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SEAWEED: *GRACILARIA*

Anicia Q. Hurtado-Ponce
Aquaculture Department
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo 5021, Philippines

ABSTRACT

This paper reviews the studies on *Gracilaria/Gracilariopsis* conducted from 1988 to 1991 by the Aquaculture Department, Southeast Asian Fisheries Development Center. It includes 114 species of macrobenthic algae collected in Panay, the nomenclature of *Gracilariopsis heteroclada* previously described as *Gracilaria* sp., and the biology, ecology, and farming systems of *Gracilariopsis.* Agar quality of the different species of *Gracilaria* and the effect of seasonal variation on the quality and quantity of agar produced from *Gracilariopsis heteroclada* were also studied.

INTRODUCTION

During the ADSEA '87, member countries of the Southeast Asian Fisheries Development Center (SEAFDEC) recommended *Gracilaria* as the number one priority for seaweed research in the following areas: 1) refinement of culture techniques, 2) basic biology, 3) product utilization, and 4) screening and characterization of natural products. The research activities (1988-1991) for *Gracilaria* at SEAFDEC Aquaculture Department (AQD) included: 1) inventory and assessment of biomass production, 2) development of seed production techniques, 3) biology-ecology of natural stock, 4) development or adaptation of techniques for pond culture and coastal farming, and 5) characterization of agar. Studies on product utilization were not conducted due to limited senior staff in the Seaweed Project, instead, an inventory of the macrobenthic algae of Panay Island, western Visayas, central Philippines was conducted to provide basic information on the taxonomy and distribution of available seaweeds.

RESEARCH ACCOMPLISHMENTS

Taxonomy

Inventory of Marine Macrobenthic Algae. From 1988-1989, marine macrobenthic algae were collected to determine the marine algal resources of Panay Is. A total of 114 species were identified which include 38 *Chlorophyceae,* 21 *Phaeophyceae,* and 55 *Rhodophyceae.* To date, there are 37 species considered as new record for Panay.

Nomenclature of Gracilaria sp. Gracilaria sp. *(=Gracilaria* sp. 2 in Trono et al. 1981) in earlier studies of SEAFDEC/ AQD is referred to in this paper as *Gracilariopsis heteroclada* (Zhang et Xia) Zhang et Xia (basionym: *Gracilaria heteroclada* Zhang et Xia) (Personal Communication).

Genera included in the Order *Gracilariales* found in western Visayas were *Gracilaria arcuata Zanardini, G. blodgettii Harvey, G. coronopifolia J. Agardh, G. eucheumoides Harvey, G. salicornia* (C. Agardh) Dawson, *G. 'verrucosa'* (Hudson) *Papenfuss, Gracilariopsis heteroclada* (Zhang et Xia) Zhang et Xia.

Biological Study of *Gracilariopsis*

Reproductive States. The reproductive states of *G. heteroclada* were studied from wild stocks gathered in Jaro district of Iloilo City. Presence of carposporophytes and tetrasporophytes was high in January (48%) and May (64%), respectively. Percentage occurrence of carposporophytes and tetrasporophytes was not significantly correlated with water temperature, salinity, and turbidity.

Ecology

Assessment of a Gracilariopsis Natural Bed. The standing crop of *G. heteroclada* natural bed at Jaro and Leganes district of Iloilo, Ivisan district of Capiz, and Batan district of Aklan was assessed monthly (de Castro et al. 1991). There was a marked seasonality in biomass of *G. heteroclada* like species of *Gracilaria* (Black and Fonck 1981, Trono and Azanza-Corrales 1981) and this differs according to locations. Correlation analysis shows an inverse relationship between biomass and rainfall in Leganes, Ivisan, and Batan.

Environmental Parameters. Temperature had no effect on the biomass of *G. heteroclada* in Leganes, Ivisan, and Batan biomass was negatively correlated with salinity in Leganes and Batan but not in Ivisan; no relationship existed between biomass and pH in Leganes, Ivisan, and Batan. On the other hand, significant differences between the monthly biomass of *G. heteroclada* were observed in Jaro. No correlation was detected between biomass and the different environmental factors (water temperature, salinity, turbidity, water movement, and the nutrient levels of water) at the natural bed of *Gracilariopsis* at Jaro.

Salinity Tolerance. G. heteroclada when reared at different levels of salinity under ambient conditions shows that it can tolerate low levels of salinity. However, plants reared in lower (5-15 ppt) and higher (35 ppt) salinities are brittle and brownish with rough surface and short branchlets. Plants grown at 20-30 parts per thousand resembled the natural characteristics of wild plants which are succulent, purplish, bushy, and healthy. Apparently, plants at 25 ppt grow best. *G. heteroclada* show similar characteristics as other euryhaline species. This preliminary findings suggest that this species can be best cultivated in seawater to brackishwater areas.

Management of a Natural Bed

Regeneration Capacity. The amount of harvest left after the first cropping is important in determining the amount of biomass available for the next cropping season. Among the 4 levels of harvest (25, 50, 75, and 100%), 75% provides the appropriate amount of "seeds" for the next cropping season. The amount of biomass to be harvested during each harvest regime should not exceed the amount of biomass available for cropping.

Harvesting Tools. Among some harvesting tools (araña, rake, scissors, or bare hands) tested on the regeneration capacity of *G. heteroclada,* araña is ineffective in areas where *Gracilariopsis* were exposed during the lowest tide. However, the results of Santelices et al. (1984) in Chile show otherwise. Earlier reports have shown that raking seaweeds brings excessive disturbance on the substrate and to the population (Luxton 1981).

Farming Systems

Cage Culture. Field culture of *G. heteroclada* using vegetative fragments inserted between braids of ropes suspended vertically inside a floating cage showed significant differences in growth rate and monthly yield (Hurtado-Ponce 1990). Any of the 3 spacing intervals may give high yield. Both growth and yield were minimum in December at all spacing intervals but maximum in April at l0 and 15 centimeters and in February at 20 centimeters. Approximately, 1.4 tons (dry) per hectare per year was produced from this system.

The specific growth rate of *G. heteroclada* grown at 25, 50, and 100 cm below the water surface with *Lates calcarifer* fingerlings in floating cages was found to be influenced by the of presence of sea bass, water depth, and month of culture (Hurtado-Ponce 1992). Growth rate of *Gracilariopsis* was highest near the water surface and lowest at 100 centimeters. High survival rate (92-100%) and production (6.8-% kilogram/cage) of *L. calcarifer* were obtained. The polyculture of *G. heteroclada* and *L. calcarifer* was encouraging.

Statistical analysis showed significant differences in specific growth rate and net production rate ($P<0.05$) among the four stocking densities (400,500,600 and 700 grams per square meter) tested in growing *G. heteroclada* in hapa nets installed to a floating cage (Guanzon and de Castro 1992). Specific growth rate and net production rate were found to be significantly different within a 12-month cultivation period. Specific growth rates and net production rates were higher during the dry season.

Pond Culture. Higher growth rate (2.5% per day) and net production rate (8.8 g/m/day) were obtained at lower stocking density (500 g /m^2) than at higher stocking density (600 and 700 g/m^2) when *G. heteroclada* was cultured in hapa nets inside a pond (de Castro, unpublished results). Production was higher during the dry season. Salinity was positively correlated while total rainfall was negatively correlated with specific growth rate and net production rate ($P < 0.05$); temperature and pH had no effect on these parameters ($P > 0.05$).

Bottom Line Cultivation. Adapting the fixed bottom line technique (Doty 1973) of cultivating *G. heteroclada,* about 12-92 tons dry weight/ha/year is produced from this method. These values are relatively high compared with the production obtained in ponds (Chiang 1981, Shang 1976) but almost identical with the reports of Hanisak (1981) and Ryther et al. (1979) in tanks.

Agar Characterization

Strain *Selection.* Agar from *G. blodgettii, G. coronopifolia,* G. *eucheumoides, G. 'verrucosa',* and *Gracilariopsis heteroclada* were screened quantitatively and qualitatively. Results showed that *G. blodgettii, G. 'verrucosa',* and *G. heteroclada* are potential sources of food agar based on their physical properties. Refinement of the extraction methodology is necessary to improve the agar qualities from these species.

Seasonal Variation of Agar Quality and Quantity. Yield, gel strength, and melting and gelling temperature of *G. heteroclada* collected in Jaro varied according to months (Luhan 1992). Gel strength of *G. heteroclada* was negatively correlated with percent dry yield but not with the different environmental factors. The gel strength of agar also differed significantly with month of sample collection.

CONCLUSIONS AND RECOMMENDATIONS

Cage culture (monoculture and polyculture) and line cultivation of *Gracilariopsis heteroclada* are possible. *G. heteroclada* is a good source of food agar and possibly bacteriological agar.

The following are recommended research areas for future work: 1) seed development techniques for outplanting, 2) mono- and polyculture of *G. heteroclada* in ponds, 3) refinement of extraction methodologies, 4) utilization of raw material and agar in aquaculture, and 5) pharmacological studies on *Gracilaria/Gracilariopsis* species.

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