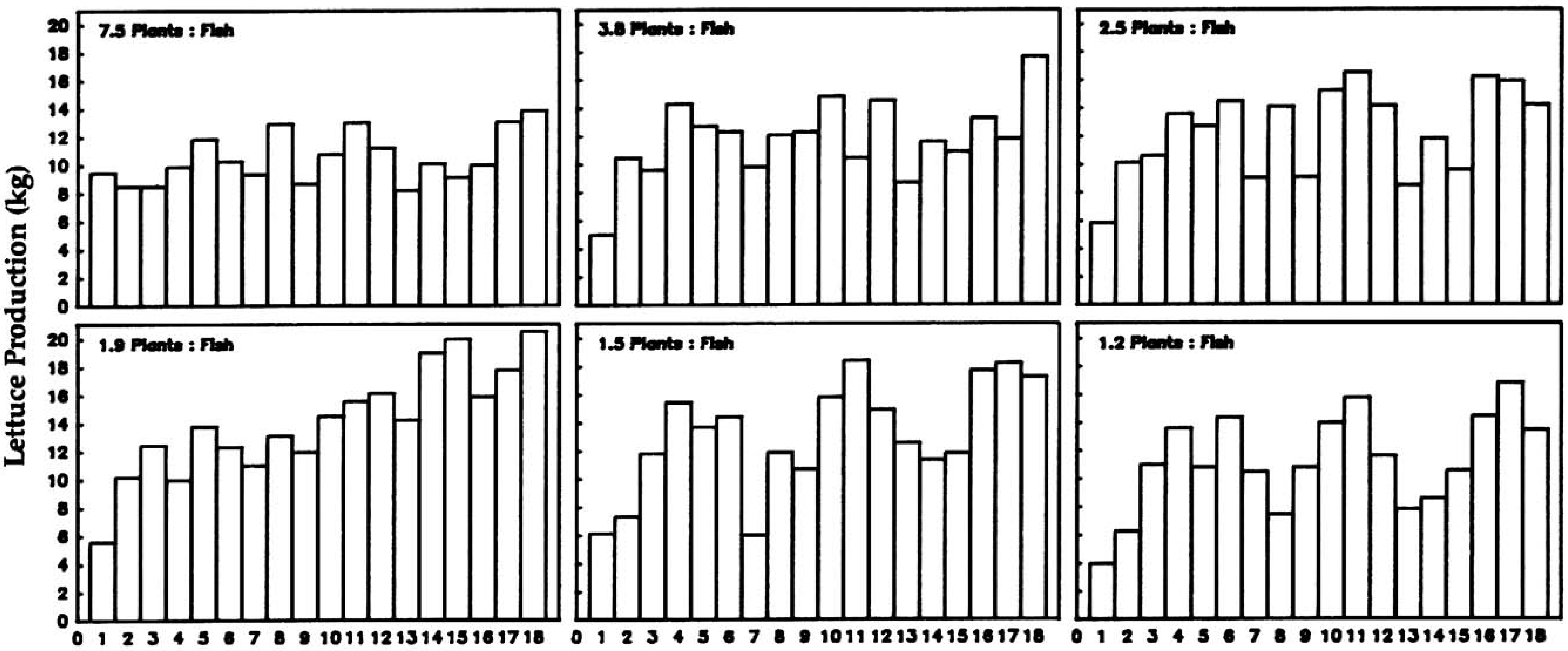


Figure 3. Lettuce production for 18 crops in integrated recirculating systems stocked at six ratios of plants to fish.

experiment demonstrated that a large quantity of lettuce plants can be grown from the nutrients of a relatively small amount of fish or a low feeding rate. Extrapolating from the results of this experiment, just one pound of feed per day, enough to feed 33 lbs of tilapia fingerlings, can sustain 189 lettuce plants and produce nearly 3,300 heads of lettuce annually. A much larger area would be needed for the plants than the fish. Growing lettuce also involves much more time and labor than culturing fish. Fish culturists originally considered vegetables to be a by-product of the fish culture operation, but the emphasis in integrated systems falls on the plant production component.

An objective comparison of integrated systems to individual production systems for lettuce and tilapia is problematic, and the results may be more reflective of system design and experimental procedures than realistic economics. The deep flowing hydroponic system, which integrates well with fish culture, may consume more water and chemicals than sand culture or the nutrient film technique, which are industry standards. Nevertheless, significant reductions in chemical and water consumption were achieved through integration for comparable production; and as more efficient management procedures are developed, inputs (e.g., nutrient supplementation) may be reduced.

Two commercial-scale systems are currently being established to evaluate annual production capabilities, develop an enterprise budget, and gauge the comparative resource requirements and profitability of integrated systems for fish culture and vegetable hydroponics.

This research was supported by Virgin Islands Hatch Project #082.

James E. Rakocy is Associate Director of AES and a research aquaculturist.

Citrus Germplasm Evaluation Under V.I. Conditions

by Feiko Ferwerda and Chistopher Ramcharan

Citrus of all species are widely grown in tropical and subtropical regions. The fruits are used mainly as a dessert or breakfast fruit and for making juices and other citrus products. Citrus is in great demand in the Virgin Islands by local residents and the increasing number of visitors. However, almost 100% of all citrus products used here are imported from the U.S. mainland or neighboring Caribbean Islands. This is partly due to the limitations imposed by soil, water and climatic constraints in the V.I. Due to these limitations, plants are often stressed, making them more susceptible to disease and insect pests. Choosing the proper citrus variety for local conditions is an essential first step for successful cultivation. A long term study at UVI-AES evaluated 21 citrus rootstock scion combinations. The results of the first five years of this investigation indicate a number of differences in the success of various citrus species.

The trial was conducted at the UVI-AES between 1984 and 1989 on Fredensborg clay soil with a pH of 8.0-8.5. The field was ploughed, disced and banked into 8-10 feet wide ridges, 20 feet apart. Plant spacing within the rows was 10 feet. The citrus plants were obtained from a certified nursery in south Florida and shipped bare-root. The trees were planted in the center of the ridges to ensure proper drainage. Weed control was accomplished using Round-up® herbicide (1 qt/ac.) around the trees and mowing as required between the rows. Trees were drip irrigated at 1 gallon/plant/day at 25 psi.

The major disease problem, foot and root rot caused by Phytopthora spp., was controlled by drenching the root-zone with a Ridomil® at 0.05 oz/gallon. Scale insects, aphids and mealy bugs were controlled by a periodical spray with Diazinon® (1 lb/acre) plus Volck oil, as needed. This insecticidal treatment also eliminated the formation of black mold on fruits and leaves. Plants received a monthly fertilizer application of sulfur coated 16-4-4 (N-P-K) at 0.25 lbs/tree. Micro nutrients (Nutrileaf) was applied as a foliar spray at a rate of 2 lbs/100 gallons. Yields were determined from hand-harvested mature fruits. Survival and yield data are illustrated in Table 1 and 2 respectively.

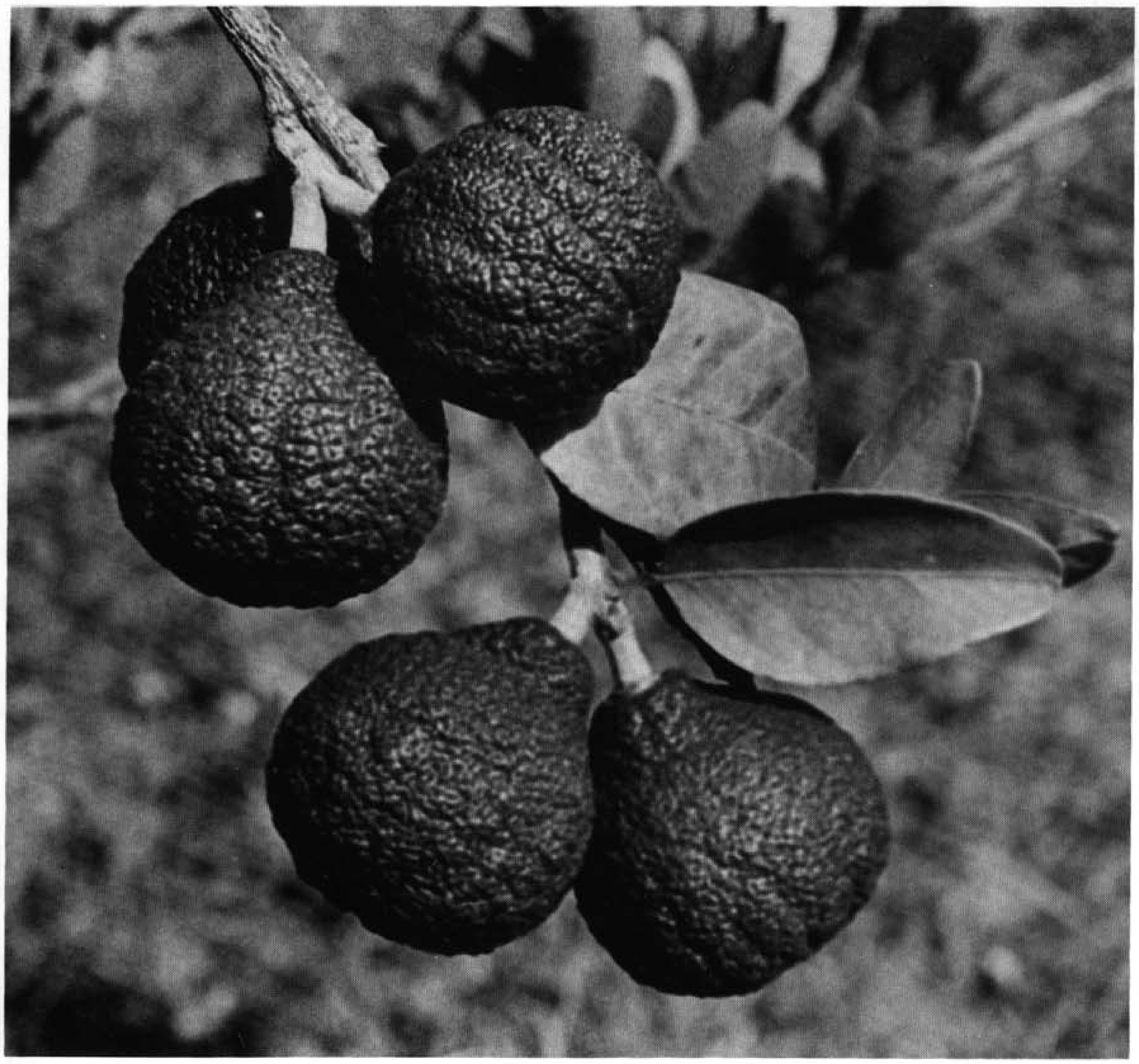
Ortanique, valencia, navel and pineapple oranges were the most environmentally tolerant orange trees (Table 1). Ortanique orange trees produced the highest yields per tree, while valencia produced the largest number of fruits per tree (Tables). Orlando tangelos produced abundant juicy fruits, even under the relatively dry conditions. The tangerines, kumquats, lemons and surprisingly the limes showed poor survivability. Thompson Pink and marsh grapefruit trees withstood local conditions very well. However, the number of fruits per tree were relatively low. Thompson Pink yielded both the highest number of fruit per tree and the highest weight per grapefruit (Table 2). Pumelo thrived well under local conditions and trees were up to 12 feet high with excellent disease resistance.

Overall results from this trial indicate that large-scale commercial production of citrus is generally not feasible in areas of St. Croix with calcareous Fredensborg soil types. The underlying soft, marl limestone limits the root-zone to the top 10-15 inches of soil profile. Although this characteristic tends to dwarf the growth habit of citrus trees, it does not necessarily affect fruit quality. The high pH-deficiencies can be overcome by strict fertilizer schedules. These trees, how-

Table 1. Percentage survivability of 21 citrus cvs. on 2 rootstocks over 5 years (1984-1989)[Z]

Scion	Rootstock[Y]	% Survivability
Ortanique orange	Unknown	100%
Valencia orange	S.O.	90%
Navel orange	S.O.	100%
Pineapple orange	Cleo	100%
Blood orange	Cleo	50%
Blood orange	S.O.	50%
Murcott orange	Cleo	80%
Temple orange	S.O.	40%
Parson Brown orange	S.O.	84%
Robinson tangerine	Cleo	20%
Ponkan tangerine	Cleo	20%
Orlando tangelo	Cleo	100%
Ruby Red grapefruit	S.O.	90%
Thompson Pink grapefruit	S.O.	80%
Marsh grapefruit	S.O.	100%
Meyer lemon	S.O.	20%
Ponderosa lemon	Cleo	0%
Persian lime	Cleo	20%
Lakeland lime	Cleo	0%
Pumelo	S	100%
Kumquat	S	20%

[Y] S.O. - Sour orange rootstock; S - seedling
Cleo - Cleopatra mandarin rootstock
[Z] 5 replicate trees/combination



Ortanique orange produced high yields under Virgin Islands conditions.

Table 2. Yield data of selected citrus cvs. on 2 rootstocks

Variety	Rootstock	Av. No. fruit tree/harvest season	Av. Wt./ fruit (lbs)
Valencia orange	S.O.	98	0.46
Pineapple orange	Cleo	81	0.54
Navel orange	S.O.	47	0.61
Parson Brown orange	S.O.	93	0.39
Ortanique orange	Seedling	78	0.63
Orlando tangelo	Cleo	128	0.38
Ruby Red grapefruit	S.O. 28	0.760	
Thompson Pink grapefruit	S.O.	29	0.903
Marsh grapefruit	S.O.	21	0.842

S.O. - Sour Orange rootstock
Cleo - Cleopatra manderin rootstock

Choosing the proper citrus variety for local conditions is the first step . . .

ever, produce relatively fewer and smaller fruit than citrus grown on ideal soil types.

For the small farmer and home gardener in the Virgin Islands with similar soil types we would recommend the following varieties. Valencia orange for its prolific bearing, good tasting fruits and its drought tolerance. Orlando tangelo performed well and produced sweet easy to peel fruits. Thompson Pink and Ruby Red grapefruit produced fruit with a well blended sweet and sour taste.

Parson Brown, pineapple, ortanique outperformed some of the recommended varieties in yield, but their fruit quality was inferior. High night temperatures and the low altitude of the experimental site may be contributing factors.

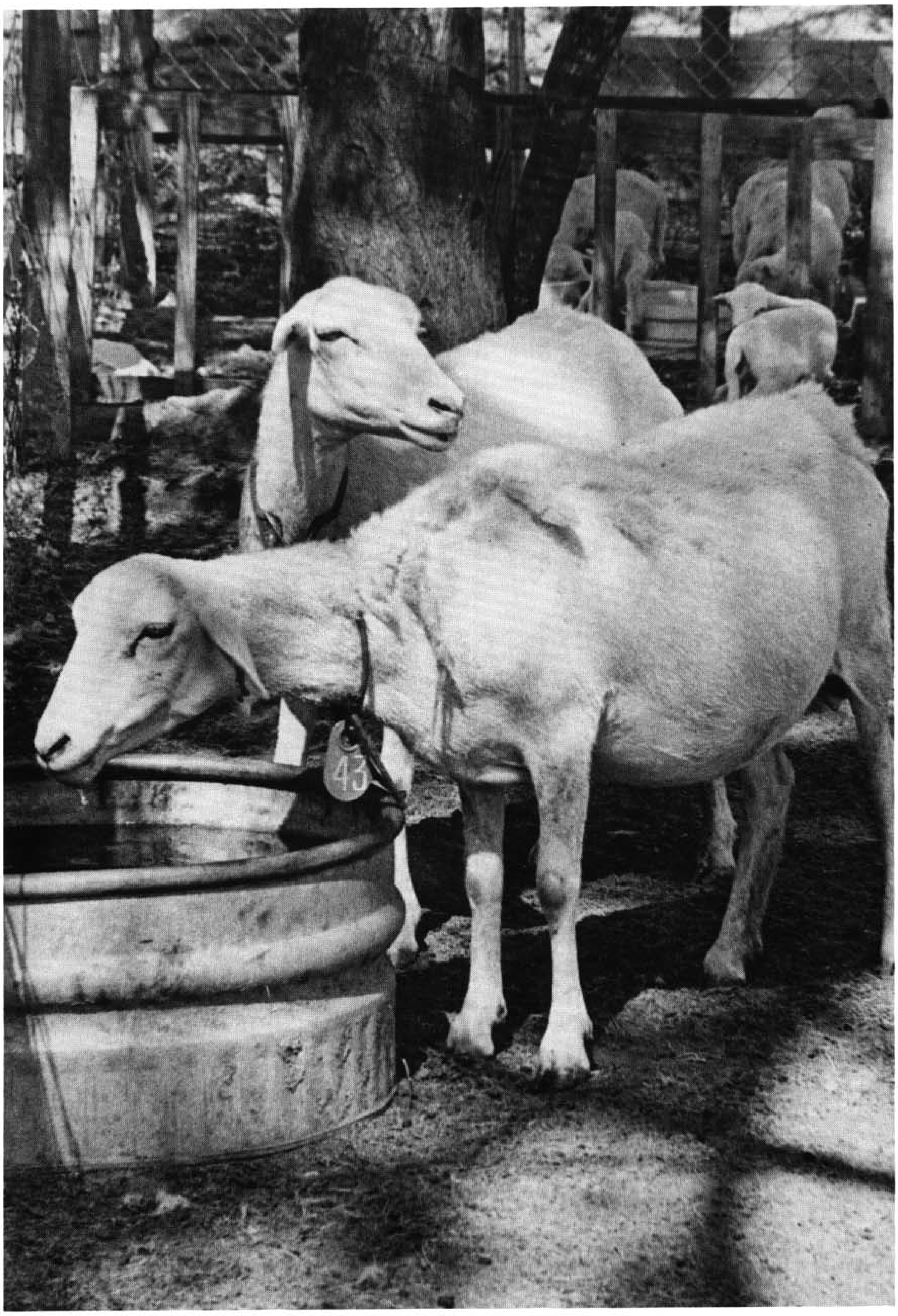
Although the W.I. lime, which is used locally as a beverage and in many dishes, thrives under most local conditions, the limes in this experiment performed poorly. The reason is unknown, but poor quality of original planting stock is suspected. The Pumelo, a vigorous disease-resistant citrus, could have some future potential with the proper introduction of its uses to local growers. The Kumquat can be grown as a potted plant and serve a dual purpose as a fruit and a unique ornamental crop.

This research was funded by Virgin Islands Hatch Project #085.

Feiko Ferwerda is a former research specialist in the Horticulture Program. Chris Ramcharan, Research Assistant Professor, is the leader of the Horticulture Program.

Reproductive Performance of Hairsheep Ewes Following Pre-Breeding Supplementation

by Stephan Wildeus



Increasing the level of nutrition prior to and during the early stages of breeding ("flushing") has successfully increased the lambing rate of sheep in temperate environments. Flushing can be accomplished by either moving the ewes to a pasture with high quality forage, or by supplementation with harvested feed, starting approximately 2-3 weeks before breeding. The beneficial effects of flushing have been observed in breeds of wool sheep under range conditions, but it has not been established if this management tool is useful under Virgin Islands conditions. Two experiments were conducted to examine the effects of different types of supplementation (energy and protein) on the reproductive performance of young and mature hairsheep at the Sheep Research Facility of the Agricultural Experiment Station on St. Croix.

In the first experiment 20 mature ewes (over 2 years of age), nursing lambs, were divided into control and treatment groups stratified by weight 4 weeks before the beginning of breeding (September 9, 1987). All ewes were grazed on the same Guinea grass *(Panicum maximum)* and tan-tan *(Leucaena leucocephela)* pasture during the day and were separated in the evening. The treatment group then received a cracked corn supplement (8 % crude protein, 3% crude fiber and 3% crude fat) at a level of 2.0 lbs/head/day. After 4 weeks, at breeding, supplementation was terminated and the lambs were removed from their dams. During the 34-day breeding period all ewes were mated to a ram that was painted daily on the brisket with colored oil to mark ewes that had been bred. Within 5 to 10 days following their respective breeding dates all ewes were examined by laparoscopy to determine ovulation rate. During the supplementation and breeding period, body weight and condition (estimate of fat cover over the ribs and vertebra) were recorded weekly. At lambing, the number of ewes lambing and the number of lambs per ewe were recorded.

In a second experiment, a similar protocol was repeated with a group of young (6 to 12 months of age) ewes (n=26) to be bred for the first time. Ewes were allocated to a control and treatment group stratified by age, weight and type of birth (single, twin). In this experiment a mixture of coconut meal and molasses was fed at a level of 0.75 lbs/head/day. The supplement was prepared fresh every day by mixing coconut meal, molasses and water in a ratio of 2 : 1 : 1.5 (12% crude protein, 7% crude fiber and 0.5% crude fiber fats on an as fed basis.) For this study the supplementation period was reduced to 3 weeks, but the remainder of the protocol was similar to the first experiment. Ewes in this second experiment were bred starting January 28, 1988 and lambed between June 26 and July 15, 1988.

In the first experiment supplemented ewes gained 4.3 lbs during the flushing period, while the control ewes lost body weight (6.7 lbs) and condition (Table 1). Most likely this loss in body weight and condition can be attributed to the lactation stress experienced by these ewes, while not receiving an adequate level of feeding to satisfy nutritional requirements. Although there was some fluctuation, both groups generally maintained the body weight and condition established during the flushing period throughout breeding (Figure 1).

Reproductive measurements indicated no significant advantages in supplementing with corn (Table 1). Supplemented ewes tended to breed earlier in the breeding season (6 days), but this difference would not result in a major economic benefit, since ewes in both groups conceived during their first estrous cycle (15-17 days). Ovulation rate was higher in the supplemented group, but was of no significance during subsequent lambing. In a separate study (unpublished data) mature ewes on a high plane of nutrition achieved ovulation rates of 2.0 on a year round basis, suggesting that non-supplemented control ewes had ovulation rates slightly below the biological optimum of the breed on St. Croix. The reason for the difference

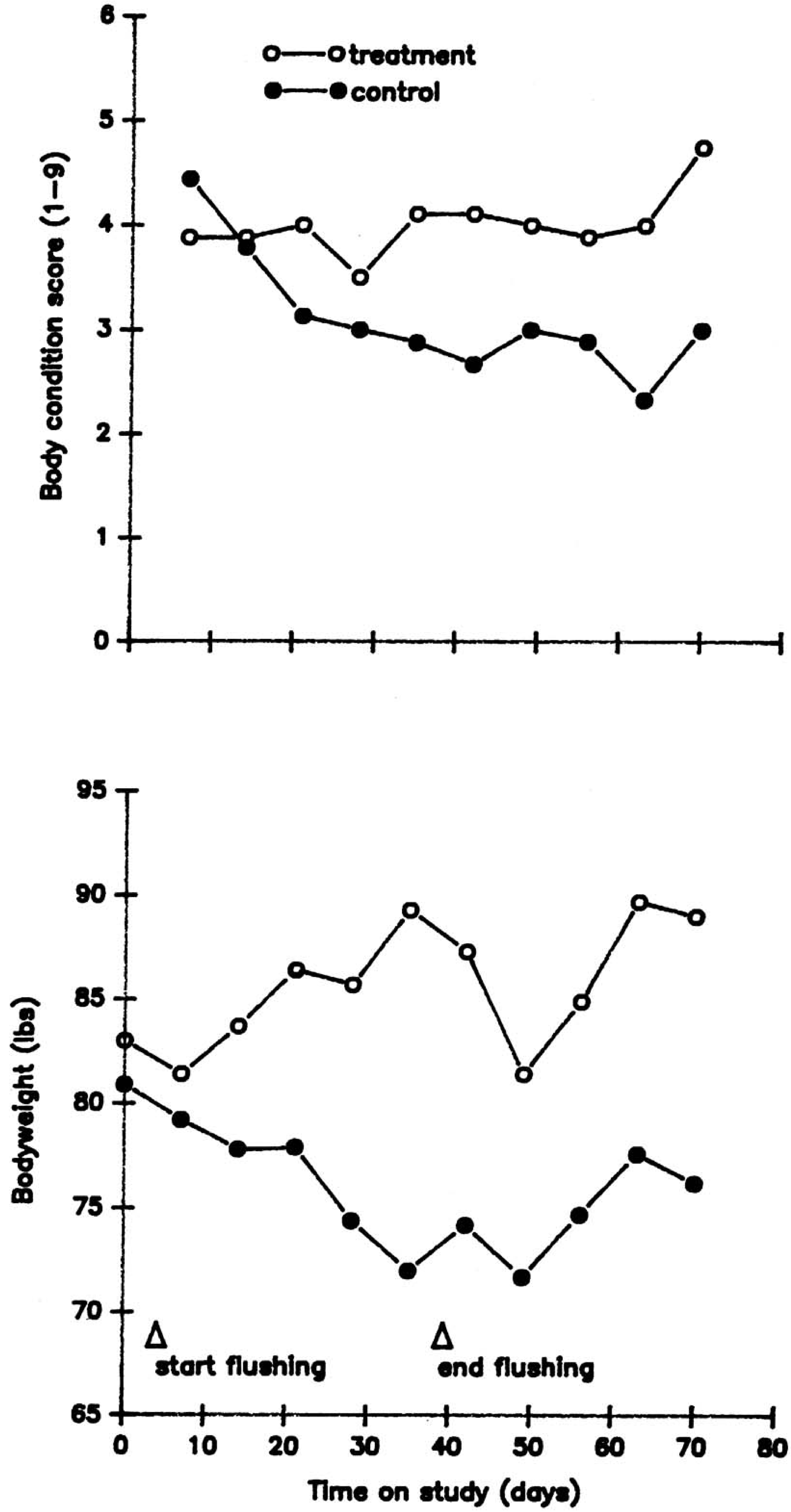
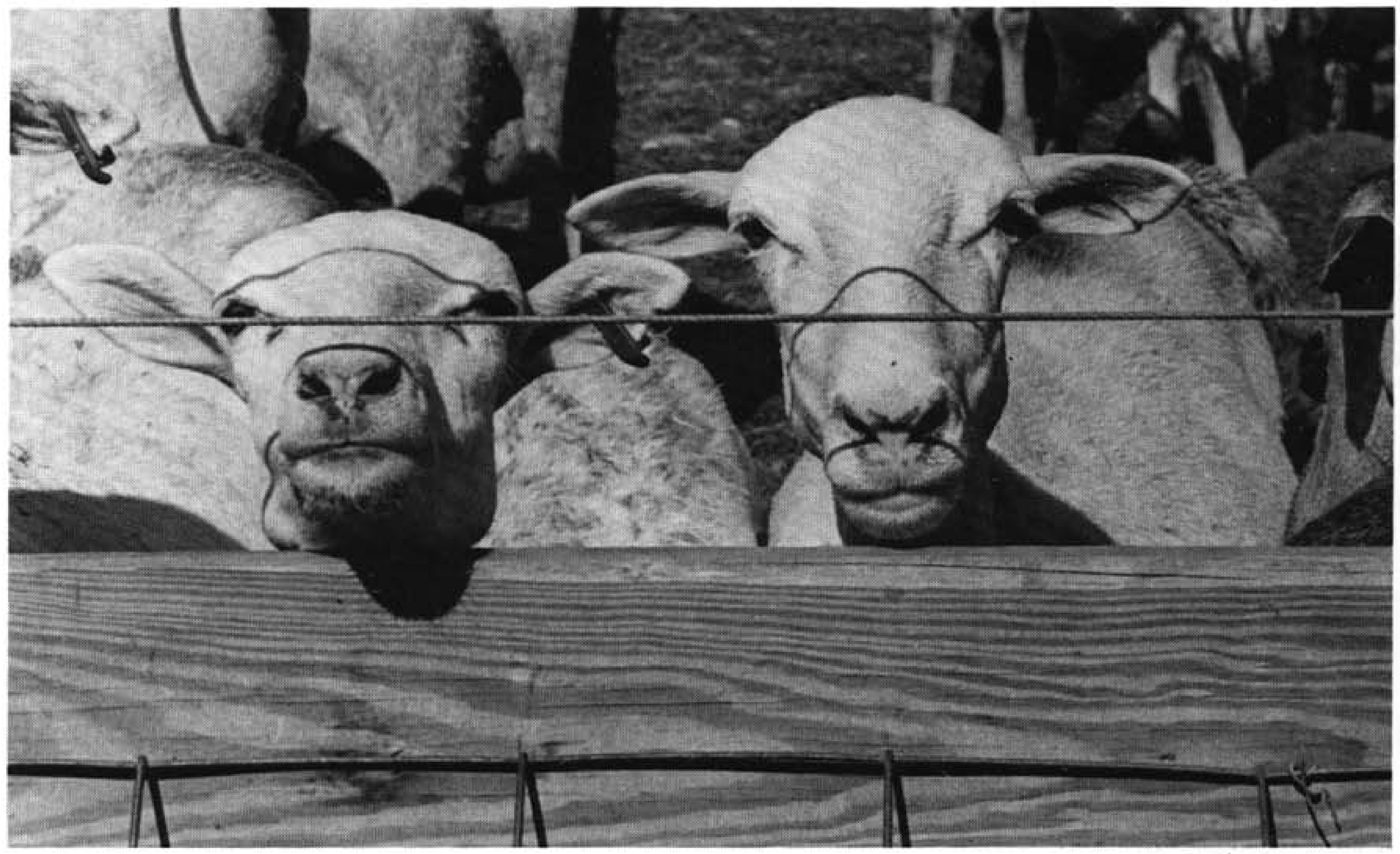


Figure 1: Body weight and condition changes in mature ewes during and after supplementation with corn (treatment).

This lack of response due to "flushing" may be partly due to the absence of a photoperiod on St. Croix.



Ewes waiting for feed.

Table 1. Body weight and condition, and reproductive performance (mean±SEM) in mature ewes fed pasture (control) or pasture with supplement prior to breeding.

	Supplemented[a]	Control
Beginning of flushing:		
Weight (lbs)	83.0±4.1	80.9±3.4
Condition (1-9)	3.89±.26	4.44±.17
After flushing:		
Weight (lbs)	87.3±3.9	74.2±2.9
Condition (1-9)	4.11±.26	2.66±.24
End of breeding:		
Weight (lbs)	89.0±4.1	76.2±2.1
Condition (1-9)	4.44±.50	3.00±.24
Days to estrus	2.6±0.8	8.9±2.1
Ovulation rate	2.00±0.19	1.78±0.22
No. of lambs/ewe lambing	1.50±0.18	1.57±0.18
No. of lambs/ewe exposed	1.33±0.23	1.22±0.28
Gestation length (days)	149.0±0.7	148.4±0.7

[a]supplemented with 2 lbs/head/day of cracked corn

Table 2. Body weight and reproductive performance (means±SEM) in hairsheep ewes lambing for the first time fed pasture (control) or pasture with supplement.

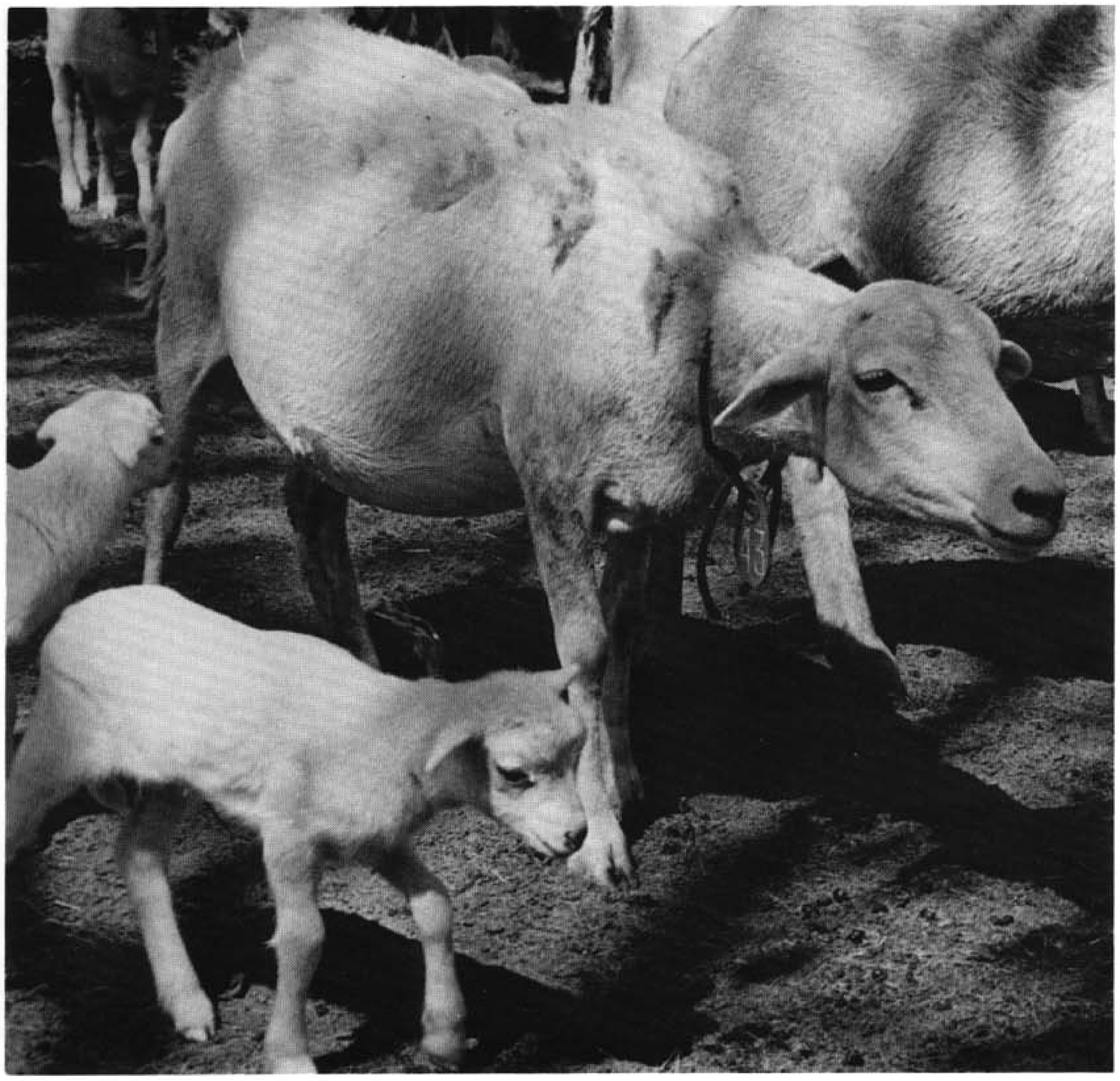
	Supplemented[a]	Control
Pre-feeding weight (lbs)	66.7±1.94	67.8±1.70
Post-feeding weight (lbs)	71.1±1.79	70.6±1.96
Weight at conception (lbs)	73.3±1.67	72.2±1.80
Days to estrus	11.2±2.27	7.9±1.43
Ovulation rate	1.27±0.18	1.42±0.15
No. of lambs/ewe exposed	1.07±0.21	1.27±0.17
Amount of lamb born (lbs)	8.42±0.59	7.81±0.74
Gestation length (days)	146.3±0.60	145.7±0.38

[a]supplemented with coconut/molasses mixture at 0.75 lbs/head/day.

between ovulation and lambing rate is not readily apparent, but may be partly the result of the surgical interference due to laparoscopy. This decline in lambing rate was the result of ewes not lambing according to their projected ovulation rate, as well as ewes failing to lamb. The number of lambs born per ewe lambing in this experiment (1.5) was lower than the value generally observed (1.7) in mature ewes lambing on pasture at the Sheep Research Facility. However, both control and supplemented ewes were equally affected by this decrease. Gestation length was similar in control and supplemented ewes.

In the second experiment body weights of control and supplemented groups were not significantly affected by the feeding regime (Table 2). After three weeks of feeding, supplemented ewes were only slightly heavier (1.5 lbs), but the difference in weight was no longer evident at the end of the breeding season (Figure 2). The weight at conception was 1.1 lbs lower in the control group.

In the young ewes pre-breeding supplementation also failed to improve reproductive and lambing performance (Table 2). Supplemented ewes displayed estrus slightly later during breeding (3.3 days) and had lower ovulation and lambing rates, but differences were not statistically significant. The amount of lamb born and gestation length were also not affected by



Hairsheep ewe with twins.

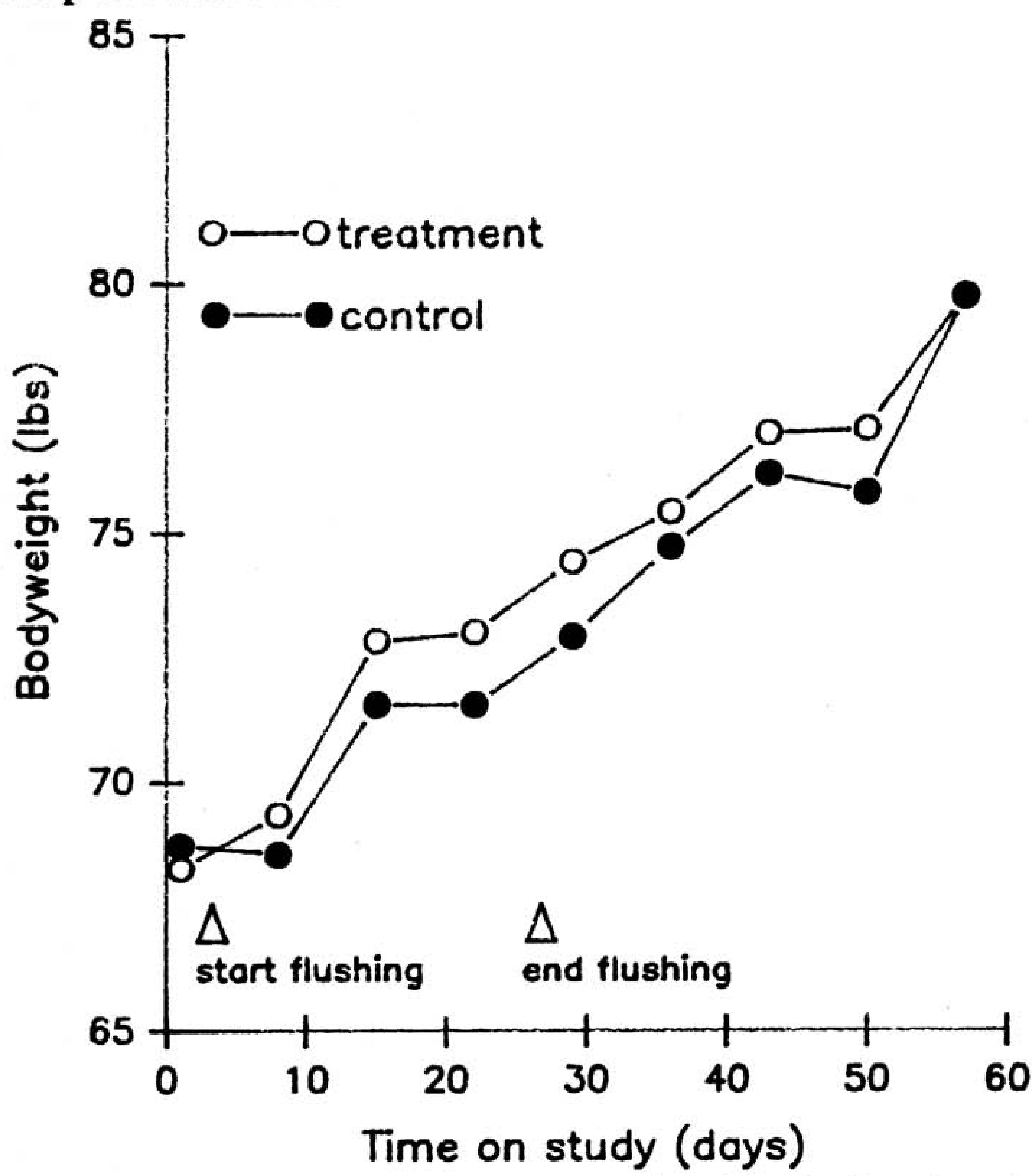


Figure 2. Body weight changes in young ewes bred for the first time during and after supplementation with coconut meal/molasses (treatment).

pre-breeding supplementation. However, gestation length was 2.5 to 3 days shorter in these younger ewes compared to the mature ewes in the first experiment.

The results from the first experiment suggest that short-term supplementation, at least at the level and for the duration practiced here, was able to generate a difference in body weight and condition, but failed to have an impact on the lambing performance of hair sheep on St. Croix. Though there was an indication of slightly higher ovulation rates following supplementation, this effect did not materialize in subsequent lambing rates. In the younger ewes no significant body weight changes were associated with pre-breeding supplementation at 0.75 lbs/head/day, and it is not clear if the lack of a response to supplementation is an indirect effect of the insufficient body weight change or a failure of the supplement to directly affect reproductive function.

At this point the data suggest that short-term supplementation prior to breeding will not result in an improved lambing performance in ewes in moderate to good body condition.

This lack of response to "flushing" may be partially a result of the absence of photoperiod-induced seasonality in breeding of sheep on St. Croix. However, the benefits of a long-term improvement in the level of nutrition, either through supplementation or improved pastures, cannot be ruled out and deserve further investigation.

The author acknowledges the technical assistance of Ms. K.T. Traugott, Ms. J.R. Fugle and Mr. A. Schuster in animal handling and data collection.

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Stephan Wildeus, Research Assistant Professor, heads the Animal Science and Forages Program.

Improving Agricultural Marketing in the U.S.V.I.

by Francois Dominique

Fruit production has been an alternative form of agriculture in the U.S. Virgin Islands from the beginning of the twentieth century. As the basis of the local economy changed from agriculture (sugar cane) to heavy industries and tourism, fruit production became the dominant crop farming activity. A 1986 study showed notable production increases of avocado, banana, lime, and mango from 1930 to 1982. During the same era sugar cane cultivation declined from 8,685 acres in 1917 to 3,676 acres in 1960, and by 1982 cultivation was down to three acres. Apparently, the high labor cost and competition for labor in the more lucrative tourism and industrial sectors has forced farmers into less labor intensive fruit crops production.

Presently, V.I. fruit growers are confronted with many adverse marketing conditions. According to the UVI Cooperative Extension Service market survey in 1987, the factors which impede trading between retailers and local producers ranked as follows: (1) dependability of supply; (2) high prices; (3) low production volume; (4) fragmented supply system; and (5) poor quality control. Over 80% of tropical fruits are imported to the island and 17% of that volume spoils (Figure 1).

Supermarkets are the largest retailers of food items. Of the 46 marketing outlets surveyed, six (6) or (13%) were supermarkets, and with the exception of mango, these outlets control the largest share (52%) of the fruit market. The major marketing outlets import an average of 82% of these commodities and, even in the case of mango were domestic production (219,510 lbs.) far exceeds the outlets' demand (197,078 lbs.), 67% of their purchases are imported (Table 1).

Of the approximate 300,000 lbs. of fruits produced, 138,000 lbs. (46%) generated farm income (Table 1). Most (76%) of this volume was marketed through direct distribution to consumers and only 33,142 lbs. (24%) were sold to supermarkets, grocery stores, roadside vendors, hotels, and restaurants. Table 2.

The V.I. market absorbs 84% of the banana production and this makes it the best seller, and the second largest cash crop ($10,121/yr.). Although it fetches the highest wholesale price (0.38/lb.) among the selected crops, the retail/wholesale price ratio of $0.57/$0.38 or simply 1.5:1 has the lowest retail markup price ($0.19). From the standpoint of farmers, such a low markup makes bananas a good wholesale crop. On the other hand, mango represents the largest quantity sold (101,628 lbs.) and yields the highest cash returns ($56,925) but has the lowest wholesale price ($0.15/lb.). The high price differential of 54 cents from the retail/wholesale ratio of 4.6 makes it a good retail crop (Table 3).

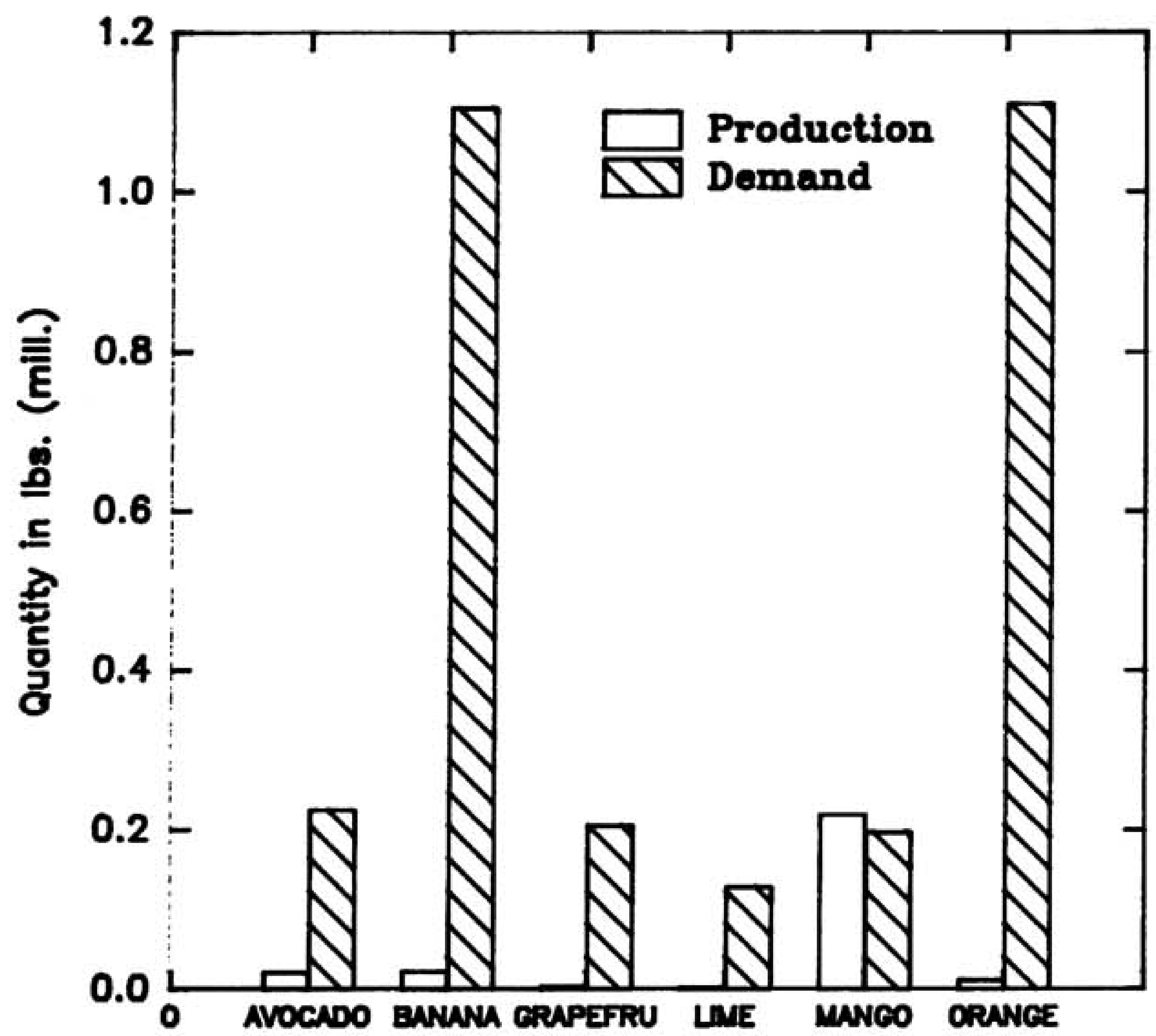
The domestic market has the capacity to absorb all the local fruits produced, and the surplus mangoes could become an export crop. But though both producers and buyers recognize the importance of volume, quality, dependability, regularity, prices, and an organized market structure, the two entities have different ranking priorities for these trade barriers.

In the Virgin Islands, the structure of marketing channels for domestic food crop production is quite simple because the system does not include processing and exporting. The two tier distribution system for fruit markets are 76% direct to consumers, and 24% through other marketing channels.

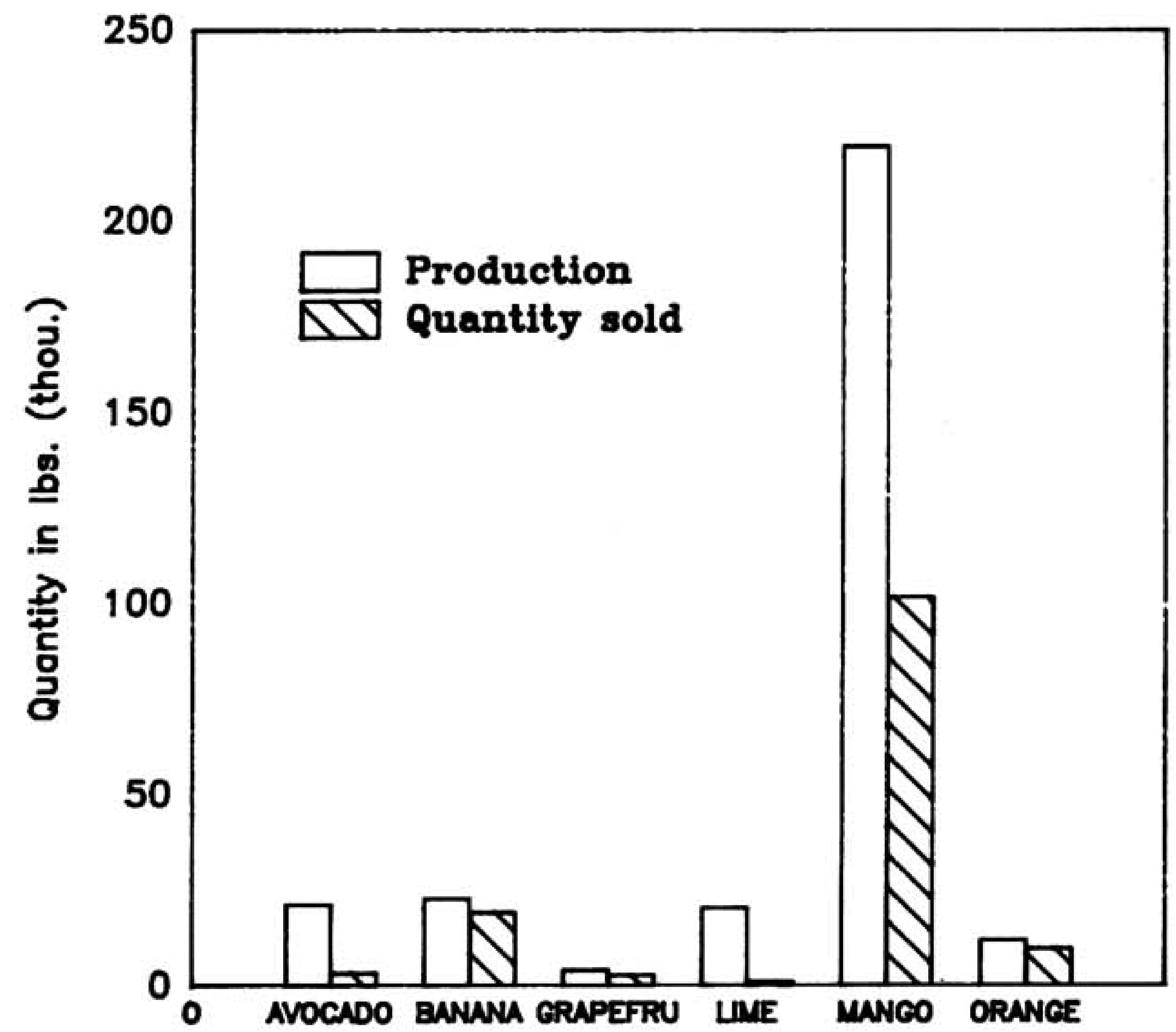
To the farmer, the strategic functioning of a marketing system is to offer a convenient outlet for produce, and to the commercial sector and the consumer, assurance of a steady supply is the vital service. Improvement of the marketing system then depends on the ability of willingness of producers to develop and capitalize on higher prices obtained by direct distribution, and to increase production and improve post-harvest techniques so as to sustain regular supplies and to meet the quality requirements of wholesalers. At the current level of domestic production, direct sales are the preferred marketing method because the consuming public poses less stringent demands on producers in terms of regularity, quantity, and quality as required by wholesalers. Many farmers discount the economic cost of retailing because of the higher prices obtained for their produce through this distribution method. Thus an effective marketing system should be geared towards expanding the range and types of consumers served, and this should offer producers expanding outlets.

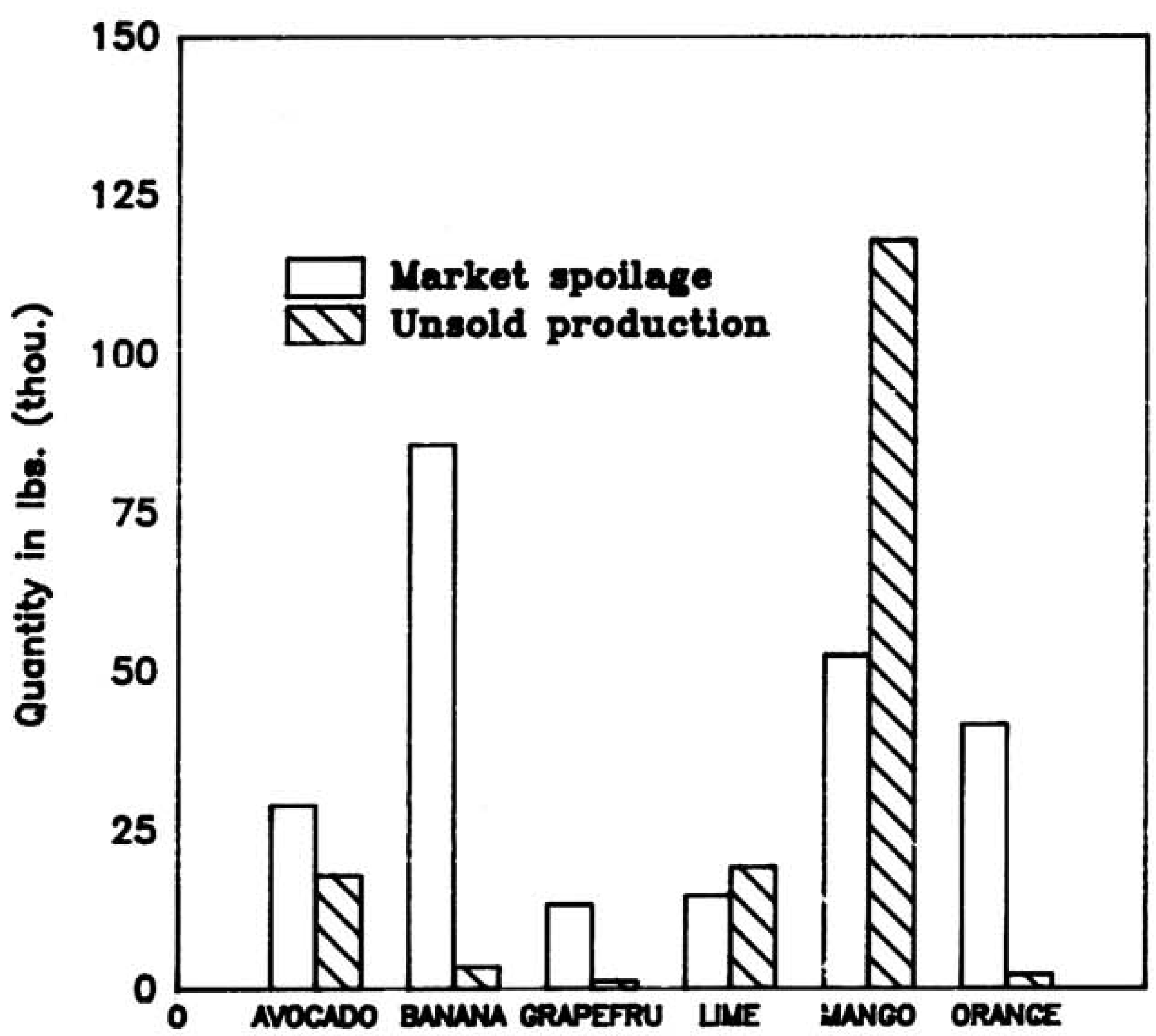
Mangoes yield high cash returns.

Even a low production level and an organized delivery system would benefit producers, wholesalers, and consumers. Ideally, producers, retailers, and consumers could trade at one center through an intermediary agency such as a marketing board. To the contrary, because prices of direct marketing are better, vendors are scattered along the road from Christiansted to Frederiksted where some have established permanent locations, while others make occasional appearances at



To the detriment of their operations, local farmers tend to use retail prices to wholesale their produce.





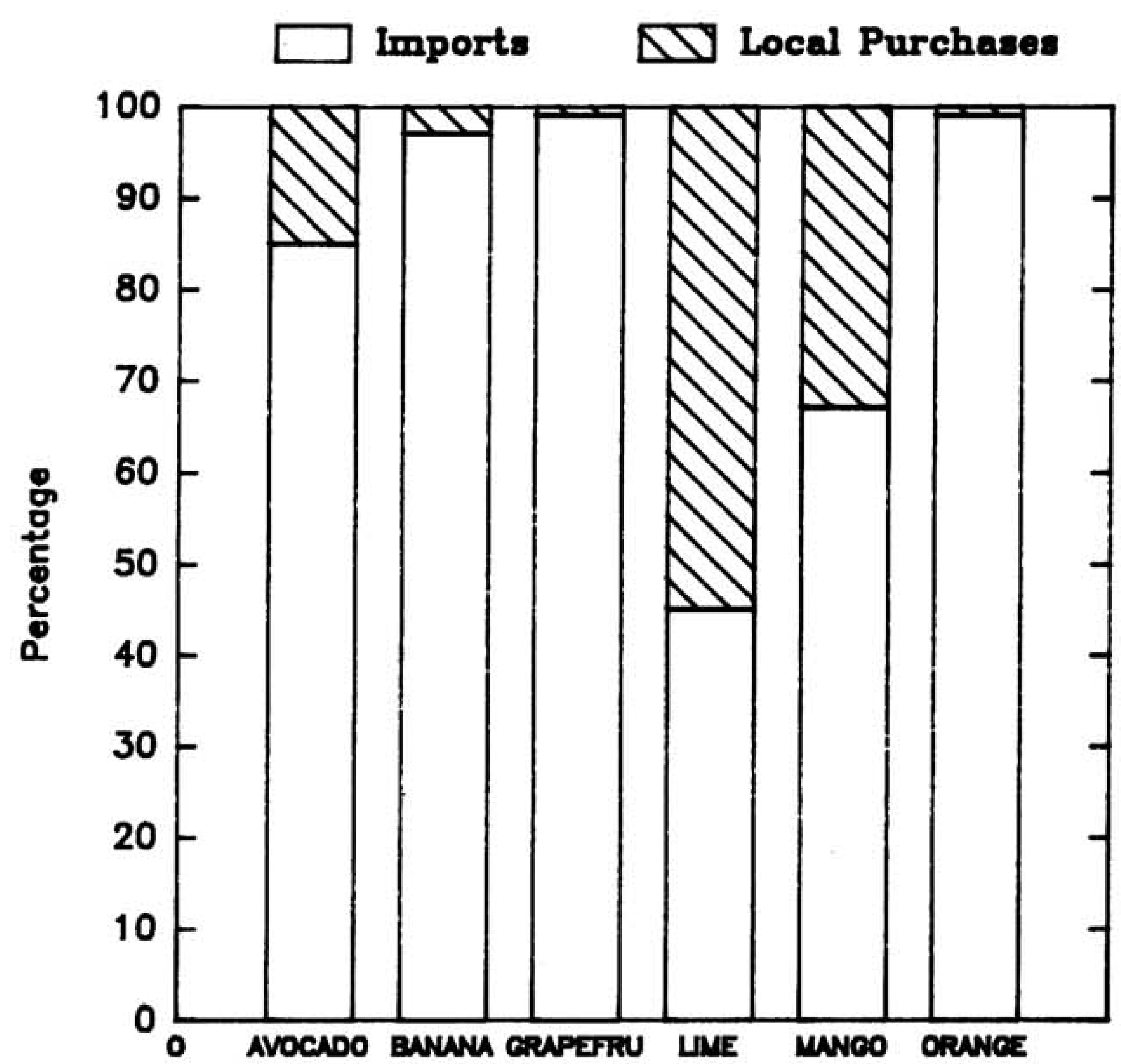


Figure 1. Aspects of fruit crop production, marketing and consumption in the U.S. Virgin Islands in 1987.

Table 1. Marketing survey of imports vs. local fruits purchased.

Fruit	Quantity Purchased (lbs.)	Source Import (%)	Local (%)
Avocado	225,120	85	5
Banana	1,104,764	97	3
Grapefruit	205,643	99	1
Lime	128,522	45	55
Mango	197,078	67	33
Orange	1,110,313	99	1
Mean	495,240	82	18

Table 2. Percentage of market share.

Fruits	Supermarket	Wholesale	Grocery	Roadside	Restaurant
Avocado	58	8	27	5	2
Bananas	75	6	15	2	2
Grapefruit	53	30	11	4	2
Lime	35	26	29	6	4
Mango	23	22	24	31	1
Orange	68	22	10	1	1
Mean	52	19	19	8	2

Table 3. Price structure of fruit crops.

Fruit	W/Sale/lb.	Retail/lb.	Wholesale/Retail Ratio
Banana	$ .38	$ .57	1.50
Orange	.34	.79	2.32
Lime	.35	1.09	3.10
Grapefruit	.32	1.04	3.20
Avocado	.20	.73	3.65
Mango	.15	.69	4.67

Table 4. Farm survey of fruitcrop production, sales and cash value.

Produce	Quantity Grown (trees)	Quantity Produced (lbs)	Quantity Sold (lbs)	Percent Sold (%)	Cash Value of Sales ($)
Avocado	143	21,450	3,395	16	2,046
Banana	1,254	22,920	19,300	84	10,121
Grapefruit	47	4,116	2,805	68	2,432
Lime	140	20,440	1,182	6	1,078
Mango	813	219,510	101,628	46	56,952
Orange	73	12,050	9,781	81	6,671

various points. The largest number of vendors gather in the area of the Sunny Isle Shopping Center on Saturday, the traditional market day in the Caribbean. The Hendrick's Market in Christiansted operates with 90% imports but the Frederiksted Market is totally abandoned.

Beyond the current level of production farms should operate as a true business enterprise (Table 4). Production should be planned, post-harvesting techniques should be improved, farmers should be aware of the competition from the mainland and other Caribbean islands, and marketing intelligence and linkages with buyers should be established.

One factor which has not received adequate attention is pricing. To the detriment of their operations, local farmers tend to use retail prices to wholesale their produce. A recent survey of the Christiansted Market by UVI students revealed that retailers preferred purchasing imported rather than domestic tomatoes because returns on the former were higher even with higher spoilage rate. This statement seems to concur with the findings of this study. Given the spoilage rates of many of the imported fruits, domestic prices could be set to clear local production.

The St. Croix Dairy Products and Good Farm of St. Croix (sprouts farming) are two examples where producers have used spoilage factor to penetrate the market. Realizing that they could produce quality items on a regular basis and at competitive prices with imports, longevity of product shelf life became the main promotional strategy.

This reseach was supported by Smith Lever Cooperative Extension Project #031.

Francois Dominique is a former Program Supervisor for the CES Community and Rural Development Program.

Temperature Build Up and Control Measures in Container-Grown Plants

by Christopher Ramcharan

Many tropical fruit and ornamental plants destined for field planting or the landscape are started in containers. Although this production method offers many advantages, high growth medium temperature build up under local conditions can reduce plant growth and quality. Temperatures above 50C have been recorded in container media and temperatures above 40C are commonly attained for more than 4 hours daily. Heat injury to plant roots can result in plant starvation effects and biochemical lesions or the accumulation of toxic byproducts.

Root-zone temperatures in container-grown plants vary with the color, design and spacing of the containers. Elevated temperatures can cause heat injury to plant roots, reducing overall growth.

Research at the Agriculture Experiment Station of the University of the Virgin Islands was conducted to determine critical root-zone temperatures (RZT) for selected tropical species and to evaluate cultural practices aimed at reducing heat stress in container-grown plants. The objectives were to evaluate the effects of plant-container type and container spacing on RZT fluctuations and growth of two commonly used ornamentals - Dracaena marginata 'tricolor', and Ixora chinensis 'maui' - and three economic fruit species - 'Carrizo' citrange citrus, 'Grande Naine' banana and Barbados solo papaya.

Containers used were 2 gallon black rigid plastic, 2 gallon rigid plastic painted white and 2 gallon black polyethylene bags inserted into black rigid plastic containers 3 inches greater in diameter than the poly bags. Metro mix growth medium (W.R. Grace, Inc., Cambridge, MA, USA) was used for transplanting.

Plant height, width and shoot and root dry weights were recorded. Diurnal RZT and solar radiation intensity fluctuations were recorded monthly in four regions of four replicated containers of each container type using a microdatalogger (Model 21X, Campbell Scientific, Logan, Utah, USA).

In a second study, plants in black rigid containers were either spaced at 18 in. on center, pot-to-pot for the entire experiment or spaced pot-to-pot for 8 weeks then spaced to 18 in. on center for the remaining 12 weeks of the experiment. A row of border plants were maintained at the same spacing around the plants from which data were collected.

Dracaena height and root and shoot dry weights were significantly greater in plants grown in the white container compared to the black rigid container (Table 1). The black poly bag inside the rigid plastic container resulted in intermediate height and root dry weight. Measured parameters of 'Carrizo' citrange and papaya were not influenced by container type. Ixora final height was reduced by the black rigid plastic container compared to the poly bad in the rigid container and shoot and root dry weight was lowest in plants in this treatment. The black containers therefore reduced overall plant growth in most species compared to the other treatments. Seedling growth variability in 'Carrizo' citrus and papaya could have masked their response to the container treatments.

The Maximum media temperature recorded was 45.5 C and temperatures above 40 C were maintained for four hours in the black rigid container (Figure 1). The maximum temperature was recorded on the western exposure of the black rigid container and temperatures in this treatment were generally 5 to 10 C higher than in the other treatments (Figure 2). Data from this experiment are consistent with growth room and laboratory research on the response of these plants to elevated container temperatures.

'Grande naine' banana height was greatest when plants were initially spaced pot-to-pot and than spaced after 10 weeks, with the continuous pot-to-pot treatment resulting in greater plant height than the 18 in. spacing (Table 2). Shoot dry weights did not reflect these differences in plant height, but root dry weight was greatest in plants spaced pot-to-pot. A similar trend was noted in papaya with

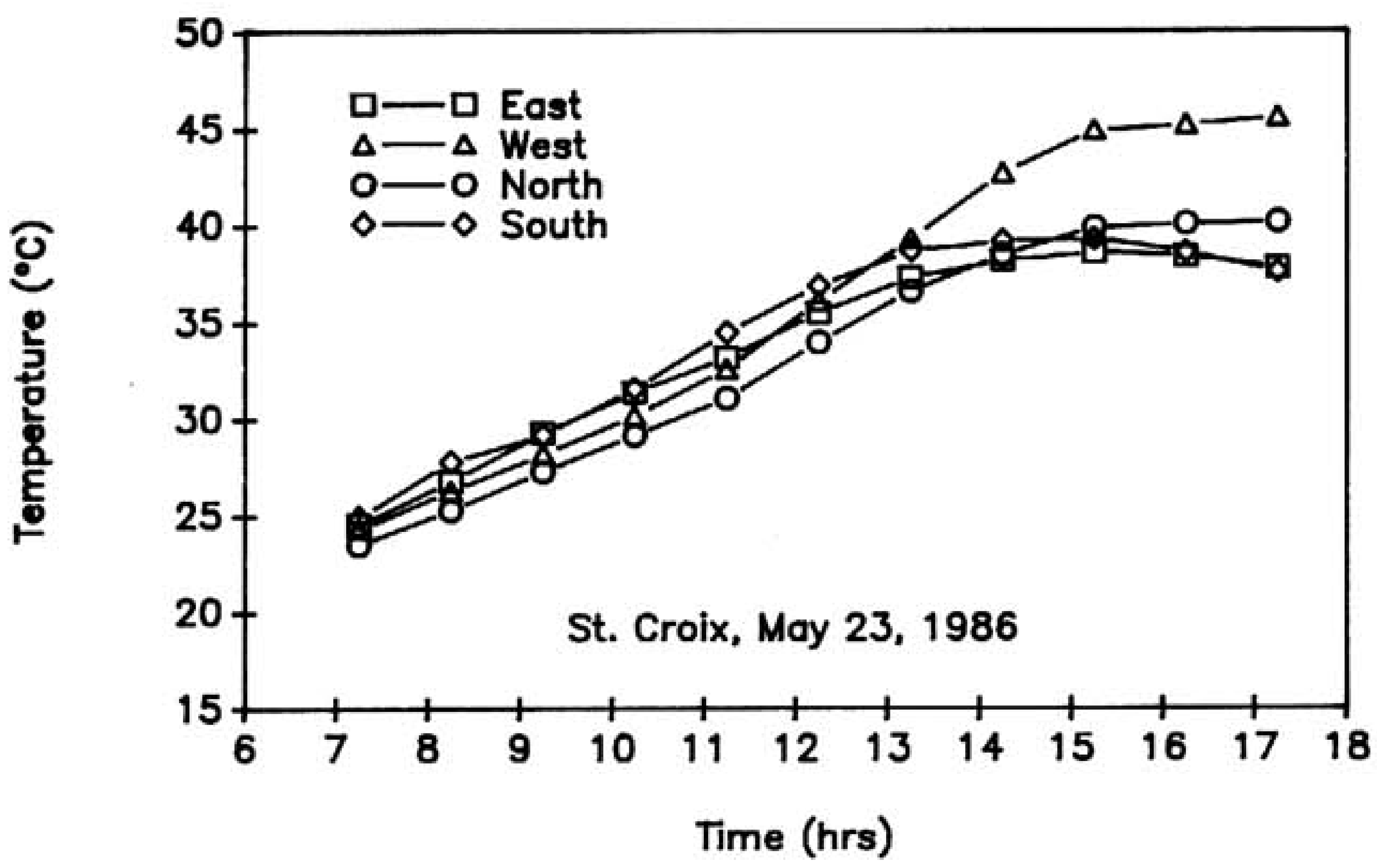


Figure 1. Mean diurnal temperature of media in black plastic containers.

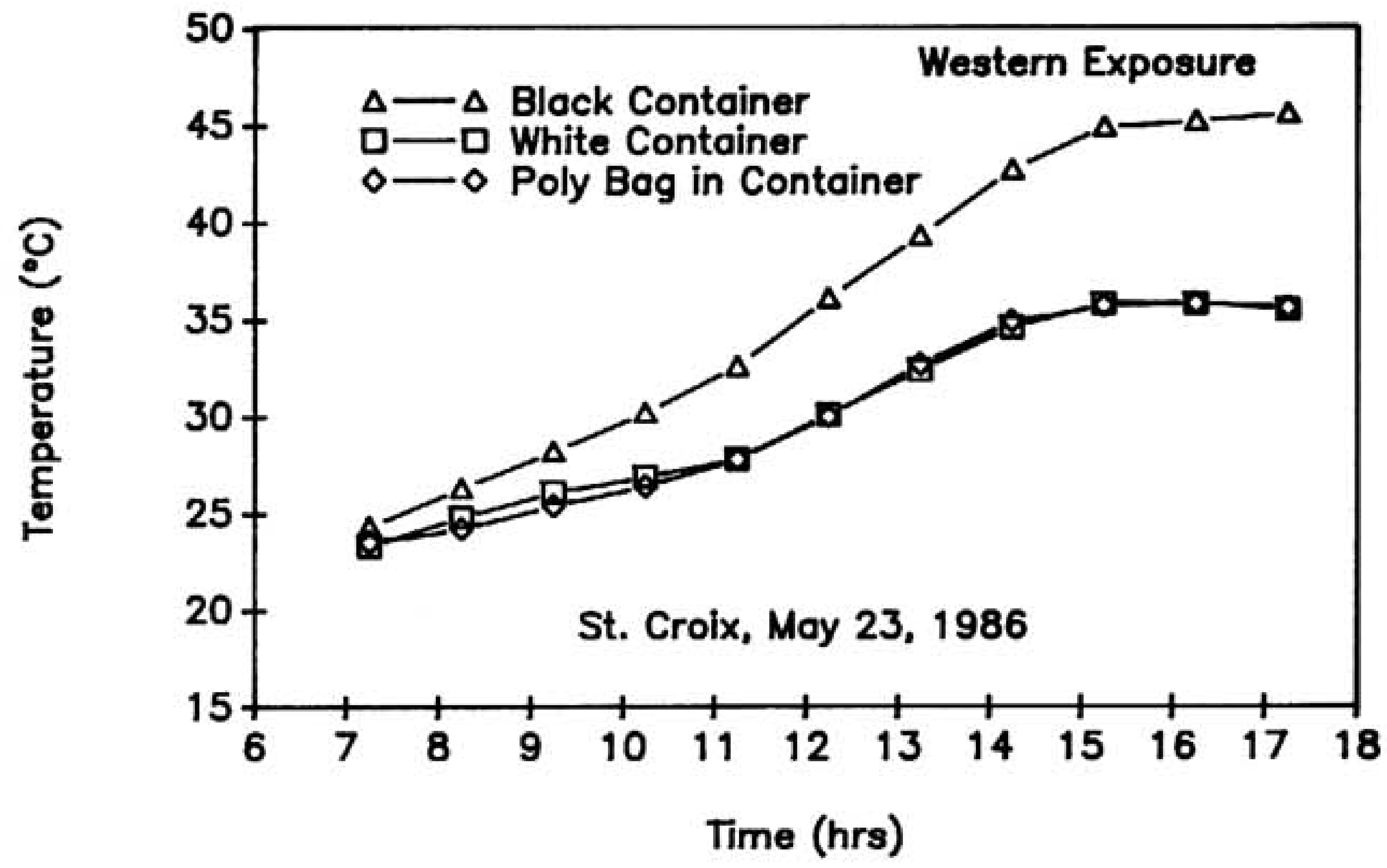


Figure 2. Mean diurnal temperature in western quadrant.

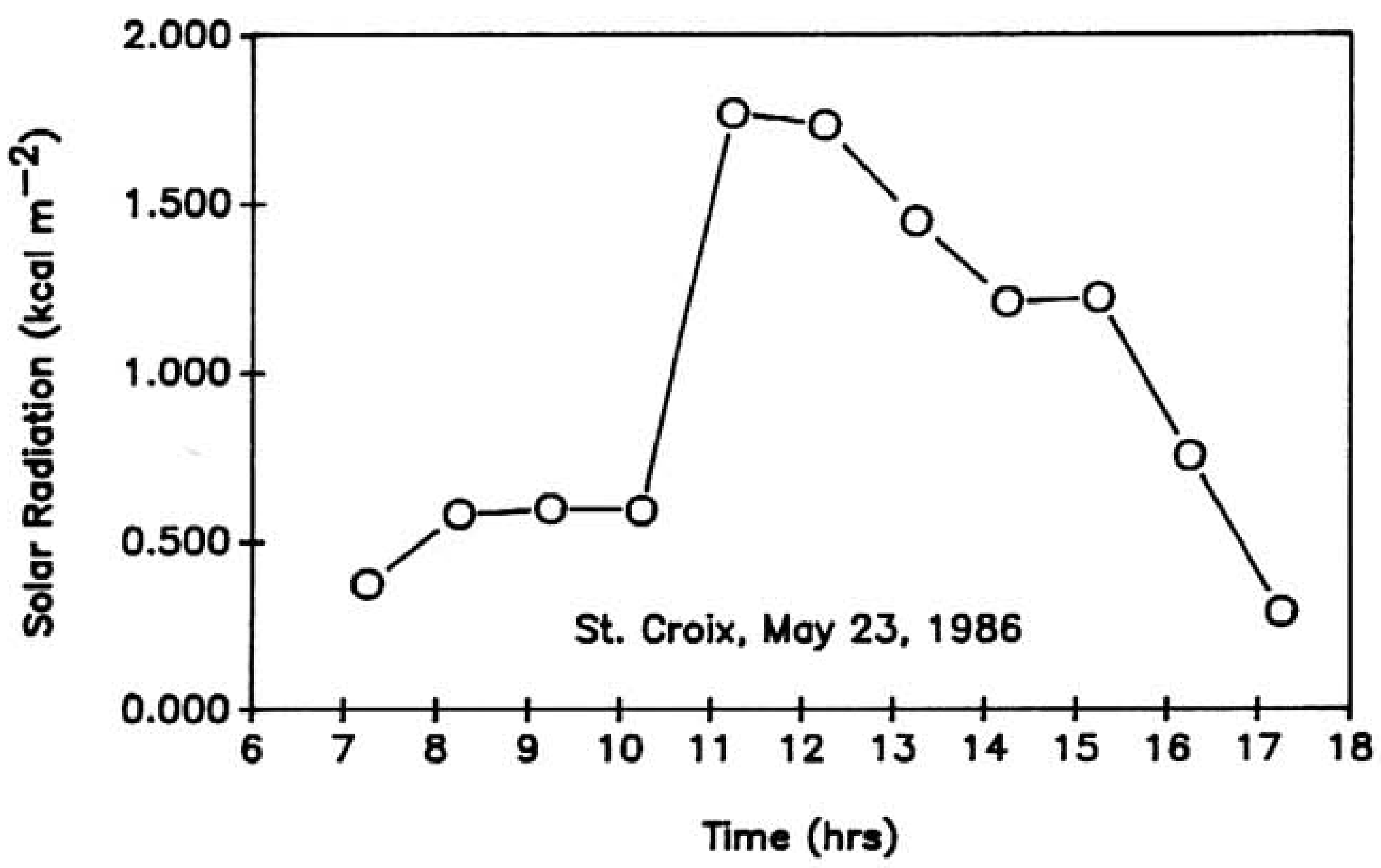


Figure 3. Diurnal solar radiation.

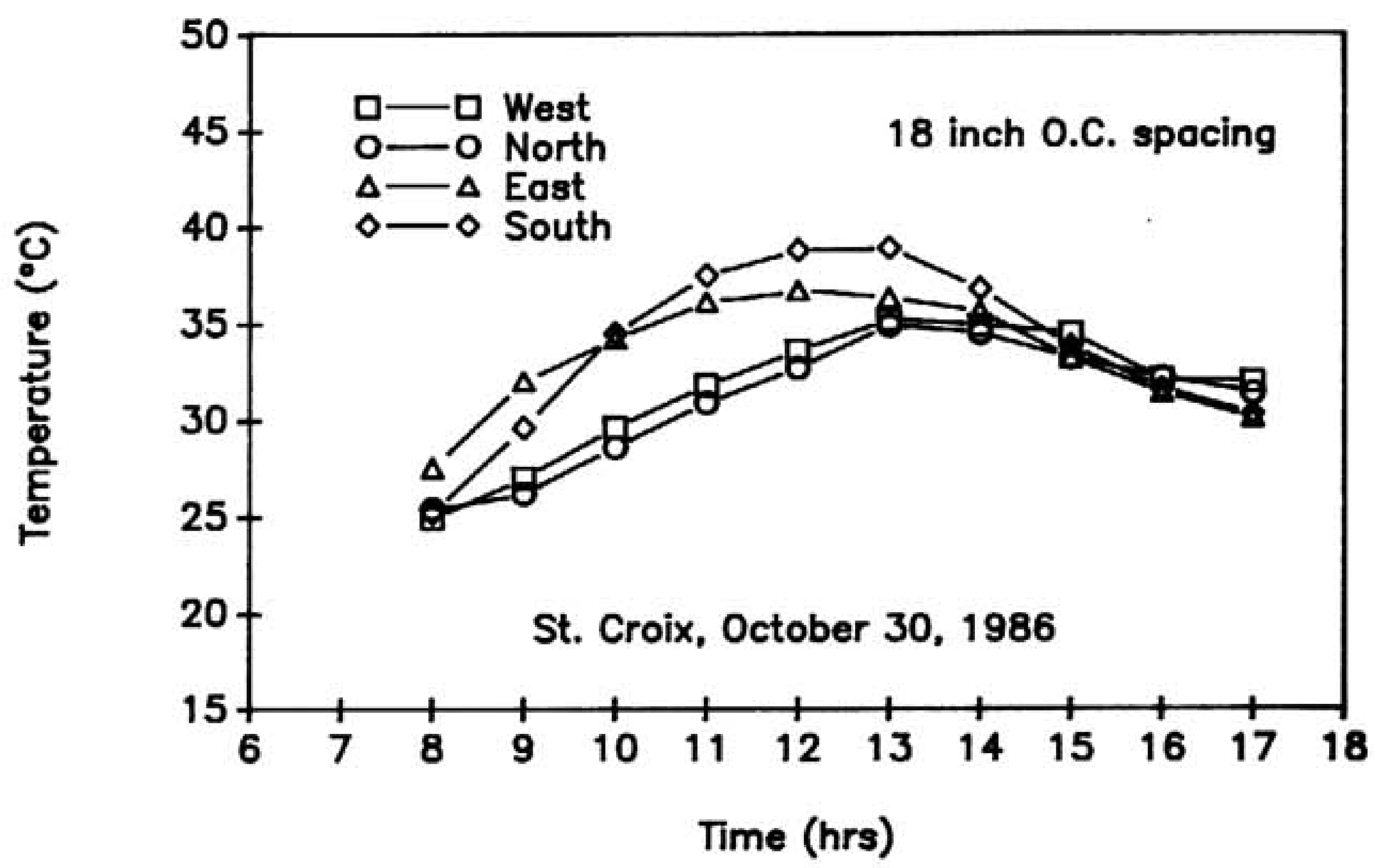


Figure 4. Mean diurnal temperature of media in black plastic spaced at 18 inches.

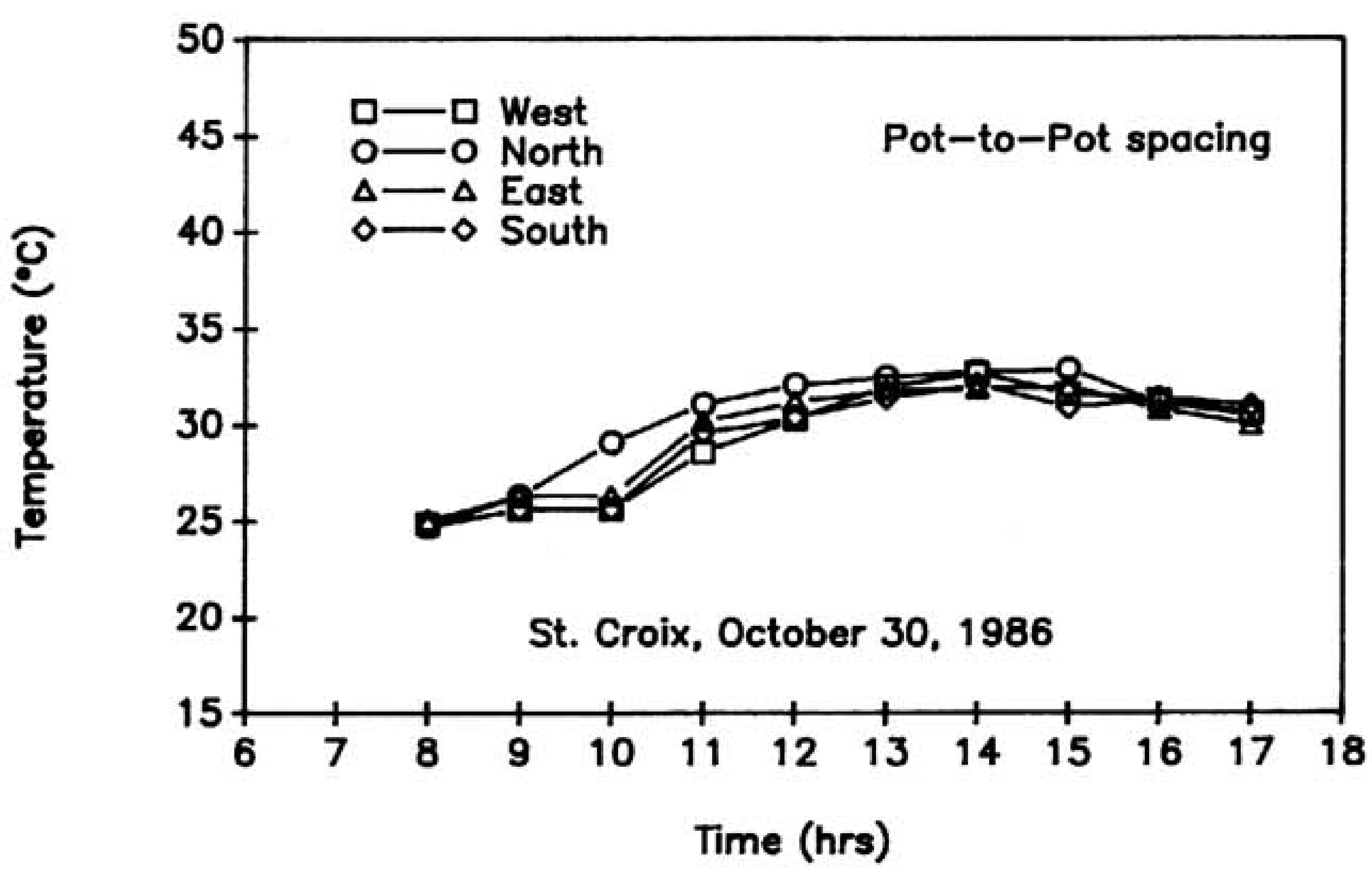


Figure 5. Mean diurnal temperature of media in black plastic spaced pot-to-pot.

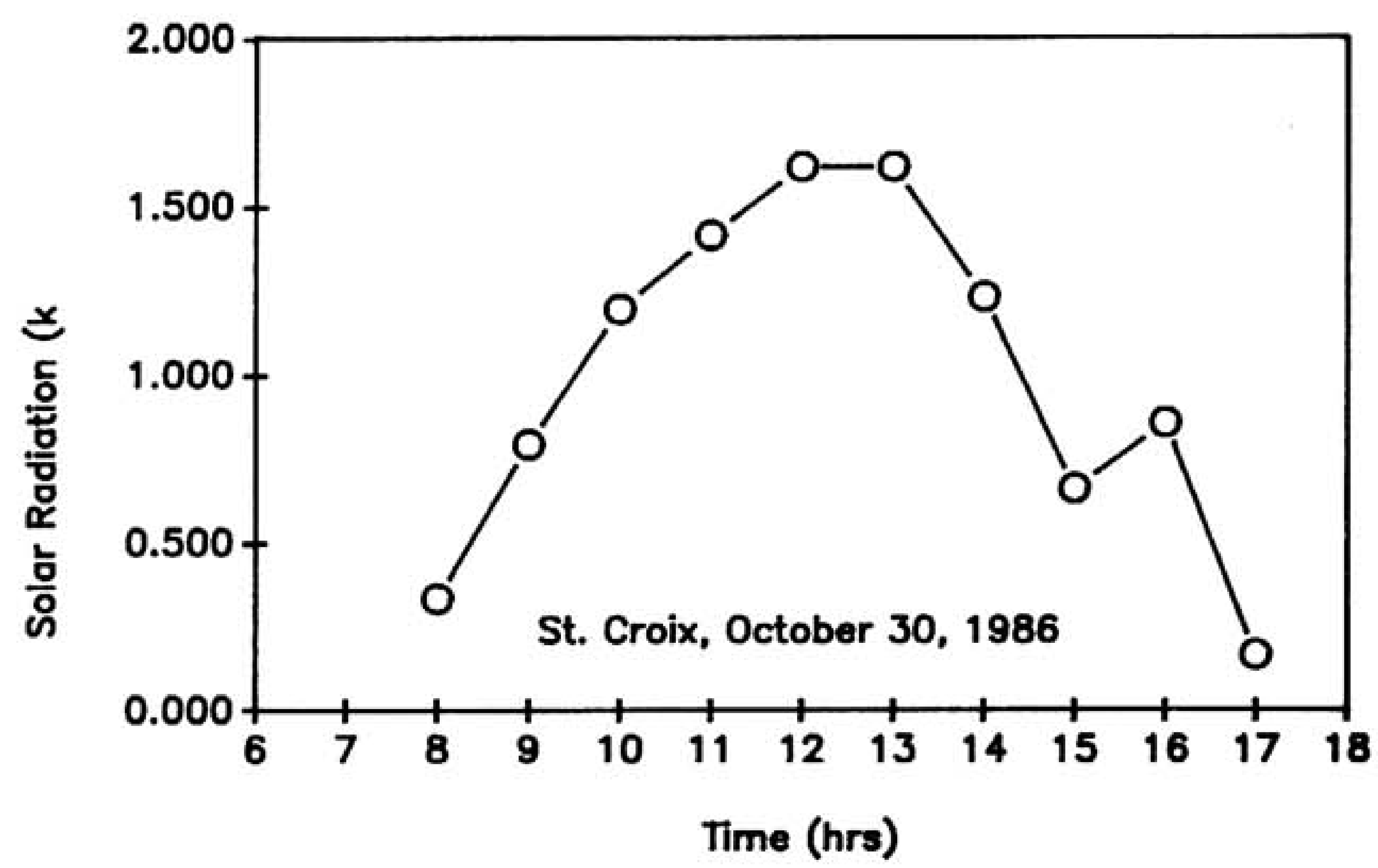


Figure 6. Diurnal solar radiation.

TABLE 1. Effects of container type on growth of Ixora, Dracaena and citrus plants produced in St. Croix, USVI.

Container Treatment	Final Height (cm)	Final Weight (cm)	Shoot Dry Weight (g)	Root Dry Weight (g)
		Dracaena Marginata 'Tricolor'		
BRP[Z]	66.5b[Y]	61.5a	25.7c	10.2b
WPRP	74.5a	55.2a	37.1a	15.2a
BPBP	70.2ab	65.2a	31.1b	12.6a
		Ixora Chinensis 'Maui'		
BRP	46.3b	49.3a	26.6b	8.6b
WPRP	53.2ab	43.0a	40.2a	11.2a
BPBP	59.4a	52.0a	42.7a	12.6a
		Carrizo Citrange		
BRP	130.7a	85.7a	60.8a	54.5a
WPRP	131.3a	65.0a	55.2a	36.8a
BPBP	122.0a	74.7a	60.8a	39.9a
		Papaya		
BRP	25.0a	31.0a	31.8a	26.1a
WPRP	26.6a	30.3a	36.4a	32.2a
BPBP	27.9a	32.8a	43.8a	32.5a

[Y] means within columns for each species followed by the same letter are not significantly different at the 5% level.

[Z] BRP = Black rigid plastic, WPRP = White painted rigid plastic, BPBP = Black poly bag in black rigid plastic.

TABLE 2. Effect of spacing treatments on growth of container grown plants in St. Croix, U.S. Virgin Islands.

Spacing Treatment	Plant Height (cm)	Plant Weight (cm)	Shoot Dry Weight (g)	Root Dry Weight (g)
		'Grande Naine' Banana		
18 In. O.c.[Z]	65.2c	76.2b	20.4a	22.2b
P/P - 18 In. O.C.	85.9a	85.6a	28.1a	16.5b
P/P	76.2b	84.9a	31.2a	30.8a
		Papaya		
18 In. O.C.	55.0b	74.2a	27.8a	9.0a
P/P - 18 In. O.C.	85.5a	81.5a	31.5a	7.8a
P/P	62.5b	78.0a	32.2a	11.6a
		Ixora Chinensis 'Maui'		
18 In. O.C.	53.5b	56.5a	48.0a	34.6a
P/P - 18 In. O.C.	65.0a	56.6a	47.9a	25.4a
P/P	68.1a	61.9a	50.5a	32.0a
		Dracaena Marginata 'Tricolor'		
18 In. O.C.	64.0a	62.4a	35.0a	22.8a
P/P - 18 In. O.C.	66.6a	57.9a	32.0a	13.8b
P/P	65.1a	58.9a	33.8a	18.5ab
		'Carrizo' Citrange		
18 In. O.C.	57.5a	20.0a	11.6a	9.2a
P/P - 18 In. O.C.	60.6a	18.8a	10.9a	7.5a
P/P	61.8a	16.9a	12.1a	8.1a

[Z] O.C. = on center spacing, P/P – 18 in. O.C. = pot-to-pot then shifted to 18 in. spacing, P/P = pot-to-pot

[Y] means within columns for each species followed by the same letter are not significantly different at the 5% level.

the tallest plants produced in containers spaced pot-to-pot, but dry weights were not affected by treatments. Dracaena shoot dry weight and plant width and height were not influenced by treatment, but plants grown on 18 inch centers had slightly more root dry weight than plants grown pot-to-pot then shifted to 18 inches. 'Carrizo' citrange were not affected by treatments. Ixora height was reduced in the 18 inch spacing but other measured parameters were not influenced by spacing treatments.

Although solar radiation in October (Figure 1) did not differ much from that recorded in May (Figure 3), temperatures in October were generally lower than those recorded during the summer months. Maximum temperatures were generally found on the southern exposure in containers spaced 18 in. on center (Figure 4), and in October, did not exceed 40 C (Figure 4,5). Maximum temperatures were generally 5 to 8 C higher in plants spaced 18 in. on center (Figure 4) compared to plants spaced pot-to-pot (Figure 5). The same trends in temperatures were noted in data collected during other months of this experiment (data not shown).

In summary, growth medium temperature fluctuations in container plants differ with time of the year in St. Croix, U.S. Virgin Islands. The western quadrant of the container medium appear to attain higher temperatures than the rest of the container in summer while the southern section heats up most later in the year. White containers or containers within shield containers decreased absorption of solar radiation and reduced the maximum attainable temperature in growth media. Cost factors might therefore-determine which container method is best for nurseries in the V.I. Incremental spacing strategies particularly pot-to-pot spacing decreased container temperatures somewhat, but not nearly to the extent that container treatment did during summer months.

The traditional black plastic containers reduced overall plant growth in most species.

Optimum growth and quality of container plants in the USVI can be achieved when cultural practices maintain media temperatures below 40 C. The feasibility of importing and using plant containers other than the traditional black plastic or black poly bags should be seriously considered by nursery plant growers in the USVI.

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Christopher Ramcharan, Research Assistant Professor, is the leader of the Horticulture Program.

Production Potential of Buffelgrass Pastures in the V.I.

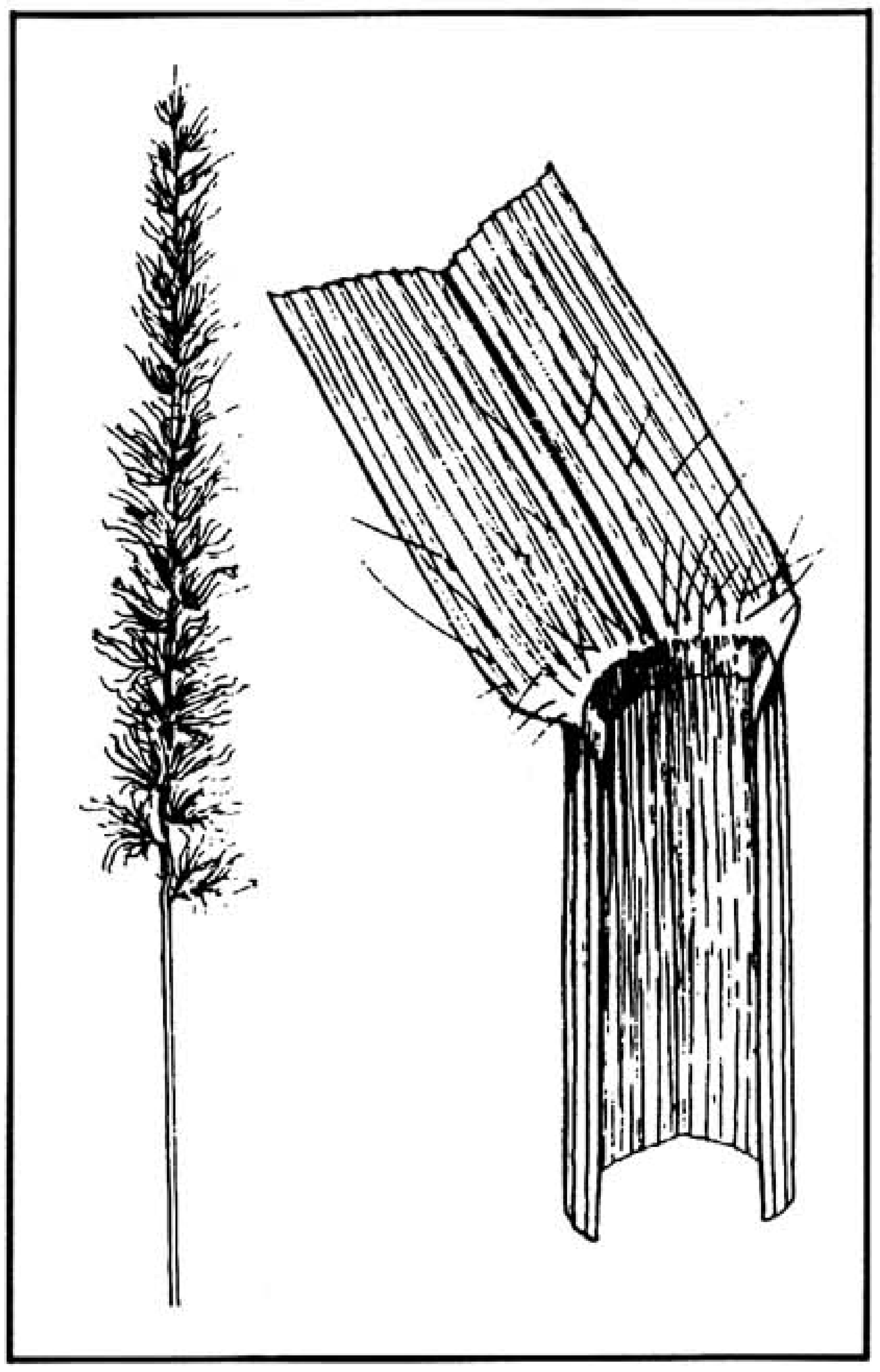
by Stephan Wildeus and Cyndi L. Wildeus

Buffelgrass, together with Pangola grass, is the most widely used introduced grass species for pasture improvement in the Virgin Islands. Buffelgrass can currently be found in a number of pastures on St. Croix and is used for both grazing and hay making. Its desirable characteristics include good drought tolerance, persistence under grazing and the ability of pasture establishment from seed.

Buffelgrass *(Cenchrus ciliaris)* has its ancestry in Africa and was introduced to the U.S. as early as 1917. Cultivars most widely used today were derived from "Common" buffelgrass, introduced into the U.S. in 1946 from northern Kenya. An official release of this cultivar followed in 1949 as T-4464. Initially, only different morphological types with no variability were available, but sexually reproducing plants were found later that made the hybridization and development of new cultivars possible. Subsequent research on buffelgrass indicated that it responds well to fertilization and irrigation. Studies measuring animal production on buffelgrass pastures showed good intake and animal growth, but stocking rates need to be adjusted to season and rainfall. In contrast, buffelgrass is ill-suited for heavy clay soils and salinity and does not withstand freezing temperatures.

Earlier studies on St. Croix by Oakes, published in 1969, reported that different cultivars of buffelgrass varied greatly in their annual dry matter yield. In a more recent experiment several new buffelgrass cultivars and a buffelgrass x birdwood grass hybrid were evaluated on St. Croix and their production measured at three different harvesting intervals. The seed for the study was obtained from the Forage Program of the Texas Agricultural Experiment Station.

To establish the test plots, seeds were germinated in flats in a greenhouse and transferred to styrofoam cups to allow a mature root system to establish. The seedlings were fertilized during root system development. Following root development, seedlings were transplanted into a Fredensborg clay loam soil. Plantings were done in one row plots with a 40 inch spacing between rows. Each row was 40 feet long and contained 38 plants consisting of three different cultivars. Each cultivar by harvesting interval combination was replicated only twice due to the limited amount of seed available.



Buffelgrass (collar and infloresence shown here) is originally from Africa.

Plots were initially irrigated and hand weeded to ensure the establishment of the seedlings, but received no fertilization.

Following a 7-month establishment period the plots were harvested with a sickle bar mower at either 4-, 8- or 12-week intervals. The yield of each plot was determined and samples (0.75 lbs) dried in a forced air oven at 140ºF for 48 hours to determine dry matter percentage. All yield data were then converted to total dry matter yield (tons/acre) for analysis. Plots were harvested over a 10-month period.

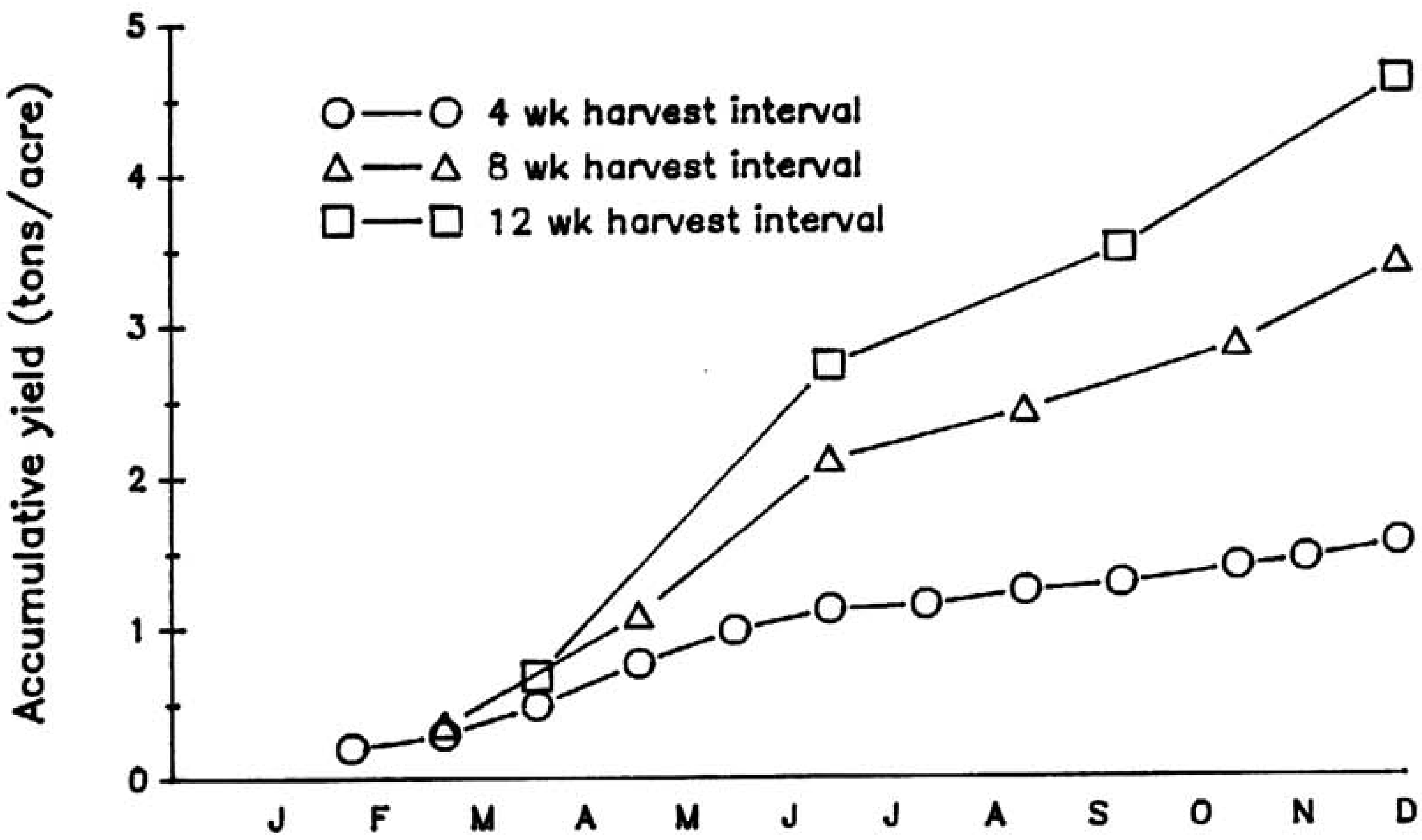
Cultivar Llano consistently produced the highest total dry matter yield at all harvesting intervals (Table 1). Nueces was the second highest producer with a reduction in yield of 10-18% over Llano. The more recently developed cultivars #209268, #409232 and #409359 performed much like Common buffelgrass, a cultivar that has found wide spread application. These latter cultivars produced only 60 and 70% of the yield of Llano and Nueces, respectively, at the 4 and 8 week harvest intervals and 73 and 86% at the 12 week harvest interval. There was no interaction between cultivars and the harvesting interval and cultivars had similar rankings at all three harvesting intervals.

The buffelgrass x birdwood grass hybrid produced the lowest amount of

Table 1. Total dry matter yield (tons/acre) of 6 buffelgrass cultivars and one buffelgrass x birdwood grass hybrid harvested at three intervals over 10-month period.

	Harvest interval		
Cultivar	**4 weeks**	**8 weeks**	**12 weeks**
Llano	2.30	4.84	6.05
Nueces	1.89	4.34	5.14
Common	1.41	3.27	4.63
209268	1.26	3.27	4.61
409232	1.54	2.68	4.21
409359	1.19	3.07	4.38
BxBW37[a]	1.16	2.33	3.24

[a]buffelgrass x birdwood hybrid



Cultivar Llano consistently produced the highest dry matter yield.

Figure 1. Accumulative dry matter yield of buffelgrass cultivars at three harvesting intervals over a 10-month period.

total dry matter at all three harvest intervals (Table 1). This hybrid was developed with a compact bur for ease of planting and to avoid problems generally associated with the planting of buffelgrass seed. However, total dry matter production was only half that of Llano at all harvesting intervals.

The accumulative dry matter yield increased markedly with an increase in the harvesting interval from 4 to 12 weeks (Figure 1). Extending the cutting frequency from 4 to 8 weeks resulted in a 122% increase and exending it to 12 weeks in a 200% increase in total yield. The relative improvement in yield due to the extended cutting frequency varied between cultivars and was highest for #209268 (160 and 266%) and #409359 (158 and 269%).

The dry matter percentage of the forage samples at individual harvests was inversely related to the prevailing rainfall at this time of the year (Table 2). During July, the driest month in the year of the study, the dry matter percentage of the buffelgrass exceeded 50%. Dry matter percentage of the buffelgrass samples was also higher with an increase in the length of the harvest interval. As a result, the buffelgrass samples harvested every 12 weeks had generally the highest dry matter percentage, reflecting the increased maturity of these stands.

The results obtained in this study confirm studies in Texas that ranked Llano over Nueces and both of these cultivars over Common buffelgrass. The annual dry matter yield of unfertilized pastures at that location ranged from 6.02 ton/acre for Common to 6.57 ton/acre for Llano. Although differences were evident in the performance of the buffelgrass at the two locations, the relative ranking in terms of dry matter yield was similar regardless of environment and management, suggesting that Llano is the most promising cultivar for use under Virgin Islands conditions.

Table 2. Dry matter percentage of buffelgrass harvested at three intervals over a 10-month period[a]

		Harvest interval		
Month	**Rainfall (in)**	**4 weeks**	**8 weeks**	**12 weeks**
February	0.25	28.1		
March	1.02	33.3	38.2	
April	4.80	29.5		
May	6.44	25.2	29.6	
June	1.71	26.4		
July	0.95	53.7	48.6	55.1
August	3.15	39.7		
September	2.65	31.6	32.4	
October	2.45	30.1		39.3
November	8.35	29.1	30.4	
December	3.45	21.4	24.4	28.8

[a]values are means of all cultivars

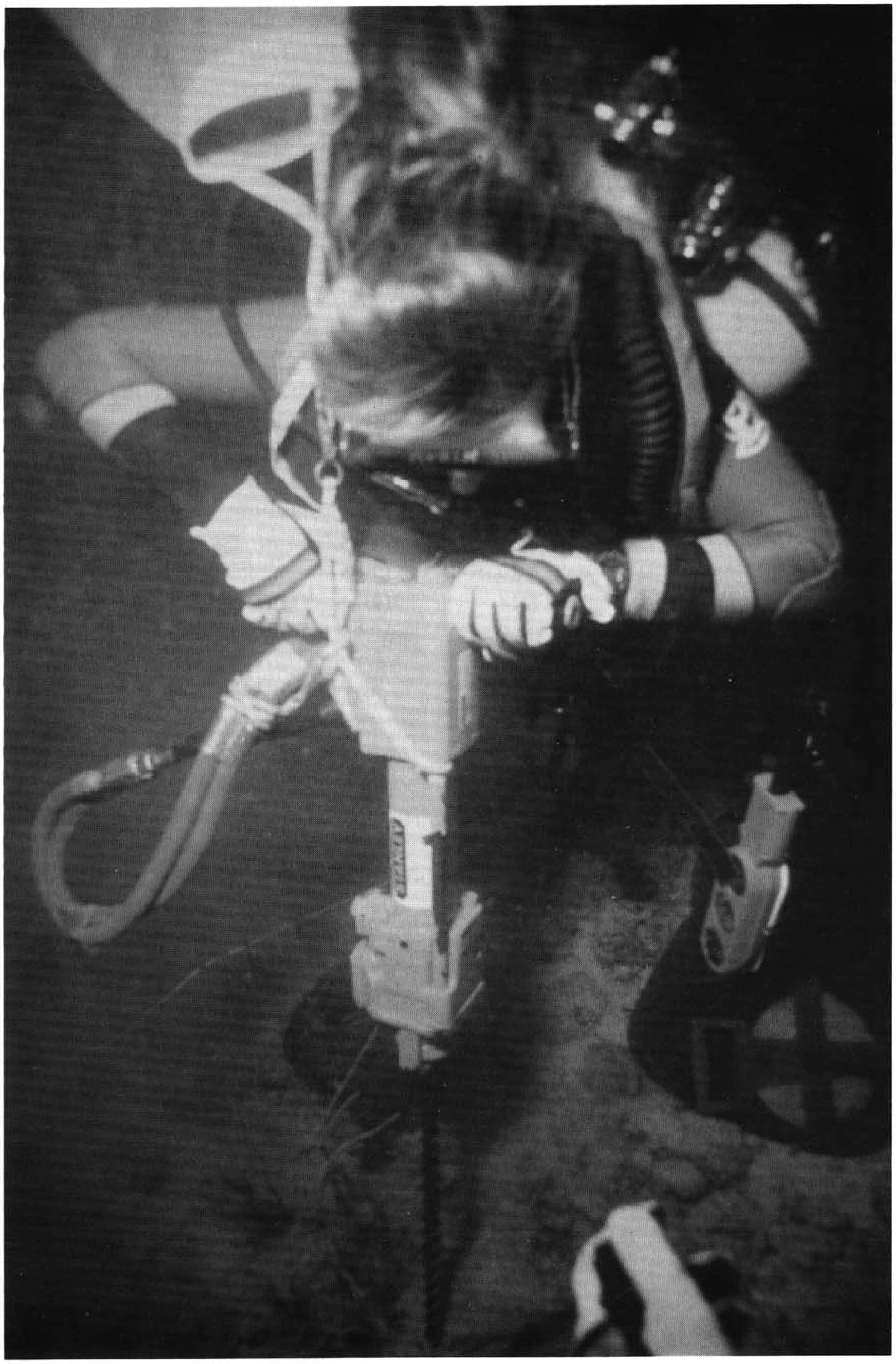
The extension of the harvesting interval to 12 weeks resulted in a substantial increase in dry matter yield, but the longer interval was also associated with a higher dry matter percentage of the buffelgrass at harvest. This increase in the maturity of the forage is related to a decline in crude protein content and thus a reduction in forage quality. Therefore harvesting intervals shorter than 12 weeks, possibly around 8 weeks, seem more beneficial when forage quality rather than total dry matter production is the primary production goal.

This research was supported by Virgin Islands Hatch Project #044.

Stephan Wildeus is leader of the Animal Science and Forages Program. Cyndi Wildeus is a research analyst.

Environmental Monitoring in the Salt River Submarine Canyon, St. Croix

by Mary Lou Coulston



A diver uses a Stanley hydraulic impact-twist drill operated by a 15-hp. hydraulic supply from the surface to provide a hole for a permanent stake.

Photo by M. Herko

As coastal development accelerates throughout the Caribbean, scientists and local government planners are recognizing the need to establish baseline data for coastal resources. Baseline data will help assess changes occurring in nearshore marine communities (whether changes are the result of natural processes or due to human activities).

The importance of long-term monitoring is well illustrated by a study conducted at Kaneohe Bay in Hawaii where dramatic differences in community structure were recorded before and after termination of sewage discharges. These differences provided evidence of the usefulness of long-term monitoring to evaluate eutrophication and sedimentation, processes which can adversely affect bottom communities. In the same study indicator species of organic pollution were identified. Because of the value shown by such long-term monitoring, many such studies are now in progress. In the Salt River study, changes in community structure are being documented along with water quality measurements to provide clues to the causes of change.

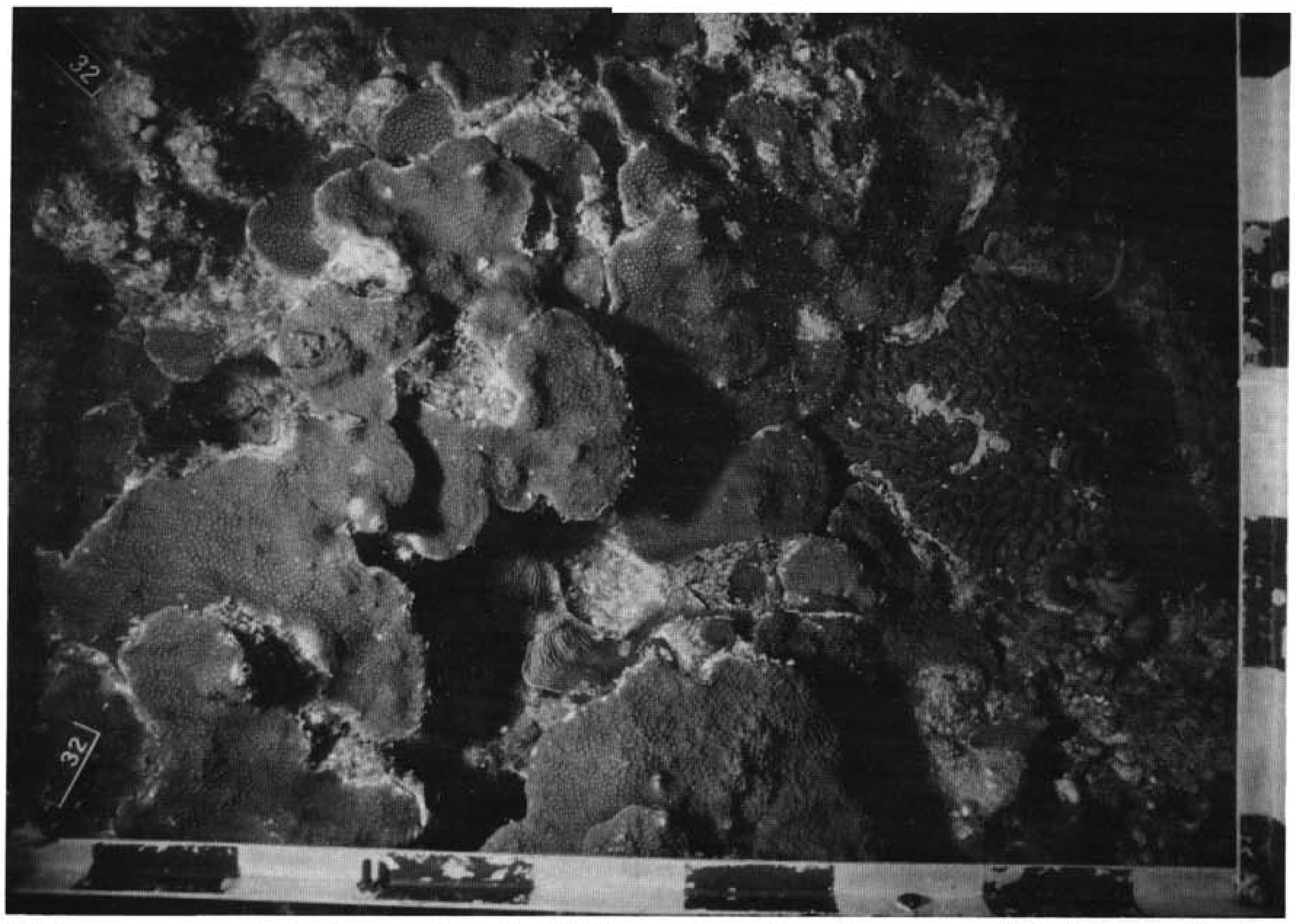
In April of 1989 a team of environmental specialists established permanent stations to monitor coral, a variety of other marine organisms, and seaweed populations in the Salt River Submarine Canyon. The Salt River program began with a 10 day undersea "saturation diving" mission in the Aquarius Habitat, operated by the National Oceanographic and Atmospheric Administration (NOAA) under the National Undersea Research Center at Fairleigh Dickinson University (NURC/FDU). Participants included staff from the University of the Virgin Islands, the Virgin Islands Department of Planning and Natural Resources (DPNR) and the National Park Service (NPS).

The Aquarius habitat is located in 60 feet of water in the center of the submarine canyon. The underwater accommodations allow divers to work long hours in the water without coming to the surface. This avoids decompression. It is possible to work nine hours below 50 feet (but above 95 feet) within a 24 hour period; below 95 feet, diver time is reduced as depth increases. Divers can be inside or outside the habitat at the 50 feet level indefinitely. During the 10 days spent in Aquarius, six divers spent a total of 268 hours working in the water at an average working depth of 88 feet. Only this type of "saturation diving" allows the necessary bottom time to set up monitoring stations at the depths studied. Surface diving was used to set up a 30 foot site in June, 1989.

During the April, 1989 mission, seven monitoring stations were established. Each consisted of six 10 meter transects (width of the transect is equal to the width of transect line) running parallel along depth contours at 60, 90 and 120 feet. At each station, seven numbered, copperplated stakes were secured with epoxy in holes drilled into dead coral substrate at 10 meter intervals along each transect. An additional station was established in June, 1989 at 30 feet with ten 10 meter transects utilizing eleven stakes. The locations of these transects are shown on a submarine canyon map (Figure 1).

Three methods were used to evaluate species composition and percent of live coral cover. The first was a linear transect method. Lines, marked off in meters, were tied between each stake. A chain with 1.3 centimeter links was spread across the reef under each line. The length of the moveable chain was unspecified, but divers seemed to prefer 1 to 1.5 meters. The type of bottom under each link was identified and recorded. This method provides a three dimensional profile of the reef rather than the two dimensional surface view provided by photographs. Calculations can be made of percent live coral, abundance of coral, percent cover of algae and other invertebrates, as well as coral species diversity, species evenness, species richness and the spatial complexity of the reef.

The second method involved photographing permanently marked 0.50 square meter quadrants. A quadrapod with a fixed Nikonis camera with a 15 millimeter lens and two strobes was placed on a premarked site. Two corners of the site were marked with 4 inch cut nails and numbered tags so that the mount can be placed on the exact same site each visit. This long-term photographic monitoring program will allow documentation of growth, mortality, recruitment, and competition of reef building corals. The photographs will be computer analyzed using automatic image processing. The computerized technology for this process is being refined by a number of researchers using similar techniques for reef monitoring. Successive photographing may prove useful in recording events such as coral bleaching, algal overgrowth, disease, and physical breakage. In this study a total of 116 permanent photoquadrants were established.



This permanent photo quadrant will be analyzed and compared to future photos of the same quadrant using computer image processing.

Photo by C. Kesling

The third technique explored was the use of 8 millimeter video camera to record all areas along each transect. Visually noted alterations on each transect can be used in evaluating major changes in reef structure.

Sediment damage is probably responsible for the majority of coral damage of local reefs. Sediments can stress corals by reducing the light available for photosynthesis, thus decreasing growth and reproductive activity. Coral growth rates are also reduced because energy is utilized by corals in the sediment removal process. This diverts this energy from other natural reef building processes. Sediment particles also can cause corals to die by smothering and scouring them. Sediment levels for the canyon were recorded during the 10 day Aquarius undersea mission by measuring turbidity and total suspended solids. Water samples were taken at the 60 foot sites and at the surface above these same sites. Sampling and analysis of canyon waters will be continued on a regular basis.

Turbidity, the light scattering properties caused by particles in the water, was measured using a Hach Model 2100A turbidimeter. Readings were expressed in Nephelometer Turbidity Units. Total suspended solids were measured following an Environmental Protection Agency procedure whereby

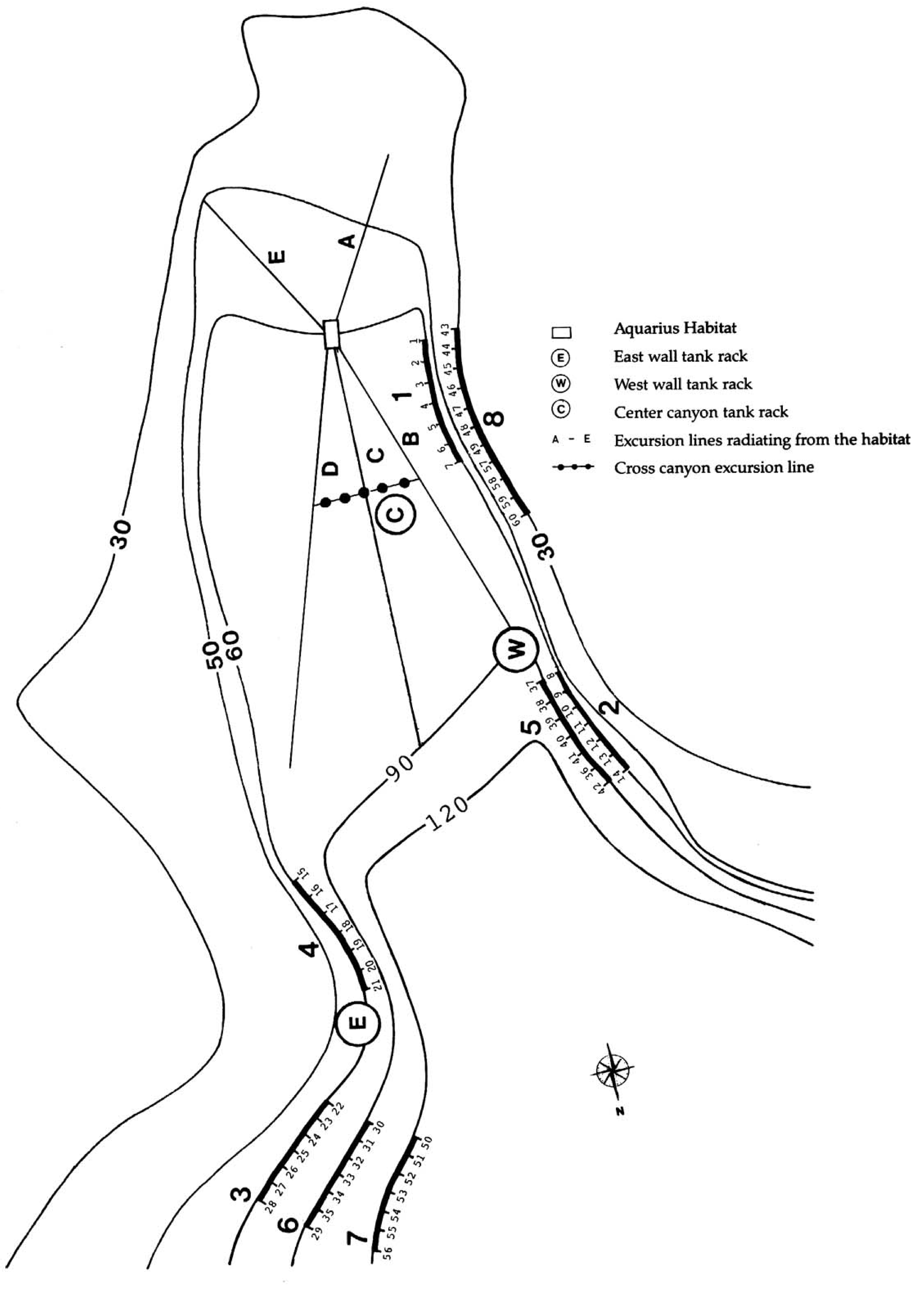


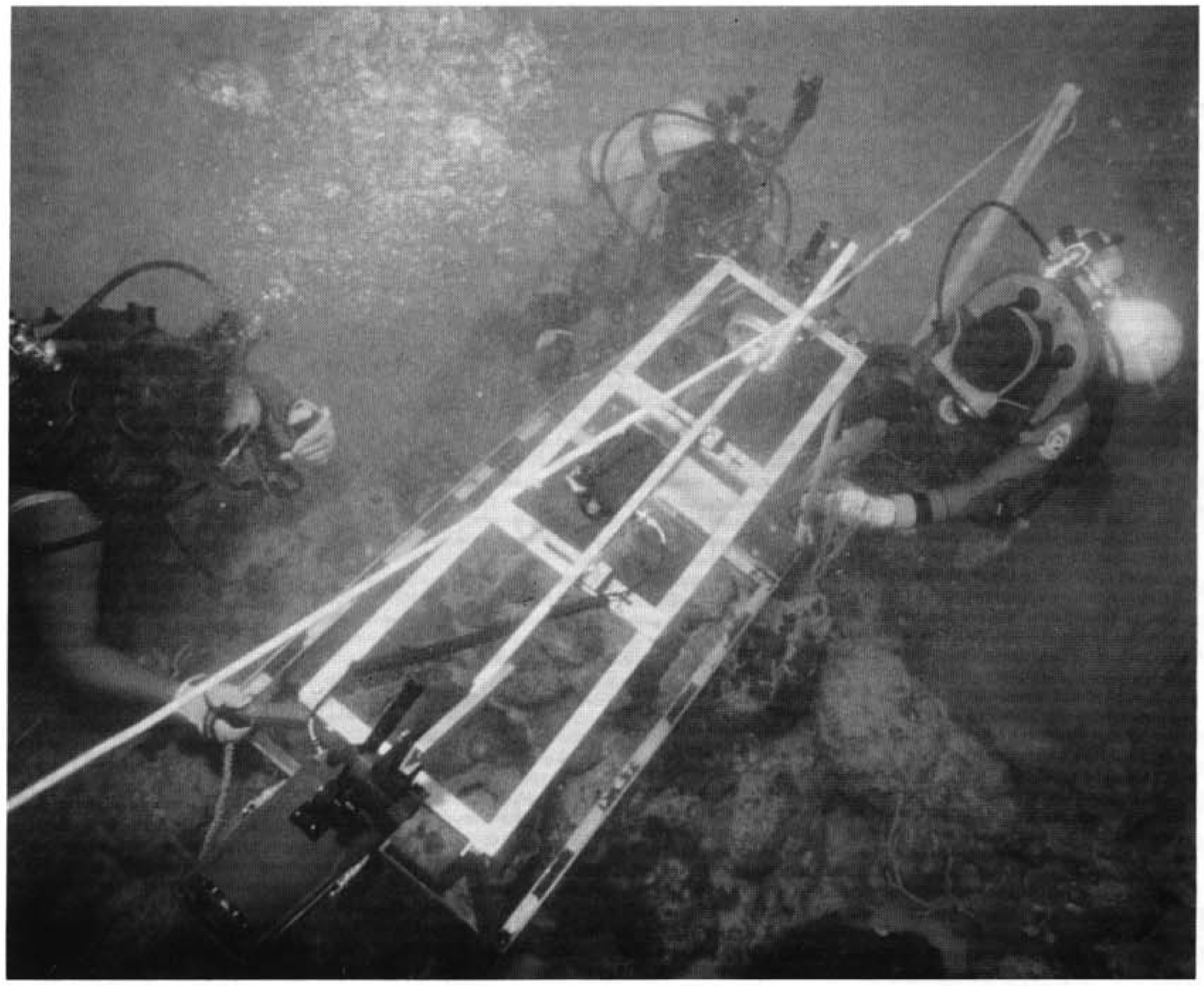
Figure 1. Map of Salt River Submarine Canyon floor accessible from the Aquarius Habitat. Marked on the 30, 60, 90 and 120 foot contours are the eight stations showing the locations of the number stakes marking individual transects.

the samples were filtered through a glass fiber filter and residue contained on the filter was dried to a constant weight at 103-105 degrees C.

Few studies actually quantify amounts of sediment that are detrimental to various species of corals. However, data continually is being gathered on sediment measurements and its relationship to coral cover. Researchers have found that 1-2 mg/liter of total suspended solids is relatively normal, whereas reduced coral cover is found where sustained rates reach 3-5 mg/liter. However, short term effects of 10-30 mg/liter following storm-induced runoff with increased current speeds have been shown to cause little damage to corals. During this study, mean total suspended solids averaged 20.26$\pm$ 4.64 mg/liter (range 8.76-31.34) and the mean for turbidity averaged 0.26$\pm$ 0.12 NTU's (range 0.11 - 0.83) with no significant difference between surface water and samples taken at 60 feet. The results indicate that Salt River Submarine Canyon does experience periods of naturally high suspended solids with low turbidity. However, interrelationships of total suspended solids, turbidity, current and organism stress in this study and from other studies are too preliminary for speculation on their meaning at this time.

A current meter was deployed in center canyon in approximately 60 feet of water. For the 10 day period the mean current speed was 4.53 cm/s (range 0 - 11.3) at a mean direction of 224.75 degrees. The meter also recorded a mean water temperature of 26.1 degrees C (range 25.5 - 26.7).

The results of this project, as well as other long-term studies being conducted in the territory, should allow the formation of a biological monitoring network to standardize data collecting techniques. Biologists from the National Park Service, West Indies Laboratory, Virgin Islands Department of Planning and Natural Resources, Division of Environmental Protection and Division of Fish and Wildlife Service and private consultants are establishing permanent monitoring sites at significant coastal areas throughout the territory to document variability and degradation of marine resources. Only when these changes are documented and evaluated with standardized techniques can possible causative agents be identified and management action effectively initiated.



Divers use a quadraped with camera and strobes to photograph the permanently established half-meter quadrants.

Photo by M. Herko

In summary, a long-term program was established in Salt River submarine canyon to monitor the bottom community. Fifty-two 10 meter transects were established at 30, 60, 90 and 120 feet with 116 permanent photoquadrats. Baseline data was collected for bottom cover using photographic techniques and linear transects along with water quality measurements. Data collection will be repeated after one year, or after significant ecological or meteorological events, to allow for the first evaluation of changes. Long term management objectives include the establishment of limits to man-made sediment loading and the regulation of activities that contribute to threatening levels of sediment in marine waters.

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Dr. Mary Lou Coulston, a research associate professor is the coordinator of the Environmental Research Center at the Caribbean Research Institute.

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Current Research Projects

A study and analysis of management systems for native grasslands in the U.S. Virgin Islands.
Efficiency of hair sheep production in the Virgin Islands.
Epidemiology and control of parasitic gastroenteritis of sheep on St. Croix.
Evaluation of reproductive potential of tropical V.I. sheep.
Increasing prolificacy in sheep and its impact on nutritional needs.
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Cage culture of tilapia in the Virgin Islands.
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No chemical control of disease of tropical food crops.
Study of mango flowering to reduce erratic behavior.
Phenological and physiogical study of mahogany in the Virgin Islands.
Biological control of nutsedge with fungal pathogens.

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