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Hatchery research sheds light on problems in sea cucumber aquaculture

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Hatchery research on the reproductive biology and culture of *Stichopus mollis* has given great insight into some of the problems facing the sea cucumber aquaculture industry. During four months of the reproductive season, some 60 or more spawning trials were conducted, and 300 dissections and 300 biopsies performed. Morphometric measurements were made on 5000 larvae spread across eight replicated experiments. A number of bulk rearing trials of 30,000 to 50,000 larvae each were conducted.

Reproductive behaviour and spawning

Considerable problems in developing hatchery technology for sea cucumbers have stemmed from the fact that it is difficult to control reproduction. A semi-lunar rhythm of reproduction and spawning was found for *Stichopus mollis* over a four-month period, both in a wild population and in captivity. This coincided with the gonad index (body wall weight to gonad weight ratio), which fluctuated depending on when spawning events occurred. Asynchrony between males and females also occurred with the gonad index of one sex often peaking before the other sex every few weeks. However, gonad index was not an accurate reflection of spawning condition.

Animals were collected from the wild every two weeks and held under controlled conditions in the laboratory. In captivity, spawning trials were always conducted at dusk as this was when their natural spawning behaviour occurred. Broodstock were always kept for two weeks, similar to the semi-lunar rhythm of gonad index and reproductive condition occurring in natural populations. Spawning also occurred naturally and with a predictable rhythm in broodstock holding tanks and lasted approximately 45 minutes.

Three spawning trials a week were conducted to determine the pattern of spawning in relation to the lunar cycle. During a trial in which animals spawned the synchrony of spawning was increased to greater than 80 per cent by placing animals in a temperature shock bath about 3–5°C above ambient. Individuals of both sexes often spawned across several days. Some asynchrony in spawning was observed as males often spawned in the days preceding a major spawning event, as did females on occasion.

Reproductive condition and gamete viability

Dissections and wet mounts of gonad tissue under microscopic examination indicated that the reproductive condition of broodstock was similar to that of natural populations. Under macroscopic examination, ripe male gonad often contained a visible lumen as did the female gonad.

Another problem facing the industry is that in a lot of cases the use of temperature shock does not induce large numbers of individuals to spawn. To investigate why this may occur, all individuals collected every two weeks from the wild for spawning trials were biopsied (a strand of gonad was extracted using a hypodermic needle and syringe) and the gonad tissue samples examined microscopically to compare differences in sperm and egg quality between spawners and non-spawners. A section of gonad tissue was also stored for later histological examination.

The index of sperm quality provided an accurate tool for assessing readiness to spawn. Predicting the readiness of females to spawn was more of a problem. With no differences in egg size and often

no difference in the distribution in egg size between spawners and non-spawners, it proved difficult to determine which females would spawn. A bioassay has been developed that may assist in determining the processes occurring prior to a spawning event that are related to ovulation and germinal vesicle breakdown in the oocyte. This will help determine which females are more likely to spawn.

The number of spawned eggs, hatch rate, time of season and the number of competent larvae developing to the feeding stage were all indicators of the quality of larvae spawned from each female. Fertilisation rate (controlled by the researcher) was usually 100 per cent and was not an indicator of larval quality.

Larval development and settlement

Larvae grew and survived through to settlement on fairly low concentrations of algae (600–3000 cells / ml / day). This was in both replicated experiments in 1-litre jars and bulk rearing trials in 100-litre tanks.

The proportion of larvae metamorphosing and settling in jar experiments was variable across different feeding regimes. Overfeeding and starvation had similar effects on larval quality and the ability of larvae to complete the larval cycle.

In bulk tanks, larvae (30,000 to 50,000) were fed 2000 cells / ml / day resulting in about 30 per cent survival through to metamorphosis with 15 to 20 per cent of these completing the transition to the pentacular stage.

Maternal effects on larvae were found throughout development in jar experiments. Egg quality effected larval lifespan, growth, survival and the proportion of larvae metamorphosing. There may be a relationship between maternal origin and the number and size of lipid spheres appearing in the larval arms prior to metamorphosis.

Larval quality and transition to subsequent stages of development was best assessed by measuring elongation of the left somatocoel, number and shape of lateral arms (looping of the ciliated band), growth in total length and the time of appearance and number of lipid spheres.

Conclusions

Two simple conclusions can be stated that directly benefit this industry:

- Always keep individual broodstock separate when spawning them
- Do not overfeed larvae

Never before has such an intensive study of inter-individual variation in reproduction of a single population of sea cucumbers both in the wild and in captivity been undertaken. The results obtained have important implications for both the sea cucumber aquaculture industry and further understanding the life history of aspidochirote sea cucumbers and echinoderms in general.

The processes that occur and contribute to spawning success and the reproductive cycle in populations of sea cucumbers have, until now, been little understood and limited to the study of whole populations and life history theory applied at the level of the population. Understanding the processes and the variation occurring at the level of the individual will greatly expand our knowledge of echinoderm life history.

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