THE BRINE SHRIMP
(*Artemia salina* Leach)

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The exploitation of naturally occuring artemia cysts was started in San Francisco Bay, California in the 1930's when Seale and Rollefsen identified it as an excellent food for fish fry. Later, artemia cysts were discovered in the Great Salt Lake in Utah and in Lake Champlin, Saskatchewan, Canada. The cysts were collected from the shores of salt lakes, dried and vacuum packed. The cysts remained viable for as long as 15 years (Bowen 1937). Bardach, et al. (1972), and Goodwin (1976) state that newly hatched artemia nauplii constitute not only the best but in most cases the only available source of live food for the earliest stages of most cultured species of fish and crustacean. Botsford (1974) also stated that older larvae and adult brine shrimps still assure the best results for culturing fish and crustaceans. Today, actual demand for artemia cysts has exceeded available supply. Over 50 tons of dry cysts are consumed yearly in aquaculture business (hatcheries), the aquarium industry, and in research program which use artemia as test organisms (Sorgeloos, et al., 1976). This product is not readily available in the Philippines and is a great constraint to hatchery operations which is just beginning in the local aquaculture industry.

The great need for this natural food has compelled the writer to try production on pilot scale in manmade salterns preparatory to commercial scale production.

Literature Review

Artemia salina Leach is a lower crustacean of 1-2 cm long which is found in nature in salt lakes and brine ponds. It belongs to the Sub-Class Branchiopoda, Order Anostraca, Family Artemiidae. In 1758, Linneaus made the first scientific description of the animal which he called "Cancer Salinus". In 1910, Daday reclassified the different salt water artemia into one single polytypic species, the Artemia salina (Linneaus 1758) Leach (1812). Today, there are more than 50 known strains found in various places in the world. Sorgeloos, et al., have started to make comparative analysis of the different strains by certain parameters, such as (a) volume of cysts harvested from the natural habitat, (b) fatty acid composition of the cysts, (c) survival of young nauplii at different temperature-salinity combinations, (d) general ecological characteristics of the population, and (e) nutritional value of the first instar or nauplii as food for fish and crustacean larvae. Of the 14 strains so far studied as to chorion thickness of the cysts, the Australian Strain has the thinnest (4.1 u), followed by the San Francisco Bay Strain (4.4 u).

The following table, made after Sorgeelos, et al. show that varying thicknesses of the chorion of the 14 strains.

Source	Thickness
Australia (unknown locality)	4.1 u
San Francisco Bay, California (wild)	4.4 u
Great Salt Lake, Utah	5.1 u
Site, France	5.2 u
Cadiz, Spain	5.3 u
Cadiz, Spain	6.7 u
San Francisco Bay (laboratory produced)	6.8 u
Palko Strain, India	7.5 u
Lake Champlin, Canada	9.4 u
Great Inagua, Bahamas	11.2 u
Tsingtao, People's Republic of China	11.6 u
Araya, Venezuela	12.0 u
Lake Champlin, Canada	13.9 u
Burgos-Pormorije, Bulgaria	15.3 u

This table is made to show the different thicknesses of the 14 strains to serve as guide in the decapsulation procedure which may call for different levels of concentration of the oxidizing agent and for different time frames to dissolve the chorion.

Sorgeloos, et al. state that so far no correlation in the thickness of the chorion to diameter size could be established. Differences in fatty acid contents, except for strains from great Inagua and Australia which were found negative, are more quantitative than qualitative (1975).

Morphology

The inactive dry cysts or "Daueriern" of Artemia salina remain in diapause as long as they are kept dry or under anaerobic conditions. Upon immersion in seawater, the cysts hydrate or absorb water and expand to spherical form. In the dehydrated state, the cysts appear like dented pingpong balls. Within the shell, metabolism starts. A number of hours later, the outer membrane bursts and the embryo appears (breaking stage) surrounded by the hatching membrane. The only features that may be seen are the nauplius eye (ocellus), a pair of antennae, a pair of antennulae, and an oval shaped body. The embryo gets out of the hatching membrane after a few hours.

Inside the hatching memberane, the newly differentiated antennae and mandible starts moving and, within a short period, the hatching memberane is ruptured and the free swimming nauplius is born. This is the first instar larva, colored brownish orange due to the presence of yolk. It has three pairs of appendages: the antennae which have

locomotory functions, the sensorial antennullae, and the rudimentary mandibles. A single red ocellus is located in the head region between the antennullae. The ventral side of the animal is covered by a large labrum.

The larva grows and differentiates through about 15 molts. The trunk and abdomen elongate; the digestive tract becomes functional; food particles are collected by the setae of the antennae; paired lobular appendages which will become thoracopods are budding in the trunk region; and the lateral complex eyes are developing on both sides of the ocellus.

From the 10th instar, the antennae lose their locomotory function and their long setae, bend forward to the head and undergo sexual differentation. All the eleven pairs of thoracopods had developed. In the males, the antennae develop into hooked graspers while in females, they become sensorial appendages. The thoracopods are now differentiated into three functional parts: the telopodites act as filters; the oar-like endopodites with long setae having locomotory activity; and the membraneous exopodites function as gills.

After 14-15 days from incubation, the 8-10 mm long adult is characterized by stalked lateral complex eyes, the sensorial antennullae, the linear digestive tract, and eleven (11) pairs of thoracopods. In the male, the antennae develop into musculated graspers with sensorial papilla at the inner sides; in the posterior part of the trunk, a paired penis develop. The female has primitive antennae with sonsorial functions and paired ovaries situated on both sides of the digestive tract behind the thoracopods. The ripe oocytes are transported from the ovaries into the unpaired brood pouch or uterus via the two oviducts (Sorgeloos et al., 1975).

The Reproductive Cycle

Precopulation is started by the male grasping the female with its antennae between the uterus and last pair of thoracopods. In this "riding" position, the couples swim around for 3-4 days. Copulation is a very fast reflex action, the male abdomen bends forward and one penis, which has become elongated to 10 times its original size, is introduced into the uterus opening. Bowen (1937) states that all offsprings in one brood have only one genotype and cross-breeding of different strains is not possible. The reproductive system of the female consists of 2 ovaries, 2 pouchlike oviducts, and a ventral median uterus.

Within the 24-48 hour period, the following happens: the female expels from the uterus the first generation as either virgin eggs or nauplii. The birth process takes from 2-10 hours. They remain there for 1-40 hours, whether copulation occurs or not. They then pass into

the uterus, the process taking less than 30 minutes. The eggs remain in the uterus for 3-5 days whether fertilized or not. The cycle is completed in 4-6 days. It must be noted that the female does not store sperm. Although the adults clasp continuously, fertilization is only effective when the eggs are in the oviducts.

The fertilized eggs develop into either free swimming nauplii which are set free by the mother. Or, when they reach the gastrula stage and dissolved oxygen level in water is low (salinity 90 plus ppt), the eggs are surrounded by a thick shell and deposited as cysts. Production of nauplii or cysts is dependent on oxygen level or when chelated iron (ferric EDTA) is present (Sorgeloos et al., 1975).

Research at Christmas Island shows that more offsprings or cysts are produced when the animals are hatched and grown in tanks at 32 ppt salinity at 26.0 degrees Celsius for 7-10 days, after which salinity is increased to 90 ppt. Newly hatched nauplius weigh 0.026 mg, sexually matured adults 1.3 mg. Adults deliver live nauplii at an average of 40 per day for 6 months. (UNIHI-TR 1973).

Parameters for Maximal Hatching Efficiency of Cysts

1. Hatching rate is extremely dependent on temperature and salinity which must be kept constant (28 degrees C and 28-32 ppt).

2. The cysts must be kept in suspension in oxygen-saturated seawater.

3. Shortly after hydration, the cysts must be illuminated for a specific time and lux generally one hour by a 40 watt flurescent tube; the immersion of cysts in continuous darkness results in lower hatching efficiency.

4. Without decapsulation, the cysts require exposure to light for 5 minutes for the San Francisco strain and 10 minutes for the Utah strain at the start of hydration and with moderate aeration. After exposure to light, the cysts should be covered with dark cloth or immersed in darkness and vigorously aerated. No cysts should sink to the bottom of the hatching cylinder; if some do, it is indicative of weak aeration.

5. After hatching and removal of nauplii, check eggs to see if some are still at breaking stage or if the shell is still whole. Continue aerating for another 24 hours, stopping aeration periodically to remove the hatched nauplii with the aid of a light beam. The nauplii are attracted to light and will gather against the light source (Sorgeloos et al., 1975).

Decapsulation of Cysts with Chemicals

Decapsulation of Artemia salina Cysts with Chemicals

a. General Principles

The efficient hatching of artemia cysts to nauplii for use as live food for fish and crustacean larvae has been a problem due to the high cost of cysts and the differences in chorion thickness. Hatching efficiency and varying hatching time give rise to problems in the use of the material and in the removal and separation of empty shells and hatching membranes.

Dr. P. Sorgeloos and Dr. E. Bruggeman of the University of Ghent, Belgium have recommended a chemical process to remove the chorion of the cysts with the use of sodium hypochlorite as the oxidizing agent.

Test runs were made following the recommended technique and results were very successful and attained hatching percentages of 90-98 percent using the locally produced cysts of the San Francisco strain.

The values to consider are:

Ratio of cysts to active product (NaOCl) - 2 gms cysts to 1 gm active product

Volume of solution (seawater plus hypochlorite) - 200 ml to 15 gms cysts

Sodium hydroxide (NaOH) to be added to the solution - 2.5 ml of 40 percent solution to 100 ml of seawater plus hypochlorite solution (2 gms NaOH/15 gms cysts). (The NaOH solution should be prepared in advance to allow for cooling)

Technical sodium thiosulphate (or Sodium sulphite) to treat decapsulated cysts - 0.5 ml of 1 percent solution per 10 gms cysts. Keep in refrigerator in a dark bottle

b. Procedure

1. Hydrate the cysts in water (sea or tap) under strong aeration for 1 hour.

2. Stop aeration and filter the cysts on a 150-200 micron screen and wash with clean water.

3. Resuspend the cysts in a bucket or glass cylinder with measured volume of seawater + hypochlorite solution and add sodium hydroxide at measured volume.

4. Stir the suspension continously with a stick to keep the cysts in suspension. Check temperature as it will gradually rise. Add ice if temperature rises higher than 40 degrees Celsius.

5. Stir the suspension from 7-15 minutes depending on color change (from brown to light orange). Time lapse difference is due to the purity of the active oxidizing agent.

6. When decapsulation is finished, filter the cysts and wash thoroughly to remove the smell of chlorine.

7. Resuspend in seawater and add sodium thiosulphate solution at measured volume and agitate the suspension for 2-3 minutes. Decapsulated cysts will sink while lighter materials like membranes, plumes, etc., will float. Remove the foreign materials from the cysts letting water out from the top drain, or siphon cysts from the bottom of the bucket.

8. Wash the cysts with clean water and they will be ready for incubation.

9. To keep the cysts for later incubation, they should be resuspended in saturated brine (250-300 gms technical salt in 1 liter of distilled water) under a strong aeration for 3-4 hours. Then siphon off the cysts as they will float and keep in saturated brine in dark containers. Do not expose to light.

c. Test Run

Decapsulation

The test run was conducted from 22-24 December 1978. The procedures:

The chemicals are prepared and 15 gms cysts are measured. The cysts are washed in freshwater to remove salt; place in a tall glass jar with 1 liter of freshwater under strong aeration for 1 hour. The cysts are then collected in a fine mesh cloth strainer. A plastic 1-gallon container is filled with 200 ml of seawater + hypochlorite solution to which is added 7.5 ml of 40% NaOH solution. The solution is stirred to mix well and the cysts are put in. The suspension is continuously stirred for 10 minutes until the cysts change in color from dark brown to light orange. Temperature is constantly checked and should never rise higher than 35 degrees Celsius.

The cysts are filtered off and washed thoroughly under the tap with running water at a slow rate, with the strainer continuously shaken, until no smell of chlorine is noticed. The cysts are then resuspended in 200 ml seawater to which is added 0.75 ml of 1% Na_2SO_3. The suspension is stirred for minutes. The cysts are filtered off and washed with tapwater.

Incubation

One teaspoon of decapsulated cysts out the whole batch are suspended in seawater (30 ppt) and aerated vigorously. After 13 hours and 14 minutes, the suspension is checked by taking a drop and mounting it on a slide to be examined under low magnification. Some nauplii would be seen swimming and most of the cysts would have broken out of the thin membrane, looking like teardrops. Aeration is resumed, and 5 hours later, the second microscopic check would show about 50 percent hatchouts and free swimming nauplii, while the rest of the embryos would be inside their hatching membranes. In my trial, about 2 percent of the cysts did not hatch, most of which had portions of the chorion undissolved.

Eighteen hours and 12 minutes from start of the incubation, the nauplii are siphoned off the separate them from the unhatched cysts, thin membranes and other materials. The nauplii are transferred to 2 aquaria of 2 gallons and on RFG tank of 6 gallons. Seawater with 30 ppt salinity is used as culture medium. Temperature is 25 degrees Celsius and pH value is 7.5. The test run was done from December 22 up to 24, 1978.

Seawater is treated with a few drops of Ambracin (Oxytetrachline Hydrochloride) and when the color of nauplii turns from light orange to white, food in the form of bread flour, breadyest, and V-22 (vitamin-mineral additive) is given in small quantities every four hours, 4 times a day. Aeration is supplied by means of airhoses (without airstones). After one week, salinity is raised by 20 ppt every 2 days until it reachs the level of 90 ppt. The larvae, with all thoracopods fully developed but before sexual maturity, are transferred to a circular raceway where they are grown to maturity.

Food Value

Newly hatched nauplii must be fed to the predator immediately for after two molting within 24 hours, individual dry weight and caloric value decrease by 20 and 27 percent, respectively.

Adult, or older and bigger larvae of artemia that have been fed with algal diet are a highly nutritious food for fish and crustacean larvae.

The use of older larvae cultured to appropriate size has several advantages:

1. The quantity of artemia cysts is reduced as the predator would need fewer of the larger larvae.

2. Food quality of older larvae is higher than the 1st instar.

3. The predator spends less energy ingesting a specified biomass of older larvae or adults.

4. Strains of artemia whose first nauplii stages are unsuitable because of pollutants, too large to be swallowed, or do not satisfy nutritionally, can become an appropriate food for large cultured species by spreading the feeding of the nauplii over a number of days (Wickens, 1972).

5. Analysis of 24 hour old nauplii (Utah strain)
Ref: Nippon Sea Farmers Co. Ltd.

81.9% moisture
55.6% crude protein (dry weight)
18.9% crude fat (dry weight)
18.3% carbohydrates (dry weight)
7.20% ash (dry weight)

6. Composition of brine shrimp (San Francisco Strain)

Stage/age	Protein %	Fat %	Calories %	Reference
egg	52.31	26.06	--	Brick
Nauplius 2 hrs	50.21	15.92	--	"
Few Hours	42.60	23.20	66.00	Dutrieu 1960
Few Hours	--	15.09	58	Khmeleva 1968
1 day	50	27.24	58.76	Coehn
Juvenile 6 days	59.72	7.00	--	Brick
Adult 10 dyas	62.78	6.51	--	"

(UNIHI-TR, 1973)

Feeding Habits and Food Preferences

In nature, artemia grazes on single-celled algae at all stages of life. They thrive in cultures of 3,000 adults or 12,000 nauplii per liter of seawater. Maximum growth is attained at salinity level of 35 ppt with 25-30 algal cells per m^3. More females are born in broods of adults feeding on Dunaliella salina. Diatoms are not recommended as feed for artemia because their siliceous exoskeleton can not be digested. Recommended food is phytoplankton which can be grown with nitrogen and phosphorus fertilizers at the ratio of 16:1. (UNIHI-TR 1973).

Artemia is a non-selective obligate filter feeder (Barker-Jorgensen 1966). All particles neither too small nor too large (small sand grains to ciliates over 5 microns) are ingested by artemia. Digestion is most efficient when concentration of food is low. Artemia may starve when concentration of food is high as food is transformed into faeces-like pellets and excreted before they can be digested. Frequent feeding at low concentration gives the best growth results.

The animal is capable of regulating its rate of feeding in such a way that, as cell concentration increases, filtration rate maintains a constant maximum value while ingestion rate increases. When concentration reaches a value at which a constant maximum ingestion rate is attained, the filtration rate falls off. In older animals, the maximum ingestion rate is reached at a lower cell concentration. The maximum filtration is dependent on cell size, the total volume of cells ingested being the same for three species of plant cells -- chlorella, Dunaliella and Phaeodactylum. Maximum filtration rate is maintained up to $50/mm^3$ for plant cells, or alternatively, the maximum number of plant cells ingested per animal per hour is in the region of 5.5×10^5 and the maximum number of sand particles is 40×10^5.

Artemia shows no appreciable ability to discriminate between plant cells and between nutritious and non-nutritious food. Artemia kept without food do not quickly empty their guts, which may appear colored with food after two weeks of starvation, but microscopically examined, revealed the contents to be almost entirely liquid. (Reeve, 1962).

Fujinaga (1969) states that it is possible to grow 50 grams of artemia per ton of water every day. Sorgeloos (personal communication) is of the opinion that it is possible to produce 1 kilo of cysts per hectare per day with a population of 100 million adults.

Artemia is sensitive to some compounds. High concentration of CO_3 and HCO_3 are lethal to artemia (Cole and Brown 1967). Potassium greater than 100 ml/L is lethal unless the Na/K ratio is at least 10:1. O_2 should be greater than 3 ml/L (UNIHI-TR 1973).

Production of Artemia in Manmade Salterns in Iloilo

a. Initial Inoculation

After the successful results made from experimental runs of culturing artemia in water taken from the ponds of the writer, Dr. Sorgeloos, with the assistance of Mr. Einstein Laviña of SEAFDEC, suggested to inoculate artemia adults and nauplii in the concrete brine tank of the writer's salt plant as well as in his ponds. Salinity levels in the tank and in the pond were checked prior to inoculation. Salinity at the tank was 84 ppt, the earth pond 64 ppt. The initial stocking consisted of 500,000 adults and 20 million nauplii. Some 200,000 adults were stocked in the earth pond of 4.5 hectares. The rest were placed in the tank. Not being sure of existence of predators (Tilapia, gobies, and poecilia), the animals were placed in an enclosure of fine mesh nylon nets of about 50 square meters area and provided with a bamboo trellis on top where coconut branches were spread to act as sun shade. The water depth was 45 cms. The water depth in the concrete tank was 75 cms. No food was given to the animals as there was plenty of lablab in both places. After 4 days, it was observed that the animals at the enclosure became weak and many died due to over-crowding, wave action, and other factors like temperature and salinity fluctuation. The water was let in the main gates to supply water to the other ponds, salinity at the earth pond dropped to 42 ppt. A closer check showed that there were many small holes at the dike and water seeped into the pond when water level rose in the canals. A puddle trench had to be dug along the side of the dikes and refilled with new clayey soil. When the next high tide occurred, the dikes were checked and many leaks were discovered. The experiment in that earth pond was given up.

At the concrete tank, the animals thrived very well. The young nauplii grew to adults and began copulating 9 days after stocking. The adults had begun producing nauplii and cysts. No food was given for two weeks due to available food in the tank. When the tank water became more transparent (Secchi disc reading at 40 cm), very fine rice bran milk, produced through soaking and squeezing of rice bran through a very fine cloth bag, was applied in the tank. Transparency was reduced to 10 cm. Temperature fluctuations ranged from 25°C in the early morning hours to 32°C at 2:00 P.M. It was noted that the animals gathered along the walls of the tank which was shaded from the sun and that at noon time, most of the animals move to the bottom. To minimize the adverse effects of fluctuations in temperature, coconut branches were floated in the tank. It was observe that the animals hide themselves under the leaves when temperature rose.

When density of the animals increased, aeration was provided by converting a spray gun compressor and another air compressor (for refilling truck and tractor tires) into aerators. Expansion tubes were made out of 3-inch PVC pipes cut to 24 inches length and drilled with 3/16 inch holes to receive air valves. The ends were closed with 5 x 5 inch (1/4 inch thick) glass glued with epoxy. The expansion tubes were made to float in the tank and air hoses with large airstones were attached to them Enough air was pumped into the expansion tubes to aerate the whole water volume.

b. Stocking in Earth Ponds

Just adjacent to the concrete tank are earth salt concentration ponds where brine is produced preparatory to pumping into the brine tanks. Salinity in these ponds ranged from 85-130 ppt. When population density in the concrete tank increased to about 1200/liter, it was decided to stock in the concentration ponds. The water level in the ponds was 35 cms and water temperature rose to 35°C during noon time. To avoid its ill effects, coconut branches were laid in the ponds in rows parallel to the concrete dikes. Some 25 million animals of different ages were stocked in two ponds initially. After two weeks when population increased in those ponds, a large portion was transferred to a third pond just adjacent. It was noted that the ponds with salinity level of 130 ppt produced more cysts which floated at the southwest corners of the ponds. (Prevailing winds from the Northeast to Southwest). The cysts were collected with very fine-mesh scoop nets from plastic sheet lined collection corners, and washed of debris and algae before being stored in glass jars in hypersaline solution (250 ppt). Separation of fertilizecysts from non-fertile ones, and from foreign materials was done thru a series of washing at different salinity levels.

c. Feeding

Food for the animals in the concrete tank consisted of rice bran milk extracted from 8 kilos of fine rice bran, which was soaked in tank water and squeezed out of a fine cloth bag. Water transparency was kept between 10-15 cms. Vigorous aeration was maintained continuously. Vitamins and mineral traces were supplied from commercial animal feed additives.

In the ponds, due to the presence of benthic algae, no food was given to the animals. The pond bottoms were raked twice a day to cause the water to become turbid and to suspend the algae. No aeration was given.

The animals thrived very well in all areas, and cysts and nauplii were produced at a fast rate. More nauplii were produced at salinity level of 70-80 ppt in the concrete tank, and more cysts were produced in the ponds with salinity level of 110-130 ppt. The concrete tank was

used to produce nauplii and to mature them for transfer to the ponds, while the ponds were used as cysts production areas. From 4,845 m^3 of water in 13,842 sq m of ponds, 18.5 kgs of cysts were collected in 65 days. Due to salinity fluctuations when occasional rain fall, cysts drop to the bottom of the ponds and mixed with benthic algae and silt. The problem of separating the cysts from other materials is still unsolved.

d. Water Change

It was observed that the animals' activity slows down after a week from the last water change (maybe due to oxygen depletion as no aeration was provided in the ponds or lowering of food concentration). When fresh seawater from the river is introduced into the ponds, the animals become very active again and more cysts were produced. Salinity level was maintained by adding saturated brine or salt crystals to the pond water. The use of brine or salt to low salinity water is much cheaper than providing aerators. Besides, the new water brings into the ponds the naturally occuring foods in the river which comes from mangrove swamps.

e. Temperature and Salinity Ranges

(A) Brine tank - area 15 x 20 x 2 m
Average water depth - 75 cms pH value 7.5 - 8
Salinity range - low 84 ppt, high 180 ppt
average for 37 days - 93.4 ppt
Temperature range - low 25°C, high 37°C
average for 37 days - 31.1°C

(B) Concentration pond No. 5 - area 1760 m^2
Average water depth - 35 cms pH value 7.0-8.2
Salinity range - low 90 ppt, high 170 ppt
average - 135.8 ppt
Temperature range - low 25°C, high 37°C
average - 34.3°C

(C) Concentration pond No. 6 - area 1598 m^2
Average water depth - 35 cms pH value - 7.0-8.5
Salinity range - low 70 ppt, high 170 ppt
average - 122.9 ppt
Temperature range - low 25°C, high 37°C
average - 34.5°C

f. Food for Milkfish Fry and Other Species

Test stocking with 15 milkfish fingerlings (10 grams) show that the fishes thrived very well and that they grew to 200-250 gms each, after 72 days in the concentration ponds. Of course, rate of growth could not be very well approximated due to the very low stocking rate (15/1759 m^2). Available food in the pond are artemia nauplii and adults, and benthic algae.

Test feeding was done with decapsulated cysts, young nauplii and adults to fry and fingerlings of milkfish, P. monodon, Metapenaeus ensis, tarpon E. Hawaiienses, and others. Milkfish fry (20-25 days old) can take 14-16 eggs per day. All the fry thrived very well, and the carnivorous species grew faster than milkfish. Mortality was almost negligible. This confirms the findings of Dr. Liao (of the Tungkang Marine Laboratory) that artemia nauplii is very good for milkfish fry during feeding experiments in SEAFDEC, Tigbauan in July, 1978. The young nauplii and adults of artemia fed with rice bran, flour, breadyeast and Vitamin B - complex extract or blue-green algae (spirulina sp., spirogyra, oscillatoria limnetica and mixed diatoms) and later on fed to the young of fish and shrimps make excellent food. The tests show that the culture and management of fry of commercial species could be much improved if kept in tanks or small raceways, and fed with decapsulated cysts, nauplii, older larvae, and later on adults of artemia in that sequence with blue green algae and mixed diatoms. Water quality could be better controlled and predators eliminated. Mortality could be kept to the minimum, and the young fish or shrimps may be stocked in rearing ponds in bigger sizes and healtheir conditions, which will have the best chances of survival. Chemical treatment for diseases and parasites could be easily performed in small tanks or ponds, as well as complete removal of other predatory species such as E. Hawaiienses (tenpounder) and Megalops sp. (tarpons) which look very similar to Chanos fry at very young stage.

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