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Effect of Light, Temperature and salinity on the growth of ARTEMIA

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Abstract*: ARTEMIA* is commonly known as the brine shrimp. It is a crustacean. It lives high saline waters. It is widely distributed throughout the world; it is the most important live feed organism. ARTEMIA lives in high saline environment where its predators cannot survive. Hence ARTEMIA can be effectively cultured in saline water. Such water bodies are found in solar saltpans, which occur all along Indian coast. More than 85% of the marine animals cultivated thus far have been offered ARTEMIA saline as food source, either together with other foods or more often as a sole diet. In most cases brine shrimp are used as freshly hatched nauplii, although out grown ARTEMIA larva are reported to be a better food than nauplli for many predators (Kelly.et.al 1977). During the last years we have had the opportunity to study in detailed the effect of various a biotic parameters on the hatcheing process. Effect of water temperature on the hatching metabolism of ARTEMIA cysts are attained around 30^0c. Lower salinities the hatching at low salinity is the P^H of the medium. From this study it appears that for most parameters studied. Considerable variability exists. Between ARTEMIA strains these initial data already provide pertinent information for the selection and practical use of brine shrimp nauplii in aquaculture.

Keywords*: Feed, Hatching, Aboitic Parameters, Artemia cysts.*

I. INTRODUCTION

Aquaculture is an advent of blue revolution leading to the production of fish and shell fish under controlled environmental conditions. In all these types of aquaculture practices i.e., fresh water aquaculture, brackish water aquaculture and Mari culture, seed production is a major constraint. Aquaculture as a whole depends on continuous supply of seed and feed. The dominant species for brackish water aquaculture is *Penaeus monodon* and dominant shellfish in freshwater aquaculture is *Macrobrachium rosenbergii*. The live feed technology in hatchery operations of selected species is taken for the present study. Hatchery production of fry (seed) has now become a routine operation for most cultivated fish and shellfish species. Billions of fish and shellfish larvae are currently being produced within hatcheries all over the world. The cultivation of larvae is generally carried out under controlled environmental conditions which are different from conventional nursery procedures. The main reason is that the developing larvae are small fragile and physiologically undeveloped. Their small size mouth, undeveloped perception organs are limiting factor in proper feed selection. The developing larvae also have to pass through different larval stages eventually changing herbivorous to carnivorous behaviour. The mouth size of the first feeding larvae usually restricts the size of food particles which can be ingested. The developmental status of the digestive system also dictates the possibility or not the larvae to digest the food ingested. The larvae will have to rely on food sources, which are:

1. Easily digestible
2. Contains necessary enzyme systems which allow autolysis
3. Supplies in abundance of all the essential nutrients required by the larval predator

Formulated feeds do not generally meet all these requirements and results in poor growth and survival; on the other hand live food organisms seems to meet all the necessary criteria for these small larvae. Live food organisms usually have a much better contrast than artificial feeds and generally have a triggering effect by their continuous movement, allowing an enhanced perception by the feeding larvae. Similarly the swimming activity of live food organisms generally assures a good distribution of food items in the water column.

The aim of present topic is to describe the various techniques employed for the production and application of live food organisms as well as their applications in shrimp hatcheries. The natural diet of most cultured species consists of phytoplankton and zooplankton found abundant in natural plankton. For culturing of fish and shrimp, readily and consistently available, practical and performing live diets need to be selected. From the practical viewpoint of the culturists a good diet should be readily available, cost-effective as well as versatile in application.

II. PRESENT STATUS OF BRINE SHRIMP PRODUCTION

In early 80's, production of *Artemia* culture using Sanfracisco Bay strain have been initiated by Bharath Salt chemicals Industries, Gujarat, India. Tata Chemicals Ltd, Gujarath achieved a production of dry cysts. In Tamil Nadu, Kelampakkam saltpan, conducted experiments on the Artemia cyst production using inorganic fertilizers. The studies focused on biological factors and their relation to hydrological factors (Rahaman et. al., 2006 a), detailed account of biological management (2006 b & 1993a, b), dynamics of solar salt works (2006 c) sedimentation of salt works (2006 d.) All along the coastline, a vast area is under salt production and these solar salt pans offer excellent scope for carrying out Artemia, culture. Most of the infrastructure required for production is already available and *Artemia* form a valuable byproduct to salt farmers. Today live diet which is widely applied in industrial larviculture of fish and shellfish is: The brine shrimp *Artemia salina*

2.1 STUDY OF THE ARTEMIA SALINA

Artemia salina is also called Brine Shrimp, is a kind of small shellfish, which belongs to the Phylum Arthropoda, class Crustacea, is distributed widely and bear high sale. *Artemia* possess strong adaptability even to bad environment and carry better productivity. The encysted form of *Artemia* may be conserved for longer time durations, and can be hatched to Nauplius after 18-30 hours and possess plentiful yolk with abundant protein and fat. The adult animal also hold high nourishment, so *Artemia* is considered excellent diet of fishes, shrimps, prawns lobsters, crabs etc.. It is reported that more than 85% aquaculture is based on *Artemia* world over. There are more than 50 geographical strains of *Artemia*. *Artemia* was first discovered in Lymington, England in 1755.

Approximately 90 percent of the world's commercial harvest of brine shrimp cysts comes from the, Great Salt Lake in Utah. Buyers might expect to pay $12 to $40 or more per pound. Normally 200,000 to 300,000 nauplii might hatch from each gram of high quality cysts. *Artemia* are extremely euryhaline, withstanding salinities from 3 ppt to 30 ppt. They can even survive short periods of time in fresh water, but cannot reproduce in it. *Artemia* survive temperatures ranging from 15 to 55^0C (59 to 131^0F). They have two modes of reproduction. Sometimes nauplii (first *Artemia* swimming stage) hatch in the ovisac of the mother and are born live. However, when the body of water where adult *Artemia* live and start drying up resulting in increased salinities, the embryos are encased in a hard capsule, or cyst, so that they are protected and can hatch later when conditions are better. The is an adaptive mechanism of *Artemia* to tide over unfavourable environmental conditions. The cyst is 200 to 300 micrometers in diameter. Its external layer is a hard dark brown shell. To withstand complete drying, temperatures over 100^0 C (212^0 F) or near absolute zero, high energy radiation, and a variety of organic solvents. The dehydrated cyst can be stored for months or years without loss of hatchability. Only water and oxygen are required to initiate the normal development of the *Artemia* embryo, but it does help the hatch rate to maintain the temperature above 25 °C (77 °F) hatched cyst makes *Artemia* a convenient, constantly accessible source of live feed for the finfish, shellfish hatchery operators.

Within 15 to 20 hours after being placed in seawater at 28^0C the shell breaks and the pre-nauplius in E-l stage appears for the first few hours, the embryo hangs beneath the cyst shell in what is called the umbrella stage. The pre-nauplius E-2 stage is then released as a free-swimming nauplius called an Instar 1 nauplius. In this stage it is brownish orange because of its yolk, reserves.

Approximately 12 hours after hatch, it molts into the second larval stage (Instar II) and starts filter feeding on microalgae, bacteria and detritus. The *Artemia* nauplius can live on yolk and stored reserves for up to 5 days or through the Instar V stage.

Lipid level and fatty acid composition of newly hatched *Artemia* nauplii can be highly variable, Many researchers (British, japan French& belgium) have studied the levels of highly unsaturated fatty acids (HUFA). Level of HUFA in *Artemia* being fed and that essential fatty acids are the principle food value of *Artemia*. When *Artemia* contain low levels of HUFA, the survival of larval fish declines. *Artemia* composition is generally in the range of 51 to 55 percent protein, 14 to 15 percent carbohydrate, 13 to 19 percent fat, and 3 to 15 percent n-3 HUFA. *Artemia* contained 28 percent crude protein, 10 percent crude fiber and 10 percent crude fat. To compensate for a poor HUFA level in *Artemia*, they can be enriched with omega yeast, vitamins (E, D, C and B_{12}), and marine oils.

2.2 Taxonomy

Brine shrimp was referred to as *Artemia* salina[Linnaeus 1758]
A. salina [Linnaeus 1758: Lymington, England](now extinct), Mediterranean area;
A. tunisiana [Bowen and Sterling 1978 synonym of A. salina]
A. parthenogenetica[Barigozzi 1974, Bowen and Sterling 1978: Europe, Africa, Asia, Australia]
A. urmiana[Gunther 1900: Iran]
A. sinica [Yaneng 1989: Central and Eastern Asia]
A. persimilis[Piccinelli and Prosdocimi 1968: Argentina]
A. franciscana superspecies: Americas, Carribean and Pacific islands, including populations reproductively isolated in nature like *A. franciscana* [Kellogg 1906] and
A.franciscana[monica Verrill 1869 -Mono Lake, California]

III. MATERIALS AND METHODS

3.1 *Artemia* Hatching Requirements: The optimum conditions for hatching *Artemia* are as follows 25°C, salinity 28-30 ppt, heavy continuous aeration, light - 2000 lux constant illumination, pH around 8. Good circulation is essential to keep the cysts in suspension. A container that is V or conical shape is best with a valve on the cap and invert, this way unhatched cysts, empty shells, and hatched nauplii can be easily removed separately. The hatching percentage and density are usually a function of water quality, Hatch rate is of cysts is usually 200,000 to 300,000 nauplii per gram of cysts, so a half teaspoon in a two liter bottle is more than enough for the typical aquarist. As for other environmental conditions, optimal hatching outputs are reached in the pH range 8-8.5.

3.2 Disinfection procedures: *Vibrio* sp. Constitutes the main bacterial flora in *Artemia* cyst hatching solutions. Most *Vibrio* bacteria can cause disease/mortality outbreaks in larval rearing, *Artemia* cyst shells may be loaded with bacteria, fungi, and even contaminated with organic impurities: bacterial contamination in the hatching medium can reach numbers of more than 10^7 CFU.ml^{-1} (= colony forming units). During hatching, bacterial development can be considerable and hatching solutions may become turbid, which may also result in reduced hatching yields. So It is recommended to apply routinely a disinfection procedure by using hypochlorite. Complete sterilization can be achieved through cyst decapsulation.

3.3 Decapsulation: The hard shell that encysts the dormant *Artemia* embryo can be completely removed by short-term exposure to a hypochlorite solution. This procedure is called decapsulation. Decapsulated cysts offer a number of advantages compared to the non-decapsulated ones:Unhatched cysts and when they are ingested by the predator: they cannot be digested and may obstruct the gut.Nauplii that are hatched out of decapsulated cysts have a higher energy content and individual weight (30-55 % depending on strain) than regular instar I nauplii, because they do not spend energy necessary to break out of the shell.Decapsulation results in a disinfection of the cyst material Decapsulated cysts can be used as a direct energy-rich food source for fish and shrimp larvae. For decapsulated cysts, illumination requirements for hatching would be lower.

The decapsulation procedure involves the hydration of the cysts removal of the brown shell in a hypochlorite solution, these decapsulated cysts can be directly hatched into nauplii, or dehydrated in saturated brine and stored for later hatching or for direct feeding. They can be stored for a few days in the refrigerator at 0 – 4°C without a decrease in hatching. If storage for prolonged periods is needed, the decapsulated cysts can be transferred into a saturated brine solution. During overnight dehydration cysts usually release over 80 % of their cellular water, and upon interruption of the aeration, the now coffee-bean shaped decapsulated cysts settle out. After harvesting of these cysts on a mesh screen they should be stored and cooled in fresh brine. Since they lose their hatchability when exposed to UV light it is advised to store them protected from direct sunlight.

3.4 Optimum conditions for Hatching *Artemia* Cysts : Temperature above 25 °C (77 °F), with 28 °C (82 °F) being optimum; 2) salinity of 25-35 ppt (1.030 density); 3) heavy continuous aeration; 4) constant illumination 5) a pH of about 8. Stocking density is set by adding no more than 5 grams of cysts per liter of water. A container that is V-shaped or conical-shaped is best (2-liter). Unhatched cysts, empty shells and hatched nauplii can be easily removed separately.

3.5 Hatching Conditions: The temperature of the seawater is preferentially kept in the range of 25-28°C; below 25°C cysts hatch more slowly and above 33°C the cyst metabolism is irreversibly stopped. On cyst hatching salinity, is approximately 20-40 g.l^{-1} Optimal hatching can be obtained in the range 5-35 g.l^{-1}. For reasons of practical convenience natural seawater is mostly used to hatch cysts. However, at 5 g.l^{-1} salinity, the nauplii hatch faster, the salinity can easily be measured by means of a refractometer or densitometer.

The pH must remain above 8 during the hatching process so as to ensure optimal functioning of the hatching enzyme. If needed, (i.e. when low salinity water is used), the buffer capacity of the water should be increased by adding up to 1 g $NaHCO_{3.}$ The other abiotic factors that is essential for hatching, such as pH, oxygen, and illumination. Strong illumination (about 2000 lux at the water surface) is essential, at least during the first hours after complete hydration, in order to trigger/start embryonic development. This level of illumination is mostly attained during daytime in transparent tanks; it is advisory to keep the hatching tanks indoors and to provide artificial illumination so as to ensure good 9tandardization of the hatching process.

3.6 Hatching quality and evaluation: An acceptable cyst product should contain minimal quantities of impurities, such as sand, cracked shells, feathers, and salt crystals, etc. Hatching synchrony must be high; when incubated in 33 g.l^{-1} sea water at 25°C, the first nauplii should appear after 12 to 16 h incubation (T_0) and the last nauplii should have hatched within 8 h thereafter (T_{100}). First-hatched nauplii will have consumed much of their energy reserves by the time that the last nauplii will have hatched and harvesting is completed. Quality cysts from Great Salt Lake yield 270,000 nauplii per gram of cysts and may yield even higher numbers of nauplii, (i.e. 320,000 nauplii/g cysts).

The following Biochemical estimations were carried out for determination of various nutrients in algae and *Artemia*. The water content was calculated by the difference in weights before and after drying of the materials in terms of percentage of water.The ninhydrin method or Moore and Stein was employed for estimating amino-acids, separated by column chromatography is very sensitive and accuracy. The method was essentially that described by Consoden et. Al. (1944). What man no.4 filter paper sheets (56 x 46 cm) were used in all

experiment. The size of the original spots formed in adding the amino-acids to the chromatograms were kept as small as possible, about 6-8nm in diameter. The solvents generally used have been phenol saturated with water at the working temperature and the n-butanol-acetic acid mixture described by Partridge (1948). All chromatograms were run for about 5 hrs at room temperature; the running time in the n-butanol-acetic acid was increased, to give a better separation of the amino acids.

The phenol solvent was removed and then the papers were first allowed to dry in air about 1 hr., when the aqueous portion of the solvent evaporated, leaving the papers dry to the touch. The strips were taken out, sprayed with ninhydrin and warmed up to reveal the positions of the amino-acid spots. Protein content in the muscle tissue was estimated by the method described by *Lowry et.al., (1951),* the principle involved is that the protein react with the Folin-Ciocalteau reagent to give a coloured complex. The colour is formed due to the reaction of the alkaline copper with the protein and the reductison of Phosphomolybdate of the reagent by tyrosin and tryptophan present in the protein. The colour compound was measured at 550nm on spectrophotometer.

Carbohydrates were estimated by the Anthrone method, described by *Caroll et.al., (1956).* The principle involved is that the sulphuric acid present in the anthrone reagent hydrolyse the di-and oligo saccharides and all monosaccharides into furfural, or furfural derivatives which react with the anthrone and produce a blue coloured complex, the intensity of which is proportional to the amount of saccharides present in the sample. The complex was read at 620nm on spectrophotometer.

The lipids were estimated by the Bligh and Dyer method (1959). The method described by soxhlet in (1879) is the most commonly used example of a semi-continuous method applied to extract lipids from foods. According to the soxhlets procedure, oil and fat from solid material are extracted by repeated washing (percolation) with an organic solvent, usually hexane or petroleum ether, under reflux in a special glass ware. The sample to be analyzed is weighed into cellulose thimbles and inserted in the extraction device. Except diethylether, all solvents may be used (about 15ml per sample), with a 75% recovery of the solvent after the extraction which is completed in 30 to 60 min, depending on the application.

Methanol chloroform mixture in the ratio 50:50 was used as the solvent for the present estimation. The acid value of fat was also determined following the method described by David T Plummer (1988). The method involves the neutralization of free fatty acids with 0.1M potassium hydroxide. For this, the chloroform-methanol solvent in which the lipids were extracted as in the above experiment is taken 5ml of this solvent containing lipids is taken, 1ml of Phenolphthalein indicator solution is added, mixed thoroughly and titrated with 0.1 mol/liter KOH until the faint pink color persists for 20-30 seconds. The number of milliliters of KOH required for neutralization is noted down and the acid content of the fat is calculated by assuming that 0.1 mol/1t KOH contains 5.6g/1t or 5.6mg/ml of KOH.

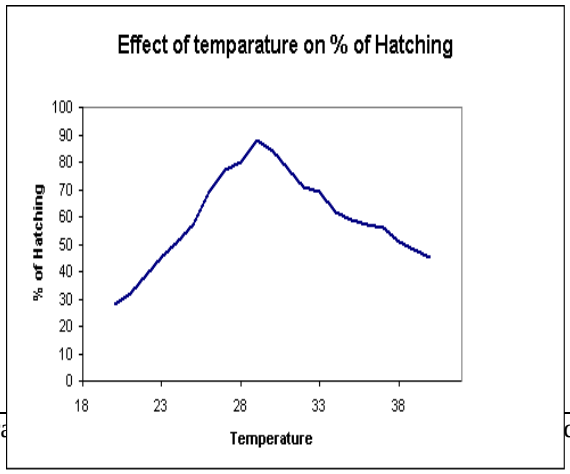
IV. RESULTS

4.I HATCHING % OF *ARTEMIA* CYSTS

During hatching of *Artemia* the temperature , light and salinity was altered from 20 to 350c, 500 to 4000 lux and 20 to 35ppt .It was observed that maximum hatching was found at 290c, 2000 lux, and 29ppt. Hatching percentage is estimated by counting the number. Of *Artemia* naupili per ml. It can be represented in the following table and graphs.

TABLE.8 EFFECT OF TEMPERATURE ON % OF HATCHING

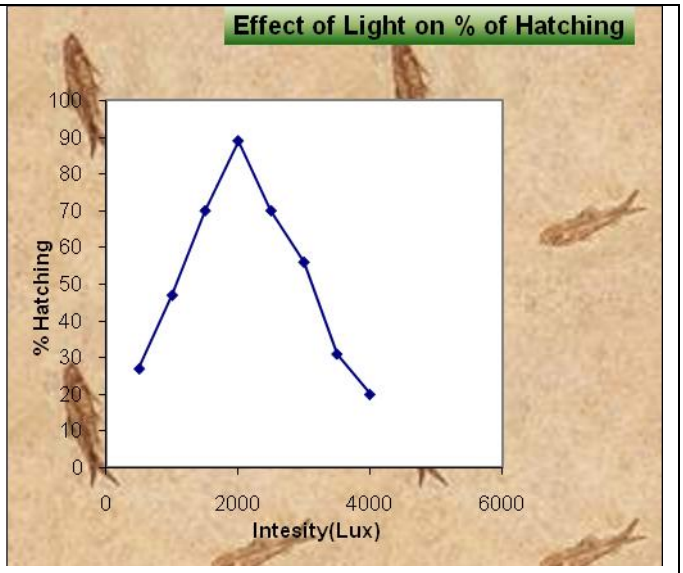
S.l. No	Temperature	% of Hatching	11	30	84
1	20	28	12	31	78
2	21	32	13	32	71
3	22	39	14	33	69
4	23	45	15	34	62
5	24	51	16	35	59
6	25	57	17	36	57
7	26	69	18	37	56
8	27	77	19	38	51
9	28	80	20	39	48
10	29	88	21	40	45



The above graph shows that hatching % is more at tempera d 35^{o}C i.e., 28% and 59%.

TABLE 9.EFFECT OF LIGHT ON HATCHING OF *ARTEMIA* CYSTS:

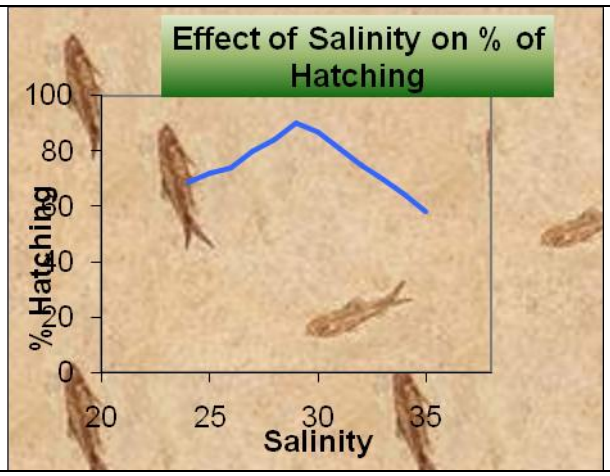
S.l.No	Intesity(lux)	% of Hatching
1	500	27
2	1000	47
3	1500	70
4	2000	89
5	2500	70
6	3000	56
7	3500	31
8	4000	20



Graph showing high % of hatching at 2000 lux i.e., 89% and minimum hatching is at 500 and 4000lux.

TABLE-10 *EFFECT OF SALINITY ON HATCHING OF ARTEMIA CYSTS*

S.l .No	Salinity in ppt	% of Hatching			
1	24	69	7	30	87
2	25	72	8	31	81
3	26	74	9	32	75
4	27	80	10	33	70
5	28	84	11	34	64
6	29	90	12	35	58



During hatching of *Artemia* salinity was altered from 24ppt to 35ppt. It is observed that maximum hatching is found at 29ppt. Hatching percentage was estimated by counting the number of *Artemia* naupili per ml. It can be represented from the above table and graph.

4.2 NUTRITIONAL VALUEOF ARTEMIA

TABLE.12 EFFECT OF LIGHT ON NUTRITIONAL CONTENT OF *ARTEMIA*

S.l. No	light(lux)	% of Protein	% of Lipid	% Carbo-hydrate
1	500.00	43.10	22.10	15.20
2	1000.00	43.20	22.30	16.10
3	1500.00	43.60	22.40	16.50
4	2000.00	43.80	22.50	16.70
5	2500.00	43.50	22.30	16.20
6	3000.00	43.30	22.10	15.80
7	3500.00	43.10	22.00	15.10

8	4000.00	43.00	21.90	14.70

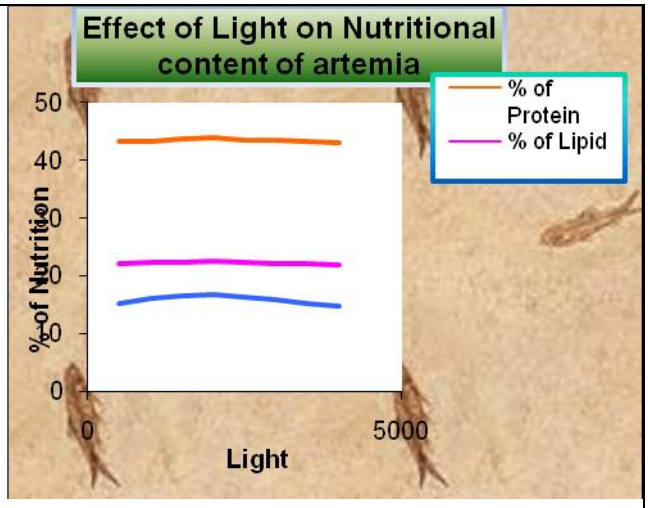


Table and graph determines the effect of light i.e., at 2000 lux protein is 43.8%,lipid 22.55%and carbohydrate 16.75 carbohydrate is much consumed than protein and lipid.

4.3 EFFECT OF TEMPERATURE Lipids and fatty acid composition, as well as the metabolism of fatty acids the ability to produce dormant cysts when environmental conditions endanger the survival of the species.
The above graph shows three different peaks of the nutritional content of protein, lipid and carbohydrate. From the graph proteins is less utilized than lipids. Compared to protein and lipid carbohydrate was much utilized with effect of temperature this changes were observed from 20^{o}C to 40^{o}C.

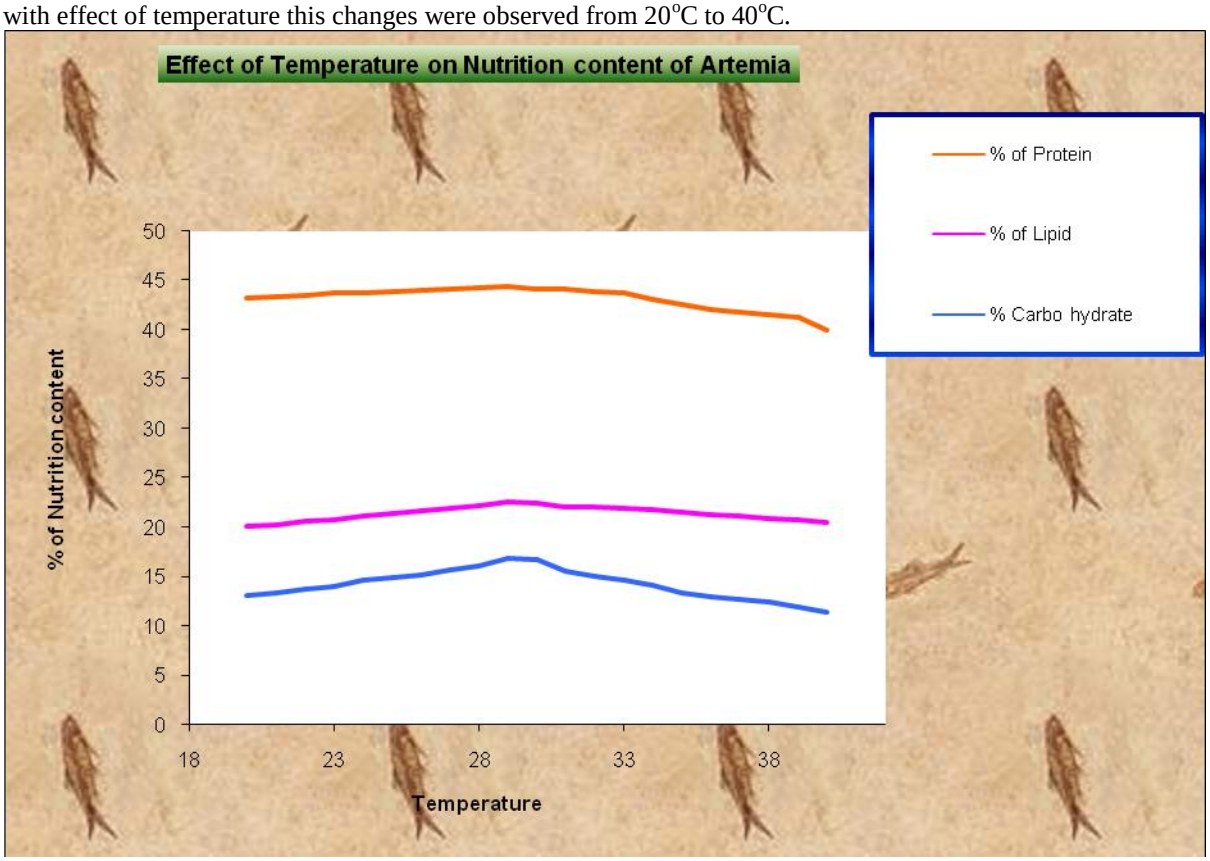


TABLE.11 EFFECT OF TEMPERATURE ON NUTRITION CONTENT OF *ARTEMIA*

S,I no	Temperature	% of Proteins	% of Lipid	% carbohydrates	S,I no	Temperature	% of Proteins	% of Lipid	% carbohydrates
1	20	43.20	20.10	13.10	12	31	44.10	22.10	15.60
2	21	43.30	20.30	13.40	13	32	43.90	22.00	15.10
3	22	43.50	20.60	13.80	14	33	43.70	21.90	14.70
4	23	43.70	20.80	14.00	15	34	43.10	21.80	14.20
5	24	43.80	21.20	14.70	16	35	42.60	21.50	13.30
6	25	43.90	21.40	14.90	17	36	42.10	21.30	13.00
7	26	44.00	21.70	15.20	18	37	41.80	21.10	12.70
8	27	44.10	21.90	15.70	19	38	41.50	20.90	12.40
9	28	44.30	22.20	16.10	20	39	41.30	20.70	11.90
10	29	44.40	22.60	16.90	21	40	40.00	20.50	11.40
11	30	44.20	22.40	16.70					

V. DISCUSSIONS

1. Artemia are extremely euryhaline, withstanding salinities from 3 ppt to 300 ppt. They can even survive short periods of time in fresh water, but cannot reproduce in it. Artemia survive temperatures ranging from 15^{o}C to 55^{o}C (59 to 131^{0}F hatch rate to maintain the temperature above 25 °C (77 °F) hatched cyst makes Artemia a convenient, constantly accessible source of live feed for the finfish hatchery operator. Artemia cysts are best stored in a tightly sealed container in a cool, and, if possible, vacuum packed.
2. Within 15 to 20 hours after being placed in seawater at 28^{0}C the shell breaks and a free-swimming nauplius called an Instar 1 nauplius is released. In this stage it is brownish orange because of its yolk reserves.
3. Artemia composition is generally in the range of 44 percent protein, 16 percent carbohydrate, 22 percent lipids obtained from the protocal used by maintaining the temperature between 20^{o}C to 40^{o}C and Artemia contained 28 percent crude protein, 10 percent crude fiber and 10 percent crude fat. To compensate for a poor HUFA level in Artemia, they can be enriched with omega yeast, vitamins (E, D, C and B_{12}), marine oils, vitamin B_{12}-producing bacteria, and commercial enrichment media .This temperature also influence the hatching percentage of cysts. From the results obtained maximum hatching percentage is found at temperature29 ^{o}C in the hatchery of coastal areas.
4. It is important to feed Artemia nauplii to fish larvae as soon as possible after hatching If there is a delay in feeding Artemia, they may also become too fast and too large for the fish larvae to catch and eat.freshly hatched nauplii are dark orange Feeding an over sized Artemia strain can cause fish larvae to grow poorly or even starve.
5. According to results obtained a 500lux and 4000 lux causes the decreased percentage of hatching and nutriernt content because light has an inpact on carbohydrate metabolism where it is utilised in the form of energy requied for hatching and nutrients metabolism.
6. Artemia has high nutritive value, high conversion efficiency, short generation time, high fecundity rate and considerable long life span. All the life stages of Artemia, i.e., cysts (after decapsulation), nauplii, juveniles, sub adults and adults are used as feed in aquaculture operations according to the feed size requirement of the predator. Live Artemia nauplii and/or adults are currently used virtually in all commercial aquaculture hatcheries many Frozen adult Artemia are widely used by aquarists, fish breeders, and aquaculturists. Live Artemia are preferable to frozen because of their higher nutritional value and live foods tend not to degrade water quality. Artemia biomass harvested from natural population are quick frozen and utilised by aquaculturists and pet fish dealers. Artemia biomass has also been used as a food additive for domestic livestock, for extraction of pharmaceutical products, in protein rich food products and is even used for human consumption in Africa and Thailand.
7. Optimal hatching outputs are reached in me pH range 8-8.5. As a consequence, the addition of $NaHCO_3$, up to 2 $g.l^{-1}$, to artificial or diluted seawater or to dense suspensions of cysts results in improved hatching.
8. An increased hatching has been reported with increasing oxygen level in the range 0.6 and 2 ppm, and hatching in a higher salinity medium will consume more of the energy reserves of the embryo. Optimal salinity for situated in the range 15-70 $g.l^{-1}$.
9. Brine shrimp cysts, when hydrated and in aerobic conditions, need a minimal light triggering for the onset of the hatching process.

10. Hatching quality in stored cysts is slowly decreasing when cysts contain water levels from 10 to 35 % H_2O. This process may however be retarded when the cysts are stored at freezing temperatures. Too severe dehydration (down to 1-2 %) results in a drop in viability. Water levels in the range 30-65 percentage initiate metabolic activities; Cysts exposed for too long a period to water levels exceeding 65% will have completed their pre-emergence embryonic development. Subsequent dehydration of these cysts results in the killing of the differentiated embryos.

11. On the other hand, a possible major drawback of decapsulated cysts is their immobility, and thus low visual attractively for the predator. Moreover, decapsulated cysts dehydrated in brine sink rapidly to the bottom, thus reducing their availability for fish larvae feeding in the water column. Extra aeration or drying is therefore needed

Although tank-produced *Artemia* biomass is far more expensive than pond-produced brine shrimp, its advantages for application are manifold: Year-round availability of ongrown *Artemia*, independent of climate or season, Specific stages (juveniles, preadult, adults) or prey with uniform size can be harvested as a function of the size preferences of the predator; and Quality of the *Artemia* can be better controlled (i.e. nutritionally, free from diseases) by maintaining controlled environmental parameters. In India, there have been no systematic efforts at exploitation or scientific culture of *Artemia* so far attempts have been recently made by M/s. Tata Chemicals Ltd. and M/s. Ballarpur Industries Ltd. in Gujarat.

VI. CONCLUSION

Information at laboratory and field studies has revealed that the Indian strain of *Artemia* is parthenogenetic and the size of the cyst and nauplii are bigger cyst produced in India costs Rs. 1,000 to 1,500. The turn of the century, India is aiming to produce 1, 00,000 tonnes of cultured shrimp. According to one estimate, by 2000 AD, about 100 tonnes of *Artemia* cysts would be required to meet the increased demand. India with a long coast line of over 6000 km has about 76,000 ha of salt pans and brine ponds, which offers excellent sites for culturing *Artemia* for cysts and biomass. The Indian strain of *Artemia* can more advantageously be used in production of biomass compared to other strains for intensive culture by virtue of its parthenogenetic and oviparous life history. Import of technology may also be considered for production of cysts and biomass from experienced countries like Thailand, Philippines, Brazil, etc.

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