Introduction of *Eucheuma* to Fanning Atoll, Kiribati, for the Purpose of Mariculture

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Abstract - Fanning Island, Line Islands, Kiribati, has been the site of a research project with the goal of eventually establishing profitable seaweed farms in the central Pacific. ***Eucheuma striatum*** Schmitz and ***E. denticulatum.*** (Burman) Collins and Hervey were propagated in Hawaii, cleaned of epiphytes and flown directly to Fanning Island. A seed stock from which a pilot farm could be developed was established at Metaua Point. The growth rates were approximately 4%/da in 50% shade and 6 %/da in full sunlight for ***E. striatum*** and 4%/da in 50% shade and 8%/da in full sunlight for ***E. denticulatum.*** Both species persisted in good health for nearly a year after the experiment ended. The accidental introduction of extraneous alien algae was a problem. It was concluded that farms here could be competitive with Asian countries and if all the suitable areas in Fanning Island lagoon were developed, 100-150 families could be supported by seaweed farms.

Introduction

Fanning Island, Line Islands, Kiribati (Fig. 1), has been the site of a research project with the goal of eventually establishing profitable seaweed farms in the central Pacific. The primary guideline for this research was to explore the algal resources on Fanning Island and to determine the feasibility of enhancing the island income by farming commercially valuable carrageenan-producing seaweed species.

Many of the key ingredients in dairy, meat, cosmetics, drugs and other products are extracts from seaweeds. The value of these extracts, usually gels such as carrageenan and agar, was $68 to 100 million per year in the United States alone (Doty, 1979). The source of nearly one third of these gels is the red algal species *Eucheuma striatum* Schmitz and *E. denticulatum* (Burman) Collins and Hervey, which are successfully grown in the Philippine Islands on well managed marine farms (Doty and Alvarez, 1973).

The marine agricultural production of seaweeds represents 38% of all the mariculture market in the world, more than mollusks or finfish (Ryther,

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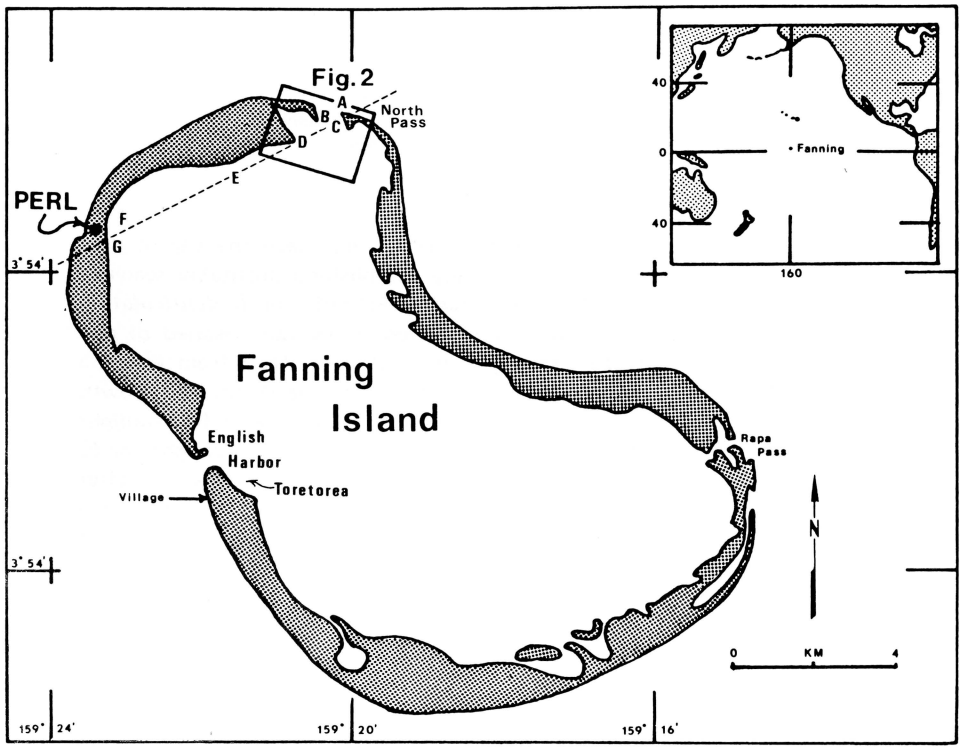

Fig. 1. Map of Fanning Island.

1981), and *Eucheuma* represents the most successfully cultured seaweed. It is relatively easy to farm, if the proper sites are used, and will yield 1-10 dry metric tons per hectare in six to eight months (Ryther, 1981). Near the equator, where Fanning Island is located, the yield could be twice this amount (Ryther, 1981).

These two species produce either a brittle gel *(E. striatum)* or a resilient gel *(E. denticulatum)* of carrageenan (Doty, 1973). There is less tonnage of *E. denticulatum* on the market and the dry weed usually sells for a higher price. My research was conducted to introduce both of these algae to previously investigated locations on Fanning Island, with special attention given to the more valuable *E. denticulatum.*

Several factors led Doty and Russell (1973) to the conclusion that Fanning Island would be suitable for the farming of *Eucheuma.* First, it is located less than four degrees north of the equator, well within a zone which rarely experiences strong, crop-devastating tropical storms. Second, it is an atoll with a lagoon and reefs which are not subjected to periodic high salinities (salt ponds) or low salinities from land run-off; the salinity must be stable for successful algal growth and survival (Dawes, 1979). Third, there

are several locations in the lagoon near the three passes which have the physical qualities necessary for *Eucheuma* farming (Doty and Russell, 1973). Fourth, the politics and economics of the island are stable. Fifth, labor is inexpensive and could easily compete with the Asian *Eucheuma* farmers.

Research on the presence of naturally occurring commercially valuable seaweeds on Fanning Island began in 1970 (DeWreede and Doty, 1970) and was completed by Tsuda et. al. (1973). A total of 98 species was listed (Tsuda et al., 1973) of which *Turbinaria ornata* (Turn.) J. Ag., *Hypnea cervicornis* J. Ag. and *Hypnea pannosa* J. Ag. are known to contain gelling substances. However, *Hypnea* species are small and the technology necessary to grow them is lacking and *Turbinaria,* the only seaweed occurring in abundance (Russell, 1973), contains alginic acid, not carrageenan. Since an alga comparable to *Eucheuma* was not present on the island, research on its introduction was initiated.

Selection and study of field sites where *Eucheuma* might be successfully grown was completed in 1972 and two equally suitable locations were found

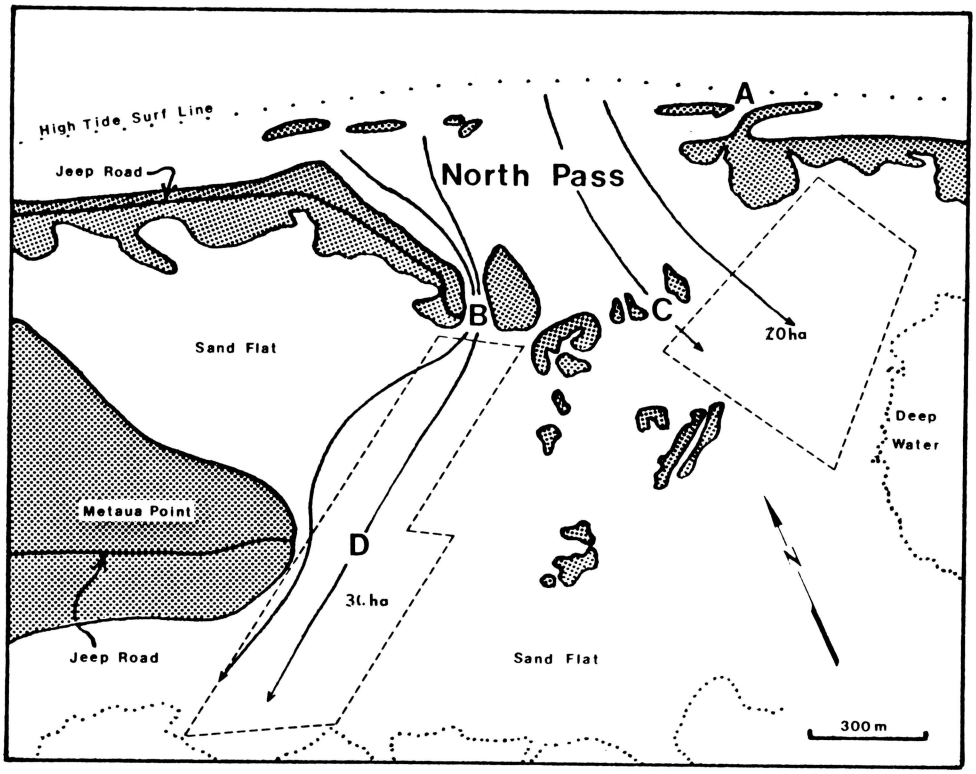

Fig. 2. Map of North Pass, Fanning Island.

near North Pass and Rapa Pass (Fig. 1). The North Pass site (Fig. 2) was both ecologically favorable and logistically more desirable. There was sufficient water depth throughout the year, adequate water motion, desirable temperature range, suitable light intensities, other fleshy algae were present and it was accessible by jeep. It was unknown, however, if *Eucheuma* would indeed survive and grow at sufficient rates on this atoll or whether a seaweed farm could bring enough income to support a Kiribati family. The hypotheses being tested in this study were: (1) *Eucheuma denticulatum* and *E. striatum* will grow at a rate sufficient for farming at the selected sites, and (2) *Eucheuma* farms would be a reasonable and potentially profitable supplementary crop for some people on Fanning Island.

Methods

Both *Eucheuma* species were propagated in Kaneohe Bay, Oahu, Hawaii, from seed stock introduced from the Philippines. The epiphytes were removed and the thalli washed before being placed into plastic bags and styrofoam containers, which were flown directly to Fanning Island from Honolulu, Hawaii (Permit to import plants, No. 10, Form B, Agricultural Division, Gilbert Islands, the Plant Ordinance 1976). After arriving on Fanning Island on October 3, 1977, the thalli were inspected again for epiphytes, washed with seawater and placed in a holding pen near the Pacific Equatorial Research Laboratory (PERL) pier (Fig. 1). Approximately 10 kg of each *Eucheuma* species was thus introduced onto Fanning Island.

These thalli were transferred to the various planting sites on October 4, 1977, where approximately 10-60 g pieces of *E. striatum* and *E. denticulatum* were tied to the inside of 2.5 x 2.5 cm mesh PVC (polyvinyl chloride) plastic coated steel wire pens (0.6 x 1.0 x 2.4 m), or to iron rods, bamboo poles, lines, nets or coral outcroppings. Plantings were made from near the open ocean at North Pass through a variety of habitats as far into the lagoon as the pier at PERL (Fig. 1). A t-test was used to analyze the growth rate data after an arcsin transformation of the percentages was made (Schefler, 1980).

Water motion was measured by means of calcium sulfate blocks to obtain a diffusion index factor (DIF) (Doty, 1971), temperature by a Taylor maximum-minimum thermometer, light intensity by a calibrated Sekonic Auto-Lumi No. 86 meter and algal wet weights by an Ohaus triple-beamed balance. Shade was provided by coconut leaves tied to the lids of the pens at Metaua Point. Evaluation of the sites was based on thallus condition at the end of the experiment, growth rates and persistence.

Information concerning labor practices, wages and other aspects of Kiribati life was obtained from the plantation manager (Bill Frew) and the heads of six Kiribati families.

Results and Discussion

A seed stock from which a pilot farm could be developed was successfully established at Metaua Point, location D (Fig. 2). Out of the six experimental locations tested this was, as expected, the only site suitable for the growth of *E. striatum* and *E. denticulatum.* All of the thalli placed at locations A, B, and C were either eaten by fish or destroyed by too rapid water motion. The thalli at locations E and F (Fig. 1) failed to grow and eventually decayed.

The incoming tidal waters that pass over location D are clear, whereas the water during the receding, outgoing, tides is milky white. The bottom consists of sand, loose coral rock, living corals, coralline algae and rubble upon which *Turbinaria ornata,* holthurians and *Echinothrix* sp. are living. The diffusion index factor was 22.5 $\pm$ 2.4 and the temperature ranged from 27 - 31^{o} C during a 24 hour period.

The growth rates of both species were too high at first. During the first two weeks *E. striatum* increased its wet weight by one percentage point and *E. denticulatum* by 2.5 percentage points (Table 1) above the growth rates recorded for them in full sunlight in Kaneohe Bay (Doty, 1978).

The higher temperature, greater light intensity and most likely lower fertilizer content of the water at Fanning Island compared to Kaneohe Bay, may have resulted in the higher growth rates of these thalli. These newly introduced species may have brought stored nutrient with them in their cells from Kaneohe Bay (Dawes, 1981), and were using them during the acclimatization phase, but this was not investigated.

Newly transplanted algae are similar to any plant when introduced to new growing conditions, they need to be protected while they acclimatize (Horstman et al., 1977). Shade was provided to protect the thalli from the higher light intensity at Fanning Island, to lower the growth rate and to reduce the adverse effects of sun bleaching (Steward, 1974). This resulted in a lower, more usual growth rate based on the Hawaiian data.

The growth rates under shaded conditions resulted in a statistically significant (95% confidence) drop in the growth rate of *E. denticulatum* which was 4.2 + 0.3 - 0.6%/da in 50% shade and 7.5 + 0.6 - 0.9%/da in full sunlight (Fig. 3). The growth rate of *E. striatum* in 50% shade was 4.0 $\pm$ 0.6%/da compared to 6.1 + 0.6 - 0.9%/da in full sunlight (Fig. 3). Although these were the only formal data gathered on their growth rates, Johnny Tarawa later reported a visual doubling in size of both species during the following month and the thalli persisted in good health to September 1978 (nearly a year later). Grazing by fishes kept the algae from spreading beyond the boundaries of the protective pen.

Table 1. Growth rates of ***Eucheuma striatum*** and ***E. denticulatum*** in sunlight and 50% shade

	Full Sunlight				50% Shade		
	4 Oct (Grams)	18 Oct (Grams)	Gain (Grams)	Rate %/da	28 Oct (Grams)	Gain (Grams)	Rate %/da
E. striatum							
$\bar{X}$	26.8	49.6	22.7	6.1	71.1	21.5	4.0
SD	15.2	30.7	16.8	2.6	47.5	17.0	1.0
E. denticulatum							
$\bar{X}$	29.3	60.1	30.7	7.5	81.8	21.7	4.2
SD	15.0	31.5	16.7	1.2	35.8	6.4	1.6

n = 12 for each column

Additional Alien Algae Introduced to Fanning Island

A potential problem with the introduction of any new agricultural crop is the simultaneous introduction of unwanted species. Druehl (1973) and North (1973) are the only papers in marine agronomy that have dealt seriously with it.

In this research, great care was taken to prevent the introduction of unwanted seaweeds, yet four additional species appeared in the pens at Metaua Point during the first month. These species were ***Acanthophora spicifera*** (Vahl) Boerg., ***Dictyota acutiloba*** J. Ag., ***Hypnea musciformis*** (Wulfen) Lamx. and ***Ulva reticulata*** Forsskal, all commonly found in Kane-

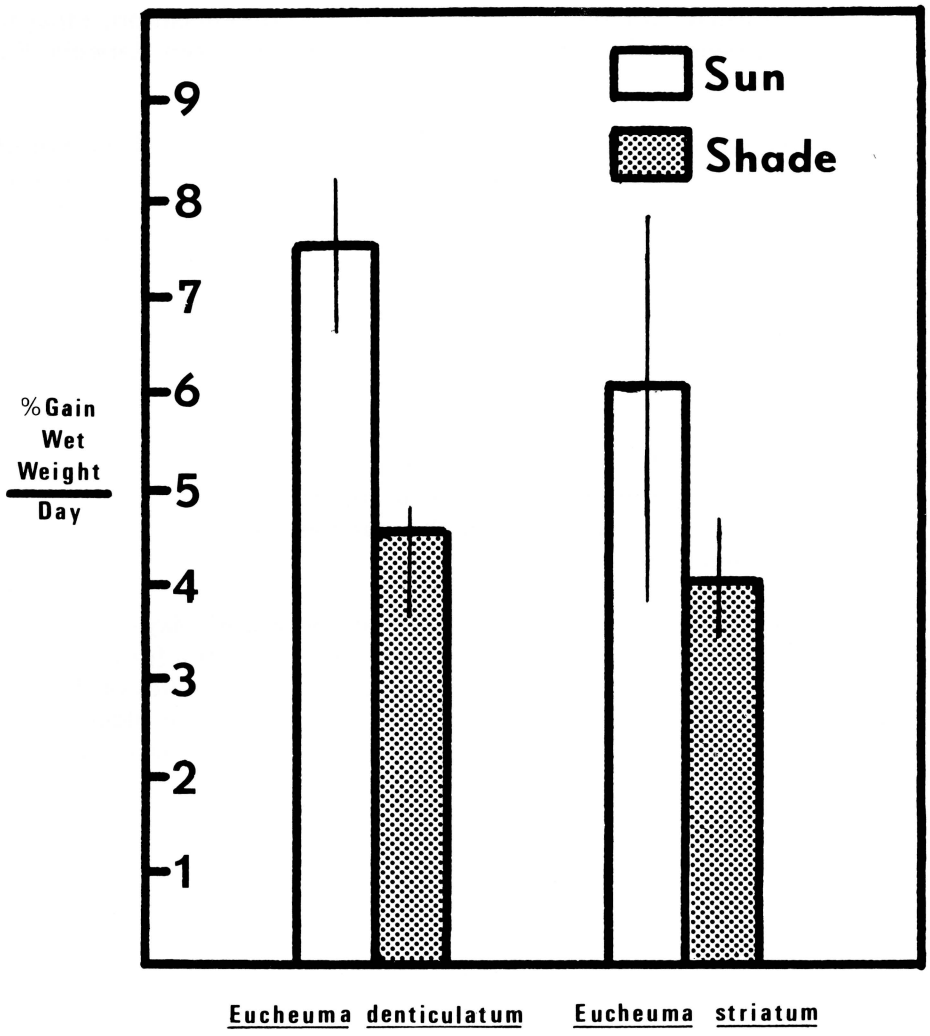

Fig. 3. Growth rates of *Eucheuma denticulatum* and *E. striatum* in full sunlight and in 50% shade.

ohe Bay, Hawaii, but not previously reported from Fanning Island. All of the alien thalli appeared as epiphytes on *Eucheuma* and were removed and destroyed.

Acanthophora spicifera is believed to have been introduced to Pearl Harbor from Guam in 1950 (Doty, 1961). Since then it has spread throughout the major Hawaiian islands (Russell, 1981) and now appears to be traveling with *Eucheuma* transplants from Hawaii to Samoa, Fiji and other islands south of Hawaii (Doty, 1978). It has been reported from Christmas Island,

Line Islands, Kiribati, for the first time (personal communication, Sapayani Ajak, 1978), growing with *Eucheuma* thalli introduced from Kaneohe Bay (Doty, 1978).

Hypnea musciformis, originally introduced to Kaneohe Bay from Florida in 1976 for commercial purposes is spreading around Oahu island and has been introduced along with *Eucheuma* to various places in the central Pacific. The other two alien species *D. acutiloba* and *U. reticulata* are native to Hawaii. Transplanting techniques need to be perfected to decrease or eliminate the spread of extraneous and often unwanted alien algal species.

Economic Situation

In 1977 the yearly income for an average family on Fanning Island was about $980.00 Australian ($1078.00 American). The minimum wage was $2.35/da and the monthly income of a six member family was about $81.70/mo Australian. This allowed the purchase of necessities, but left little for luxury purchases or savings.

The average work week for a plantation laborer was 4½ days/week or 36 hours/week and the main source of income was cutting copra (dried coconut endosperm). In 1976 there were 227 males and 210 females on Fanning Island, of which 103 males and 107 females were 16 years or older. About 80% were employed by the copra plantation, 7% by the government of Kiribati, 8% by PERL and 3% by the church or other agencies. There was no unemployment and the manager said he could easily use more men to cut copra. However, Bill Frew has informed me that the majority of the islands of Kiribati are overpopulated, unemployment is a problem and a migration to Fanning Island from Tarawa and other islands is expected.

Food gathering and animal raising activities are done by the adult males and amounts to an additional 34 3/4 hours labor per week, for a total working week of 71 hours. These data indicate there are essentially no free hours during the week for a man to run a seaweed farm as a volunteer. The indigenous people on Fanning Island would need support from an outside source until the farm becomes fully productive.

According to Doty and Alvarez (1973) most family groups could not adequately care for more than a one hectare farm. Such a farm could produce 30-60 dry tons of *Euchuema* per year and could be sold for $200-400/ton for a total of at least $6,000 for a year's crop. Even if the price were to drop to only $50/ton American, a price so low the farmers in the Philippines will no longer grow the crop (Ricohermoso and Deveau, 1977), the people on Fanning Island could still receive $1,500 or $520 more than their normal yearly income. The price paid for dry *Eucheuma* is stabilized by the purchasing companies and such a drastic drop in value will probably not occur

If an industrious yojng male were properly supported until the first few shipments of *Eucheuma* could be delivered a seaweed industry on Fanning Island would be assured.

About 30 hectares are probably suitable for *Eucheuma* farms at North Pass near Metaua Point and another 20 hectares appear to be suitable farther to the northeast (Fig. 2). If areas could be developed at Rapa Pass and English Harbor near Toretorea 100-150 families could be supported by seaweed farms on Fanning Island.

The economic benefits to Fanning Island of even 30 seaweed farms would be in excess of $180,000/yr. Seaweed farms would provide more income for the people, would not conflict with copra activities, and would provide employment on over-populated atolls (Small, 1972). *Eucheuma* farming utilizes an atoll's two major resources, its people and the sea.

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