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Research for the project *Economics of Giant Clam Mariculture* (Project 8823) is sponsored by the Australian Centre for International Agricultural Research (ACIAR), G.P.O. Box 1571, Canberra, A.C.T. 2601, Australia. The following is a brief outline of the Project:

The technical feasibility of culturing giant clams for food and for restocking tropical reefs was established in an earlier ACIAR project. This project is studying the economics of giant clam mariculture, to determine the potential for an industry. Researchers will evaluate international trade statistics on giant clams, establish whether there is a substantial market for them and where the major overseas markets would be. They will determine the industry prospects for Australia, New Zealand and South Pacific countries, and which countries have property right factors that are most favourable for commercial-scale giant clam mariculture. Estimates will be made of production/cost functions intrinsic in both the nursery and growth phases of clam mariculture, with special attention to such factors as economies of scale and sensitivity of production levels to market prices.

Commissioned Organization: University of Queensland.

Collaborators: James Cook University, Townsville, Queensland; South Pacific Trade Commission, Australia; Ministry of Primary Industries, Fiji; Ministry of Natural Resources and Development, Kiribati; Silliman University, Philippines; Ministry of Agriculture, Fisheries and Forests, Tonga; Forum Fisheries Agency, South Pacific; ICLARM, Manila, Philippines.

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Pacific Giant Clams and Their Products: An Overview of Demand and Supply Factors

ABSTRACT

Due mainly to overharvesting, the world's natural stocks of giant clams have been seriously depleted and most species are now listed as endangered species under CITES (The Convention on International Trade in Endangered Species). There is a perceived shortage of clam supplies in the Pacific Islands and in Chinese areas such as Taiwan and Hong Kong. The development of techniques for the aquaculture (mariculture) of giant clams however raises the possibility of a new source of supply. In this paper, the type of clam products that are likely to be in demand are discussed, elements that may influence these demands are identified and factors that are likely to determine supplies are highlighted. It is anticipated that future ACIAR supported research will enable the economic prospects and possible industry pattern of development of Pacific giant clam mariculture to be pinpointed more precisely.

Keywords: Giant clam farming, aquaculture, mariculture, supply and demand,

JEL Classification: Q57, Q31

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1. Background

Pacific giant clams are marine bivalve molluscs. There are 7 species in existence and they are confined in their natural distribution to the warmer waters of the Pacific and Indian Oceans. In fact, the natural distribution of some of the largest species is even more restricted, being confined to tropical waters bounded on the eastern side by Fiji and Tonga and bounded on the western side by northwest Australian waters and those of Indonesia (Munro and Heslinga, 1982). Natural stocks of giant clams (particularly those species which grow to the largest size) have been seriously depleted throughout their natural ranges, principally as a result of harvesting by man. Increased harvesting pressure came from three sources: (1) Greater subsistence and domestic consumption in the countries with natural stocks, (2) harvesting by foreign vessels (often Taiwanese vessels but sometimes Australian) for export of giant clam muscles principally to Taiwan; and (3) involvement of domestic import-export firms (very often traders and processors playing an important middleman role) in the export of giant clam products.

Because of the serious depletion of natural stocks of giant clams many governments in the Pacific have prohibited or restricted the export of giant clam products. Furthermore, all species have now been listed under CITES (The Convention on International Trade in Endangered Species). This means that signatories to this Convention should prohibit the export or import of the species concerned. But not all countries are signatories to the Convention; a signatory can exclude certain species, and of course the law can be circumvented in other ways, e.g. by deception or vague labelling.

Against this background of dwindling natural stocks, scientists have developed techniques to mariculture and aquaculture giant clams. (Lee 1988). Papers given at the ACIAR Workshop on Giant Clams - Townsville 18-22 April (Copland and Lucas, 1988), organized by Professor John S. Lucas provide a useful overview of current scientific status of clam farming, see also Heslinga and Fitt (1987). Clam farming technology has advanced rapidly in recent years. Major scientific research centres are located at the Micronesian Mariculture and Demonstration Center (MMDC) in Palau, and at James Cook University in northern

Australia. Research is also being conducted at other locations. For example, in the Philippines both at Silliman University and at the University of the Philippines, in Fiji by the Department of Primary Industry, in Papua New Guinea at the University of Papua New Guinea and in the Solomon Islands by the International Centre for Living Aquatic Resource Management (ICLARM). Several governments are interested in the prospects for giant clam mariculture as an industry for development and a number of firms, including Australian firms, have commenced pioneering efforts in the commercial development of giant clam farming. The Australian Centre for International Agricultural Research has been and is a major financial sponsor of scientific and technological advance in this area, principally through its commissioning of research with and through James Cook University.

The mere fact, however, that it is technically and ecologically possible to cultivate Pacific giant clams does not mean that it is economic to do so. Market prospects, production economics and the social structure in a country, including arrangements relating to property rights, may be such as to prevent economic success. Whether or not giant clam mariculture will be economically successful and where is unknown at this time. However, there are definite prospects for its economic success (Tisdell, 1986; Tisdell and Menz 1988). With this in mind, ACIAR has just (March 1989) commissioned a project, "Economics of Giant Clam (*Tridacnid*) Mariculture", with the University of Queensland and under the leadership of the author to

"provide guidance on market prospects for giant clams and trading arrangements, production economics and supply, marine property rights as these affect the economics of giant clam mariculture, and the value of giant clam mariculture in development as a component of productive possibilities in less developed countries in the Indo-Pacific region, especially South Pacific countries".

The Center for Tropical and Subtropical Aquaculture located in Hawaii is also to commence a project developing marketing strategies for Pacific giant clams and examining markets for them. This marketing project will complement the ACIAR funded socio-economic project.

2. Demand for Pacific Giant Clams

To predict the demand for the economic use of giant clams and the supply likely to be forthcoming from mariculture is a very difficult problem. This is because on the demand side

there is no longer an international market of significance for giant clams from natural sources. Also, supplies from the wild have virtually dried up because of depletion of stocks, restrictions on harvesting and/or on export by governments. The application of CITES to all species of giant clam is also a contributing factor. Furthermore, harvest from the wild usually involved larger and older clams and the products supplied by these may be somewhat different to those which it is economic to supply from aquacultured giant clams. Therefore markets which have existed in the recent past or which exist now in a restricted form may be a poor guide to the demand for maricultured clams. Nevertheless, past and existing attenuated markets do give some guide to possible market outlets for giant clams.

The meat of the giant clam can be divided into two components: (1) the adductor muscle and (2) the mantle. The muscle is in greatest demand and in the past, Chinese demand has principally been for the adductor muscle which has to be separated from the mantle. The adductor muscle appears to be relatively small in young clams and it may not pay to separate it from the mantle. We cannot **assume** that the market value (price) of the adductor muscle is linearly related to the weight or size of the muscle (cf. Munro, 1985). Evidence needs to be obtained about the relationship. Not only the muscle but also the mantle of giant clams is consumed by Pacific islanders. A demand exists for it at least in the Pacific islands.

For larger clams, market potential exists for both the adductor muscle and the mantle of clams. However, the possibilities for commercially marketing these items are limited because of transport time. They can, however, be chilled, frozen or preserved in other ways. For example, in Fiji, Feeders in the past traded in frozen clam meat. The adductor muscles were separated from the mantles. The muscles were packed in medium sized cardboard boxes and frozen for export principally to Australia for re-export to Taiwan. The net weight of the carton was about 10 kg. The mantles were packed in blister packs and frozen for supply to retail outlets (supermarkets) in Fiji.

The project may also be preserved in other ways. In Micronesia for instance, dried sticks are formed from it, and it is eaten in a similar way to 'jerky' or 'biltong'. Other low cost methods of preserving it for at least a short period of time may exist. For example, meat of giant clams is reported to be exported from Tokelau to Samoa to friends etc., in barrels and these clams appear to withstand a journey of a few days. Also, some shipment in a similar form has been reported to take place in Tuvalu from the southern islands to Funafuti by plane.

The meat of the clam can be consumed in either cooked or raw form. Usually, but not always, when it is consumed in raw form it is marinated in lime or lemon juice. Westerners may find that the mantles of older clams have a 'strong taste' from the algae present. This may be disguised by making curried clams.

Apart from the direct table use of the clam meat, it is reported to have been used in other ways. One exporter from the Solomon Islands claimed in the past to have exported clam mantles to SAFCOL which in his view resold it for use as flavouring for soups. Clams are also believed by a number of Chinese to have aphrodisiac properties and, I have had a report from a Filipino that a number of Filipinos believe that it is useful for those infected by malaria to eat it.

At present, the period of time for which it is likely to be economic to hold maricultured clams before marketing or harvesting them is uncertain. This will be influenced by discount rates, growth rates of clams with time, additional costs of retaining clams, mortality rates and whether or not a price premium applies to products from older clams. Present indicators, however, are a total cultivation period before harvest of not more than 5 years is optimal. It is even possible that harvest at approximately 2-3 years is optimal.

This period of cultivation would be similar in length to that for oysters. At this stage, giant clams of the *gigas* species are "plate-sized". They may be served in the shell raw (with condiments) and appear to lend themselves to inclusion in Japanese cuisine (see Anon, 1988). (At this age, the clams are quite immature and there is little point in separating the adductor muscle from the mantle.) In order to tap this potential market, the clams should desirably be kept alive until they are required for the preparation of a dish. There may be a market for clams for sashimi-style dishes amongst Japanese tourists to countries where clams are cultivated and there may be scope for air-freighting of live young clams to Japan to satisfy possible demand there. However, **many** Japanese have no knowledge of giant clams (Dawson, 1986), so there is not a ready-made market in Japan. But in the south of Japan, especially in the Okinawa area, there appears to be some knowledge of and consumption of giant clams (Yamaguchi, pers. comm. 1988).

The market for small-sized clams for consumption needs more investigation. Also, there is a need to consider the minimum age that a clam needs to reach before it is economic to freeze or chill clam meat for resale and/or separate the adductor muscle from the mantle. Some

questions that need to be considered in relation to the final market for clam meat are: Will it be limited principally to restaurants and hotel trade? Is there scope for its sale by specialised seafood retailers? Is there a prospect of its sale in supermarkets and what type of product is likely to be needed for this trade?

Shells of clams are also a marketable product, and in the past have been traded internationally. These are often sold by shell shops at beach locations whether or not clams are indigenous to the area. The Philippines was a considerable centre for export of these shells to Australia, Japan and the USA. Evidence from the Philippines indicates that the value of the shells often exceeded the price obtained for the meat (Juinio et al., 1986). The value of a shell can be expected to depend on such factors as its conformation, colouring and size. In the commercial farming of giant clams and in selecting breeding stock, attention should be given to the possible value of shells as well as meat. The market for shells, although valuable, may be more limited in size than the potential market for clam meat.

Markets also exist for live clams. A market exists in the USA for giant clams suitable for saltwater aquariums. This market is being tapped by the Micronesia Mariculture and Demonstration Center. Although this could be a significant outlet, the size of market will be limited (e.g. would be at least constrained by the number of saltwater aquariums).

The development of giant clam mariculture will also result in a market for live clams used in the industry. A developing market already exists for 'seed clams', that is, small clams from nurseries suitable for ocean grow-out or further husbandry prior to final sale. One expects also, if the industry becomes established, that a market will develop in breeding stock. In due course specialisation in production may occur (e.g. some firms in the giant clam farming industry may specialise in the breeding and raising of seed clams whereas others will be specialised in the ocean grow out of giant clams).

Existing data on patterns of consumption of giant clam products (now and in the recent past) are extremely limited and often unreliable. Furthermore, in so far as they relate to giant clams harvested from the wild, they may give a misleading impression of the demand for maricultured giant clams because the size composition of the harvest may be different. Furthermore, consumption of giant clam meat has been declining because of reduced availability of supplies. This means that in some regions, that inhabitants who once were familiar with clam meat no longer know it and in other regions the inhabitants have not been

able to experience it. Thus, to a large extent the sale of maricultured giant clam products in international markets may hinge upon the opening up of new markets and reestablishing demand. But, of course, there are still areas in the Pacific islands where current knowledge of and consumption of giant clams continues to take place especially in subsistence communities.

3. Supply of Pacific Giant Clams

The future supply of giant clams for human use and consumption depends primarily on the success or otherwise of giant clam farming. Natural stocks, except in Australian waters, are very low and recovery of populations by natural recruitment is uncertain.

A number of factors can be expected to influence the supply of farmed clams. These include economic, ecological and social factors. Ecological requirements for giant clam culture include salty, clear, warm water either in the intertidal zone or not so deep as to interfere with penetration of sunlight. The availability of sunlight is important to the growth of giant clams since they live in a symbiotic association with algae, zooanthellae, in their mantle. The waters in and around tropical atolls are ideal for giant clam production. Water near river outlets is usually unsuitable because of the occurrence of 'freshes' in the environment and in many cases, the presence of sediment.

The extent to which giant clams can be grown successfully outside their known natural range is unclear. Many species which occur in Australia and the Pacific islands to the north of Australia are not present in the west Pacific e.g. in the Hawaiian Islands or Samoa. Furthermore, giant clams do not occur in the Atlantic Ocean. This raises the question of whether they can be successfully translocated and, from an ecological point of view, whether this is desirable. Already attempts are being made to introduce species of clams into new environments, which appear to be ecologically suitable for them but are beyond their known natural range. Possibly they can be farmed successfully in the Western Pacific and even the Caribbean.

It might also be noted that some areas in the Pacific which were once ecologically suited to the growing of giant clams are no longer suitable for the purpose. This is because of the increase in marine pollution caused by industrial, urban and economic growth (e.g. in the Philippines, Thailand and Indonesia especially Java). In some cases too, the clearing of the

land for agriculture has affected river run-off and resulted in increased marine sedimentation. Pollutants from urban, mining and industrial growth can involve heavy metals, sediments and sewerage, all of which have a serious impact on the survival, growth and acceptability of giant clams for human consumption.

Australia has a large area in the north suitable for the farming of giant clams and most of the islands in the Southwest Pacific have substantial areas suitable for this purpose. Pollution pressures on these areas are less than in Southeast Asia.

However, economic success depends upon a lot more than biological possibilities. It is influenced by a whole range of factors which determine the prices received by clam farmers and the costs of their production. In addition, the nature of property rights and of social arrangements in relation to production have a bearing on economic success. Where marine property rights are uncertain or poorly defined or costly to enforce, there is little incentive to cultivate clams, since cultivators may not reap the rewards of their efforts. In the Pacific islands, reef areas adjoining villages are **normally** at least *de facto*, the property of each adjoining village. Collective rules apply to the use of the reef by villagers. The property situation is one of *rerum communis* rather than *rerum nullium*. It is necessary to study these arrangements in detail to determine areas in the Pacific where social and property right arrangements are likely to be conducive to the cultivation of giant clams, either for subsistence use or for marketing. Furthermore, are there areas in the Pacific where private foreign investment in the development of giant clam farming is likely to be a commercial success and where are they located? What types of business arrangements may be most successful (e.g. joint ventures)?

Giant clam farming has been seen as a possible useful productive component in the development of atoll economies in the Pacific. It undoubtedly has potential in this regard, especially to supplement local diets. But whether it will be able to support an export industry or a substantial export in such countries is quite uncertain. Poor infrastructures, high transport costs and infrequent transport departures may militate against this (e.g. in an atoll country such as Tuvalu). High quality of product and freshness needs to be maintained for some markets, (e.g. the potential Japanese market for young live clams). In fact, Australia may be much better placed in terms of its transport system and technology to meet this demand than the Pacific islands. Southeast Asian countries would also have the advantage of proximity, and regular plane and other connections with potential international markets. In the past,

however, the larger Pacific islands have successfully exported frozen giant clam meat (e.g. Fiji, Papua New Guinea and the Solomon Islands). So presumably if clams can be grown to a size sufficiently large to warrant freezing this will continue to be a possible method of export. There may indeed be some international specialization by countries in the supply of giant clams or giant clam products with different characteristics.

4. Concluding Observations

It is likely that a market will develop for maricultured clams. Already a market exists in the aquarium trade and is being supplied with such clams. To the best of my knowledge, supplying this market is a successful commercial venture on the part of MMDC. A market can also be expected to develop for farmed clams for use in the restaurant and hotel speciality food trade. One can easily see giant clam dishes being consumed as special items at tourist resorts in places such as Cairns or in Hawaii where some tourists are prepared to pay a premium for exotic dishes. Indeed, the CTSA (Center for Tropical and Subtropical Aquaculture) will be exploring the scope for this possible market outlet in Hawaii. But on the surface this is a small or specialty market. The scope for developing and supplying wider markets has yet to be determined. Much may depend in developing countries on the way in which the product is promoted and presented. One should not underestimate the scope for introducing new products in developed countries. An interesting development at some tourist resorts in Queensland is the sale of crocodile burgers. These are expensive but there is a demand for them on the part of adventurous holiday makers.

Clearly the economic success of giant clam farming will depend on many factors, and it will be impossible to predict precisely the development of the industry. But the economic project which is now commencing and which is to be supported by ACIAR and the marketing project being funded by CTSA, should help to bring a realistic economic perspective to bear on this development. Hopefully, the results will provide a guide to the development of the industry and will be of value to producers and firms, as well as governments interested in the development of the industry.

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