5. Optimising penaeid larvae growth and nutrition: methods for *Artemia*, copepods and rotifers

Frances D'Souza[1]

The growth and nutrition of penaeid prawn larvae have been studied at the CSIRO Marine Laboratory for the last 20 years, initially from an ecological perspective but more recently to service the needs of aquaculture. The approaches that have been used are outlined in this paper; their application to other planktonic animals used as live prey for fish larviculture, particularly *Artemia*, copepods and rotifers, is discussed.

Optimising growth of prawn larvae

The Larvatron, funded by FRDC in 1985, was built as a fully automated apparatus for culturing larvae and zooplankton (Figure 5.1). With the ability to maintain up to 200 one-litre culture vessels in a small area, it reduces costs of labour, equipment and space. In each vessel, conditions such as salinity, temperature and algal cell density are monitored every 2 h and adjusted automatically to their pre-set levels through exchange of 10% of the culture volume. Continual cycling of the vessels around the track ensures uniform light and temperature conditions and avoids positional effects that can occur with bench culture systems.

The Larvatron is ideally suited to factorial experiments because of the large number of treatments and high replication afforded. The salinity and/or temperature tolerance of *Penaeus semisulcatus* larvae is one example of a factorial experiment performed with the Larvatron (Jackson and Burford, unpubl.) (Figure 5.2). Five salinities and five temperatures were assessed with four replicate cultures for each salinity–temperature combination. The hydrological tolerances of new species of copepods could be quickly determined with the Larvatron. Similarly, the factors affecting resting egg production in rotifers and copepods could be defined.

[1] CSIRO Marine Research. (See details in appendix.)

The Larvatron adapts easily as a screening tool, as demonstrated in a comparison of 20 algal diets fed to *P. monodon* larvae (D'Souza *et al.*, in press) (Figure 5.3). Five species of algae, fed as two forms (live or concentrated by centrifugation) and at two densities, were assessed with five replicates for each treatment. Finding the best algal diet for growth of new copepod, rotifer and *Artemia* strains or species could be simplified and made more rigorous with the Larvatron.

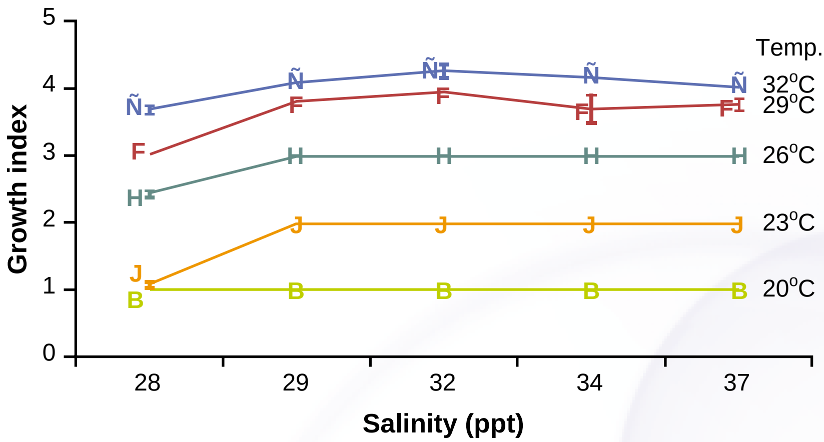

Figure 5.2. *Temperature and salinity tolerance of* Penaeus semisulcatus *larvae.*

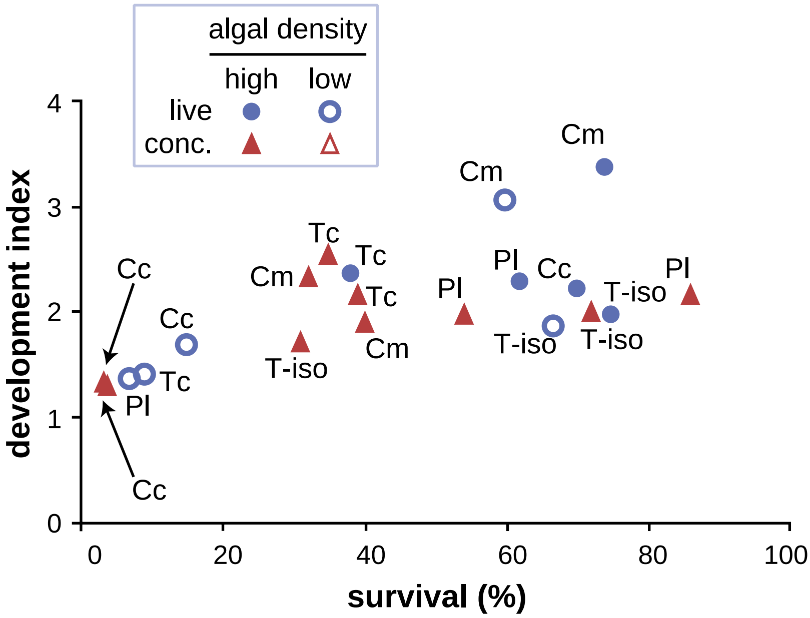

Figure 5.3. Effect of algal diet (live or concentrate) fed at different densities (high = 100 000, low = 50 000 cells per millilitre) on growth and survival of Penaeus monodon *larvae. Cm =* Chaetoceros muelleri*; Cc =* C. calcitrans*; Pl =* Pavlova lutheri*; T-ISO = Tahitian* Isochrysis *sp.; Tc =* Tetraselmis chuii.

Nutritional requirements of prawn larvae

A lack of defined formulated diets has meant that the nutritional requirements of prawn larvae have been studied largely by manipulating their natural diet of microalgae as well as by feeding microencapsulated nutrients. Live prey species also rely on microalgae. Thus the nutritional composition, enrichment and requirements of live prey organisms can also be examined using the following techniques.

1. **Mixed algal diets**
   Mixed algal diets promoted faster growth and higher survival of prawn larvae than did single algal diets (D'Souza and Loneragan, 1999). The nutritional compositions of the algae and the prawn larvae were determined to identify nutritional components essential or growth-promoting for the larvae. Arachidonic acid (20:4*n*-6) was identified as a possible growth promoter.

2. **Altering algal nutritional composition**

   By growing an alga in a nitrogen-deficient medium it is possible to increase its carbohydrate content three-fold and to reduce the *n*-3:*n*-6 fatty acid ratio by half (D'Souza and Kelly, 2000). The effect of feeding an alga grown in this manner on the growth and biochemical composition of prawn larvae has been studied. The high-carbohydrate, low-*n*3:*n*6 ratio alga did not affect survival but arrested development of the prawn larvae.

3. **Nutrient depletion studies**

   The changes in content of lipid, protein, carbohydrate and individual fatty acids of prawn larvae occurring during feeding and starvation have been used as a qualitative means of determining nutrient requirements (D'Souza, 1998). Nutrients that are conserved during starvation are considered more important to the animal than those that are metabolised. For example, when prawn larvae were starved over a 42-h period, eicosapentaenoic acid was conserved whereas linolenic acid was rapidly depleted within 12 h (Figure 5.4). In the absence of defined, formulated diets for fish larvae, the nutrient depletion technique would be a valuable tool for determining their nutritional requirements.

4. **Isotope-labelling of microalgae**

   The transfer of nutrients across trophic levels can be followed by feeding labelled microalgae to prawn larvae. Specific nutrients in the alga, such as fatty acids, can be enriched with natural or radioactive isotopes. In this way it is possible to determine the origin of individual fatty acids: whether they were synthesised or modified by the larvae, directly taken up from the algal diet or whether they originated from a maternal source through the egg yolk.

5. **Microencapsulation**

   Lipid has been encapsulated in gelatine–acacia microcapsules with the intention of examining the influence of encapsulated lipid on the growth of prawn larvae (D'Souza, Guest and Southgate, unpubl.). It is possible to encapsulate individual fatty acids to examine their role in larval metabolism.

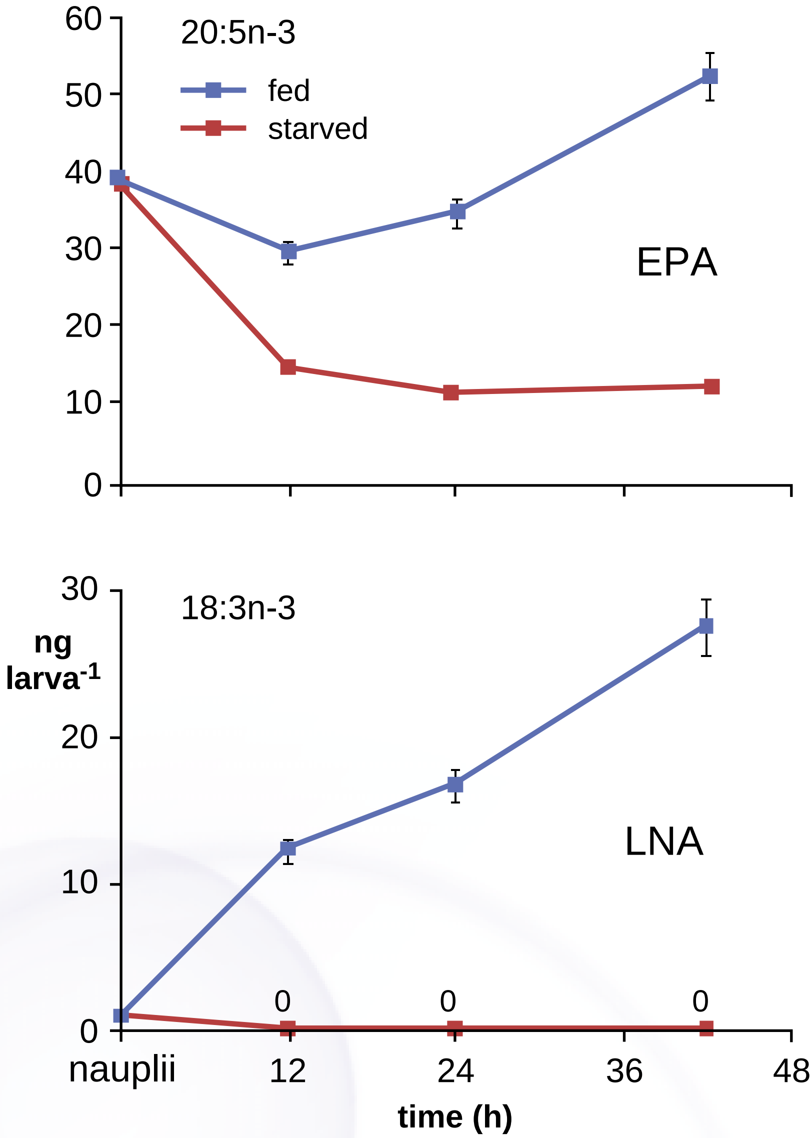

Figure 5.4. *Changes in fatty acid content in fed and starved* Penaeus *spp. larvae.*

Conclusion

Penaeid prawn larvae share aspects of their biology with live prey species for fish larvae. Thus, the techniques and equipment such as the Larvatron, developed for studying prawn larvae nutrition and growth, can easily be adapted for studies with *Artemia,* copepods and rotifers. The finfish aquaculture industry can greatly benefit from the knowledge and expertise gained from prawn larvae research.

References

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