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On the *Artemia* Population from Korangi Creek Saltworks, Karachi, Pakistan

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The natural population of *Artemia* appeared in the last week of October following a drop in the average temperature (26°-33°C) by large scale hatching of cysts. It established rapidly by ovo-viviparous mode of reproduction and acquired peak density of 13 individuals per liter in November-December (20°-26°C) and disappeared during May-June (day temperature, 37°C and above). The optimal temperature regime for sustenance and growth of population was 23°-28°C. A wide range of salinity tolerance was observed but the temperature appeared to play a role more important than salinity in controlling growth, survival, and reproduction of Artemia in the saltworks of Korangi Creek.

Key words: *Artemia* population, Saltworks, Karachi, Temperature variations.

Introduction

Use of live *Artemia nauplii* as feed dates back to 1933, when Seale (1933) first introduced the concept of live feeding in larval culture. The significance of *Artemia* as live feed in hatchery operations and aquarium pet industry is now very well recognized. The reports (Santos *et al* 1980; Smets *et al* 1985) indicated an integrated use of cysts and biomass, from hatchery to grow out operation. *Artemia* is not only a nutritive feed organism, but also controls the overall hydro-biological activities in solar salt production operations. It also determines the production of salt both in quantity and quality (Davis 1978, 1980; Sorgeloos 1983, 1988) by consuming the algal blooms. These algal blooms are developed by naturally available organic and inorganic nutrients, metabolites and decaying *Artemia* which act as a substrate for the development of red halophilic bacteria, *Halobacterium* (Jones *et al* 1981). Owing to its red colour, the Halobacterium increases the heat absorption and hence increases the salt quantity and reduces the dissolved organic matter, which results in the formation of larger salt crystals, thus improving the quality of salt.

Keeping in view the immense importance of *Artemia* in larval feeding and salt production, it was planned to inoculate *Artemia* in salt pans of Karachi coast for commercial production of cysts. During the survey work, a native parthenogenetic population of *Artemia* was found. This was the first record of *Artemia* occurrence from Pakistan (Sultana *et al* 1991). The present paper describes the seasonal population and physical parameters of the salt pans studied over a period of two years, from May 1991 through May 1993. Laboratory studies were also made of biology of *Artemia*.

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Materials and Methods

Korangi Creek Saltworks cover an area of about 40 acres. The salt production operates throughout the year, since the rainfall is rare, not more than 164 mm per year (mean of 10 year i.e. 1987-1996). The saltworks include reservoirs or the maturation ponds, intermediate salinity ponds and the crystallization ponds. Seawater of 37-38 ppt salinity is pumped from the creek into the reservoirs, which are the largest and deepest ponds (0.5-0.75m). All other ponds are 35-45cm deep. Seawater is left in reservoirs for maturing until a salinity of 85-90 ppt is acquired. This water is transferred to intermediate salinity ponds through a water course by gravity flow, which in turn, is transferred to the crystallization ponds when a salinity >220 ppt is reached.

Artemia were collected from the intermediate ponds for a period of two years, from May 1991 through May 1993, by a hand net and scoop net of 120 μm mesh size from the sides and corners of the ponds. Collections were made fortnightly during the first year and monthly in the second year, but the samples have been pooled for analysis and presented as monthly samples. Temperature and salinity were recorded regularly, during the time of sample collection, while the pH and dissolved oxygen were recorded occasionally. For quantitative analysis the total volume of pond water was calculated. Twenty random samples of one litre water were taken from different parts of the pond. These samples were pooled and distributed uniformly by thorough mixing. Three random samples (one-liter water) were then taken and the mean was calculated for the estimation of population density.

In the laboratory, live Artemia were kept in glass aquaria and, for individual observations, in a beaker, in triplicate. For feeding *Artemia,* algae were collected from the same salt pans and cultured in the laboratory. Seawater was also prepared with the salt collected from the same saltworks.

Results and Discussion

On visual observation, *Artemia* were found to be more concentrated on the sides and corners of the ponds rather than the middle of the pond. Figure 1 shows the percent occurrence of A. *nauplii,* pre-adult and adult, during the period of the study. The population was found well established in May 1991 with a large number of nauplii, pre-adults and adults i.e. reproducing by ovo-viviparity. In June 1991, the entire population died due to a drastic rise in water temperature that reached to about 40°C (air temperature 43°C). Population reappeared in the last week of October 1991, following the fall of average temperature (26°-28°C during the day), probably by quiescent cysts of dead Artemia population and became rapidly established due to the ovoviviparous mode of reproduction. This population remained stable till May 1992, with the peak density of 13 individuals per liter during November-December. In May 1992 almost the entire population again died (air temperature 41°C) leaving very few *Artemia* alive, which took shelter at deep intake points of the intermediate salinity ponds, where a small sluice gate is installed to regulate the water intake. During May 1992 through May 1993, population followed the same basic pattern i.e. appearing in October and dying in May. The only exception was a few leftover *Artemia* of the previous population (May 1992) which increased in number at the intake points and little adjoining parts of the watercourse. This small but dense population persisted there till July 29 1992, when unusually high rainfall, intermittently from July 29 through August 12 1992, washed away this population. As described previously, the dominant mode of reproduction was ovoviviparous at a salinity <220 ppt and a large number of overlapping populations were observed as long as they survived. In the natural population, cyst production was quite insignificant and a small number of cyst was observed floating on the water surface, along with the *Artemia nauplii* and adults. Oviparity was never observed as a dominant mode of reproduction in the natural population (salt pans) during the study period, though the cyst formation occurred when the temperature suddenly and abruptly rose and the population died (May-June).

Figure 2 presents the physical parameters i.e salinity and temperature of the intermediate salinity ponds during the study period. The salinity ranged from 85 to 220 ppt, and the temperature varied between 19.5° to 39°C. The pH and dissolved oxygen values were recorded occasionally and the range of pH was found between 7.24 to 8.78 and that of D.O, 1.1 to 2.3 mg per litre.

In the laboratory studies, it was observed that, *nauplii* reached the adult stage in 12.5 days at a temperature of 30°-35°C, in 13.5 days at 26°-31°C and in 18-20 days at 18°-25°C. Each adult reproduced at a rate of 70-110 (average=94±15) *nauplii* or cysts every 4-6 days. The life span was about five months. Spawning took place every fourth day at 30°-35°C, every fifth day at 26°-30°C, and from 6-7 days at 18°-25°C. These experiments were performed at two different salinities, i.e. 80 and 120 ppt. No variation was observed in the results due to difference in the salinity.

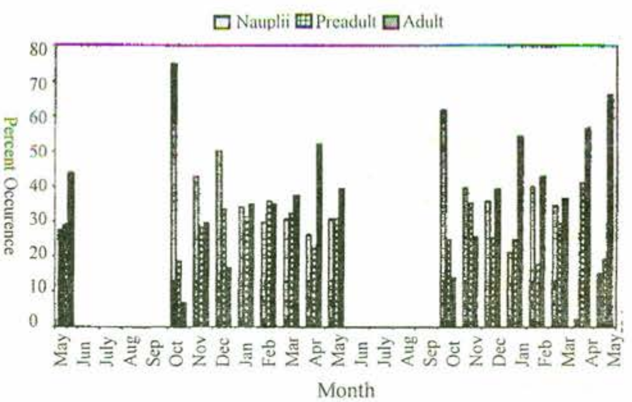

Fig 1. Occurrence of *A.nauplii,* preadult, and adult, in the Korangi Creek Saltworks, during May 1991 through May 1993.

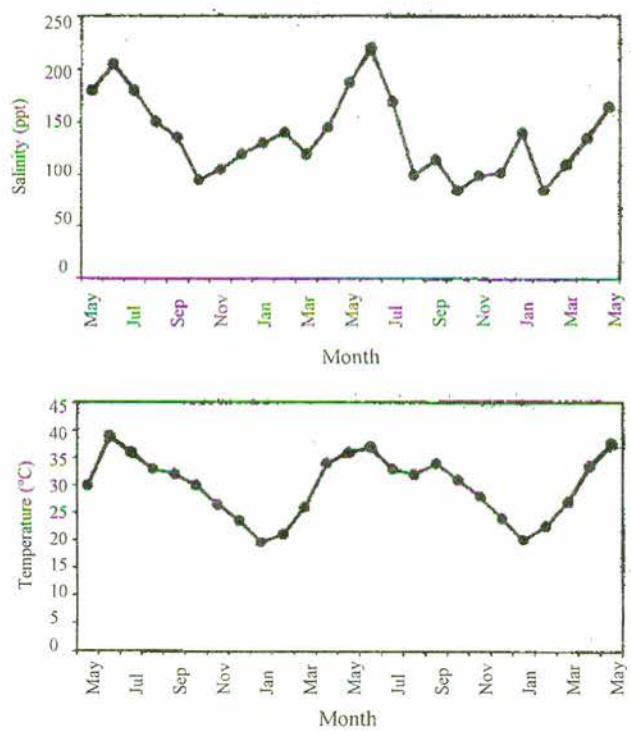

Fig 2. Seasonal Variation of salinity (ppt) and temperature (°C) in the Korangi Creek Saltworks during May 1991 through May 1993

At temperatures below 10°C, the populations gradually switched to oviparity but as soon as the temperature rose, hatching startsed again. Temperature of 37°C and above was lethal for Artemia in salt works, where the salinity value was also considerably high (>90 ppt).

Salinity when gradually increased was tolerated by *Artemia* up to 220 ppt; hatching also took place at this salinity but *Artemia* did not survive when transferred from a salinity of 120 ppt to 220 ppt directly. To study the tolerance of low salinity, *Artemia* were kept in a small outdoor pond of $1 m^2$. The temperature was not controlled and day-night variation was between 14°-25°C. The salinity was maintained at 12 ppt. The population survived very well and reached to adult stage in 14 days. The spawning took place at every fifth day. Adult *Artemia* were harvested from this pond to assess their nutritional quality. During washing of live *Artemia* with fresh water to remove debris and algae, not only did *Artemia* survive for 4-6 hours but hatching of innumerable *nauplii* also occurred during this period. These *nauplii* were then transferred to 100 ppt salinity water, where they grew to adult stage.

Parthenogenetic strains of *Artemia* have been recorded from 14 different locations in India (Vanhaecke *et al* 1987). The salinity and temperature ranges mentioned for those strains were comparatively low. Ramamoorthy and Thangaraj (1980) reported egg bearing adults and *nauplii* in salinities between 56 and 101 ppt. Royan *et al* (1978) observed larvae of *Artemia* in 130-160 ppt salinity. Ramanathan and Natarajan (1987) found adult eggs and nauplii in a salinity range of 55-160 ppt in the Didwana Salt Lake population, which is the closest (27°17"N-74°25"E) to Karachi, where they observed no hatching of cyst at 13+5°C and the maximum salinity tolerated by adults was 203 ppt. The salinity range of 90-150 ppt and water temperature of 20°-25°C were optima as reported by Bhargava *et al* (1987).

Korangi Creek Saltworks, Karachi (24° 48"N and 66° 58"E) generally has a warm climate, ruled by the monsoon regime. Air temperature generally follows a bimodal pattern with major peak in May-June and minor in September-October. The lowest temperatures prevail during December-January, which then gradually increase from February onwards and attain its maximum in May-June. After the onset of SW-monsoon, the temperature decreases due to the presence of a cloud cover and rain. The temperature again rises in September and October and gradually declines again.

The reproductive and life span traits are directly related to the environmental characteristics. Life history varies among strains due to the diversity among *Artemia* habitats (Browne 1980; Amat 1982; Browne *et al* 1984). Growth and survival of *Artemia* are greatly influenced by temperature and salinity (Wear and Hasle 1987). According to Lenz (1987) in large temperate lakes like Mono Lake and Great Salt Lake, where annual salinity variations are small, the seasonality is determined primarily by the temperature cycle.

It was observed both in the laboratory studies and in salt pans that salinity did not play a role as important as the temperature did, in seasonal reappearance of the *Artemia* population at Korangi Creek Saltworks. The variation of salinity was considerable, i.e. 12-240 ppt in the laboratory and 85-220 ppt in the intermediate salinity ponds of saltworks during this study. Seasonality in the appearance of *Artemia* was primarily determined by temperature in the salt pans. In the laboratory, temperature never reached above 35°C and it was possible to maintain *Artemia* population throughout the year, although not with the same abundance. The concept of seasonality in a sub-tropical area like Pakistan is possibly not so strong as in the temperate region. As mentioned earlier, there was a large number of overlapping populations per year. Temperature of 23°-28°C was optimal for growth of *Artemia* population. Above this temperature survival rate was low. The observation needs further experimentation to study the effect of salinity and temperature separately and in combination on the life cycle of *Artemia.*

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