Chapter 4
Results
CHAPTER 4

RESULTS

4.1 Diversity and distribution of turtles in certain districts of Manipur

Diversity and distribution of turtles were studied in 4 valley districts (Imphal East, Imphal West, Thoubal and Bishnupur) and hilly Churachandpur district of Manipur during 2011-2014. During three years of field work, 98 no. of individuals of 8 different species of 7 different genus from 3 families were located. The species were Cuora amboinensis, Cuora mouhotii, Cyclemys dentata, Melanochelys trijuga, Amyda cartilaginea, Nilssonia hurum, Indotestudo elongata and Manouria emys. C. amboinensis was obtained the highest number of individuals and was found in all 4 districts of the central valley of Manipur. M. emys, I. elongata and C. mouhotii were found only in hilly district of Churachandpur. C. amboinensis was found only in valley districts. Some species like C. dentata, A. cartilaginea, N. hurum and M. trijuga were found in both valley and hill districts. The details of distribution of all the species were given in detail below:

All the families of the turtle species found in the Manipur during the present study falls under suborder Cryptodira and have the basic taxonomical classification.

Kingdom: Animalia; Phylum: Chordata; Class: Reptilia; Order: Testudines; Suborder: Cryptodira
Table 4.1.1: Distribution of *Cuora amboinensis* in central valley districts

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>Dist</th>
<th>Habitat type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>M Canchipur</td>
<td>780</td>
<td>24°44'33.20&quot;N 93°56'44.55&quot;E</td>
<td>IE</td>
<td>Imphal river</td>
</tr>
<tr>
<td>2.</td>
<td>M Canchipur</td>
<td>779</td>
<td>24°44'33.76&quot;N 93°56'40.13&quot;E</td>
<td>IE</td>
<td>-do</td>
</tr>
<tr>
<td>3.</td>
<td>F Urup</td>
<td>788</td>
<td>24°43'13.87&quot;N 93°58'11.99&quot;E</td>
<td>IE</td>
<td>Irir river</td>
</tr>
<tr>
<td>4.</td>
<td>F Iroisenba</td>
<td>783</td>
<td>24°48'24.95&quot;N 93°53'15.65&quot;E</td>
<td>IW</td>
<td>paddy field</td>
</tr>
<tr>
<td>5.</td>
<td>F Canchipur</td>
<td>779</td>
<td>24°45'13.23&quot;N 93°51'22.11&quot;E</td>
<td>IE</td>
<td>paddy field</td>
</tr>
<tr>
<td>6.</td>
<td>F Nilakuthi</td>
<td>791</td>
<td>24°53'08.02&quot;N 93°55'11.94&quot;E</td>
<td>IE</td>
<td>Imphal river</td>
</tr>
<tr>
<td>7.</td>
<td>F Kongba</td>
<td>782</td>
<td>24°47'11.95&quot;N 93°57'42.30&quot;E</td>
<td>IE</td>
<td>Kongba</td>
</tr>
<tr>
<td>8.</td>
<td>M Hiyangthang</td>
<td>775</td>
<td>24°43'08.51&quot;N 93°53'55.48&quot;E</td>
<td>IW</td>
<td>Nambul river</td>
</tr>
<tr>
<td>9.</td>
<td>F Hitanthang</td>
<td>776</td>
<td>24°43'10.31&quot;N 93°54'02.95&quot;E</td>
<td>IW</td>
<td>-do</td>
</tr>
<tr>
<td>10.</td>
<td>F Phoubackchou</td>
<td>770</td>
<td>24°32'36.00&quot;N 93°51'25.31&quot;E</td>
<td>IW</td>
<td>Loktak lake</td>
</tr>
<tr>
<td>11.</td>
<td>Ju Phoubackchou</td>
<td>769</td>
<td>24°32'51.74&quot;N 93°51'24.62&quot;E</td>
<td>IW</td>
<td>-do</td>
</tr>
<tr>
<td>12.</td>
<td>F -do</td>
<td>769</td>
<td>-do</td>
<td>IW</td>
<td>-do</td>
</tr>
<tr>
<td>13.</td>
<td>M -do</td>
<td>769</td>
<td>-do</td>
<td>IW</td>
<td>-do</td>
</tr>
<tr>
<td>14.</td>
<td>M Phoubackchou</td>
<td>769</td>
<td>24°32'35.38&quot;N 93°51'30.76&quot;E</td>
<td>IW</td>
<td>-do</td>
</tr>
<tr>
<td>15.</td>
<td>F Lamphelpat</td>
<td>778</td>
<td>24°49'06.08&quot;N 93°55'03.02&quot;E</td>
<td>IW</td>
<td>Lamphelpat</td>
</tr>
<tr>
<td>16.</td>
<td>M Naoremthong</td>
<td>783</td>
<td>24°48'26.93&quot;N 93°54'50.55&quot;E</td>
<td>IW</td>
<td>Nambul river</td>
</tr>
<tr>
<td>17.</td>
<td>Ju Patsoi part II</td>
<td>779</td>
<td>24°47'14.44&quot;N 93°51'24.15&quot;E</td>
<td>IW</td>
<td>paddy field</td>
</tr>
<tr>
<td>18.</td>
<td>F Laphupat tera</td>
<td>769</td>
<td>24°27'39.09&quot;N 93°51'18.93&quot;E</td>
<td>IW</td>
<td>Drain</td>
</tr>
<tr>
<td>19.</td>
<td>F Laphupat tera</td>
<td>769</td>
<td>24°28'11.64&quot;N 93°51'47.31&quot;E</td>
<td>IW</td>
<td>-do</td>
</tr>
<tr>
<td>20.</td>
<td>M Phubala</td>
<td>769</td>
<td>24°32'06.97&quot;N 93°45'55.03&quot;E</td>
<td>BPR</td>
<td>Loktak lake</td>
</tr>
<tr>
<td>21.</td>
<td>M -do</td>
<td>769</td>
<td>-do</td>
<td>BPR</td>
<td>-do</td>
</tr>
<tr>
<td>22.</td>
<td>Ju Phubala loktak shore</td>
<td>769</td>
<td>24°32'13.91&quot;N 93°45'47.05&quot;E</td>
<td>BPR</td>
<td>-do</td>
</tr>
<tr>
<td>23.</td>
<td>M Keibul heiga</td>
<td>769</td>
<td>24°29'12.43&quot;N 93°49'29.36&quot;E</td>
<td>BPR</td>
<td>KNLP</td>
</tr>
<tr>
<td>24.</td>
<td>F Keibul heiga</td>
<td>769</td>
<td>24°29'47.11&quot;N 93°49'46.44&quot;E</td>
<td>BPR</td>
<td>-do</td>
</tr>
<tr>
<td>25.</td>
<td>Ju -do</td>
<td>769</td>
<td>-do</td>
<td>BPR</td>
<td>-do</td>
</tr>
<tr>
<td>26.</td>
<td>F Ningthoukhong</td>
<td>769</td>
<td>24°34'44.03&quot;N 93°45'55.67&quot;E</td>
<td>BPR</td>
<td>Loktak lake</td>
</tr>
<tr>
<td>27.</td>
<td>M Khoijuman khullen</td>
<td>772</td>
<td>24°35'39.01&quot;N 93°47'08.79&quot;E</td>
<td>BPR</td>
<td>Loktak lake</td>
</tr>
<tr>
<td>28.</td>
<td>M Toubul</td>
<td>769</td>
<td>24°37'09.67&quot;N 93°48'14.16&quot;E</td>
<td>BPR</td>
<td>paddy field</td>
</tr>
<tr>
<td>29.</td>
<td>F Thanga</td>
<td>769</td>
<td>24°29'56.86&quot;N 93°45'55.67&quot;E</td>
<td>BPR</td>
<td>Loktak lake</td>
</tr>
<tr>
<td>30.</td>
<td>F Lilong</td>
<td>779</td>
<td>24°42'13.55&quot;N 93°55'11.57&quot;E</td>
<td>TBL</td>
<td>Imphal river</td>
</tr>
<tr>
<td>31.</td>
<td>F Lilong</td>
<td>779</td>
<td>24°42'14.00&quot;N 93°54'52.85&quot;E</td>
<td>TBL</td>
<td>-do</td>
</tr>
<tr>
<td>32.</td>
<td>M Irong Ichil</td>
<td>780</td>
<td>24°38'22.60&quot;N 93°55'09.37&quot;E</td>
<td>TBL</td>
<td>Imphal river</td>
</tr>
<tr>
<td>33.</td>
<td>M Arong</td>
<td>770</td>
<td>24°26'45.14&quot;N 93°53'50.46&quot;E</td>
<td>TBL</td>
<td>Pumlen lake</td>
</tr>
<tr>
<td>34.</td>
<td>F -do</td>
<td>771</td>
<td>-do</td>
<td>TBL</td>
<td>-do</td>
</tr>
<tr>
<td>35.</td>
<td>F Arong</td>
<td>771</td>
<td>24°26'33.00&quot;N 93°53'53.43&quot;E</td>
<td>TBL</td>
<td>-do</td>
</tr>
<tr>
<td>37.</td>
<td>Ju Tokpaching</td>
<td>771</td>
<td>24°25'50.33&quot;N 93°52'59.18&quot;E</td>
<td>TBL</td>
<td>-do</td>
</tr>
<tr>
<td>38.</td>
<td>M Nungpakthabi</td>
<td>776</td>
<td>24°25'30.81&quot;N 93°53'22.07&quot;E</td>
<td>TBL</td>
<td>Pumlen lake</td>
</tr>
</tbody>
</table>

*Cuora amboinensis* was located from central valley only. Elev(msl): Elevation mean sea level is given in metres; Dist: District; M: Male; F: Female; ju: Juvenile; Coordinates are given in degrees, minutes, and seconds; KNLP: Keibul Lamjao National Park; IE: Imphal East; IW: Imphal West; TBL: Thoubal; BPR: Bishnupur
Table 4.1.2: Distribution of *Cyclemys dentata* in 5 districts of Manipur

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>District</th>
<th>Habitat type</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>F Keirao</td>
<td>783</td>
<td>24°44'18.97&quot;N 93°57'19.84&quot;E</td>
<td>IE</td>
<td>Valley river</td>
<td>Imphal river</td>
</tr>
<tr>
<td>2.</td>
<td>F Liklai</td>
<td>658</td>
<td>24°04'30.96&quot;N 93°33'48.98&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Tuivai river</td>
</tr>
<tr>
<td>3.</td>
<td>F Hiangtam</td>
<td>700</td>
<td>24°02'01.41&quot;N 93°33'56.66&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Tuivai river</td>
</tr>
<tr>
<td>4.</td>
<td>ju -do-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>M Khuanggin</td>
<td>479</td>
<td>24°07'41.69&quot;N 93°19'28.10&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>500 m from Tuivai river</td>
</tr>
<tr>
<td>6.</td>
<td>ju Maokot</td>
<td>604</td>
<td>24°08'45.97&quot;N 93°32'57.43&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Tuivai river</td>
</tr>
<tr>
<td>7.</td>
<td>F Tuivelzang</td>
<td>606</td>
<td>24°07'54.77&quot;N 93°32'22.12&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Tuivai river</td>
</tr>
<tr>
<td>9.</td>
<td>M Wangoo tera khokmakhong</td>
<td>774</td>
<td>24°20'40.68&quot;N 93°51'03.07&quot;E</td>
<td>BPR</td>
<td>Valley river</td>
<td>Manipur river after meeting Chakpi river</td>
</tr>
<tr>
<td>10.</td>
<td>F Laphupat tera</td>
<td>773</td>
<td>24°27'37.67&quot;N 93°51'37.58&quot;E</td>
<td>IW</td>
<td>Valley river</td>
<td>Manipur river lower course</td>
</tr>
<tr>
<td>11.</td>
<td>Ju Tuilaiphai</td>
<td>770</td>
<td>24°20'45.56&quot;N 93°35'25.71&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Tuila river</td>
</tr>
<tr>
<td>12.</td>
<td>M Tuilaiphai</td>
<td>769</td>
<td>24°20'50.69&quot;N 93°35'23.48&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Tuila river</td>
</tr>
<tr>
<td>13.</td>
<td>M Suahzahau</td>
<td>612</td>
<td>24°09'46.96&quot;N 93°31'43.69&quot;E</td>
<td>CCPUR</td>
<td>Hill stream</td>
<td>Near Tuivai river</td>
</tr>
<tr>
<td>14.</td>
<td>F Urup</td>
<td>785</td>
<td>24°43'47.72&quot;N 93°58'39.71&quot;E</td>
<td>IE</td>
<td>Valley river</td>
<td>Iril river bank</td>
</tr>
<tr>
<td>15.</td>
<td>F Sadu koireng</td>
<td>809</td>
<td>25°01'39.59&quot;N 94°01'37.63&quot;E</td>
<td>IE</td>
<td>Valley river</td>
<td>Near Iril river</td>
</tr>
</tbody>
</table>

M: Male; F: Female; ju: Juvenile; Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in degrees, minutes, and seconds; IE: Imphal East; IW: Imphal West; TBL: Thoubal; BPR: Bishnupur; CCPUR: Churachandpur
### Table 4.1.3: Distribution of *Cuora mouhotii* in Churachandpur district, Manipur

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Sex</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>Mongken</td>
<td>634</td>
<td>24°06'38.34&quot;N 93°31'44.40&quot;E</td>
<td>Dry specimen, hill slope, tropical moist deciduous forest</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>Hiangtam</td>
<td>726</td>
<td>24°02'23.67&quot;N 93°33'56.89&quot;E</td>
<td>Tropical moist deciduous forest Near Tuivai river</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>Shinzang</td>
<td>1126</td>
<td>24°18'22.93&quot;N 93°23'38.79&quot;E</td>
<td>Tropical wet hill forest</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>Leizangphai</td>
<td>348</td>
<td>24°21'45.60&quot;N 93°20'40.94&quot;E</td>
<td>Tropical evergreen forest</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>Sainouzang</td>
<td>384</td>
<td>24°20'26.31&quot;N 93°21'15.91&quot;E</td>
<td>Tropical evergreen forest</td>
</tr>
</tbody>
</table>

All the individuals during the present study were located from Churachandpur district only; Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in degrees, minutes, and seconds. M: Male; F: Female

### Table 4.1.4: *Melanochelys trijuga* distribution in BPR and CCPUR district of Manipur

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Sex</th>
<th>Site</th>
<th>Elev (m)</th>
<th>Coordinate</th>
<th>District</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>Keibul Heiga</td>
<td>770</td>
<td>24°29'47.11&quot;N 93°49'46.44&quot;E</td>
<td>BPR</td>
<td>KNLP</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>Tuilaiphai</td>
<td>773</td>
<td>24°20'45.56&quot;N 93°35'25.71&quot;E</td>
<td>CCPUR</td>
<td>Tropical evergreen forest, hill stream nearby</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>Suahzahau</td>
<td>661</td>
<td>24°09'45.24&quot;N 93°31'40.86&quot;E</td>
<td>CCPUR</td>
<td>Tropical deciduous forest. Near Tuivai river</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>Maokot</td>
<td>606</td>
<td>24°08'47.92&quot;N 93°32'58.02&quot;E</td>
<td>CCPUR</td>
<td>Near Tuivai river, Tropical deciduous forest</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>Leizangphai</td>
<td>288</td>
<td>24°21'34.06&quot;N 93°20'40.40&quot;E</td>
<td>CCPUR</td>
<td>Tropical evergreen forest near Tuipi river</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>Leizangphai</td>
<td>318</td>
<td>24°21'15.80&quot;N 93°20'41.21&quot;E</td>
<td>CCPUR</td>
<td>do</td>
</tr>
</tbody>
</table>

*Melanochelys trijuga* was located from BPR and CCPUR district only. Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in degrees, minutes, and seconds. M: Male; F: Female; BPR: Bishnupur; KNLP: Keibul Lamjao National Park; CCPUR: Churachandpur
Table 4.1.5: *Amyda cartilaginea* distribution in BPR and CCPUR district of Manipur

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Sex</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>Dist</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>F</td>
<td>Tiulien</td>
<td>71</td>
<td>24° 23'11.50&quot;N 93° 01'30.64&quot;E</td>
<td>CCPUR</td>
<td>Barak river bank</td>
</tr>
<tr>
<td>2.</td>
<td>F</td>
<td>Tallian</td>
<td>246</td>
<td>24° 22'09.32&quot;N 93° 19'29.19&quot;E</td>
<td>CCPUR</td>
<td>Tuipi river</td>
</tr>
<tr>
<td>3.</td>
<td>M</td>
<td>Tangjeng Khunou</td>
<td>768</td>
<td>24° 19'31.80&quot;N 93° 51'22.54&quot;E</td>
<td>BPR</td>
<td>Lower course of Manipur river.</td>
</tr>
<tr>
<td>4.</td>
<td>M</td>
<td>Bungjang</td>
<td>255</td>
<td>24°21'06.98&quot;N 93°20'00.89&quot;E</td>
<td>CCPUR</td>
<td>Tuipi river,</td>
</tr>
<tr>
<td>5.</td>
<td>F</td>
<td>Phainuam</td>
<td>207</td>
<td>24°25'03.96&quot;N 93°21'11.94&quot;E</td>
<td>CCPUR</td>
<td>Near river Tuipi,</td>
</tr>
<tr>
<td>6.</td>
<td>M</td>
<td>Sartuinek</td>
<td>46</td>
<td>24°18'06.20&quot;N 93°03'39.83&quot;E</td>
<td>CCPUR</td>
<td>Barak river</td>
</tr>
<tr>
<td>7.</td>
<td>M</td>
<td>Sipikawn</td>
<td>43</td>
<td>24°14'17.86&quot;N 93°01'26.69&quot;E</td>
<td>CCPUR</td>
<td>Tuivai river</td>
</tr>
<tr>
<td>8.</td>
<td>F</td>
<td>Suahzahau</td>
<td>593</td>
<td>24°09'45.26&quot;N 93°31'53.56&quot;E</td>
<td>CCPUR</td>
<td>Tuivai river</td>
</tr>
<tr>
<td>9.</td>
<td>F</td>
<td>Tuolbung</td>
<td>67</td>
<td>24°23'41.79&quot;N 93°07'46.51&quot;E</td>
<td>CCPUR</td>
<td>Barak river</td>
</tr>
</tbody>
</table>

*Amyda cartilaginea* was located from BPR and CCPUR district only. Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in degrees, minutes, and seconds. BPR: Bishnupur; CCPUR: Churachandpur; M: Male; F: Female

Table 4.1.6: Distribution of *Nilssonia hurum* in CCPUR and TBL districts of Manipur

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Sex</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>Dist</th>
<th>habitat type</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>M</td>
<td>Sartuinek</td>
<td>48</td>
<td>24°18'08.23&quot;N 93°03'44.21&quot;E</td>
<td>CCPUR</td>
<td>Hilly river</td>
<td>Barak river bank</td>
</tr>
<tr>
<td>2.</td>
<td>F</td>
<td>Irong ichil</td>
<td>779</td>
<td>24°38'24.10&quot;N 93°55'09.22&quot;E</td>
<td>TBL</td>
<td>Valley river</td>
<td>Confluence of Imphal and Thoubal river</td>
</tr>
<tr>
<td>3.</td>
<td>F</td>
<td>Laphupat Tera</td>
<td>772</td>
<td>24°28'14.28&quot;N 93°51'50.37&quot;E</td>
<td>TBL</td>
<td>Valley river</td>
<td>Manipur river lower course</td>
</tr>
<tr>
<td>4.</td>
<td>M</td>
<td>Sipikawn</td>
<td>45</td>
<td>24°14'28.35&quot;N 93°01'33.21&quot;E</td>
<td>CCPUR</td>
<td>Hilly river</td>
<td>Barak river meets Tuivai river</td>
</tr>
<tr>
<td>5.</td>
<td>F</td>
<td>Tuikumualumm</td>
<td>243</td>
<td>24°22'30.82&quot;N 93°20'23.42&quot;E</td>
<td>CCPUR</td>
<td>Hilly stream</td>
<td>Barak river bank</td>
</tr>
<tr>
<td>6.</td>
<td>F</td>
<td>Tipaimukh</td>
<td>43</td>
<td>24°14'25.10&quot;N 93°01'31.98&quot;E</td>
<td>CCPUR</td>
<td>Hilly river</td>
<td>Barak river bank</td>
</tr>
<tr>
<td>7.</td>
<td>M</td>
<td>Tipaimukh</td>
<td>45</td>
<td>24°14'28.35&quot;N 93°01'33.21&quot;E</td>
<td>CCPUR</td>
<td>Hilly river</td>
<td>Barak river bank</td>
</tr>
<tr>
<td>8.</td>
<td>F</td>
<td>Tallian</td>
<td>246</td>
<td>24°22'07.05&quot;N 93°19'28.08&quot;E</td>
<td>CCPUR</td>
<td>Hilly river</td>
<td>Tuipi river</td>
</tr>
</tbody>
</table>

*Nilssonia hurum* was located from CCPUR and TBL districts only. Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in Degrees, minutes, and seconds. TBL: Thoubal; CCPUR: Churachandpur; M: Male; F: Female
Table 4.1.7: Distribution of *Indotestudo elongata* in CCPUR district of Manipur

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Sex</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>M</td>
<td>Tuikumallum</td>
<td>250</td>
<td>24°22'23.60&quot;N 93°20'22.83&quot;E</td>
<td>Tuipi river, tropical wet evergreen forest</td>
</tr>
<tr>
<td>2.</td>
<td>F</td>
<td>Tuolbung,</td>
<td>60</td>
<td>24°23'23.34&quot;N 93°07'49.22&quot;E</td>
<td>Near Barak river, hill slope, tropical wet forest</td>
</tr>
<tr>
<td>3.</td>
<td>F</td>
<td>Phainuam</td>
<td>207</td>
<td>24°25'03.96&quot;N 93°21'11.94&quot;E</td>
<td>Near river Tuipi, tropical wet evergreen forest</td>
</tr>
<tr>
<td>4.</td>
<td>F</td>
<td>Sipikaun</td>
<td>68</td>
<td>24°13'04.65&quot;N 93°01'22.58&quot;E</td>
<td>Near Tuivai river, tropical evergreen forest.</td>
</tr>
<tr>
<td>5.</td>
<td>M</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>6.</td>
<td>F</td>
<td>Tipaimukh</td>
<td>112</td>
<td>24°13'59.77&quot;N 93°01'31.43&quot;E</td>
<td>Barak river bank, tropical wet semi evergreen forest</td>
</tr>
<tr>
<td>7.</td>
<td>M</td>
<td>Tuilaiphai</td>
<td>769</td>
<td>24°20'50.69&quot;N 93°35'23.48&quot;E</td>
<td>Tropical evergreen forest</td>
</tr>
</tbody>
</table>

CCPUR: Churachandpur; All the individuals of *Indotestudo elongata* were located from Churachandpur district only; M: Male; F: Female; Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in Degrees, minutes, and seconds.

Table 4.1.8: *Manouria emys* distribution in Churachandpur district of Manipur

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Sub sp.</th>
<th>Location</th>
<th>Elev (msl)</th>
<th>Coordinates</th>
<th>Site features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>M. emys</em></td>
<td>Maokot</td>
<td>625</td>
<td>24°08'05.59&quot;N 93°32'28.65&quot;E</td>
<td>Tropical moist deciduous forest, near Tuivai river.</td>
</tr>
<tr>
<td>2.</td>
<td><em>M. emys phayrei</em></td>
<td>Leizangphai</td>
<td>351</td>
<td>24°21'16.57&quot;N 93°20'48.29&quot;E</td>
<td>Tropical wet evergreen forest near Tuipi river</td>
</tr>
<tr>
<td>3.</td>
<td><em>M. emys</em></td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>4.</td>
<td><em>M. emys</em></td>
<td>Tipaimukh</td>
<td>56</td>
<td>24°14'28.32&quot;N 93°01'34.89&quot;E</td>
<td>Barak river bank, tropical wet evergreen forest.</td>
</tr>
<tr>
<td>5.</td>
<td><em>M. emys phayrei</em></td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>6.</td>
<td><em>M. emys phayrei</em></td>
<td>Tuikumallum,</td>
<td>250</td>
<td>24°22'30.09&quot;N 93°20'27.47&quot;E</td>
<td>Near Tuipi stream, tropical wet evergreen forest</td>
</tr>
<tr>
<td>7.</td>
<td><em>M. Phayrei</em></td>
<td>Bualkot,</td>
<td>682</td>
<td>24°03'29.05&quot;N 93°33'57.55&quot;E</td>
<td>Tropical moist deciduous forest, near Tuivai</td>
</tr>
<tr>
<td>8.</td>
<td><em>M. emys Phayrei</em></td>
<td>Khuanggin,</td>
<td>531</td>
<td>24°07'07.83&quot;N 93°19'55.77&quot;E</td>
<td>Near Tuivai river, southern edge of Kailam WLS has tropical evergreen forest.</td>
</tr>
<tr>
<td>9.</td>
<td><em>M. emys phayrei</em></td>
<td>Leizangphai</td>
<td>286</td>
<td>24°21'32.28&quot;N 93°19'35.82&quot;E</td>
<td>Tropical wet evergreen forest, near Tuipi stream.</td>
</tr>
</tbody>
</table>

All the individuals were located from Churachandpur district only; Elev(msl): Elevation mean sea level is given in metres; Coordinates are given in degrees, minutes, seconds; M: Male; F: Female; Sub. sp: Sub species; Coordinates are given in degrees, minutes, and seconds.
Fig 4.1.1: Local distribution of turtle species in central valley and Churachandpur district, Manipur observed during the present survey.
Plate 4.1.1: Geoemydidae (*Cuora amboinensis* and *Melanochelys trijuga*): A: *Cuora amboinensis* (carapace view); B: *Cuora amboinensis* (Plastron view); C: *Cuora amboinensis* Carapace view (juvenile); D: *Cuora amboinensis* Plastron view (juvenile); E: *Melanochelys trijuga* (Carapace view); F: *Melanochelys trijuga* (Plastron view);
Plate 4.1.2: Geoemydidae (Cyclemys dentata and Cuora mouhotii); A: Cyclemys dentata carapace view (adult); B: Cyclemys dentata plastron view (Adult); C: Cyclemys dentata carapace view (juvenile); D: Cyclemys dentata plastron view (Juvenile); E: Cuora mouhotii (Carapace view); F: Cuora mouhotii (Plastron view)
Plate 4.1.3: Trionychidae; A: *Amyda cartilaginea* (carapace view). Prominent nodules are seen at anterior end of the carapace. B: *Amyda cartilaginea* (Plastron view); C: *Nilssonia hurum* (carapace view). Carapace has large round eye or peacock like cavities. D: *Nilssonia hurum* (Plastron view);
Plate 4.1.4: Testudinidae; A: *Indotestudo elongata* (carapace view). The head is yellowish and body elongated; B: *Indotestudo elongata* (plastron view). C: *Manouria emys* (carapace view); D: *Manouria emys phayrei* subspecies plastron (Pectoral scutes meets widely at the midline); E: Another type of *Manouria emys phayrei* in which pectoral scutes meet just at a point in midline; F: *Manouria emys emys* subspecies plastron.
4.1.1 Family Geoemydidae

*Cuora amboinensis* (Malayan Box Turtle) (Plate 4.1.1)

IUCN status: Vulnerable A1d+2d ver 2.3

CITES: Appendix II

During the present study, *Cuora amboinensis* was encountered most among the turtles with 38 individuals from 4 districts of central valley of Manipur. Relative density of the species was found to be 38% (Plate 4.1.5). Out of these 38 individuals, 21 were found in different Lakes, 11 in rivers and 4 in paddy fields. The species was encountered most in the Loktak lake, Pumlen lake, Keibul Lamjao National Park (KNLP) and Lamphelpat (Table 4.1.1) The bulk of population was from Loktak lake. 6 individuals were encountered in Loktak Lake. Most of the encounters were on the western shore of the lake in Bishnupur district and eastern shore in Phoubackchao area in Imphal west district. The species was also encountered from the hills like Thanga that emerges out of the Loktak lake. It was also encountered at Phumdis of the lake during the survey and by the villagers. Another lake nearby Loktak Lake called Pumlen lake was also seen the population of the species with an encounter of 3 individuals. The population of the species were also recorded from small pockets of wetland in the centre of urban Imphal area called Lamphelpat.

Another habitat connected with Loktak Lake is KNLP (Plate 3.1.3A) consisting of thick Phumdis and is the only floating national park in the world. KNLP was surveyed from 2 sides. One was from Keibul Heiga, a village on northern park periphery and another from Khordak village on the eastern side of KNLP. 3 individuals were located from the park. The species was also seen by locals at the Toya Ching (Toya hill) on the eastern side of the park. It is also reported to be found on Pabot Ching.
(Pabot hill) too. Due to several limiting factors it was difficult to survey extensively within the park.

The maximum numbers of *C. amboinensis* have been encountered in the Loktak lake and Imphal river drainage. 11 individuals were recorded from Loktak and 2 from drainage outlet towards Manipur river. Imphal river which runs through all districts of the valley has got 7 individuals and another one from its tributary Kongba river. Interestingly three individual of the species were also found in one of the most polluted rivers of the state, the Nambul River, one from Naoremthong in Imphal urban area and the other two from Hiyangthang, south of Imphal city. The species were also found at paddy fields during rainy seasons. Four individuals were found in paddy fields in different parts of the state. They were Patsoi, Canchipur, Iroisenba and Toubul. Toubul is however located very near to Loktak lake. Among the districts maximum individuals were found from Imphal West district locating 12 individual from the district and it was followed by Bishnupur district with having 10 encounters. Thoubal and Imphal East also encountered 9 and 7 individuals respectively (Table 4.11).

In the present study out of 38 individuals, 14 individuals are found to be male, 18 individuals were found to be female and 6 happened to be juvenile. The species was encountered maximum during monsoon season and along the west coast of Loktak Lake.

*Cylemys dentata* (Asian Leaf Turtle)

IUCN status: Lower Risk/near threatened ver 2.3

CITES: Not listed

During the present study 15 individuals of *Cylemys dentata* (Plate 4.1.2) were encountered from both central valley and Churachandpur district (Table 4.1.2). A
maximum of 9 individual were encountered from Churachandpur district. 3 individuals were encountered from Imphal east and one each from Imphal West, Thoubal and Bishnupur district. It was found that 9 individuals were located from hill streams including 3 juveniles, whereas 6 individuals were located in valley streams. During the present study maximum encounters were from Tuivai River from which 7 individuals were found. Five individuals were located from Imphal river (Manipur River) and its tributaries. One individual was found at Keirao Imphal east at Imphal river. One species was recorded from the Tuivai river near Liklai village, located in southern CCPUR along Tedim road south of Maokot, Singngat. Two individuals were found at Tuivai river near Hiangtam village southern Churachandpur, south of Maokot. Another individual was found by locals from the Tuivai River near Khuanggin village, southern Churachandpur. Another individual was located near the bank of Tuivai River near Maokot village. Another individual was found at Chakpi River, a tributary of Manipur River near the village of Toupokpi, at the southern end of Thoubal district, bordering Churachandpur district. One individual was also located from Manipur River downstream from the point of meeting with Chakpi River Wangoo Tera Khokmakhong village. One specimen was located from Manipur River near Laphupat Tera in Thoubal district. The site lies downstream of point where Manipur River is joined by the outlet stream from Loktak Lake called Laphupat Tera. One specimen was also reported found near Iril River at Sadu Koireng village in Imphal east district bordering hills of Senapati district. Iril River at this point flows into valley after it enters from hilly area. The specimen was also found at Tuili river near Tuilaiphai village, Churachandpur district. Tuili river is a tributary of Tuivai river that flows northward at this point towards Tuivai river. Another specimen was also found by locals at Tuivai stream near Suahzahau
village North West of Tuivai River. Most of the population were found from the flowing hill streams and maximum in Tuivai River. The minimum elevation where species was found was 479m and maximum elevation was 806m (Table 4.1.2).

**Cuora mouhotii (Keeled Box Turtle) (Plate 4.1.2)**

IUCN status: Endangered A1d+2d ver 2.3

CITES: Appendix II

Five individuals of *Cuora mouhotii* including one dried dead specimen were recorded during the present survey (Table 4.1.3). Among them 3 were males and 2 were females. All the 5 individuals were located from the hilly forest of Churachandpur district. The dry specimen was found at the Tropical moist deciduous forest near Monken village. One individual was located from Hiangtam village. Another individual was located from tropical evergreen forest near Leizangphai village. The 4th individual was found at wet hill forest near Shinzang village. The other individual found in tropical evergreen forest near Sainouzang village was the biggest among 5 weighing 850 grams.

**Melanochelys trijuga (Indian Black Turtle) (Plate4.1.1)**

IUCN status: Lower Risk/near threatened ver 2.3

CITES: Appendix II

During the present survey 7 specimens including 3 male and 4 female were sighted (Table 4.14). A male and a female specimen were reported by locals of Tuilaiphai (Churachandpur district) from paddy fields near hilly stream of Tuili river, (Tuila river). It was encountered around 80m away from the stream. The species was also found near Tuivai river near Suahzahau village and Maokot village. The species
was also found from tropical evergreen forest very near to hilly stream at Leizangphai village, Churachandpur. An individual was also found trapped during night near at Phumdi of Keibil Lamjao National Park (KNLP) at Keibil Heiga village (Bishnupur district). It is the only specimen found from the valley district while all others were from the hilly Churachandpur district. Keibil Heiga village lies at the periphery of KNLP which is the only floating national park in the world.

4.1.2 Family Trionychidae

Amyda cartilaginea (Asiatic softshell turtle) (Plate 4.1.3)

IUCN status: 
Vulnerable A1cd+2cd ver 2.3

CITES: 
 Appendix II 

During the present study 9 individuals of Amyda cartilaginea, (5 females and 4 males) were found (Table 4.15). Eight of them were from the rivers of Churachandpur district. The species were found from Barak River in places like Tiulien, Tuolbung. It was also found from Tuipi River from places like Tallian, Buangjang, Phainuam. The specimen from Tuipi river, 1 km from Phainuam was the biggest among all weighing 4850 gms. On specimen were also found from Imphal River, Tangjeng Khunou village, Bishnupur district. The area is located downstream of the meeting point between Chakpi River and Imphal River.

Nilssonia hurum (Peacock softshell turtle) (Plate 4.1.3)

IUCN status: 
Vulnerable A1cd+2d ver 2.3

CITES: 
Appendix I
During the present study 8 individuals of *Nilssonia hurum* (3 male and 5 females) were found in different places of hills and valley (Table 4.1.6). The species was trapped from Imphal river at Irong Ichil, Thoubal district. Another specimen was also recorded from Laphupat Tera. The place has a drainage that connects Loktak Lake with the Imphal River. Here Loktak Lake drained out to Manipur river. The other individuals of *Nilssonia hurum* were found from low flowing hilly streams and rivers. The species was located found from Barak River in places like Sartuinek, Sipuikawn, Tipaimukh and Tallian. The species was also found from Tuipi river of Churachandpur from places like Tuikumuallum.

### 4.1.3 Family Testudinidae

*Indotestudo elongata* (Elongated Tortoise/ Yellow headed tortoise) (Plate 4.1.4)

IUCN status: Endangered A1cd+2cd ver 2.3

CITES: Appendix II

During the present study 7 individuals (3 male and 4 females) including one dry shell were recorded (Table 4.1.7). The species was found from tropical evergreen forest near Tuikumuallum village. Another individual was found at Barak river bank near Toulbung village. Another individual was also found from a tropical evergreen forest around 1 km from Phainuam village. It was the biggest *I.elongata* specimen found during the present survey weighing about 2000 gms. An individual was also located near Tuilaiphai village near Tuila river by villagers. A dry specimen was also reported from a house of the Sipuikawn village western Churachandpur district. An individual was also reported by villagers near Sipuikawn village and another was also found from
Tipaimukh nearby. Tipaimukh has a hot, humid climate located at the meeting point of Tuivai and Barak river in western Churachandpur district.

*Manouria emys* (Asian forest tortoise) (Plate 4.1.4)

IUCN status: Endangered A1cd+2cd ver 2.3

CITES: Appendix II

During the present study 9 individuals of *Manouria emys* were encountered from Churachandpur district (Table 4.1.8). *Manouria emys* has two subspecies; *Manouria emys phayrei* and *Manouria emys emys*. Both the subspecies were found during the survey. Two individuals were found on tropical evergreen forest near to hilly stream at Leizangphai village, a village located on the edge of propose Kailam wildlife sanctuary. The area has tropical evergreen forest having large bamboo patches with hilly stream flowing nearby (Plate 3.1.1F). Another individual was also found from Tuikumuallum village near Leizangphai village. Tuikumuallum has Tuipi River. One individual of *Manouria emys* was found from tropical moist deciduous forest, nearly 100m from Tuivai river near Maokot village. Another individual was also found from tropical evergreen forest at Tipaimukh in the westernmost Churachandpur near to the Mizoram border. Near that point Barak River meets Tuivai. The species was also found from Bualkot, near Tuivai river bank in the southern Churachandpur. The species was also found near Tuivai river bank at khuanggin village on the southern Churachandpur. A total of 5 *Manouria emys phayrei* sub species and 4 *Manouria emys emys* subspecies were found during the survey. One individual from unknown location was also rescued from traders. Due to uncertainty in locality it was not counted during the present study.
Table 4.1.9: Distribution of different turtle species across various habitats in the central valley and Churachandpur district recorded during the present study.

<table>
<thead>
<tr>
<th>Species</th>
<th>Habitat</th>
<th>Regions</th>
<th>Elevation range (msl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuora amboinensis</td>
<td>Loktak lake, KNLP, Pumlen Lake, Lamphelpat, Imphal river and its tributaries, Nambul river</td>
<td>Central valley</td>
<td>769-788</td>
</tr>
<tr>
<td>Cyclemys dentata</td>
<td>Imphal river and its tributary Iril river, Chakpi river. Tuivai river and Tuila river of Churachandpur</td>
<td>Central valley and Churachandpur</td>
<td>479-809</td>
</tr>
<tr>
<td>Melanochelys trijuga</td>
<td>Floating Phumdi (vegetation mass) of KNLP. Tropical evergreen forest near Tributaries of Barak river (Tuivai river, Tuili river, Tuipi river) of Churachandpur district.</td>
<td>Central valley and Churachandpur</td>
<td>318-773</td>
</tr>
<tr>
<td>Cuora mouhotii</td>
<td>Tropical evergreen forest, Tropical moist deciduous forest</td>
<td>Churachandpur</td>
<td>348-1126</td>
</tr>
<tr>
<td>Nilssonia hurum</td>
<td>Barak river and its tributaries (Tuivai river, Tuipi river). Manipur (Imphal ) river</td>
<td>Central valley and Churachandpur</td>
<td>43-779</td>
</tr>
<tr>
<td>Amyda cartilaginea</td>
<td>Barak river and its tributaries (Tuivai river, Tuipi river). Manipur (Imphal ) river</td>
<td>Central valley and Churachandpur</td>
<td>43-768</td>
</tr>
<tr>
<td>Indotestudo elongata</td>
<td>Tropical evergreen forest, tropical moist deciduous forest near hilly streams of Barak, and its Tributaries(Tuivai, Tuipi and Tuila)</td>
<td>Churachandpur district</td>
<td>68-769</td>
</tr>
<tr>
<td>Manouria emys</td>
<td>Tropical evergreen forest and Tropical moist deciduous forest near stream of Barak and its tributaries (Tuivai and Tuipi hilly streams )</td>
<td>Churachandpur district</td>
<td>56-682</td>
</tr>
</tbody>
</table>

Central valley: All area under 4 central valley districts (Imphal east, Imphal west, Thoubal and Bishnupur); Churachandpur: whole Churachandpur district.

Table 4.1.10: Distribution of turtles in different habitat types

<table>
<thead>
<tr>
<th>Habitats</th>
<th>CA</th>
<th>CD</th>
<th>CM</th>
<th>MT</th>
<th>AC</th>
<th>NH</th>
<th>IE</th>
<th>ME</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loktak lake</td>
<td>13</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>13</td>
</tr>
<tr>
<td>Pumlen lake</td>
<td>6</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>6</td>
</tr>
<tr>
<td>KNLP</td>
<td>3</td>
<td>na</td>
<td>na</td>
<td>1</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>4</td>
</tr>
<tr>
<td>Lamphelpat</td>
<td>1</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>1</td>
</tr>
<tr>
<td>IRS</td>
<td>8</td>
<td>6</td>
<td>na</td>
<td>1</td>
<td>2</td>
<td>na</td>
<td>na</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Nambul river</td>
<td>3</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>3</td>
</tr>
<tr>
<td>Paddy field</td>
<td>4</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>4</td>
</tr>
<tr>
<td>Barak river</td>
<td>0</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>3</td>
<td>4</td>
<td>na</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Barak tributaries</td>
<td>0</td>
<td>9</td>
<td>na</td>
<td>na</td>
<td>5</td>
<td>2</td>
<td>na</td>
<td>na</td>
<td>16</td>
</tr>
<tr>
<td>Tropical evergreen forest</td>
<td>0</td>
<td>na</td>
<td>3</td>
<td>4</td>
<td>na</td>
<td>na</td>
<td>7</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Tropical moist deciduous forest</td>
<td>0</td>
<td>na</td>
<td>2</td>
<td>2</td>
<td>na</td>
<td>na</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

The table shows the number of individuals of the species recorded in different habitats. Total denotes the total number of individuals of all species found in the habitat. KNLP: Keibul Lamjao National park; IRS: Imphal river and its tributaries in valley region; CA: C. amboinensis; CD: C. dentata; CM: C. mouhotii; MT: M. trijuga; AC: A. cartilaginea; NH: N. hurum; IE: I. elongata; ME: M. emys; na: Not available
During the present study Loktak lake and Pumlen lake was found hosting maximum Cuora amboinensis (Table 4.1.10). Imphal River and its tributaries host 4 different turtle species. The hilly tributaries of Barak river hosts 3 turtle species. The tropical evergreen forest of Churachandpur hosts 4 different species and among them 3 species (C. mouhotii, I. elongata and M. emys) are listed as endangered by IUCN.

Besides there had been earlier documentation of Morenia petersi and Pangshura tentoria (Linthoi and Sharma, 2009), which had not been encountered during the current survey. Local conservation workers of people for Animals (PFA) used to pick up animals encountered by locals and released it to its habitat. There were encounter of Indotestudo elongata and leaf turtle at Kwakta, Bishnupur district by locals (PFA, 2015). PFA (2014a) rescued one Assam Leaf Turtle from Chingmeirong. A big Ganges softshell turtle weighing 5 kg was also encountered by the locals from a drain at Atoukhong, Lilong constituency, Thoubal district and later handed over to People for animals (PFA) to be released at Loktak Lake (PFA, 2014b). Another Ganges softshell turtle was also encountered by local from a drainage canal at Sagolband, Imphal West District (PFA, 2013). A cumulative list of turtle fauna so far recorded from central valley of Manipur and Churachandpur district based on the current survey and other literatures is presented in table 4.1.1.
Table 4.1.1: District wise turtle diversity observed during the present survey.

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>species</th>
<th>Central Valley</th>
<th>Hill</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IE</td>
<td>IW</td>
</tr>
<tr>
<td>1.</td>
<td>Cuora amboinensis</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>2.</td>
<td>Cyclemys dentata</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Cuora mouhotii</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>4.</td>
<td>Melanochelys trijuga</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>5.</td>
<td>Amyda cartilaginea</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>6.</td>
<td>Nilssonia hurum</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>7.</td>
<td>Indotestudo elongata</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>8.</td>
<td>Manouria emys</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

IE: Imphal East; IW: Imphal West; BPR: Bishnupur; TBL: Thoubal; CCPUR: Churachandpur district; na: Not encountered during the present survey.

Table 4.1.12: Checklist of turtles in Manipur

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Turtle species</th>
<th>Family</th>
<th>Region</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cuora amboinensis</td>
<td>Geoemydidae</td>
<td>Central valley</td>
<td>Current survey</td>
</tr>
<tr>
<td>2.</td>
<td>Cyclemys dentata</td>
<td>Geoemydidae</td>
<td>Central valley, CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>3.</td>
<td>Cuora mouhotii</td>
<td>Geoemydidae</td>
<td>CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>4.</td>
<td>Melanochelys trijuga</td>
<td>Geoemydidae</td>
<td>Central valley, CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>5.</td>
<td>Morenia petersi</td>
<td>Geoemydidae</td>
<td>Central valley</td>
<td>Linthoi and Sharma, 2009</td>
</tr>
<tr>
<td>6.</td>
<td>Amyda cartilaginea</td>
<td>Trionychidae</td>
<td>Central valley, CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>7.</td>
<td>Nilssonia hurum</td>
<td>Trionychidae</td>
<td>Central valley, CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>8.</td>
<td>Nilssonia gangetica</td>
<td>Trionychidae</td>
<td>Central valley</td>
<td>PFA, 2014</td>
</tr>
<tr>
<td>9.</td>
<td>Indotestudo elongata</td>
<td>Testudinidae</td>
<td>CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>10.</td>
<td>Manouria emys</td>
<td>Testudinidae</td>
<td>CCpur</td>
<td>Current survey</td>
</tr>
<tr>
<td>11.</td>
<td>Pangshura tentoria</td>
<td>Geoemydidae</td>
<td>Central valley</td>
<td>Linthoi and Sharma, 2009</td>
</tr>
</tbody>
</table>

Central valley includes 4 districts (Imphal West, Imphal East, Thoubal and Bishnupur); CCpur: Churachandpur district.

Overall Shannon’s diversity index (H) was 1.83. Among five districts studied during the present survey Churachandpur district recorded maximum diversity of turtles. The district has got 50 individuals from 7 species belonging to three families. It
has the highest Shannon’s diversity index of 1.92. It was followed by Thoubal district and Bishnupur district having a value of 0.72. Imphal west have the least diversity having an index of 0.27.

Table 4.1.13: Turtle diversity indices in different districts of Manipur

<table>
<thead>
<tr>
<th>Districts</th>
<th>Shannon’s diversity index (H)</th>
<th>Simpson index (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imphal east</td>
<td>0.61</td>
<td>0.53</td>
</tr>
<tr>
<td>Imphal west</td>
<td>0.27</td>
<td>0.85</td>
</tr>
<tr>
<td>Bishnupur</td>
<td>0.72</td>
<td>0.56</td>
</tr>
<tr>
<td>Thoubal</td>
<td>0.72</td>
<td>0.56</td>
</tr>
<tr>
<td>All valley</td>
<td>0.74</td>
<td>0.64</td>
</tr>
<tr>
<td>Churachandpur</td>
<td>1.92</td>
<td>0.13</td>
</tr>
<tr>
<td>Total study area</td>
<td>1.83</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Overall Simpson index (D) of all districts was 0.20 (Table 4.1.13). Among the five districts studied Churachandpur got the lowest Simpson index with a value of 0.13 (Table 4.1.13). Imphal west got the highest Simpson Index with the value 0.85.

Fig 4.1.2: Males, Females and Juveniles recorded during the survey.
CA: *C.amboinensis*; CD: *C.dentata*; AC: *A. cartilaginea*; NH: *N.hurum*; IE: *I. elongata*; ME: *M.emys*; MT: *M.trijuga*; M: Male; F : Female; Ju: juvenile
Fig 4.1.3: Seasonal encounter of turtles during the survey

P.M: Pre monsoon; Mon: Monsoon; P.Mon: Post Monsoon; Win: Winter

Fig 4.1.4: Turtle distribution across various districts during 2011-2014.

IW: Imphal West; IE: Imphal East; BPR: Bishnupur; CCPUR: Churachandpur
Fig 4.1.5: Relative density of different turtle species.
4.2 Physico-chemical parameters studies of selected freshwater turtle habitats

The findings of habitat parameters of Loktak lake, Imphal river and Nambul river during 2012-2014 are present four ways:

i) Seasonal value of a year: The monthly values of physico-chemical parameters taken together for a season of a year, present a seasonal value of the particular year (Table 4.2.1-4.2.3). It gives the quantification of physico-chemical parameters of different water bodies in different seasons of a year of different water bodies.

ii) Seasonal value of all 3 years: For every water bodies, mean of all the monthly values of the same season across 3 years were added together and taken mean to present as the seasonal values of 3 years (Table 4.2.4). In each season every year, two monthly recordings were made and therefore 6 monthly recordings across 3 years. Thus every seasonal mean is derived from 6 monthly values across 3 years.

iii) Overall mean: The mean of a particular physico-chemical parameters of a water body recorded during whole study period irrespective of seasons were taken (Table 4.2.5). Thus overall pH of Loktak means the mean of all recorded pH values of Loktak in all the three year irrespective of seasons. It gives an overall quantification of the parameter of the water body.

iv) The maximum and minimum range: The Maximum and minimum range of every parameter for every water bodies (Table 4.2.6).
<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>WT</th>
<th>pH</th>
<th>CON</th>
<th>TRANS</th>
<th>DO</th>
<th>FCO₂</th>
<th>NT</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>PM</td>
<td>Mean</td>
<td>23.00</td>
<td>7.66</td>
<td>140.33</td>
<td>71.20</td>
<td>7.95</td>
<td>7.06</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.40</td>
<td>±5.28</td>
<td>±4.25</td>
<td>±0.17</td>
<td>±0.52</td>
<td>±0.06</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>26.67</td>
<td>7.14</td>
<td>172.44</td>
<td>90.31</td>
<td>6.56</td>
<td>22.29</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.32</td>
<td>±0.28</td>
<td>±10.50</td>
<td>±7.24</td>
<td>±0.39</td>
<td>±4.88</td>
<td>±0.12</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>24.50</td>
<td>7.33</td>
<td>148.50</td>
<td>96.33</td>
<td>6.95</td>
<td>10.84</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±3.83</td>
<td>±0.17</td>
<td>±9.69</td>
<td>±1.51</td>
<td>±0.29</td>
<td>±2.96</td>
<td>±0.10</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>16.00</td>
<td>7.38</td>
<td>145.17</td>
<td>105.83</td>
<td>8.09</td>
<td>7.78</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.21</td>
<td>±26.18</td>
<td>±6.18</td>
<td>±0.20</td>
<td>±0.52</td>
<td>±0.10</td>
</tr>
<tr>
<td>2013</td>
<td>PM</td>
<td>Mean</td>
<td>22.00</td>
<td>7.32</td>
<td>146.17</td>
<td>81.50</td>
<td>7.08</td>
<td>19.27</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±2.19</td>
<td>±0.28</td>
<td>±33.25</td>
<td>±12.01</td>
<td>±0.45</td>
<td>±2.30</td>
<td>±0.07</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>26.50</td>
<td>7.22</td>
<td>203.33</td>
<td>92.83</td>
<td>6.43</td>
<td>24.03</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.13</td>
<td>±4.41</td>
<td>±12.42</td>
<td>±0.75</td>
<td>±1.02</td>
<td>±0.10</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>22.50</td>
<td>7.13</td>
<td>159.83</td>
<td>101.17</td>
<td>7.26</td>
<td>11.10</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.42</td>
<td>±14.13</td>
<td>±18.16</td>
<td>±0.36</td>
<td>±3.38</td>
<td>±0.06</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>16.00</td>
<td>7.14</td>
<td>138.67</td>
<td>89.83</td>
<td>8.03</td>
<td>5.30</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±2.19</td>
<td>±0.20</td>
<td>±9.46</td>
<td>±16.68</td>
<td>±0.34</td>
<td>±0.15</td>
<td>±0.04</td>
</tr>
<tr>
<td>2014</td>
<td>PM</td>
<td>Mean</td>
<td>20.50</td>
<td>7.26</td>
<td>139.67</td>
<td>77.08</td>
<td>7.11</td>
<td>7.03</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.20</td>
<td>±11.84</td>
<td>±4.96</td>
<td>±0.33</td>
<td>±0.18</td>
<td>±0.04</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>26.50</td>
<td>7.40</td>
<td>196.17</td>
<td>70.05</td>
<td>6.14</td>
<td>23.62</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.13</td>
<td>±11.92</td>
<td>±3.15</td>
<td>±0.09</td>
<td>±2.52</td>
<td>±0.07</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>23.58</td>
<td>7.13</td>
<td>177.00</td>
<td>97.33</td>
<td>6.90</td>
<td>12.61</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±2.84</td>
<td>±0.30</td>
<td>±26.39</td>
<td>±10.84</td>
<td>±0.71</td>
<td>±4.14</td>
<td>±0.06</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>16.00</td>
<td>7.04</td>
<td>158.67</td>
<td>100.67</td>
<td>7.20</td>
<td>5.83</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.00</td>
<td>±0.20</td>
<td>±21.57</td>
<td>±1.53</td>
<td>±1.07</td>
<td>±0.90</td>
<td>±0.05</td>
</tr>
</tbody>
</table>

PM: Pre monsoon; M: Monsoon; PSM: Post monsoon; Win: Winter; WT: Water temperature (°C); CON: Conductivity (μS/cm); TRANS: Transparency (cm); DO: Dissolve Oxygen (mg/l); FCO₂: Free Carbon dioxide (mg/l); NT: Nitrate (mg/l); Ca: Calcium (mg/l).
Table 4.2.2: Physico chemical parameters of Imphal River during 2012-2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>WT</th>
<th>pH</th>
<th>CON</th>
<th>TRANS</th>
<th>DO</th>
<th>FCO₂</th>
<th>NT</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>PM</td>
<td>Mean</td>
<td>24.00</td>
<td>7.65</td>
<td>150.83</td>
<td>74.30</td>
<td>5.36</td>
<td>10.78</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.25</td>
<td>±24.96</td>
<td>±5.43</td>
<td>±0.54</td>
<td>±0.96</td>
<td>±0.08</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>26.00</td>
<td>7.50</td>
<td>216.44</td>
<td>61.73</td>
<td>4.92</td>
<td>11.90</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.87</td>
<td>±0.40</td>
<td>±23.46</td>
<td>±13.76</td>
<td>±0.52</td>
<td>±2.32</td>
<td>±0.10</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>23.50</td>
<td>7.09</td>
<td>197.17</td>
<td>30.05</td>
<td>6.28</td>
<td>11.16</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.15</td>
<td>±11.23</td>
<td>±2.29</td>
<td>±0.51</td>
<td>±1.48</td>
<td>±0.07</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>17.50</td>
<td>7.06</td>
<td>110.00</td>
<td>77.78</td>
<td>6.25</td>
<td>10.87</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.25</td>
<td>±20.09</td>
<td>±9.15</td>
<td>±0.23</td>
<td>±1.21</td>
<td>±0.03</td>
</tr>
<tr>
<td>2013</td>
<td>PM</td>
<td>Mean</td>
<td>22.50</td>
<td>7.42</td>
<td>164.83</td>
<td>54.10</td>
<td>6.01</td>
<td>12.98</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.47</td>
<td>±56.43</td>
<td>±8.31</td>
<td>±0.45</td>
<td>±1.80</td>
<td>±0.08</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>26.00</td>
<td>7.36</td>
<td>230.83</td>
<td>33.20</td>
<td>5.98</td>
<td>15.98</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.00</td>
<td>±0.15</td>
<td>±12.06</td>
<td>±23.59</td>
<td>±0.96</td>
<td>±2.35</td>
<td>±0.17</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>22.50</td>
<td>7.35</td>
<td>143.67</td>
<td>47.13</td>
<td>6.07</td>
<td>12.83</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±2.74</td>
<td>±0.36</td>
<td>±11.27</td>
<td>±0.76</td>
<td>±0.67</td>
<td>±2.52</td>
<td>±0.08</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>16.50</td>
<td>7.10</td>
<td>110.67</td>
<td>68.90</td>
<td>6.51</td>
<td>12.15</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.36</td>
<td>±12.39</td>
<td>±3.77</td>
<td>±0.58</td>
<td>±2.10</td>
<td>±0.05</td>
</tr>
<tr>
<td>2014</td>
<td>PM</td>
<td>Mean</td>
<td>22.50</td>
<td>7.13</td>
<td>150.67</td>
<td>64.62</td>
<td>5.83</td>
<td>11.92</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.22</td>
<td>±27.37</td>
<td>±4.09</td>
<td>±0.61</td>
<td>±1.74</td>
<td>±0.07</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>25.50</td>
<td>7.32</td>
<td>256.00</td>
<td>15.43</td>
<td>5.34</td>
<td>14.98</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.25</td>
<td>±35.71</td>
<td>±1.89</td>
<td>±0.62</td>
<td>±1.72</td>
<td>±0.14</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>23.00</td>
<td>7.20</td>
<td>209.50</td>
<td>51.98</td>
<td>5.75</td>
<td>13.32</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±2.19</td>
<td>±0.15</td>
<td>±69.93</td>
<td>±16.68</td>
<td>±0.47</td>
<td>±2.21</td>
<td>±0.10</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>16.67</td>
<td>7.17</td>
<td>108.00</td>
<td>67.00</td>
<td>6.11</td>
<td>10.97</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>±0.58</td>
<td>±0.35</td>
<td>±12.17</td>
<td>±2.00</td>
<td>±0.61</td>
<td>±0.68</td>
<td>±0.05</td>
</tr>
</tbody>
</table>

PM: Pre monsoon; M: Monsoon; PSM: Post monsoon; Win: Winter; WT: Water temperature (°C); CON: Conductivity (μS/cm); TRANS: Transparency (cm); DO: Dissolve Oxygen (mg/l); FCO₂: Free Carbon dioxide (mg/l); NT: Nitrate (mg/l); Ca: Calcium (mg/l).
Table 4.2.3: Physico chemical parameters of Nambul River during 2012-2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>WT</th>
<th>pH</th>
<th>CON</th>
<th>TRANS</th>
<th>DO</th>
<th>FCO₂</th>
<th>NT</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>PM</td>
<td>Mean</td>
<td>23.20</td>
<td>6.8</td>
<td>343.67</td>
<td>25.90</td>
<td>4.38</td>
<td>20.36</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.4</td>
<td>±22.71</td>
<td>±1.41</td>
<td>±0.22</td>
<td>±3.50</td>
<td>±0.06</td>
<td>±1.67</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>25.89</td>
<td>7.1</td>
<td>348.11</td>
<td>30.26</td>
<td>4.86</td>
<td>12.80</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.78</td>
<td>±0.1</td>
<td>±43.22</td>
<td>±7.44</td>
<td>±0.65</td>
<td>±1.48</td>
<td>±0.08</td>
<td>±4.26</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>24.00</td>
<td>6.9</td>
<td>302.50</td>
<td>27.12</td>
<td>4.72</td>
<td>21.65</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.3</td>
<td>±2.88</td>
<td>±1.49</td>
<td>±0.36</td>
<td>±3.65</td>
<td>±0.06</td>
<td>±5.80</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>19.50</td>
<td>6.7</td>
<td>238.50</td>
<td>31.15</td>
<td>3.39</td>
<td>27.43</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.3</td>
<td>±13.78</td>
<td>±1.37</td>
<td>±0.19</td>
<td>±0.90</td>
<td>±0.07</td>
<td>±2.83</td>
</tr>
<tr>
<td>2013</td>
<td>PM</td>
<td>Mean</td>
<td>22.50</td>
<td>7.0</td>
<td>276.83</td>
<td>28.07</td>
<td>5.27</td>
<td>23.89</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.1</td>
<td>±65.30</td>
<td>±4.55</td>
<td>±0.53</td>
<td>±6.01</td>
<td>±0.09</td>
<td>±2.38</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>27.00</td>
<td>7.1</td>
<td>409.67</td>
<td>17.65</td>
<td>5.08</td>
<td>13.92</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.1</td>
<td>±14.47</td>
<td>±11.01</td>
<td>±0.17</td>
<td>±2.14</td>
<td>±0.08</td>
<td>±2.94</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>23.00</td>
<td>6.9</td>
<td>316.83</td>
<td>40.12</td>
<td>4.85</td>
<td>23.79</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.2</td>
<td>±10.83</td>
<td>±1.97</td>
<td>±0.38</td>
<td>±3.74</td>
<td>±0.04</td>
<td>±5.67</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>19.50</td>
<td>6.8</td>
<td>312.17</td>
<td>44.25</td>
<td>4.23</td>
<td>22.93</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.64</td>
<td>±0.3</td>
<td>±8.23</td>
<td>±4.88</td>
<td>±0.25</td>
<td>±2.37</td>
<td>±0.06</td>
<td>±3.12</td>
</tr>
<tr>
<td>2014</td>
<td>PM</td>
<td>Mean</td>
<td>22.00</td>
<td>7.0</td>
<td>305.33</td>
<td>23.60</td>
<td>4.77</td>
<td>17.28</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.10</td>
<td>±0.2</td>
<td>±22.38</td>
<td>±1.23</td>
<td>±0.41</td>
<td>±1.65</td>
<td>±0.07</td>
<td>±2.23</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>Mean</td>
<td>26.50</td>
<td>7.0</td>
<td>364.17</td>
<td>11.73</td>
<td>4.95</td>
<td>18.75</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.1</td>
<td>±35.91</td>
<td>±1.78</td>
<td>±0.56</td>
<td>±5.67</td>
<td>±0.11</td>
<td>±1.17</td>
</tr>
<tr>
<td></td>
<td>PSM</td>
<td>Mean</td>
<td>23.50</td>
<td>6.9</td>
<td>315.50</td>
<td>36.17</td>
<td>5.48</td>
<td>23.42</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.55</td>
<td>±0.2</td>
<td>±12.24</td>
<td>±2.79</td>
<td>±0.31</td>
<td>±2.82</td>
<td>±0.03</td>
<td>±1.32</td>
</tr>
<tr>
<td></td>
<td>Win</td>
<td>Mean</td>
<td>17.67</td>
<td>6.5</td>
<td>281.67</td>
<td>31.03</td>
<td>3.88</td>
<td>17.14</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.58</td>
<td>±0.1</td>
<td>±11.15</td>
<td>±1.16</td>
<td>±0.18</td>
<td>±2.72</td>
<td>±0.05</td>
<td>±0.95</td>
</tr>
</tbody>
</table>

PM: Pre monsoon; M: Monsoon; PSM: Post monsoon; Win: Winter; WT: Water temperature (°C); CON: Conductivity (μS/cm); TRANS: Transparency (cm); DO: Dissolve Oxygen (mg/l); FCO₂: Free Carbon dioxide (mg/l); NT: Nitrate (mg/l); Ca: Calcium (mg/l).
Table 4.2.4: Mean seasonal values of physico chemical parameters of different water bodies during 2012-2014.

<table>
<thead>
<tr>
<th>Season</th>
<th>WT</th>
<th>pH</th>
<th>CON</th>
<th>TRANS</th>
<th>DO</th>
<th>FCO₂</th>
<th>NT</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loktak lake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>Mean</td>
<td>21.83</td>
<td>7.41</td>
<td>142.06</td>
<td>76.59</td>
<td>7.38</td>
<td>11.12</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.72</td>
<td>±0.34</td>
<td>±19.59</td>
<td>±8.59</td>
<td>±0.52</td>
<td>±6.07</td>
<td>±0.06</td>
</tr>
<tr>
<td>M</td>
<td>Mean</td>
<td>26.57</td>
<td>7.29</td>
<td>188.05</td>
<td>85.24</td>
<td>6.40</td>
<td>23.17</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.21</td>
<td>±0.24</td>
<td>±16.85</td>
<td>±12.65</td>
<td>±0.49</td>
<td>±3.46</td>
<td>±0.11</td>
</tr>
<tr>
<td>PSM</td>
<td>Mean</td>
<td>23.53</td>
<td>7.18</td>
<td>161.78</td>
<td>98.28</td>
<td>7.03</td>
<td>11.51</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±2.86</td>
<td>±0.31</td>
<td>±20.89</td>
<td>±11.70</td>
<td>±0.49</td>
<td>±3.41</td>
<td>±0.10</td>
</tr>
<tr>
<td>Win</td>
<td>Mean</td>
<td>16.00</td>
<td>7.22</td>
<td>145.27</td>
<td>98.40</td>
<td>7.89</td>
<td>6.39</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.46</td>
<td>±0.24</td>
<td>±20.01</td>
<td>±13.02</td>
<td>±0.59</td>
<td>±1.27</td>
<td>±0.07</td>
</tr>
<tr>
<td></td>
<td>Imphal river</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>Mean</td>
<td>23.00</td>
<td>7.40</td>
<td>155.44</td>
<td>64.34</td>
<td>5.73</td>
<td>11.89</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.03</td>
<td>±0.38</td>
<td>±37.24</td>
<td>±10.29</td>
<td>±0.58</td>
<td>±1.72</td>
<td>±0.08</td>
</tr>
<tr>
<td>M</td>
<td>Mean</td>
<td>25.86</td>
<td>7.41</td>
<td>231.86</td>
<td>40.35</td>
<td>5.34</td>
<td>13.95</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.01</td>
<td>±0.30</td>
<td>±29.28</td>
<td>±24.96</td>
<td>±0.80</td>
<td>±2.78</td>
<td>±0.14</td>
</tr>
<tr>
<td>PSM</td>
<td>Mean</td>
<td>23.00</td>
<td>7.21</td>
<td>183.44</td>
<td>43.06</td>
<td>6.03</td>
<td>12.44</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±2.14</td>
<td>±0.25</td>
<td>±48.76</td>
<td>±13.31</td>
<td>±0.57</td>
<td>±2.20</td>
<td>±0.11</td>
</tr>
<tr>
<td>Win</td>
<td>Mean</td>
<td>16.93</td>
<td>7.10</td>
<td>109.87</td>
<td>72.07</td>
<td>6.33</td>
<td>11.40</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.16</td>
<td>±0.30</td>
<td>±14.87</td>
<td>±7.70</td>
<td>±0.47</td>
<td>±1.60</td>
<td>±0.04</td>
</tr>
<tr>
<td></td>
<td>Nambul river</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>Mean</td>
<td>22.5</td>
<td>6.9</td>
<td>308.6</td>
<td>25.9</td>
<td>4.8</td>
<td>20.5</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.3</td>
<td>±0.3</td>
<td>±48.4</td>
<td>±3.3</td>
<td>±0.5</td>
<td>±4.8</td>
<td>±0.1</td>
</tr>
<tr>
<td>M</td>
<td>Mean</td>
<td>26.4</td>
<td>7.1</td>
<td>370.3</td>
<td>21.4</td>
<td>4.9</td>
<td>14.8</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.9</td>
<td>±0.1</td>
<td>±42.7</td>
<td>±11.0</td>
<td>±0.5</td>
<td>±4.1</td>
<td>±0.1</td>
</tr>
<tr>
<td>PSM</td>
<td>Mean</td>
<td>23.5</td>
<td>6.9</td>
<td>311.6</td>
<td>34.5</td>
<td>5.0</td>
<td>23.0</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.0</td>
<td>±0.2</td>
<td>±11.2</td>
<td>±6.0</td>
<td>±0.5</td>
<td>±3.4</td>
<td>±0.1</td>
</tr>
<tr>
<td>Win</td>
<td>Mean</td>
<td>19.1</td>
<td>6.7</td>
<td>276.6</td>
<td>36.4</td>
<td>3.8</td>
<td>23.6</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±0.0</td>
<td>±0.3</td>
<td>±35.8</td>
<td>±7.3</td>
<td>±0.4</td>
<td>±4.3</td>
<td>±0.1</td>
</tr>
</tbody>
</table>

PM: Pre monsoon; M: Monsoon; PSM: Post monsoon; Win: Winter; WT: Water temperature (°C); CON: Conductivity (μS/cm); TRANS: Transparency (cm); DO: Dissolved Oxygen (mg/l); FCO₂: Free Carbon dioxide (mg/l); NT: Nitrate (mg/l); Ca: Calcium (mg/l).
Table 4.2.5: Comparison of physico chemical parameters of three water bodies during 2012-2014

<table>
<thead>
<tr>
<th>Water bodies</th>
<th>WT</th>
<th>PH</th>
<th>CON</th>
<th>TRANS</th>
<th>DO</th>
<th>FCO₂</th>
<th>NT</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loktak lake</td>
<td>Mean</td>
<td>22.42</td>
<td>7.21</td>
<td>161.07</td>
<td>89.08</td>
<td>7.11</td>
<td>13.75</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±4.21</td>
<td>±0.33</td>
<td>±26.74</td>
<td>±14.58</td>
<td>±0.74</td>
<td>±7.48</td>
<td>±0.12</td>
</tr>
<tr>
<td>Imphal river</td>
<td>Mean</td>
<td>22.57</td>
<td>7.29</td>
<td>175.24</td>
<td>53.63</td>
<td>5.82</td>
<td>12.52</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±3.45</td>
<td>±0.33</td>
<td>±56.16</td>
<td>±20.89</td>
<td>±0.72</td>
<td>±2.35</td>
<td>±0.12</td>
</tr>
<tr>
<td>Nambul river</td>
<td>Mean</td>
<td>23.20</td>
<td>6.91</td>
<td>320.68</td>
<td>28.89</td>
<td>4.69</td>
<td>20.10</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±2.82</td>
<td>±0.26</td>
<td>±50.53</td>
<td>±9.72</td>
<td>±0.67</td>
<td>±5.43</td>
<td>±0.10</td>
</tr>
</tbody>
</table>

WT: Water temperature (°C); CON: Conductivity (μS/cm); TRANS: Transparency (cm); DO: Dissolve Oxygen (mg/l); FCO₂: Free Carbon dioxide (mg/l); NT: Nitrate (mg/l); Ca: Calcium (mg/l).

Table 4.2.6: Range variation of physico chemical parameters of all three water bodies during 2012-2014

<table>
<thead>
<tr>
<th>Physico-chemical parameter</th>
<th>Water bodies</th>
<th>Max</th>
<th>Min</th>
<th>Permissible limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WHO</td>
</tr>
<tr>
<td>Water temperature (WT)</td>
<td>Loktak</td>
<td>27</td>
<td>16</td>
<td>30-35</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>26</td>
<td>16.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>27</td>
<td>17.7</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>Loktak</td>
<td>7.66</td>
<td>6.85</td>
<td>6.5-8</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>7.65</td>
<td>7.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>7.1</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>Conductivity (CON)</td>
<td>Loktak</td>
<td>196.17</td>
<td>138.67</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>256</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>409.67</td>
<td>238.5</td>
<td></td>
</tr>
<tr>
<td>Transparency (TRANS)</td>
<td>Loktak</td>
<td>105.83</td>
<td>70.05</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>77.78</td>
<td>15.43</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>36.17</td>
<td>11.73</td>
<td></td>
</tr>
<tr>
<td>Dissolve Oxygen (DO)</td>
<td>Loktak</td>
<td>8.09</td>
<td>6.14</td>
<td>5-7</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>6.28</td>
<td>4.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>5.48</td>
<td>3.39</td>
<td></td>
</tr>
<tr>
<td>Free Carbon dioxide (FCO₂)</td>
<td>Loktak</td>
<td>24.03</td>
<td>5.30</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>15.98</td>
<td>10.78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>27.43</td>
<td>12.80</td>
<td></td>
</tr>
<tr>
<td>Nitrate (NT)</td>
<td>Loktak</td>
<td>0.48</td>
<td>0.19</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>0.47</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>0.51</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Loktak</td>
<td>13.51</td>
<td>10.67</td>
<td>100-300</td>
</tr>
<tr>
<td></td>
<td>Imphal</td>
<td>15.85</td>
<td>10.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nambul</td>
<td>22.05</td>
<td>13.79</td>
<td></td>
</tr>
</tbody>
</table>

WHO: World Health Organisation; BIS: Bureau of Indian Standards; ICMR: Indian Council of Medical Research; CPCB: Central pollution Control Board; NA: Not available

WT (°C); CON (μS/cm); TRANS(cm); DO(mg/l); FCO₂(mg/l); NT (mg/l); Ca(mg/l)
4.2.1 Temperature

The monsoon period showed highest temperature in all three water bodies and winter demonstrated lowest water temperature (Table 4.2.4). There has been no significant difference among water bodies in its temperature ranges during the study period of 2012-2014(Table 4.2.6). Overall comparison shows Loktak having higher temperature (Table 4.2.5). Water temperature ranges were within standard permissible limits (Table 4.2.6).

4.2.2 pH

The highest pH of 7.66±0.40 was recorded at Loktak lake (Table 4.2.1) during pre monsoon (2012) and the lowest of 6.5±0.1 was recorded at Nambul during winter 2014(Table 4.2.3). The 3 years highest seasonal pH of 7.41± 0.34 was recorded during pre monsoon at Loktak lake and the lowest of 6.7±0.3 was recorded during winter at Nambul River (Table 4.2.4). Imphal River shows a gradual decline of decrease of pH towards winter. Nambul River showed a first increase in pH from pre monsoon to monsoon but decreases towards post monsoon and winter. Thus overall water ranged from slightly basic to acidic during cold seasons in all water bodies with varying magnitude with Nambul be slightly acidic and Loktak be slightly alkaline. The current values were within permissible limits (Table 4.2.6).

4.2.3 Conductivity

Conductivity ranges from minimum of 108±12.17 μS/cm at Imphal River during winter (2013) to a maximum of 409.67±14.47 μS/cm at Nambul River during monsoon (2013). The highest seasonal value of 370.3±42.7 μS/cm was noted at Nambul during monsoon and the lowest of 109.87±14.87 μS/cm at Imphal River during winter (Table 4.2.4).
Comparatively, water of Nambul River exhibited higher conductivity than other two water bodies (Table 4.2.5). Conductivity increased from pre monsoon to monsoon followed by decline towards winter.

4.2.4 Transparency

Transparency was observed a maximum of 105.83±6.18 cm at Loktak Lake during winter 2012 (Table 4.2.1) and a minimum of 11.73±1.78 cm at Nambul during monsoon 2014 (Table 4.2.3). Maximum seasonal value was observed at 98.40±13.02 cm in Loktak Lake during winter and minimum of 21.4±11.00 cm in Nambul during monsoon (Table 4.2.4). Higher transparency was noted by the water of Loktak lake and Imphal river. Nambul river showed least transparency during winter among three water bodies (Table 4.2.5). Transparency was seen higher at post monsoon and winter seasons.

4.2.5 DO

The highest value of DO recorded was 8.09±0.20 mg/l in Loktak Lake during winter (2012) and the lowest value of 3.39±0.19 mg/l in Nambul in winter (2012). Seasonal averages showed a maximum seasonal DO of 7.89±0.59 mg/l in Loktak Lake during winter and minimum of 3.8±0.4 mg/l in Nambul during winter. Overall comparison showed Loktak water body with higher DO. The minimum DO of 3.39±0.19 by Nambul river was below the prescribed limit of CPCC(Table 4.2.6).

Seasonally Loktak Lake and Imphal River had higher DO during winter while Nambul in contrast had lower DO during winter.
4.2.6 Free Carbon dioxide (FCO$_2$)

Free Carbon dioxide (FCO$_2$) was found to have the highest value of 27.43±0.9 mg/l at Nambul during winter (2012) and a lowest of 5.30±0.15 mg/l at Loktak during winter (2013). The highest seasonal value of 23.6±4.3 mg/l was recorded in Nambul during winter and lowest of 6.39 ± 1.27 mg/l in Loktak winter.

Seasonally FCO$_2$ was higher during monsoon and post monsoon in Loktak lake and Imphal river (Table 4.2.4). Nambul displayed higher FCO$_2$ during post monsoon and winter. Water quality of Nambul exhibited lower FCO$_2$ during rainy season. Comparatively Nambul had higher FCO$_2$ values (Table 4.2.5).

4.2.7 Nitrate

Nitrate value varied from 0.51±0.11 mg/l at Nambul during monsoon ,2014 (Table 4.2.3) to 0.17±0.05 mg/l at Imphal River winter 2014(Table 4.2.2). Seasonality in Nitrate quantity in water ranged from 0.43±0.11 mg/l at Nambul River during pre monsoon to 0.18± 0.04 mg/l at Imphal River during winter (Table 4.2.4). Nitrate level declined during dry seasons although Nambul showed little variation. Loktak Lake and Imphal River exhibited a first rise in nitrate value from pre monsoon to monsoon and followed by its decline towards winter. During the present study Nitrate content was found within the WHO (2008) permissible limits (Table 4.2.6).

4.2.8 Calcium

The highest quantity of Calcium 22.05±1.67 mg/l was observed in Nambul during pre monsoon 2012(Table 4.2.3) and lowest of 10.67±1.03 mg/l was observed in Loktak during pre monsoon (Table 4.2.1). Highest seasonal value of 21.3 ±2.1mg/l was
found during pre monsoon Nambul River and the lowest of 11.50 ±1.54mg/l was noted in Loktak lake during winter. During the present study calcium content was found within the (BIS, 2012) and (WHO, 2008) permissible limits (Table 4.2.6).

4.3 Analysis of variation in shell morphometry of the turtles recorded

The extensive survey on both the hilly and valley districts could locate 98 individuals of 8 turtle species of 3 families. The turtles among different families presented striking differences in their shell morphometry while those within the same families have near identical shell morphological features. Within the same families there are some species which shows different morphological variations at different stages of life. Sometimes it was not easy to distinguish species especially among the softshell turtles since they show different colouration at different life stages. Thus the colouration alone could not differentiate species. Negligible differences in male and female shell measurements could be recorded.
Table 4.3.1: Morphometry of *Cuora amboinensis* and *Cyclemys dentata*

<table>
<thead>
<tr>
<th>Species</th>
<th>CCL</th>
<th>CCW</th>
<th>SCL</th>
<th>SCW</th>
<th>PL</th>
<th>PW</th>
<th>SH</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>20.8</td>
<td>20</td>
<td>18.6</td>
<td>11</td>
<td>17.8</td>
<td>8.6</td>
<td>7.3</td>
<td>1050</td>
</tr>
<tr>
<td>Min</td>
<td>9.9</td>
<td>9.6</td>
<td>7.4</td>
<td>5</td>
<td>8.3</td>
<td>4.7</td>
<td>2.6</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>17.2</td>
<td>16.1</td>
<td>13.9</td>
<td>8.5</td>
<td>13.6</td>
<td>7.0</td>
<td>5.3</td>
<td>598.7</td>
</tr>
<tr>
<td>SD</td>
<td>±3.1</td>
<td>±2.8</td>
<td>±3.3</td>
<td>±1.8</td>
<td>±2.6</td>
<td>±1.1</td>
<td>±1.3</td>
<td>±263.9</td>
</tr>
<tr>
<td>Male</td>
<td>20.6</td>
<td>18</td>
<td>18</td>
<td>11</td>
<td>15.7</td>
<td>8.6</td>
<td>6</td>
<td>900</td>
</tr>
<tr>
<td>Min</td>
<td>15.2</td>
<td>14.2</td>
<td>11</td>
<td>7</td>
<td>11.5</td>
<td>6</td>
<td>4.2</td>
<td>400</td>
</tr>
<tr>
<td>Mean</td>
<td>17.14</td>
<td>15.57</td>
<td>13.71</td>
<td>8.5</td>
<td>13.6</td>
<td>7.0</td>
<td>5.3</td>
<td>598.7</td>
</tr>
<tr>
<td>SD</td>
<td>±2.28</td>
<td>±1.53</td>
<td>±3.05</td>
<td>±1.56</td>
<td>±1.74</td>
<td>±0.97</td>
<td>±0.66</td>
<td>±187.5</td>
</tr>
<tr>
<td>Female</td>
<td>20.8</td>
<td>20</td>
<td>18.6</td>
<td>11</td>
<td>17.8</td>
<td>8.6</td>
<td>5.3</td>
<td>7</td>
</tr>
<tr>
<td>Min</td>
<td>15.2</td>
<td>16.5</td>
<td>13</td>
<td>8.3</td>
<td>14.1</td>
<td>7.2</td>
<td>5.1</td>
<td>550</td>
</tr>
<tr>
<td>Mean</td>
<td>19.11</td>
<td>18.21</td>
<td>15.82</td>
<td>9.64</td>
<td>15.58</td>
<td>7.72</td>
<td>6.25</td>
<td>772.22</td>
</tr>
<tr>
<td>SD</td>
<td>±1.35</td>
<td>±1.18</td>
<td>±1.79</td>
<td>±0.88</td>
<td>±1.25</td>
<td>±0.47</td>
<td>±0.87</td>
<td>±151.7</td>
</tr>
<tr>
<td>Juvenile</td>
<td>13</td>
<td>12.2</td>
<td>9.8</td>
<td>6.4</td>
<td>10.3</td>
<td>5.7</td>
<td>3.9</td>
<td>200</td>
</tr>
<tr>
<td>Min</td>
<td>9.9</td>
<td>9.6</td>
<td>7.4</td>
<td>5</td>
<td>8.3</td>
<td>4.7</td>
<td>2.6</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>11.50</td>
<td>10.98</td>
<td>8.77</td>
<td>5.85</td>
<td>9.32</td>
<td>5.25</td>
<td>3.35</td>
<td>158.3</td>
</tr>
<tr>
<td>SD</td>
<td>±1.24</td>
<td>±1.02</td>
<td>±0.94</td>
<td>±0.57</td>
<td>±0.82</td>
<td>±0.39</td>
<td>±0.50</td>
<td>±37.6</td>
</tr>
<tr>
<td>CD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>25.5</td>
<td>23.7</td>
<td>24.0</td>
<td>17.8</td>
<td>22.5</td>
<td>18.2</td>
<td>9.0</td>
<td>2000.0</td>
</tr>
<tr>
<td>Min</td>
<td>9.6</td>
<td>9.2</td>
<td>9.3</td>
<td>6.7</td>
<td>8.3</td>
<td>5.2</td>
<td>3.1</td>
<td>220.0</td>
</tr>
<tr>
<td>Mean</td>
<td>19.7</td>
<td>17.9</td>
<td>17.8</td>
<td>12.5</td>
<td>16.7</td>
<td>11.8</td>
<td>5.9</td>
<td>1164.7</td>
</tr>
<tr>
<td>SD</td>
<td>±5.7</td>
<td>±5.1</td>
<td>±5.1</td>
<td>±3.7</td>
<td>±4.8</td>
<td>±4.1</td>
<td>±2.0</td>
<td>±580.6</td>
</tr>
<tr>
<td>Male</td>
<td>25</td>
<td>23.3</td>
<td>23</td>
<td>16.5</td>
<td>22.5</td>
<td>18.2</td>
<td>9</td>
<td>1800</td>
</tr>
<tr>
<td>Min</td>
<td>18.46</td>
<td>16.55</td>
<td>16.48</td>
<td>11.18</td>
<td>15.65</td>
<td>10.40</td>
<td>4.97</td>
<td>900.00</td>
</tr>
<tr>
<td>Mean</td>
<td>22.27</td>
<td>20.37</td>
<td>20.02</td>
<td>14.74</td>
<td>18.97</td>
<td>14.72</td>
<td>7.09</td>
<td>1390.00</td>
</tr>
<tr>
<td>SD</td>
<td>±2.67</td>
<td>±2.65</td>
<td>±2.63</td>
<td>±2.21</td>
<td>±2.62</td>
<td>±2.87</td>
<td>±1.68</td>
<td>±394.33</td>
</tr>
<tr>
<td>Female</td>
<td>25.5</td>
<td>23.7</td>
<td>24</td>
<td>17.8</td>
<td>22</td>
<td>16.5</td>
<td>8.5</td>
<td>2000</td>
</tr>
<tr>
<td>Min</td>
<td>16</td>
<td>14</td>
<td>13</td>
<td>9.5</td>
<td>13.4</td>
<td>9.4</td>
<td>4.2</td>
<td>850</td>
</tr>
<tr>
<td>Mean</td>
<td>22.1</td>
<td>19.7</td>
<td>19.8</td>
<td>13.4</td>
<td>18.6</td>
<td>12.3</td>
<td>6.2</td>
<td>1392.9</td>
</tr>
<tr>
<td>SD</td>
<td>±3.1</td>
<td>±3.1</td>
<td>±3.5</td>
<td>±2.8</td>
<td>±2.9</td>
<td>±2.4</td>
<td>±1.6</td>
<td>±408.7</td>
</tr>
<tr>
<td>Juvenile</td>
<td>10.2</td>
<td>9.5</td>
<td>9.6</td>
<td>7.1</td>
<td>8.8</td>
<td>5.7</td>
<td>3.6</td>
<td>300</td>
</tr>
<tr>
<td>Min</td>
<td>9.6</td>
<td>9.2</td>
<td>9.3</td>
<td>6.7</td>
<td>8.3</td>
<td>5.2</td>
<td>3.1</td>
<td>220</td>
</tr>
<tr>
<td>Mean</td>
<td>9.8</td>
<td>9.3</td>
<td>9.4</td>
<td>6.9</td>
<td>8.6</td>
<td>5.4</td>
<td>3.3</td>
<td>256.7</td>
</tr>
<tr>
<td>SD</td>
<td>±0.3</td>
<td>±0.2</td>
<td>±0.2</td>
<td>±0.2</td>
<td>±0.3</td>
<td>±0.3</td>
<td>±0.3</td>
<td>±40.4</td>
</tr>
</tbody>
</table>


CCL, CCW, SCL, SCW, PL, PW are expressed in centimetres; BW is expressed in grams.
Table 4.3.2: Morphometry of *Cuora mouhotii* and *Melanochelys trijuga*

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>CCL</th>
<th>CCW</th>
<th>SCL</th>
<th>SCW</th>
<th>PL</th>
<th>PW</th>
<th>SH</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>All</td>
<td>Max</td>
<td>18.5</td>
<td>15.6</td>
<td>17</td>
<td>14</td>
<td>15</td>
<td>13.7</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>14.6</td>
<td>12.8</td>
<td>13.1</td>
<td>8.7</td>
<td>11.5</td>
<td>8.2</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>16.32</td>
<td>14.12</td>
<td>14.90</td>
<td>10.36</td>
<td>12.96</td>
<td>10.66</td>
<td>4.38</td>
<td>610.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.58</td>
<td>±1.22</td>
<td>±1.67</td>
<td>±2.17</td>
<td>±1.35</td>
<td>±2.40</td>
<td>±0.67</td>
<td>±185.07</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Max</td>
<td>16.5</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>13.3</td>
<td>10.5</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>14.6</td>
<td>12.8</td>
<td>13.1</td>
<td>8.7</td>
<td>11.5</td>
<td>8.2</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>15.37</td>
<td>13.60</td>
<td>13.83</td>
<td>10.57</td>
<td>12.27</td>
<td>9.07</td>
<td>4.30</td>
<td>500.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.00</td>
<td>±1.22</td>
<td>±1.02</td>
<td>±2.98</td>
<td>±0.93</td>
<td>±1.25</td>
<td>±0.79</td>
<td>±132.29</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>Max</td>
<td>18.5</td>
<td>15.6</td>
<td>17.0</td>
<td>10.7</td>
<td>15.0</td>
<td>13.7</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>17.0</td>
<td>14.2</td>
<td>16.0</td>
<td>9.4</td>
<td>13.0</td>
<td>12.4</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>17.75</td>
<td>14.90</td>
<td>16.50</td>
<td>10.05</td>
<td>14.00</td>
<td>13.05</td>
<td>4.50</td>
<td>775.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±1.06</td>
<td>±0.99</td>
<td>±0.71</td>
<td>±0.92</td>
<td>±1.41</td>
<td>±0.92</td>
<td>±0.71</td>
<td>±106.07</td>
</tr>
<tr>
<td>MT</td>
<td>All</td>
<td>Max</td>
<td>24.4</td>
<td>21</td>
<td>20</td>
<td>14</td>
<td>19</td>
<td>13</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>15</td>
<td>14</td>
<td>12.2</td>
<td>8</td>
<td>12</td>
<td>7.2</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>24.4</td>
<td>21</td>
<td>20</td>
<td>14</td>
<td>19</td>
<td>13</td>
<td>7.4</td>
<td>1400</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±3.21</td>
<td>±2.67</td>
<td>±3.21</td>
<td>±2.14</td>
<td>±2.67</td>
<td>±2.14</td>
<td>±1.07</td>
<td>±207.88</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Max</td>
<td>22.8</td>
<td>20</td>
<td>19</td>
<td>13</td>
<td>18</td>
<td>12</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>16.8</td>
<td>15</td>
<td>13</td>
<td>9</td>
<td>13</td>
<td>8</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>20.8</td>
<td>18.3</td>
<td>17.0</td>
<td>11.7</td>
<td>16.3</td>
<td>10.7</td>
<td>6.5</td>
<td>1216.7</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±3.5</td>
<td>±2.9</td>
<td>±3.5</td>
<td>±2.3</td>
<td>±2.9</td>
<td>±2.3</td>
<td>±1.2</td>
<td>±230.9</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Max</td>
<td>24.4</td>
<td>21</td>
<td>20</td>
<td>14</td>
<td>19</td>
<td>13</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>15</td>
<td>14</td>
<td>12.2</td>
<td>8</td>
<td>12</td>
<td>7.2</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>19.4</td>
<td>17.3</td>
<td>16.1</td>
<td>11.1</td>
<td>15.4</td>
<td>9.8</td>
<td>6.0</td>
<td>1125.0</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±4.2</td>
<td>±3.3</td>
<td>±3.6</td>
<td>±2.9</td>
<td>±3.2</td>
<td>±2.7</td>
<td>±1.2</td>
<td>±221.7</td>
</tr>
</tbody>
</table>


CCL, CCW, SCL, SCW, PL, PW are expressed in centimetres; BW is expressed in grams.
### Table 4.3.3: Morphometric ratios of the turtle species under family Geoemydidae

<table>
<thead>
<tr>
<th>Species</th>
<th>CCL/CCW</th>
<th>CCL/SCL</th>
<th>CCL/PL</th>
<th>CCL/SH</th>
<th>SCL/SCW</th>
<th>PL/P</th>
<th>W</th>
<th>SCL/SH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>1.10±0.04</td>
<td>1.28±0.15</td>
<td>1.32±0.04</td>
<td>3.55±0.13</td>
<td>1.68±0.23</td>
<td>1.89±0.04</td>
<td>2.83±0.46</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.05±0.03</td>
<td>1.21±0.07</td>
<td>1.23±0.06</td>
<td>3.09±0.29</td>
<td>1.64±0.06</td>
<td>2.02±0.06</td>
<td>2.55±0.21</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>1.05±0.02</td>
<td>1.31±0.04</td>
<td>1.23±0.03</td>
<td>3.4±0.205</td>
<td>1.50±0.04</td>
<td>1.77±0.04</td>
<td>3.17±0.80</td>
<td></td>
</tr>
<tr>
<td><strong>CD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>1.09±0.02</td>
<td>1.11±0.02</td>
<td>1.18±0.04</td>
<td>3.22±0.40</td>
<td>1.36±0.08</td>
<td>1.30±1.12</td>
<td>2.88±0.33</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.12±0.05</td>
<td>1.12±0.06</td>
<td>1.19±0.04</td>
<td>3.63±0.48</td>
<td>1.49±0.12</td>
<td>1.52±0.15</td>
<td>3.23±0.41</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>1.05±0.02</td>
<td>1.04±0.02</td>
<td>1.15±0.02</td>
<td>2.96±0.13</td>
<td>1.37±0.02</td>
<td>1.58±0.03</td>
<td>2.84±0.17</td>
<td></td>
</tr>
<tr>
<td><strong>CM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>1.13±0.03</td>
<td>1.11±0.01</td>
<td>1.25±0.01</td>
<td>3.62±0.40</td>
<td>1.36±0.25</td>
<td>1.36±0.08</td>
<td>3.26±0.34</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.19±0.01</td>
<td>1.08±0.02</td>
<td>1.27±0.05</td>
<td>3.98±0.39</td>
<td>1.65±0.08</td>
<td>1.07±0.03</td>
<td>3.70±0.42</td>
<td></td>
</tr>
<tr>
<td><strong>MT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>1.13±0.01</td>
<td>1.23±0.05</td>
<td>1.28±0.01</td>
<td>3.19±0.04</td>
<td>1.46±0.01</td>
<td>1.54±0.07</td>
<td>2.59±0.08</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.12±0.04</td>
<td>1.21±0.03</td>
<td>1.26±0.02</td>
<td>3.23±0.06</td>
<td>1.46±0.07</td>
<td>1.59±0.10</td>
<td>2.68±0.08</td>
<td></td>
</tr>
</tbody>
</table>

CCL: Curve Carapace Length; CCW: Curve Carapace Width; SCL: Straight Carapace Length; SCW: Straight Carapace Width, PL: Plastron Length; PW: Plastron width; BW: Body weight; M: Male; F: Female; J: Juvenile

### Table 4.3.4: Morphometric measurements of *Amyda cartilaginea*

<table>
<thead>
<tr>
<th>Sex</th>
<th>CCL</th>
<th>CCW</th>
<th>SCL</th>
<th>SCW</th>
<th>PL</th>
<th>PW</th>
<th>SH</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>37</td>
<td>29.7</td>
<td>32.4</td>
<td>37.2</td>
<td>37.5</td>
<td>32.5</td>
<td>10.1</td>
<td>5500</td>
</tr>
<tr>
<td>Min</td>
<td>26.8</td>
<td>20.1</td>
<td>23.1</td>
<td>20.8</td>
<td>27.1</td>
<td>23.4</td>
<td>7.4</td>
<td>3850</td>
</tr>
<tr>
<td>Mean</td>
<td>32.78</td>
<td>25.82</td>
<td>29.17</td>
<td>26.54</td>
<td>33.24</td>
<td>28.81</td>
<td>8.61</td>
<td>4633.33</td>
</tr>
<tr>
<td>SD</td>
<td>±3.68</td>
<td>±3.27</td>
<td>±3.52</td>
<td>±4.80</td>
<td>±3.78</td>
<td>±3.88</td>
<td>±0.83</td>
<td>±497.49</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>35.6</td>
<td>26.2</td>
<td>31.5</td>
<td>37.2</td>
<td>35.8</td>
<td>32.2</td>
<td>8.7</td>
<td>4800</td>
</tr>
<tr>
<td>Min</td>
<td>26.8</td>
<td>20.1</td>
<td>23.1</td>
<td>20.8</td>
<td>27.1</td>
<td>23.4</td>
<td>7.4</td>
<td>3850</td>
</tr>
<tr>
<td>Mean</td>
<td>31.10</td>
<td>23.33</td>
<td>27.25</td>
<td>26.70</td>
<td>31.38</td>
<td>27.78</td>
<td>8.03</td>
<td>4275.00</td>
</tr>
<tr>
<td>SD</td>
<td>±4.86</td>
<td>±3.23</td>
<td>±4.62</td>
<td>±7.66</td>
<td>±4.72</td>
<td>±4.83</td>
<td>±0.56</td>
<td>±433.01</td>
</tr>
<tr>
<td>female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>37</td>
<td>29.7</td>
<td>32.4</td>
<td>28.5</td>
<td>37.5</td>
<td>32.5</td>
<td>10.1</td>
<td>5500</td>
</tr>
<tr>
<td>Min</td>
<td>31.4</td>
<td>25.8</td>
<td>28.6</td>
<td>24.8</td>
<td>32.5</td>
<td>24.2</td>
<td>8.2</td>
<td>4550</td>
</tr>
<tr>
<td>Mean</td>
<td>34.12</td>
<td>27.82</td>
<td>30.70</td>
<td>26.42</td>
<td>34.74</td>
<td>29.64</td>
<td>9.08</td>
<td>4920.00</td>
</tr>
<tr>
<td>SD</td>
<td>±2.08</td>
<td>±1.55</td>
<td>±1.46</td>
<td>±1.40</td>
<td>±2.37</td>
<td>±3.27</td>
<td>±0.72</td>
<td>±351.07</td>
</tr>
</tbody>
</table>

CCL: Curve Carapace Length; CCW: Curve Carapace Width; SCL: Straight Carapace Length; SCW: Straight Carapace Width, PL: Plastron Length; PW: Plastron width; BW: Body weight.

CCL, CCW, SCL, SCW, PL, PW are expressed in centimetres; BW is expressed in grams
Table 4.3.5: Morphometric measurements of *Nilssonia hurum*

<table>
<thead>
<tr>
<th>Sex</th>
<th>CCL</th>
<th>CCW</th>
<th>SCL</th>
<th>SCW</th>
<th>PL</th>
<th>PW</th>
<th>SH</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL</td>
<td>Max</td>
<td>35.00</td>
<td>31.40</td>
<td>33.00</td>
<td>27.40</td>
<td>37.30</td>
<td>38.50</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>24.80</td>
<td>23.00</td>
<td>23.40</td>
<td>19.40</td>
<td>25.40</td>
<td>19.30</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>30.94</td>
<td>26.86</td>
<td>28.86</td>
<td>23.83</td>
<td>32.50</td>
<td>29.59</td>
<td>8.57</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±3.75</td>
<td>±3.23</td>
<td>±3.39</td>
<td>±2.91</td>
<td>±4.23</td>
<td>±7.52</td>
<td>±1.33</td>
</tr>
<tr>
<td>Male</td>
<td>Max</td>
<td>33.00</td>
<td>26.50</td>
<td>29.40</td>
<td>24.60</td>
<td>34.00</td>
<td>32.20</td>
<td>9.40</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>28.50</td>
<td>23.80</td>
<td>27.00</td>
<td>22.00</td>
<td>30.00</td>
<td>23.60</td>
<td>8.00</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>31.20</td>
<td>25.80</td>
<td>28.53</td>
<td>23.57</td>
<td>32.53</td>
<td>29.10</td>
<td>8.83</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±2.38</td>
<td>±0.89</td>
<td>±1.33</td>
<td>±1.38</td>
<td>±2.20</td>
<td>±4.78</td>
<td>±0.74</td>
</tr>
<tr>
<td>Female</td>
<td>Max</td>
<td>35.00</td>
<td>31.40</td>
<td>33.00</td>
<td>27.40</td>
<td>37.30</td>
<td>38.50</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>24.80</td>
<td>23.00</td>
<td>23.40</td>
<td>19.40</td>
<td>25.40</td>
<td>19.30</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>30.75</td>
<td>27.65</td>
<td>29.10</td>
<td>24.025</td>
<td>32.475</td>
<td>29.95</td>
<td>8.375</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>±4.93</td>
<td>±4.29</td>
<td>±4.65</td>
<td>±3.94</td>
<td>±5.71</td>
<td>±9.87</td>
<td>±1.75</td>
</tr>
</tbody>
</table>

CCL: Curve Carapace Length; CCW: Curve Carapace Width; SCL: Straight Carapace Length; SCW: Straight Carapace Width, PL: Plastron Length; PW: Plastron width; BW: Body weight.

Table 4.3.6: Morphometry ratios of turtle species under family Trionychidae

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>CCL/CCW</th>
<th>CCL/SCL</th>
<th>CCL/PL</th>
<th>CCL/SH</th>
<th>SCL/SCW</th>
<th>PL/PW</th>
<th>SCL/SH</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>All</td>
<td>±1.27</td>
<td>±1.13</td>
<td>±0.99</td>
<td>±3.81</td>
<td>±1.11</td>
<td>±1.16</td>
<td>±3.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.06</td>
<td>±0.02</td>
<td>±0.02</td>
<td>±0.24</td>
<td>±0.11</td>
<td>±0.07</td>
<td>±0.24</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>±1.33</td>
<td>±1.14</td>
<td>±0.99</td>
<td>±3.86</td>
<td>±1.05</td>
<td>±1.13</td>
<td>±3.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.03</td>
<td>±0.02</td>
<td>±0.01</td>
<td>±0.38</td>
<td>±0.14</td>
<td>±0.03</td>
<td>±0.38</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>±1.23</td>
<td>±1.11</td>
<td>±0.98</td>
<td>±3.76</td>
<td>±1.16</td>
<td>±1.18</td>
<td>±3.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.02</td>
<td>±0.02</td>
<td>±0.03</td>
<td>±0.07</td>
<td>±0.02</td>
<td>±0.09</td>
<td>±0.11</td>
</tr>
<tr>
<td>NH</td>
<td>All</td>
<td>±1.15</td>
<td>±1.07</td>
<td>±0.95</td>
<td>±3.63</td>
<td>±1.21</td>
<td>±1.13</td>
<td>±3.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.06</td>
<td>±0.03</td>
<td>±0.02</td>
<td>±0.23</td>
<td>±0.01</td>
<td>±0.15</td>
<td>±0.26</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>±1.21</td>
<td>±1.09</td>
<td>±0.96</td>
<td>±3.53</td>
<td>±1.21</td>
<td>±1.13</td>
<td>±3.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.05</td>
<td>±0.03</td>
<td>±0.03</td>
<td>±0.03</td>
<td>±0.02</td>
<td>±0.12</td>
<td>±0.13</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>±1.11</td>
<td>±1.06</td>
<td>±0.95</td>
<td>±3.71</td>
<td>±1.21</td>
<td>±1.13</td>
<td>±3.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.03</td>
<td>±0.00</td>
<td>±0.02</td>
<td>±0.30</td>
<td>±0.01</td>
<td>±0.19</td>
<td>±0.28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>CCL</th>
<th>CCW</th>
<th>SCL</th>
<th>SCW</th>
<th>PL</th>
<th>PW</th>
<th>SH</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>All</td>
<td>31</td>
<td>27</td>
<td>25.6</td>
<td>16.5</td>
<td>19.5</td>
<td>17.5</td>
<td>11</td>
<td>1950</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>21.5</td>
<td>20</td>
<td>18</td>
<td>11</td>
<td>15.3</td>
<td>14</td>
<td>7</td>
<td>950</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>26.4</td>
<td>22.0</td>
<td>21.5</td>
<td>13.4</td>
<td>17.3</td>
<td>15.6</td>
<td>8.6</td>
<td>1471.4</td>
</tr>
<tr>
<td></td>
<td>SD ±3.1</td>
<td>±2.5</td>
<td>±2.5</td>
<td>±1.8</td>
<td>±1.4</td>
<td>±1.4</td>
<td>±1.3</td>
<td>±356.9</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Max</td>
<td>26.5</td>
<td>21</td>
<td>21.6</td>
<td>14</td>
<td>17.5</td>
<td>15.5</td>
<td>9</td>
<td>1350</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>21.5</td>
<td>20</td>
<td>18</td>
<td>11</td>
<td>15.3</td>
<td>14</td>
<td>8.5</td>
<td>950</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>24.0</td>
<td>20.4</td>
<td>19.9</td>
<td>12.8</td>
<td>16.4</td>
<td>14.8</td>
<td>8.8</td>
<td>1166.7</td>
</tr>
<tr>
<td></td>
<td>SD ±2.5</td>
<td>±0.5</td>
<td>±1.8</td>
<td>±1.3</td>
<td>±1.1</td>
<td>±0.8</td>
<td>±0.3</td>
<td>±202.1</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>Max</td>
<td>31</td>
<td>27</td>
<td>25.6</td>
<td>16.5</td>
<td>19.5</td>
<td>17.5</td>
<td>11</td>
<td>1950</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>11</td>
<td>16</td>
<td>14</td>
<td>7</td>
<td>1350</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>28.1</td>
<td>23.1</td>
<td>22.8</td>
<td>13.8</td>
<td>16.3</td>
<td>16.3</td>
<td>8.5</td>
<td>1700.0</td>
</tr>
<tr>
<td></td>
<td>SD ±2.5</td>
<td>±2.9</td>
<td>±2.3</td>
<td>±2.3</td>
<td>±1.4</td>
<td>±1.6</td>
<td>±1.8</td>
<td>±255.0</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>All</td>
<td>57</td>
<td>55</td>
<td>47</td>
<td>35</td>
<td>44.5</td>
<td>41</td>
<td>21</td>
<td>20100</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>38.5</td>
<td>34</td>
<td>32</td>
<td>22.5</td>
<td>31</td>
<td>27</td>
<td>15</td>
<td>7000</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>48.11</td>
<td>44.74</td>
<td>39.11</td>
<td>30.17</td>
<td>38.50</td>
<td>34.83</td>
<td>18.67</td>
<td>13422.22</td>
</tr>
<tr>
<td></td>
<td>SD ±6.85</td>
<td>±7.62</td>
<td>±5.47</td>
<td>±4.94</td>
<td>±5.38</td>
<td>±5.17</td>
<td>±2.60</td>
<td>±4460.32</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Max</td>
<td>55</td>
<td>55</td>
<td>44.5</td>
<td>35</td>
<td>43.5</td>
<td>39</td>
<td>21</td>
<td>17400</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>38.5</td>
<td>34</td>
<td>32</td>
<td>22.5</td>
<td>31</td>
<td>27</td>
<td>15</td>
<td>7000</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>48.50</td>
<td>46.00</td>
<td>39.63</td>
<td>30.75</td>
<td>39.13</td>
<td>35.25</td>
<td>18.75</td>
<td>13225.00</td>
</tr>
<tr>
<td></td>
<td>SD ±7.06</td>
<td>±8.76</td>
<td>±5.59</td>
<td>±5.63</td>
<td>±5.60</td>
<td>±5.68</td>
<td>±2.63</td>
<td>±4412.39</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>Max</td>
<td>52</td>
<td>47</td>
<td>35</td>
<td>44.5</td>
<td>41</td>
<td>21</td>
<td>20100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>38.5</td>
<td>34</td>
<td>32</td>
<td>22.5</td>
<td>31</td>
<td>27</td>
<td>15</td>
<td>7000</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>47.80</td>
<td>43.74</td>
<td>38.70</td>
<td>29.70</td>
<td>38.00</td>
<td>34.50</td>
<td>18.60</td>
<td>13580.00</td>
</tr>
<tr>
<td></td>
<td>SD ±7.50</td>
<td>±7.47</td>
<td>±6.00</td>
<td>±4.94</td>
<td>±5.80</td>
<td>±5.39</td>
<td>±2.88</td>
<td>±5011.69</td>
<td></td>
</tr>
<tr>
<td>M. emys</td>
<td>All</td>
<td>51</td>
<td>48</td>
<td>43</td>
<td>33.5</td>
<td>42</td>
<td>39</td>
<td>20</td>
<td>15500</td>
</tr>
<tr>
<td>emys</td>
<td>Min</td>
<td>38.5</td>
<td>34</td>
<td>32</td>
<td>22.5</td>
<td>31</td>
<td>27</td>
<td>15</td>
<td>7000</td>
</tr>
<tr>
<td>Sub sp.</td>
<td>Mean</td>
<td>47.13</td>
<td>44.25</td>
<td>38.25</td>
<td>30.00</td>
<td>38.75</td>
<td>34.50</td>
<td>18.50</td>
<td>12750.00</td>
</tr>
<tr>
<td></td>
<td>SD ±5.79</td>
<td>±6.85</td>
<td>±4.57</td>
<td>±5.05</td>
<td>±5.25</td>
<td>±5.20</td>
<td>±2.38</td>
<td>±3883.73</td>
<td></td>
</tr>
<tr>
<td>M. emys</td>
<td>All</td>
<td>57</td>
<td>55</td>
<td>47</td>
<td>35</td>
<td>44.5</td>
<td>41</td>
<td>21</td>
<td>20100</td>
</tr>
<tr>
<td>phayrei</td>
<td>Min</td>
<td>38.5</td>
<td>34</td>
<td>32</td>
<td>22.5</td>
<td>31</td>
<td>27</td>
<td>15</td>
<td>7000</td>
</tr>
<tr>
<td>Sub sp.</td>
<td>Mean</td>
<td>48.90</td>
<td>45.14</td>
<td>39.80</td>
<td>30.30</td>
<td>38.30</td>
<td>35.10</td>
<td>18.80</td>
<td>13960.00</td>
</tr>
<tr>
<td></td>
<td>SD ±8.19</td>
<td>±8.97</td>
<td>±6.54</td>
<td>±5.45</td>
<td>±6.09</td>
<td>±5.75</td>
<td>±3.03</td>
<td>±4937.9</td>
<td></td>
</tr>
</tbody>
</table>


CCL, CCW, SCL, SCW, PL, PW are expressed in centimetres; BW is expressed in grams.
Table 4.3.8: Morphometric ratios for the family Testudinidae

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>CCL/CCW</th>
<th>CCL/SCL</th>
<th>CCL/PL</th>
<th>CCL/SH</th>
<th>SCL/SCW</th>
<th>PL/PW</th>
<th>SCL/SH</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>All</td>
<td>1.20</td>
<td>1.22</td>
<td>1.52</td>
<td>3.10</td>
<td>1.62</td>
<td>1.11</td>
<td>2.53</td>
</tr>
<tr>
<td></td>
<td>±0.07</td>
<td>±0.03</td>
<td>±0.07</td>
<td>±0.48</td>
<td>±0.10</td>
<td>±0.02</td>
<td>±0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1.17</td>
<td>1.21</td>
<td>1.46</td>
<td>2.72</td>
<td>1.55</td>
<td>1.11</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>±0.09</td>
<td>±0.02</td>
<td>±0.05</td>
<td>±0.29</td>
<td>±0.01</td>
<td>±0.02</td>
<td>±0.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.22</td>
<td>1.24</td>
<td>1.57</td>
<td>3.39</td>
<td>1.67</td>
<td>1.10</td>
<td>2.74</td>
</tr>
<tr>
<td></td>
<td>±0.05</td>
<td>±0.03</td>
<td>±0.02</td>
<td>±0.38</td>
<td>±0.11</td>
<td>±0.03</td>
<td>±0.27</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>All</td>
<td>1.08</td>
<td>1.23</td>
<td>1.25</td>
<td>2.58</td>
<td>1.30</td>
<td>1.11</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>±0.05</td>
<td>±0.03</td>
<td>±0.05</td>
<td>±0.09</td>
<td>±0.08</td>
<td>±0.05</td>
<td>±0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1.06</td>
<td>1.22</td>
<td>1.24</td>
<td>2.59</td>
<td>1.30</td>
<td>1.11</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>±0.06</td>
<td>±0.04</td>
<td>±0.04</td>
<td>±0.09</td>
<td>±0.09</td>
<td>±0.06</td>
<td>±0.13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.10</td>
<td>1.23</td>
<td>1.26</td>
<td>2.57</td>
<td>1.31</td>
<td>1.10</td>
<td>2.08</td>
</tr>
<tr>
<td></td>
<td>±0.04</td>
<td>±0.03</td>
<td>±0.05</td>
<td>±0.10</td>
<td>±0.08</td>
<td>±0.05</td>
<td>±0.12</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>emys</td>
<td>All</td>
<td>1.07</td>
<td>1.23</td>
<td>1.22</td>
<td>2.55</td>
<td>1.29</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>±0.05</td>
<td>±0.04</td>
<td>±0.05</td>
<td>±0.10</td>
<td>±0.10</td>
<td>±0.07</td>
<td>±0.15</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>phayrei</td>
<td>All</td>
<td>1.09</td>
<td>1.23</td>
<td>1.28</td>
<td>2.60</td>
<td>1.32</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>±0.05</td>
<td>±0.02</td>
<td>±0.03</td>
<td>±0.09</td>
<td>±0.07</td>
<td>±0.04</td>
<td>±0.09</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3.9: Man-Whitney U test for the turtle species found during the present study

<table>
<thead>
<tr>
<th></th>
<th>CCL</th>
<th>CCL/CCW</th>
<th>CCL/SCC</th>
<th>CCL/PL</th>
<th>CCL/SH</th>
<th>SCL/SCW</th>
<th>PL/SH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>MWU</td>
<td>45.00</td>
<td>31.00</td>
<td>27.00</td>
<td>31.50</td>
<td>13.00</td>
<td>65.50</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>100.0</td>
<td>136.0</td>
<td>132.0</td>
<td>136.5</td>
<td>118.0</td>
<td>120.5</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-1.46</td>
<td>-2.29</td>
<td>-2.52</td>
<td>-2.27</td>
<td>-3.34</td>
<td>-0.2</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>0.14</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>0.15a</td>
<td>0.02a</td>
<td>0.01a</td>
<td>0.02</td>
<td>0.00a</td>
<td>0.79a</td>
</tr>
<tr>
<td>CM</td>
<td>MWU</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>3.00</td>
<td>3.00</td>
<td>1.00</td>
<td>2.00</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-1.23</td>
<td>-1.22</td>
<td>-1.23</td>
<td>0.00</td>
<td>-1.26</td>
<td>-1.23</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>1.00</td>
<td>1.00</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>0.67a</td>
<td>0.67a</td>
<td>0.76a</td>
<td>0.76a</td>
<td>0.17a</td>
<td>0.35a</td>
</tr>
<tr>
<td>CD</td>
<td>MWU</td>
<td>12.00</td>
<td>9.00</td>
<td>10.50</td>
<td>10.50</td>
<td>5.00</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>33.00</td>
<td>19.00</td>
<td>20.50</td>
<td>20.50</td>
<td>15.00</td>
<td>17.00</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-0.00</td>
<td>-0.65</td>
<td>-0.32</td>
<td>-0.32</td>
<td>-1.49</td>
<td>-1.07</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>1.00</td>
<td>0.52</td>
<td>0.74</td>
<td>0.75</td>
<td>0.14</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>1.00a</td>
<td>0.61a</td>
<td>0.76a</td>
<td>0.76a</td>
<td>0.17a</td>
<td>0.35a</td>
</tr>
<tr>
<td>MT</td>
<td>MWU</td>
<td>5.00</td>
<td>1.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>15.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>11.00</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-0.408</td>
<td>-1.852</td>
<td>-1.11</td>
<td>-1.11</td>
<td>-1.85</td>
<td>-0.408</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>.683</td>
<td>.064</td>
<td>.266</td>
<td>.266</td>
<td>.266</td>
<td>.683</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>.857a</td>
<td>.114a</td>
<td>.400a</td>
<td>.400a</td>
<td>.400a</td>
<td>.857a</td>
</tr>
<tr>
<td>NH</td>
<td>MWU</td>
<td>2.00</td>
<td>0.00</td>
<td>1.00</td>
<td>2.00</td>
<td>0.00</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>5.00</td>
<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
<td>3.00</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>0.00</td>
<td>-1.63</td>
<td>-0.78</td>
<td>0.00</td>
<td>-1.55</td>
<td>-1.23</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>1.00</td>
<td>0.10</td>
<td>0.44</td>
<td>1.00</td>
<td>0.12</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>1.00a</td>
<td>0.33a</td>
<td>0.67a</td>
<td>1.00a</td>
<td>0.33a</td>
<td>0.33a</td>
</tr>
<tr>
<td>AC</td>
<td>MWU</td>
<td>2.00</td>
<td>0.50</td>
<td>1.00</td>
<td>3.00</td>
<td>3.00</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>5.00</td>
<td>6.50</td>
<td>7.00</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-0.58</td>
<td>-1.48</td>
<td>-1.19</td>
<td>0.00</td>
<td>-1.48</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>0.57</td>
<td>0.14</td>
<td>0.24</td>
<td>1.00</td>
<td>0.14</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>0.80a</td>
<td>0.20a</td>
<td>0.40a</td>
<td>1.00a</td>
<td>0.20a</td>
<td>1.00a</td>
</tr>
<tr>
<td>ME</td>
<td>MWU</td>
<td>8.00</td>
<td>8.00</td>
<td>4.00</td>
<td>6.50</td>
<td>7.00</td>
<td>9.00</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>29.00</td>
<td>14.00</td>
<td>10.00</td>
<td>12.50</td>
<td>13.00</td>
<td>30.00</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-0.26</td>
<td>-0.26</td>
<td>-1.29</td>
<td>-0.64</td>
<td>-0.52</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>0.79</td>
<td>0.79</td>
<td>0.19</td>
<td>0.52</td>
<td>0.61</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>0.91a</td>
<td>.091a</td>
<td>.26a</td>
<td>0.55a</td>
<td>0.72a</td>
<td>0.91a</td>
</tr>
<tr>
<td>IE</td>
<td>MWU</td>
<td>2.00</td>
<td>2.00</td>
<td>1.50</td>
<td>1.00</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>WW</td>
<td>5.00</td>
<td>5.00</td>
<td>4.50</td>
<td>4.00</td>
<td>5.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>-0.94</td>
<td>-0.94</td>
<td>-1.17</td>
<td>-1.38</td>
<td>-0.93</td>
<td>-1.38</td>
</tr>
<tr>
<td></td>
<td>Asymp. p</td>
<td>0.35</td>
<td>0.35</td>
<td>0.24</td>
<td>0.16</td>
<td>0.36</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Exact p</td>
<td>0.53a</td>
<td>0.53a</td>
<td>0.27a</td>
<td>0.27a</td>
<td>0.53a</td>
<td>0.27a</td>
</tr>
</tbody>
</table>

4.3.1 *Cuora amboinensis*

Thirty eight numbers of *C. amboinensis* (Plate 4.1.1) were observed of which 14 individuals were male, 18 individuals were female and the rest 6 were juvenile. Male to female ratio of 0.78 remind the dominance of females within the population. During the present study the juveniles had less marked vertebral keel (Plate 4.1.1C). Instead it had a faint brown line running antero-posteriorly at the median of the shell where the keel is supposed to be developed in adult. It had also marked radiations away from the dark blotches towards midline in the plastron. The limb got yellow striation and patches against the dark olive background. The body was little broadened posteriorly with having maximum SCW at 8\textsuperscript{th} marginal scute. Concentric growth annuli could be clearly seen with dotted patches at the centre of the ring. In adults the vertebral keel was more prominent with light brown colouration running antero-posteriorly at the median of the carapace (Plate 4.1.1A). There were radiations from the blotches in the plastron. In the 3\textsuperscript{rd} and 4\textsuperscript{th} plastral scute there was concentric angular markings instead of radiating lines as seen in juveniles. Male had slightly concave plastron, thicker tails and longer claws. Females had almost flat plastron, short tail short claws.

SCL ranged from 11 to 18cm (Table 4.3.1) in males, 13 to 18.6cm among females and 7.4 to 9.8cm among juveniles (Table 4.3.1). BW ranged from 400 to 900g among males, 550 to 1050g among females and 100 to 200g among juveniles. The morphometric ratio values have been shown in table 4.3.2.

CCL/SH was 3.55 in males and 3.09 in females (Table 4.3.3). It was noted that males had higher CCL/SH which shows steeper carapace of males compared to females. SCL/SCW was almost equal between male and female. SCL/SH ratio was 2.83 for
males and 2.55 for females. There was little difference of SCL/SH ratio among sexes which signifies that both sexes are almost equally domed.

Man-Whitney U test shows statistically significant sexual size dimorphism in *Cuora amboinensis* by parameters CCL/CCW, CCL/SCL, CCL/PL, CCL/SH with having Exact Sig. (2-tailed) less than 0.05 (Table 4.3.9). Females are more broader than males significantly.

### 4.3.2 *Cyclemys dentata*

During the present study 15 individuals of *Cyclemys dentata* including 7 females, 5 males and 3 juvenile were found. The adult’s body was domed (Plate 4.1.2A) while juveniles (Plate 4.1.2C) were less domed. The colour was reddish brown. The vertebral keel was very prominent (Plate 4.1.2 A). There were radiating rays of black colour against brown plastron in each scute (Plate 4.1.2 B). There were thick scales on both fore and hind limbs. There were concentric rectangular rings in each scute and fine dark rays radiating from centre towards border of each scute. Male had almost concave plastron while female had almost flat plastron. In juveniles the posterior marginals are serrated (Plate 4.1.2 C). There were unique pattern of striations. The radiating lines in juveniles were of convergent radiation. The fine prominent lines were seen at border of scutes. The middle portion did not have any lines and was smooth. The colour was reddish brown. The shape was almost oval with maximum width seen at 8th marginal scute. The shell was less curved, dorso-ventrally compressed and slopes gradually in angle. In plastron too there was a convergent striation. Striations were prominent at borders and were smooth at the centre of each scute. There were alternative striation of
light brown and black. The middle of each scute had no striations and was dark brown in colour with small black patches. Serration begins from 8\textsuperscript{th} marginals. The plastron was flat which is peculiar of juveniles as it shows no sign of sexual maturity.

SCL had range variation of 9.3 to 24.0 cm among all individuals. SCL ranged from 16.5 to 23cm in males, 13 to 24cm in females and 9.3 to 9.6 cm in juveniles (Table 4.3.1). The heaviest among all was 2250g. The morphometric ratios are given (Table 4.3.3). Mean CCL/CCW of 1.11(near to value1) signifies that the anterio-posterior and lateral curvatures of shell were almost similar. SCL/SH was 2.88 for males 3.22 and females. It showed that males are more domed. Higher value of SCL/SH indicates the depression in shell and inversely lower value indicates higher degree of domeness. SCL/SCW was 1.36 in males, 1.49 in females and 1.37 in juveniles. Lower SCL/SCW in juveniles suggest that juveniles are almost circular. The average CCL of males is 19.7± 6.2 and average body weight was 1190 ±730 g.

Sexual size dimorphism studied through Man- Whitney U test reveals that there is no any statistically significant difference (all \( p \) value >0.05) between males in females of \textit{Cyclemys dentata} in samples studied (Table 4.3.9).

4.3.3 \textit{Cuora mouhotii}

Five individuals of \textit{Cuora mouhotii} (Plate 4.1.2E) with 3 males and 2 female were obtained. No robust range or average could not be taken between sexes due to lesser sample number. Little variation in colouration and body pattern was observed among individuals. SCL ranged from 13.1 to 17 cm (Table 4.3.2). Body weight ranged
from 400 to 850g. Mean SCL/SCW was 1.36 for males and 1.65 for females. It signifies that males and females are almost identical in elongation with slightly in favour of males. Sexual size dimorphism studied through Man Whitney U test reveals that there was no any difference of statistical significances within *Cuora mouhotii* (all $p$ value $>0.05$) between males in females in samples studied (Table 4.3.9).

### 4.3.4 *Melanochelys trijuga*

During the present study 7 individuals of *Melanochelys trijuga* (Plate 4.1.1.E). Due to less sampling, a robust comparison between males and females could not be performed. Morphometric values are given in table 4.3.2 while morphometric ratios are given in table 4.3.3. SCL ranges from 12.2 to 20 cm (Table 4.3.2). SCL/SH was 2.59 for males and 2.68 for females (Table 4.3.3) which shows near identical degree of shell depression between male and female. SCL/SCW was 1.46 for males and 1.46 for females which shows almost similar degree of roundness. Similarly PL/PW also shows almost similar values between males and females.

### 4.3.5 *Amyda cartilaginea*

Large tubercles were seen at anterior tip and posterior region of the carapace (Plate 4.1.3A). A prominent line of tubercles at midline of carapace was noted. Shell oval in shape with widening posteriorly. The central region of the plastron was greyish while rest is whitish. Males have thicker tails that extend beyond carapace end. All individuals were adults. Morphometric values are given in table 4.3.4 and morphometric ratios are given in table 4.3.6. SCL ranges from 23.1 to 32.4 cm (Table 4.3.4). SCW ranges from 20.8 to 37.2 cm. BW ranges from 3850 to 5500g. Five females and 4 males
were studied. Mean SCL/SCW was 1.05 for males and 1.16 for females denotes similar
degree of roundness among males and females. Sexual size dimorphism studied trough
Man Whitney U test reveals that there is no any difference of statistical significances
(all \( p \) value >0.05) between males in females of \textit{A. cartilaginea} samples studied (Table 4.3.9).

4.3.6 \textit{Nilssonia hurum}

There were reticulations all over the carapace and dorsal surface of head (Plate 4.1.3.C). There were four big eyes like circles with an inner circular black blotch. Males have thicker and longer tails with cloaca positioned near tail tip. All individuals were adults. Morphometric values and ratios are given in table 4.35 and 4.36 respectively.

SCL ranges from 23.4 to 33 cm (Table 4.3.5). Body weight ranges from 3550 to 5100g. CCL/CCW was 121±0.05 and 1.11±0.03 for males and females respectively (Table 4.3.6). SCL/SCW was same for males and females respectively which shows that males and females are almost identical in degree of roundness. Sexual size dimorphism studied through Man Whitney U test reveals that there is no any difference of statistical significances (all \( p \) value >0.05) between males in females of \textit{N.hurum} in samples studied (Table 4.3.12).

4.3.7 \textit{Indotestudo elongata}

The species have elongated body, yellowish shell with black blotches in each scute (Plate 4.1.4). Posterior nuchal scute was present with also having deeply notched plastron at posterior end. Males had shorter tails, concave plastron and shorter claws in hind limb. Females had posses flat plastron; longer and curved claws in hind limb.
During the present study 7 individuals of *Indotestudo elongata*, 3 males and 4 females were analysed for morphometric studies. The morphometric values and ratios are given in table 4.3.7 and Table 4.3.8 respectively. SCL ranged from 18 to 25.6cm (Table 4.3.7). BW ranged from 950 to 1950g.

SCL/SCW was 1.55 for males and 1.67 for females (Table 4.3.8). Degree of elongation (SCL/SCW) was almost similar in between males and females with slightly in favour of females. The mean SCL/SCW of 1.62 for all individual denotes higher degree of body elongation. Sexual size dimorphism studied through Man Whitney U test reveals that there is no any difference of statistical significances (all p value >0.05) between males in females of *Lelongata* in samples studied (Table 4.3.12).

**4.3.8 Manouria emys**

During the present survey 9 live adult individuals of *Manouria emys* (Plate 4.1.4 C) were found including 4 males and 5 females. Both the subspecies *Manouria emys phayrei* and *Manouria emys emys* were found during the survey. Remarkable difference noticed between the two subspecies was the plastron. In sub species *M.e.phayrei* the pectoral scutes touch each other in midline (Plate 4.1.4 D) whereas in sub species *M.e.emys* pectoral scutes were not connected and got separated before midline (Plate 4.1.4 F). In another type within the *Manouria emys phayrei* subspecies there observed a plastron type in which triangular pectoral touches exactly at a point in the midline (Plate 4.1.4 E). Thus three types of plastron within the two subspecies were observed. Morphometric measurements and ratios are given in table 4.3.7 in table 4.3.8.
SCL ranged from 32 to 47cm (Table 4.3.7). Male SCL ranged from 32 to 44.5cm while female SCL ranged from 32 to 47cm. No marked differences in length were observed between males and females. BW ranged from 7 to 20.1 kg. Among subspecies, SCL ranges from 32 to 47 cm in *Manouria emys phayrei* and 32 to 43 cm in *M. emys emys*. BW ranges from 7 to 15.5 kg in *M. emys emys* and 7 to 20.1kg among *M. emys phayrei* (Table 4.3.7). Subspecies *M. emys phayrei* was observed to be bigger comparatively. SCL/SCW was 1.30 for males and 1.31 for females which are almost identical (Table 4.3.8).

A comparison between the two subspecies during the present study shows that *Manouria emys phayrei* was bigger than *Manouria emys emys* in the locality. Man-Whitney U test reveals that no significant sexual size difference was observed between male and females during the present study.
4.4 Genetic variation studies among *Manouria emys* population

The PCR purified product of three markers presented good and clear band against 100bp ladder without any noise (Plate 4.4.1). 19 sequences developed from the present study were utilized for diversity studies (Table 4.4.1). The processed sequence length of three markers (two mitochondrial partial coding sequences Cytochrome b and cytochrome oxidase and the Nuclear R35 Intron) were 828bp, 301 bp and 399bp respectively (Table 4.4.2). Fifteen COI, 12 cyt b and 1 R35 secondary sequences from GenBank (Appendix 7) were also utilised to study the genetic variation of *Manouria emys* in northeast and East India. The base compositions are illustrated (Table 4.4.2). The description of the best model was chosen through MEGA 6 (Table 4.4.4).

Table 4.4.1: GenBank accession from the present studies that were used for genetic variation analysis

<table>
<thead>
<tr>
<th>Popset</th>
<th>GenBank Acc.no</th>
<th>Popset</th>
<th>GenBank Acc.no</th>
<th>Popset</th>
<th>GenBank Acc.no</th>
</tr>
</thead>
<tbody>
<tr>
<td>GU M1</td>
<td>KU976951</td>
<td>MN1</td>
<td>KX668555</td>
<td>GUT1</td>
<td>KX002256</td>
</tr>
<tr>
<td>GU M2</td>
<td>KU976952</td>
<td>MN2</td>
<td>KX668556</td>
<td>GUT2</td>
<td>KX002257</td>
</tr>
<tr>
<td>GU M3</td>
<td>KU976953</td>
<td>CC1</td>
<td>KX668557</td>
<td>GU T4</td>
<td>KX002258</td>
</tr>
<tr>
<td>GU M4</td>
<td>KU976954</td>
<td>CC2</td>
<td>KX668558</td>
<td>GU T5</td>
<td>KX002259</td>
</tr>
<tr>
<td>GU M5</td>
<td>KU976955</td>
<td>CC3</td>
<td>KX668559</td>
<td>GUT6</td>
<td>KX002260</td>
</tr>
<tr>
<td>GU M6</td>
<td>KU976956</td>
<td>CC4</td>
<td>KX668560</td>
<td>GU T7</td>
<td>KX002261</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CC5</td>
<td>KX668561</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GU M1-6: COI sequences; MN1-2; CC1-5: cyt b sequences; GU1-7: R35 gene intron sequences
Plate 4.4.1 Gel Images for PCR products; A: Gel image of cyt b PCR products; B: Gel image of COI PCR products; C: Gel image of R35 PCR products. GU ME of COI and GU T3 of R35 did not obtain clear chromatogram and therefore let out of analysis.
Table 4.4.2: Base composition of the sequences

<table>
<thead>
<tr>
<th></th>
<th>Seq</th>
<th>GU M1</th>
<th>GU M2</th>
<th>GU M3</th>
<th>GU M4</th>
<th>GU M5</th>
<th>GU M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>COI</td>
<td></td>
<td>Length</td>
<td>301</td>
<td>301</td>
<td>301</td>
<td>301</td>
<td>301</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A (%)</td>
<td>27.2</td>
<td>27.2</td>
<td>27.2</td>
<td>27.2</td>
<td>27.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C (%)</td>
<td>26.9</td>
<td>26.9</td>
<td>26.9</td>
<td>26.9</td>
<td>26.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G (%)</td>
<td>19.3</td>
<td>19.3</td>
<td>19.3</td>
<td>19.3</td>
<td>19.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T (%)</td>
<td>26.6</td>
<td>26.6</td>
<td>26.6</td>
<td>26.6</td>
<td>26.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Seq</th>
<th>MN 1</th>
<th>MN 2</th>
<th>CC1</th>
<th>CC2</th>
<th>CC3</th>
<th>CC4</th>
<th>CC5</th>
</tr>
</thead>
<tbody>
<tr>
<td>cyt b</td>
<td></td>
<td>Length</td>
<td>828</td>
<td>828</td>
<td>828</td>
<td>828</td>
<td>828</td>
<td>828</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A (%)</td>
<td>28.9</td>
<td>28.9</td>
<td>28.9</td>
<td>28.9</td>
<td>28.9</td>
<td>29.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C (%)</td>
<td>30.8</td>
<td>30.6</td>
<td>30.6</td>
<td>30.8</td>
<td>30.6</td>
<td>30.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G (%)</td>
<td>12.4</td>
<td>12.6</td>
<td>12.6</td>
<td>12.4</td>
<td>12.6</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T (%)</td>
<td>27.9</td>
<td>28.0</td>
<td>28.0</td>
<td>27.9</td>
<td>28.0</td>
<td>28.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Seq</th>
<th>GU T1</th>
<th>GU T2</th>
<th>GU T3</th>
<th>GU T4</th>
<th>GU T5</th>
<th>GU T6</th>
<th>GU T7</th>
</tr>
</thead>
<tbody>
<tr>
<td>R35</td>
<td></td>
<td>Length</td>
<td>399</td>
<td>399</td>
<td>399</td>
<td>399</td>
<td>399</td>
<td>399</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A (%)</td>
<td>30.8</td>
<td>30.8</td>
<td>30.8</td>
<td>30.8</td>
<td>30.8</td>
<td>30.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C (%)</td>
<td>23.8</td>
<td>23.8</td>
<td>23.8</td>
<td>23.8</td>
<td>23.8</td>
<td>23.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G (%)</td>
<td>19.0</td>
<td>19.0</td>
<td>19.0</td>
<td>19.0</td>
<td>19.0</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T (%)</td>
<td>26.3</td>
<td>26.3</td>
<td>26.3</td>
<td>26.3</td>
<td>26.3</td>
<td>26.3</td>
</tr>
</tbody>
</table>

The sequences were developed from *Manouria emys* of Churachandpur district, Manipur.

COI: Cytochrome Oxidase I; cyt b: Cytochrome b; R35: R35 RNA fingerprinting gene intron;
GU M1-GU M6: COI sequences; MN1-MN2; CC1-CC5: cyt b sequences; GU1-GU7: R35 gene intron sequences
Table 4.4.3: Physico–chemical features of the sequences

<table>
<thead>
<tr>
<th>Marker</th>
<th>Seq</th>
<th>GU</th>
<th>M1</th>
<th>GU</th>
<th>M2</th>
<th>GU</th>
<th>M3</th>
<th>GU</th>
<th>M4</th>
<th>GU</th>
<th>M5</th>
<th>GU</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>COI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight ds (kDa)</td>
<td></td>
<td>92474.8</td>
<td>92474.8</td>
<td>92474.8</td>
<td>92474.8</td>
<td>92474.8</td>
<td>92474.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP.(°C)</td>
<td></td>
<td>185.975</td>
<td>185.975</td>
<td>185.975</td>
<td>185.975</td>
<td>185.975</td>
<td>185.975</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C+G (%)</td>
<td></td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A+T (%)</td>
<td></td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cyt b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight ds (kDa)</td>
<td></td>
<td>252714.6</td>
<td>252769.6</td>
<td>252769.6</td>
<td>252714.6</td>
<td>252769.6</td>
<td>252769.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP.(°C)</td>
<td></td>
<td>511.597</td>
<td>511.596</td>
<td>511.596</td>
<td>511.597</td>
<td>511.596</td>
<td>511.595</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C+G (%)</td>
<td></td>
<td>57.6</td>
<td>57.9</td>
<td>57.9</td>
<td>57.6</td>
<td>57.9</td>
<td>57.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A+T (%)</td>
<td></td>
<td>43.2</td>
<td>43.1</td>
<td>43.1</td>
<td>43.2</td>
<td>43.1</td>
<td>43.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight ds (kDa)</td>
<td></td>
<td>122895.6</td>
<td>122895.6</td>
<td>122895.6</td>
<td>122895.6</td>
<td>122895.6</td>
<td>122895.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP.(°C)</td>
<td></td>
<td>246.548</td>
<td>246.548</td>
<td>246.548</td>
<td>246.548</td>
<td>246.548</td>
<td>246.548</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C+G (%)</td>
<td></td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A+T (%)</td>
<td></td>
<td>42.9</td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td>68.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MW: Molecular weight (g/mole); MP: Melting point; Predictions are in neutral buffered solutions (pH 7 - 8) with monovalent cation (Na+) concentrations from 1.2 M down to 1.5mM, divalent cation (Mg++) concentrations from 600 mM down to 0.01 mM, and triphosphates (dNTPs) concentrations up to 120% of the divalent cation concentration.

There was restriction cut variation among cyt b MN1 and MN2 of Churanchandpur, Manipur samples by FaiI (restriction endonucleases) at position 561 (Table 4.4.4). For COI and R35 variation naturally did not arise as there were no sequence variations.

Table 4.4.4: Restriction site variation among cyt b MN1 and MN2 using Restriction mapper

<table>
<thead>
<tr>
<th>RE</th>
<th>Sequence</th>
<th>Site Length</th>
<th>Overhang</th>
<th>Frequency</th>
<th>Cut Positions MN1</th>
<th>Cut Positions MN2</th>
</tr>
</thead>
</table>

RE: restriction endonuclease; MN1 and MN2 are from Churanchandpur, Manipur
Table 4.4.5: Maximum likelihood model parameters for the datasets as estimated in the MEGA 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COI</th>
<th>cyt b</th>
<th>R35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequences</td>
<td>22</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>Model</td>
<td>K2+G</td>
<td>HKY+G</td>
<td>JC</td>
</tr>
<tr>
<td>Rate matrix</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A=&gt;T</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>A=&gt;C</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>A=&gt;G</td>
<td>0.22</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>T=&gt;A</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>T=&gt;C</td>
<td>0.22</td>
<td>0.27</td>
<td>0.08</td>
</tr>
<tr>
<td>T=&gt;G</td>
<td>0.01</td>
<td>0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>C=&gt;A</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>C=&gt;T</td>
<td>0.22</td>
<td>0.22</td>
<td>0.08</td>
</tr>
<tr>
<td>C=&gt;G</td>
<td>0.01</td>
<td>0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>G=&gt;A</td>
<td>0.22</td>
<td>0.24</td>
<td>0.08</td>
</tr>
<tr>
<td>G=&gt;T</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>G=&gt;C</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>BIC</td>
<td>1599.73</td>
<td>2295.10</td>
<td>1235.84</td>
</tr>
<tr>
<td>AICc</td>
<td>1307.98</td>
<td>2013.25</td>
<td>1170.76</td>
</tr>
<tr>
<td>LnL</td>
<td>-610.70</td>
<td>-966.43</td>
<td>-574.33</td>
</tr>
<tr>
<td>Invariant(I)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Gamma distribution(G)</td>
<td>0.060</td>
<td>0.251</td>
<td>n/a</td>
</tr>
<tr>
<td>Transition/Transversion bias (R)</td>
<td>8.524</td>
<td>4.344</td>
<td>0.5</td>
</tr>
<tr>
<td>Total position in the final dataset</td>
<td>301</td>
<td>451</td>
<td>395</td>
</tr>
</tbody>
</table>

K2: Kimura 2; JC: Jukes-Cantor; HKY: Hasegawa-Kishino-Yano.
4.4.1 Genetic variation studies of *Manouria emys* of Churachandpur district, Manipur using cytochrome b

There were nucleotide substitutions in 4 positions (Table 4.4.6). All substitutions were transition. The substitutions were among sequences of different subspecies. Within the same subspecies there were no substitutions.

Table 4.4.6: Nucleotide substitutions within cyt b of CCPUR *M.emys* samples

<table>
<thead>
<tr>
<th>Position</th>
<th>Seq</th>
<th>Consensus base</th>
<th>Substituted base</th>
<th>Substitution type</th>
</tr>
</thead>
<tbody>
<tr>
<td>396</td>
<td>MN2</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC3</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC4</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC5</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>489</td>
<td>CC3</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC4</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC5</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>561</td>
<td>MN1</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC3</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC4</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC5</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>605</td>
<td>MN2</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC3</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC4</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
<tr>
<td></td>
<td>CC5</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
</tbody>
</table>

MN1.CC1,CC2 are *Manouria emys emys* subspecies; MN2, CC3-5 are *Manouria emys phayrei* subspecies; MN1-2; CC1-5 are the cyt b sequences of the samples collected from Churachandpur, Manipur.

The Maximum genetic p- distance shown within the PopSet of Manipur based on Cytochrome b dataset was 0.009 between MN1 and MN2. (Appendix 14). The subspecies *Manouria emys emys* (MN1, CC1,CC2) shows a genetic distinction from
that of subspecies *Manouria emys phayrei* (MN2, CC3, CC4, CC5). The Maximum genetic distance among specimens of *Manouria emys* from Northeast and East India ranges was found to be 0.031 between ZS1 T3 and MN1 (Appendix 15). The specimen from Manipur (MN1, MN2, CC1, CC2, CC3, CC4, CC5) showed greater genetic distance from samples from other parts of Northeast India and East India.

![Figure 4.4.1: Evolutionary relationships of *Manouria emys* of Churachandpur, Manipur based on Cytochrome b marker using Maximum Likelihood method. ZSI T31 and ZSI T32 are placed as outgroups.](image)

The evolutionary history was inferred by using the Maximum Likelihood method based on the Hasegawa-Kishino-Yano model (Hasegawa et al., 1985). The tree with the highest log likelihood (-680.4496) is shown. The percentage of trees in which the associated taxa clustered together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 9 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 451 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura et al., 2013)
Fig. 4.4.2: Evolutionary relationships of *Manouria emys* of Churachandpur, Manipur based on Cytochrome b marker using Maximum Parsimony method

ZSI T31 and ZSI T32 are placed as outgroups

The evolutionary history was inferred using the Maximum Parsimony method. Tree #1 out of 8 most parsimonious trees (length = 14) is shown. The consistency index is (1.000000), the retention index is (1.000000), and the composite index is 1.000000 ( 1.000000) for all sites and parsimony-informative sites (in parentheses). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The MP tree was obtained using the Subtree-Pruning-Regrafting (SPR) algorithm (Nei and Kumar, 2000) with search level 1 in which the initial trees were obtained by the random addition of sequences (10 replicates). The analysis involved 9 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 451 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Nei and Kumar, 2000).
Fig. 4.4.3: Evolutionary relationships of *Manouria emys* of Churachandpur, Manipur based on Cytochrome b marker using Neighbor-Joining method.

ZSI T31 and ZSI T32 are placed as outgroups

The evolutionary history was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). The optimal tree with the sum of branch length = 0.03104213 is shown. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the p-distance method (Nei and Kumar, 2000) and are in the units of the number of base differences per site. The analysis involved 9 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 451 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura et al., 2013).
4.4.2 Genetic variation studies of *Manouria emys* of Northeast India using cytochrome b

The analysis of nucleotide substitution of cytochrome b sequence from various parts of Northeast India reveals that there were nucleotide substitution in 16 positions including 11 transitions and 5 transversion (Table 4.4.7).

Table 4.4.7: Nucleotide substitutions in *Manouria emys* cyt b samples from various parts of northeast India

<table>
<thead>
<tr>
<th>Position</th>
<th>Sequence</th>
<th>Consensus base</th>
<th>Substituted base</th>
<th>Substitution type</th>
</tr>
</thead>
<tbody>
<tr>
<td>309</td>
<td>MN1-2, CC1-5</td>
<td>A</td>
<td>G</td>
<td>Transition</td>
</tr>
<tr>
<td>336</td>
<td>MN1-2, CC1-5, T37-38</td>
<td>C</td>
<td>A</td>
<td>Transversion</td>
</tr>
<tr>
<td>392</td>
<td>T41-42</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>393</td>
<td>T41-42</td>
<td>T</td>
<td>G</td>
<td>Transversion</td>
</tr>
<tr>
<td>475</td>
<td>T3-4; T26-26; T25-26, T31-32</td>
<td>C</td>
<td>G</td>
<td>Transversion</td>
</tr>
<tr>
<td>489</td>
<td>MN2, CC3-5, T37-38, T41-42</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>540</td>
<td>T-37,38</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
<tr>
<td>550</td>
<td>T31-32</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
<tr>
<td>561</td>
<td>MN-2, CC3-5, T3-4, T25-26</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>605</td>
<td>MN1, CC1-2, T37-38, T41-42</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>616</td>
<td>T3-4,25-26,31-32</td>
<td>A</td>
<td>G</td>
<td>Transition</td>
</tr>
<tr>
<td>687</td>
<td>T3-4,25-26,31-32</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>690</td>
<td>T3-4</td>
<td>C</td>
<td>T</td>
<td>Transition</td>
</tr>
<tr>
<td>693</td>
<td>T3-4,25-26</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>744</td>
<td>MN1-2, CC1-5</td>
<td>A</td>
<td>C</td>
<td>Transversion</td>
</tr>
<tr>
<td>750</td>
<td>MN1-2, CC1-5</td>
<td>T</td>
<td>A</td>
<td>Transversion</td>
</tr>
</tbody>
</table>

MN1-2; CC1-5 are sequences from Churachandpur, Manipur samples. The rest are samples from northeast and East India.
Figure 4.4.4: Evolutionary relationships of *Manouria emys* of Northeast India based on Cytochrome b marker using Maximum Likelihood method

AY434643.1 and DQ497310.1 are placed as outgroups

The evolutionary history was inferred by using the Maximum Likelihood method based on the Hasegawa-Kishino-Yano model (Hasegawa et al., 1985). The tree with the highest log likelihood (-974.7730) is shown. The percentage of trees in which the associated taxa clustered together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. All positions containing gaps and missing data were eliminated. There were a total of 451 positions in the final dataset.
Figure 4.4.5: Evolutionary relationships of Manouria emys of Northeast India based on Cytochrome b marker using Neighbour joining method
AY434643.1 and DQ497310.1 are placed as outgroups

The phylogeny tree was also constructed by comparing sequences available from other parts of northeast India. The evolutionary history was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). The optimal tree with the sum of branch length = 0.18181818 is shown. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The evolutionary distances were computed using the p-distance method (Nei and Kumar, 2000) and are in the units of the number of base differences per site. The analysis involved 19 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 451 positions in the final dataset.
Figure 4.4.6: Evolutionary relationships of *Manouria emys* of Northeast India based on Cytochrome b marker using Maximum Parsimony method

AY434643.1 and DQ497310.1 are placed as outgroups.

The evolutionary history was inferred using the Maximum Parsimony method. Tree #1 out of 2 most parsimonious trees (length = 245) is shown. The consistency index is (0.983607), the retention index is (0.986441), and the composite index is 0.970336 (0.970270) for all sites and parsimony-informative sites (in parentheses). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The MP tree was obtained using the Subtree-Pruning-Regrafting (SPR) algorithm (Nei and Kumar, 2000) with search level 1 in which the initial trees were obtained by the random addition of sequences (10 replicates). There were a total of 407 positions in the final dataset.
4.4.3 Genetic variation studies of *Manouria emys* of Northeast India using COI

The analysis of COI nucleotide substitution reveals that there were nucleotide substitutions in 10 positions among various sequences from northeast India. It includes 7 transitions and 3 transversion (Table 4.4.8).

Table 4.4.8: Nucleotide substitutions in *Manouria emys* COI samples from Northeast and eastern India.

<table>
<thead>
<tr>
<th>Position</th>
<th>Sequence (s)</th>
<th>Consensus base</th>
<th>Substituted base</th>
<th>Substitution type</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>T3-4, T25-26; AUTK-63</td>
<td>C</td>
<td>A</td>
<td>Transversion</td>
</tr>
<tr>
<td>106</td>
<td>T-31-32, T37-38</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>118</td>
<td>T-31-32, T37-38</td>
<td>A</td>
<td>G</td>
<td>Transition</td>
</tr>
<tr>
<td>127</td>
<td>T-31,32,37,38</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>154</td>
<td>T-31-32, T37-38</td>
<td>A</td>
<td>G</td>
<td>Transition</td>
</tr>
<tr>
<td>226</td>
<td>T3-4, T25-26, T31-32, T37-38</td>
<td>A</td>
<td>G</td>
<td>Transition</td>
</tr>
<tr>
<td>274</td>
<td>T-31-32, T37-38</td>
<td>A</td>
<td>G</td>
<td>Transition</td>
</tr>
<tr>
<td>290</td>
<td>T3-4, T25-26, T31-32, T37-38</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>300</td>
<td>T-3, 4, 25, 26, 31, 32, 37, 38</td>
<td>G</td>
<td>C</td>
<td>Transversion</td>
</tr>
<tr>
<td>301</td>
<td>GU_M1-GU_M6</td>
<td>G</td>
<td>C</td>
<td>Transversion</td>
</tr>
</tbody>
</table>

GU_M1-GU_M6 are sequences from samples from Churachandpur, Manipur obtained during the current study. Rest are sequences from Northeast and East India obtained from GenBank.

Maximum genetic p-distance of 0.027 was observed between Manipur samples (GUM1-GUM6) and T31-32, T37-38 (Appendix 15). The latter samples are reported to be from Mizoram and West Bengal (Kundu, 2015) but exact locations were not known. The subspecies *Manouria emys phayrei* and *Manouria emys emys* shows clear genetic
distinction. There was no genetic p-distance among *Manouria emys* samples of Manipur irrespective of their subspecies. The specimen from Manipur shows genetic distinction from specimens from other parts of Northeast India and East India.

Figure 4.4.7: Evolutionary relationships of *Manouria emys* of Northeast India based on COI marker using Maximum Likelihood method. AUTK6 and AUTK7 are placed as outgroups.

The evolutionary history was inferred by using the Maximum Likelihood method based on the Kimura 2-parameter model (Kimura, 1980). The tree with the highest log likelihood (-616.3405) is shown. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. The analysis involved 21 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 301 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura et al., 2013).
Figure 4.4.8: Evolutionary relationships of *Manouria emys* of Northeast India based on COI marker using Neighbor-Joining method. AUTK6 and AUTK7 are placed as outgroups.

The evolutionary history was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). The optimal tree with the sum of branch length = 0.13745847 is shown. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the p-distance method (Nei and Kumar, 2000) and are in the units of the number of base differences per site. The analysis involved 21 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 301 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura et al., 2013).
Figure 4.4.9: Evolutionary relationships of *Manouria emys* of Northeast India based on COI marker using Maximum Parsimony method. AUTK6 and AUTK7 are placed as outgroups.

The evolutionary history was inferred using the Maximum Parsimony method. Tree #1 out of 10 most parsimonious trees (length = 44) is shown. The consistency index is (0.926829), the retention index is ((0.957746), and the composite index is 0.892446 (0.887667) for all sites and parsimony-informative sites (in parentheses). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The MP tree was obtained using the Subtree-Pruning-Regrafting (SPR) algorithm (Nei and Kumar, 2000) with search level 1 in which the initial trees were obtained by the random addition of sequences (10 replicates). The analysis involved 22 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 301 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura et al., 2013).
4.4.4 Genetic variation studies of *Manouria emys* of Churachandpur district, Manipur using R35 nuclear gene intron.

There are 6 sequences of R35 marker. Within the popset, no nucleotide variation was observed. It was therefore compared with available sequence AY434647.1. The sequence could be sourced from Asian pet trade (Spinks et al., 2004). There were 3 transition and 4 deletion in the sequence AY434647.1.

**Table 4.4.9: Positional base pair variation among R35 sequences**

<table>
<thead>
<tr>
<th>Position</th>
<th>Seq</th>
<th>Consensus base</th>
<th>Substituted base</th>
<th>Substitution type</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>AY434647.1</td>
<td>G</td>
<td>A</td>
<td>Transition</td>
</tr>
<tr>
<td>65</td>
<td>AY434647.1</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>202</td>
<td>AY434647.1</td>
<td>T</td>
<td>C</td>
<td>Transition</td>
</tr>
<tr>
<td>328</td>
<td>AY434647.1</td>
<td>C</td>
<td>0</td>
<td>deletion</td>
</tr>
<tr>
<td>329</td>
<td>AY434647.1</td>
<td>A</td>
<td>0</td>
<td>deletion</td>
</tr>
<tr>
<td>330</td>
<td>AY434647.1</td>
<td>A</td>
<td>0</td>
<td>deletion</td>
</tr>
<tr>
<td>331</td>
<td>AY434647.1</td>
<td>A</td>
<td>0</td>
<td>deletion</td>
</tr>
</tbody>
</table>

The source of AY434647.1 was from Asian pet trade (Spinks et al., 2004).

A Maximum genetic p-distance of 0.1 was observed between the R35 nucleotide sequences of Manipur samples (GUT1-7) and AY434647.1 based on R35 intron sequence (Table 4.4.10). Among Samples of Manipur there were no any genetic distances. (Table 4.4.10). The distance based on R35 could not produce any distinctness at subspecies level of *Manouria emys*. However, pronounced genetic distinctness was observed between the local populations and AY434647.1 (Spinks et al., 2004). The
analysis of p-distances using different dataset reveals that there is clear distinctness of *Manouria emys* of Manipur from other out group analysed.

Table 4.4.10: Genetic p distance among R35 sequences

<table>
<thead>
<tr>
<th></th>
<th>0.005</th>
<th>0.005</th>
<th>0.005</th>
<th>0.005</th>
<th>0.005</th>
<th>0.005</th>
<th>0.005</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY434647.1</td>
<td>0.010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GU_T1</td>
<td>0.010</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GU_T2</td>
<td>0.010</td>
<td></td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GU_T4</td>
<td>0.010</td>
<td></td>
<td></td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GU_T5</td>
<td>0.010</td>
<td></td>
<td></td>
<td></td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GU_T6</td>
<td>0.010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>GU_T7</td>
<td>0.010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
</tbody>
</table>

The number of base differences per site from between sequences are shown. Standard error estimate(s) are shown above the diagonal.

**Figure 4.4.10: Evolutionary relationships of *Manouria emys* of based on nuclear intron R35 marker using Maximum Likelihood method**

The evolutionary history was inferred by using the Maximum Likelihood method based on the Jukes-Cantor model (Jukes and Cantor, 1969). The tree with the highest log likelihood (-574.3308) is shown. The analysis involved 7 nucleotide sequences. There were a total of 395 positions in the final dataset.
Figure 4.4.11: Evolutionary relationships of *Manouria emys* of based on nuclear intron R35 marker using Neighbour Joining method

The evolutionary history was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). The optimal tree with the sum of branch length = 0.01012658 is shown. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches (Felsenstein, 1985). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the p-distance method (Nei and Kumar, 2000), and are in the units of the number of base differences per site. The analysis involved 7 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 395 positions in the final dataset.

4.4.5 RNA secondary structure prediction of COI and Cytochrome b sequences of *Manouria emys* from Manipur

The RNA secondary structure of COI sequence has minimum fold energy of -85.1 Kcal/mol, while RNA structure of cyt *b* has minimum fold energy of -150.5 Kcal/mol respectively (Table 4.4.11). All of the mRNA predicted shows low free energy predicting a stable structure.
Fig 4.4.12: RNA Secondary structure of cyt b and COI of *Manouria emys*

A: cyt b MN1; B: COI GU M1

Table 4.4.11: Predicted RNA secondary structure parameters

<table>
<thead>
<tr>
<th></th>
<th>Min fold Energy (Kcal/mol)</th>
<th>Stem with bifurcation Position</th>
<th>Dangling A Position</th>
<th>Dangling C Position</th>
<th>Stem with hairpin Position</th>
<th>ΔG (Kcal/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COI</td>
<td>-85.1</td>
<td>22..298</td>
<td></td>
<td></td>
<td></td>
<td>-73.3</td>
</tr>
<tr>
<td>cyt b</td>
<td>-150.5</td>
<td>4..79</td>
<td>3</td>
<td>-0.5</td>
<td>80</td>
<td>-6.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90</td>
<td>-0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>818</td>
<td>-1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4.6 Protein structure prediction

Among the 7 cytochrome b sequences of Manipur analysed, only 2 different amino acid sequences were obtained (Appendix 9). The change of amino acid takes place in 202 amino acid position where Isoleucine substitutes Tyrosine. Two sets of amino acid from sequence set (MN1, CC1, CC2), (MN2, CC4, CC5 and CC7) were obtained. Amino acid sequences of the same set were same. Therefore only 2 amino acid sequences from each set were considered for protein structure analysis. The considered sequences were MN1 and MN2. MN1 represents *Manouria emys emys* sequences (MN1, CC1 and CC2) while MN2 represents *Manouria emys phayrei* (MN2, CC4, CC5 and CC7). Among the 6 COI sequences, the nucleotide and amino acid sequence were identical and therefore select one GU M1 as a representative.

Analysis of the protein predicted from two partial coding sequence of cytochrome b revealed that 276 amino acid sequence long cytochrome b partial coding sequence has a molecular weight of 31063.8 and 31075.8 (Table 4.4.12). The protein MN1 and MN2 has same number of positively charged residues (11) and negatively charged residues (9). The aliphatic index is however slightly different with MN1 having a lower value of 120.14 while MN2 have 121.56 (Table 4.4.12). The analysis of the protein predicted from sequence partial coding sequence of COI revealed that 100 amino acid sequence long cytochrome b partial coding sequence with a molecular weight 10605.5 has 1 positively charged residue and 4 negatively charged residues (Table 4.4.12). The aliphatic index was 106.40. The total numbers of hydrophobic and hydrophilic residues were 70 and 18 respectively.
Table 4.4.12: Protein characteristics using ProtParam (Gasteiger et al., 2005a)

<table>
<thead>
<tr>
<th>Protein characteristics</th>
<th>COI(GU M1)</th>
<th>cyt b MN1 (M.emys.emys)</th>
<th>cyt b MN2 (M.emys.phayrei)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of amino acids</td>
<td>100</td>
<td>276</td>
<td>276</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>10605.5</td>
<td>31063.8</td>
<td>31075.8</td>
</tr>
<tr>
<td>Theoretical pI</td>
<td>4.64</td>
<td>8.52</td>
<td>8.52</td>
</tr>
<tr>
<td>Total number of negatively charged residues (Asp + Glu)</td>
<td>4</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Total number of positively charged residues (Arg + Lys)</td>
<td>1</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Formula</td>
<td>C&lt;sub&gt;493&lt;/sub&gt;H&lt;sub&gt;751&lt;/sub&gt;N&lt;sub&gt;117&lt;/sub&gt;O&lt;sub&gt;122&lt;/sub&gt;S&lt;sub&gt;9&lt;/sub&gt;</td>
<td>C&lt;sub&gt;1483&lt;/sub&gt;H&lt;sub&gt;2237&lt;/sub&gt;N&lt;sub&gt;346&lt;/sub&gt;O&lt;sub&gt;365&lt;/sub&gt;S&lt;sub&gt;11&lt;/sub&gt;</td>
<td>C&lt;sub&gt;1484&lt;/sub&gt;H&lt;sub&gt;2239&lt;/sub&gt;N&lt;sub&gt;346&lt;/sub&gt;O&lt;sub&gt;364&lt;/sub&gt;S&lt;sub&gt;11&lt;/sub&gt;</td>
</tr>
<tr>
<td>Extinction coefficients (M-1 cm-1)</td>
<td>19480</td>
<td>57995a; 57870b</td>
<td>57995a; 57870b</td>
</tr>
<tr>
<td>Abs 0.1% (=1 g/l)</td>
<td>1.837</td>
<td>1.867ª; 1.863b</td>
<td>1.867a; 1.863</td>
</tr>
<tr>
<td>Instability index (II)</td>
<td>28.44</td>
<td>33.69</td>
<td>33.69</td>
</tr>
<tr>
<td>Aliphatic index</td>
<td>106.40</td>
<td>120.14</td>
<td>121.56</td>
</tr>
<tr>
<td>Grand average of hydropathicity (GRAVY)</td>
<td>0.772</td>
<td>0.690</td>
<td>0.709</td>
</tr>
<tr>
<td>Total no of hydrophobic residues</td>
<td>70</td>
<td>174</td>
<td>175</td>
</tr>
<tr>
<td>Total no of hydrophilic residues</td>
<td>18</td>
<td>72</td>
<td>71</td>
</tr>
</tbody>
</table>

Extinction coefficients are in units of M-1 cm-1, at 280 nm measured in water.
a: assuming all pairs of Cys residues form cystines; b: assuming all Cys residues are reduced; hydrophobic residues: (A,F,G,I,L,M,P,V,W); hydrophilic residues: (C,N,Q,S,T,Y)

Table 4.4.13: protein characteristics predicted using RasWin and Discovery studio programme

<table>
<thead>
<tr>
<th>Protein characteristics</th>
<th>COI(GU M1)</th>
<th>cyt b MN1 (M.emys.emys)</th>
<th>cyt b MN2 (M.emys.phayrei)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H- bonds</td>
<td>66</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>Helices</td>
<td>5</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Strands</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Turns</td>
<td>11</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Groups</td>
<td>100</td>
<td>276</td>
<td>276</td>
</tr>
<tr>
<td>Atoms</td>
<td>745</td>
<td>2202</td>
<td>2203</td>
</tr>
<tr>
<td>bonds</td>
<td>769</td>
<td>2276</td>
<td>2277</td>
</tr>
<tr>
<td>Net formal charge</td>
<td>-3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
The predicted protein structure of cyt $b$ are almost identical and differ only on number of atoms and bonds in which cyt $b$ MN1 have slightly smaller values than cyt $b$ MN2 (Table 4.4.13). Predicted COI structure does have 5 helices and 11 turns (Table 4.4.13)

Fig.4.4.13: 3D structure of cyt $b$ MN1 ($Manouria emys emys$)
PMDB acc no. PM0080584.

Fig 4.4.14: Hydropathicity for cyt $b$ MN1($Manouria emys emys$)
Fig 4.4.15: Ramachandran Plot file for cyt b MN1 (*Manouria emys emys*).

Number of residues in favoured region: (~98.0% expected) : 264 (96.4%)
Number of residues in allowed region: (~2.0% expected) : 9 (3.3%)
Number of residues in outlier region: 1 (0.4%)

Figure 4.4.16: 3D structure verification of cyt b MN1 (*Manouria emys emys*) using ERRAT.
Fig. 4.4.17: 3D structure of cyt $b$ MN2 (*Manouria emys phayrei*)
PMDB Acc no. PM0080585

Fig 4.4.18: Hydropathicity for cyt $b$ MN2 (*Manouria emys phayrei*)
Fig 4.4.19: Ramachandran Plot file for cyt b MN2 (Manouria emys phayrei)

Number of residues in favoured region (-98.0% expected) : 264 (96.4%)
Number of residues in allowed region ( ~2.0% expected) : 9 (3.3%)
Number of residues in outlier region : 1 (0.4%)

Program: ERRAT2
File: /var/www/SAVES/Jobs/9739050/errat.pdb
Chain#: 1
Overall quality factor**: 98.881

*On the error axis, two lines are drawn to indicate the confidence with which it is possible to reject regions that exceed that error value.
**Expressed as the percentage of the protein for which the calculated error value falls below the 95% rejection limit. Good/high resolution structures generally produce values around 95% or higher. For lower resolutions (2.5 to 3Å), the average overall quality factor is around 95%.

Figure 4.4.20: 3D structure verification of cyt b MN2 (Manouria emys phayrei)
Fig 4.4.21: 3D structure of COI GU M1 (*Manouria emys*)
PMDB Acc. no. PM0080583

Fig 4.4.22: COI GU M1 Hydropathicity for COI GU M1 (*Manouria emys*)
Fig 4.4.23: Ramachandran Plot file for COI GU M1 (Manouria emys)

<table>
<thead>
<tr>
<th>Region</th>
<th>No. of Residues</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most favoured regions</td>
<td>65</td>
<td>84.4%*</td>
</tr>
<tr>
<td>Additional allowed regions</td>
<td>10</td>
<td>13.0%</td>
</tr>
<tr>
<td>Generously allowed regions</td>
<td>2</td>
<td>2.6%</td>
</tr>
<tr>
<td>Disallowed regions</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Non-glycine and non-proline residues</td>
<td>77</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 4.4.24 3D structure verification of COI GU M1 (Manouria emys) using ERRAT.

Program: ERRAT2
File: /var/www/SAVES/Jobs/7872833/errat.pdb
Chain#: 1
Overall quality factor**: 84.444

*On the error axes, two lines are drawn to indicate the confidence with which it is possible to reject regions that exceed that error value.

**Expressed as the percentage of the protein for which the calculated error value falls below the 95% rejection limit. Good high resolution structures generally produce values around 95% or higher. For lower resolutions (2.5 to 3Å) the average overall quality factor is around 91%.
Hydropathicity of cyt b (M. emys. emys) shows non-polar nature (Fig 4.4.14). Ramachandran plot of the cyt b (M. emys. emys) protein shows that 264 residues were present in most favoured region (96.4%). (Fig 4.4.15). The allowed region has 9 residues (3.3%). 1 residue was in outlier region (0.4%). Hydropathicity of cyt b (M. emys phayrei) shows non-polar nature (Fig 4.4.19). Ramachandran plot of the cyt b protein (M. emys phayrei) shows that 264 residues were present in most favoured region (96.4%). (Fig 4.4.20). The allowed regions have 9 residues (3.3%). 1 residue are in outlier region (0.4%).

Hydropathicity of COI shows non-polar nature (Fig 4.4.24). Ramachandran plot of the COI protein shows that 65 residues were present in most favourable region (84%). (Fig 4.4.25). The additional allowed regions has 10 residues (10%). 2 residues are in generously allowed region (13%) and no any residue are present in disallowed region (0%).

The overall quality factors predicted by ERRAT verification programme for COI protein was 84.44. The overall quality factors predicted by ERRAT verification programme for cyt b protein (M. emys emys) was 98.881. The overall quality factors predicted by ERRAT verification programme for cyt b protein (M. emys phayrei) was 98.881. There were no marked variation in physico chemical parameters of proteins Cytochrome b protein between Manouria emys emys and Manouria emys phayrei.