STUDY AREA
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3.1. Topography

The study was carried out in the erstwhile Koraput district of Orissa state. Koraput lies on 17° 50' and 20° 30' north latitude and 81° 27' and 84° 10' east longitude. It is the southern most and largest district of Orissa state situated at the tri-junction formed by the states of Orissa, Andhra Pradesh and Madhya Pradesh. In the early part of this century, the Koraput district was referred to as Jeypore hill tracts as it formed a part of Jeypore Presidency state. A major part of the Koraput district comes under east central India which is one of the nine geographical zones based on physiography, climate and hydrology (Rao, 1984).

Koraput district is bounded by Kalahandi and Phulbani districts of Orissa and Raipur district of Madhya Pradesh on its north, Ganjam district of Orissa and Srikakulam district of Andhra Pradesh on its east, Visakhapatnam and Vizianagaram districts of Andhra Pradesh on its southeast, East Godavari and Khammam district of Andhra Pradesh on its south and Bastar district of Madhya Pradesh on its west. Thus, Koraput district is bordered by ten other districts belonging to three states and becomes a nodal point for population movement between districts and states.

The total area of the district is 26,961 sq.km. The district is highly undulating one, covered with numerous hills, forests and is crisscrossed with numerous perennial and seasonal
streams and channels. The district could be divided into four distinct physiographic zones, based on altitude and topography (Rajagopalan et al, 1990). They are:

**Zone I (Eastern Koraput zone, +900 m MSL):** The eastern part of the district is a plateau, starting from near the peaks of Jeypore hills (Pottangi) to Koraput town. It extends from southern most parts of Kalahandi district in Orissa to the Khammam and East Godavari districts of Andhra Pradesh. The plateau is slightly tilted to the west. The hills present in this zone are the tallest and the highest peak of the state (Deomali: 1647 m) is also situated in this zone. In the west, it descends to the 600 m plateau towards Jeypore town. This zone consists of undulating land scattered with numerous small hills. Except the hills which border the state, others have been denuded of their forest probably due to the shift cultivation practices. At places where deforestation has not advanced far, the hills are still covered with low shrubs, though disfigured by patches of shift cultivation. Three main rivers viz., Indravathi, Kolab and Machkund traverse most part of this plateau and westward into the Godavari basin in Andhra Pradesh.

**Zone II (Jeypore zone, +600 m MSL):** This is also a plateau, starting from the foot hills of western part of Koraput zone and lies centrally in the district. The Jeypore zone consists mostly of flat land except on the eastern side, where there are a few isolated hills covered with forest. Some of these hills have a height of +900 m MSL. In the south, the zone descends into the Malkangiri zone as steep Ghats and in the east it slopes down to Kalahandi district. The greater part of Jeypore plateau drains westward through the rivers Kolab and Indravati and their
tributaries into the river Godavari in Andhra Pradesh. But at the northern corner it drops down into the valley of the 'Tel', a tributary of Mahanadi. There are some intervening hills within the plain land. This zone forms the principal granary of the district. There are numerous villages with wide tracts of paddy cultivation and fine growth of 'sal' and other timbers.

Zone III (Rayagada zone, +300 m MSL): To the north eastern part of Koraput zone lies the Rayagada zone at an elevation of about 300 m. This area consists of two broad almost parallel valleys of Vamsadhara and Nagavalli rivers, which are guarded by ranges of high and rugged hills. In northern (Gunupur) and eastern (Bissam Cuttack) parts of this zone, there are thick forest tracts.

Zone IV (Malkangiri zone, +150 m MSL): This is the southern most part of the district with flat land and is separated from the Jeypore zone by high hills in the north. To its east lies the mountain ranges which are continuous with those in eastern side of Koraput zone. The most important ranges are those of Bonda hills inhabited by one of the most primitive tribes of India, the 'Bondas'. To the eastern side of these hills lies the Machkund valley. The southern most tip of this zone is only about 40 kms from the junction of Sabari and Sileru rivers, near Sileru. The zone, in total, is one of the thickest jungle covered areas, called 'Dandakaranya'.

There are six major rivers in Koraput district. The rivers Vamsadhara and Nagavalli, flow eastwards through coastal plains directly into the Bay of Bengal. Indravati, Kolab and Machkund
drain westwards into the basin of Godavari. The other river of importance is `Tel' flows into Kalahandi and joins the Mahanadi.

The villages in each zone differ not only in their altitudes but also in their topography (ecotopes), water bodies and vegetation. Based on the topography, villages in these zones can broadly be classified into four different ecotopes viz., hilltop, foot hill, plain and riverine.

**Hilltop:** Villages that are situated either on hilltops or on slopes are grouped as hilltop ecotope. Perennial streams are the sole source of water in these villages. Paddy cultivation is done seasonally by terracing streambeds. The streams and the terraced paddy fields are the major mosquito larval habitats.

**Foot hill:** Villages which are located at or within 500 m from foot of the hills are classified as foot hill ecotope. Streams, rivulets, terraced paddy fields, wells and ponds are the major larval habitats in this ecotope.

**Plain:** Villages located on flat but undulating land and at least two km away from foot hill or rivers are grouped as plain ecotope. Ponds, paddy fields and wells are the major source of anopheline immatures.

**Riverine:** Villages situated on the banks of rivers and at least two km away from foot hills are
included under riverine ecotope. All the different types of larval habitats that are found in plain villages are common in this ecotope in addition to rivers.

3.2. Climate

Climate of the district varies in different physiographic zones due to the difference in altitude, rainfall and temperature. The climate in general is characterized by hot summer (March to June), rainy (July to October) and cold season (November to February). The summer is severe in Rayagada and Malkangiri and mild in Koraput zone.

3.2.1. Temperature

The seasonal changes in climate are similar all over the district. However, there are some variations between the zones. The climate is generally hot between March and June in all zones. The data for the years 1993 to 1995 show that the mean maximum temperature ranged from 23.9°C to 34.3 °C in Koraput zone, 27.1°C to 38.1 °C in Jeypore zone, 18.2°C to 39.2 °C in Malkangiri zone and 21.5°C to 43.5 °C in Rayagada zone. The highest temperature was recorded in the months of May and June in all zones. In later part of June, the temperature started decreasing following the onset of rains. The temperature was considerably lesser during November to February. The mean minimum temperature ranged from 4.7°C to 21.3 °C in Koraput zone, 13.8°C to 29.6 °C in Jeypore zone, 17.1°C to 34.0 °C in Malkangiri zone and
8.5°C to 24.0 °C in Rayagada zone. The lowest temperature was recorded in Koraput zone which has the coolest climate. While the climate of Jeypore zone is intermediate, Rayagada and Malkangiri zones are hotter.

3.2.2. Rainfall

The average annual rainfall of the district is 1446 mm. More than 80% of the rainfall occurs during June to September under the influence of southwest monsoon. Maximum rainfall is in the month of August. The distribution of rainfall is influenced by the Eastern Ghat ranges. The Malkangiri and Jeypore zones which are on the wind-ward side (western side of the hills) receive higher rainfall compared to the other two zones. The average annual rainfall was 1521.8 mm between 1901 and 1950, 1652.2 mm between 1951-1960, 1430.6 mm between 1975 and 1980 and 1353.3 mm between 1981 and 1987. The average rainfall of the district shows a declining trend from the middle of the present century. This is probably due to the gross ecological changes brought about by deforestation for the purpose of slash and burn type of cultivation (Chandrasekaran, 1983).

3.3. Demographic features

The district has a population of 29,99,606 (1991 census) of which 55.2 % is tribals and 14 % belongs to schedule castes. The erstwhile Koraput district alone accounts for 23% of
Orissa's total tribal population. Out of 62 tribes inhabiting the Orissa state, as many as 51 are found in Koraput district. Population density of the district is 111 per sq.km. There are about 11,000 thinly populated villages/hamlets. Most of the villages which are situated on hilltops, foot hills and other remote areas are connected by narrow jungle or hilly paths, which are trekked only on foot. The literacy rate is only 20.03% (1991 census).

A typical village is a settlement comprising half a dozen to fifty families belonging to one of the aboriginal tribes. The houses are small, constructed out of either puddled earth or of jungle wood poles covered with a thin mud coating and thatched with jungle grass or occasionally with leaves of date palm. The walls of the houses are plastered using coloured mud at frequent intervals as a cultural practice, which is known to adversely affect the efficacy of residual insecticidal spraying done for malaria control. Most of the holdings are mixed ones having both cattle and man under a common roof. The man to cattle ratio is 1: 0.88.

The major occupation of the people is agriculture and collection of forest products. A total of 12506.55 sq. km of area in the district is under forest cover (44.5% of total area of the district) and the forests contribute to about 61% of total revenue of the district.

The forest is deciduous type with sal as climax species interspersed with bamboo. The forest produce includes timber, firewood, bamboo and minor forest produce viz., tamarind, kengu leaves, hill brooms, gum, oil seeds, medicinal plants etc. Principal crops cultivated are
paddy, maize, ragi, alasi and mustard. Apart from these, a variety of vegetables such as potato, onion, cabbage, cauliflower, beans, chilly, radish, brinjal, tomato etc. are cultivated in most of the villages. Three types of cultivation are practiced in this area (a) 'slash and burn' on hill slopes ("Podu" cultivation), (b) terracing the stream beds into paddy fields in hilltop and foot hill areas and (c) cultivation in plain land. Terracing is also being practiced in plain lands as the terrain is undulating.

3.4. Malaria problem and its control

The erstwhile Koraput district contributes to almost one fifth of all malaria cases reported in Orissa state. More than 90% of these cases was due to P. falciparum and on an average about 15 deaths due to cerebral malaria were being recorded annually (Rajagopalan et al., 1990). Prevalence of all the four species of human malaria parasites was reported in this district, P. falciparum being the predominant one (Jambulingam et al., 1991). It is worth noting that the erstwhile Koraput district which accounts for only 0.36% of the population of India, recorded 6.1% of all P. falciparum cases of the country during 1985. Malaria incidence peaks twice in a year, one between July and August and the other between November and December. The major vector is An. fluviatilis which is predominantly endophilic and anthropophilic (80%) in Malkangiri zone while it is exophilic and less anthropophilic (25%) in other zones. An. culicifacies and An. annularis are the secondary vectors (Parida et al., 1991).
Overall, API recorded in the Koraput district was 15.02 (the average of 1986-96). In Koraput zone, Slide Positivity Rate (SPR) was 12.69% in 1994 and 10.72% in 1995 and Annual Parasite Incidence (API) was 15.74 in 1994 and 14.07 in 1995. In Rayagada zone, SPR was 13.44% in 1994 and 13.29% in 1995 and API was 16.80 in 1994 and 17.55 in 1995. There are 42 PHCs in the district and API in these PHCs, varied widely. Those PHCs having hilly terrain recorded consistently higher API. The Data on malaria prevalence in Dasmantpur PHC (Source: NMEP) is presented in Table 3. API was 16.0 in 1994 and 13.4 in 1995. From the available NMEP records, it is not possible to get data on prevalence of gametocyte carriers separately. The results of the sample blood surveys carried out in the study villages during different seasons are given in Table 4. The Gametocyte rate was 1.11%, 3.96% and 4.27% in hot rainy and cold seasons.

DDT was introduced in Jeypore hills for the control of malaria in Bengal-Nagpur Railways (Senior White, 1945). While the DDT spraying was successful in reducing the abundance of *An. fluviatilis*, DDT spraying in other parts of Jeypore hills for a period of over 18 months did not bring any change in *An. fluviatilis* abundance (Senior White and Ghosh, 1946). Prior to the implementation of the national control programs, a WHO/UNICEF malaria control demonstration was launched (1949-1951) in the Bissum Cuttack and Rayagada taluk areas in Rayagada zone.

The entire district of Koraput was under DDT spray from the time of inception of the
Table 3. Malaria prevalence in Dasmantpur PHC, Koraput district, Orissa during 1994-1995.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>BSC</th>
<th>+VES</th>
<th>PF</th>
<th>SPR</th>
<th>SFR</th>
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<tbody>
<tr>
<td>JAN'94</td>
<td>127</td>
<td>16</td>
<td>15</td>
<td>12.60</td>
<td>11.81</td>
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<tr>
<td>FEB</td>
<td>502</td>
<td>55</td>
<td>50</td>
<td>10.96</td>
<td>9.96</td>
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<tr>
<td>MAR</td>
<td>721</td>
<td>118</td>
<td>115</td>
<td>16.37</td>
<td>15.95</td>
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<tr>
<td>APR</td>
<td>739</td>
<td>80</td>
<td>79</td>
<td>10.83</td>
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</tr>
<tr>
<td>MAY</td>
<td>679</td>
<td>71</td>
<td>70</td>
<td>10.46</td>
<td>10.31</td>
</tr>
<tr>
<td>JUN</td>
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<td>181</td>
<td>179</td>
<td>13.07</td>
<td>12.92</td>
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<tr>
<td>JUL</td>
<td>1319</td>
<td>137</td>
<td>132</td>
<td>10.39</td>
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</tr>
<tr>
<td>AUG</td>
<td>739</td>
<td>41</td>
<td>46</td>
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<tr>
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<td>51</td>
<td>51</td>
<td>7.62</td>
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<tr>
<td>OCT</td>
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<td>29</td>
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<td>9.06</td>
</tr>
<tr>
<td>NOV</td>
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<td>28</td>
<td>28</td>
<td>6.10</td>
<td>6.10</td>
</tr>
<tr>
<td>DEC</td>
<td>705</td>
<td>61</td>
<td>58</td>
<td>8.65</td>
<td>8.23</td>
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<tr>
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<td>10</td>
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<td>147</td>
<td>147</td>
<td>10.04</td>
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<tr>
<td>JUL</td>
<td>1677</td>
<td>160</td>
<td>158</td>
<td>9.54</td>
<td>9.42</td>
</tr>
<tr>
<td>AUG</td>
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<td>4.53</td>
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<tr>
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<td>4.39</td>
<td>4.39</td>
</tr>
<tr>
<td>OCT</td>
<td>810</td>
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<td>53</td>
<td>9.01</td>
<td>6.54</td>
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<td>105</td>
<td>105</td>
<td>9.67</td>
<td>9.67</td>
</tr>
<tr>
<td>DEC</td>
<td>897</td>
<td>77</td>
<td>77</td>
<td>8.58</td>
<td>8.58</td>
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</tbody>
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BSC=blood smear collected, +VES=slides positive for malaria parasites, PF= *Plasmodium falciparum*, SPR= slide positivity rate, SFR= slide *falciparum* rate.
Table: 4. Results of sample blood survey in Malitola and Balighat villages.

<table>
<thead>
<tr>
<th>VILLAGE</th>
<th>SEASON</th>
<th>POP</th>
<th>BSC+VES</th>
<th>SPR</th>
<th>Pf</th>
<th>SFR</th>
<th>SGR</th>
<th>Pv</th>
<th>Pm</th>
<th>Mix</th>
<th>Gamete.</th>
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</tr>
<tr>
<td>Malitola</td>
<td>hot(Mar)</td>
<td>250</td>
<td>165</td>
<td>6</td>
<td>3.6</td>
<td>4</td>
<td>2.4</td>
<td>0.6</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Balighat</td>
<td>hot(Mar)</td>
<td>294</td>
<td>105</td>
<td>7</td>
<td>6.7</td>
<td>6</td>
<td>5.7</td>
<td>1.9</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Malitola</td>
<td>Rain(Jul)</td>
<td>250</td>
<td>112</td>
<td>18</td>
<td>16.1</td>
<td>15</td>
<td>13.4</td>
<td>3.6</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Balighat</td>
<td>Rain(Jul)</td>
<td>294</td>
<td>140</td>
<td>31</td>
<td>22.1</td>
<td>27</td>
<td>19.3</td>
<td>5.7</td>
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<tr>
<td>Malitola</td>
<td>Cold(Nov)</td>
<td>250</td>
<td>143</td>
<td>26</td>
<td>18.2</td>
<td>19</td>
<td>13.3</td>
<td>4.2</td>
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<tr>
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<td>294</td>
<td>138</td>
<td>37</td>
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<td>34</td>
<td>24.6</td>
<td>5.8</td>
<td>1</td>
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</tbody>
</table>

Gamete. = slides positives for gametocytes, POP = population, BSC = blood slides collected, +VES = slides positives for malaria parasites, SPR = slide positivity rate, SFR = slide *falciparum* rate, SGR = slide gametocyte rate, Pf = *Plasmodium falciparum*, Pv = *Plasmodium vivax*, Pm = *Plasmodium malariae*, MIX = slides positive for more than one malaria parasite species.
National Malaria Eradication Programme (1953). Since then, no studies on entomological as well as epidemiological aspects of malaria and its persistence have been undertaken. In 1972, DDT was replaced with BHC in 26 PHCs. The reasons for the switch over are not known. However, the areas receiving BHC spraying continue to record higher API compared to areas receiving DDT spraying. The study villages have been sprayed with DDT under the National Malaria Control Programme (NMCP) along with other parts of India. Since then, the programme is continuing with the modifications under eradication programme in 1958 and modified plan of operation in 1977.