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Effects of temperature on behavior, growth, development and survival of young milkfish, *Chanos chanos* Forsskal

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Effects of three temperature treatments on activity, feeding, growth, development and survival of young milkfish (*Chanos chanos*) were investigated in the laboratory. Depressed temperature ($< 22.6^oC$), like hypoxial condition ($<$ 1 ppm O_2) and nightfall, decreased activity, responsiveness and food intake, while elevated temperature of up to 33^oC had the opposite effects. Growth and development were fastest in fish maintained in high test temperature ($\bar{x}$ = 29.55^oC) and followed by specimens in ambient temperature treatment ($\bar{x}$ = 26.79^oC). Those in low test temperature ($\bar{x}$ = 20.67^o) had the least growth and completely inhibited to metamorphose into juveniles during the 3 month rearing period. Growth response of fish transferred to another test temperature depended not only on present rearing temperature but also on previous acclimation temperature. Highest survival ($\bar{x}$ = 99.7%) was obtained in high temperature treatment but not significantly different ($P > 0.05$) from ambient temperature ($\bar{x}$ = 97.7%). However, survival in both higher test temperatures differed ($P < 0.05$) from low temperature treatment ($\bar{x}$ = 76.7%) (Figure 1).

The milkfish in their natural habitat or pond environment encounter daily or seasonal temperature variations which greatly influence their growth and well being. Lin (1968) reported that milkfish in Taiwan behave normally at temperatures between 20^o to 33^oC and become sluggish below 20^oC. The young milkfish in the present study, however, were still sluggish at temperatures of up to 22.6^oC. This discrepancy may be due to lower thermal experience of Taiwan specimens which provide them anticipatory adjustment to cope with lower temperatures.

Field observations also indicate that young milkfish abandon schooling behavior at night with decreased activity and responsiveness to movements and vibrations in their environment (Buri 1980). Since predation is the most probable cause of mortalities in nature and in ponds, lowering of activity and of ability to respond to stimuli whether it be brought about by nightfall or environmental stressors such as depressed temperature or hypoxial condition, would render the fish vulnerable to intense predation.

Milkfish swimming against the current when pond water is being renewed has been regarded by Schuster (1960) as a rheotactic response. According to Villaluz (1953) such habit is not observed in well oxygenated and deep ponds which are cooler than shallow ponds. A parallel

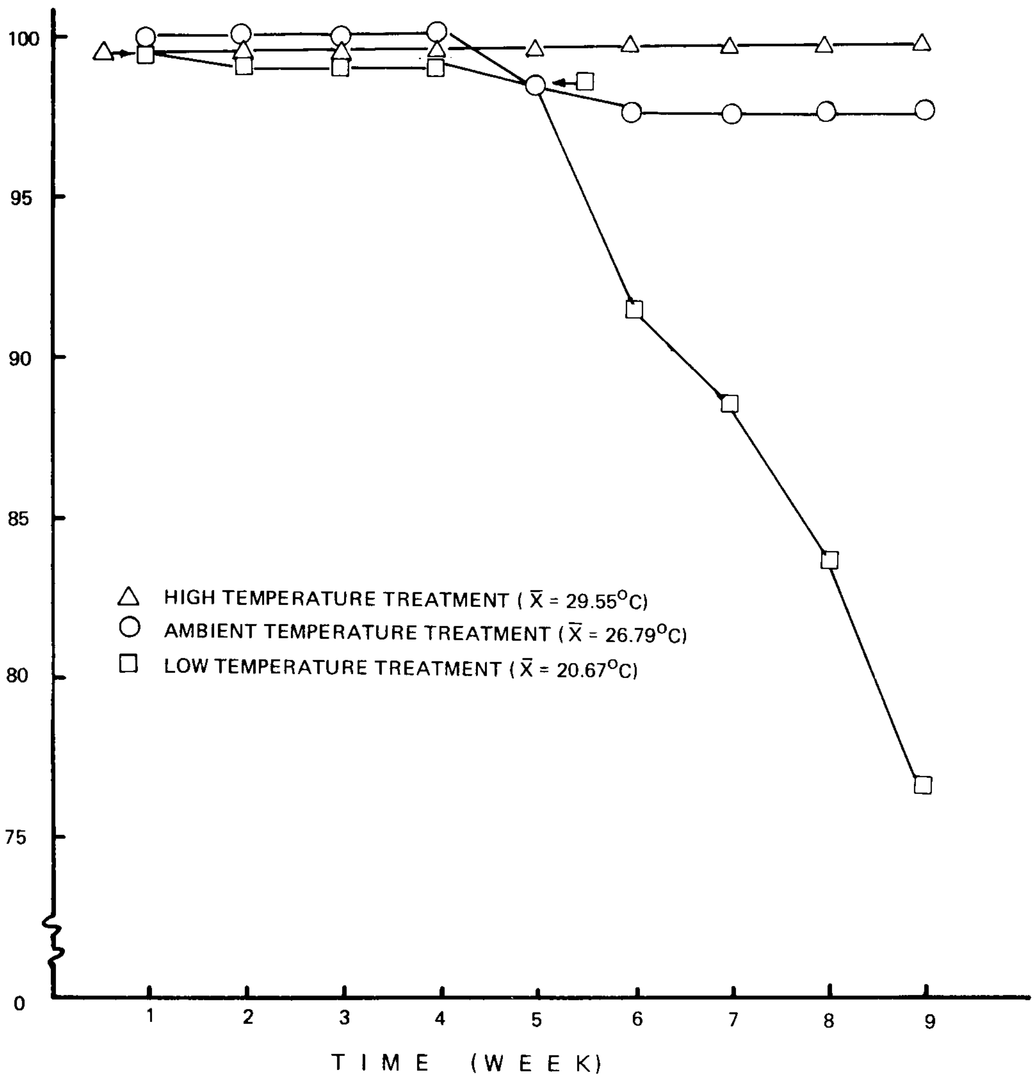

Figure 1. **Survival curves of young milkfish at various temperature treatments. There were three replicate groups at each treatment. Survival rate in high temperature not significantly different at $P < 0.05$ from ambient temperature but both treatments significantly different at $P < 0.05$ from low temperature.**

situation has been observed in the present experiment when the fish crowd to source of aeration under hypoxial condition while generally ignoring the same when rearing water is newly replaced. This, coupled with increased activity of fish when transferred to higher or lower temperature than acclimation temperature, indicates active avoidance of environmental stressors and not a response to water current per se.

In the light of current observations, it is apparent that milkfish are opportunistic feeders capable of taking in a variety of food and taking them from several different situations. They feed by preference, in the present case, *Brachionus,* but turn to other food and even their own faeces when their preferred food has been exhausted.

Milkfish in higher temperatures have the fastest food intake. Since the rate of digestion is also highly temperature dependent and can be measured by time elapsing between food intake and defecation (Kapoor *et al.* 1975), the primary process of digestion in the milkfish therefore increased by a factor of about 2 times for a 10°C change. The effect on growth is clearly illustrated by comparing the monthly means of length and weight of specimens maintained in low ($\bar{x}$ = 20.67°C) and high ($\bar{x}$ = 29.55°C) test temperatures. Except in the first month of rearing, mean linear measurements of fish held in high temperature are roughly 2 times greater than those maintained in low temperature and monthly mean weight about 10 times greater. Such effect was also noticed when milkfish were transferred to lower or higher test temperatures in the third month of rearing.

The approximate temperature limits for successful development from larval to juvenile periods appear to be 23.7 to 33°C. Rate of development is faster at high temperature and dependent on length rather than age of fish. Since increasing fish biomass would enhance growth and development rate related to length of fish, interaction between temperature and fish biomass on development of young milkfish is expected although not demonstrated in the present study.

Results also show that daily exposure of early transition stage to increasing temperature at 1°C per hour would be lethal if the temperature is increased from 25.8 to 34°C. This means that the time of exposure is more critical to survival than the magnitude of the temperature change. However, a very high recovery potential from thermal stress is indicated since all the affected fish except one recovered completely, assuming normal activity and feeding within 30 minutes of transfer to 27°-29°C.

Elevated temperature stimulates appetite and digestive efficiency in high temperature treatment. The absence of this stimulating factor in ambient temperature and the depressive effect of low temperature on appetite may have resulted into poor food utilization. Burrows (1972) states that at higher temperature diet utilization efficiency is increased and when food intake is high, the vitamin content per unit weight of diet can be lower than when the intake is reduced. Based on this, it appears that "nutritional stress" may have caused mortalities in ambient and low temperatures. Moreover, the symptom of the disease strongly suggest vitamin deficiency considering that all dead fish in low temperatures were suffering from scoliosis and lordosis. These conditions are attributed by Halver (1972) as vitamin C deficiency. The detrimental effect of overcrowding, however, cannot be precluded. It can be pointed out that when stocking density was decreased no mortality occurred and the fish in all treatments were healthy at the end of the experiment.

The methods and results of the current experiment can be applied to develop a land-based mass-production technology in rearing milkfish fry to fingerlings and no insurmountable difficulties are foreseen. The advantages of the new system would include the following:

Mortalities due to predation and unfavorable environment which are the primary causes of low survival in traditional nursery ponds can be eliminated;

Milkfish fry can be grown into fingerlings at high density of 10,000 pieces/m^3. The area required to produce 1,000,000 fingerlings for example would be reduced to 200 m^2 instead of 10,000 m^2 or more as practiced presently;

Growth and size variation can be controlled through fish biomass and/or thermal manipulation;

Pre-conditioning of fish to salinities obtained in ponds or other bodies of water where the fish would be stocked can be facilitated. This would prevent stress and minimize mortalities after stocking. High mortality of about 36% has been reported to occur within 3 days of stocking milkfish fingerlings in Laguna de Bay (Smith, 1981); and,

Fish can be held indefinitely without impairing their well being and possibly improve their growth potential.

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