8. GENERAL DISCUSSION

Indiscriminate discharge of sewage and domestic wastes has been found to enrich water bodies and encourage the prolific invasion and spread of aquatic weeds of which, water hyacinth is the most noxious one. River Tamirabarani is no exception to this, the same is the situation prevailing in the river. Generally the physico chemical parameters do not exceed much the standard set for drinking water and water for domestic usage. However, the biological criterion exceeds the standards set and the nitrate and phosphate level par the eutrophication level. Dissolved oxygen in river Tamirabarani was in the range of 3.90 to 6.26 mg/l. It is suggested that the level of oxygen 3 to 5 mg / l is indicative of healthy state of aquatic systems and values below 3 mg / l are hazardous and may lead to lethal consequences (Ellis *et al.,* 1948). Hence this makes it clear that the river can hold in itself a healthy population of biotic communities. values are high (Sharma, 2001; Singhai *et al.* 1990). According to Vollenweidder (1968) values much lower than 1.0 mg / l PO_4 is sufficient for eutrophication. Water samples collected from river Tamirabarani were found to contain phosphate in the range of 0.11 mg/l to 0.43 mg/l. Nitrate-nitrogen concentration beyond 0.15 mg/l is indicative of eutrophication (Sawyer, 1966). It is obvious that nitrate level in river Tamirabarani is much beyond the above said, indicating the greater risk of eutrophication and invasion of aquatic macrophytes. Added to this are further problems when, by a series of reactions, nitrates are converted by N-nitrogen compounds that act directly as carcinogenic agents as reported by (Harilal *et al.,* 2004).

Results of the laboratory studies show that *N. eichhorniae* caused more biomass reduction during summer than during winter (Table 5.04). Similarly, *N. bruchi* caused more damage during winter, but in summer damage caused was comparatively lower (Table 5.05). This might be because; the adults of *N. eichhorniae* were tolerant to warmer temperatures and fed more than *N. bruchi* and *N. bruchi* was more tolerant to cooler temperatures (Perkins 1974). Englemann (1970) also documents that environmental factors may alter the feeding rate of an insect. When the two species were put in combination biomass reduction was quite moderate. The present study also reveals that when tested in different numbers, the optimum number for causing effective damage was 4 weevils per plant. This is evidenced from Tables 5.07. and 5.08. During summer 12 *N. eichhorniae*/3 water hyacinth plants have brought about a reduction of 38.70%, which is the maximum among all treatments tested for. At densities above and below this number reduction percentage is lower. The reason might be that sufficient damage could not be effected with lower number of weevils and at higher numbers there might be competence with each other, which might affect feeding rate. Forno (1981) and Goyer and Stark (1984) also report that damage by *N. eichhorniae* at low densities does not kill the plant, but reduces the growth rate and fecundity. *N. eichhorniae* adults prefer feeding on young leaves, but it appears that eggs are not laid in, and young larvae do not usually feed on young leaves (Center, 1987). Females scrap more than the males. Males are smaller than females in size and food consumption is also lesser compared to females. De Loach and Cordo (1976) also report that female scrap more than the males. It may be stated that increased feeding by females may be to obtain more energy for their fecundity.

Study on drought tolerance indicates that *N. bruchi* and *N. eichhorniae* can survive for up to 26 and 49.6 days (Table 6.19) in the presence of only food. This means that the weevils can find sustenance in dry tanks by hiding among the weed debris. However, reduced survival rate of *N. bruchi* could be due to higher transpirational rates of structural or physiological differences like regulation of spiracular openings (Jayanth, 1987). With attribute to tolerance of drought, these weevils are suitable candidates for biological control of water hyacinth even in water bodies that become dry during summer, which is a common phenomenon in many parts of India. Techniques for determining the safety of bioagent, in terms of its fidelity towards the use of the target plant, consist mainly of bioassays of host specificity (Pemberton, 2000). In the present study the two weevil species showed differences in their avoidance behaviour as seen from these results (Table 6.22 and Table 6.23). Water extracts of all plants showed high repellency against the weevils except pomgranate and paddy. However, weevils do not feed and oviposit on them and hence are not pests. This may be due to presence of more amount of repelling chemicals than the fresh leaves. De Loach (1976) reported that feeding of *N. eichhorniae* was greater on *E. crassipes* than on any of the other plants he tested. He further stated that the weevils preferred to feed on other species belongs to the family Pontederiaceae next to *E. crassipes*. In the present study, the behaviour, feeding and fecundity of *N. bruchi* and *N. eichhorniae* were studied. Feeding scars and eggs were found only on the water hyacinth leaves. De Loach (1976) concluded that *N. bruchi* is sufficiently host specific to introduce into the U.S. to control water hyacinth, based on ovipositional preference and the feeding of adults and larvae. *N. eichhorniae* which was imported into India in

1982 and found to be specific to water hyacinth (Nagarkatti and Jayanth, 1984) has already established under field conditions in Bangalore.

Water hyacinth mite has brought about a biomass reduction of 12.59% (Figure 6.04). It can be clearly stated that mite alone cannot cause complete damage to water hyacinth plants but they can serve as a biocontrol agent along with the weevils, *N. eichhorniae* and *N. bruchi.* Snail has been able to reduce water hyacinth biomass by 48.5%. Slightly larger group has been able to cause about 43 – 60% reduction (Table. 6.10). The snail has been found to feed on leaves and petioles of water hyacinth, when leaves and petioles were damaged, aerenchymatous cells in petioles decayed rapidly due to water logging (Murugesan *et al.,* 2001). *Gesonula punctifrons* has been found to cause considerable damage to water hyacinth plants (Table 6.12). However, from the host preference study, *Gesonula punctifrons* has been found to consume agricultural crops. An organism can be used as biocontrol agent only when it is host specific. When this grasshopper is released as the biocontrol agent it is capable of causing damage to the economically important agricultural and horticultural crops in the locality and not host-specific and hence cannot be a biocontrol agent. In the present study grasscarp has been able to bring about reduction of 27 – 72% (Table 6.13).

The decline was manifested by decrease in total biomass. Along with the decline in total biomass were significantly smaller plant sizes, lower number of living leaves and lower daughter plants. For the first three months number of adult weevils recovered on plants were low and sporadic. This was partly due to the low number of weevils released and the time taken for the weevil population to increase. After three months (when the first generation weevil adults began to emerge) number of adults collected per plant began to increase. Throughout the area the leaves of virtually every water hyacinth plant are scarred by the feeding marks of *Neochetina* adults, plants are much less vigorous and have a lower weight. Adult feeding was heavy and it was not unusual to observe completely girdled petioles and large areas of the laminar cuticle removed. This type of feeding ruptures the leaf surface and causes increased desiccation, browning and curling of the affected lamina (Center and Durden, 1986). Another affected area was the plant crown where numerous larvae and larvae feeding galleries occur. Decrease in petiole length and root length and number of plants per meter square closely followed increases in weevil population. Cassani *et al.* (1981) also document that the arthropods alone significantly reduced the shoot height by about 50%. When the weevil attacked floating plants number of leaves per plant and the petiole diameter were reduced in almost all seasons. Generally arthropod damages correlated with reduction of lamina and petiole sizes and number of live leaves per plant, an indication of stress due to the biotic agents. Under severe weevil damage, the root length was reduced (Charudattan *et al.*, 1978).

To combat the extensive proliferation of water hyacinth various strategies can be followed, but the success in implementing the particular method relies on the economic and environmental feasibility. Considering these, biological control is cheap and the method is best suited for the developing countries. The initial investment of money is for the procuration of biocontrol agents and to monitor their establishment in the field. Moreover the greatest advantage in this method is that, once the biocontrol agents are released they multiply very quickly along with the extensive proliferation of water hyacinth resulting in suppression of the weed growth after complete establishment and hence said to be a self-perpetuating strategy.

The danger posed by water hyacinth is already felt to great extent. The economic and environmental consequences are felt to a greater extent in seriously infected water bodies. Control measures are needed to tackle the crisis with water hyacinth. Three main strategies can be adopted: First is to get rid of the really gross accumulation of the weed as quickly as possible; secondly to accelerate the multiplication of highly efficient bio-control agents and third is to put money into research on water hyacinth growth, propagation rates and dispersal dynamics. This would bring the water hyacinth problem under control. The present study emphasizes the interactions of the Biocontrol agents with the water hyacinth plants and their efficiencies in reducing their biomass and the findings therefore pertain to management of water hyacinth in a sustainable way.