9. SUMMARY

Turtles are ancient animals that evolved into shelled form over 200 million years ago. Currently, about 326 species in 95 genera are recognized. The highest turtle diversity occurs in the Asian sub-continent including the northeastern part of India. 26 species of non-marine chelonians have been reported from India, a majority of which are found in the northeastern region of India (Pawar and Choudhury, 2000). At present, there are 28 species of freshwater turtles and tortoises in India (CFH/MCBT, 2006). The northeastern region of India has the highest species diversity with 24 species or 25 taxa.

The Southeast Asian Box Turtle *Cuora amboinensis* belongs to the family Geoemydidae. It is globally red-listed as vulnerable (IUCN, 2009) and it is feared that the species might become threatened with extinction unless the international trade for consumption as meat is regulated. Asia’s turtle fauna is highly threatened due to over-harvesting for food, medicine and the international pet trade. Genetic variation at species level helps to identify the taxonomic units and to determine the species distinctiveness that can provide essential information for conservation, systematics, ecological and evolutionary studies. Molecular studies can play an important role in conservation policy by identifying distinct evolutionary lineages of turtles, and directing limited conservation resources towards finding and protecting these in the wild.

Turtles and tortoises in the state of Manipur in the northeastern region is relatively unexplored. Very few records are available on the turtle fauna of the state which include Shamungou (1982; 1987), Arunkumar and Singh (1999), Salam (2006), Linthoi and Sharma (2009), Robindro and Khuraijam (2012) and Linthoi and Sharma (2013). The present study has been able to investigate and inventorize the freshwater turtle faunal diversity of the state with special reference to the Malayan Box Turtle *Cuora amboinensis* in Loktak lake of Manipur and adjoining districts.

Loktak lake the lone Ramsar site in Manipur state have been endowed with biodiversity richness. It plays an important role in the ecological and economic security of the state. The primary study area was in the Loktak lake and it’s adjoining areas in
Bishnupur district. The other study sites included potential sites in the nine districts of Manipur viz., Imphal East, Imphal West, Thoubal, Bishnupur, Chandel, Churachandpur, Senapati, Tamenglong and Ukhrul districts.

During the present investigation, 10 species of turtles and tortoises were documented in the state of Manipur with a total of 179 individuals of turtles and tortoises belonging to three families. Altogether, 3 families, out of which Geoemydidae (n=151) with 6 species; Testudinidae (n=16) with 2 species and Trionychidae (n=12) with 2 species were documented. The Tamenglong district was found to have the highest species diversity with 7 species.

During the status assessment, the main threats identified were hunting or fishing for meat, followed by small scale trade in fish markets, pets, accidental encounters, deforestation, medicinal utility and eventually by other factors like forest fires during cultivation, predation, superstitious beliefs and symbolism etc.

*Cuora amboinensis* turtle laid eggs during September to November of clutch sizes 1, 3 and 3 respectively in the wild and a clutch size of 5 and 4 in captivity. During the present investigation the egg size in the natural habitat as opposed to the captive ones was found to be relatively smaller which may be attributed to the larger populations in the wild stock compared to the captive held colonies. The sex ratios recorded in this investigation was found to be unequal and male biased with 51 males and 35 females of the turtle *Cuora amboinensis*. The sex ratio for the Malayan box turtle during the present investigation was found to be 1.46:1, which did not deviate significantly from a 1:1 ratio. The habitat preference of the turtle was found to be aquatic and generally encountered in rice paddies, marshes, shallow ponds and even regularly intruding in the urban areas.

The highest availability of the turtles was observed during the monsoon season with 32.7% frequency of encounters, followed by the post monsoon season with 19.8%, the pre-monsoon with 16.7% and the least in the winter season with 0.4%.

Environmental parameters influence the distribution, abundance and activity of animals and plants. Study of the physico-chemical water quality parameters in and around the Loktak lake during the pre-monsoon, monsoon, post-monsoon and winter months could serve as important monitoring indicator for breeding and habitat optimality.
suitability studies and overall maintenance of ecosystem health. Water temperature ranges from 9°C to 23°C, dissolved oxygen 5.7 mg/l to 9.3 mg/l, free CO₂ 3.3 mg/l to 6.4 mg/l and total alkalinity ranges from 32 mg/l to 62.1 mg/l. Elements like Iron, Chloride, Sulphate, Magnesium, Calcium and Iron were also detected and assessed. Nutrients concentrations, *viz.*, Chloride, Sulphate, Calcium and Magnesium did not follow a definite pattern at any particular location. The pH of water ranged between 6.2 to 8.3 at all the sampling sites in different seasons. Dissolved oxygen varied with water temperature and is depleted during monsoon season when temperature is on higher side.

The ultimate controlling factor is the temperature that influence upon the nesting. Further, the rainfall has also proved to be a major influencing factor in nesting preparation and pattern. The reproductive traits within the populations of turtles are known to be relatively plastic and are most likely due to the changing environmental conditions.

Turtles have been the subject of numerous morphometric and growth studies. Morphometrics are commonly used to aid in identification of sex as well as age, growth, and other characteristics like colour variation. In *Cuora amboinensis* the size dimorphism between the male and female is quite prevalent. The highest SCL during the present investigation was recorded for two wild caught females with 212mm and the highest recorded male SCL of 211mm was measured during the study period.

Importance of fecundity as a factor that influence the body size in females favor them to produce more offspring. An annotated list of the turtles and tortoises occurring in the ex-situ repository of the state at the Manipur Zoological Gardens (MZG) was also made. Alltogether, 50 individuals of turtles and tortoises are housed at the MZG. The Malayan Box Turtle, *Cuora amboinensis* having a mean SCL of 138mm and a mean SCW of 108mm with a total number of 29 species is found to be the most abundant in captivity, followed by *Cyclemys gemeli* having a mean SCL of 152mm and a mean SCW of 116mm with 8 individuals.

Sexual size dimorphism is common in both plants and animals which in fact reflect the adaptation of male and female to their different reproductive activities. The Mann-Whitney U test has signified the size differences in terms of SCL, SCW, SH and BW in the investigation. *C.amboinensis* and *C.gemeli* provided identical results with
significant differences in the SCL, SCW and BW parameters. However, *A. cartilaginea, M. emys* and *I. elongata* could not reproduce any significant differences as such.

The study of allometric growth showed positive allometry with the parameters SH/SCL to SCL and BW/SCL to SCL in the *C. amboinensis* turtle.

The present study investigated the dietary role of wild caught *Cuora amboinensis* and overall diet preferences in captivity. Additional dietary notes on few of the other wild caught turtle species were also recorded during the study period. Alltogether, 10 females, 10 males and 5 wild caught juveniles that provided both stomach and faecal samples were used during the present investigation. The overall dietary composition was primarily comprised of plant materials at 88% and 84% in the stomach and faecal analysis thereby confirming it’s herbivory preferences. However, the juveniles were found to be relatively carnivorous in dietary preferences. The present study may infer that absolute carnivory or herbivory is low in *C. amboinensis* and maybe graded as an opportunistic omnivore.

The knowledge of genetic background of a species and its population structure is crucial for success in breeding, management and conservation programs. The present investigation involved the evaluation of genetic diversity within six samples of *Cuora amboinensis* available in Manipur state and one from Assam state based on the RAPD technique. The polymorphism levels observed in the six sample size of this study was much higher which ranges from 33.33% to 58.33% against the low RAPD polymorphism (4.5%) in Blanding’s turtle. However, in various snake species the mean band frequency was 47% in eight Egyptian snakes; 76% in black rat snakes. Thus, the range variation of the investigation is very much satisfactory with a very small size. The present investigation on the genetic diversity of *C. amboinensis* might be beginning and might provide several clues in resolving many of the conservation related problems.