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Mass culture of A*rtemia franciscana*: An art of technology perfection

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ABSTRACT

Mass production of *Artemia franciscana* through batch culture system revealed high hatching rate and percentage efficiency from Utah than with California strains cysts. Observations showed significant growth in terms of length weight and culture period with rice bran-malt combination in comparison to rice bran alone fed *A. franciscana*. An Air Water Lift System (AWL) replaced the traditional method in removing the debris from the culture tank. An ideal stocking density of 5000 nauplii L^{-1} yielded 6Kg of *A. franciscana* 3500 L^{-1} $week^{-1}$. The cost benefit analysis on *A. franciscana* revealed an attractive profit of US $ 637.47/11 months.

Key words: *Artemia franciscana*; mass production, raceway system.

INTRODUCTION

The various stages of *A. franciscana* constitute an ideal live-feed for shrimp, food fish larvae and ornamental fish that can handle a 0.5 mm size prey[1-2]. The development of *A. franciscana* from larval to adult stages takes 15-17 molts in around two weeks[3]. The adult female *A. franciscana* showed viviparous and oviparous condition at 20-25 ‰ and >40 ‰ salinities respectively. In high salinities, the eggs entered dormancy period and remained as cysts within the brood pouch of the adult females. Cysts were collected from the salt pans or produced under captivity. On hydration, these cysts produced nauplii. In commercial fish farms and shrimp hatcheries, these cysts are de-capsulated to feed fishes and shrimps. Earlier studies[4-5] described the process of hatching and culturing *Artemia sp.* on large scale under controlled environmental conditions. Earlier investigations revealed the optimum photoperiod and temperature on reproduction of brine shrimp[6]. Investigations[7-11] reported the utility of different feed to enhance growth of *Artemia sp*. However, the above studies showed *Artemia sp* yield with high expenditure. Therefore, based on the above findings, the present study perfected mass production of *A. franciscana* using (1) combination of rice bran and malt (Pearl millet powder) as feed at low cost budget, (2) AWL system for effective removal of debris from the culture tank and (3) economics worked out to determine the feasibility of *A. franciscana* culture under mass production.

MATERIALS AND METHODS

A cement tank of 5000 L (Fig.1) was constructed with Air Water Lift System (AWL)-Raceway type by following the designs[4]. The tank was filled with 3.5m^3 of seawater. The tank was undisturbed for 24-36 h to allow insoluble particles at the bottom of the tank and the debris removed by AWL system. Salinity was maintained at 36-37‰. Following the methodology[12], the hatching rate, percentage and efficiency were determined for Utah and California *A. franciscana* cysts before they were cultured. Following earlier techniques, cysts were hatched and separated[5].

Based on the above studies, the nauplii were stocked at different densities, (1200, 2500, 3000 and 5000 numbers L^{-1}) in the culture tank to determine the feasible stocking density and quantity of cysts required for mass production.

Micronized rice bran (20-40 µm) from 80 g to 480 g (wet weight) was fed to nauplii, metanauplii, pre-adult and adult stages in the tank respectively.

In another experiment, rice bran and malt (Pearl millet powder) combination in the ratio of 2:1 was used (40:20 g). This feed was mixed in seawater and allowed to settle for 30-45 min. The supernatant water was discarded and the residue dissolved and fed to the *A. franciscana* nauplii using a 50-µm mesh size net. The quantity of feed was gradually increased to 80:40 g as nauplii grew to adult. Variables, such as pH, temperature, light and salinity were maintained at 8.0, 30°C, 1000 lux and 36-37 ‰ respectively.

In the present study, a modified procedure using Air Water Lift system (AWL) for efficient removal of the debris from the culture tank (Fig. 2) replaced the plate separator and filter screen[4].

The biomass of *A. franciscana* was periodically determined by calculating the wet weight of *A. franciscana* L^{-1} of medium and computed to the total volume of medium in the tank[3]. *A. franciscana* adults (10-15%) were partially harvested once in two weeks to prevent excess stocking density and also to supplement as feed for shrimps and aquarium fishes.

RESULTS

The qualitative analysis of cysts revealed the hatching efficiency, rate and percentage in California and Utah strains to be 65,000 nauplii g^{-1} of cysts, 33-36 h, 69.56 % @ 250 mg cysts and 83,200 nauplii g^{-1} of cysts, 24-30 h, 82.35% @ 250 mg cysts respectively (Table 1). The quantity of cysts required to stock 1200, 2500, 3000 and 5000 nauplii l^{-1} was 64.6 g, 134.6 g, 161.5 g and 269.2 g respectively. Table 2 represents the various stocking density that yields biomass in net weight of *A. franciscana* adults $week^{-1}$. An average length

Table - 1: Hatching efficiency, rate and percentage of California and Utah strain cysts of *A. franciscana*

Hatching Efficiency

Cysts	Average No. of nauplii	HE = No. of nauplii g^{-1} cysts
California	40	65,000
Utah	52	83,200

Hatching Rate

Cysts	Mean No. of cysts	Mean nauplii counted at3 h incubation (hours) 18	21	24	27	30	33	36	Total No. of nauplii hatched	Un-viable cysts
California	20	-	-	2	2	4	4	6	18	2
Utah	20	1	2	5	5	5	-	-	18	2

Hatching Percentage

Cysts	Cysts (mg)	No. of hatched nauplii	No. of un-hatched cysts	Hatching % = No. of hatched nauplii/ Total No. of nauplii X 100
California	250	112	49	69.56
Utah	250	140	30	82.35

and weight of 19 mm and 5.0 mg in 28 d in adult *A. franciscana* was observed when rice bran-malt combination was used. However, the average length and weight was found to be 15 mm and 2.6 mg in 36 d respectively in rice bran alone fed *A. franciscana*. The quantity of 80-480 g was required when rice bran alone as feed. In rice bran-malt combination, the quantity of 20 g: 40 g-40 g: 80 g was found sufficient for the growth of *A. franciscana*. Statistical test by ANOVA revealed significant differences between the two feeds and growth in terms of weight (mg) of *A. franciscana* (Table 3). Mortality was 0.1% in rice bran-malt fed *A. franciscana* when compared to 3 % mortality in rice bran fed *A. franciscana*.

Biomass calculation yielded 6 Kg of *Artemia* week^{-1} @ 5000 nauplii L^{-1} stocking density. The cost benefit analysis on mass culture of *A. franciscana* revealed US $ 637.47 for a capital and a recurring expenditure of US $ 916.0 and US $ 132/11 months respectively (Table 4). A month's lean period was calculated for shut down period.

Table - 2: Stocking densities and biomass production of *A. franciscana* in the present study and references

S.D Nauplii l^{-1}	Wet weight (Kg)/ L^{-1} week^{-1}	Wet weight (Kg)/ L^{-1} week^{-1}	References (g/Kg^{-1} L^{-1}/ d^{-1})
1200	0.42	1.5	present study
2500	0.88	3.1	present study
3000	1.14	4.0	present study
5000	1.71	6.0	present study
10000	-	-	15.72g/15days[a]
4000	-	-	45g/55 days [b]
3000	-	-	4Kg/20 days [c]

[a]: Maldonado and Rodriquez (2005), [b]: Maldonado et al. (2003),
[c]:Zmora and Shpigel (2006)

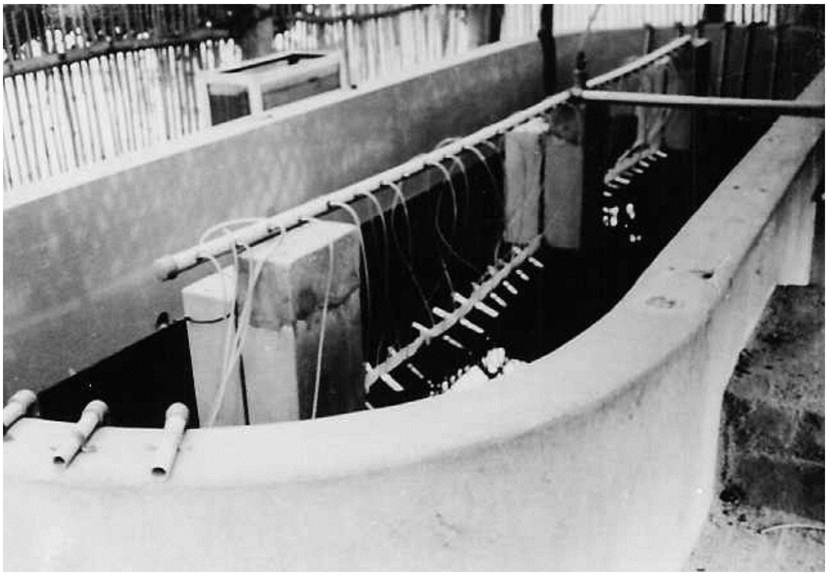

Fig. -1: *Artemia franciscana* in raceway system culture tank

Table - 3: ANOVA between growth of *A. franciscana* and two feed (rice bran and rice bran-malt combination)

	df	SS	F
Regression	1	14.4200997	560.8653*
Residual	26	0.668471728	
Total	27	15.08857143	

Df: degree of freedom, SS: Sum of squares,
F: F table value =4.21, * : significant

Table - 4: Cost benefit analysis on mass culture of *Artemisia franciscana*

I	**Capital Investment**	US $
1.	Construction of tank	185.00
2.	Cost of acrylic plates with AWL system	70.00
3.	Blowers (0.5HP-2 Nos.) & accessories	575.00
4.	Temporary shed (thatched roof)	70.00
5.	Cysts (269.2 Kg)	7.00
6.	Salinity refractometer	9.00
	Total Investment	**916.00**
II.	**Recurring Expenditure**	
1.	Power consumption	10.00
2.	Feed: rice bran (1.62 Kg), Malt (0.81Kg)	0.18
3.	Miscellaneous	2.79
4.	Recurring investment /month	12.00
5.	Recurring investment /11months	**132.00**
III.	**Interest**	
	@ 13% per annum I+ II (Capital investment + Recurring expenditure) ($1048)	136.24
IV.	**Revenue**	
	@ 5000 nauplii l^{-1}@ $ 3.43 Kg^{-1} wet weight of *A. franciscana*@ 24 Kg/month, for 11 months	905.71
V.	**Cost benefit analysis**	
	Revenue- (Recurring expenditure + interest/year) on loan component of US $ 1048	**637.47**

DISCUSSION

Utah strain was preferred over California strain cysts for the mass production of *A. franciscana* due to high hatching efficiency, hatching rate and hatching percentage (Table 1). Among the four stocking densities, observation showed the stocking density of 5000 nauplii l^{-1} yielding biomass of 6 Kg of *A. franciscana* $week^{-1}$, enterprising for mass production since, low or very high stocking density increased the cost of production or mortality of the *A. franciscana* adults respectively (Table 2).

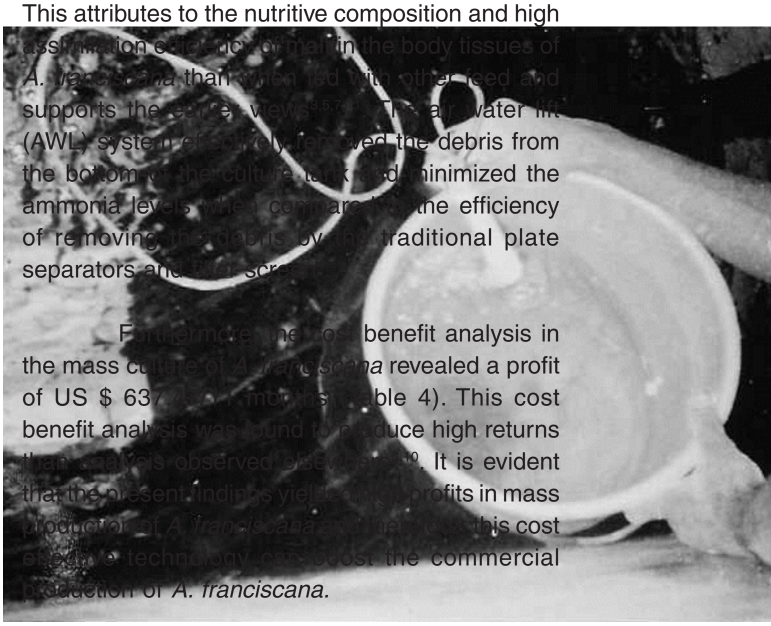

Fig. - 2: Air Water Lift System (AWL) removing debris from the culture tank

This biomass yield was higher than the biomass reported earlier[9]. Significant growth of *A. franciscana* (in terms of average length, weight and number of days to develop from nauplii to adult) was observed when rice bran-malt combination was used as feed than with *A. franciscana* fed with rice bran alone. This may attribute to the high protein composition in malt (27-32 %) than with rice bran (12-20 %) and support the earlier investigations[7, 11]. In the mass culture, more quantity of rice bran as feed was required for their growth (80-480 g) while lesser quantity (20g:40 g - 40 g:80 g) of feed was sufficient when rice bran-malt combination was provided to attain high biomass. This biomass using rice bran-malt combination was also found high when compared to the biomass with other feed, reported in the earlier studies[5,9-10]. Statistical test by ANOVA revealed significant differences between the two feeds and their respective growth by weight of *A. franciscana* (Table 3).

Further, reinvestigations on the earlier studies[8-9] revealed a characteristic odor to emanate from the culture tank with rice bran in single or fertilizer fed brine shrimps. In the present study, rice bran-malt combination cultured *A. franciscana* emanated no such odor. Earlier studies[8, 12] revealed high mortality rates with other feed fed *A. franciscana* than with rice bran-malt combination. This attributes to the nutritive composition and high assimilation efficiency of malt in the body tissues of *A. franciscana* than when fed with other feed and supports the earlier views[3,5,7,11]. The air water lift (AWL) system effectively removed the debris from the bottom of the culture tank and minimized the ammonia levels when compared to the efficiency of removing the debris by the traditional plate separators and filter screen.

Furthermore, the cost benefit analysis in the mass culture of *A. franciscana* revealed a profit of US $ 637.4 / 11 months (Table 4). This cost benefit analysis was found to produce high returns than analysis observed elsewhere[2,10]. It is evident that the present findings yielded high profits in mass production of *A. franciscana* and therefore, this cost effective technology can boost the commercial production of *A. franciscana.*

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