GUIDELINES FOR THE MANAGEMENT OF THE BRINE SHRIMP (*Artemia franciscana*) AT AL WATHBA WETLAND RESERVE

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Introduction

Al Wathba Wetland Reserve is located 40 km east of Abu Dhabi Island on the left side of the truck road to Al Ain. The water body extends for approximately 1.5 km in length and 0.5km in width with a maximum depth of almost two metres. Al Wathba Reserve exists primarily because it is supplied with tertiary treated waste water from the Mafraq Waste Water Treatment Plant (WWT). The salinity of the water throughout the lake is variable due to the fresh water input and because of the underlying sabkha substrate. The maximum salinity recorded in the lake is 230 ppt although typically the salinity is 180 ppt which is approximately 5 times higher than that of sea water.

The sabkha substrate and high evaporation rates have made the water body a hypersaline habitat. The only invertebrates that are able to live in this harsh habitat are brine shrimps (*Artemia fransiscana)* and occasionally blood worms (*Chironomus* sp.) that both feed on algae. Brine shrimps are the main food resource for the greater flamingos (*Phoenicopterus ruber*) as well as providing supplementary food for the other wading birds species which feed mainly on algae.

Fig. 1 Adult *Artemia* sp**.**

The life cycle of *Artemia* begins from either a dormant cyst that is extremely hard and may remain viable for few years or an ovoviviparous egg which hatches immediately. During periods of low salinity and temperature, the cysts begin to rehydrate and open to release the first stage larva which is known as a nauplius larva. The larvae will remain in this stage for about 12 hours feeding from the yolk sac before moulting to the second instar which is known as the metanaupliar stage, they remain known as metanauplii until the sixth moult when they are termed post-metanauplii; following the 12^{th} moult they are termed post-larval and by the 17^{th} moult they are regarded as adult. From the second instar onwards, they feed on small algal cells; by the time they reach an adult size of 10mm length they are able to feed on large conglomerates of algae.

Under optimum conditions of food supply and lack of stress due to increased salinity or decreased dissolved oxygen the female shrimp may produce eggs. These eggs will hatch after being released from the ovisac to produce nauplius larvae. The female shrimp can live for up to 3 months and produce up to 300 nauplii every four days under optimum conditions.

Brine shrimp inhabit hypersaline lakes and ponds where there are few aquatic predators and competitors - the salt content of these lakes may reach 250 ppt. In general, brine shrimp can survive temperatures of between 6^{o} C and 40^{o} C with an optimum breeding range of 25^{o} C to 30^{o} C. Cysts can tolerate a much wider range of temperatures (from below freezing to almost 100^{o} C). Salinity tolerance can vary for different strains of *Artemia*. Under laboratory conditions and at a temperature of between 20 to 26^{o}C, *Artemia franciscana*, which is the species that occurs at Al Wathba, can tolerate salinities of up to 260 ppt (saturation), as temperature increase tolerance to salinity decreases. At a temperature of 32^{o}C and salinity of 200ppt, survival of adult artemia is reduced by almost 70%. *Artemia* can tolerate pH ranging from 7 to 10 whilst the optimal range for cyst hatching is pH 8 to 8.5. Cyst survival is unaffected by salinity or pH.

Fig. 2 Female brine shrimps with egg sacs

The Artemia study was conducted in order to understand the relationship between the environmental conditions and brine shrimp population dynamics. The study started in early 2002 and has continued for more than one year. Water samples were collected monthly from 14 fixed sites at the surface and bottom of the water column. The parameters measured were water temperature, depth, salinity, pH, nitrite, nitrate, phosphate, Ca^{++} and Mg^{++}. Artemia adults and cysts present in the samples were counted in the laboratory under a stereomicroscope.

Purpose of the guidelines

The purpose of the guidelines is to allow decision makers to develop a management regime for the freshwater input of the lake. Appropriate management of the water input, and therefore water level, has an influence on the salinity of the lake which has a direct effect on the population of *Artemia* which in turn influences the numbers of flamingos resident and potentially breeding at the lake.

Parameters that can be controlled

The input of fresh water is the main parameter that can be controlled at the lake. Controlling the water input allows a degree of control over the salinity. Developing a regime for water input throughout the year is vital to ensure the optimum salinity for cyst hatching and subsequent population development.

The relationship between *Artemia* and salinity

Salinity is one of the most important physical factors affecting the artemia life cycle at the lake. As ambient temperature increases, the water salinity subsequently increases due to evaporation. Normally, at salinities of less than 80 ppt, *Artemia* reproduce by laying eggs, which hatch immediately upon release (such a strategy is referred to as being ovoviviparous). As the salinity increases above 80 ppt the eggs no longer hatch on contact with water, but instead become cysts; they do this by forming a hard outer shell (known as a chorion) around the egg itself. Cysts will only hatch when the salinity is less than 25 ppt. Consequently, if at some point the salinity has exceeded 80 ppt, then in order to restore the *Artemia* population, it is necessary to try to reduce the salinity to less than 25 ppt, or to at least have some parts of the lake where the salinity is less than 25 ppt.

Relationships between *Artemia* and temperature

Temperature is the other major factor that has direct effect on the population dynamics of artemia. *Artemia* are able to survive relatively high temperatures, up to 40^{o} C. However, they stop reproducing as temperatures rise above 30^{o} C. Consequently, we have to accept that as summer (May to September) approaches, natural mortality within the artemia population will increase (the summer water temperature at Al Wathba regularly exceeds 40^{o} C at 1.75m depth). During the cooler months of October to April, when the water body falls to approximately 20 ^{o} C, reproductive rate will increase, provided that salinity is less than 80 ppt and that the artemia are reproducing using the ovoviviparous strategy.

The relationship between water inputs and salinity

The fresh water input has a direct effect on salinity and water level. Fresh water input decreases the salinity of the water body whilst increasing the water level. Between May and September, when the temperature is at its maximum, water level decreases due to natural evaporation and therefore the salinity increases.

The need for all year-round water level management.

The key to ensuring maximum breeding of artemia is to manage the water level during the hottest time of the year (May to September). If the water level is low and there is no additional water input, temperature and salinity will increase and cysts will be formed. Following this, during early October when the ambient temperature has fallen, fresh water can be input to the lake in order to reduce salinity and maintain the water body at a lower temperature. This will trigger the hatching of cysts and the lake body will be at the optimum salinity and temperature for maximum reproductive rate within the artemia population. If, on the other hand, the water level remains high during the hottest time of the year, the artemia population will simply die due to temperature increase and few cysts will be formed. Furthermore, because the levels are high, it will be impossible to input sufficient fresh water from the Mafraq Waste Water Treatment Plant to trigger cyst hatching, and consequently the population will not develop.

Potential catastrophes and how to deal with them

1. Failure to reduce water level during summer (May to August).

In summer, temperature and salinity of water increases; therefore the mortality of artemia population and cyst formation will increase as well. So, failure to reduce water level during summer has an effect on water input in winter. In winter, when the temperature falls to within the optimum range required for cyst hatching, it would be impossible to put sufficient amount of fresh water into the lake in order to decrease the salinity (see: The need for all year-round water level management). It is strictly recommended to avoid any excessive water inputs to the lake during summer thus allowing it to partly dry out (by evaporation as a result of temperature increasing up to 48^{o} C). Drying the lake in summer will help towards putting sufficient amounts of fresh water in winter to enhance the hatching process. Drying of the lake will also help to combat the algal blooms that have occurred towards the end of summer, in the past.

2. Insufficient fresh water input during early winter.

Insufficient fresh water input during early winter (the beginning of the hatching and breeding season of *Artemia*) will also have an effect. Too little water input to the lake would fail to reduce the salinity and cysts will remain dormant. If the reason for too little fresh water being input is that the water levels are too high, then we recommend using pumps to lower the water level in order that fresh water can be input. Without low salinity water input, the *Artemia* population will simply not develop.

3. Salinity greater than 80 ppt throughout the lake during winter

If the salinity is greater than 80 ppt throughout the lake during winter either because of insufficient low salinity water input or because of failure to reduce water levels in summer, the cysts will not hatch and thus remain dormant. It is not necessary to reduce the salinity in the whole lake but it is important to have some parts of the lake with lower salinities (below 25 ppt) where cyst may be able to hydrate and complete their life cycle.

4. Effect of Algal blooms

Algae are known to be the main food source for *Artemia*. The algal growth will start to increase if cysts do not hatch in winter due to any of the above mentioned reasons. This situation, where the main predator of algae is absent, would drive algae to bloom in the lake which is also known as red tide. Following the bloom, algal death and subsequent decomposition deplete dissolved oxygen in the water thus making the habitat unsuitable for organisms requiring dissolved oxygen, such as brine shrimp. To avoid such a situation the lake should be dried in summer so the over growth of algae will start to die because of dehydration.

Glossary of Terms

Algal bloom	A rapid increase in the number of algal cells especially in summer.
Artemia	A small crustacean belongs to the phylum *Arthropoda* (joint-legged invertebrates).
Blood worm	The larvae of chironomid non-biting midges.
Cyst	Fertilized eggs in diapause that are surrounded by a thick shell (chorion).
Fresh water	Low salinity secondary treated waste water, from Mafraq WWT plant.
Ovoviviparous eggs	Fertilized eggs that develop into free-swimming nauplii immediately upon contact with water.

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