Hydrobiologia **204/205**: 521–525, 1990.
S. C. Lindstrom and P. W. Gabrielson (eds), Thirteenth International Seaweed Symposium.

The farmed *Eucheuma* species (Gigartinales, Rhodophyta) in Danajon Reef, Philippines: carrageenan properties

R. Azanza-Corrales & P. Sa-a
Marine Science Institute, University of the Philippines Diliman, Quezon City 1101, Philippines

Key words: carrageenan, *Eucheuma*, mariculture, seaweed, yield

Abstract

Six cultured 'strains' of *Eucheuma denticulatum* and *E. alvarezii*, from which stocks can be selected for the development of a *Eucheuma* 'seedling bank', were tested for their carrageenan quality from June to November 1988. Percent yield of all the varieties taken together was apparently higher in June, becoming lower in November (regression, r -0.785, probability, $p \leq 0.001$). Stepwise regression analysis was done to determine the existence of any relationship between any of the following parameters: gel strength, viscosity, sulfate content, month of sampling, and yield, whether taken individually or in combination. Results show variations of the yield with the month of sampling. ANOVA was performed to test whether there are differences in sulfate levels, gel strength, and viscosity between the *Eucheuma alvarezii* morphotypes. There was no significant difference between the green and the brown types.

Introduction

Eucheuma, consumed as food in the Philippines, is an important source of carrageenan that has numerous applications in the food and pharmaceutical industries (McHugh & Lanier, 1983). Mariculture of two *Eucheuma* species, *E. denticulatum* (Burman) Collins et Hervey and *E. alvarezii* Doty (recently transferred to *Kappaphycus* as *K. alvarezii* (Doty) Doty), is a major small-scale industry in many coastal areas in the Philippines (Doty, 1987). Since the introduction of *Eucheuma* farming in Danajon Reef, 124° 35′ E 10° 17′ N (Fig. 1) in 1976 (Lim & Porse, 1981), about seven out of the ten or more variants of *Eucheuma* appear to have become distinct 'varieties'. As part of a research effort to gather baseline data for the development of a seedling bank for cultivated *Eucheuma* in the area, this paper presents the results of the quantitative analysis of carrageenan extracted from six of these morphotypes.

Dawes *et al.* (1974) found pronounced seasonal variations in the carrageenan, total carbohydrate, protein, and lipid of Florida *Eucheuma*. Later, Dawes *et al.* (1977) and Dawes (1979) found no differences in carrageenan yield between sexual stages of *Eucheuma*. Laserna *et al.* (1981) made preliminary investigations on the physicochemical properties of carrageenan from specimens identified as *E. spinosum* (L.) J. Agardh and *E. striatum* Schmitz, which could have been *E. denticulatum* and *E. alvarezii*, respectively. Fuller & Mathieson (1972) studied the carrageenan ecology of *Chondrus crispus* and found seasonality in its production. They also noted variation in the quality of yield between coastal and estuarine populations.

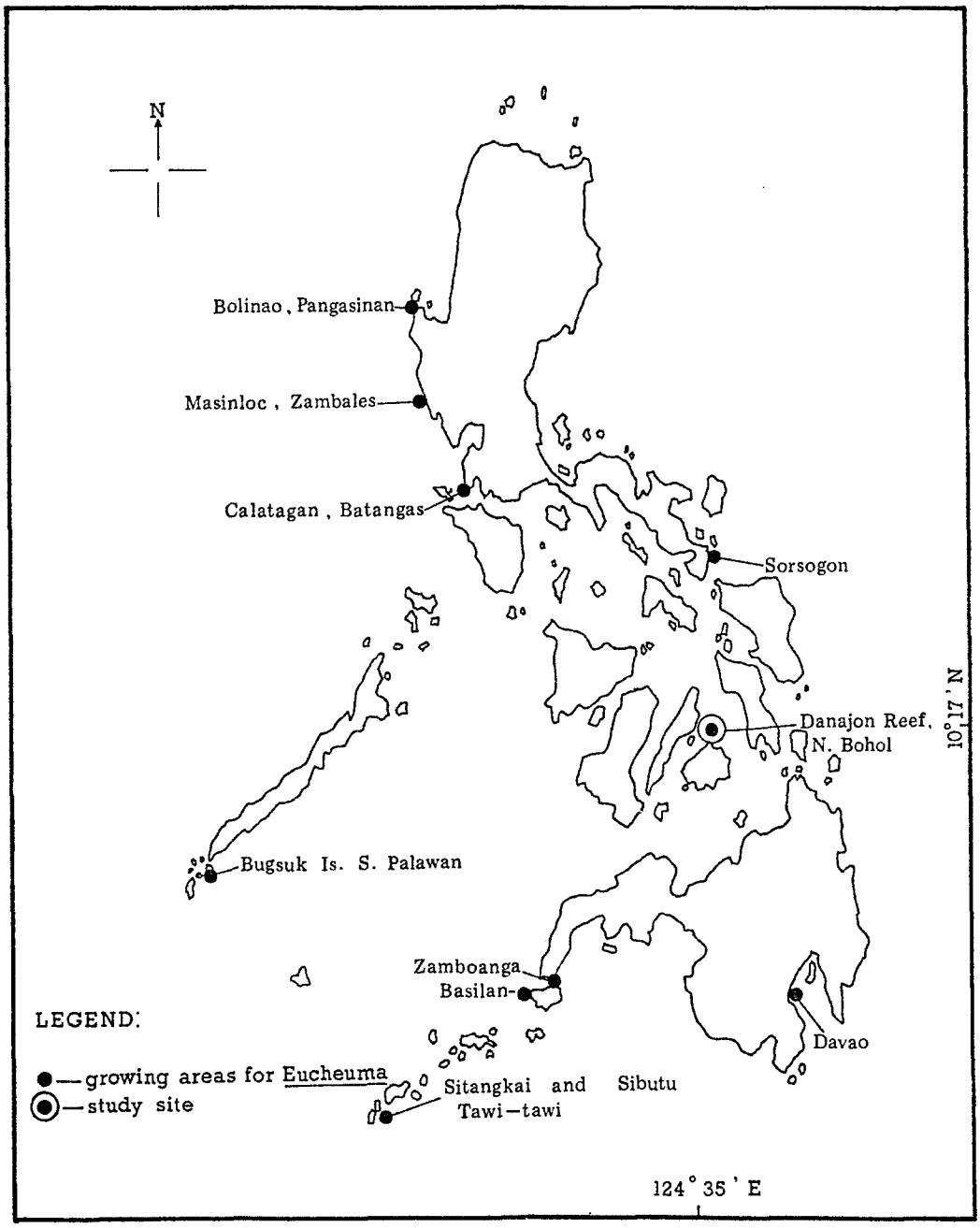

Fig. 1. Map of Philippines showing present *Eucheuma* producing areas, including study site at Danajon Reef.

Materials and methods

The six *Eucheuma* morphotypes sampled for carrageenan content, *E. denticulatum* green and brown (EDG and EDB) and *E. alvarezii* green and brown (EAG1, EAG2, EAB1, and EAB2), are described elsewhere.

Samples weighing approximately 250 g were collected monthly from June to November from the study site in Danajon Reef, which at present

is a major growing area for *Eucheuma*. They were washed, cleaned of epiphytes, and sun-dried for about five days prior to extraction. Extraction was done following the method of Laserna *et al.* (1978). The clean, anhydrous yield was weighed, and samples for spectrofluorimetric assay, viscosity, and gel strength were weighed accordingly. Spectrofluorimetric assays measuring sulfate levels were done using a Hitachi Model 204 fluorescence spectrophotometer. Viscosity and gel strength measurements were determined according to the method of Veroy & Montaño (1981). The procedure for testing gel strength was modified by using a 3% solution since the gels of all the varieties did not set at the prescribed 2% concentration. During sampling, water movement at the site was determined using the clod card method (Doty *et al.*, 1976). Salinity and temperature data were recorded using a refractometer and a thermometer, respectively. The data were analyzed using one-way ANOVA and the Pearson Product correlation test.

Results and discussion

Table 1 shows the physico-chemical properties of the carrageenans extracted from the six *Eucheuma* morphotypes. The values for clean, anhydrous yield, ranging from 18.00 to 56.65%, show a lower range than the carrageenan yield obtained by McCandless (1978), which was 30–70% of the dry weight of the algae. Stepwise regression analysis was done to determine the existence of any

Table 1. Physical properties of carrageenan extracted from six *Eucheuma* strains.

	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
% Yield						
EDG	26.50	41.45	30.30	32.05	23.25	27.85
EDB	41.00	52.00	27.70	32.05	21.50	27.50
EAG1	36.00	52.35	34.25	27.75	30.75	21.50
EAG2	37.25	56.65	37.70	23.95	30.75	19.35
EAB1	40.75	37.65	47.40	30.10	24.45	20.10
EAB2	36.20	38.50	43.75	27.60	22.70	18.00
% Sulfate						
EDG	49.99	48.60	41.55	44.34	35.88	43.03
EDB	38.95	41.45	43.99	43.33	34.07	40.80
EAG1	31.42	38.61	29.25	32.40	29.59	32.88
EAG2	33.61	36.52	35.62	29.39	27.71	30.52
EAB1	33.31	29.62	30.40	28.99	28.74	32.24
EAB2	33.46	30.70	30.74	29.33	30.18	32.10
Viscosity (cps)						
EDG	257.50	60.00	52.50	61.50	65.00	162.50
EDB	170.00	64.00	52.50	57.00	47.50	122.50
EAG1	176.00	250.00	175.00	69.50	50.00	257.00
EAG2	159.00	178.00	97.50	75.00	270.00	90.00
EAB1	227.50	196.00	160.00	86.00	221.20	176.50
EAB2	174.50	197.00	180.00	115.00	106.50	108.00
Gel Strength (gcm^{-2} at 3% solution)						
EAG1	140.00	150.00	108.00	100.00	148.00	320.00
EAG2	190.00	190.00	168.00	152.00	260.00	248.00
EAB1	90.00	150.00	140.00	190.00	200.00	200.00
EAB2	150.00	170.00	120.00	150.00	244.00	300.00

relationship between any of the following parameters: yield, sulfate content, gel strength, viscosity, and month of sampling, whether taken individually or in combination. Results show variations of the yield with the month of sampling. Percent yield of all varieties taken together apparently was higher in June, becoming lower in November ($r = -0.785$, $p \leq 0.001$). It seems that with the environmental data available, only water movement showed a pattern (Table 2) that could explain this result. Increased water movement at the site from August to October, as evidenced by the increased diffusion of the clod cards exposed at the site, may have caused abrasion and breakage of the thalli (Doty, 1987). Subsequent repair by the production of new cortical layers over the affected parts (Azanza-Corrales & Dawes, 1989) would mean the synthesis of protoplasmic constituents with little accumulation of cell wall material of which carrageenan is a component (Doty, 1987). Fuller & Mathieson (1972) stated that a complex interaction of many factors probably is responsible for producing seasonal changes of carrageenan, and foremost among these factors is nutrient availability. Although further studies on *Chondrus crispus* need to be conducted, it has been noted that a correlation exists between nutrient and carrageenan yield (Fuller & Mathieson, 1972). Similar work should be done with the cultured *Eucheuma* in the Philippines.

Both strains of *Eucheuma denticulatum*, EDG and EDB, exhibited higher levels of sulfate (34.07–49.99%) compared to the *E. alvarezii* strains (27.71–38.61%). Doty (1987) reported sulfate content to be 30% or more for *E. denticulatum* and 28% or less for *E. alvarezii*. Laserna *et al.* (1981) obtained 21.32% and 31.86% for samples identified as *Eucheuma striatum* and *E. spinosum*, which could have been specimens of *E. alvarezii* and *E. denticulatum*, respectively. Because of the higher sulfate levels, both EDG and EDB did not form gels even when the concentration of the extract was increased to 3%.

Table 2. Summary of environmental data at Danajon Reef, N. Bohol, Philippines.

Month	Clod Card (DF)	Salinity	Temperature
May	1.20	35	–
Jun	lost	34	–
Jul	1.43	34	–
Aug	1.67	34	22.27–26.83
Sep	1.64	34	23.30–30.00
Oct	1.61	34	21.67–30.00
Nov	lost	34	–

The viscosities, ranging from 47–270 cps, do not follow a definite pattern. Viscosity measurements for *Eucheuma denticulatum* morphotypes were low from July to October (47.50–65.00 cps). Laserna *et al.* (1981) reported viscosity values of *Eucheuma striatum* and *E. spinosum* at 85 and 230 cps, respectively. ANOVA was performed to test whether there are differences in sulfate levels, gel strength, and viscosity between the *E. alvarezii* morphotypes. There was no significant difference between the green and the brown morphotypes.

This is an on-going study, and with the acquisition of more data, definite statements can be made regarding carrageenan seasonality and its implications on *Eucheuma* farming in the Philippines.

Acknowledgements

Financial support provided by the International Development Research Centre (IDRC)-Canada is gratefully acknowledged. We also are grateful to Ms. R. Veroy and Mr. Ang Put, Jr. for reviewing the manuscript.

References

Azanza-Corrales, R. & C. J. Dawes, 1989. Wound healing in Eucheuma alvarezii var. tambalang Doty. Bot. mar. 32: 229–234.

Dawes, C. J., 1979. Physiological and biological comparisons of Eucheuma spp. (Florideophyceae) yielding iota-carrageenan. Proc. int. Seaweed Symp. 9: 199–208.

Dawes, C. J., J. M. Lawrence, D. Cheney & A. Mathieson, 1974. Ecological studies of Floridian Eucheuma (Rhodophyta, Gigartinales). III. Seasonal variation of carrageenan, total carbohydrate, protein, and lipid. Bull. mar. Sci. 24: 286–299.

Dawes, C. J., N. F. Stanley & D. J. Stancioff, 1977. Seasonal and reproductive aspects of plant chemistry, and ι-carrageenan from Floridian Echeuma (Rhodophyta, Gigartinales). Bot. mar. 20: 137–147.

Doty, M. S., 1987. The production and use of Eucheuma. In M. S. Doty, J. F. Caddy & B. Santelices (eds), FAO Fisheries Technical Paper 281: 123–161.

Doty, M. S., J. R. Pishu, B. J. Cook, E. K. Zablackis & I. A. Levine, 1976. Experiments with Gracilaria in Hawaii 1983–1985. Bot. Sci. Paper No. 46: 123–161.

Fuller, S. & A. Mathieson, 1972. Ecological studies of economic red algae. IV. Variations of carrageenan concentration and properties in Chondrus crispus Stackhouse. J. exp. mar. Biol. Ecol. 10: 49–58.

Laserna, E. C., G. J. B. Cajipe, R. L. Veroy & A. H. Luistro, 1978. Spectrofluorimetric assay of carrageenan and agar from Philippine seaweeds. Kalikasan, Philip. J. Biol. 7: 110–116.

Laserna, E. C., R. L. Veroy, A. H. Luistro & G. J. B. Cajipe, 1981. Extracts from some red and brown seaweeds of the Philippines. Proc. int. Seaweed Symp. 10: 443–448.

Lim, J. R. & H. Porse, 1981. Breakthrough in the commercial culture of Eucheuma spinosum in northern Bohol, Philippines. Proc. int. Seaweed Symp. 10: 601–606.

McCandless, E. L., 1978. The importance of cell wall constituents in algal taxonomy. In D. E. G. Irvine & J. H. Price (eds), Modern Approaches to the Taxonomy of Red and Brown Algae. The Systematics Association Special Volume No. 10. Academic Press, London: 63–85.

McHugh, D. G. & B. V. Lanier, 1983. The world seaweed industry and trade: developing Asian producers for greater participation. ADB/FAO InfoFish Market Report, Vol. 6, 30 p.

Veroy, R. L. & N. Montaño, 1981. Analytical methods: determination of moisture content and physical properties. In G. C. Trono & E. G. Fortes (eds), Report on the Training Course on Gracilaria Algae. (A Training Subproject under FAO/UNDP Project RAS/79/041) Manila, April 1–30, 1981. South China Sea Fisheries Development and Coordinating Program, Manila: 125–126.