CONCLUSIONS

During the survey conducted between November 1996 and June 2001, nine species of frogs and toads (Amphibia: Anura) belonging to eight genera and four families, viz., Microhylidae, Ranidae, Rhacophoridae and Bufonidae were identified. These include Microhyla ornata, Kaloula pulchra, Euphlyctis cyanophlyctis, Limnonectes limnocharis, Hoplobatrachus tigerinus, Rana taipehensis, Polypedates leucomystax, Bufo melanostictus and Rana sp. (which is yet to be identified). A total of 41 sites were surveyed for collection of larval and adult anurans. These included temporary and permanent freshwater systems, ephemeral pools and slow flowing streams. Other sites included low lying paddy fields, tea, teak or rubber plantations, human habitations, forests and wastelands in urban, suburban and rural areas, spread over the three districts of
Cachar, Karimganj and Hailakandi in South Assam, Northeastern India.

However, in the recent years this important group of organisms has been facing serious threats in this area due to various anthropogenic activities. The threats can be summarised as:

1. Habitat destruction due to urbanisation and increasing human settlements, reclamation of wet lands for urban construction, improper waste disposal, construction of roads, bridges etc. and rampant deforestation.

2. The use of chemical fertilizers, pesticides and fungicides in agricultural fields and tea gardens.

3. Indiscriminate killing of frogs and toads for food, biological experiments and use in traditional medicine by practitioners of alternative medicine.

4. Lack of knowledge regarding the utility of anurans in the ecosystem and lack of general awareness.

From the present study, a status can be assigned to these nine anurans. *Microhyla ornata, Rana taipehensis* and *Kaloula pulchra* are 'rare', *Hoplobatrachus tigerinus* is 'vulnerable and possibly rare'; *Euphlyctis cyanophlyctis, Limnonectes limnocharis* and *Bufo melanostictus* are 'abundant', *Polypedates leucomystax* is 'common' and *Rana* sp. is 'data deficient' at this stage. Some difference is observed between the status of these anurans at the national level and that recorded in the Barak Valley region.
The morphometry of tadpoles and adults showed some significant variations within the species. Among the tadpoles studied (viz., *B. melanostictus, L. limnocharis, E. cyanophlyctis, Rana sp.* and *M. ornata*) the largest was *E. cyanophlyctis* and the smallest was of *M. ornata*. The study revealed variations in tail depth, height as well as length when compared to the total length. *E. cyanophlyctis* tadpoles were found to have the strongest and most muscular tail. Variations were also observed in mouth parts like labial tooth row formula; position and size of the eyes, etc. *L. limnocharis* complex showed significant morphological variations similar to that observed in the Japanese population (Kuromoto, 1968) and in Orissa (Mohanty et al., 1995). Variations were also observed among the adults in snout-vent length, head length, head width, leg length, webbing between digits, position of eye etc. A positive correlation was also noticed between snout vent length and head width and snout vent length and leg length.

The spawning behaviour, choice of breeding site and duration of larval life also exhibited distinct variations among the species. *M. ornata* had the shortest larval duration of 30-34 days, followed by *P. leucomystax* (40 days). The duration in *B. melanostictus, L. limnocharis* and *Rana sp.* varied between 69 days to 74 days. Environmental factors like rainfall, temperature and relative humidity probably influenced the larval duration as was also seen by several other workers (Parker, 1960; Savage, 1961; Alcala, 1962; Dimmitt and
Ruibal, 1980). Shorter duration of larval period is a characteristic feature of tropical anurans (Heyer, 1973) which is prompted by unpredictability of habitats, risk of predation and environmental vagaries.

Analysis of the gut content of tadpoles of 4 anurans (viz., *B. melanostictus*, *M. ornata*, *L. limnocharis* and *E. cyanophlyctis*) showed them to be continuous feeders as was also reported earlier (Savage, 1951, '61; Jenssen, 1967). The herbivore-detritivore anuran larvae showed a distinct preference for detrital material, as revealed by its high percent abundance, percent frequency of occurrence and percent area occupied. *E. cyanophlyctis* showed the highest preference for detritus presumably because they are bottom dwellers, as was also shown by Khan and Mufti (1995). A certain degree of selective feeding on different algal genera available was also observed with low dietary overlap between certain species.

In the adult anurans (viz., *B. melanostictus*, *L. limnocharis* and *E. cyanophlyctis*) there was a general preference for insects. Ants were the most abundant and frequent in *B. melanostictus* as well as in *L. limnocharis*. Juveniles of *B. melanostictus* were found to feed significantly more on mites than the adults. Such preference was also observed in *Pseudophryne corroboree* (Pengilley, 1971) and *Dendrobates pumilio* (Donnelly, 1991). *E. cyanophlyctis* and *L. limnocharis* were seen to feed on aquatic organisms. From the present investigation it can be stated that *B. melanostictus* and
L. limnocharis are ant specialists while E. cyanophlyctis was a generalist. High degree of niche overlap was also revealed between the species. Size of prey was also an important factor with all the species preferring smaller prey items. The number and percentage of empty gastrointestinal tract reflected that B. melanostictus was a voracious feeder with no empty tract and largest number of prey items per stomach. This indicated greater foraging success in B. melanostictus as compared to E. cyanophlyctis and L. limnocharis. Therefore, from the present findings it can be concluded that B. melanostictus and L. limnocharis are widely foraging types and E. cyanophlyctis is a sit and wait forager.

The toxicological experiments revealed that endosulfan is highly toxic as revealed by the high mortality rate as well as behavioural changes like bending of the body at the body tail junction, erratic swimming, tremor and reduction in the body-tail length. M. ornata was found to be the most sensitive, B. melanostictus the most tolerant and L. limnocharis was intermediate. Copper was also found to be detrimental to tadpoles when the concentration exceeded a certain concentration. Behavioural changes like lethargy and reduction in activity in B. melanostictus tadpoles was also observed. A progressive decline in growth rate with increasing concentration of copper was observed in B. melanostictus tadpoles. However, B. melanostictus tadpoles were more resistant to copper than endosulfan which may be due to
the enhanced metallothionein and metallothionein-like protein synthesis, which is believed to provide a protective role against the toxic effects of a number of elements like copper, cadmium and zinc (Hamilton and Mehrle, 1986; Rainbow and Dallinger, 1993; Sharma and Sharma, 1995).

From an ecological point of view it is therefore possible to conclude that endosulfan is extremely toxic to anuran tadpoles both in acute and chronic toxicity tests. The tadpoles of *B. melanostictus* were found to be slightly more resistant to cupric chloride both in short and long term exposure.

Considering all the threats it becomes essential to evolve various appropriate conservation and monitoring approaches. It is felt that creating awareness among the local people is essential for effective conservation. Redesigning the course curriculum and making it supportive to conservation practices is necessary. Remote sensing techniques may be used to monitor degradation of wetlands and other aquatic bodies as well as the loss of valuable forest cover. Research activities developing techniques for restoration of the endangered anuran species can also help to save this interesting and important group of vertebrates.