Gourmet vs long-life food for mariculture larvae – Exploring preserved microalgae products as a feed for shellfish larvae

In order for mariculture to develop in the Pacific Islands region, the supply of mariculture seed or juveniles at a suitable economy and sustainable level is a problem that still requires research and development. While pathways exist to supply mariculture activities via the fishing of wild seed such as juvenile marine fish (milkfish) or the collecting of wild bivalve spat (giant clams and pearl oysters), these activities can negatively impact wild fisheries and cause plastic pollution and water quality degradation if they are not well managed. A Pacific Community project has been investigating the use of preserved microalgae products as part of developing technological improvements that may improve the supply of mariculture seed in the Pacific.

The production of mariculture seed from hatcheries offers advantages for sustainability, including a regular and consistent supply of seed and the ability to incorporate genetic improvements, particularly for the resistance of aquaculture stocks to risks associated with disease and climate change. The technology and management required to produce seed, even for animals with short larval cycles, is still difficult to implement in the Pacific Islands. However, there are now many examples in the region of established giant clam production, a group of organisms with easily managed larval and on-land juvenile rearing cycles.

Extending this productivity to other mariculture candidates of nutritional and economic value, such as sea cucumbers and rock oysters (*Crassostrea* and *Saccrostrea*), requires the simplification and application of hatchery methodologies. This can be established by private sector and community efforts, but sometimes there is no access to funds to develop mariculture seed supply operations based around current industry standard procedures.

The costs and impacts of live feed production

The production of live feed – microalgae, rotifers, copepods and artemia – is necessary for mariculture. Live feed is susceptible to contamination and supply continuity. For most mariculture species of interest in the Pacific Islands, the production of marine microalgae is essential. The production of live marine microalgae may account for around 40% of hatchery costs for rearing bivalve seed for example (Coutteau and Sorgeloos 1992; Helm 2004).

While extensive methods (culture in ponds) of live food production are used to produce mariculture seed in Asia in particular, they require significant capital expenditure for the construction of ponds and for water supplies, both of which may impact on coastal environments. Marine hatcheries with small footprints, both physically and financially, will benefit from new technologies such as solar power, mobile communications, and preservation of live food. This will enable their adoption and operation in areas of the Pacific Islands that have opportunities – with respect to water quality, broodstock availability and community need (economic or nutritionally) – to establish mariculture production.

Preserved feeds: Pastes and powders

Replacing cultured live microalgae with preserved microalgae is one strategy being pursued in marine hatcheries in the Pacific to simplify and reduce operational costs. There have been several trials that have produced the seed of sea cucumbers and pearl oysters using preserved (concentrated and refrigerated) microalgae pastes (Duy et al. 2016; Militz 2018; Southgate 2015). In addition to the available pastes, marine microalgae are now available as freeze-dried powders. These could be advantageous because it is not necessary to establish cold supply chains, which are difficult to manage in more isolated regions of the Pacific.

Comparison trial

The Pacific Community, in partnership with the Cawthron Institute of New Zealand, has had the opportunity to use the New Zealand's Ministry of Foreign Affairs and Trade and Pacific Community's Funding with Intent mechanism to contribute to this development of live microalgae replacement technology. The project has employed two experienced Pacific Island hatchery technicians to investigate the potential of more newly available freeze-dried microalgae in comparison with pastes and live microalgae (Vignier 2023). Both Tuaine Turua from the Cook Islands' Ministry of Marine Resources, and Rennie Reymond from Kiribati's Ministry of Natural Resource Development, worked at the Cawthron Aquaculture Park for four weeks in November 2022 to complete a trial using Greenshell™ mussels (*Perna canaliculus*) as an analogue animal for the invertebrates commonly under culture in the Pacific (oysters and sea cucumbers).

While microalgae pastes have been trialled in the Pacific, there has been no comparison with live microalgae because the facilities and staff for its culture are often not available in Pacific Island marine hatcheries. The trial at Cawthron enabled a comparison with live microalgae and the performance of the Greenshell™ mussel larvae was considerably better with standard live feed methods when compared with microalgae pastes and the newer freeze-dried versions.

Figure 1. Preparation of the freeze-dried algal treatment (from top left, clockwise): A) weighing and adding the algal powder to filtered seawater; B) blending to make up stock solution; C & D) feeding diluted preparations of freeze-dried algae to each larval rearing tank.

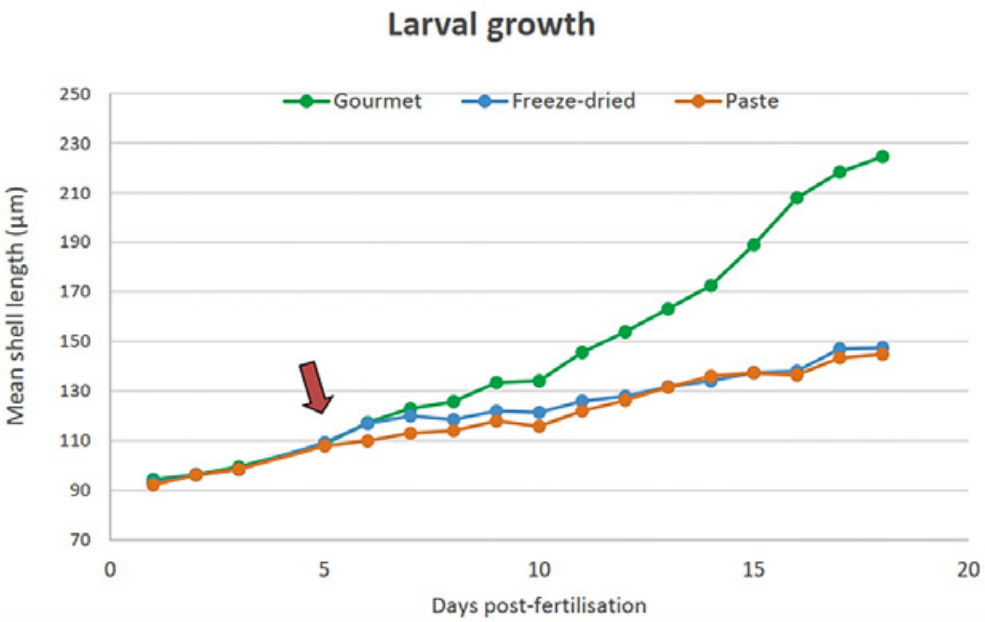

Figure 2. Greenshell™ mussel larval growth, expressed as mean shell lengths (in µm), assessed from day 1 post fertilisation until day 18 post fertilisation. Different feeding regimes consisting of gourmet algae (green), freeze-dried (blue) and paste (orange).

Despite the ease of preparation and storage of both freeze-dried and microalgae pastes, currently there is a large drop in both survival and growth of Greenshell™ mussel larvae fed on these (Fig. 1). Some growth was recorded for both freeze-dried and paste diets and a partial substitution of live microalgae may prove practicable (Fig. 2). The results of the trial suggest that feeding the preserved microalgae might be better in the latter part of the larval cycle, when larvae are larger and food particle size is less critical to ingestion.

Greenshell™ mussels show a preference for gourmet food, and this lends support to the idea that ingestion is very particular for different invertebrate species and selection for particle size and palatability for the species under culture in the Pacific (pearl oysters, rock oysters and sea cucumbers) may give different results (Fig. 3).

A way forward for Pacific mariculture?

Currently the use of preserved diets leads to a significant impact on marine invertebrate larvae performance, which may be offset in the Pacific Islands by a good amount of gametes and high-quality water. However, the implication that live food culture will still form the basis of operations for mariculture in the Pacific Islands leads to questions of scale and location for marine hatcheries. If marine hatchery operations, for species with live food requirements, still require a high level of capital and operational investment to produce live feed, then they are liable to be beyond the financial capacity of communities that have no significant government support.

Centralising marine hatchery production, coupled with regulatory and funding standardisation, in respect to both biosecurity for seed translocation and capital and operating costs, may provide a pathway forward. Further technological advancements in feed and cultured species' performance may, in the future, enable a) marine hatchery technology to be utilised by communities with moderate financial inputs, and b) ecosystem regeneration and nutritional improvements for these communities.

In the meantime, the efforts of Pacific Island aquaculture technicians like Tuaine and Rennie remain critical to fulfilling the aspirations of their governments and communities in developing mariculture in the Pacific. The potential of mariculture can then be realised in the blue economies of Pacific Island countries.

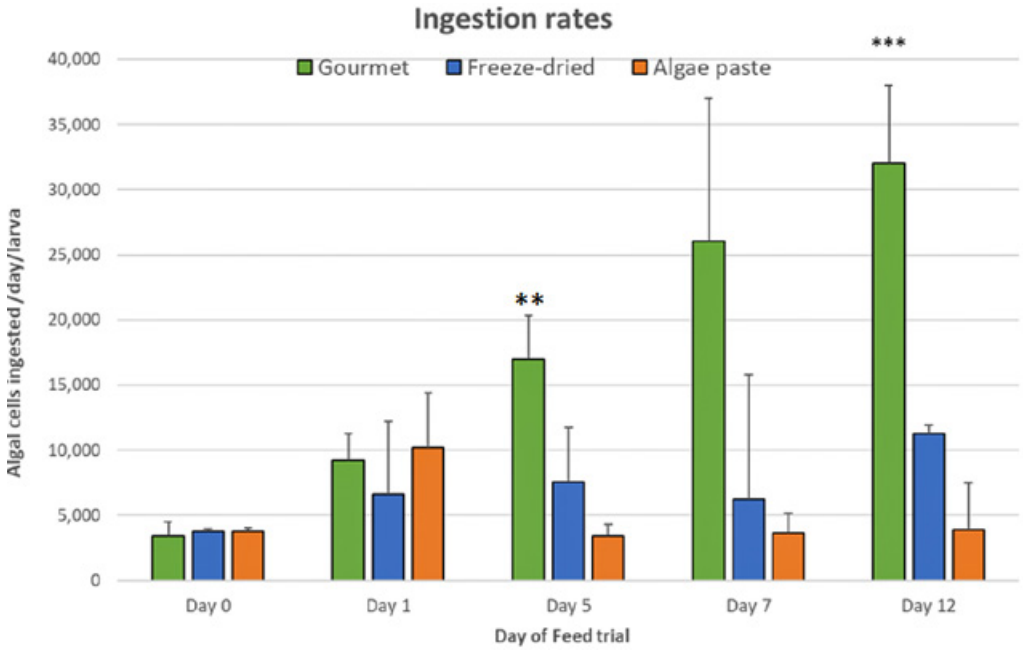

Figure 3. Mean ingestion rate of Greenshell™ mussel larvae fed for 123 days with different algal diets: live microalgae (green), freeze-dried (blue) and pastes (orange). Ingestion rates expressed as number of algae cells ingested per larva per day. ** *** significant difference

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References

Coutteau P. and Sorgeloos P. 1992. The use of algal subsitutes and the requirement for live alage in the hatchery and nursery rearing of bivalave molluscs: an international survey. Journal of Shellfish Research 11(2):467–467.

Duy N.D.Q., Francis D.S., Pirozzi I. and Southgate P.C. 2016. Use of micro-algae concentrates for hatchery culture of sandfish, *Holothuria scabra*. Aquaculture 464:145–152.

Helm M.M. 2004. Hatchery culture of bivalaves: A practical manual. Rome, Italy: Food and Agriculture Organization of the United Nations.

Militz T.A., Leini E., Duy N.D.Q. and Southgate P.C. 2018. Successful large-scale hatchery culture of sandfish (*Holothuria scabra*) using micro-algae concentrates as a larval food source. Aquaculture Reports 9:25–30.

Southgate P.C, Beer A.C. and Ngaluafe P. 2015. Hathcery culture of the winged pearl oyster, *Pteria penguin*, without living micro-algae. Aquaculture 451:121–124.

Vignier J. 2023. Exploring the value of preserved microalage products as a shellfish larval feed. Nelson, New Zealand: Cawthron Institute.

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