

Novel Device and Method for Fast Water Change in the Hatchery Culture of Pacific Oyster Larvae

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During the hatchery culture process of Pacific oyster larvae, larval metabolites and the accumulation of dead larvae and microalgae contribute to an increase in the organic content of the water, leading to the proliferation of bacteria and deterioration in water quality. Frequent seawater changes are therefore necessary for the successful hatchery culture of oyster larvae. In order to shorten the time taken for water changes and to decrease larval loss and mortality, we designed a method for fast water change by manufacturing a new, specialized device. One large cage was split into six areas with six sieves that could be used to change water synchronously. Two operators coordinated the transport of two sieves of larvae to the new pond while keeping the remaining four sieves filtering. We also investigated the advantages of the new method by comparing it with two traditional methods of changing water. It was found that the new method has the higher efficiency and higher larva recovery rate than the two traditional methods. This new device and operation process have great application prospects in hatchery culture of Pacific oyster larvae.

Key Words: *Crassostrea gigas*, fast water change, new device, hatchery culture, Pacific oyster larvae

INTRODUCTION

Hatchery culture has been widely used since the 1960s for the successful production of various bivalve larvae (Helm et al. 2004). Several decades of continuous technological improvements have seen increased survival rates (Castagna 1975; Chen et al. 2011; Guo, 2004; Lind et al. 2009), which has allowed the expansion of the mollusc culture industry. Even though the global output is very large, the unit value of output is low, and breeding efficiency is not optimized (Lipton et al. 1992). The quality and quantity of larvae determine the level of production (Dao et al. 1996). Therefore, a key issue is to enhance hatchery efficiency and reduce the unnecessary waste of larvae. When larvae are reared in ponds for a long period of time without water changes, the metabolites of the larvae and the accumulation of dead larvae and microalgae can lead to the proliferation of bacteria and deterioration of water quality (Blogoslawski et al. 1978). This results in the decline of larval quality and even large-scale mortality (Robert et al. 1996). Thus, timely water change is essential for the successful hatchery culture of mollusc larvae.

Currently, mollusc hatcheries usually change water using a single cage. It is a simple design, however, time is wasted because it demands that one person continuously handles a single cage. Errors can occur using this method due to fatigue as a result of handling the sieve for a long time, such as the sieve slipping out of the operators' hand and the larvae escaping. In addition, long time filtering will result in the sieve becoming clogged by various impurities, which reduces the efficiency of the water exchange. Larvae can also get crushed together as they pass through the mesh, leading to injury or even death.

In this study, we designed a method for fast water change by manufacturing a new, specialized device. Specifically, one large cage was split into six areas with six sieves that could be used to change water synchronously. Two operators coordinated the transport of two sieves of larvae to the new pond while keeping the remaining four sieves filtering. This new device is as simple as the traditional method, however, it was designed to shorten the time taken for the water change and to reduce the human resources and labor intensity. Low labor intensity was expected to reduce larval loss caused by fatigue. Regularly switching sieves in the new method was undertaken to keep the surface of the sieves

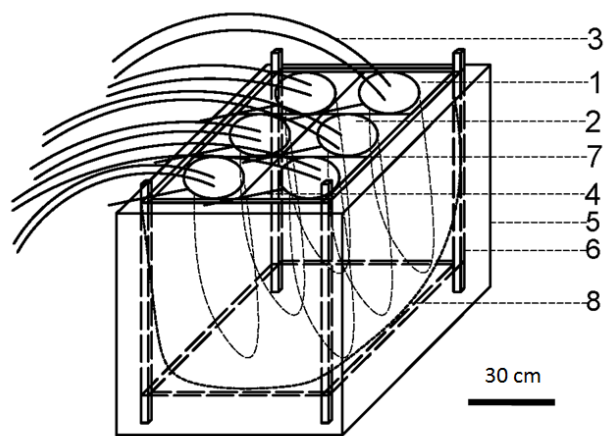


Fig. 1. A schematic diagram of the new fast water change device, consisting of the small areas (1); small sieve bags (2); hoses (3); small sieve handles (4); buffer water tank (5); wooden frame (6); metal wire with plastic wrap (7) and the big sieve bag (8).

clean, preventing larvae from mechanical damage, with the aim of increasing both the recovery rate of the larvae and the speed of water change. We investigated the advantages of the new method by comparing it with two traditional methods of changing water.

MATERIALS AND METHODS

Experimental Ponds, Larvae and Equipment

There were three experimental groups, each consisting of one 'old' pond and one 'new' pond. The 'old' ponds were those requiring water change in which there were Pacific oyster larvae with average shell height of 120 μm and the 'new' ponds were those with fresh seawater. The 'old' ponds had the larvae density of 20 individuals per cm³ and the seawater volume of 20 m³. The 'new' ponds had the same volume of seawater without larva. Two operators were assigned to each pair of ponds. Three methods of water change were carried out at the same time and did not interfere with each other. Standard equipment, including 300 mesh sieves, wooden frames, water tanks, buckets, hoses, bailers, timers etc. were prepared. Three replicates were designed.

Traditional Water Change Method 1

In this method, operators A and B did not interfere with each other, nor cooperate. They each sat on the flat of the drain and held a bucket, containing a sieve bag, with

both hands. Each operator siphoned water from the old pond through a hose into the sieve bag. The hose was pulled out from the water in the old pond every 30 min and the larvae in the sieve bag were flushed into the new pond. This was repeated until the water surface of the old pond was reduced to the surface of the drainage ditch. The two operators then went down to the drain and repeated the water change procedure until the water surface of the old pond was approximately 5 cm away from the pond bottom. The process was timed. Three replicates were designed.

Traditional Water Change Method 2

In this method, operators A and B also did not interfere with each other, nor cooperate. They put two cages tied with sieve bags into the old pond and put one hose into each sieve bag. The operators then used the siphon method to drain off seawater from the old pond. While the water was filtering through the sieve bags, the operators agitated the wooden frames of the cages to prevent excessive larvae accumulating on the surface of the sieves and resulting in damage and mortality. The operators continued until approximately half of the water in the old pond had been drained, and the larvae were highly concentrated in the remaining pond water. They then shook the frames three times and removed them from the pond. The operators then both went down to the drain and put hoses into the sieve bags in buckets, and changed the water by the siphon method as per traditional method 1. The process was timed. Three replicates were designed.

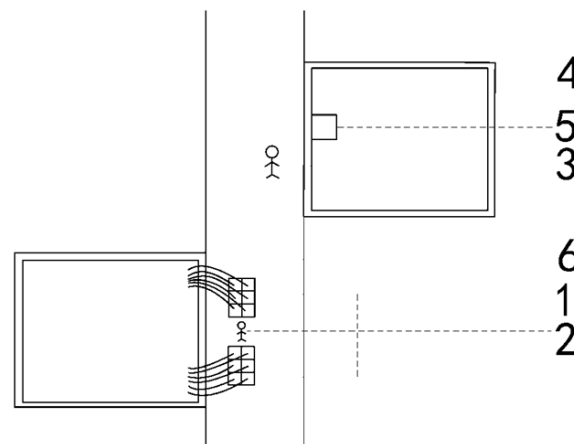


Fig. 2. Flow chart of the water change method, consisting of the new water change device (1); operator A (2); operator B (3); the new pond (4); buoyancy cage with a sieve (5) and the old pond (6).

Larva Recovery Rate

We sampled 4 mL of water at four corners of the 'old' ponds before water change and at four corners of the 'new' ponds after water change, respectively, and the larva number in each 4 mL of water was decided under microscope. Then, the larva recovery rates of the three methods were obtained by calculating the ratios of the average larva numbers of before and after water change. Three replicates were designed.

Statistical Analysis

The differences in time of water change and larva recovery rate among three kinds of methods were analyzed using SPSS 20.0 software (Chicago, IL, United States) with one-way variance (ANOVA) followed by Student–Newman–Keuls multiple comparisons test. Differences were considered statistically significant when $p < 0.05$.

RESULTS

The structure of the Novel Device and the Method for Fast Water Change

Firstly, the wooden frame was divided into six small square areas (0.3 m in side length) using metal wire with plastic wrap. Then, six small sieves with small handles were respectively arranged in each area. A large sieve bag surrounded the sides and the base of the wooden frame. After these additions had been made, the wooden

frame was placed inside a buffer water tank. The upper edge of the water tank was 5 cm lower than the edge of the wooden frame. Each small sieve was equipped with a hose bringing seawater from the old pond into the new system (Fig. 1). Two independent systems were made and placed in the drain near the old pond where the operators utilized siphons to move seawater from the old pond into the small sieve bags for filtration (Fig. 2). Larvae were collected in the sieve bags.

Operator A transported the small sieve bags containing larvae every 3 min to operator B who carefully washed the larvae into the new pond using water from the buoyancy sieve cage (Fig. 2). During the transport of each small sieve to the new pond, the remaining 11 small sieve bags were still filtering seawater. Larvae transportation was conducted in this way until the water surface of the old pond was approximately 5 cm away from the pond bottom. At this stage, the remaining larvae were of poor quality, so filtering was stopped and the remaining pond water including the remaining larvae was drained. The two operators then removed the big sieve bag tied to the wooden frame, turned it over in the new pond and flushed the larvae out using the water in the sieve cage. The process was timed.

Comparison of the New and Traditional Water Change Methods

Results indicated that the average time consumed in the new fast water change method was 10.6% of that in the traditional water change method 1 and 11.4% of

Table 1. Time of water change (hours) using the three methods and larva recovery rate of the three methods after water change.

Methods		New Fast Water Change Method	Traditional Water Change Method 1	Traditional Water Change Method 2
Time Used (hours)	NO. 1	1.5	15.0	13.0
	NO. 2	1.6	15.0	13.9
	NO. 3	1.6	14.4	14.4
	Mean ± SD	1.57**	14.8	13.77
Recovery Rate	NO. 1	96%	91%	92%
	NO. 2	98%	93%	94%
	NO. 3	98%	93%	95%
	Mean ± SD	97.3%	92.3%	93.7%

** denoted $P < 0.01$.

that in the traditional water change method 2 (Table 1; $P < 0.01$).

Interestingly, the larva average recovery rate was the highest (97.3%) in the new fast water change method, compared with 92.3% in the traditional water change method 1 and 93.7% in the traditional water change method 2, with the same manpower (Table 1; $P < 0.01$).

DISCUSSION

Using the two traditional methods, we observed problems with the larvae accumulating on the surface of the sieves, along with organic matter and other impurities, and clogging the mesh. The larvae were crushed against each other as a result of this crowding, leading to injury and even death. The new fast water change method involved transferring larvae every 3 min, in comparison with the 30 min used in the traditional methods, and thus overcame this issue of the filter clogging, and decreased the larva death rate and increased the efficiency of water change. With the traditional methods, if the frequency of larval transfers to the new pond were to be increased, operators would have to stop filtering water more often, which would increase the total time taken to conduct the water change. Additionally, if the number of sieves was increased, there would need to be more operators, further reducing efficiency. The new fast water change method using the specialized device we designed has been shown in this study to overcome these shortcomings.

In addition, the two traditional methods were highly labor intensive. Operators were required to handle the sieves continuously in order to prevent the surface of the sieve going under the water surface of the bucket and consequently losing larvae. However, in the new water change device, the small areas where the small sieves were positioned were always above the top edge of the buffer water tank, so there was no need to continuously handle the sieves, thus largely reducing labor intensity, which has the potential to reduce larval loss caused by human error.

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