'^WAHARLAL NEHRU UNIVERSITY

SPATIAL AND TEMPORAL VARIATIONS IN THE INCIDENCE OF MALARIA IN ORISSA 1968-1976 : A STUDY IN MEDICAL GEOGRAPHY

Dissertation submitted in partial fulfilment of the
requirements for the Degree of

MASTER OF PHILOSOPHY

by

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I certify that the dissertation entitled "Spatial and Temporal Variations in the Incidence of Malaria in Orissa 1968-1976: A Study in Medical Geography", submitted by SHEELA RAUTRAY, in fulfilment of six credits out of the total requirement of twenty-four credits for the degree of Master of Philosophy (M.Phil.) of the University, is, to the best of my knowledge, a bona fide work and may be placed before the examiners for evaluation.

Supervisor

Supervisor

Chairman

Dated: 14.5.1979.

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Chapter I

INTRODUCTION

Chapter I

INTRODUCTION

1.1 The present study stems from the emerging interest of geographers in understanding the environmental aspects of human diseases. Studies related to malaria have evoked keen interest in recent years. An attempt is made here to understand the patterns of incidence of malaria in Orissa especially in view of its recent upsurge. Unlike some health studies conducted *per se* without reference to the prevailing environmental and socio-economic structures, this study adopts the approach of spatial analysis. It aims at identifying the spatial distribution of malaria and its environmental correlates.

It must be noted however, that such studies relating environment, man and disease, need to be carried out as an interdisciplinary investigation with a team of medical men, epidemologists, entomologists, biologists, environmentalists and geographers, each contributing their expertise to a common and vital problem. The present study therefore, examines only the spatial and environmental aspects of malaria. It is hoped that the questions raised here would generate more comprehensive and indepth studies for enriching our understanding and thus contributing to the eradication of malaria in India as a whole and Orissa in particular.

1.2 Statement of the Problem

Geographic factors have a considerable influence on malaria through the vector, the causative agent and the host or man. Depending on their ecological requirements different species are dominant in differing environments in varying densities, thus causing varying intensity in the incidence of malaria. The spatial approach is therefore essential to the understanding of the disease ecology of malaria.

A recent study on malaria in India[1] has thrown light on the broad spatial patterns of incidence in Orissa. From this study we find that Orissa is highly malarious and has an interesting incidence pattern. The present study is undertaken as an indepth analysis of the spatial and temporal variations in the incidence of malaria in Orissa from 1968 to 1976. The study is carried out on a detailed section level and is therefore a spatio-temporal one, along three time periods of 1968-1972 and 1976 and covering over 2,500 sections.

The aim of the study is two-fold. (1) The first is to identify the spatial patterns of incidence and see if any meaningful patterns exist of the study. The focus would be to identify the areas of high incidence over the years which may be acting as centres of malaria diffusion. (2) The second objective is to analyse the inter-relationships of malaria in terms of the physical and social environment with a view to explain the identified incidence pattern. The

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1 Rais Akhtar and A.T.A. Learmouth, "Resurgence of Malaria in India, 1965-1976", Geojournal, vol. 1, no. 5, 1977, pp. 69-79.

objective of this study would therefore be an attempt to answer the following questions - Is there any significant malaria pattern in Orissa? What are the ecological characteristics of the malarious areas? How far do the geographical factors (both physical and human) in Orissa explain the incidence pattern? Are there any malaria foci in Orissa?

1.3 The Significance of Malaria

The question that one is answering here is, "why has malaria been chosen as the disease under study?" There are several reasons for this.

(1) The first is the fact that in the last two-three years malaria has always been in the news. In recent times, the incidence has shot up with a resurgence of malaria from 1965. The disease has again emerged as a serious health problem of national importance. Indian health authorities may soon be forced to declare an Indian Malaria Year to focus attention on and combat this disease. So much money has been and is being spent on malaria eradication yet the problem is growing. Are there any socio-cultural, economic and environmental factors involved in the incidence of malaria?

(2) From the host of diseases, malaria presents an interesting distribution pattern, and only a geographer, with his cartographic sophistication and spatial orientation coupled with a broad cultural and physical knowledge, can tackle this problem.[2] A wide range of geographical factors

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2 L. S. Fonaroff, "Malaria Geography: Problems and Potentials for the Profession", The Professional Geographer, vol. 15, November 1963, p. 5.

contribute to the maintenance of high levels of malaria. The nature of relationships between the 3 vital components of malaria (man - vector - parasite) is such that they can be, to a significant extent, explained through geographical perspectives. The study of malaria, hence, offers immense interest and scope for research to a geographer.

(3) The understanding of the spatial aspects of malaria is essential as the disease has serious economic implications. The population exposed to malaria is very large and the number affected is highest for any single disease. As a result of the high morbidity the loss in productivity through loss in man hours is high and is of crucial importance to any economy.[3] Areas of high incidence need to be identified and attempts made to control and eradicate malaria in these foci.

(4) A national programme, called the national malaria eradication programme (NMEP) functions to deal with the problem of malaria. The NMEP is an organized programme covering the entire country. This is a data oriented programme as the control measures are implemented on the basis of the statistics collected. The availability of detailed data at a micro level for different time periods proved to be a strong deciding factor in favour of research on malaria.

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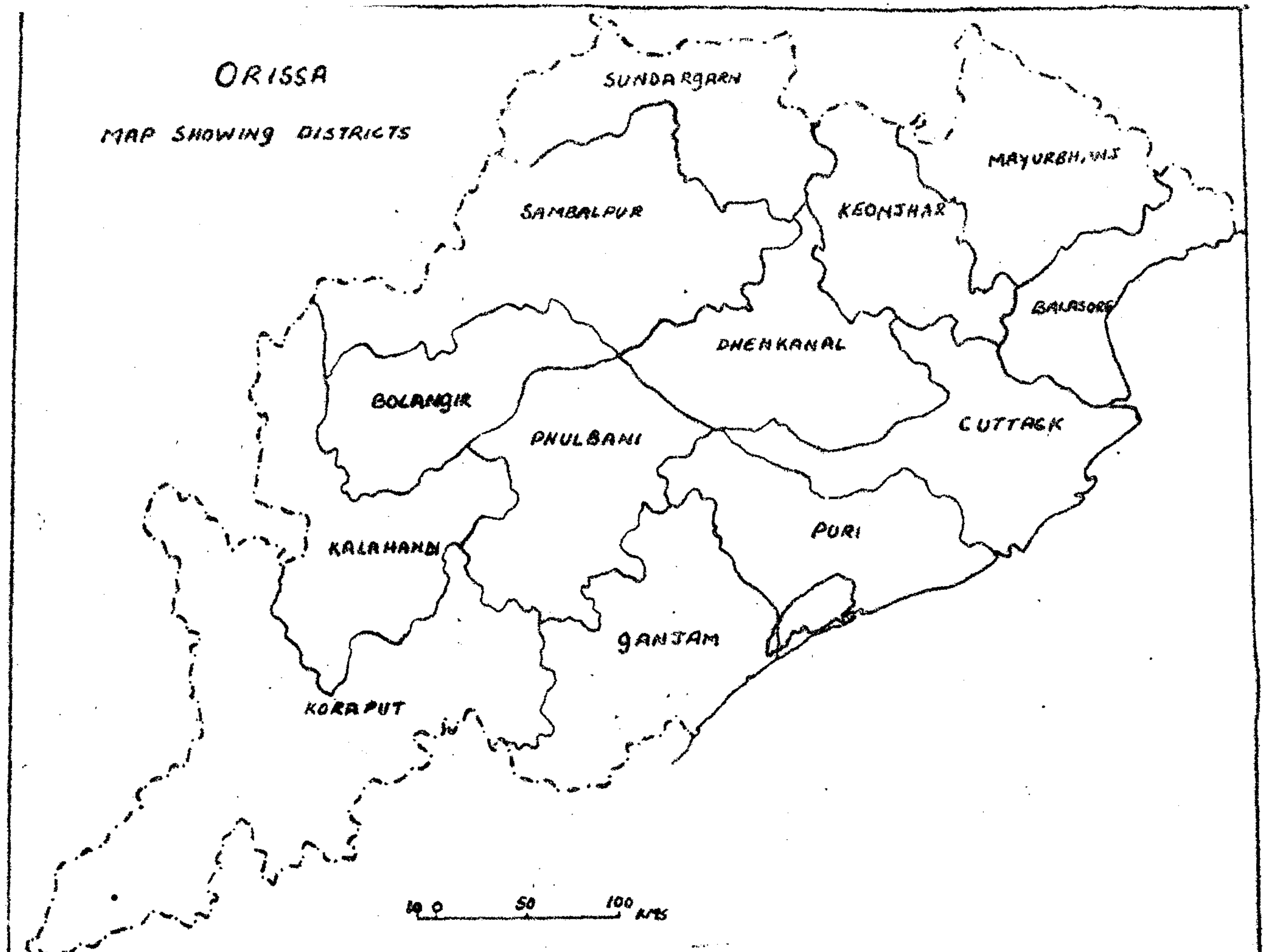
3 G. D. Bernis de, Some Considerations About Programme and Project Evaluation Techniques in the Field of Health, 1975.


ORISSA
MAP SHOWING DISTRICTS
SUNDARGARH
MAYURBHANJ
SAMBALPUR
KEONJHAR
BALASORE
DHENKANAL
BOLANGIR
CUTTACK
PHULBANI
PURI
KALAHANDI
GANJAM
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MAP 1.1

(5) Finally, while there has been a good deal of research on the clinical aspects of malaria, there is a dearth of studies on the spatial and environmental aspect of the disease. In India studies in medical geography are confined largely to nutritional deficiency diseases, cholera, small pox, diseases of the digestive tract, with very few studies on malaria.[4] When this is viewed against the background that malaria is a leading contributor to morbidity in India the void in malarial research seems even greater. In this study, therefore, an attempt is made to study and highlight this neglected aspect of malaria geography.

1.4 The Choice of the Region

Orissa was chosen as the study area for the following reasons:

(1) The State is a significant malaria affected area. Studies on India have highlighted the probable existence of a core of hyper-endemicity in the State as stated earlier. The State therefore has a lot to offer in terms of malarial research.

(2) Within the State there exist apparent regional contrasts in the incidence of malaria. Besides, Orissa offers that strong geographical contrast between coastal non-tribal densely peopled plains and the tribal-sparsely

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4 M. Raza, ed., "Geography of Health and Nutrition Section", ICSSR Journal of Abstracts and Reviews: Geography, vol. 1, 1975, pp. 18-24.

populated - forested-highland interior. An attempt is made to help explain the variations in incidence through a variation in environmental conditions.

(3) Malaria is said to be related with development as it is more prevalent among the poorer and backward communities.[5] In terms of socio-economic development Orissa has made little progress and offers a strong regional contrast in terms of development.

(4) Probably an important factor deciding the choice of Orissa was the fact that it is the home state of the present student. This is a vital advantage when it comes to collection of data and other information. Moreover, there exists a strong bond of attachment for the home state and it is in response to this sentiment that Orissa was chosen as the study area.

1.5 Data Base

In attempting any empirical research, one of the major problems encountered is the availability of sufficient and reliable data. The present study was no exception. After days of running around the state health officials, data was finally procured. All the statistics regarding the incidence of malaria and the species has been collected from the officer of the State Malaria Officer in the Health Directorate, Bhubaneshwar. Data was taken for three time periods 1968, 1972 and 1976.

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5 R. M. Prothero, Migrants and Malaria, London: Longman, 1965.

For 1968, it was collected at the centre level while for 1972 and 1976 it was at the section level. The State of Orissa is divided into 15 malaria units each covering a population of 1.5 million. Each unit is further divided into centres there being 127 centres. Each centre is again divided into sectors and each sector consists of 4-6 sections. A section covers a population of 10,000 and there are over 2,500 sections in the entire state.

Data for 1968 and 1976 was collected under the following heads: Total population of centre/section; total incidence of malaria; number of cases attributed to the different species, mainly PV & P 7. For 1972, data was[6] available only for total cases and species data was absent. Age-wise incidence data at the unit level was collected for 1965 and 1974 and figures for month-wise incidence of the units was collected for 1976.

Besides the data on malaria cases, information regarding population density, irrigation and tribal population was taken from the 1971 census publications on Orissa. Data regarding rice acreage, and annual figures for climate was.

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6 Before progressing any further a word has to be made regarding the preciseness of the data. Statistics in such a large number and at such a detailed micro level may include a certain amount of error but it is hoped that the margin of error is even over most of the state. As the NMEP is itself a data based programme it is hoped that the discrepancies in data are small. Whatever be the data constraints, it is a reflection of any good research work to make the optimum use of it, to achieve meaningful results.

taken from the Bureau of Economics and Statistics publication "Statistics of Orissa", 1973. Month-wise climate data for the different stations was taken from the 30 year average values of the Indian Metereological Report. Month-wise rainfall data was aggregated for 1976 from the Indian daily weather report published by the Indian Metereological Department for 1976. This data was available at the Metereological Office, Delhi.

1.6 Methodology

The data collected regarding the incidence of malaria in Orissa has to be meaningfully made use of to attain optimum results. The data has to be analyzed to show where certain conditions of malaria are present and to assess whether the spatial pattern of incidence can be explained through a correlation of this pattern with other geographical factors. Our aim is therefore two-fold and the method employed to achieve the results is simple.

The basic tool of a geographer namely his cartographic skill is made ample use of to let the data reveal itself. Maps have been prepared showing the incidence pattern and the temporal and spatial changes are identified through a comparison of these maps. Likewise, maps have been made to show the varying geographical factors like population density, tribal population, irrigated area, relief, soils, drainage, temperature, humidity and rainfall, forests and area under rice. Correlation between these factors and the incidence pattern has also been attempted through a comparison and superimposition of maps. There was no need felt for the application of any elaborate statistical technique for this study. The results arrived at through the map correlations were sharp and brought out the spatial aspects of the problem. Moreover, a sophisticated technique besides being time taking would also prove difficult as the unit of study of the incidence differs from that of the other factors. The malaria sections do not coincide with the administrative boundaries of the state and hence a statistical analysis would present a problem.

The incidence map[7] for 1972 and 1976 is at the section level and it must be stated that the section boundaries have been drawn on the basis of population covered by each section in a police station as a section level map was not available. For 1968, the centre's incidence value has been marked and isopleths drawn as the centre level map was also not available. The class groups for 1972 and 1976 are the same to enable a comparison and to bring out the sharp changes over the years.

For the geographical factors to be studies, an attempt was made to get the data at the lowest unit possible. The percentage of irrigated area, population density and the

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7 The map showing incidence is based on the API values. The API is the annual parasite index which represents the number of malaria cases per thousand population. The API values for 1972 and 1976 were calculated for all the sections while for 1968 they were calculated for each centre.

percentage of tribal population have been mapped at the police station level this being the smallest unit of available data. There are 301 police stations in the state. Temperature, rainfall and humidity data was collected stationwise and isolines were drawn for each of these factors. Similarly, in the relief map, contours are drawn of 150 metres, 300 m, 600 m, and 900 m to reveal the nature of topography. The drainage map shows the drainage pattern with the major rivers marked out and it also shows the canals and reservoirs located in the state.

Besides the incidence map, there are two maps for 1968 and 1976 showing the pattern of the plasmodium distribution over the state. This species map is at the centre level for 1968 and at the section level for 1976. The choropleth map is made showing the percentage of PV to P 7.

Besides the visual interpretation provided by these maps, the study is also supplemented by graphs to bring out certain general aspects of malaria in the state. The graphs illustrate the seasonal nature and age-wise incidence of malaria in Orissa.

It must again be emphasized that no elaborate techniques were employed in this study as the need for them was not felt. Especially, for this particular study where the emphasis is on the spatial approach, the use of maps to represent the data bringsabout the patterns sharply and at a glance. Whatever, conclusions have been arrived at through this cartographic technique have been satisfying, though further detailed research may warrant the use of some statistical techniques.

1.7 Outline of the Study

The proposed structure of the thesis is presented below.

The first chapter introduces the problem under study, the significance of such a study, the data base and the methodology adopted.

The second chapter is a survey of literature on studies conducted along similar lines in different parts of the world where malaria is prevalent.

The main aspects of the malaria cycle are discussed in chapter III to emphasize the inter-relations between man - vector - parasite.

A description of the malaria situation in India would enrich our understanding of the disease in Orissa. Chapter IV studies the nature of malaria incidence in India and the measures adopted to combat the disease.

It is necessary to know the environmental background of Orissa to understand the spatial aspects of malaria. In chapter V the geographical aspects of the state are highlighted with reference to malaria.

The main body of the thesis are chapters VI and VII. In chapter VI the spatial patterns in the incidence of malaria in Orissa are identified for 1968, 1972 and 1976. This chapter begins with a broad over-view of malaria in Orissa to provide a better understanding of the detailed spatial picture of incidence.

In chapter VII the pattern of incidence is correlated with selected environmental and human factors in an attempt to explain the patterns of incidence identified.

Chapter VIII focusses attention on another aspect of resurgence - the changing geography of the parasite from 1968 to 1976.

The concluding chapter IX presents a summary of the major findings and some questions raised for further micro level research. In conclusion two theoretical spatial models, of diffusion and interaction are proposed.

Chapter II

A REVIEW OF LITERATURE DEALING WITH THE SPATIAL ASPECTS OF MALARIA

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A REVIEW OF LITERATURE DEALING WITH THE SPATIAL ASPECTS OF MALARIA

Interest in the studies of the geographical aspects of malaria is growing as an important developing branch of medical geography. This can be seen from the following survey of the recent contributions in this field. This chapter is divided into two parts, the first dealing with general aspects of malaria and the second with specific area studies.

2.1 General Aspects

As early as 1902, a medical man S. P. James[1] had emphasized the spatial dimension of malaria research, "when all factors considered, some regions too, appear in themselves to be more or less malarious than others and some importance is doubtless attached to the Regional factor".

But it was not until a decade or so ago that interest was generated in research on the geographical aspects of malaria. Fonaroff[2] focussed attention on those areas of research to which geographers may contribute. A major factor in understanding the malaria map relates to man in some cultural setting as this defines the degree and conditions of exposure

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1 S. P. James, Malaria in India, Scientific Memoirs, Officers of the Medical and Sanitary Departments, Government of India, Calcutta, 1902, p. 83.

2 L. S. Fonaroff, "Malaria Geography: Problems and Potentials for the Profession", The Professional Geographer, vol. 15, November 1963, pp. 1-7.

that a group presents to the environment. Regional variation in land use and vector ecology have introduced unexpected twists in disease geography. Fonaroff is of the view that there is some relationship between malaria geography, regional settlements and development. The common affinities of physical geography and malaria have always been recognized yet no sustaining liaison has been established between the groups. Among the physical elements he mentions climate, hydrographic conditions, landscape, soil and configuration of water bodies. He identifies some questions as falling within the ambit of interest of geographers and that need to be answered in malaria geography. They are: How and why do men interfere with their environment and what are the social, economic and demographic consequences of such interference? Malaria levels in many areas do not always correlate with rainfall but may with economic and social stress - How can this be measured? What is the relationship between mosquito population, disease levels and fluctuating urban densities?

While Fonaroff deals with the conceptual and theoretical aspects of malaria geography, Datta and Dutt[3] map out the existing picture of malaria in the world, with an aim to identify a global pattern of incidence. The authors begin by discussing the different aspects of the malarial cycle in a general ecological background. For the life cycle of the malarial parasite to continue, the parasite, vector, and host

3 H. N. Datta and A.K. Dutt, "Malarial Ecology: A Global Perspective", Social Science and Medicine, U.K.

need certain kinds of ecological bases. Temperature, rainfall, humidity, soils, drainage, attitude, economic conditions and cultural habits are all in some way related to the cycle. The authors have identified the 15°C and 32°C isotherms as the haunts of malaria and based on this world maps have been prepared for July and January. From the maps it is evident that there is a northward shift of malaria in July and a southward shift in January with the tropics being the overlapping zones of year round malaria. The authors propose that at the equator malaria is found till 8,000 ft, at 20° latitude till 6,000 ft, at 30° till 5,000 ft and at 40° latitude till 3,000 ft. This shows the impact of latitude on the altitudinal range of malaria. Maps showing temperature, rainfall and attitude conditions for the world are combined to prepare a map showing the areas of the world that are physically most susceptible to malaria, in order to emphasize the areas of hyper-endemicity.

The above studies bring out the fact that a geographer's contribution to malaria can be meaningful. It follows that from the general we come to the specific and the second part of this chapter which deals with specific case studies of malaria undertaken in different parts of the world. The studies are tackled in chronological order to trace the trends in studies of this kind.

2.2 Specific Area Studies

Ackerknecht's study[4] contrasted the different exposures

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4 E. H. Ackerknecht, Malaria in the Upper Mississippi

(Footnote contd.)

that the French and American frontier communities presented to the disease environment. Both the regions were malarious but the American community had a higher incidence. This was explained by the cultural factors of settlement types and land use, and the changes in malaria levels were concurrent with changes in housetypes and land use patterns.

Local variations in land use techniques and disease incidence provide immense research potential for geographers. One such study[5] brings to light how some malaria-free tidal mangrove areas of Malaya became infected in the reclamation measures that were taken in this region. Originally the local vector occupied the low zone sunlit pools while the higher mangrove zone was malarious. With clearing, the disease geography was reversed as the low zone became malarious and the higher zone became malaria-free.

The relationship between man and the anopheles is worked out in a four stage framework.[6] This scheme broadly defines the pertinent circumstances that often shape the malaria map. The four stages signify the progress of

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Valley, 1760-1900. Bull, History of Medicine, Supp. 4, Baltimore, Johns Hopkins, 1945, in L. S. Fonaroff, "Malaria Geography: Problems and Potentials for the Profession", Professional Geographer, vol. 15, November 1963, p. 2.

5 Watson Malcolm, The Prevention of Malaysia in the Federated Malay States, New York: Dirtton & Co., 1921, in Fonaroff, op. cit.

6 F. Sinton, League of Nations Health Organization. C.H./Mal./202, 23 March 1933, in Fonaroff, op. cit.

development in region: (1) While land is being brought under cultivation and is characterized by the presence of non-immune labour force and infected migrants or _vice versa_, there is usually an increase in the incidence of malaria; (2) In stage 2, there is extension of cultivation with the migrant labour still providing a reservoir for Malaria infection. Stages (3) and (4) mark the stabilization of population, the development of medical facilities and a decrease in the number of migrants. As a result, we find, usually, a decrease in the incidence.

An inquiry into the pattern of incidence as related to environmental factors reveals that malaria in Ceylon is mainly in the lowlands and rarely above 3,000 ft.[7] On the basis of rainfall Ceylon is divided into 3 zones - the wet zone with over 40" rainfall, intermediate zone with 20-40" and dry zone with less than 20" rain. In the wet zone there are two peaks of malaria in May-June and December-January corresponding to the periods of high rainfall. In the dry zone the peak incidence is in December-January the months of highest rain when small pools are formed. The intermediate zone is the epidemic area while the hilly country and low country wet zone are areas of low endemicity. The whole dry zone is a hyper-endemic area as it engages the attention of the agriculturists in relation to colonization schemes.

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7 K. J. Rustomjee, "A Brief Account of the Epidemology of Malaria in Ceylon", _Calcutta Geographical Review_, vol. 5, December 1943, pp. 135-39.

An earlier study on Orissa[8] highlights the malarious parts of the state for eradication purposes. The entire belt of the northern plateau and eastern ghats were hyper-endemic while the coastal zone and inland plateau also had a high degree of endemicity with focal outbreaks in the Chilka coast area. The author also identifies the spatial distribution of the chief vectors in the state in terms of the hilly forested areas, plains and coastal tracts. The hilly and forested belt of Jaypore, Koraput, Phulbani Kala-handi, and Sundargarh have year round transmission with little seasonal variations while in the plains it is mostly during the post-monsoon period.

A clear exposition of the human ecology of disease and a strong advocacy of an ecological human geography of a most dynamic kind is found in Prothero's work.[9] Malaria is said to be also related to human activity, and one form of activity, probably a crucial factor in incidence is migration. Prothero illustrates the significance of various types of migration for malaria distribution and incidence and especially as complicating factors in the implementation of a control programme with reference to Africa. In Africa migration, especially in the case of nomadic, daily and seasonal migration, forms an excellent agency for malaria transmission. The study

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8 J. K. Sehgal, "Progress of Malaria Eradication in Orissa State during 1965-66", Bulletin of the Indian Society for Malaria and Communicable Diseases, vol. 5, 1968, pp. 88-93.

9 R. M. Prothero, Migrants and Malaria, London, Longmans, 1965.

does not end with migration only, instead the resulting cultural problems are also studied. The attitude of the nomads who have accepted malaria as a part of life, their temporary settlement patterns; the difficulties of enumerating the migrants and the numerous political boundaries dividing the state, all present problems in the control of the disease. Besides presenting the general aspects of migrants and their impact on malaria, the author further emphasizes his point with the help of case studies.

The importance of cultural factors and malaria in Trinidad is the basis of Fonaroff's paper.[10] In this paper, the author clearly demonstrates the close association between the climatic conditions, the vector and the cacao plantation which affords an ideal environment both for the vector (A. Bellator) and its access to the host. The other malaria vector is A. aquasalis which is found in the coastal swamps. Much of Trinidad's sugar cultivation is within flight range of these swamps and this further emphasizes the importance of studying the spatial relations of vectors' habitats and presence of man's activities.

The above studies were all undertaken when control measures for malaria were introduced and total eradication envisaged. In the last five years we have seen the failure of these programmes and a resurgence of malaria in India and South East Asia. This has generated re-newed interest among

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10 L. S. Fonaroff, "Man and Malaria in Trinidad: Ecological Perspectives of a Changing Health Hazard", Annals of the Association of American Geographers, vol. 58, 1968, pp. 526-56.

researches regarding the reasons for the resurgence and changes in the pattern of malaria before and after the resurgence.

Some of these points have been answered in a recent paper with regard to India.[11] The authors have identified 1965 as the year of resurgence and have attempted to give reasons for this resurgence. The resurgence of the vector in terms of its spatial dimension is similar as in 1940s with A. Culcifacies the dominant vector and A. Stephensi the chief vector in urban areas. In terms of the parasite, plasmodium vivax remains the most important with plasmodium falciparum dominant over middle India in a belt from east to west and in Assam. The API figures are mapped for each year from 1965 to 1975 to see the spatial patterns over time. The incidence of 1975 was correlated with geographical factors of which population density revealed a negative correlation; irrigation revealed an inverse correlation and intensity of cropping an inverse relation, there being no clear relationship with the other variables. From a comparison of the series of maps the authors identify four foci which have acted as centres of diffusion. These four are: (1) Kutch saltmarsh, (2) Madhya Pradesh hill forests, (3) Orissa hill forests and (4) Assam hill forests. Their study raises a lot of questions needing detailed research and the present study stems from this macro level analysis.

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11 Rais Akhtar and A.T.A. Learmouth, "The Resurgence of Malaria in India, 1965 to 1976", Geojournal, vol. 1, no. 5, 1977, pp. 69-79.

Hyma and Ramesh have attempted a meso level study of malaria in Tamil Nadu,[12] where they describe the areal variations and trends in Malaria during 1965 to 1975 and trace the behaviour pattern of disease by areas of incidence and seasons. This is a unit level study there being 24 units in the state. The incidence map reveals the sharp rise in incidence in 1975 over 1963-64. The interior North-West emerges as the nucleus of malaria concentration which is explained by the labour migration to the area for many purposes and the construction of two irrigation projects located there. The seasonal pattern shows 2 peaks of incidence corresponding to the rainly months in July-August (higher peak) and in December. The transmissions season and chief vector species for the state have been chalked out. An important point that emerges from this study is the reversal of units from maintenance to consolidation phase which has serious implications.

The survey of literature on the spatial and environmental aspects of malaria makes it clear that geographer's can make meaningful contributions to the study of the disease. With the recent resurgence and spatial spread of Malaria, studies of this kind become even more vital to help identify high incidence foci and explain the reasons for their prevalence so that control measures may be successfully implemented.

12 B. Hyma and A. Ramesh, "The Geographic Distribution and Trends in Malaria Incidence in Tamil Nadu", National Geographic Journal of India, March-June 1977, pp. 40-60.

Chapter III

THE MALARIA CYCLE

Chapter III

THE MALARIA CYCLE

3.1 For there to be any occurrence of malaria three elements are essential - man, malarial parasite: female anopheles mosquito. The understanding of the basic relationships between the parasite-host-vector and the victim is vital to any study of malaria. These three elements exist in an environment which affects the functioning of each of them. This is illustrated with the help of the given diagram below:

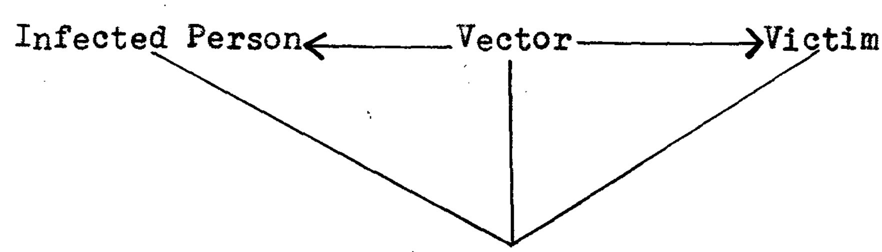

Fig. 3.1 Environment (Physical and Human)

(Source: R.M. Prothero, <u>Migrants and Malaria</u>, London: Longmans Fig. 2).

Between these three factors themselves there is an interlocking chain of relationships. The vector is the female anopheles mosquito; the host is the infected man having malarial parasites in his blood and the victim is the fresh case of malaria.

The perpetuation of malaria is dependent upon the process of transmission. The female A. mosquito needs a blood meal for the maturation of its eggs and hence bites human beings every 48 hours or so. When a female A. mosquito bites an infected person harbouring malarial parasites in his blood, the parasites enter the stomach of the mosquito. This mosquito starts spreading malaria, when it bites healthy persons after a period of 10 days as the parasite requires about this much time for its further development.

The parasites injected by the mosquito lodge and develop in a man's liver and spleen. After a week to 10 days they enter his blood stream where they multiply in the red blood corpuscles and attack them. This cycle of destruction takes 48-72 hours and is responsible for the periodicity of the bouts of malaria fever every 48-72 hours. Depending on the parasite is the nature of fever, with tertian malaria occurring every second day and quartan malaria every fourth day. In the tropics the nature of fever is of the 48 hour cycle type.[1] A simple flow diagram illustrates the malaria cycle discussed above.

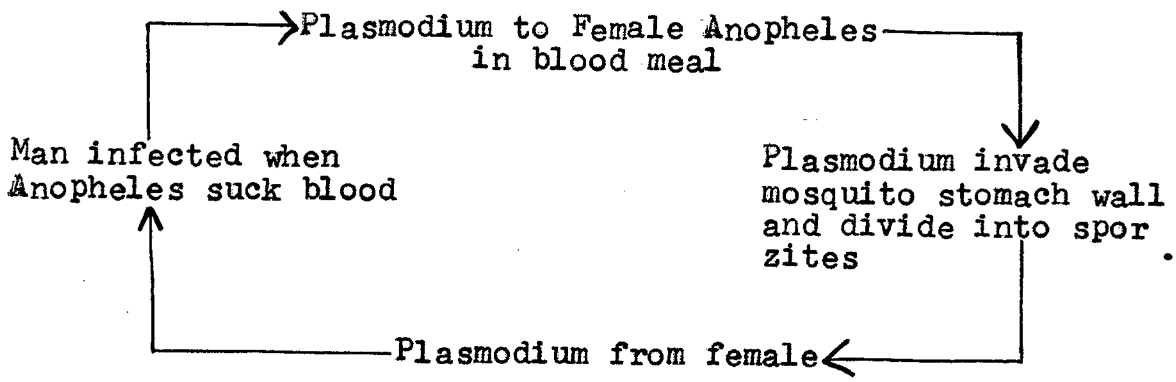

Fig. 3.2 The Malaria Cycle, A Simple Flow Diagram

(Source: A.T.A. Learmouth, <u>Patterns of Disease and Hunger</u>, Fig. 15)

1 F. Hawking, "The Clock of the Malaria Parasite", <u>Scientific American</u>, June 1970, in vol. 9 Readings in Life Sciences, offprint 1181, pp. 3399-3407.

3.2 The Vector

The incidence of malaria is largely dependent on the distribution of the Anopheles mosquito and wherever the latter are unable to breed we find no trace of the disease. There are a number of varieties of the anopheles of which the following are of importance. A. stephense mainly in urban areas; A. Philippinensis mainly in Bengal and Bihar; A. minimus found in hilly terrain; A. Sundaicus along the eastern coast and A. culcifacies found along the west coast.[2] The different mosquitoes are found in varying environments with each species tending to have a particular ecological habitat. But as a general rule, mosquitoes are not found in areas where summer temperatures fall below 60°F (15.5°C). High altitudes above an elevation of 3,000 meters are malaria free as also the regions beyond 60°N and 30°S.[3] The reaction of insects to temperature is presented in the given graph.

Besides temperature, mosquitoes require adequate moisture conditions for breeding and are therefore absent in the deserts. They breed under conditions of heavy rainfall in fresh or brackish water. At the end of the dry season when the onset of the rains provides increased water, there results an explosive rise in mosquito breeding. A seasonal peak of malaria is related to both the amount and the distribution of

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2 An Experienced Professor, Preventice and Social Medicine, 1969, Calcutta: Current Publications.

3 A.C. Cleggy and P.C. Cleggy, Man Against Disease, 1973 London: Heineman Ltd., pp. 202-19. "Protozoan Parasites of Man - Malaria".

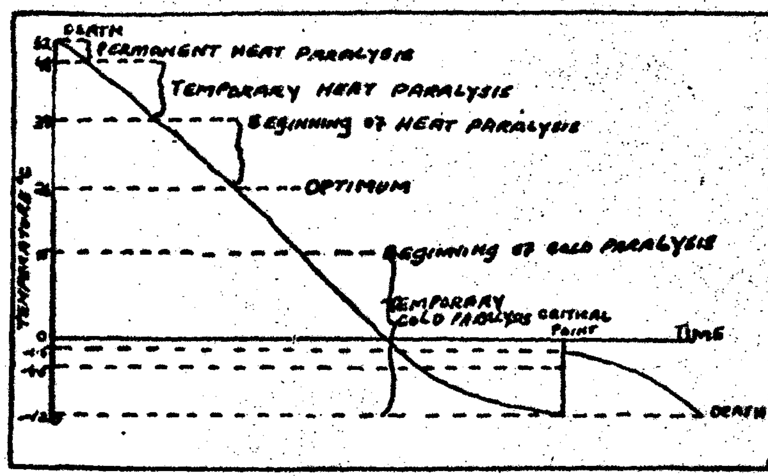

Fig. 3.3 REACTION OF INSECTS TO TEMPERATURE.

(SOURCE : HOWE G.M., MAN, ENVIRONMENT AND DISEASE IN BRITAIN, DAVID CHARLES, NEWTON ABBOT, Fig. 21).

rainfall. Mosquitoes can breed in fish ponds; clear slow running water; rice fields; shallow wells and pools; cisterns and tanks. Mosquitoes bite voraciously when the atmospheric relative humidity is high and they avoid both heat and light.

The longevity of the female Anopheles mosquito varies with the availability of food, temperature and humidity. Hot, dry summers may reduce their life span to only two weeks while increased humidity has protective effects on the longevity of the Anopheles. A relative humidity of 55 per cent at 70°F ensures the normal life span of the Anopheles and a long life span entails a longer period of transmission by the mosquito. For the eggs to develop into adults climate plays an important role as very dry and cold climates retard this development, which is much faster in July and August or the post-rainy season. The optimal conditions for mosquitoes are between 22° and 30°C with over 60 per cent relative humidity. Areas with rainfall between 30 and 60 inches have high potential for malaria with over 60 inches rainfall regions having highest potential and in below 30 inches rainfall areas the occurrence of malaria decreases.[4]

3.3 The Parasite

The sexual phase of the parasite requires a certain temperature. The dependence of the parasite on certain ecological conditions is not as clearly established as that of

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4 H.M. Datta and A.K. Dutt, "Malaria Ecology: A Global Perspective", Social Science and Medicine (U.K.), 1974.

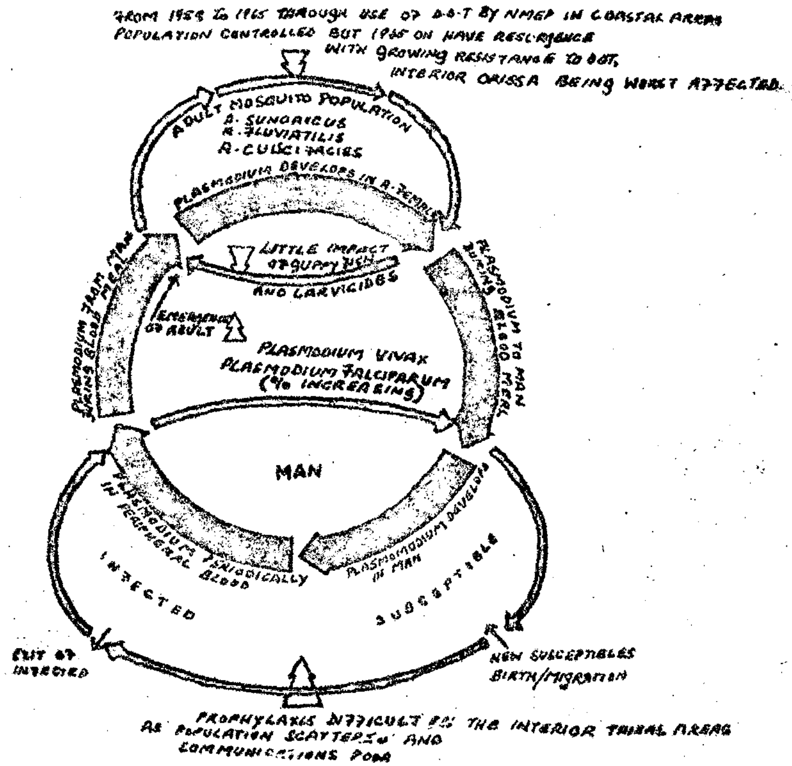

Fig. 3.4 <u>THE MALARIA CYCLE – ORISSA</u>

(AFTER : LEARMONTH A.T.A., PATTERNS OF DISEASE AND HUNGER, DAVID-CHARLES, NEWTON ABBOT, 1978. Fig. 22).

the mosquito. The main species of plasmodium affecting man are plasmodium vivax (PV), plasmodium falciparum (P F), plasmodium malariae, and plasmodium ovale. Of these the first two are mainly responsible for the incidence of malaria.

PV is found in temperate areas as its sexual cycle is completed in lower temperature while P F is confined to tropical and sub-tropical lands as it needs a higher temperature. The minimum temperature below which the development of parasites gets retarded is 19°C for P F and 15°C for PV. Very high temperatures are also harmful to parasites and over 32°C their survival is low while the ideal temperature for PV and P F is around 20°C.[5]

3.4 <u>The Malaria Cycle in Orissa</u>

In concluding this chapter, a malaria cycle is constructed for Orissa on the lines of that given for Morocco (Fig.3·4). There are three elements having interlocking cycles the man - vector - parasite. In this model besides illustrating the malaria cycle an attempt is made to depict the breaks in the cycle through eradication measures.

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5 Ibid.

Chapter IV

MALARIA IN INDIA - A HISTORICAL REVIEW

Chapter IV

MALARIA IN INDIA - A HISTORICAL REVIEW

Malaria has had a long history in India with reference made to it since ancient times. The Atharva Veda (1500 BC) gives a clinical description of the seasonal approach of fevers. Susruta, the father of ancient Indian medicine, refers to the mosquito as the vector of the disease associated with chill and fever.[1] To cope with this pressing public health problem various programmes were chalked out since early twentieth century.

4.1 Organizations and Eradications Measures

The earliest organization to deal with the disease was the Central Malaria Bureau in 1910 which became the Malaria Survey of India in 1927. In 1935 a Malaria Institute of India was established. All these programmes were instituted by the British and their influence was confined to areas of immediate interest to them - the mining, plantation areas and their own townships.[2] The control of malaria was hence limited in its coverage to a few pockets. The nature and transmission of malaria being what it is these sporadic efforts at controlling malaria were not very successful. By independence, the situation was grave as a large part of the country remained

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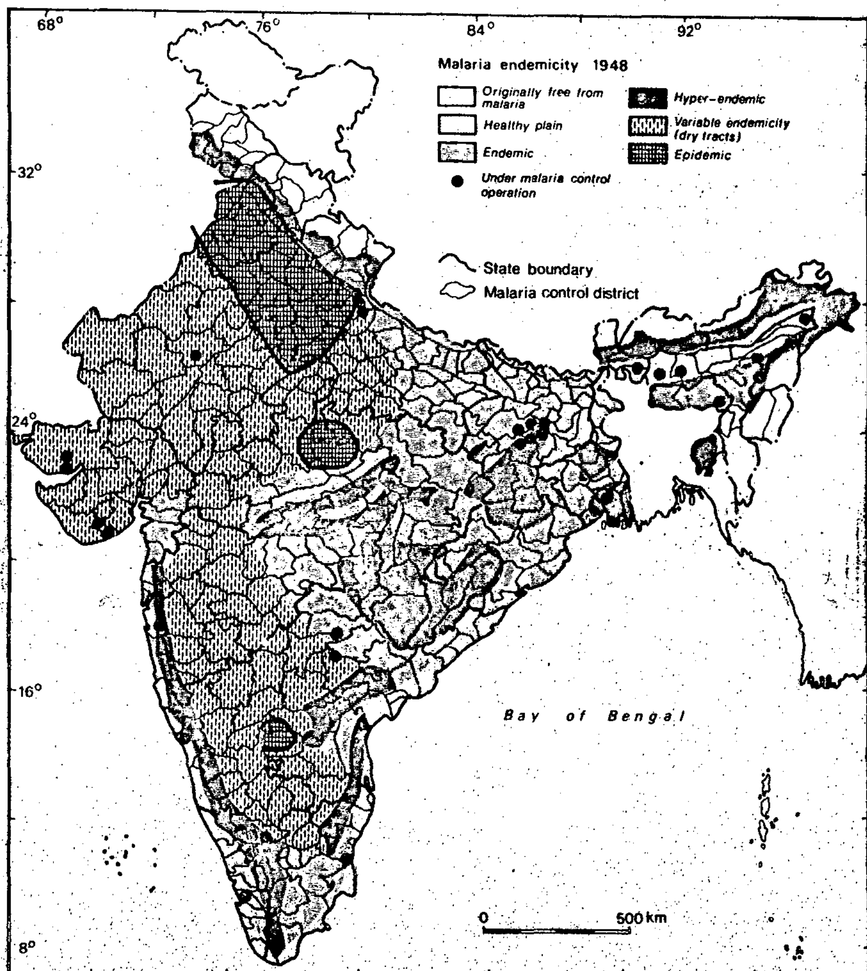
1 Report of the Special Committee to Review the Working of the NMEP and to recommend measures for improvement, New Delhi, 1967, p. 2.

2 Harry Cleaver, "Political Economy of Malaria De-Control", in Economic and Political Weekly, vol. 11, no. 36, September 1976, pp. 1463-73.

Fig 4.1

Malaria endemicity 1948, after malaria survey of India.



(SOURCE : AKHTAR R. AND LEARMONTH A.T.A., "THE RESURGENCE OF MALARIA IN INDIA 1965–76," GEOJOURNAL, VOL 1, NO. 5. 1977, FIG 1).

highly malarious showing a rising trend of incidence. The need was felt for a national programme focussing attention on malaria and covering the whole country and thus the National Malaria Control Programme (NMCP) came into being in 1953. Before this control programme was undertaken in 1945 it was estimated that 75 million people suffered from malaria and about 8 lakhs died directly due to it.[3] Under the NMCP, DDT was sprayed in areas with a high incidence of malaria to check the growth in vector population. The results of the control programme were very encouraging and on the insistence of the World Health Organization, it was felt that the programme should change over to eradication.

4.2 The NMEP

The National Malaria Eradication Programme (NMEP) came into operation in 1958. Malaria eradication work is the world's biggest public health campaign against a communicable disease. The NMEP covered the entire country except areas of over 5,000 feet above sea-level consisting of a population of around fifteen million in a zone where transmission does not occur.[4]

For the purpose of eradication the country was divided into malaria units with a total of 393.25 units covering a population of 527 million. Each unit now covers a population

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3 Rais Akhtar and A.T.A. Learmouth, "Resurgence of Malaria in India, 1965-1976", Geojournal, vol. 1, no. 5, 1977, pp. 69-79.

4 "Why Malaria Again?", NMEP (New Delhi), 1977, p. 4.

of 1.5 million and is broken up into sub-units covering a population of 40,000. The sub-units are further broken up into sectors and each sector consists of 4-5 sections each covering 10,000 people.[5]

The NMEP consists of four phases of preparatory, attack, consolidation and maintenance. Of these, the whole country has passed through the first stage as a result of the earlier programmes. The attack phase includes those areas of high incidence demanding regular spraying of all the houses with surveillance introduced after two years. In the consolidation phase there is only focal spraying of areas where cases have been found and surveillance continues. In the final maintenance phase there is intensive surveillance as transmission is reduced to nearly zero. Initially the programme was very successful with morbidity being reduced from 75 million to about one lakh per year in 1965. At this stage 75 per cent of the country was in the advanced phase of eradication and only 25 per cent was in the attack phase.[6]

The eradication programme received setbacks after 1965 due to various reasons.[7] (1) The first is that insecticide sprays could not be carried out according to the time schedule because of the delayed receipt of imported insecticides following the closure of the Suez Canal in 1965. (2) Most of the

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5 S. L. Dhir, _NMEP_ - _Retrospect and Prospect_, NMEP, New Delhi, 1970.

6 Ibid.

7 "Why Malaria Again?", NMEP, _op. cit._, p. 3.

financial resources for eradication came from the USA and this aid for the programme ceased in 1965 hampering the supply of insecticides, drugs and other equipment. (3) The cost of insecticides rose tremendously after the oil crisis, leading to a reduction in purchasing power. (4) The loss of urgency in achieving total eradication once the initial results were achieved, resulted in the programme getting less priority than before. (5) Due to the continued use of DDT the malaria mosquito has developed resistance to DDT and this necessitated a switch to costlier drugs like BHC and Malathion. (6) The malarial parasite (especially P 7) has also developed resistance, in some parts to the common anti-malarial. (7) Lastly, the people's cooperation in accepting the spraying has decreased as most other insect pests killed earlier by the sprays, have now developed resistance to it.

Viewing the rising trend of malaria, since 1965, all over the country, the NMEP was revised.[8] It was suggested that the emphasis be shifted again on control as a short-term measure and then eradication as a long term aim. This suggestion was made after noting with dismay the reversal of many units into their former phase of attack or consolidation.

4.3 The Indian Situation

The table below shows the incidence of malaria in India

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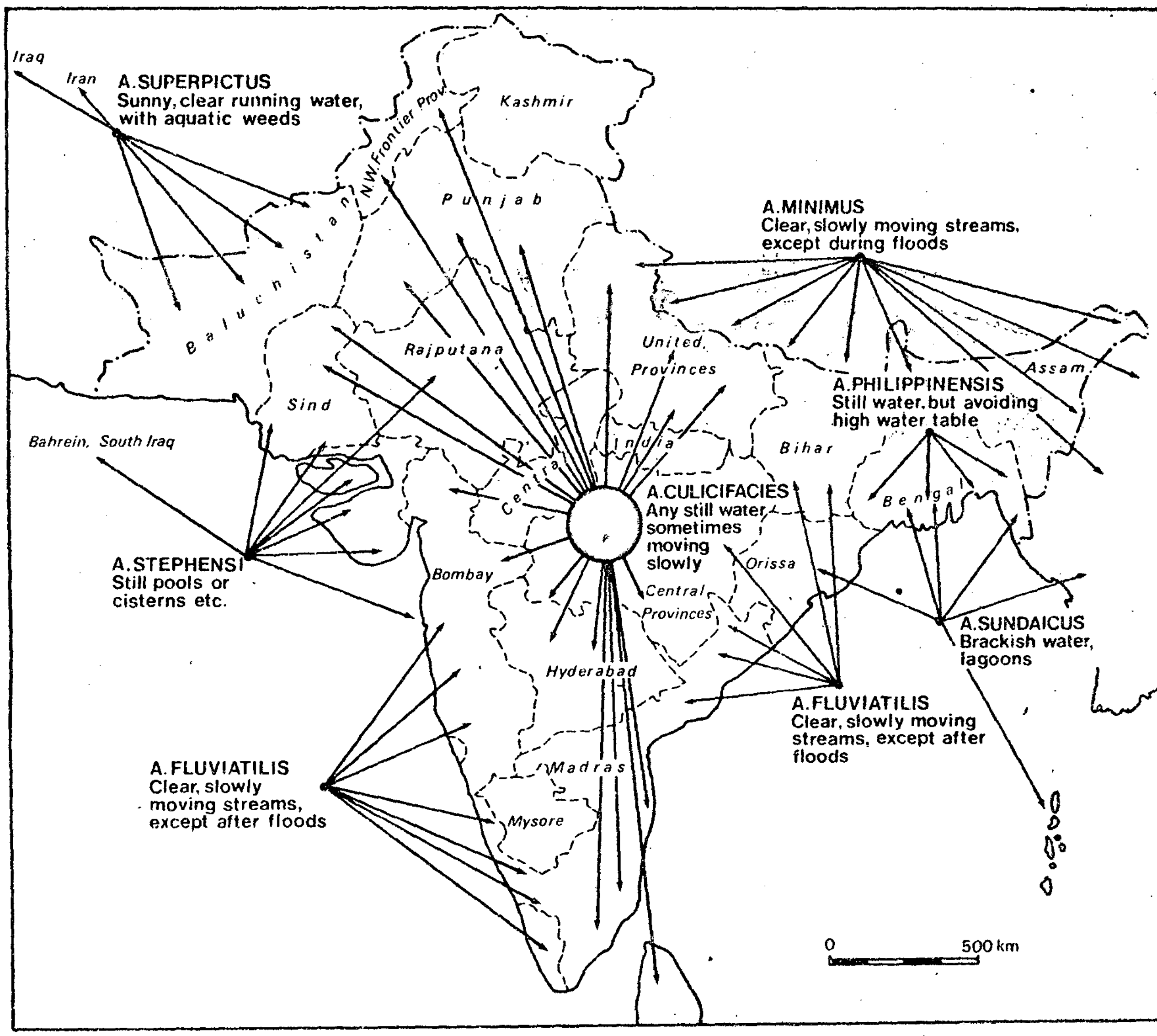
8 Report of the Consultative Committee of Experts to Determine Alternative Strategies under NMEP, Delhi, August 1974, p. 1.



MAP 4·2 VECTOR MAP OF INDIA.

SOURCE: LEARMONTH A.T.A., "THE RESURGENCE OF MALARIA IN INDIA, 1965-76," GEOJOURNAL, VOL. 1, NO. 5, 1977. Fig. 2.

from 1965 to 1976 after the resurgence.[9]

Table 4.1

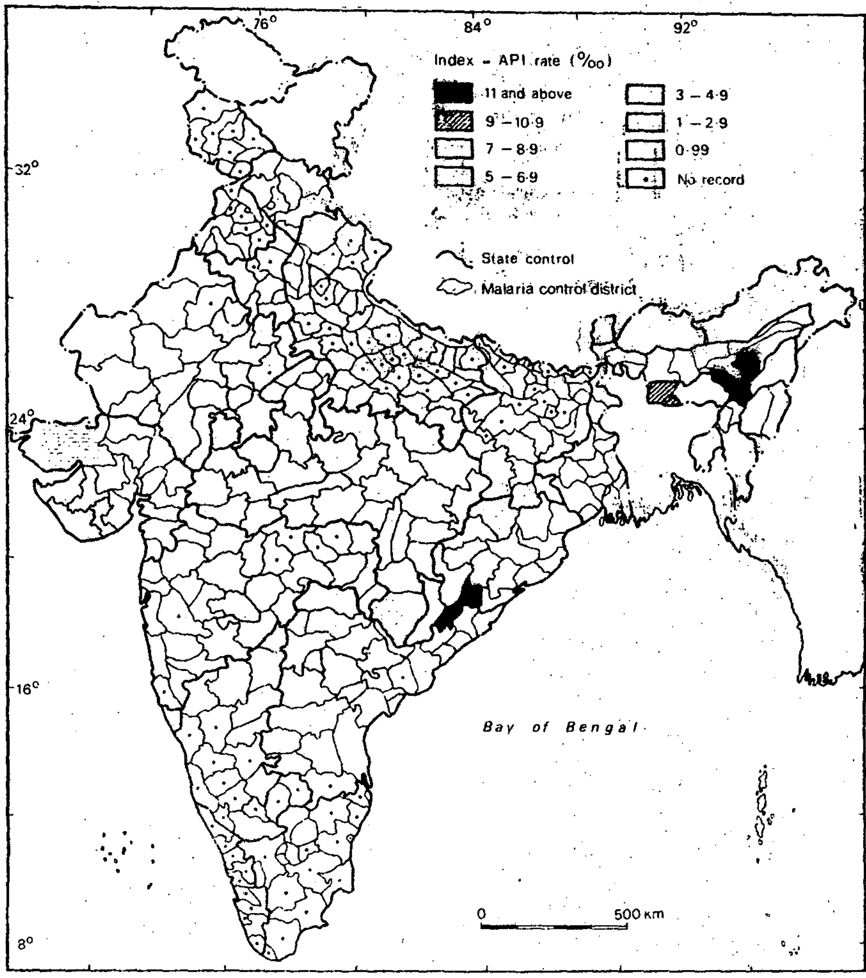
Year	Total Cases	Deaths
1965	100,185	-
1966	148,136	-
1967	278,621	-
1968	274,881	-
1969	348,697	-
1970	694,647	-
1971	1,323,118	-
1972	1,362,806	-
1973	1,934,485	-
1974	3,167,658	30
1975	5,166,142	99
1976	5,830,300	40

The resurgence of malaria can be viewed through the vector - parasite and the incidence pattern itself. The chief vector of malaria in India is A. culcifacies (A = Anopheles) which is found in the entire northern belt, Central India, Andhra Pradesh and Tamil Nadu. This vector can breed in any still water that is sometimes moving slowly. A. fluviatilis is found in the entire west, Andhra coast and Bihar favouring clear, slowly moving streams except after floods. In the Ganges delta and Orissa the chief vector is

9 Rais Akhtar and A.T.A. Learmouth, op. cit.

MAP 4·3

Annual parasite index rate 1965



SOURCE: LEARMONTH A.T.A., "THE RESURGENCE OF MALARIA IN INDIA," GEOJOURNAL, VOL. 1, NO. 5, 1977. Fig. 3.

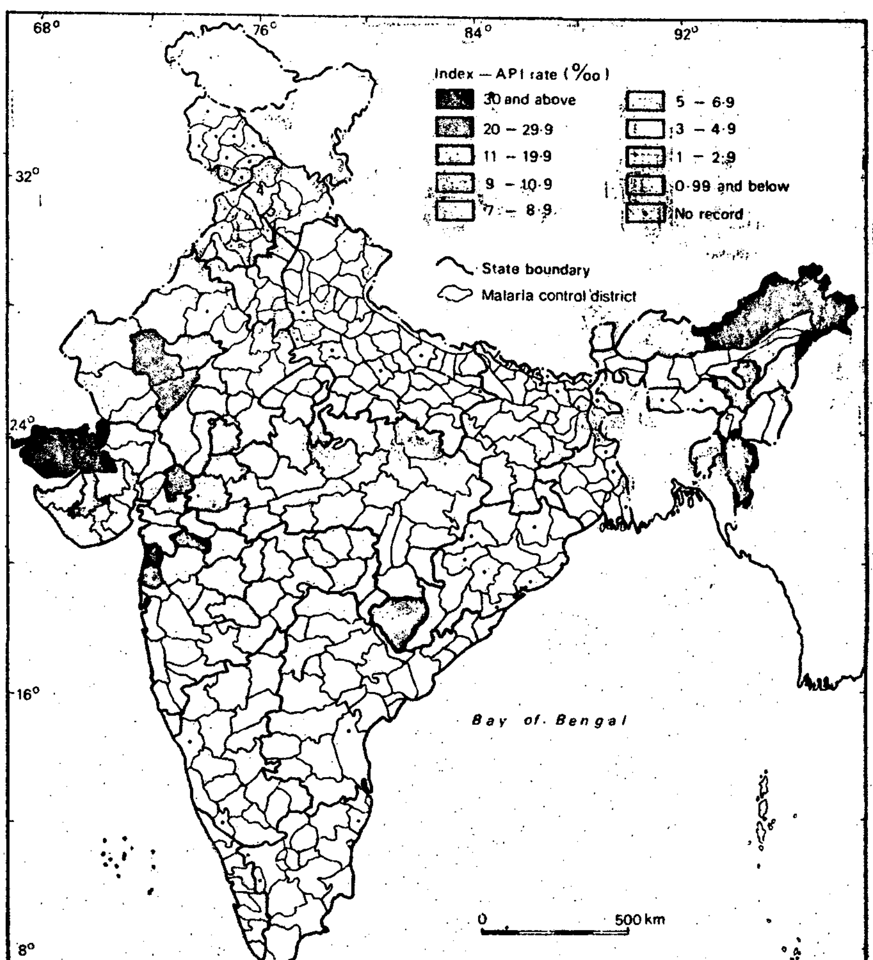
A. sundaicus which breeds in brackish water and lagoons. A. stephensi is the chief vector in urban areas breeding in small pools or cisterns. The vector map is given alongside showing the distribution of the various species.

Plasmodium vivax (PV) is the main species of the malarial parasite in India and is less virulent than plasmodium falciparum (PF). Incidence of falciparum malaria is rising and PF cases are found in a large belt running east to west in Central India and in Assam. This belt roughly corresponds to the tribal highland core of the Indian heartland which though is an areas of low density yet total population exposed is large. These two parasites are the major contributors to malaria in India.

For the country as a whole the incidence of malaria was fairly low in 1965 (map 4.3) with north and south India recording no cases. The main belt of incidence stretched right across Central India from Gujarat to Orissa with the north-east also recording a high incidence. In 1970, there is seen an overall rise in API rates with North and South Orissa still exhibiting low API rates. Gujarat, Rajasthan, North Maharashtra and the North-East reveal a high rise in malaria cases. In 1976, a map (4.4) of the API rates sharply illustrates the steep rise in malaria in all parts of the country. The entire Indo-gangetic plain, Rajasthan, Gujarat, Maharashtra, Karnataka, Madhya Pradesh, Orissa and the north-east record high API rates of 20 and above. Only Kerala, a large part of the Tamil Nadu and Andhra Pradesh, the northern

Fig 4·3

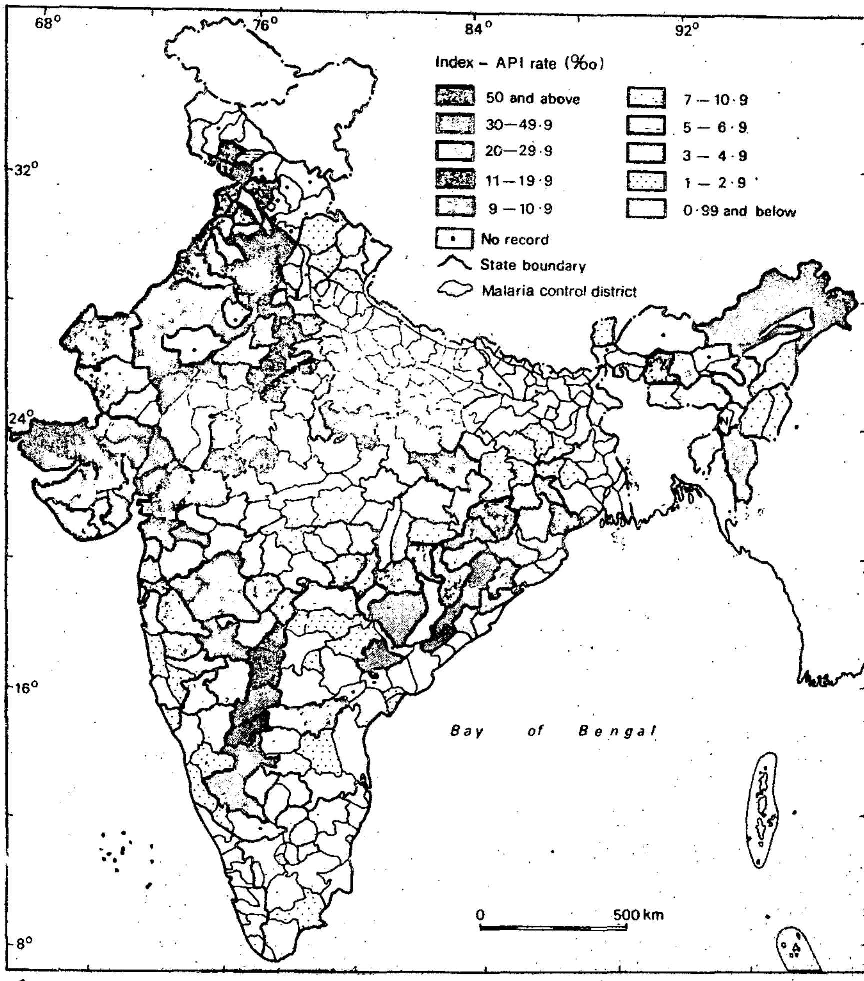
Annual parasite index rate 1970



(SOURCE : AKHTAR R. AND LEARMONTH A.T.A., "THE RESURGENCE OF MALARIA IN INDIA, 1965–76," GEOJOURNAL, VOL 1., No. 5, 1977. Fig. 4).

MAP 4·5

Annual parasite index rate 1976



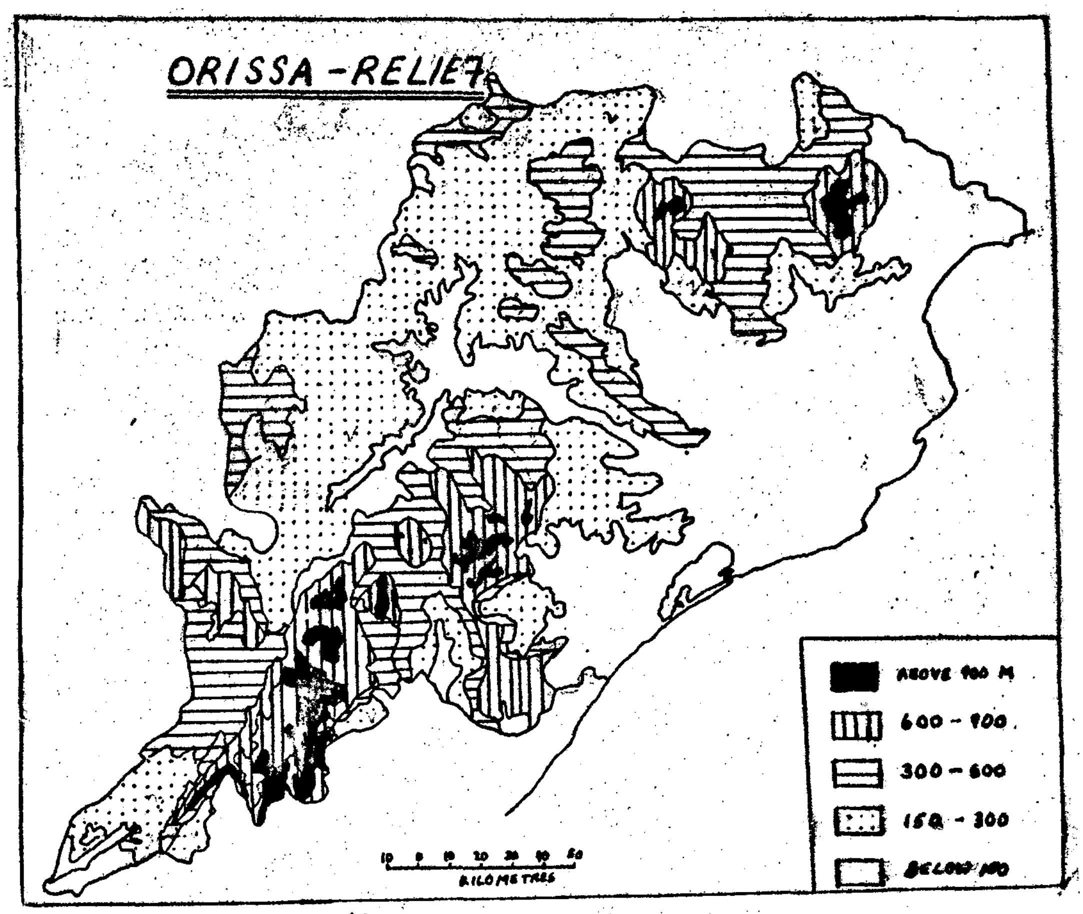
SOURCE: LEARMONTH A.T.A., "THE RESURGENCE OF MALARIA IN INDIA, 1965–76," GEOJOURNAL, VOL. 1, NO. 5, 1977. Fig. 6.

districts of Uttar Pradesh, Bihar and West Bengal are the small areas of low incidence.

In all the yearly incidence maps we find that Orissa consistently has high levels of malaria.

Chapter V

THE GEOGRAPHICAL SETTING OF ORISSA WITH REFERENCE TO MALARIA



MAP 5·1

Chapter V

THE GEOGRAPHICAL SETTING OF ORISSA WITH REFERENCE TO MALARIA

Since, as we have noted earlier, malaria in its incidence and spread is significantly influenced by the natural environment of the region, an attempt is made here to present the main aspects of Orissa's physical build and biotic cover as a preliminary to our analysis.

5.1 Landscape Factors Significant in Incidence of Malaria

Although the geological evolution, lithology and structural factors provide the region with its base, Orissa's present land forms are largely the product of its recent geological history of uplifts, peneplantation and the associated transport and deposition of the denuded material.[1] The geological matrix ranges from the Archaeans, Dharwars, Gondawanas to the recent alluvium. The first major distinction is the one between Orissa's highlands in the interior, stretching from the Mayurbhanj plateaus to the Baudh Khondmals in the south rather spectacularly broken by the Mahanadi valley and the coastal lands abutting the Bay of Bengal and consisting of the Mahanadi delta in the centre and the alluvial stretches to the north and south. For our purpose, these major features may be further classified, after Chatterji, into (a) the Garhjat Hills in the north, (b) the Baudh Khondmals complex in the south with its extension in the Bolangir

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1 D.N. Wadia, Geology of India (London: Macmillans, 1944), pp. 308-27.

valley of the Chhattisgarh basin in the west, and (c) the Coast lands.[2]

The highlands show features of erosional topography ranging from furrowed steep scarp edges, undulating plateaus with levelled summit plains, basins at elevation rimmed with rounded hills and undulating pediplain expanses below seamed with major rivers and their tributaries showing here and there worn out "whale backs", dykes and knolls.[3] The region is drained by the river systems of the Brahmanai, and Mahanadi, with many parallel flowing other rivers which include Subernrekha, Baitarani, Rishi Kulya, Vamsadhara rising from the hill scarps and emptying their waters directly to the Bay of Bengal. The extreme southwest is drained westward by the head streams of the Godavari.

The coastlands with their extensive stretches of alluvium stand in sharp contrast to the highlands. But even here there are immense local variations in landscape that are significant not only in human occupance and land use, but are more relevantly in understanding the patterns of incidence of malaria. The stream meanders, levees in the deltaic region, and entrenched river and stream beds mark the alluvial landscape, and increasingly southwards remnant hills are striking features in topography, many of them having played

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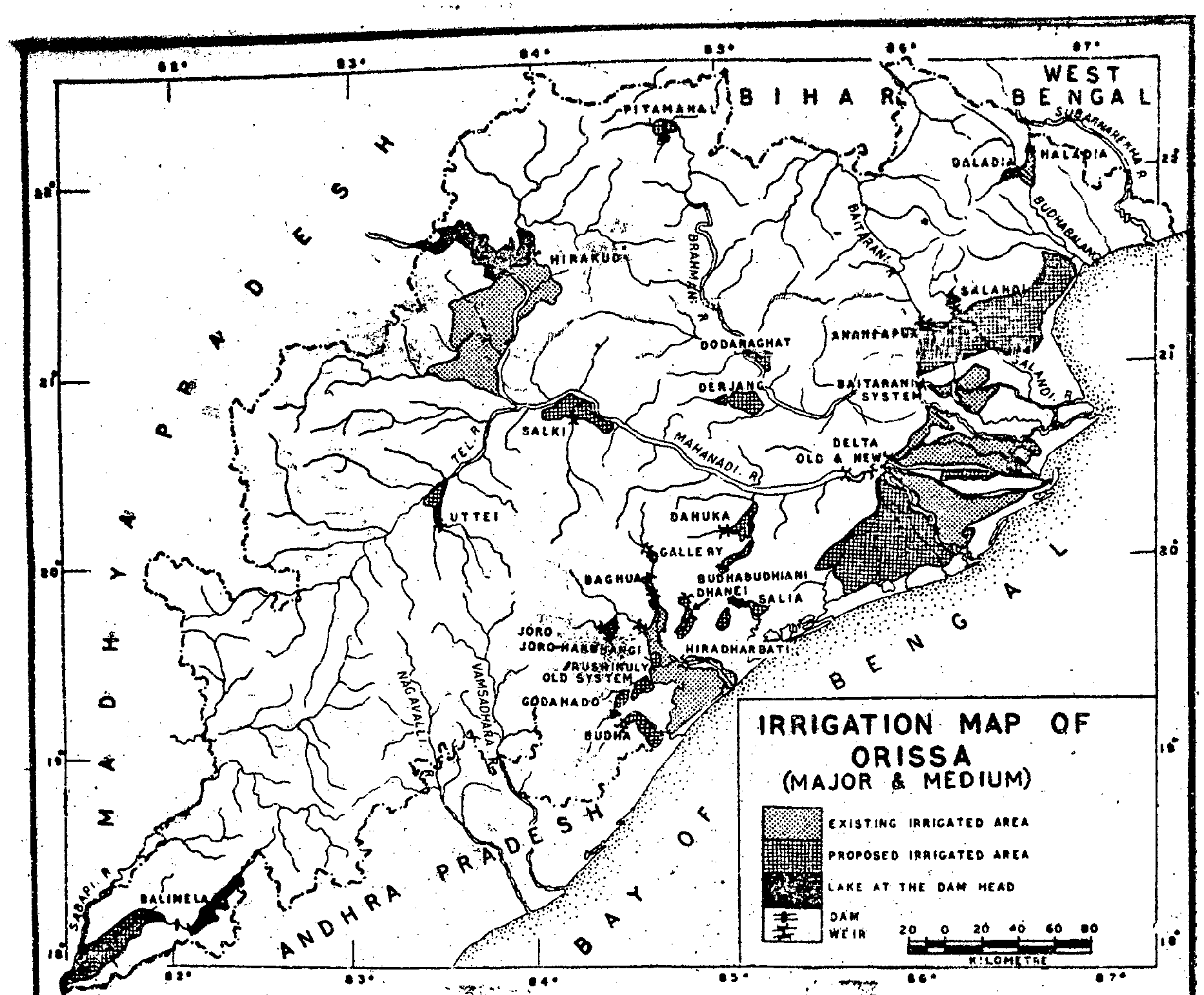
2 S.P. Chatterji, National Atlas Organization, Physical Plate: Orissa.

3 K.L.V. Raman Rao and R. Vaidyanathan, "Evolution of Features Over the Keonjhar Pediplain", Geol. Min. & Met Society, India, 1974.



MAP 5.2

SOURCE: SINHA B.N., Geography of ORISSA, NBT, New Delhi, 1971. MAP 15.

their historic role ~~as having played their historic role~~ as defensive sites.[4] The shore line processes contribute to the formation of the major bay with its limits marked off by the mouths of the Subernarekha and Brahmani. In the middle, the prograding delta of the Mahanadi shows at its shore line the formation of spits and sandbars, all smoothened by northward moving wave action, which in the case of the Chilka Lake and its lesser counterparts locks the draining waters into lagoons. The coastline south of the delta is straight, and all along the entire coastline there is a shelving marine platform.

5.2 Hydrological Regime in Relation to Landforms

The regime of rainfall in relation to the Orissan landforms has an important bearing in our problem. The mon-soonal seasonal rainfall, heavy in the east and south-east and progressively declining west and north-west, saturates the soils, with some rain water percolating underground and most of it rubs off as a surface flow. The torrential regime of the rainy season is followed by shrunken water courses, threaded channels, cut-off pools and deep but stagnant follows. Except on the steeper flanks of the hill ranges and the trans-verse gorges of the rivers of which the Mahanadi reach is more spectacular, the stream courses are graded, with developing meanders, terraces and abandoned courses as typical features.

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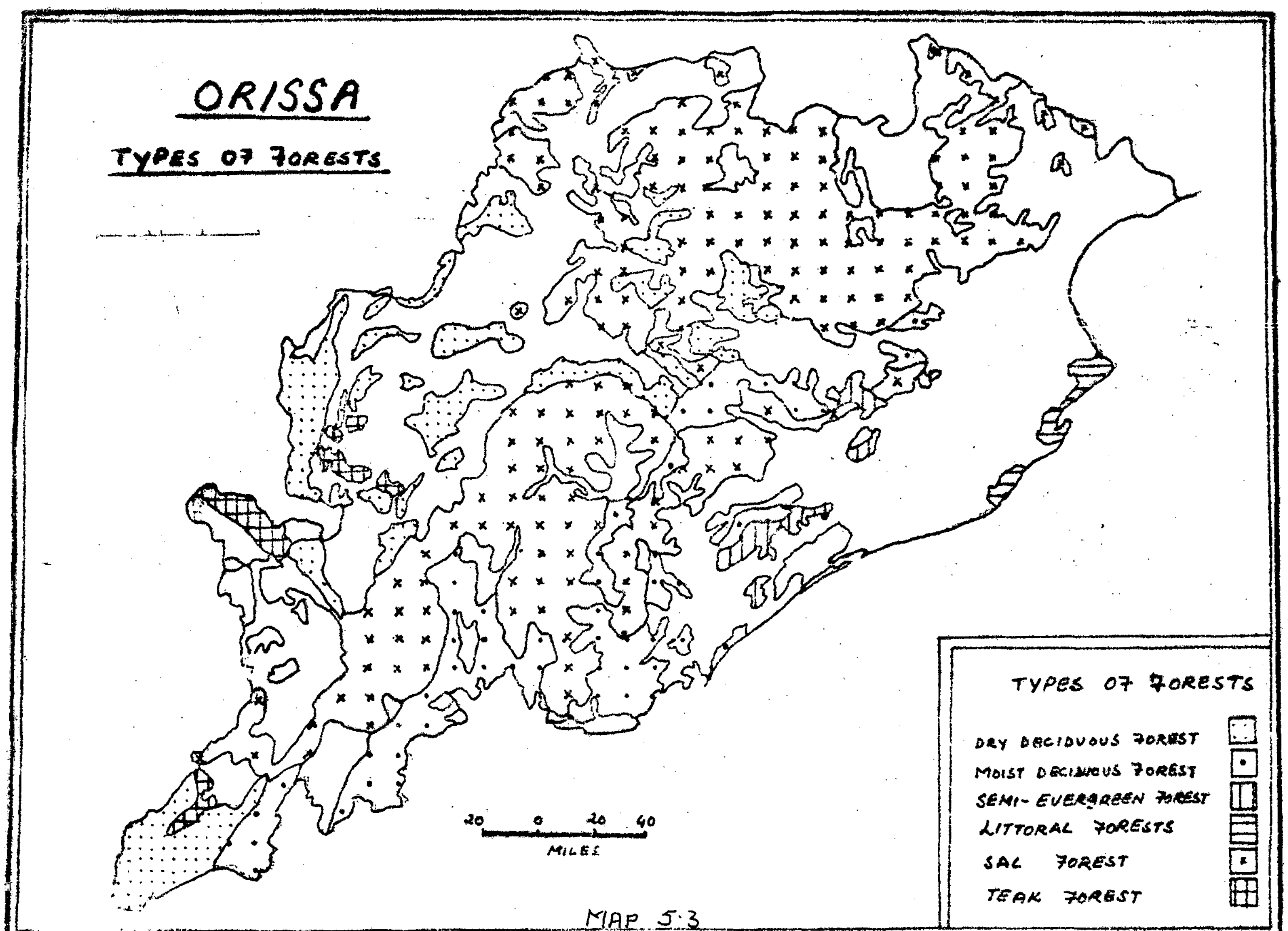
4 Dhaulagiri, Khandagiri, Udaygiri.


ORISSA
TYPES OF FORESTS
20 0 20 40
MILES
TYPES OF FORESTS
DRY DECIDUOUS FOREST
MOIST DECIDUOUS FOREST
SEMI-EVERGREEN FOREST
LITTORAL FORESTS
SAL FOREST
TEAK FOREST

MAP 5.3

With the advance of summer conditions, almost all the water features tend to dry up, some totally dried up while others as shrunken stagnant pools. These hydrological conditions, coupled with temperature and humidity associations, are, it is suggested, significant in the incidence of malaria.

5.3 <u>The Biotic Cover</u>

Orissa is still one of the fortunate States which retains vegetal cover to a large extent. The proportion of forest cover is 44.6 per cent of the total geographical area.[5] Baudh Khondamals and Sundargarh areas have a cover of over 70 to 55 per cent. However, there are hardly any areas which have not been affected by timber cutting, shifting cultivation ('<u>podu</u>'), permanent clearance for agriculture and over grazing. In the existing cover, the ecosystems with their plant-animal species interaction and the impact of tribal communities have suffered degradation which has been further aggravated in the shadow of modernization: forest operations and timber and fuel wood utilization, minerals exploitation and building of dams and communications. The natural environmental contrast is reflected in the distribution and densities of population and their occupational patterns. The lowlands are densely populated (250 per km2) with an element of urbanization with Puri, Bhubaneshwar ~~and led by~~ and Cuttack as principal centres but rural communities dominate with their rice economy

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5 R.L. Singh, ed., <u>A Regional Geography of India</u>, Varanasi, 1971, p. 758.

largely dependent on rains but increasingly making use of irrigation, especially in the command areas of the Hirakund Dam and the deltaic distributaries. Except for the short winter, it is the moist heat that influences human activity.

In the highland areas, there is a contrast between the cultivated tracts and the enclosing forested hills often descending on slopes and the upper valley courses. The tree covered areas are important from the point of view of both plant and human ecology. Vegetation types range from the moist deciduos, mixed, to scrub and stunted bushes. Grass-lands form an important element in the mixed and scrub types, and sharp local changes are introduced by edaphic factors; undulating hollows, for example, are covered with bamboos, especially Dendrocalamus strictus, and xerophytes cover the lateritic soils. On the lowlands, clumps of trees, usually of economic value like the mango (Mangifera i.) and Tamarind (Tamarindus i.) on lower elevations and scrub on the isolated knolls; the coastline carries extensive mangrove vegetation and typical salt water flora including Poonang (Callophllum inophyllum) in the interior tracts and all of course decorated here and there by coconut palms fringing the embankments of the better soils and cashew nut clumps in the scrubby patches on the poorer soils.

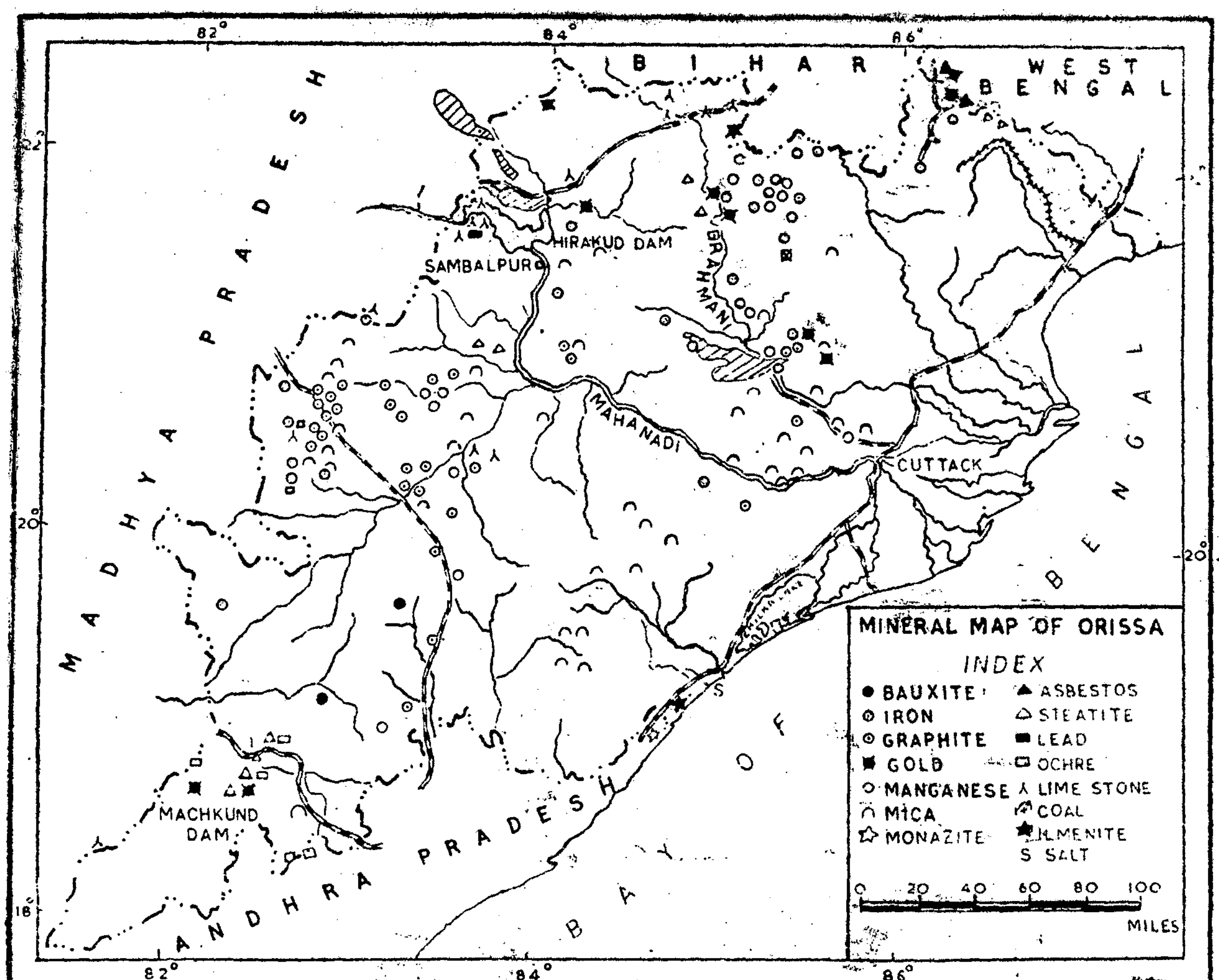
But it is in forested highlands that the man-nature interaction is seen at the best, though in a declining form. The traditional energy cycle consists of good and thick plant growth, animal life - wild and partly arboreal - with an infusion of domesticated animals, and the tribal communities which tend them and draw their needs from them as well as whatever that nature offers.

5.4 The Tribal Setting

Of the 23.1 per cent of tribal population in the State, the Bhuyians, the hill Kharias, Agarias, of the Northern plateau lands, the Kultas of the central plateaus and the Bhatras of the southern hills, are now agriculturally oriented, but not so the others like the Koltachasas, the Bhatras, Koyyas, and Savaras of the southern hills. Thus there is a wide range from the most tribal tax elements in the hills to the advanced farming communities of the low lands which exhibit a varying degree of interaction with the natural environment: from the Savaras who are almost a part of the natural ecosystem to the skilled Khandayats of the lowlands who operate in their agrarian environment within what is largely a man-made ecosystem. And within this web of biological interaction, diseases including malaria, act as interruptors to the human energy contributions to the ecosystems.

5.5 Mineral Wealth

The fact that Orissa is rich in minerals has its overtones in the incidence of malaria. The inclusion of minerals in this study is based on two facts: (1) Mining activities lead to population movements in the nature of in-migrating labour force who may act as carriers of infection or as the



MAP 5·4

SOURCE : SINHA B.N., GEOGRAPHY OF ORISSA, NBT, NEW DELHI, 1971. MAP 17.

susceptible population;[6] and (2) Large scale mining activity is a form of man-environment interaction that brings with it many changes in the form of new settlements springing up and the landscape changing (with areas being dug up, communications developing and construction work taking place). All these activities result in creating conditions for breeding (by the hollows where water collects) and thus leading to a rise in malaria incidence.

The spatial picture of mining activities shows the nature of concentration of minerals in the state. The highly mineralized region covers the districts of Sundargarh, Mayurbhanj, Keonjhar, Sambalpur, Bolangir, Kalahandi and Koraput where over 200 mines are working to exploit different minerals.[7] It is in north, west and south Orissa that the mining activities are concentrated (map no.5). Among the important minerals, iron ore is found mainly in Sundargarh (Bonai), North and South Keonjhar and North West Mayurbhanj. Coal reserves in Orissa are found at Rampur in Sambalpur and at Talcher in Dhenkanal. Manganese is mostly found around Joda in North Keonjhar in Sundargarh and North Bolangir with some found around Rayagarh in Koraput. Chromite is largely found in Surkinda in Cuttack, in South Keonjhar and Dhenkanal. Limestone and dolomite are located in Sundargarh, Dungri

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6 R.M. Prothero, Migrants and Malaria, London: Longmans, 1965.

7 B.N. Sinha, Geography of Orissa, New Delhi: National Book Trust, 1971, pp. 114-22.

(Sambalpur), and Koraput. Fire-clay is mainly found in Belpahar in Sambalpur while China-clay is mined near Jashipur (Mayurbhanj). Graphite occurs in Koraput, Kalahandi, Bolangir and Sambalpur while Bauxite is found in Sambalpur, Bolangir and Kalahandi.

From the spatial pattern of minerals distribution it is clear that mining activities are largely found in North Orissa and some in West and South Orissa. Whether this pattern has any impact on malaria incidence will be discussed in its appropriate context.

Chapter VI

INCIDENCE OF MALARIA IN ORISSA - A SPATIO-TEMPORAL ANALYSIS

Chapter VI

INCIDENCE OF MALARIA IN ORISSA - A SPATIO-TEMPORAL ANALYSIS

Before examining the detailed section level incidence pattern, a broad overview of malaria in Orissa is given to help in understanding better the micro level spatial picture. This introduction to malaria in Orissa traces the broad incidence patterns over the years and also studies the seasonal and age-wise incidence pattern for the state.

6.1 Malaria in Orissa 1948-1976: A Broad Overview

From our general study of India we find that the state is intensively malarious on account of a major part of it being hilly, and flood affected.[1] This present analysis is on a broad unit level the state being divided into 15 units. Table VI.1 gives the incidence figures for the state since 1961.

Table VI.1

Incidence in Orissa

Year	No of Cases
1961	5,052
1962	11,758
1963	17,376
1964	31,796
1965	24,992
1966	9,949

1 Rais Akhtar and A.T.A. Learmouth, "The Resurgence of Malaria in India, 1965-1976", Geojournal, vol. 1, no. 5, 1977, pp. 69-79.

1967	18,561
1968	31,794
1969	28,962
1970	11,388
1971	33,260
1972	51,226
1973	1,89,767
1974	2,97,701
1975	3,17,669
1976	32,92,052

In 1948, we find that a large part of south-western Orissa is hyper-endemic with regard to malaria. This includes the entire units of Jeypore, Rayagada, Bhawanipatna, Phulbani and large parts of eastern Bolangir, northern Sundargarh and northern Keonjhar. Surprisingly, the state also boasts of a malaria free area in north Gangam extending into eastern Bhanjanagar and West Puri. The rest of the state has endemic malaria. The hyper-endemic belt of western Orissa is a part of the larger core covering Central India. From 1951 to 1960 malaria was responsible for over 50 per cent of deaths resulting from all diseases in the state.[2]

In 1965 (map 4.2), Rayagada had an API rate of over 11 which was the only area in the country having such a high rate, with the exception of an area in Assam. Bhawanipatna, Phulbani

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2 Census of India, vol. XII, Orissa Part 1-B, Report on Vital Statistics and Fertility Survey, 1961.

and Sundargarh had an API of 3-5 while Jeypore had a value of 1-3. The rest of the state had an API value of <0.99.

In 1970 (map 4.4), there are six units which have no record of malaria incidence and ~~on the whole~~ incidence shows a fall in the state as a whole. In Rayagada unit there is a distinct decline in incidence from over 11 API to 1-4 API while the other units show an API of <0.99.

The 1976 API map (4.5) sharply brings out the phenomenal rise in incidence from 1970 to 1976. Within Orissa no units have an API of less than 3 and Puri and Jajpur are the 2 units with the lowest API rate between 3 and 5. Phulbani has the highest rate of 30-50 followed by Rayagada (20-30). From a comparison of the 4 years we find that Rayagada, Phulbani and Bhawanipatna have persistently had high incidence, over the years. Another point of interest is that 1970 was a year of low incidence for the whole state.

This broad analysis of the spatial patterns of incidence raises some questions, the answers to which can emerge only after a detailed indepth study which follows. In terms of transmission and chief vector species, Orissa can be divided into (1) the hilly areas of year round transmission with a peak in October-November and March-April with the chief vectors being A. fluviatilis, A. varuna and A. minimus; (2) the plains where transmission begins in July (with a peak in October) and ends in November with A. Annularis the chief vector and (3) the coastal areas where there is transmission throughout the year except June and A. Sundaicus is the chief

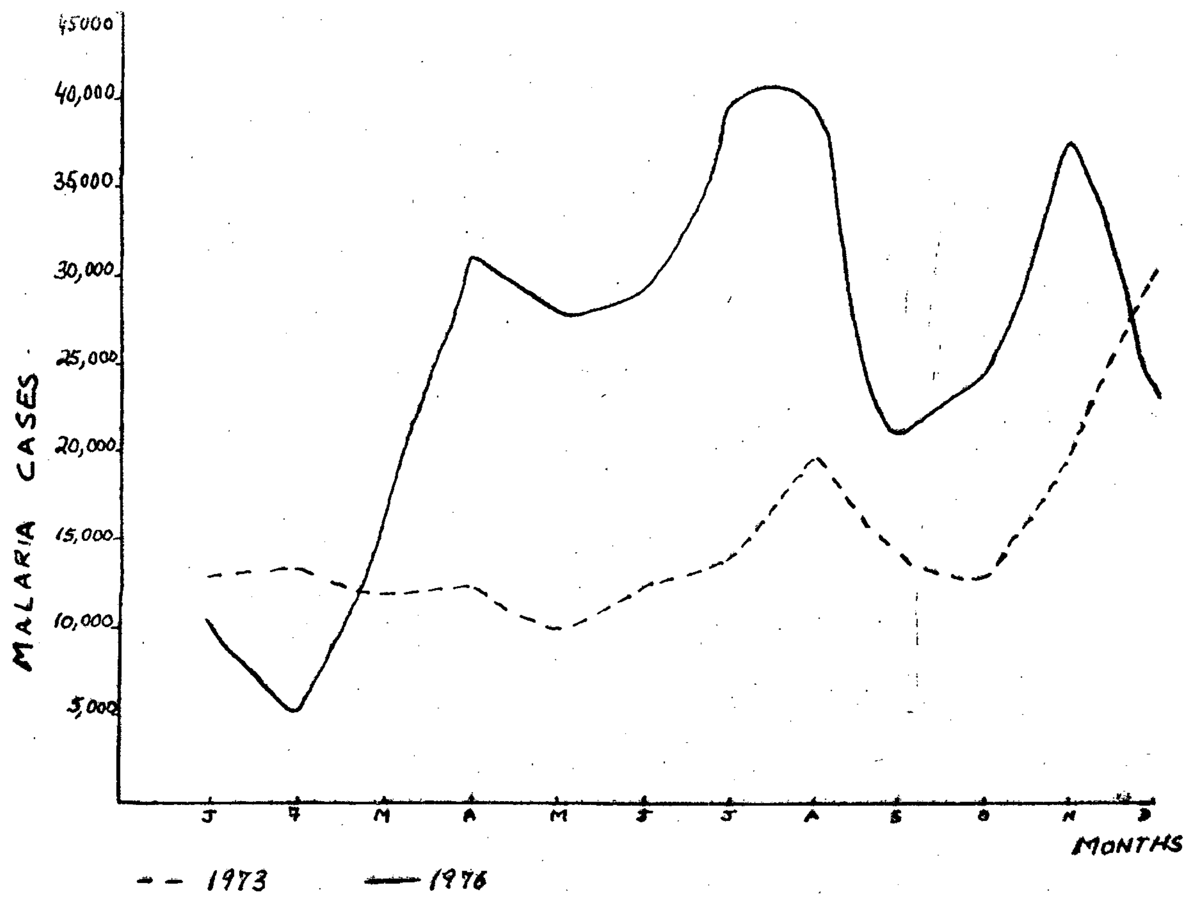

Fig. 6·1 ORISSA - MONTH WISE INCIDENCE

vector species.[3]

Besides identifying the spatial patterns of incidence, two other general aspects of malaria in Orissa have been studied. The first concerns the seasonal rythmn of malaria for Orissa as a whole while the second deals with the age-wise pattern of incidence at the unit level. Both these studies would provide a further insight into the understanding of malaria in Orissa.

6.2 Month-wise Incidence of Malaria in Orissa

The seasonal pattern of malaria incidence in the state is shown below for two time periods 1973 and 1976 (Fig. 6.1). One obvious fact that emerges from the graph is the sharp rise in number of cases between 1973 and 1976.

The graph for 1973 reveals that the peak incidence occurs in November-December while a smaller peak is to be found in August. In the other months there does not seem to be much changes. The peak of July-August is preceded by a month of lower incidence in May due to the dry conditions prevailing.

The graph for 1976 shows a marked variation from the 1973 one. It begins with a very low value for January-February rising till April, after which there is a slight fall preceding the peak of July-August. This post-monsoon peak is followed by a fall till September-October and then in November there is

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3 F.J. Dy, "Present Status of Malaria Control in Asia", WHO Bulletin, vol. II, 1954, pp. 725-63.

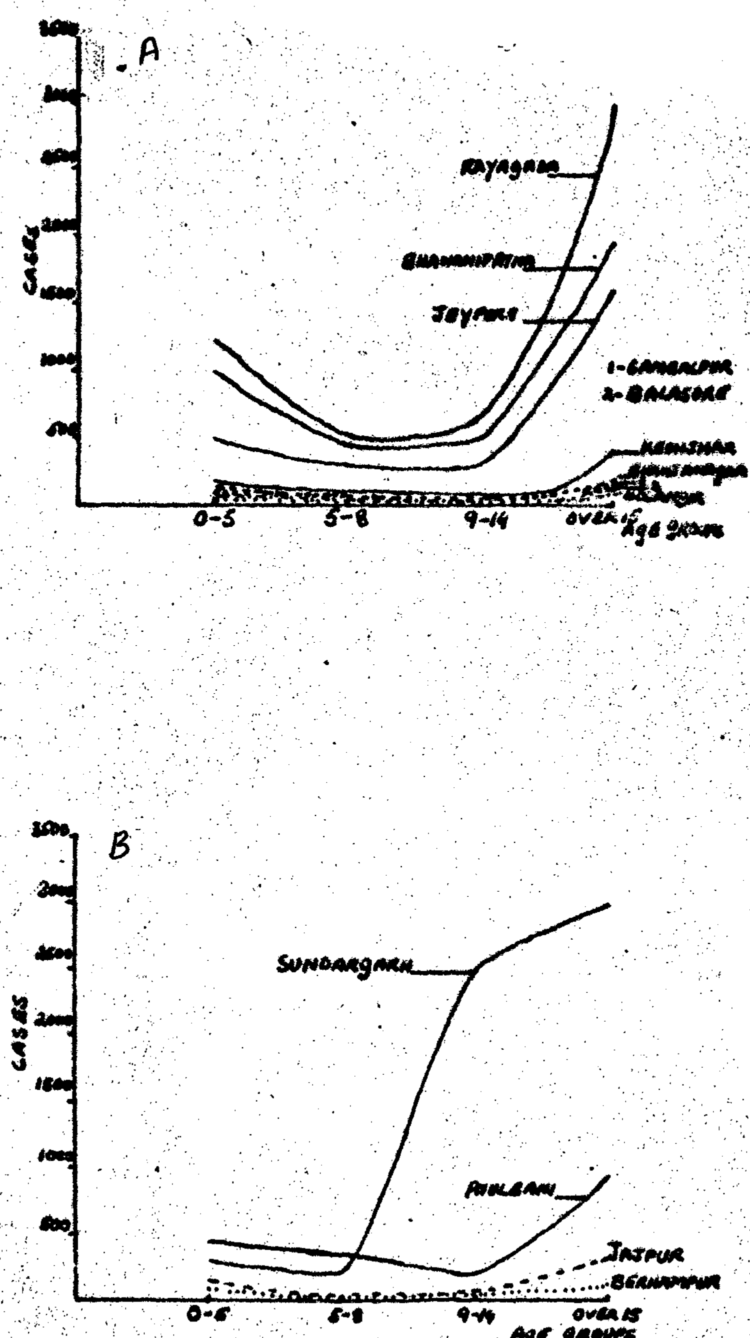


Fig. 6-2 SHOWING AGE-WISE INCIDENCE IN UNITS – 1965.

another peak. Unlike the 1973 graph in 1976 there are 2 major peaks with the July-August being more pronounced. The higher peak in November-December in 1973 can be explained by the higher winter rainfall during this year. The graph clearly brings out that the drier months are the low incidence months both in May-June and September-October and that the seasonal rythmn of incidence of malaria in Orissa is characterized by 3 peaks.

6.3 Age-wise Incidence in Orissa

A demographic aspect has been introduced to the study to determine whether there is any correlation between age and malaria. The age-wise incidence is plotted on a graph for two time periods of 1965 and 1974, 1965 was chosen as this was the year when the resurgence began and 1974 was the last year for which figures for age-wise incidence were available. The figures are available for each malaria unit for the following age groups - 0-5, 5-8, 9-14, and over 15, there being a break-up of the first group in 1974 to below 1 year and 1-4.

In 1965 (Fig. 6.2A&B), the broad pattern of the graphs is that incidence is nearly constant from 0-5 to 9-14 age group after which it rises sharply, which can be explained by the fact that the over 15 age group category covers a large number of years. Within this pattern one exception is Sundargarh which shows a steep rise in incidence from 5-8 to 9-14 age group with a more gradual rise in the over 15 group. All

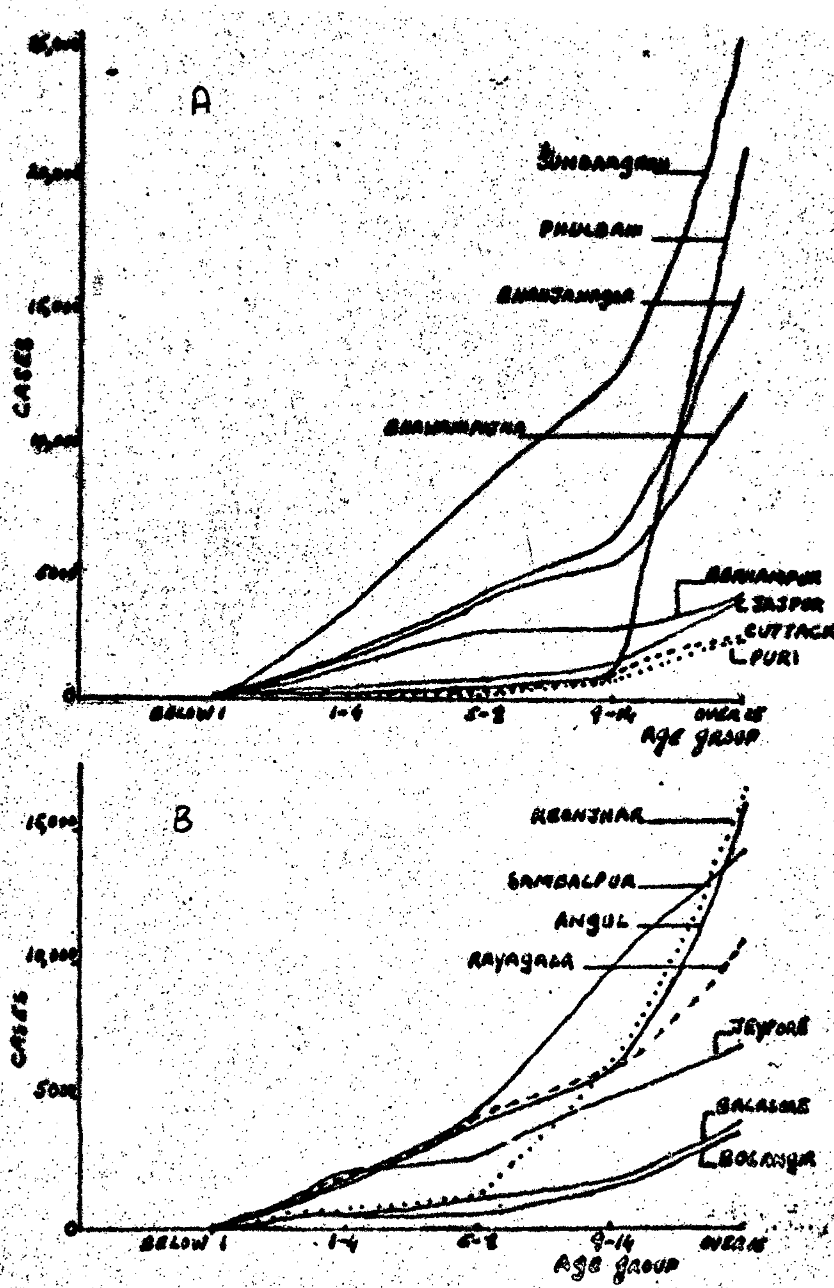


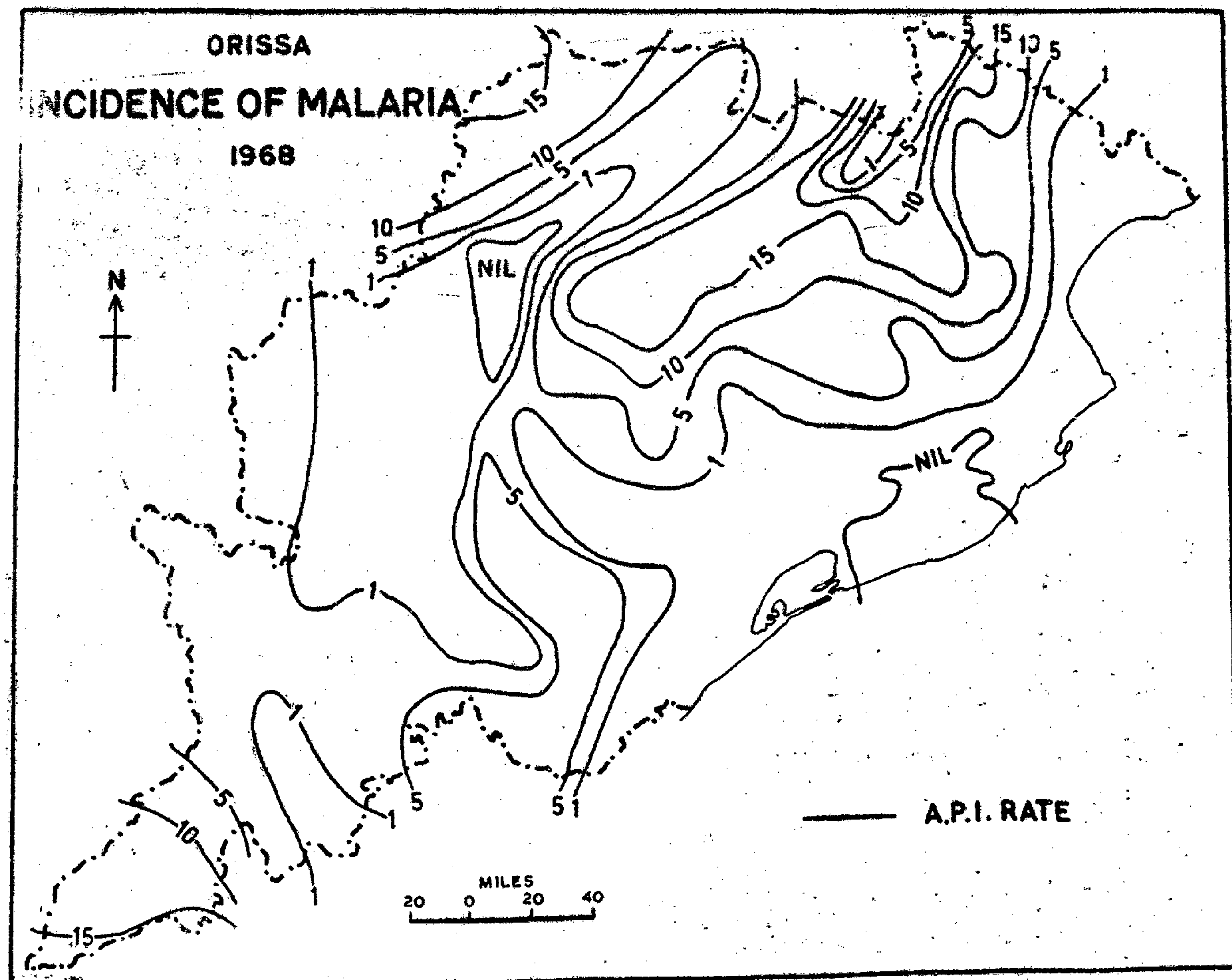
Fig. 6·3 SHOWING AGE-WISE INCIDENCE IN UNITS – 1974.

the coastal units along with Sambalpur, Keonjhar and Bolangir show a nearly constant incidence pattern for all age groups with a very gradual increase in the over 15 group. On the other hand Rayagada, Jeypore, Bhawanipatna and Phulbani units show a small rise in the 0-5 age group followed by a decline and then a steep increase in the over 15 group. This reveals that in these malarious units Malaria among infants is greater and also the incidence in the over 15 age group is much higher than in the other units. Rayagada shows highest incidence in the 0-5 and over 15 age groups.

In 1974 (Fig. 6.2A&B) the graphs clearly show the phenomenal rise in overall incidence in 1974. The occurrence of malaria is very low among the infants or the below 1 age group in all the units. But in 1974 there is a steady rise in incidence with each successive age group, the rise being steepest in the over 15 group. Balasore, Bolangir, Berhampur, Jeypore, Puri and Cuttack units reveal a low incidence pattern in all age groups with a gradual rise in the over 15 age group. In contrast to this, Sundargarh, Phulbani, Bhanjanagar, Bhawanipatna, Sambalpur, Angul, Keonjhar, Rayagada and Jeypore units show a higher incidence in all the age groups with a very steep rise in the over 15 age group. Highest incidence figures for all age-groups are recorded by Sundargarh unit. Phulbani unit has the steepest rise in incidence from the 9-14 to over 15 group. From the graphs it is evident that variations in age-wise incidence are sharpest in the interior units as compared to the coastal ones.

If the graphs for 1965 and 1974 are compared we find that age-wise variations in incidence have risen over the years being larger in 1974 than in 1965. Sundargarh unit reports high incidence and variation in both 1965 and 1974. Most of the other units also show a similar pattern in 1965 and 1974. In 1965, the rise in incidence in the over 15 category for Phulbani was not as steep as it was in 1974. Malaria among infants is low for most districts and incidence is highest for the over 15 age group. This age group consists of the work force of a population and the higher prevalence of malaria within this age group has serious economic considerations, involving loss of man hours and labour productivity. This rise in incidence in the over 15 age group could also be a reflection of the decrease in immunity against malaria among the higher age groups due to a fall in incidence till 1965. With resurgence the higher age groups are probably most affected as they interact maximum with the environment. This is only an assumption and one needs more detailed data (with the over 15 age group being further broken up into smaller categories) before any conclusions can be drawn.

After having introduced the broad patterns of incidence in the State, we begin our in-depth spatial study. This is aimed at analyzing the spatial pattern of incidence to see if any meaningful picture emerges. The study, at a section level for 1972-76 and a centre level for 1968, combines an analysis of the temporal changes by covering the three years of 1968-1972-1976. This three year data is reduced to maps (6.1, 6.2,


ORISSA
NCIDENCE OF MALARIA
1968
N
NIL
NIL
A.P.I. RATE
MILES
20 0 20 40

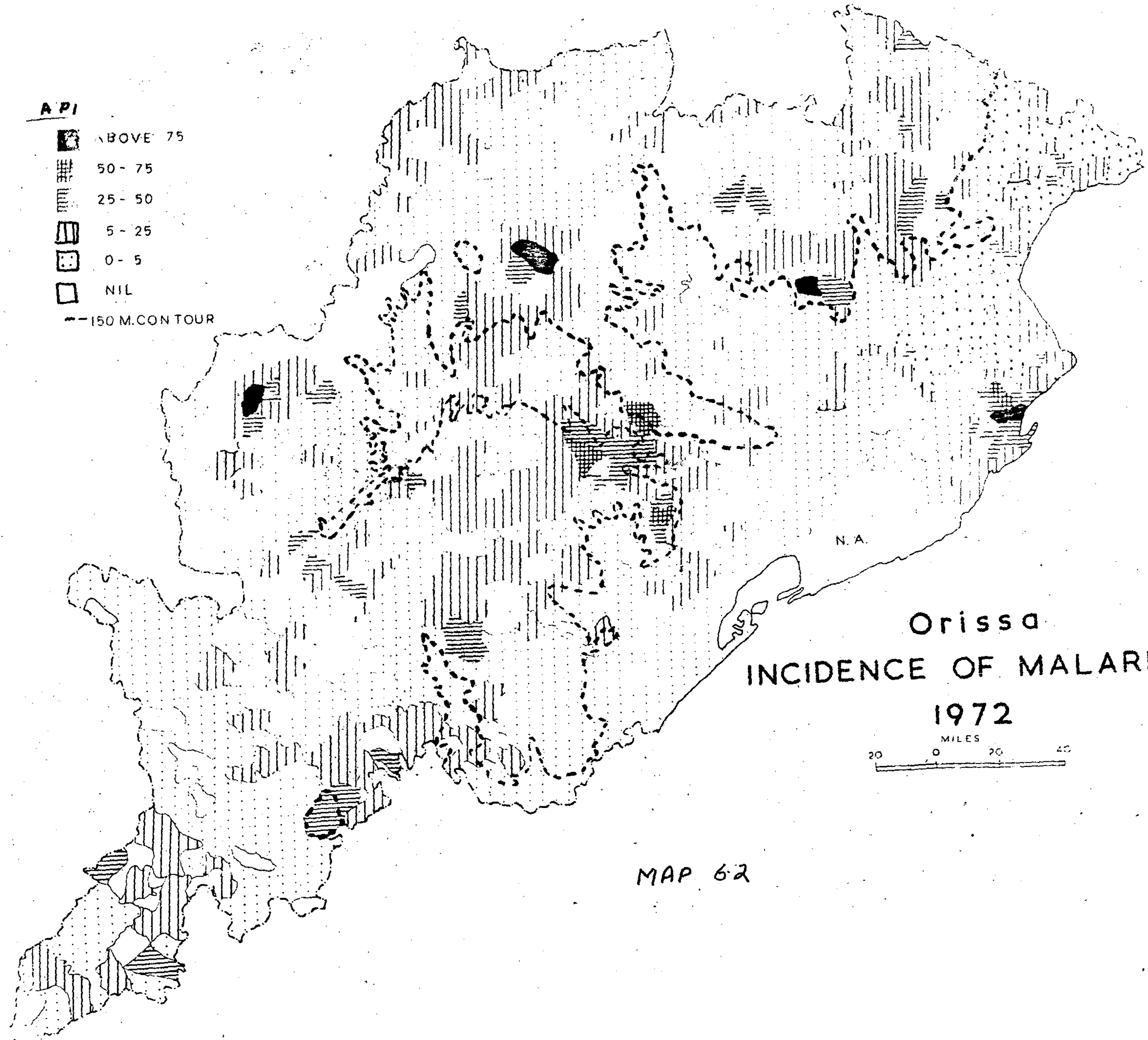
MAP 61

6.3). The reasons for taking these three years is based wholly on the availability of data for these specific years. The resurgence of malaria in India began from 1965 but detailed data was available only from 1968 and then only for 1972 and 1976 at the section level. The study was carried out for 1976 as data was not available for 1978 or 1977 and also because 1976 was the year recording highest incidence since the resurgence.

6.4 Incidence in 1968

For 1968, the incidence map (No. 6.1) is at a centre level and as the map of centre boundaries was not available, variations in incidence are shown through isolines.

The spatial picture as evident from this map is that the coastal plain areas of Balasore, Cuttack, Puri and Ganjam districts show a very low incidence below 5 API with many pockets of no incidence within them. The interior districts reveal a higher incidence rate. Highest API values of 28.8 are registered in Naktideul (in South Sambalpur) followed by Thakurmunda in South Mayurbhanj which has a rate of 19.7. Barkote in East Sambalpur with 15.8; Lephripara in West Sundargarh with 15.8, Bangriposi in North Mayurbhanj with 14.5; Kalimela in South Koraput with 14.5; Berhampur in West Balasore with 12.7; Riamal in South Sambalpur with 11; Pallahara in North West Dhenkanal with 10.6 and Harichandanpur in South Keonjhar with 10.4 are the centres with a API rate above 10. The areas of high incidence are South Koraput, a



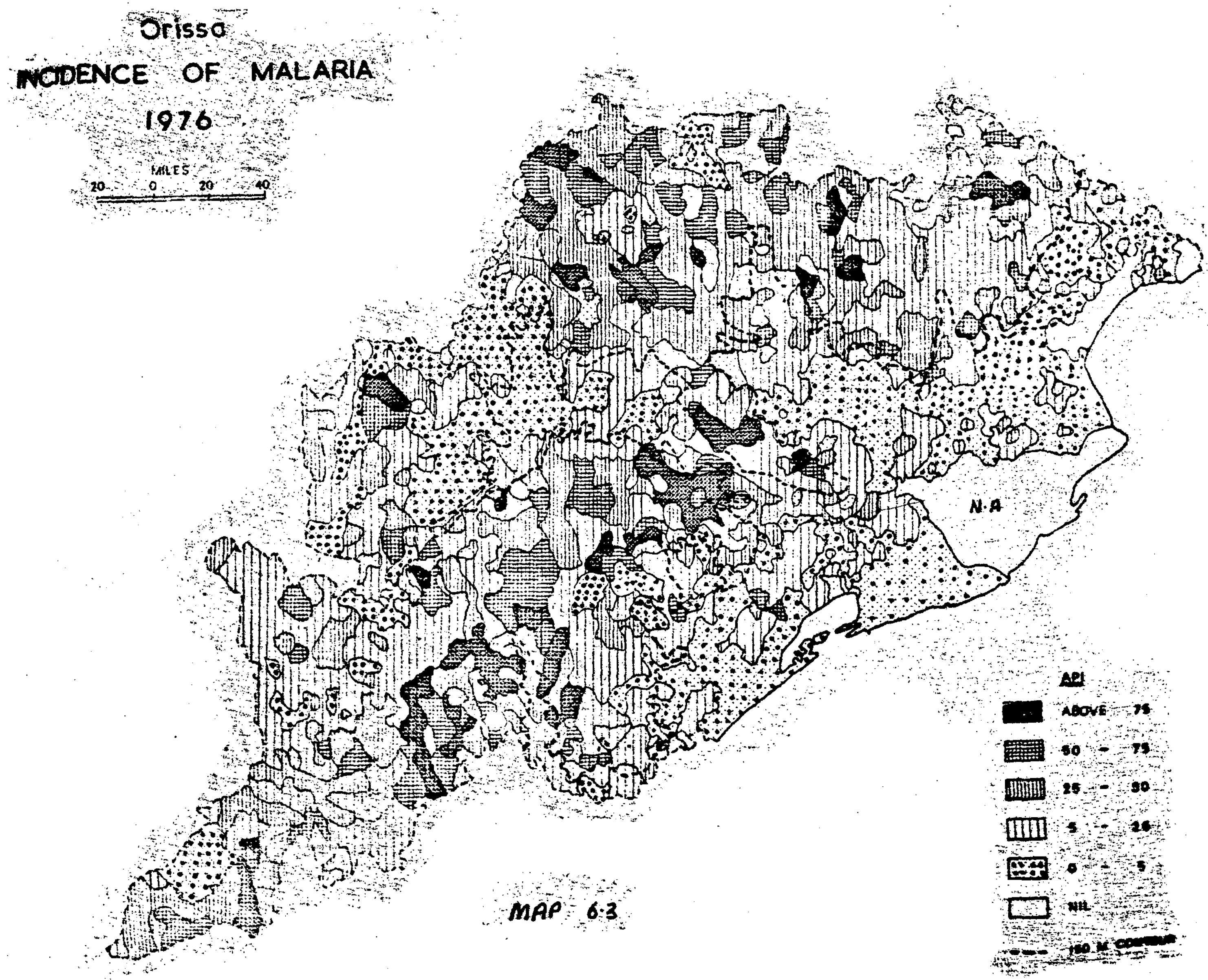
Orissa
INCIDENCE OF MALARIA
1972

MAP 6.2

large area comprising of South East Sambalpur and North Dhenkanal, South East Keonjhar and South West Mayurbhanj and North Mayurbhanj. From among all the districts Mayurbhanj has the highest incidence. In the intermediate level of incidence (5 to 10 API) lie Phulbani, Dhenkanal, Kalahandi districts and large parts of Rayagada, Jeypore centres, Bolangir and Sambalpur districts. The coastal areas are the low incidence areas with two pockets of high malaria in West Balasore and West Ganjam corresponding to the hillier parts of the two districts.

6.5 Incidence in 1972

The incidence picture in 1972 is very different from that in 1968. The map for 1972 (No.6·21) reveals an increase in incidence for the state as a whole. But, the coastal areas are still areas of low incidence below 10 API as also are the northern, western and southern peripheries of the state. It is the interior tract of Orissa that is the area of high incidence above 50 API. This area of high malaria is in the form of a belt running through the heart of the country from north-east to South-west. The reasons for the existence of this belt are a combination of relief, slope, climate and vegetation which are discussed in detail in the next chapter. This high incidence zone covers southern and north-eastern Koraput, North West Bolangir, South West Sambalpur and Jujomara in central Sambalpur, a large contiguous area in North Phulbani - South Dhenkanal - North West Puri, South Keonjhar, South Mayurbhanj and another small pocket in Cuttack


Orissa
INCIDENCE OF MALARIA
1976
MILES
20 0 20 40
N·A
API
ABOVE 75
50 - 75
25 - 50
5 - 25
0 - 5
NIL

MAP 6·3

around the Mahanadi delta. The reasons for these high malaria levels emerge when these areas are examined against the existing environmental conditions as is attempted in the next chapter. The highest API rate registered is 131 in South Keonjhar which is much higher than the figure in 1968. There are 13 sections recording an API rate of over 50.

6.6 Incidence in 1976

The map for 1976 (No. 6.3) clearly brings out the sharp rise in incidence from 1972 to 1976. The class groups for the two years of 1972 and 1976 are kept the same to facilitate comparison. The emerging picture for 1976 is that, once again, the coastal areas are areas of lower incidence below 25 API which include Balasore, Cuttack, coastal Puri and coastal Ganjam districts, a large part of eastern Dhenkanal. Besides the coastal plains, other areas of low incidence are a large part of Bolangir and South West Sambalpur district. Medium level incidence (25 to 50 API) was found in Northwest Koraput, North and West Kalahandi and a contiguous area comprising East Keonjhar and West Mayurbhanj. The areas under high incidence above 50 API have expanded their spatial coverage in 1976. These areas recording a very high incidence are South and East Koraput extending into Southwest Ganjam and Southwest Phulbani; central Sambalpur; Northwest Bolangir and, Southwest Sambalpur; Southwest Sundargarh; Northwest Keonjhar and central Mayurbhanj. Sundargarh, Sambalpur and Phulbani districts may be labelled highly malarious as large parts of them have high incidence. The eastern and western peripheral zones of the state have a much lower API rate as compared to the intensely malarious interior. The high incidence belt extends from Koraput in the South through Phulbani to Sambalpur and Sundargarh in the north with an offshoot towards Keonjhar and Mayurbhanj.

The reasons for the spatial pattern being what it is are not easy to seek as they depend on multiple factors. The identification of these factors and their role in terms of incidence would be the aim of the next chapter.

6.7 A Comparison Between the Incidence in 1968-1972-1976

The most important temporal change that emerges from a glance at the three incidence maps is the sharp rise in malaria from 1968 to 1976. While most of the state had an API rate of below 10 in 1968 in 1976 a large part of Orissa (40 sections)* had an API rate of over 100. The rise in incidence from 1968 to 1972 though very obvious was not as marked and sharp as that between 1972 and 1976. This shows that the increase in incidence is greater in 1976 than in 1972. Besides the total increase in numbers, there has also been a spatial expansion of high incidence areas over the years. In 1968, areas of high incidence were few with the highest API being only 28.8, in 1972, the areas of high incidence

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* The break-up of the 40 sections having an API of over 100 is 15 in Koraput; 8 in Puri; 5 in Sambalpur; 3 in Mayurbhanj; 2 each in Bolangir, Phulbani, Sundargarh and Dhenkanal and one in Ganjam.

increased with the highest API rate being 100. In 1976, the highest API rate was 398 (in North West Puri) and the spatial coverage of areas with an API of above 50 has risen. The maps hence clearly focus on the spatial spread of malaria through an increase in the high and medium incidence areas.

The spatial pattern of incidence has not undergone much change over the years. The areas of low and high incidence have by and large remained the same with only some expansion and reduction over the years. In 1968, the coastal plains were the areas of very low and no incidence and this was true of 1972 and 1976. Though the incidence over the years had risen in the low incidence region yet the coastal plains remained areas of low incidence for the three time periods. The spatial extent of this low incidence zone has reduced a little from 1968 to 1976 but by and large the coastal tracts retained their low incidence character. Similarly, the interior belt of Orissa running Northeast to Southwest has persisted as an area of high malaria over the years. Within this belt API rates have sharply risen from 1968 to 1976 but in each of the 3 year periods, this interior belt was an area of high incidence. The spatial extent of this belt has grown from 1968 to 1976 and it roughly extends from Koraput in the South to Mayurbhanj in the north being broader in the North and narrowing down in the South. A comparison of the three maps hence shows a consistency in the persistence of the broad spatial patterns of incidence in 1968, 1972 and 1976.

ORISSA

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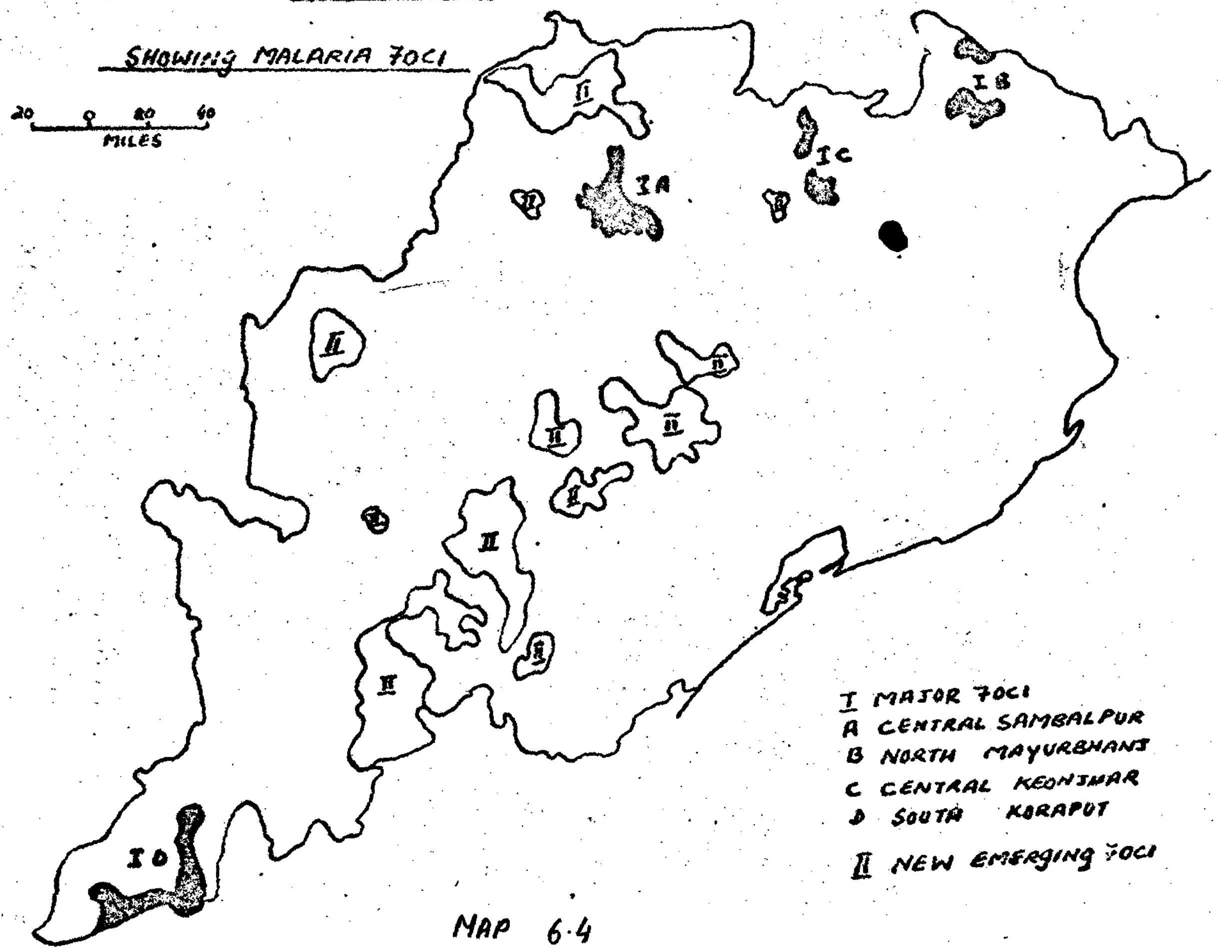

MAP 6.4

6.8 Identification of Cores

One of the aims of a spatial and temporal comparison of the three incidence maps is to try and identify certain areas where a high incidence of malaria has persisted over the years. These stable areas of continuing high API rates of over 75 API are the endemic cores serving as malaria foci from where the spatial diffusion of the disease occurs (Map No. 6.4).

High incidence areas which were present in 1968 and persisted in 1972 as cores were: (1) in Koraput district around Lakshmipur and in the extreme Southeast near Gunupur; (2) in Sambalpur district North of Naktideul; (3) in Keonjhar district, one North of Keonjhar and one South of Harichandanpur and (4) in Mayurbhanj district in the North near Bisoi and one South of Bisoi and a big core east of Thakurmunda. Other areas of high incidence in 1972 but which had low incidence in 1968 are - around Bhawanipatna in Kalahandi district, in North West Bolangir; around Hirakud, in Sambalpur; a contiguous area in extreme northeast of Phulbani and extending into West Dhenkanal and a small pocket South of Daspalla in Puri district.

Areas which have persisted in having high API rates through 1968, 1972 and 1976 are singled out as endemic cores in this study. From a study of the 3 maps four endemic cores have been identified. These four cores are the first Jamankira in central Sambalpur, South Koraput, South central Keonjhar and North Mayurbhanj. Of these the first core is the most crucial as it has had very high API rates in 1968, 1972 and 1976.

Other cores that are pockets of high incidence in 1972 and 1976 are in (1) North West Bolangir; (2) around Hirakud; (3) North Phulbani; (4) South Dhenkanal; (5) central Keonjhar; (6) South West Ganjam; (7) North East Koraput; (8) around Bhawanipatna and (9) Central Mayurbhanj. These 9 cores are of recent emergence between 1972 and 1976 but are of vital importance as in 1976 we find that a spatial expansion of cores occurs instead of the earlier pattern of small scattered pockets. This is especially true of 2 large areas which have developed as foci, namely (1) North East Koraput - South West Ganjam - South West Phulbani and another (2) North East Phulbani - West Puri - South West Dhenkanal. The growing spatial spread of these two large cores poses a threat of malaria that needs to be checked.

It is interesting to note that while on the one hand we find the number and spatial coverage of cores growing in 1976 there are certain districts with an absence of cores, viz. Kalahandi, Balasore, Cuttack and Puri districts are free of any notable malaria foci. While the explanation for this is the fact that the last three districts are the coastal districts of low incidence the reasons for Kalahandi district having a low incidence and only a small core are not easy to find. ~~and~~ ~~(ii)~~ Another interesting fact that needs further study is the sharp rise in incidence over most of Sundargarh district in 1976 especially the western part which has registered very high API rates in 1976, after being a district of fairly low incidence till 1972.

What are the reasons for this phenomanal rise in Sundargarh? Why is interior Orissa so malarious? Why have certain pockets persisted as foci? Why is western Orissa - North West Koraput and Western Kalahandi an area of lower incidence? Do certain geographical factors favour malaria? These are some crucial questions the answers to which are sought in the next chapter.

Chapter VII

CORRELATION OF INCIDENCE WITH SPECIFIC ENVIRONMENTAL AND HUMAN FACTORS

Chapter VII

CORRELATION OF INCIDENCE WITH SPECIFIC ENVIRONMENTAL AND HUMAN FACTORS

The purpose of this chapter is to identify possible correlations between the pattern of incidence and certain selected variables. The choice of variables is based on the fact that (1) data for them was available to some detailed level and also (2) the fact that other research indicates that malaria may be dependent on these variables.[1] It is on the findings of this chapter that certain relationships may be established and generalizations drawn.

7.1 Pattern of Incidence and Relief

Relief forms an important environmental factor affecting malaria as it includes altitude, drainage and slope of the land, all three being of considerable influence on the pattern of incidence.[2] A greater emphasis is laid on altitude as malaria is greatly dependent on it the high mountainous areas of over 5,000 feet being malaria free.

The relief map (5.1) has to be correlated with the pattern of incidence for each of the 3 years of 1968, 1972 and 1976. For 1968, the correlation reveals that the plains or areas below 150 metre contour are areas of low malaria, while it is in the hilly tracts that higher incidence of malaria is

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1 P. Hehir, _Malaria in India_, London, 1935.

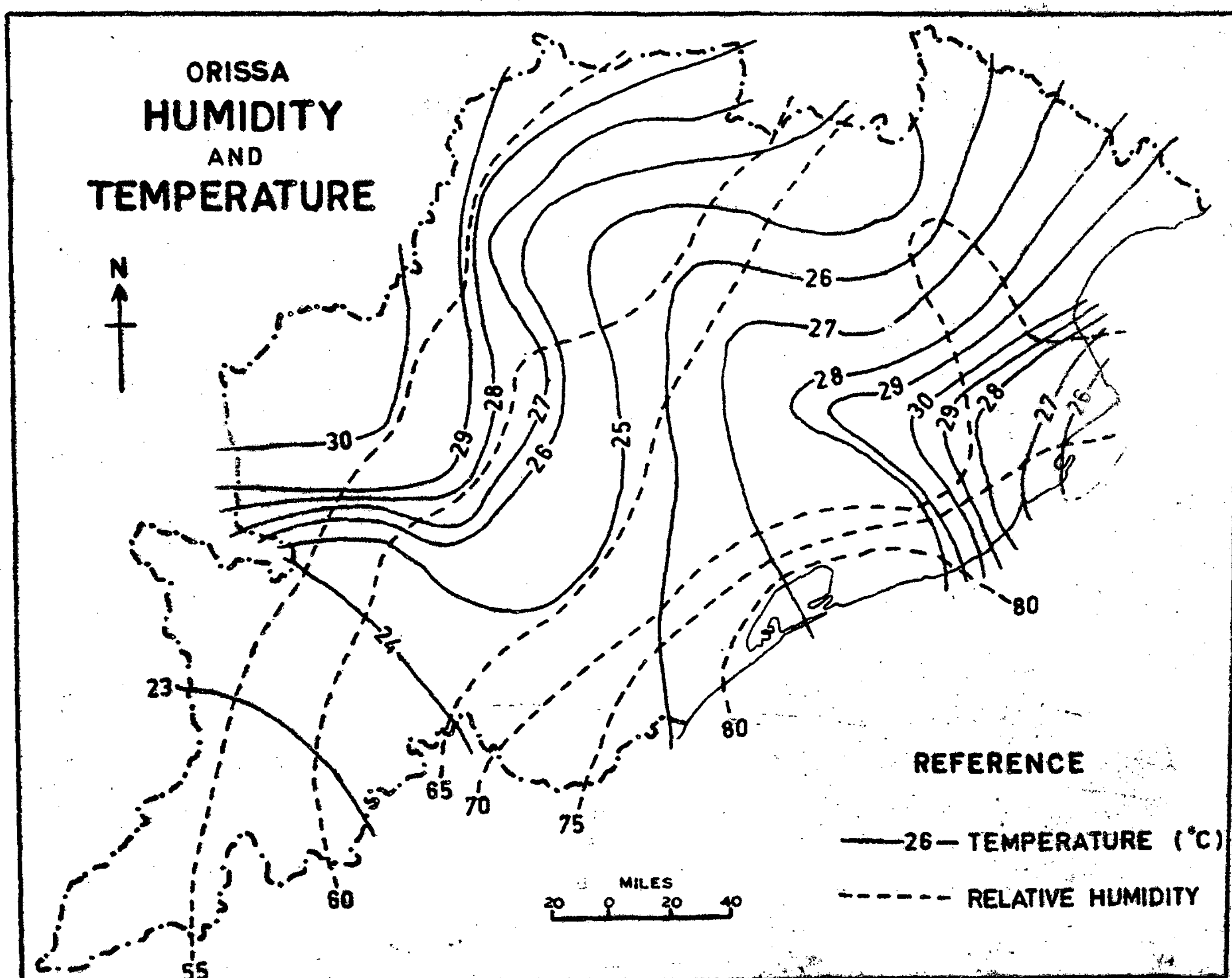
2 H.O.T. Iyengar, "Topography of Land in Relation to Malaria", in _Symposium on the Malaria Problems in India_, 1938, pp. 181-4.

found. The entire interior belt of hill country also records higher incidence, especially in South East Koraput, North East Koraput, Central and Eastern Sambalpur, South Keonjhar and Central Mayurbhanj. All these areas mentioned are hilly areas mainly between 300 and 600 metres and going up to 900m in Mayurbhanj and Koraput. Areas above 900m are small and are hence, not as conspicuous as malaria free regions. In 1968, there seems to be a strong correlation between relief in terms of altitude and malaria.

In 1972, the 150 metre contour envelops areas of low incidence, in other words, the plains are the areas, where incidence is low. The high and a large part of the medium incidence areas lie above this contour and one can state that malaria is confined mainly to elevations above 150m. The only exception being a pocket of high incidence in the Mahanadi delta, which may be explained by its swampy and poor drainage character. The four coastal districts of Balasore, Cuttack, Puri and Ganjam are largely areas of low incidence and low relief as also, a large part of East Dhenkanal. While Koraput is largely a district of high relief in 1972, it has a low malaria incidence except in South and North East Koraput, where the high relief and high malaria are coterminous. The hilly terrain of North East Phulbani - South West Dhenkanal - West Puri records a high incidence in 1972. This is an area of a series of small hills and plateaus ranging between 300 and 600 metres. While the other high incidence areas of South Keonjhar and Central Mayurbhanj are also areas of high relief(300-900metres). There are two pockets of high incidence in Central Sambalpur and North-West Bolangir, which correspond to areas of intermediate relief of 300-600 metres. Areas in Kalahandi and Koraput of over 900m have a low incidence. The correlation pattern that emerges in 1972 is that in the areas below 150 metres malaria is less prevalent; while above 900 metres, it is also less met with. The peak malarious areas are those lying within 300-600 metres. One notable exception to this is North-West Koraput, a plateau area lying between 300 and 600m but which records a low incidence. A possible explanation for this would be the success at reducing malaria of the Dandakaranya project - North-West Koraput forming a part of this project.

Though, the intensity and spatial spread of incidence has risen markedly in 1976 yet one interesting fact remains the same between 1968-72 and 1976. This is the fact that the 150m contour, again, encompasses those areas of comparative low incidence in 1976. The low-lying plains record the lowest API values for the year except for a few pockets. Considering the phenomenal rate of increase of incidence, it is surprising that the plains were least affected, though, compared to 1972, even the plains have registered an increase in incidence. The very hilly tracts of above 900m in South Koraput and Kalahandi, again, remain areas of low incidence. The picture that exists in 1976 also points to the fact that the very high to high incidence areas are of intermediate relief, between 300 and 600 metres being the peak malarious tracts. The intensely malarious interior belt from South-East Koraput - North-East Koraput - South Western Ganjam - Phulbani - West Puri - West Dhenkanal-central Sambalpur - West and East Sundargarh - South and West Keonjhar and central Mayurbhanj is the area lying between 300 and 600 metres. This high incidence belt stretches Northeast-Southwest and is broken in small pockets by the river valleys. This middle hilly country is also characterized by steep rise in elevations except in Sundargarh and North Sambalpur, where there is a gradual rise.

The Mahanadi valley plays the role of a huge tongue penetrating into the interior from West-East and in this way, extending the low incidence tracts in the interior. The other rivers of the State are also responsible for their surrounding plains having a lower incidence than the other parts of the State. The high incidence areas are mainly the dissected plateaus of the Eastern ghats, while the higher peaks in the ghats are areas of low occurrence of malaria. Altitudes are not so high in the State to mark out any area as malaria-free. In 1976, a year of very high incidence, the picture revealed is that the Eastern and Western parts of the State record a lower incidence that the other parts of the State. If this is examined with reference to the relief map, it is found that the Eastern districts and the Western part of Orissa are areas of low relief. While the Eastern part consists of the low-lying plains, the Western part also is characterized by fairly low relief in South Sambalpur,



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80
REFERENCE
26 TEMPERATURE (°C)
RELATIVE HUMIDITY
MILES
20 0 20 40

MAP 7.1

Bolangir, Kalahandi and North-West Koraput with a gradual rise in elevation except for North-West Kalahandi.

The four major malaria foci are found between 300 and 600 metres with the exception of Lakshmipur in North Koraput where elevations are over 600 but below 900 metres. The nature of topography in these core areas is that of undulating plateau surfaces. These four major foci are not along any important river but their gradual slope and undulating topography may lead to water stagnation.

7.2 Pattern of Incidence and Climate

Climate is the second important environmental factor to be correlated with incidence of malaria ~~(map 6)~~. The three important components of climate chosen for this study are temperature, rainfall and relative humidity as each of these plays an important role in influencing malaria.[3] Data for temperature and relative humidity is available at a station level and enables a spatial comparison, while that for rainfall is available only at a district level.

The relation between temperature and relative humidity and malaria in 1968 is not very clear. The temperatures isotherms reveal lower temperatures towards the coast, then, higher temperatures away from the coast, then decreasing as one goes further inland and in the heart of the State, again, showing an increasing trend towards further inland (map 7.1).

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3 P. Herir, op. cit.

The temperature ranges from 30°C to 25°C. The temperature map shows that lower temperatures prevail in the interior part of Orissa which has lower temperatures from Koraput in the South to Keonjhar-Mayurbhanj in the North with temperatures rising away from this interior belt. North Orissa has much higher temperatures in Sundargarh and Sambalpur than South Orissa. When this temperature pattern is superimposed upon the incidence map for 1968, certain interesting facts come to light. The central-interior belt of high incidence largely corresponds to the trough of low temperature in the State. The only exception being Sundargarh, where high incidence and high temperatures are met with. At this point, it must be stated that Orissa, as a whole, experiences hot weather throughout the State and the low temperatures mentioned are only in terms of spatial variation. The coastal districts of high temperatures have low incidence as also Bolangir, Kalahandi and Western Sambalpur. The zone of high incidence lies between the 25°C and 27°C isotherms the only exception being South Koraput, where high incidence occurs between 23°C and 25°C.

The picture of relative humidity (RH) shows a decrease from the coast to the interior. The highest RH values of 80 per cent are recorded around the Chilka Lake area, while in Western Orissa, the values fall to 55 per cent. If this is compared with the incidence picture of 1968, we find that high humidity does not play as important a role in affecting malaria in Orissa, while humidity below 55 per cent also does not favour malaria. It is in areas having humidity between 55 per cent and 70 per cent that the malarious areas exist with 65 per cent RH being the optimal humidity value favouring malaria.

But as already stated, the 1968 picture of correlation is not very clear and any generalizations made would depend upon the correlation in 1972 and 1976, where detailed incidence data is available.

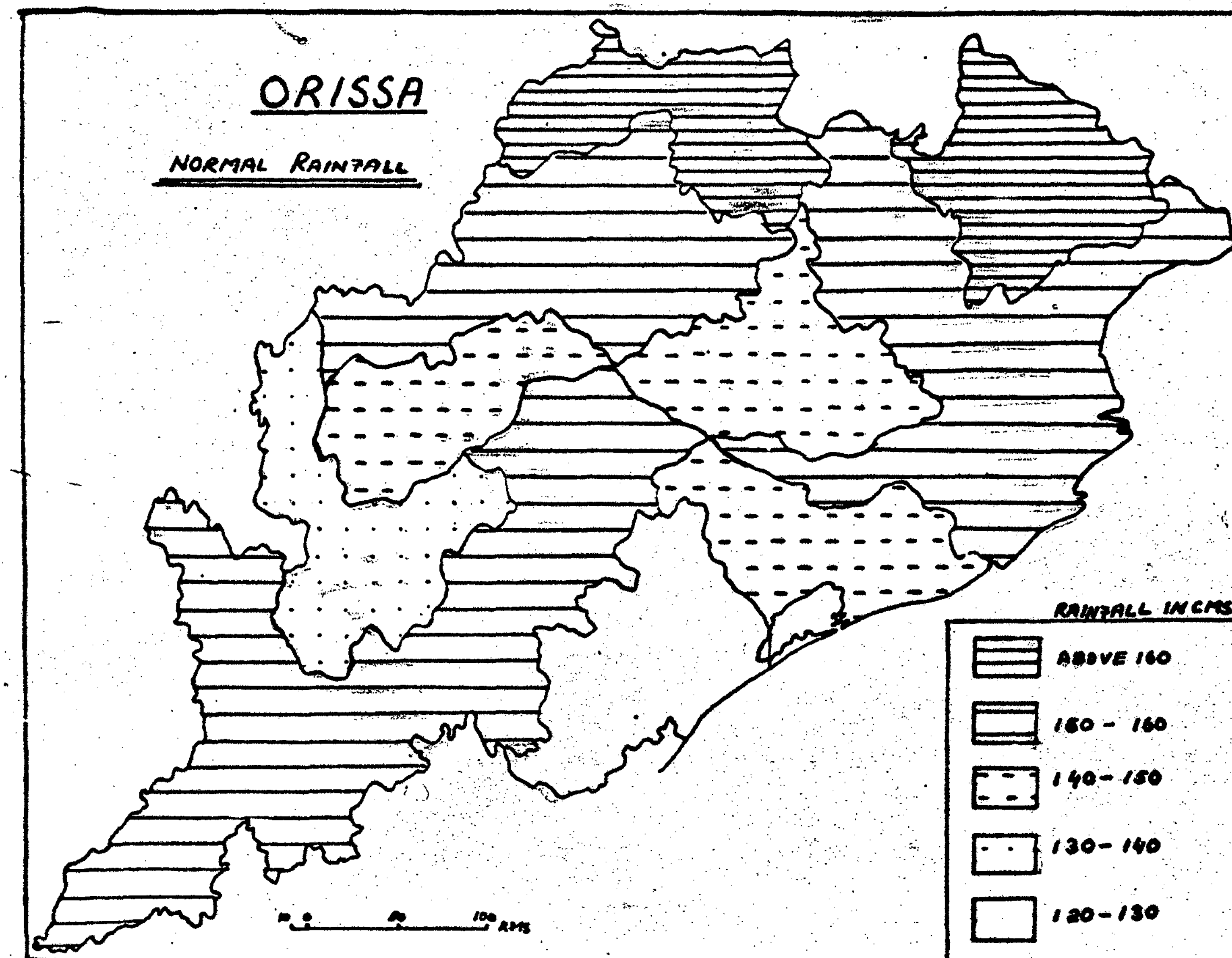
In 1972, the picture depicted in 1968, changes somewhat, though, the essential characteristics remain the same The high temperature interior zone, again, remains an area of high incidence, while away from this zone both temperatures and incidence rates decline. The highest incidence rates occur between 25°C and 27°C. One exception is Koraput, where low incidence is met with low temperatures. The high temperature areas of above 27°C are, by and large, areas of lower incidence comprising the coastal districts, Dhenkanal, Bolangir, Kalahandi and large parts of Sundargarh and Sambalpur districts.

In 1972, high humidity (70-80 per cent) coastal districts record a lower incidence of malaria except for a small pocket of high incidence in the Mahanadi delta region. The areas with humidity below 60 per cent reveal a pattern of lower incidence in West Koraput, Kalahandi, Bolangir and large parts of Sundargarh and Sambalpur districts. The areas of higher incidence are found between 65 per cent and 70 per cent humidity isolines.

1976 is marked by a steep rise in incidence as revealed in the map. The essential picture remains the same as in 1972. The central low temperature zone corresponds to the high incidence zone this time extending from South Koraput to Sundargarh with an extension in West Keonjhar and central Mayurbhanj. This zone of high incidence has expanded spatially and now, areas bordering the low temperature trough also report higher incidence. The higher temperature coastal districts, Bolangir, and Dhenkanal still have a lower incidence from the rest of the State. Certain exceptions to this picture are West Koraput, which has lower temperatures and a low incidence and Western parts of Sambalpur and Sundargarh districts, which have higher temperatures and high incidence. 25°C-27°C temperature zone envelops the areas of high incidence with high incidence occurring at 23°C in Koraput only.

The areas of high humidity of over 70 per cent are the coastal districts that show low incidence. On the other hand, Western Orissa with a humidity of below 55 per cent in West Koraput, Kalahandi and Bolangir districts also records a lower incidence. The interior area of high incidence corresponds to the region of humidity between 60 per cent and 70 per cent.

From a comparison of the results of the three years obtained through a correlation between climate and incidence, certain important factors come to light. The first is that malaria in Orissa is not confined to the hottest parts of the



ORISSA
NORMAL RAINFALL
RAINFALL IN CMS
ABOVE 160
150 - 160
140 - 150
130 - 140
120 - 130
10 0 50 100 KMS

MAP 7.2

State rather the malarious areas are found mainly between 25°C and 27°C temperature in the interior of the State. The second important fact is that a very high RH does not correspond to a high incidence of malaria instead, RH values between 60 per cent and 70 per cent cover the areas of high incidence. On the other hand, with a fall in humidity to below 60 per cent, there results a decline in the incidence of malaria.

As the rainfall figures are available only for districts, a spatial comparison between it and the incidence of malaria is not as meaningful. Nonetheless, an attempt is made to broadly study the rainfall incidence patterns. The highest rainfall districts are Mayurbhanj, then, Sundargarh, Phulbani and Balasore. Ganjam records the lowest rainfall followed by Kalahandi, Dhenkanal, Bolangir and Puri. Broadly, it may be stated that the higher rainfall districts also reveal a higher incidence pattern, while the lower rainfall districts have a low pattern of incidence. The high incidence districts of Mayurbhanj, Keonjhar, Koraput, Phulbani, Sambalpur and Sundargarh are also the districts of higher rainfall, being hillier. For a more meaningful correlation to emerge between rainfall and incidence, detailed data on rainfall is needed.

7.3 Seasonal Pattern of Climate and Incidence

The seasonal pattern of incidence is compared with monthly rainfall, temperature and humidity (30 year average

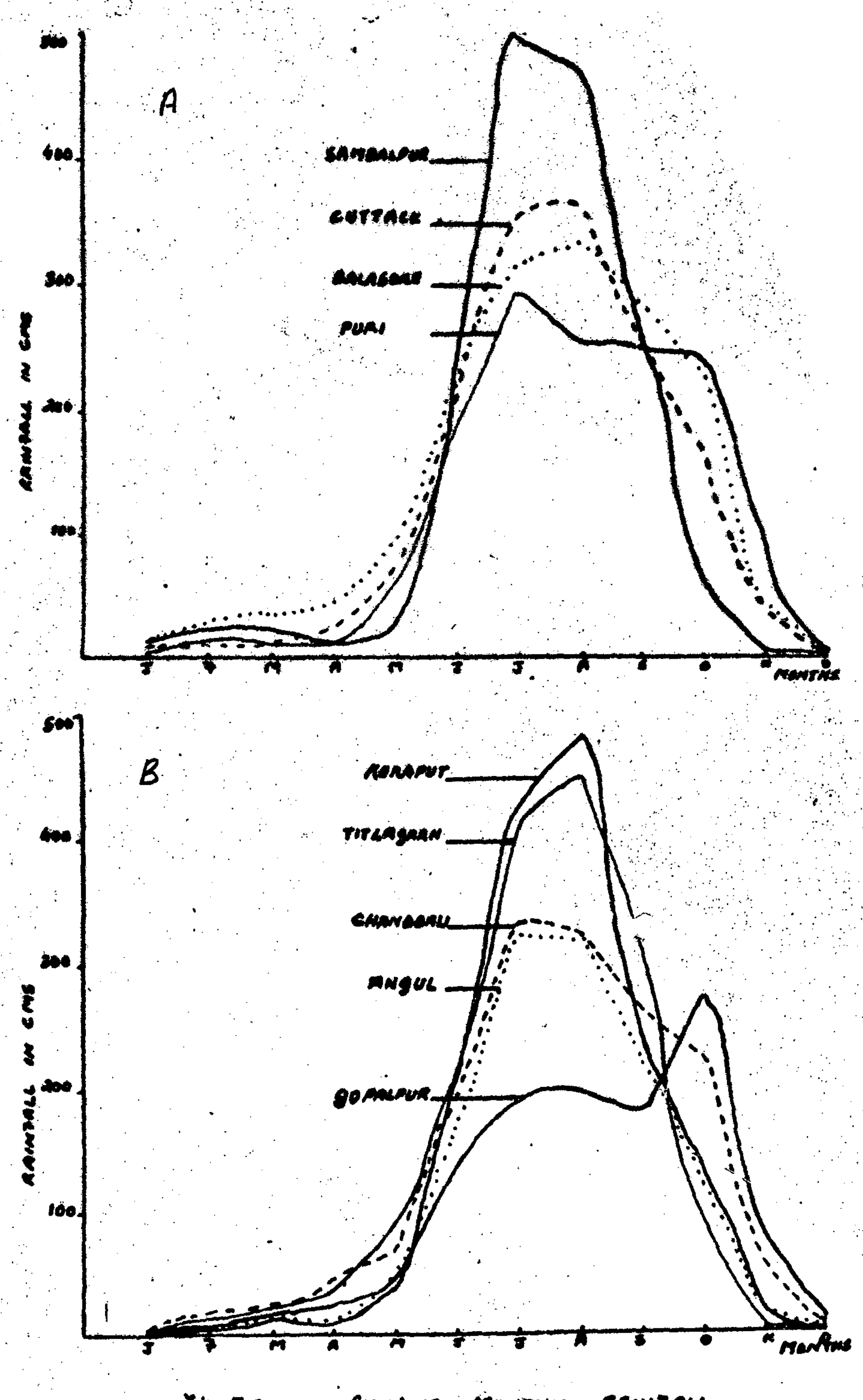


Fig. 7.2 SHOWING MONTHLY RAINFALL

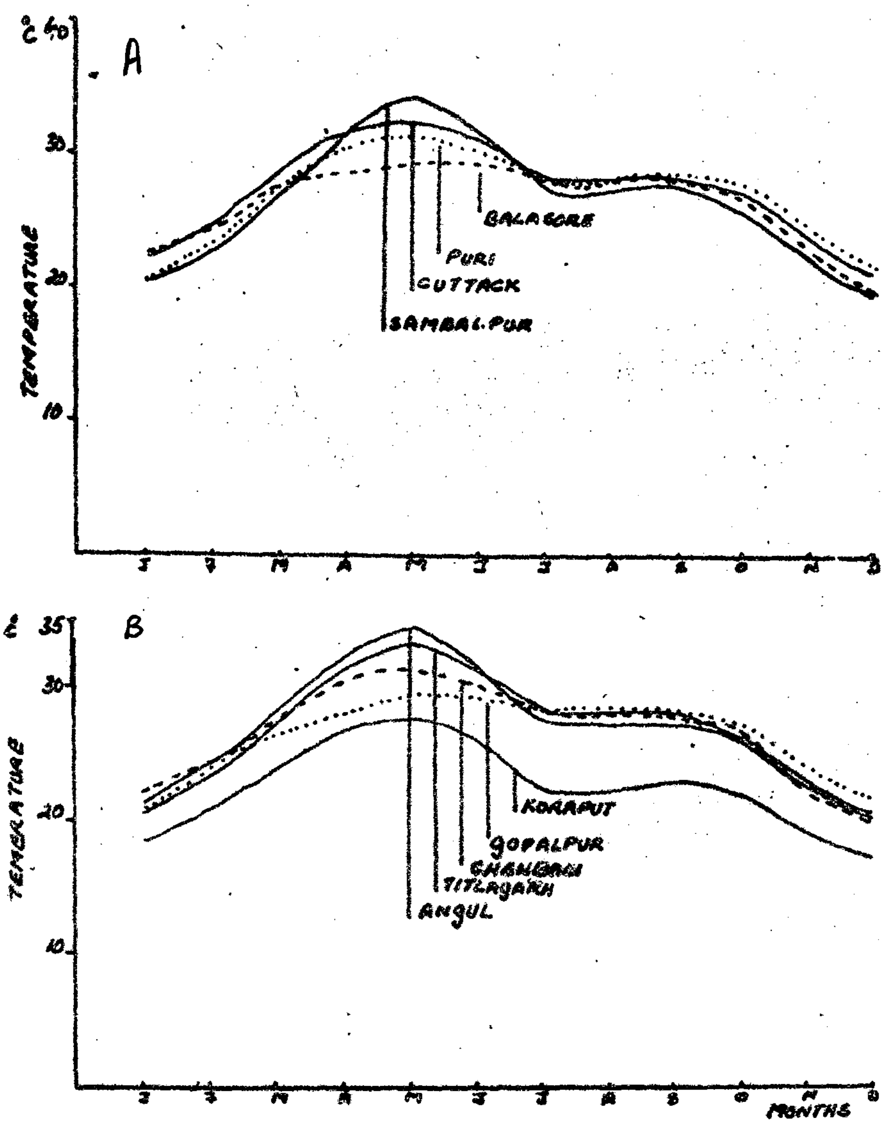


Fig. 7.1 SHOWING MONTH-WISE TEMPERATURE

data) to see if any correlation emerges. The monthly temperature for the different observatories is plotted on a graph (Fig. 7.1A&B). The temperature pattern shows a general rise from January to May the month of highest temperature for all the observatories. There is a fall in temperature from May to July with nearly constant temperatures till December. This trend is found in all the stations with Koraput recording lowest temperature values and Titlagarh having highest values and there being not much variation among the other stations.

The monthly rainfall graphs (Fig. 7.2A&B) for the stations show that rainfall is lowest in December-January rising till July-August and then, falling steeply to December. The stations of Gopalpur and Puri record a smaller peak in October but for all the stations, the peak rainfall is in July-August. Highest rainfall is found in Sambalpur, followed by Koraput and Titlagarh. There is not much variation in the rainfall values of the stations with most months recording nearly same values except for July, August and September. In these 3 months, there is a large variation with Sambalpur recording highest values for July-August followed by Koraput and Titlagarh. Low rainfall in July-August is found in Gopalpur (has winter maximum), Puri and Chandbali, which have high rainfall in October. The interior stations show greater seasonal variations in rainfall than the coastal ones.

The humidity graph (Fig. 7.3A&B) shows a pattern that is fairly similar in all the stations. Humidity is fairly

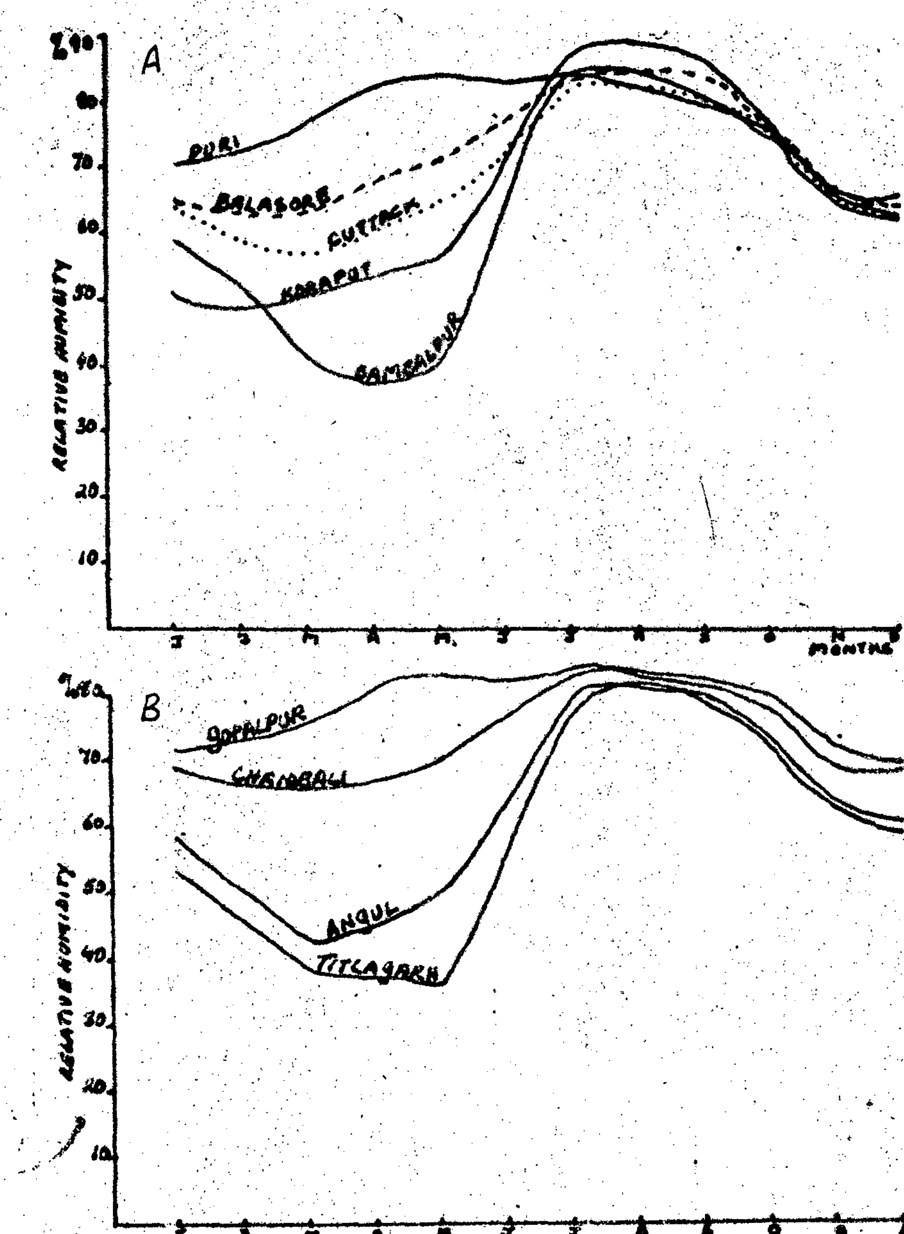


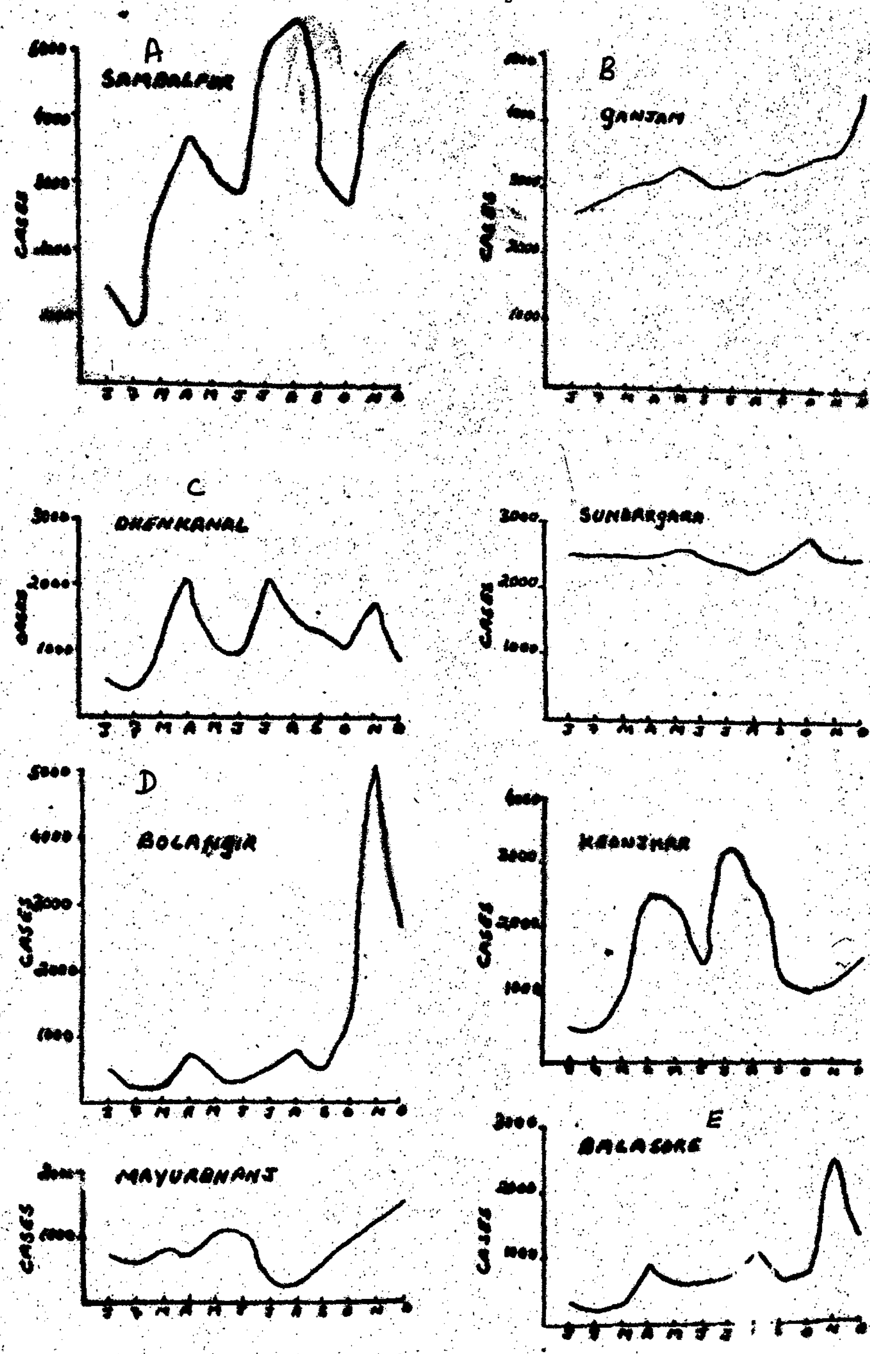
Fig. 7.3 **SHOWING RELATIVE HUMIDITY - MONTH WISE**

high in January gradually decreasing till March, then, showing an upward trend till July/August after which it falls till December. From the graph, it is clear that there is not much variation in humidity between the stations from July to December. The highest humidity values are in July and August with April-May recording the lowest values. Lower humidity exists in the interior districts with Sambalpur and Titlagarh having the lowest values, while the coastal districts have higher humidity. The variation in monthly humidity is also greater in the interior than in the coast. There is a steep rise in humidity and rainfall from April to July and this rise is steepest in the interior.

Against this picture of monthly temperature, rainfall and humidity is studied the monthly pattern of incidence for the various districts. The purpose of such an exercise is to determine (1) whether any seasonal pattern of incidence exists and (2) whether the pattern can be explained through climatic factors.

Sambalpur (Fig. 7.4A) shows a high incidence of malaria with 3 peaks in April, July-August and November-December with July-August being the months of maximum incidence and January-February being the months of lowest incidence. The monthly variation in incidence is large in the case of Sambalpur being largest between December and January. The variations in rainfall, temperature and humidity are also highest in Sambalpur being greatest for the months of July and August. The very high rainfall in July-August after a

Fig. 7.4 Showing seasonal incidence – unit-wise.



nearly dry spell could explain the rise in incidence in July-August. The peaks in April and December are more difficult to explain.

Ganjam (Fig. 7.4B)

Incidence shows a rising trend from January to December with the highest peak being in December. The unit is conspicuous by an absence of any peak in July-August. When this is viewed against the monthly climatic data, we find that Ganjam has a high winter rainfall the peak being in October, while in July-August, rainfall is lower. This winter maxima rainfall may explain the peak incidence in December further strengthening the view that malaria is highly dependent on rainfall. Humidity during December is 70 per cent and temperatures are high 22°C.

Dhenkanal (Fig. 7.4C)

Incidence reveals a 3 peak pattern with clearly defined peaks in April, July and November with lowest values in February. The Peak in July is explained by the high rainfall in July and August but the peaks in April and November are difficult to explain as rainfall and humidity are low during these months and there is not much variation in temperature.

Bolangir (Fig. 7.4D)

It also has a 3 peak incidence pattern with a very pronounced peak in November and the other two being very small peaks. The very steep November peak is, again, not easy to explain as Bolangir has little winter rain, while it

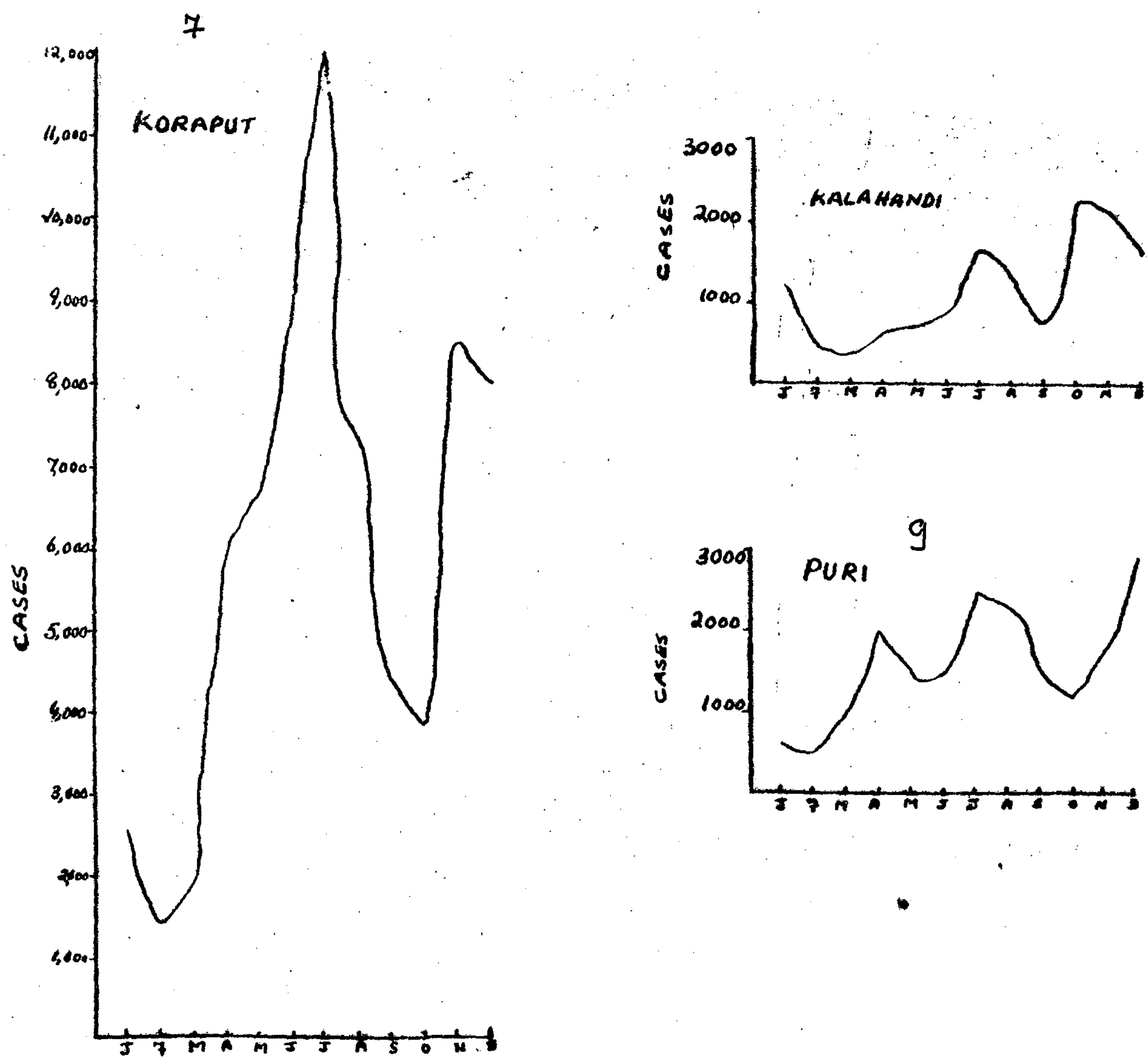

7
KORAPUT
CASES
12,000
11,000
10,000
9,000
8,000
7000
6,000
5,000
4,000
3,000
2,000
1,000
J F M A M J J A S O N D
KALAHANDI
CASES
3000
2000
1000
9
PURI
CASES
3000
2000
1000

Fig. 7.4

has high rainfall in July-August but no corresponding high peak of incidence. The low incidence till June would be because of the very low humidity conditions.

<u>Balasore (Fig. 7.4E)</u>

There are 3 peaks of incidence with November being the month of highest incidence. The peak in November is explained as this is an area of winter rain in October with high rainfall in July-August also. The peak in April could be a result of rising temperature and humidity conditions.

<u>Koraput (Fig. 7.4F)</u>

The incidence graph for Koraput reveals a two peak pattern with a very sharp rise in July followed by a less steep rise in November. Incidence rises very markedly from February to July with peak in July being highest from among all the other districts. The very high incidence in July can be explained by the very high rainfall in July-August along with high humidity. The sharp rise in incidence from February to July may be a result of the increasing temperatures, which fall in the winter months to below $20^{\circ}C$.

<u>Puri (Fig. 7.4G)</u>

Incidence in Puri also reveals a three peak pattern with one in April, July-August and November with November being the month of highest incidence. This district is also one of high winter rainfall, which could explain the November peak.

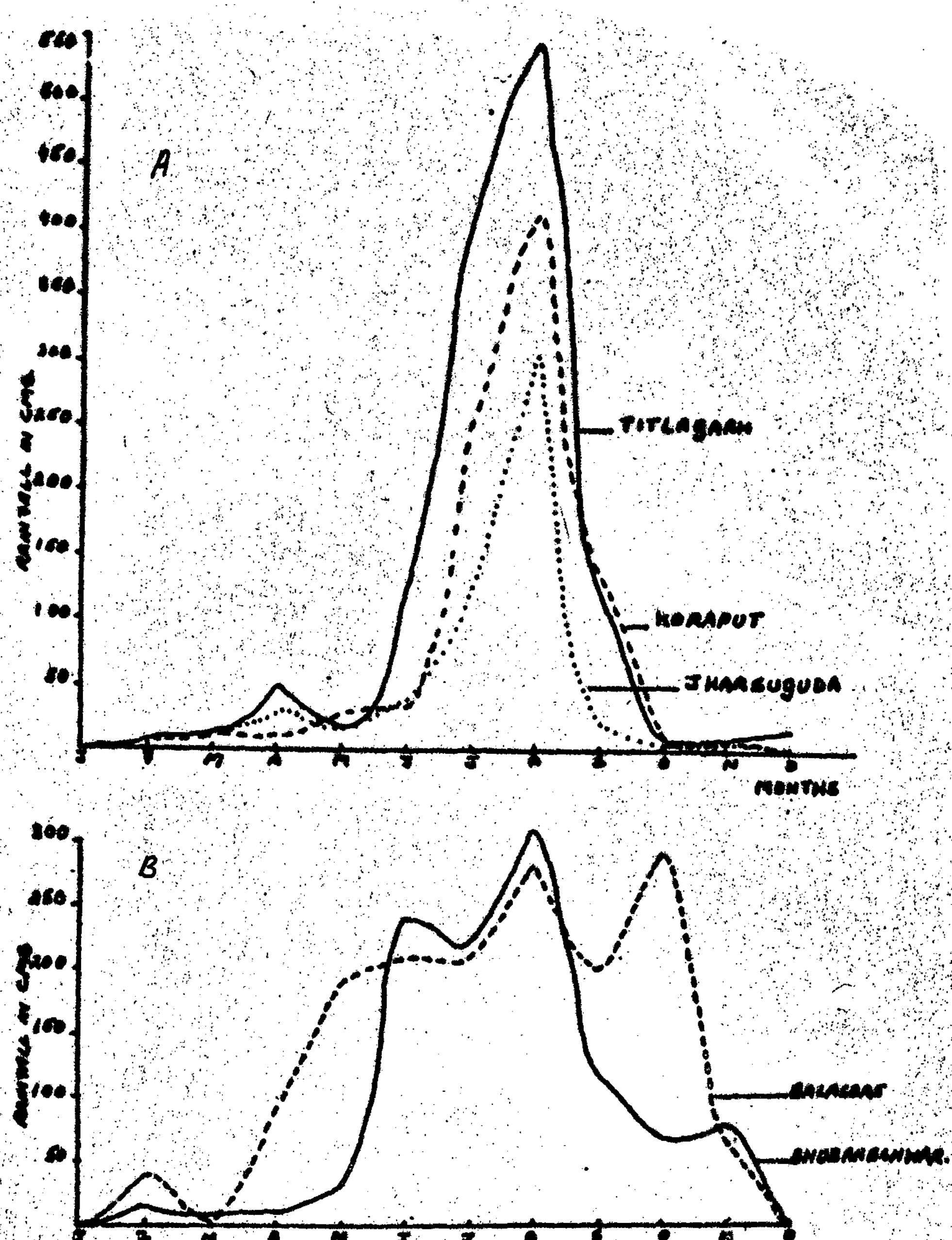
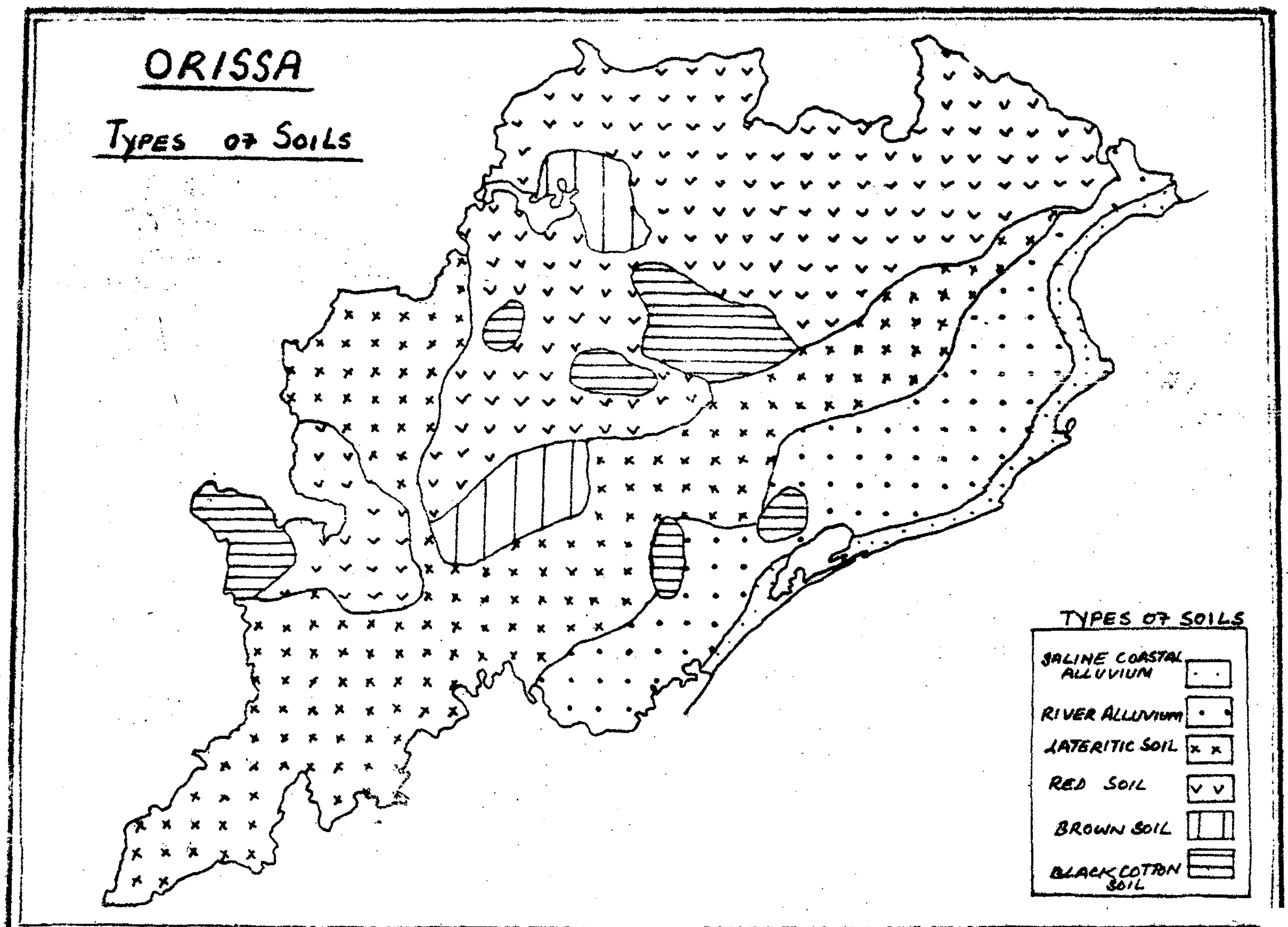


Fig. 7.5 SHOWING MONTHLY RAINFALL IN 1976.

From our comparison with the 30 year monthly average data we find that rainfall does play a role in determining the seasonal pattern of incidence of malaria. As the monthly incidence figures are for 1976, it was felt that for a more meaningful picture of correlation monthly rainfall values for 1976 should be correlated with incidence in 1976 for selected stations. With this in mind, daily rainfall data for 1976 was aggregated for each month and then graphs drawn (Fig 7.5A&B). The selected stations are Koraput, Jharsuguda, Balasore, Bhubaneshwar and Titlagarh. In the case of Titlagarh we find that there is not much change in the pattern of rainfall in 1976 except for a slight rise in August. But when compared to incidence in Bolangir we find that rainfall plays a subdued role as the month of highest incidence is November-December while rainfall is highest in July-August when there is a very small peak of incidence. Rainfall in Koraput in 1976 is highest in July-August which is also the month of maximum incidence. In Jharsuguda, July-August are the months of highest rainfall but incidence reveals no marked peak patterns in Sundargarh. Both Bolangir and Koraput have high incidence in November-December but have no winter rains. In the coastal districts the two stations of Balasore and Bhubaneshwar reveal a stronger correlation between incidence and rainfall in 1976. In 1976, the correlation between incidence and rainfall is stronger for the coastal areas while in the interior stations it is not as clear. The high winter incidence in the interior may be explained by the late



ORISSA
TYPES OF SOILS
TYPES OF SOILS
SALINE COASTAL ALLUVIUM
RIVER ALLUVIUM
LATERITIC SOIL
RED SOIL
BROWN SOIL
BLACK COTTON SOIL

MAP 7·3

monsoons of 1976.

The findings of this correlation exercise between climatic factors and monthly incidence have been summed up in chapter IX.2.

7.4 Pattern of Incidence and Soil Cover

The relationship between soil conditions and incidence needs detailed analysis before any meaningful conclusions may be drawn. Nonetheless, a broad correlation is attempted to highlight future directions for research.

The soil map of ~~India~~ ORISSA (7.1) clearly shows the dominance of lateritic soil in South Orissa and all along the coastal plains till Balasore in the North. North Orissa, on the other hand, is covered with red soil from Sambalpur to Mayurbhanj in the East. In the coastal plains and river valleys is found the river alluvium.

When the soil map is compared to the incidence map for both 1972 and 1976, we see that the laterite and red soil areas coincide with the areas of high incidence with some exceptions in Kalahandi and Bolangir districts. On the other hand, the coastal plains with their fertile alluvium are the areas of low incidence of malaria. Both the red soil and lateritic soil are poor for plant life due to their poor drainage characteristics. This could, probably, to some extent, explain the higher incidence in these soil regions as compared to the well-drained alluvial soil of the coasts. Soils having poor drainage do play a role in influencing the incidence of malaria by providing ideal breeding grounds for the mosquitoes through water stagnation. At a broad level, we find that in Orissa, the poorly drained lateritic and red soils do correspond, by and large, to areas of high incidence, while the more well-drained soil areas record low incidence. Exceptions are found in the black cotton soil area of South-West Dhenkanal, which is an area of high incidence and in North-West Kalahandi, where we find the presence of lateritic soils but a low incidence. This is only a broad analysis and one needs to carry out detailed localized studies to identify concrete relationships.

7.5 Pattern of Incidence and Forests

Forest play a vital role in malaria incidence as forest growth creates conditions for breeding in the jungle streams, ditches, still pools and holes in trees and thus favouring malaria.[4] The high temperature and high rainfall and the dense forests create a biotic environment conducive to the mosquito population.

As already seen in the forest map (map 5.3), Orissa is thickly forested with the distribution being very uneven. The coastal region with high population density has little or no forests as also the inland tracts of the river valleys. Forests have also disappeared from portions of Koraput,

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4 A.T.A. Learmonth, "Geography and Health in the Tropical Forest Zone", in R. Miller and Jwatson, eds., Geographical Essays in Memory of Alan G. Ogilvie, London: Nelson, 1969, pp. 195-200.

Phulbani and Ganjam, where shifting or Podu cultivation is practised. Phulbani has the highest area under forests (over 70 per cent) followed by Koraput, Dhenkanal, Sundargarh and Keonjhar with Balasore (5 per cent) having the lowest acreage followed by Cuttack and Puri.

When this distribution picture is compared with the incidence maps for 1972 and 1976, we find a strong correlation emerging. Those areas of dense forest growth are the areas of a high incidence, while those areas of Sparse forests have low incidence. The districts of thick forest cover like Sundargarh, Koraput, Mayurbhanj, Phulbani, Keonjhar and Dhenkanal are the districts of highest incidence also. The only exception to this is Kalahandi, where there are dense forests but a lower incidence. This fact may be explained partially by the fact that a large part of the forests of Kalahandi are the dry deciduous forests, which reflect on the low rainfall conditions of the district, which in turn, probably results in a decrease in malaria. Other areas of dry deciduous forests are areas of lower incidence as in West Koraput and parts of Bolangir and Sambalpur. It is the central belt of tropical moist deciduous that is a region of high malaria as moisture conditions are suitable for mosquito breeding. The coastal areas of little or no forests are areas of low malaria incidence. It can be summarized, therefore, that forests do play a positive role in increasing incidence by creating an ideal habitat for mosquito breeding.

7.6 Pattern of Incidence and Irrigation

Malaria is often believed to be partly a man-made disease. Among the many man-made phenomenon, irrigation is, probably, of most crucial importance to malaria.[5] The presence of large reservoirs, tanks and canals mean the presence of stagnant or slowly moving water, which provides the breeding ground for the mosquitoes. It is keeping this view in mind, that irrigation has been included as an explanatory variable in this study.

The irrigation map for Orissa (map 7.2) shows the irrigated area at a police-station level for 1971. The same map has been correlated to the pattern of incidence for 1972 and 1976 as the spatial character of the irrigated area remains essentially the same. The map for irrigated area clearly brings out the low level of irrigation in the State. Three important areas of higher irrigation can be identified: (1) the Rushikulya area in Ganjam; (2) the Mahanadi delta area and (3) the Hirakud area in Sambalpur. Besides these areas, Kalahandi, Bolangir and most of Sambalpur districts have some irrigation, while for the rest of the State, irrigation is below 5 per cent. In the three areas of high irrigation, irrigation is largely through canals, while over the rest of the State, it is through tanks. Canal irrigation is confined to the flat low-lying plains, while the hillier

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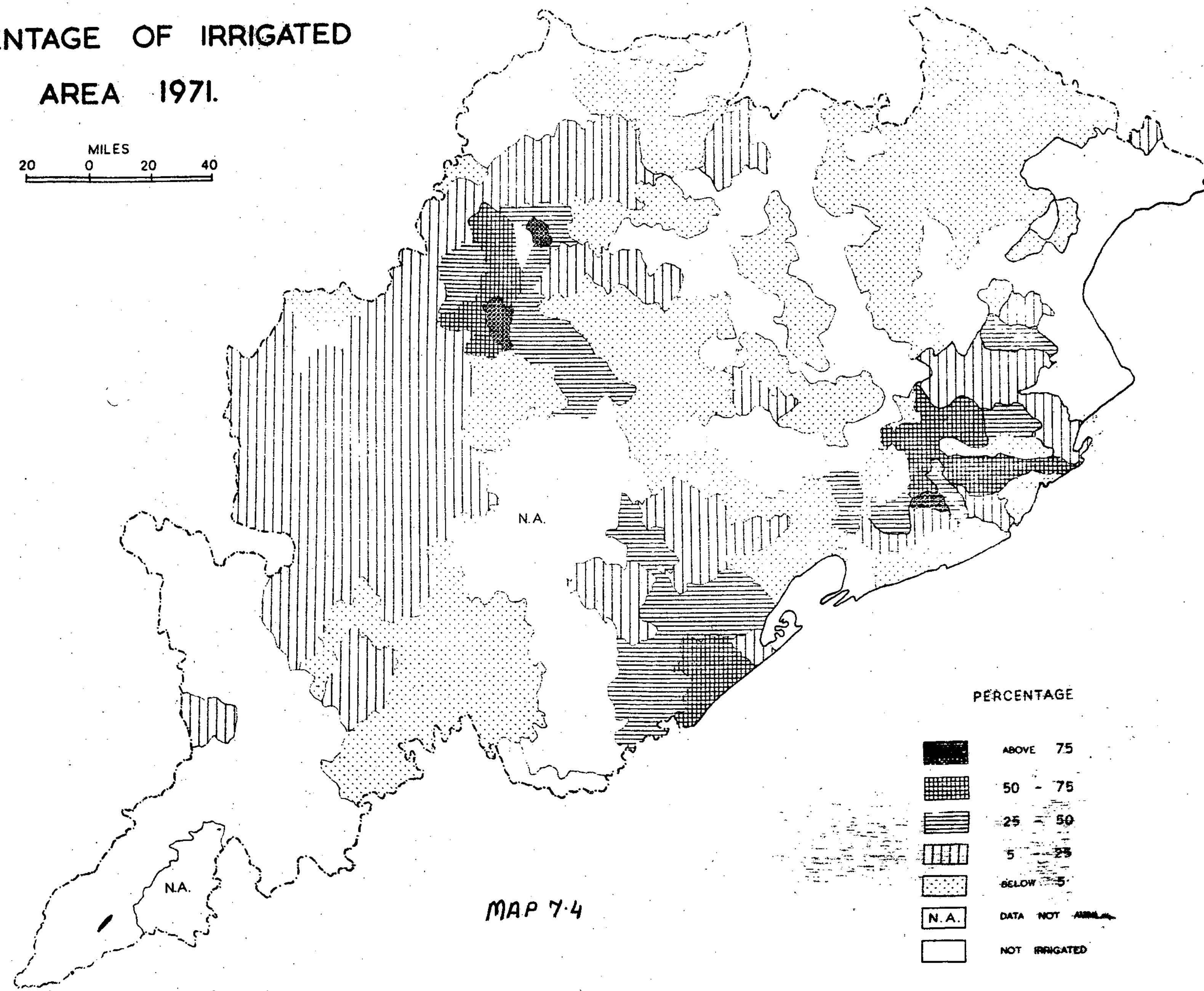
5 W.C. Sweet, "Irrigation and Malaria", in *Symposium on the Malaria Problems in India*, 1938, pp. 185-90.

Orissa
PERCENTAGE OF IRRIGATED AREA 1971.



MAP 7·4

areas have tank irrigation.

When irrigation is compared to incidence in 1972, we find that the areas of high incidence tend to largely coincide with areas of low irrigation. The entire central belt of high incidence is an area of low irrigation with the exception of the Hirakud area. The hilly malarious interior has hardly any irrigation. On the other hand, the coastal districts of Cuttack, Puri and Ganjam with a high irrigated area are areas of low incidence. The general assumption that irrigation leads to a rise in incidence is refuted by our observations in Orissa. The only area conforming to this assumption is the area served by the Hirakud project, where high irrigation and high incidence is met with.

If the same irrigation map is compared with the incidence map of 1976, we do not find much change from the earlier picture. The high incidence areas are not areas of high irrigation rather they are characterized by low irrigation generally. The areas of lower incidence are, by and large, areas of high irrigation with the exception of Balasore and East Dhenkanal, where low irrigation and low incidence is found. In 1976, we find that the high irrigation area around Hirakud has emerged as an area of high incidence encompassing Sambalpur, Eastern Bolangir and North Phulbani. In 1976, we find an increase in areas of high incidence having low irrigation due to the spatial diffusion and increase of malaria.

The main points that emerge from this correlation are that (1) high irrigation is not accompanied by high incidence.

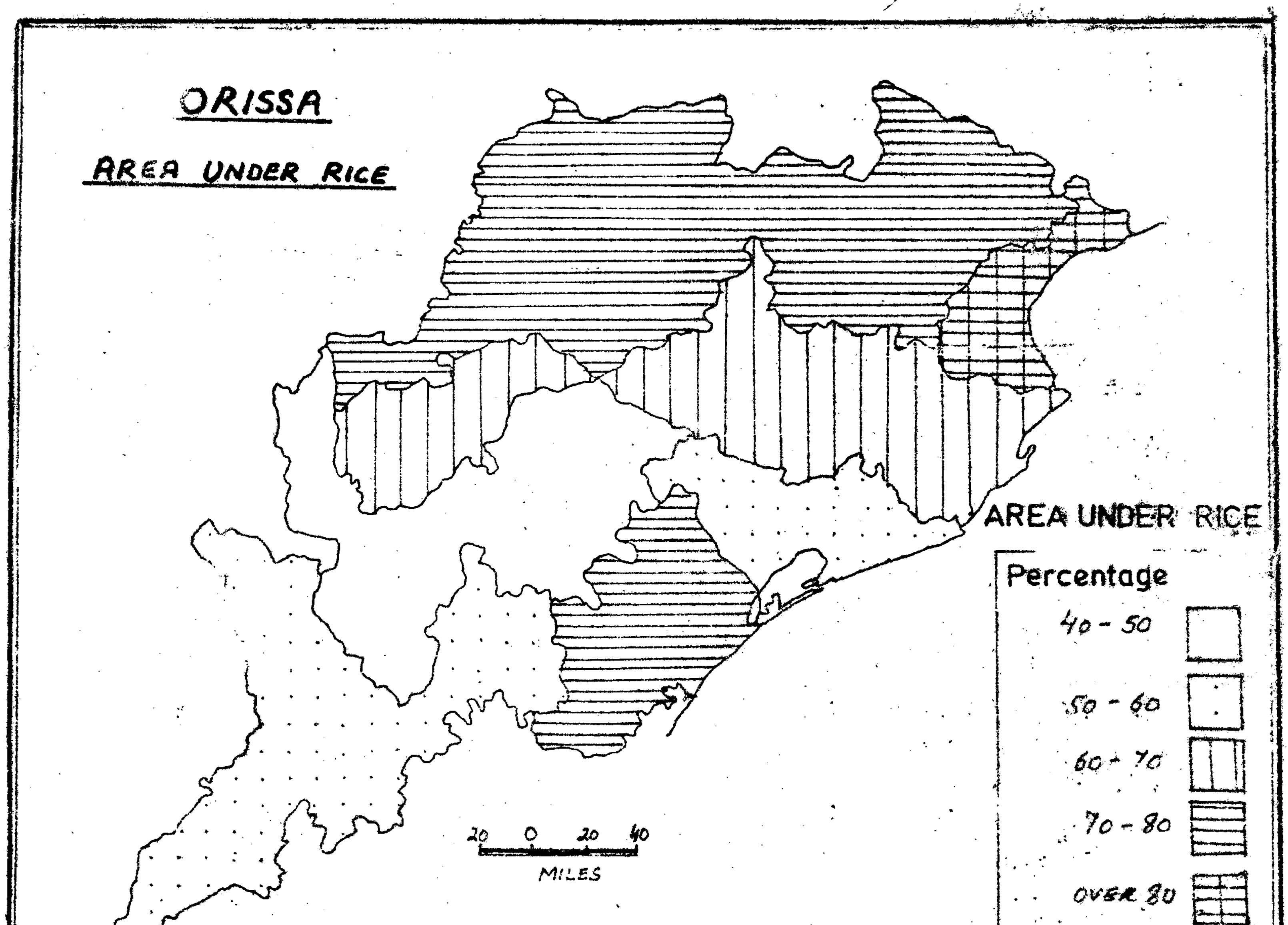
Only in the case of Hirakud, do we find that high irrigation has led to a higher incidence as evident in 1976. Generally, the areas of higher irrigation are the river deltas and low-lying plains of Bolangir and Kalahandi, which are characterized by lower incidence. Balasore is an area of low irrigation and low incidence and along with the Hirakud area supports the assumption of high irrigation leading to higher malaria. But on the whole, this hypothesis needs further testing in the light of the Hirakud experience.

7.7 Rice Cultivation and Incidence

Rice-growing usually has a direct impact on malaria as the factors that favour rice-growing to a large extent are the factors that favour malaria.[6] The only difficulty facing a comparison of the two is that while the malaria incidence data is available on a detailed level, the data for area under rice cultivation is available only at the district level. Nonetheless, a broad idea of the interaction between the two can be attempted.

If the area under cultivation ~~(map 7.3)~~ is compared with the incidence maps for 1972 and 1976, we find that areas of higher cultivation are the areas of lower incidence, while the low cultivation areas are the high incidence areas. The entire hilly central zone of Orissa characterized by high malaria records the lowest acreage under cultivation. The

6 G.D. de Bernis, "Some Considerations about Programme and Project Evaluation Techniques in the Field of Health", 1975.

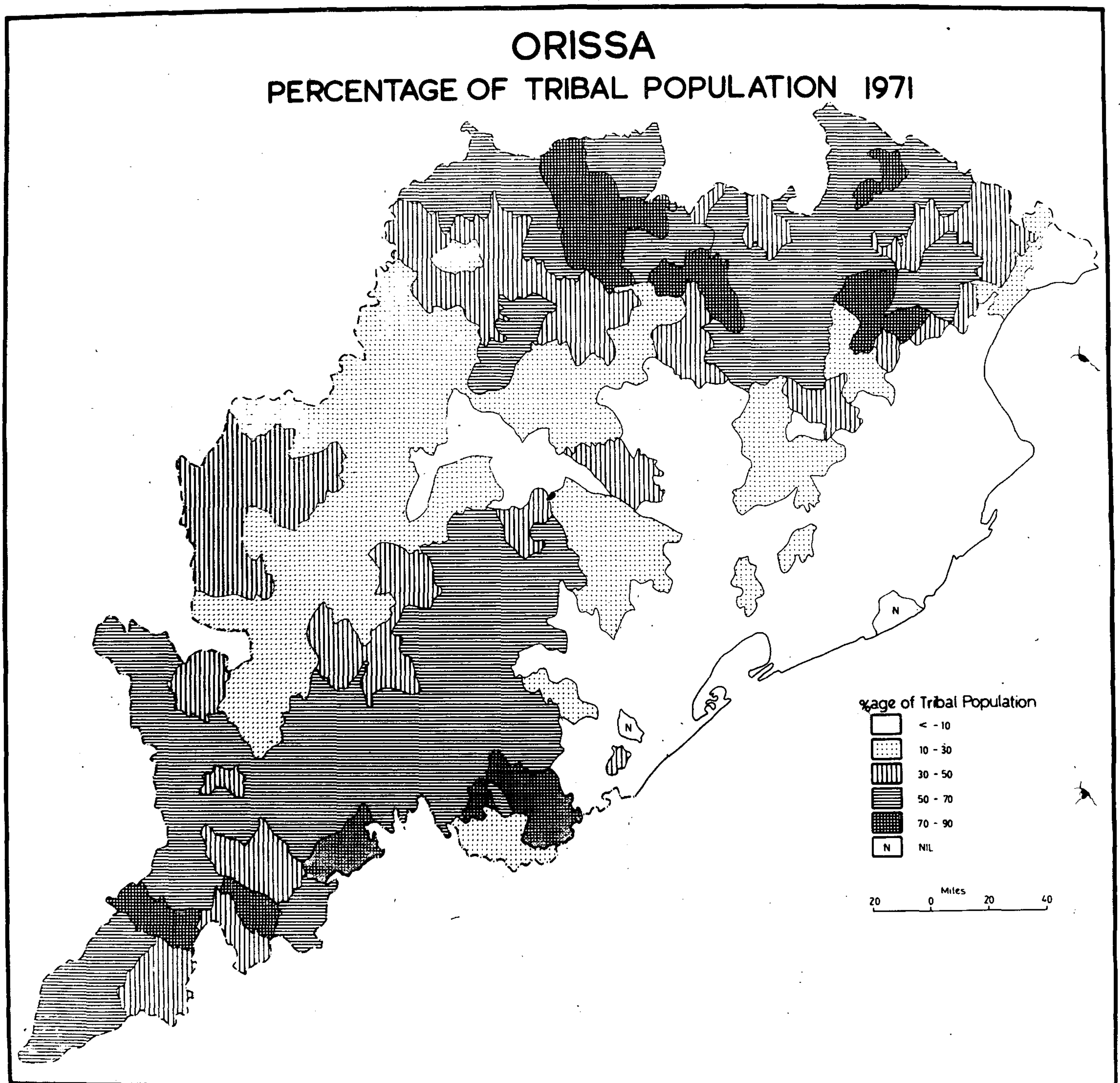

ORISSA
AREA UNDER RICE
AREA UNDER RICE
Percentage
40 - 50
50 - 60
60 - 70
70 - 80
OVER 80
20 0 20 40
MILES
MAP 7.5

coastal districts having a high acreage under cultivation have a low incidence. This pattern is explained by the fact that in hilly terrain, cultivation is difficult and it is this particular environment that is conducive to malaria being a region of high rainfall and dense forests.

The correlation pattern between acreage under rice (MAP 7.I) and incidence of malaria is not as clear. The districts of high cultivated area are not necessarily those with high acreage of rice and those of low cultivated area do not record low rice acreage also. Balasore, which records highest rice acreage has a low incidence of malaria, while Koraput and Phulbani showing low rice acreage record very high incidence figures. The high rice acreage districts of Sambalpur, Sundargarh, Mayurbhanj and Keonjhar are those having high incidence. Kalahandi and Puri with low rice acreage are largely low incidence districts. Cuttack, Bolangir and Dhenkanal with fairly high rice acreage have low incidence except for West Dhenkanal and North-West Bolangir. In the Northern districts, we find that high rice cultivation and high incidence are met with. To draw any generalizations on such a comparison is risky and detailed micro-level data on rice cultivation is needed for a meaningful picture to emerge.

7.8 Tribal Population and Incidence

Besides, environmental factors, there are certain cultural factors that could influence malaria. A very important one from among these is the presence of tribal populations


ORISSA
PERCENTAGE OF TRIBAL POPULATION 1971
%age of Tribal Population
< - 10
10 - 30
30 - 50
50 - 70
70 - 90
N NIL
Miles
20 0 20 40
N

MAP 7·6

which present some social setbacks to malaria and its eradication.[7] Orissa has a very large tribal segment and the spatial distribution of tribals correlated with the incidence of malaria may reveal interesting results.

The given map (map no. 7.4) shows the percentage of tribal population to total population at a police-station level for 1971. From this map, it is clear that the hilly forested tracts of the State are the tribal areas. Tribal populations are largely concentrated in North Orissa and South Orissa, the two areas separated by the Mahanadi river valley. In North Orissa, the tribal belt extends in a continuous stretch from Sundargarh in the West to Mayurbhanj in the East and includes Sundargarh, Keonjhar and Mayurbhanj districts and a large part of Eastern Sambalpur district. In South Orissa, the tribal belt includes the districts of Koraput, Phulbani, South-West Ganjam and a pocket in North Kalahandi and North-West Bolangir. In these two tribal belts, the tribals are in a majority over most areas. Coastal Orissa, Dhenkanal, North Sambalpur, East Bolangir and South Kalahandi districts are the areas of low tribal population. Within the tribal belt, South-central Sundargarh, South-West and North Mayurbhanj, West Keonjhar, South Ganjam and parts of B. Koraput have a tribal concentration of over 70 per cent.

If the tribal population map is correlated with the

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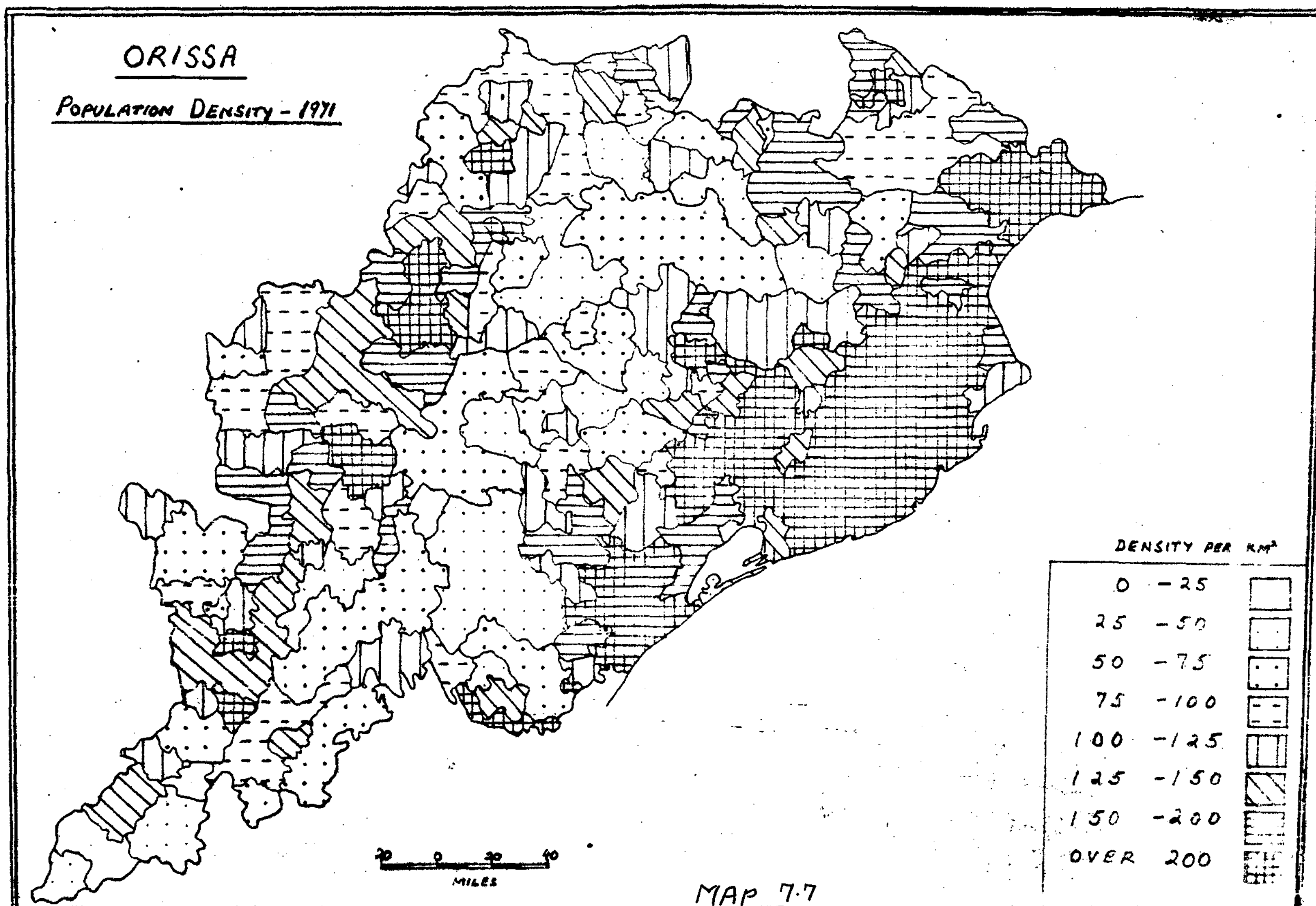
7 H.S. Dhillon and S.B. Kar, "Malaria Eradication - An Investigation of Cultural Patterns and Beliefs Among Tribal Populations in India (Orissa)", <u>WHO/Malaria Series</u>.

incidence map of 1972, it is clear that by and large, the areas of high tribal concentration coincide with areas of high incidence. This is hardly surprising as it is the hilly tracts, which house the tribes and are also malarious as seen from our earlier correlations. The tribal areas of South and East Koraput, Phulbani, Eastern Sambalpur, Keonjhar and Mayurbhanj reveal a high incidence of malaria. As compared to this, the non-tribal coastal districts, Dhenkanal, Bolangir and Kalahandi have a lower incidence. Some exceptions to this pattern are North-West Koraput, which has a high tribal segment but a low pattern of incidence. Parts of Sundargarh, also, have a high percentage of tribal population but a lower incidence. North-East Phulbani has a low tribal population but a high incidence.

In 1976, the picture becomes even sharper. The rise in incidence is maximum in the tribal areas. The high tribal segment areas report a high incidence of malaria. The districts of Sundargarh, Keonjhar, Mayurbhanj and Phulbani along with most of Koraput and East Sambalpur have both a high tribal population and a high incidence. Large parts of the tribal Sundargarh district, which had low incidence in 1972, report high incidence in 1976. The coastal districts of Cuttack, Puri, Balasore and most parts of Ganjam, Dhenkanal, Kalahandi and Bolangir, which have a low tribal segment, also, have a low incidence. Within these districts, those areas of higher tribal concentrations have higher incidence as is found in North-West Bolangir, South-West Ganjam, West and


ORISSA
POPULATION DENSITY - 1971
DENSITY PER KM²
0 - 25
25 - 50
50 - 75
75 - 100
100 - 125
125 - 150
150 - 200
OVER 200
20 0 20 40
MILES

MAP 7.7

North Dhenkanal, West Puri and Western Balasore. The only anomaly areas are North-West Koraput, which has a large tribal population but a low incidence rate due to, probably, the concentrated efforts of the Dandakaranya authorities to control the disease here. Another pocket of anomaly is North-East Phulbani, where a low tribal population and high incidence is met with. Besides, these two mentioned areas for the rest of the State, the pattern is clear. Tribal areas do record a higher incidence of malaria than the non-tribal areas. In fact, another important point that emerges is that tribal areas previously reporting a lower incidence are in 1976 areas of high incidence suggesting the spatial spread of malaria to areas of near control in the tribal belt.

7.9 Pattern of Incidence and Population Density

The map, showing population density is on a police-station level and for 1971 (map no. 7.3).

This map shows that coastal Orissa is an area of high density of over 200 persons per sq. km. Balasore, Cuttack, Puri and a large part of Ganjam districts record high densities. Besides the coastal plains, small pockets of high density are to be found in East Dhenkanal, Titlagarh in South Bolangir, Kesinga in North-East Kalahandi, Nowrangpur and Jeypore in Koraput, Dungripalli and Loisingha in West Bolangir, Sambalpur, Barpali, Bargarh, Brajrajnagar and Jharsuguda in Sambalpur district. All the above-mentioned police-stations have a density of 200 persons per sq. mile.

High density is associated with all the plain areas of below 150 metre contour whereas with a rise in altitude, we find a fall in density. Very low densities are found in Venkatapalam and Mudulipada in South Koraput and Belghar in South-West Phulbani, where density falls to below 25 persons per sq. km. The central hilly tract of Orissa is the low density area of the State.

When population density is correlated with incidence of 1972, we find that by and large, it is the low density areas that have a high incidence, while it is the high density areas that report low incidence. Coastal Orissa records high densities but low incidence, while the hilly interior has low density but high incidence of malaria. The areas of high incidence are all areas of low density in 1972, though, areas of medium incidence report low to medium density.

Even in 1976, the high incidence areas are areas of low density but in some high density areas, incidence has risen in 1976. On the whole, most of the high density areas have a lower incidence except in the interior, where the high density pockets in Koraput record a higher incidence.

From this analysis, it is evident, that high population density and malaria are not co-existent, rather an inverse correlation is to be found with high incidence and low population density and vice-versa. The role of density in affecting incidence is hence not clear.

7.10 Role of Socio-Cultural Factors in Malaria

Besides physical factors, there are some cultural factors that also influence malaria. But while the impact of physical factors is discernible through the use of some techniques, the role of cultural factors is more difficult to determine. In this study, the role of cultural factors has not been statistically assessed, but nonetheless, their probable influence has been discussed. A study of interaction between culture and health is especially important in countries like India, where people have adopted certain health practices, habits and medicaments and a view of health along traditional lines and are not very receptive to the new forces of change.[8]

A question often raised in connection with malaria is whether it is a social disease. The more direct is man's contact with his environment the greater is the incidence of malaria. Malaria is largely present in agriculture, where primitive practices are in use and poor land-use is the result met forming especially, rice-growing with its partially submerged fields has a direct impact on malaria, which becomes of greater relevance if it is combined with living in the fields. An important factor that enters into malaria epidemiology is: the natural history of man. Orissa offers a varied cultural front with its strong tribal segment. Moreover, the State has till very recently been unexposed to the forces of change with the result that customs, traditions, beliefs and

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8 Ibid.

living habits have undergone little change over the years and this is, specially, more true of the tribals. Orissa has a majority of its people living in rural areas (80 per cent) and its urban population is only a recent outcome. In the rural areas, the impact of modern preventive health measures is negligible as the exposure to them is a very recent phenomenon and is enjoyed by a small number. The large rural segment of Orissa is scattered in numerous villages mostly below 500 population and this makes the diffusion of new ideas all the more difficult. Educational level is rather low (26.2 per cent literacy) and this determines the attitude towards health. Occupation of people influences health as people engaged in agriculture specially rice cultivation are more exposed to diseases like malaria, and this is true of Orissa where over 70 per cent of the population is engaged in agriculture and rice is the dominant crop.

The incidence map makes it very clear that the entire State suffers from a high incidence of malaria with the tribal areas being intensely malarious. The eradication programme in Orissa has not met with great success - why? What are the factors hampering eradication in Orissa? How have the tribals reacted to eradication? These are some of the questions that spring to the mind and their answers lie deeply rooted in the cultural ethos of the region. Most of the houses in Orissa are made of mudwalls and bricks and have thatched roofs. The lack of a cement or smooth finish gives rise to many nooks and dark corners, where the mosquitoes rest. The thatched roof provides breeding conditions during rains for the mosquitoes. Besides this, the walls are lime-washed or mud plastered regularly, which negates the effect of D.D.T. Moreover, there is not much cooperation from the people to allow spraying. Even when allowed, spraying is not permitted in the entire house - the kitchen, prayer room, and females' quarters are generally left unsprayed. This is because the idea of having the spray men enter the inner parts of the house has not yet been accepted. In recent years, the people's cooperation in accepting the spray has decreased as the insects and mosquitoes, which died earlier, have, now, developed resistance to the insecticides.

Malaria has been a scourage for so long that people have accepted it and are not too bothered, when they suffer from it. In Orissa, the conditions were such that malaria thrived and hence, the disease does not hold much fear and not much is done to get rid of it, as in the case of small-pox. The living habits of the people are such that no significant preventive measures are involved. The use of mosquito-nets or any other precautionary measure to keep away mosquitoes is by a negligible number with the majority sleeping in the open as they cannot afford these comforts. Almost every house has a pond or a well in its backyard providing conditions for mosquito breeding. This presence of a well in most houses is the source of water for all purposes for the household. Besides this well, there usually is a pond ("pokhari") in each village, which is most often a fish pond. The village's consumption of fish is caught there. Many rich households have a fishpond of their own in their houses.

There is a need in spreading anti-malaria consciousness and making these measures a part of life, with clean surroundings and well-maintained water courses.

7.11 The Tribal Area Problems

From our study one find that it is in the tribal areas that incidence of malaria is highest. Why is it so? Besides, the favourable environmental conditions in these areas, there are certain socio-cultural factors that play an important role in maintaining these high levels of malaria among the tribals.

Dhillon and Kar[9] undertook a study to go into the causes of why eradication is a failure among the tribals. Their findings throw a lot of light on the beliefs and customs of the tribals and their way of life. Health was not listed as a major problem by the tribals, who laid more emphasis on irrigation, roads, etc. Amongst the diseases mentioned, fever or malaria holds high priority. In their perception of diseases, the causative agents are thought to be evil spirits rather than any micro-organisms. Hence, the concept of transmission of disease and its prevention is a hard to accept concept for them. The idea of mosquitoes or sick persons being carriers of malaria is alien to them and a mosquito bite is not considered harmful only irritating. The general treatment for disease is mainly through magico-religious rituals. It is only

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9 Ibid.

as a last resort that help from the health centres is sought and this is more often an exception rather than the rule.

Malaria is described by the tribals as fever with shivering ('kampoojhar') and is an accepted problem. It is viewed as a mild, self-limiting disease that gets cured by itself in a few days. The major effect of malaria is on the children, reflecting that a certain degree of immunity is built up against it over the years. The tribals regard climatic factors as causative for malaria. The disease is associated with agriculture in that when a person working in the fields in summer is exposed to rains, his body temperature drops suddenly resulting in fever, which comes with chill and shivering. Generally, no treatment is taken for malaria as it is considered a self-limiting disease.

Tribals use of clothing is very limited and this leads to greater exposure to mosquitoes and a higher probability of getting malaria. House plastering is associated with deeply-held religious, ceremonial and aesthetic traditions and is done usually 8-10 times annually. The effects of D.D.T. spraying are, hence, negated by this regular plastering of walls. While the tribals are aware of a small decline in malaria, it is not attributed to the spraying of D.D.T. Spraying is not liked and considered useless as people are not aware of its benefits in eradicating malaria. Moreover, it is believed that D.D.T. increases bed bugs which have now become resistant to it unlike before. A greater acceptance is revealed in the use of anti-malarial drugs as a result of its direct and quicker demonstrative results.

The need for educating the tribals about malaria and its eradication measures needs hardly to be exaggerated. Efforts should be made to involve the village leaders and educate the people through them as acceptance of ideas is, then, easier. The aim of the education should be that malaria is communicable and a mosquito bite can cause malaria. The exceedingly high rate of illiteracy amongst the tribals makes their education process difficult, though, visual aids like documentaries could be immediately effective.

An understanding of the tribals' attitudes and customs is essential in aiding and achieving eradication and it is here that the role of socio-cultural factors assumes greater importance.

This chapter was a correlation exercise in identifying the role of various environmental and human factors on incidence, as the spatial patterns of these factors does influence the spatial pattern of incidence. The various variables chosen in this chapter can be integrated quantitatively by working out a correlation matrix. This matrix would help in revealing statistically the nature of correlation between these variables chosen and incidence. From the correlation values arrived at it would be possible to identify the main causal factors of incidence in a given area. Such a quantitative exercise can be attempted in future research, for selected sample areas where detailed data is available regarding the different indicators.

Chapter VIII

THE CHANGING GEOGRAPHY OF THE PLASMODIUM: AN ASPECT OF RESURGENCE

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THE CHANGING GEOGRAPHY OF THE PLASMODIUM: AN ASPECT OF RESURGENCE

Malaria in India is largely of the plasmodium vivax (PV) type but in recent years with resurgence the incidence of falciparum cases is rising and is even reported in many states where it was not prevalent before. Majority of the deaths from malaria are from falciparum infections and it accounted for 12 per cent of the total malaria cases in 1976, while in 1973 it was only 6.8 per cent. In the country, 55 districts in 15 states and union territories account for 80 per cent of the total falciparum cases.[1]

This trend at the national level is reflected with greater clarity in Orissa as seen from Table VIII.1.

Table VIII.1

PF Cases in Orissa

Year	PF Cases
1961	676
1962	2,960
1963	4,006
1964	6,939
1965	7,466
1966	7,141
1967	15,449
1968	24,854

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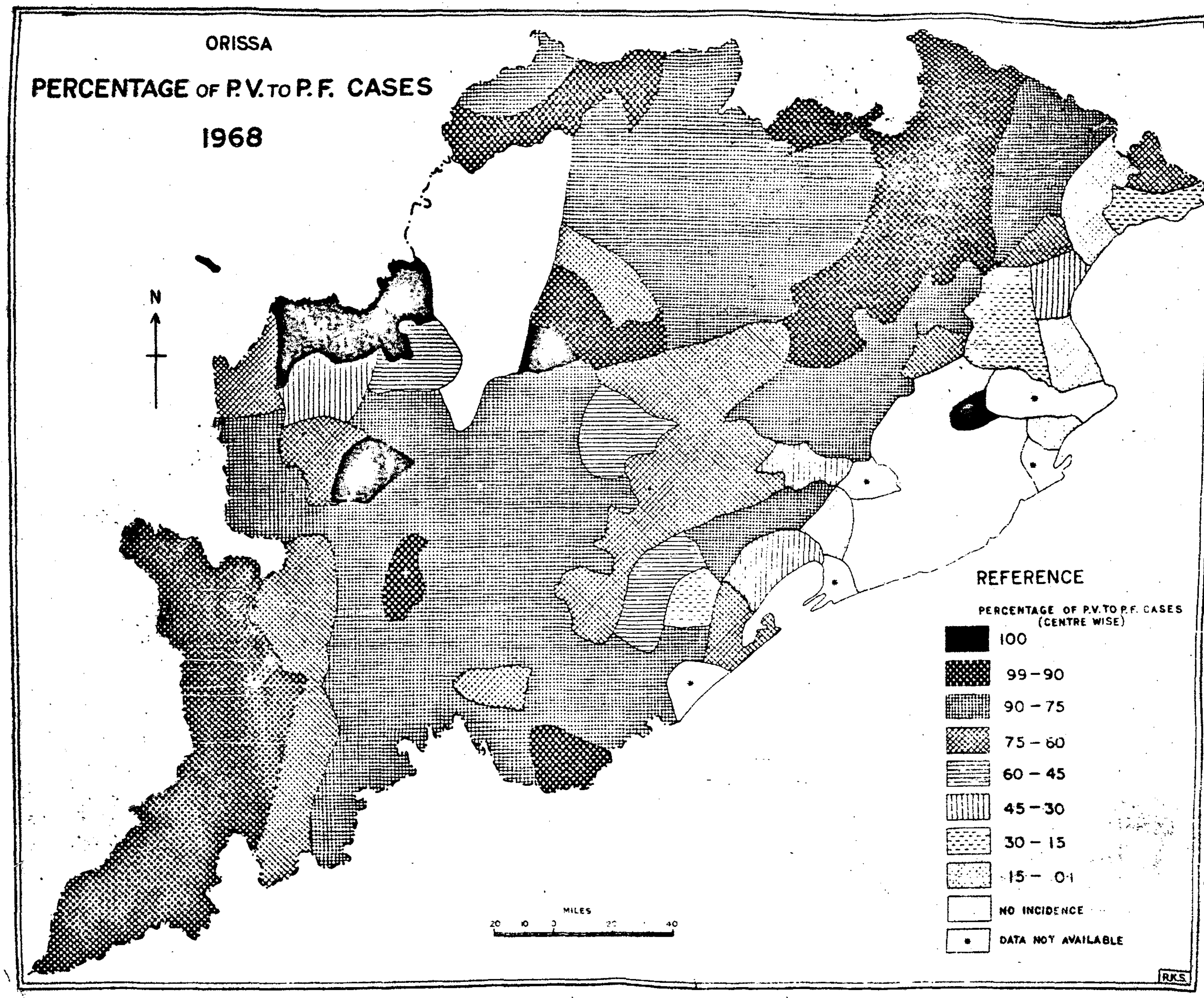
1 Dr. V.S. Orlov and Dr. D.D. Arora, "Intensive Need for Containment of PF Malaria", NMEP, Newsletter (New Delhi), December 1977, pp. 21-22.


ORISSA
PERCENTAGE OF P.V. TO P.F. CASES
1968
N
REFERENCE
PERCENTAGE OF P.V. TO P.F. CASES (CENTRE WISE)
100
99 – 90
90 – 75
75 – 60
60 – 45
45 – 30
30 – 15
15 – 0·1
NO INCIDENCE
DATA NOT AVAILABLE
MILES
20 10 0 20 40
RKS

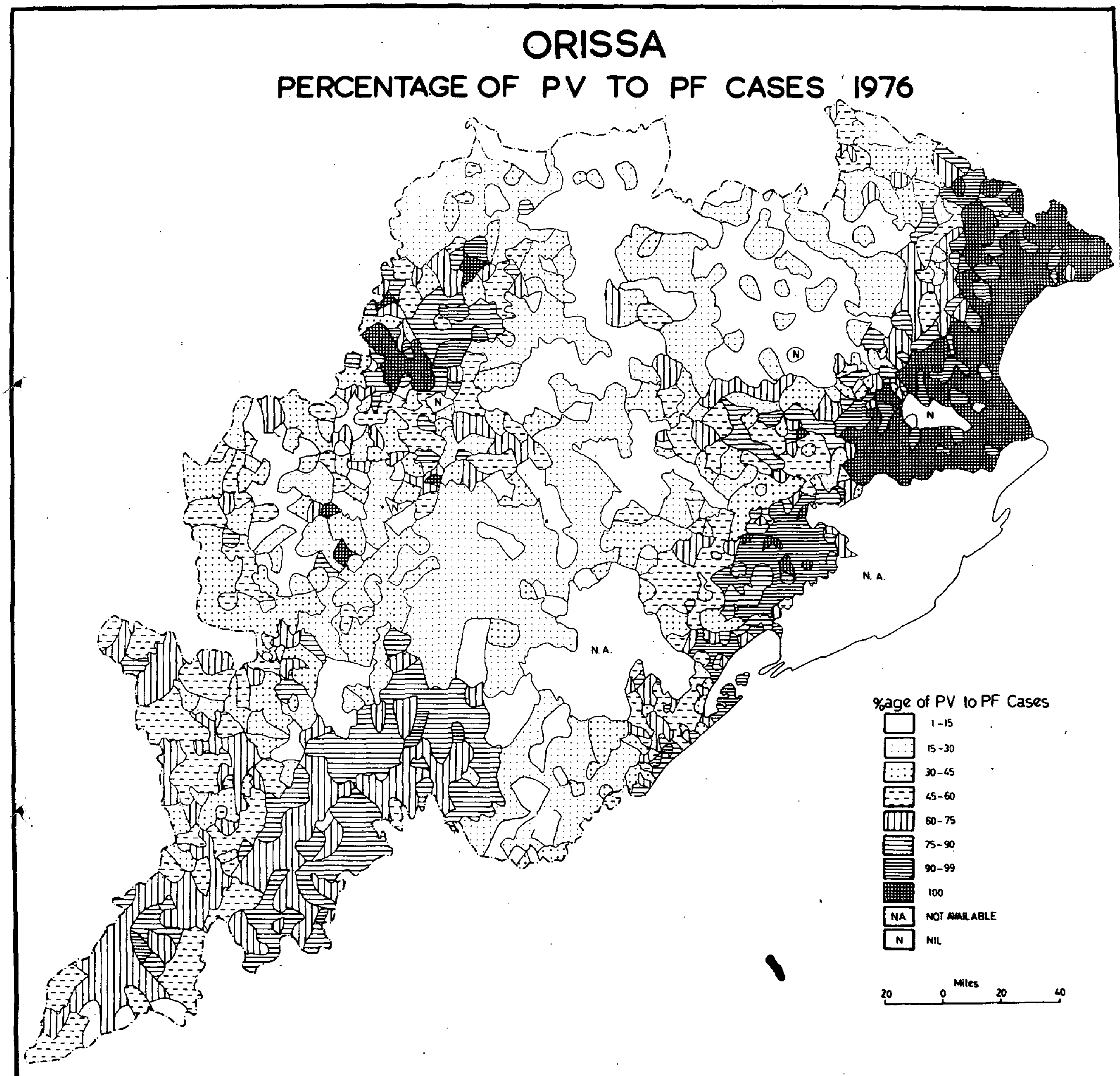
MAP 8·1

1969	22,379
1970	5,346
1971	13,562
1972	23,458
1973	79,379
1974	1,54,665
1975	1,47,760

The changing pattern of the plasmodium between 1968 and 1976 in the state is evident from the two maps. The aim of preparing these maps is to identify and demarcate those areas of rising falciparum cases. This is necessary as the PF is resistant to chloroquine and is a more virulent form of malaria that needs to be immediately controlled. The emphasis on the percentage of PV cases to PF cases is laid to assess the changing trends in species distribution in an area. Earlier studies have shown that PF has formed a significant part of the resurgence of malaria in a belt across middle India. From the species map for 1976 it is clear that resurgence in malaria in Orissa is associated with an increase in PF cases.

8.1.1 PV to PF Cases in 1968

In Orissa it is the PV and PF types of malaria that together account for nearly the total malaria cases. In 1968 malaria in Orissa was largely the PV type accounting for over 70 per cent of the cases in most of the state. In coastal Orissa we find a higher predominance of the PF type of malaria especially in Balasore and around the Chilka coast. Another


ORISSA
PERCENTAGE OF PV TO PF CASES 1976
N
N
N
N
N. A.
N. A.
%age of PV to PF Cases
1-15
15-30
30-45
45-60
60-75
75-90
90-99
100
NA
NOT AVAILABLE
N
NIL
Miles
20
0
20
40

MAP 8.2

pocket of PF incidence is North West Bolangir. Besides these areas the rest of the state has a PV majority and which is more so in the interior areas. This was the existing pattern of species distribution in 1968.

8.1.2 PV to PF Cases in 1976

The picture in 1976 after a gap of 8 years changes drastically. The 1968 pattern of PV majority over most of the state is not to be found in 1976. The interior hilly areas of Koraput, parts of Kalahandi, Bolangir, Western Sambalpur and Eastern Mayurbhanj are the areas of PV majority. The coastal areas which were largely having a PF type of malaria in 1968, in 1976 report a PV majority. Balasore which had higher PF malaria in 1968, has high PV in 1976 denoting a complete switch in species. Most of central Orissa is dominated by the PF type found in Sundargarh, Keonjhar, Western Mayurbhanj, Phulbani, Southern Ganjam, parts of Kalahandi, Bolangir, West Dhenkanal and Cuttack. In this large area there has also been a change but from PV to PF type. Phulbani, Sundargarh and Keonjhar districts are entirely under falcifarum malaria in 1976.

From a comparison of the two maps it is obvious that over the years there has been a large-scale introduction of PF malaria especially seen in the central belt of Orissa. There seems to be a replacement of species from 1968 to 1976 with PF areas becoming PV and *vice versa*. Koraput, Dhenkanal and East Mayurbhanj are the only areas where PV has a majority in both years. A small pocket around Banki in Cuttack district and another in North West Bolangir also record PF majority in both years.

8.2 PV: PF Distribution and Incidence

An attempt is made to correlate the species pattern with the incidence pattern for 1968 and 1976 to determine if any relationship exists between the two. As there is no species data for 1972, a comparison for this year is not possible.

For 1968, there is no definite correlation between incidence and species. Incidence for most of the state is low and the main species is PV. The high incidence areas generally have a PV type of malaria with PF in the coastal district of Balasore which has low incidence. Another area of falciparum malaria is North West Bolangir which also records low malaria. Areas of PF malaria are few and report low malaria while the higher incidence areas have a PV type of malaria. From the picture in 1968, it is not possible to draw any conclusions as there is no strong obvious correlation between the species distribution and the pattern of incidence.

In 1976, there is a marked change from 1968 in both the species distribution and the incidence maps. From a comparison of the two maps for 1976 it is very clear that the resurgence of malaria is accompanied by the emergence on a large-scale of the falciparum type of malaria. The correlation between incidence and species is much clearer in 1976. The PV areas are confined to the coastal tracts, Koraput district and around Hirakud in Sambalpur. The PV majority areas have a lower incidence except in the case of South and North East Koraput and the Hirakud area where there is high incidence. The intensely malarious areas of central Orissa where incidence has risen phenomenally between 1968 and 1976 are the areas of PF majority. Except in parts of Kalahandi and Bolangir, the rest of the PF majority areas report high incidence rates. This clearly points out that areas of falciparum malaria have incidence rates. The rise in falcifarum malaria is associated therefore with the resurgence of malaria and this is a trend that needs immediate attention in terms of control measures.

Chapter IX

CONCLUSION

Chapter IX

CONCLUSION

9.1 Findings of the Study

We may now summarise our findings and indicate some problems emerging for the purposes of further research.

(1) Among the general aspects of malaria in Orissa, the pattern of seasonal incidence is one. From this analysis (Fig. 6.1) it is seen that the state in its annual cycle has two prominent peaks of incidence in July-August and November-December with a smaller peak in April. The first peak is the most prominent recording highest incidence whereas incidence is lowest in January-February. The high peak in July-August is explained by the fact that these two months are the months immediately following the monsoon when breeding conditions for the mosquito are created. The reason for a peak in November-December may be again due to the influence of the retreating monsoon which brings rainfall to north and coastal Orissa. The smaller peak in April is more difficult to explain but may be a result of rising temperature and humidity conditions. The trough of low incidence in January-February seems to be a result of the low temperature conditions and absence of rains. This is the seasonal rhythm for the state as a whole and a more meaningful picture emerges from the spatial variations in seasonal incidence.

(2) The seasonal pattern of incidence for the districts (Fig. 7.4 ~~and 7.5~~) reveals that most have a three peak pattern in April, July and November. The districts with

highest incidence in July are Koraput, Sambalpur, Keonjhar and Dhenkanal. Ganjam, Bolangir, Mayurbhanj, Balasore, Sundargarh, Kalahandi, and Puri have November as the month of highest incidence. The interior districts show a greater seasonal variation in incidence than the coastal districts the only exception being Sundargarh which has the least seasonal variation from among all the districts. Koraput has the maximum seasonal variation followed by Sambalpur. These two districts also record the highest incidence in the state. Those districts having high winter rainfall tend to have their main peak in November as is the case with Puri, Balasore, Ganjam and Mayurbhang. Most districts have a high incidence in July-August as this is the period following the monsoons. The presence of a small peak in April could probably be explained by the fact that temperature and humidity begin rising as a result of which incidence may receive an impetus. Some questions which emerge from this seasonal incidence are why the very sharp peak of incidence in November in Bolangir and in Kalahandi?

(3) The age-wise variations in incidence have increased from 1965 to 1974 (Fig. 6.2A and B; 6.3A and B). Malaria is less prevalent among infants of below one year. The age group affected maximum by malaria is that of over 15 years. This fact is of vital importance as it implies that the population most afflicted by malaria is the working force of the State. This has great economic implications as it would mean a high loss in man hours and productivity. From this observation a question that arises is: whether increasing human interaction

with the environment leads to a higher occurrence of malaria?

(4) The incidence maps (Nos. 6.1, 6.2, 6.3) reveal a marked temporal increase in malaria from 1968 to 1976. The phenomenal rise in incidence from 1968 to 1976 points to the resurgence of malaria in Orissa. The rise in incidence is sharper between 1972 and 1976 than between 1968 and 1972 which shows the faster rate of malaria spread during recent years.

(5) Besides the rise in absolute number of cases over the years (Tables 4.1 and 6.1) there is also found a spatial expansion of the high incidence areas of above 75 API over the years. Areas above 50 API and more specifically above 75 API cover larger areas in 1976 than in 1968 or 1972 - as seen in the North East Koraput - South West Ganjam - South West Phulbani and North East Phulbani - South West Dhenkanal - West Puri areas of high incidence. In other words, malaria in Orissa reveals spatial and temporal changes.

(6) Though areas of high incidence have expanded spatially the basic spatial pattern of incidence remains essentially the same over the years. While incidence has shot up, those areas of low incidence have remained low while the same areas of high incidence have remained high over the years. In some peripheral low incidence areas the incidence has become high in 1976 but an area of high incidence becoming low is not found. The central hilly and forested belt of the state offers conditions conducive to the prevalence of malaria in terms of relief, rainfall, temperature, forests and socio-economic conditions. It is for these reasons that this belt has

persisted as the malarious tract of Orissa over time. In the coastal districts the low incidence found is not as much a result of adverse environmental conditions as it is of the concentration and partial success of the eradication measures in this area. But even, within this area the Mahanadi delta which offers conditions ideal for malaria (with its floods, swamps and marshes, sluggish waterflow, and stagnant water pools) reports a very high incident in 1972 but a comparison in 1976 was not possible as data was not available for this area in 1976.

(7) The study has identified the persistent or endemic cores where malaria was high from 1968 to 1976 (map 6.4). These chief foci are Jamankira and Jujomora in Central Sambalpur; South Koraput; South Keonjhar and North Mayurbhanj. Of these the first core is most crucial as it had ~~the~~ high~~est~~ API values in 1968 and 1976. All the four cores are located in the plateau areas of high rainfall, poor drainage and forests, and high tribal population. The last two cores are located in areas of heavy mining activity.

Besides these four major foci there are other smaller cores that have developed between 1972 and 1976. They are in North West Bolangir, around Hirakud in Sambalpur, North Phulbani, South West Dhenkanal, central Keonjhar, South West Ganjam, North East Koraput, around Bhawanipatna and in central Mayurbhanj (map no. ~~13~~ 6.4). The new cores are largely found close to the major cores except in the case of North East Phulbani and South Dhenkanal. The foci of any disease needs to be identified as it is from here that the spatial diffusion of disease takes place. An attempt is made to mark out the directions of diffusion of malaria with regard to the four main foci as seen in Map No. 6.4. One finds that in 1976 a spatial expansion of two cores has taken place which have merged to cover a large area. These are the North East Phulbani - South West Dhenkanal - West Puri core and the North East Koraput - South West Ganjam - South West Phulbani core.

(8) As compared to the increase in foci and their spread, we find that there are certain districts having an absence of any notable foci. Balasore, Cuttack, Puri and Kalahandi are free of any cores except for a small one around Bhawanipatna. In the three coastal districts and coastal Ganjam the role of eradication measures explains the absence of any foci. The probability of the Mahanadi delta area being an important foci cannot be ruled out but due to the lack of data for 1976 it cannot be tested. The absence of any notable foci in Kalahandi is difficult to explain. The very steep and hilly nature of terrain along with low humidity and rainfall may partially explain the existing situation but this area provides scope for further research before any conclusions can be drawn.

(9) An important fact that emerges from this study is that Sundargarh district reports a sharp rise in incidence from 1968 to 1976. Even in 1972, it had fairly moderate API rates below 50 but in 1976 the entire district records very high API values above 50. Probable reasons for this can only

be suggested as this is another area for further research. This border district is a very important mining and industrial district of Orissa being very rich in mineral wealth. The rise in mining activities and the expansion of industry with the location of the Rourkela Steel Plant may have resulted in the rise in the immigrants. This is evident from the fact that Sundargarh has recorded (in 1971) the highest percentage decadal growth of 35.87 per cent and leads in Orissa in inter-state immigration and these in-migrants may have acted as carriers of malaria into Sundargarh. It is also possible that mining operations lead to formation of ill drained structures and stagnant pools because of the springing up of new settlements and construction work. These are only speculations and they need to be tested in a micro-regional environmental study.

(10) Altitude and incidence present an interesting correlation as evident from this study. Areas lying below 150 metre contour are areas of lower incidence in Orissa. Likewise, areas lying above 900 metre contour are also areas of low incidence due to the adverse effects of altitude on the mosquitoes. The reason for the low-lying plains having a low incidence is based to a large extent on the prevalent eradication measures here. The peak malarious areas lie between 300 and 600 metres in the northern plateaus and the eastern hills. In terms of altitude therefore, 300-600 metres offers the most favourable conditions for malaria.

(11) Besides altitude, slope plays an important role in malaria incidence, as on it depends the nature of drainage.

Steep slopes allow for no water collection and hence fewer mosquitoes while gradual slopes have water collecting in hollows and pools. In north Orissa, north of the Mahanadi, the slopes are gradual and the undulating plateau surfaces favour slow drainage and water collection. This may be a causal factor in the higher incidence of malaria in this region. On the other hand South of the Mahanadi valley slopes are steeper but there are also wide open upland plateaus fringed with hills in Phulbani, East Koraput and South West Ganjam where the incidence is also high. The flat plains are areas of low incidence. Thus, malaria appears to be associated with gradual slopes and undulating surfaces of the plateau topography.

(12) Malaria in Orissa is not confined to the hottest parts of the state, rather the malarious areas are found between 25°C and 27°C and in the interior. From our study, one finds, that temperature does not seem to play a very significant role in the incidence pattern as over most of the state temperatures are high and there is not much variation except in the hilly parts of South Orissa. The relationship between variations in humidity and incidence is not quite clear though the findings support the view that a humidity of 60-70 per cent and high incidence go together. Areas with over 70 per cent and under 60 per cent humidity have low incidence. With lower humidity, incidence falls as it becomes drier as seen in Kalahandi district. The low incidence associated with over 70 per cent humidity in the coastal tracts is better explained in terms of the eradication measures already referred to.

Rainfall reveals a clearer relationship from among the three climatic variables. Higher rainfall districts record high incidence and <u>vice versa</u>. Malaria in Orissa has a stronger correlation with rainfall than with the other two climatic factors. This point is further strengthened when we study the seasonal pattern of incidence and rainfall and observe the peaks in incidence being controlled by rainfall.

(13) The red and lateritic soils of poor drainage covering most of interior Orissa correspond to the higher incidence areas of the state. The areas of river alluvium report a lower incidence with the soil having a better drainage capacity. However, more analysis needs to be done on the relation between soils and malaria for a definite correlation to be established. These red and lateritic soils are used locally for building purposes. This construction work would mean areas being dug up and then pools forming with the rains which would act as breeding sources for the mosquitoes. This is only a tentative observation and this aspect merits further research.

(14) The districts of dense forest cover are the areas of high incidence (Map No.57) - Sundargarh, Koraput, Keonjhar, Phulbani and the forested parts of Dhenkanal and Ganjam. The areas having low forest cover are also the areas of low incidence. The only exceptions being Kalahandi where the dry deciduous forest cover may explain the low incidence due to lack of adequate moisture conditions. But, by and large, forests do seem to play a promoting role in the incidence of

malaria in Orissa.

(15) The relationship between irrigation and malaria incidence in Orissa is not quite clear in terms of present findings. Malaria in Orissa is largely found in the plateaus and hills where irrigation is low. It is the coastal tracts of Orissa that have a higher irrigated area but incidence is low. This does not conclusively prove the role of irrigation as much of the incidence is curtailed by eradication measures. But, in the Hirakud area the development of irrigation coincides with a rise in incidence in 1976. This inverse relationship between incidence and irrigation that is found in Orissa corroborates the finding at the national level by Akhtar and Learmonth.[1] More micro-level studies under controlled observations are necessary to understand this relationship which is generally regarded as a causal one.

(16) Rice cultivation creates conditions favourable for malaria as the flooded rice fields provide ideal breeding ground for the mosquitoes. As data on rice acreage was available only at the district level, this exercise in correlation is of a very generalized nature. In north Orissa, high rice cultivation and high incidence is met with but in South Orissa we find that low rice cultivation corresponds to high incidence and high rice acreage and low incidence is met with. The reason for South Orissa having low rice cultivation is the nature of terrain which restricts the cultivation of this crop.

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1 Rais Akhtar and A.T.A. Learmonth, "The Resurgence of Malaria in India, 1965-1976", Geojournal, vol. 1, no. 5, 1977, pp. 69-79.

But even in these areas acreage under rice is increasing and this cultivation of more land, along with the other environmental factors could explain the high incidence in South Orissa. It is necessary to establish if there is a relationship between the annual agricultural calendar including methods of watering of specific crops and incidence of malaria.

(17) Tribal population and incidence show a strong positive correlation in the state - tribal areas recording a higher incidence of malaria than the non-tribal areas. Some tribal areas reporting low incidence in 1972 were reporting a high incidence in 1976. Therefore, with the resurgence there has been a spatial spread of malaria in the tribal belt and the rise in incidence in 1976 was most marked in these areas. It is necessary to analyse further now for this rise in incidence is due to (a) immigrating carriers causing diffusion in new areas, (b) conditions favourable in the new areas for the malaria cycle and (c) lack of physiological immunity among the tribals or the non-tribal in-migrants and (d) the social inhibitions of the tribals to accept and adopt anti-malaria measures.

(18) An exception to the above finding is North West Koraput where we notice a high tribal segment but low malaria. The reason for this could be the fact that North West Koraput forms part of the Dandakaranya project for tribal development. This is a 'package' programme in which one of the main efforts was to control malaria which was high in the 1960s in this area. The low incidence of malaria in this region may be a

result of the success of this project in controlling the disease. This only emphasizes the need for similar measures in other tribal parts of the state.

(19) Population density has a negative correlation with incidence further proving the point that Akhtar and Learmonth[2] made in their study conducted at the national level. Low density areas are characterized by high incidence while high density areas have a low incidence. Population density by itself hence does not play a positive role in influencing incidence as the densely peopled areas have low incidence as it is here that the eradication measures are strong. Malaria in Orissa thus spreads over a large part of the state affecting smaller population groups rather than concentrations of population.

(20) One aspect of resurgence in Orissa is the sharp rise in falciparum cases (Map Nos. 8.1 and 8.2). The plasmodium distribution reveals marked temporal change between 1968 and 1976. In 1968, over 70 per cent of the malaria cases in Orissa were of the vivax type but in 1976 we find falciparum malaria emerging as a major contributor. Besides temporal changes there have been interesting spatial changes. Between 1968 and 1976 a reversal of species has occurred in coastal Orissa (PF to PV) and Central Orissa (PV to PF). The entire districts of Phulbani, Sundargarh and Keonjhar are under falciparum malaria. Areas of PV majority report low incidence

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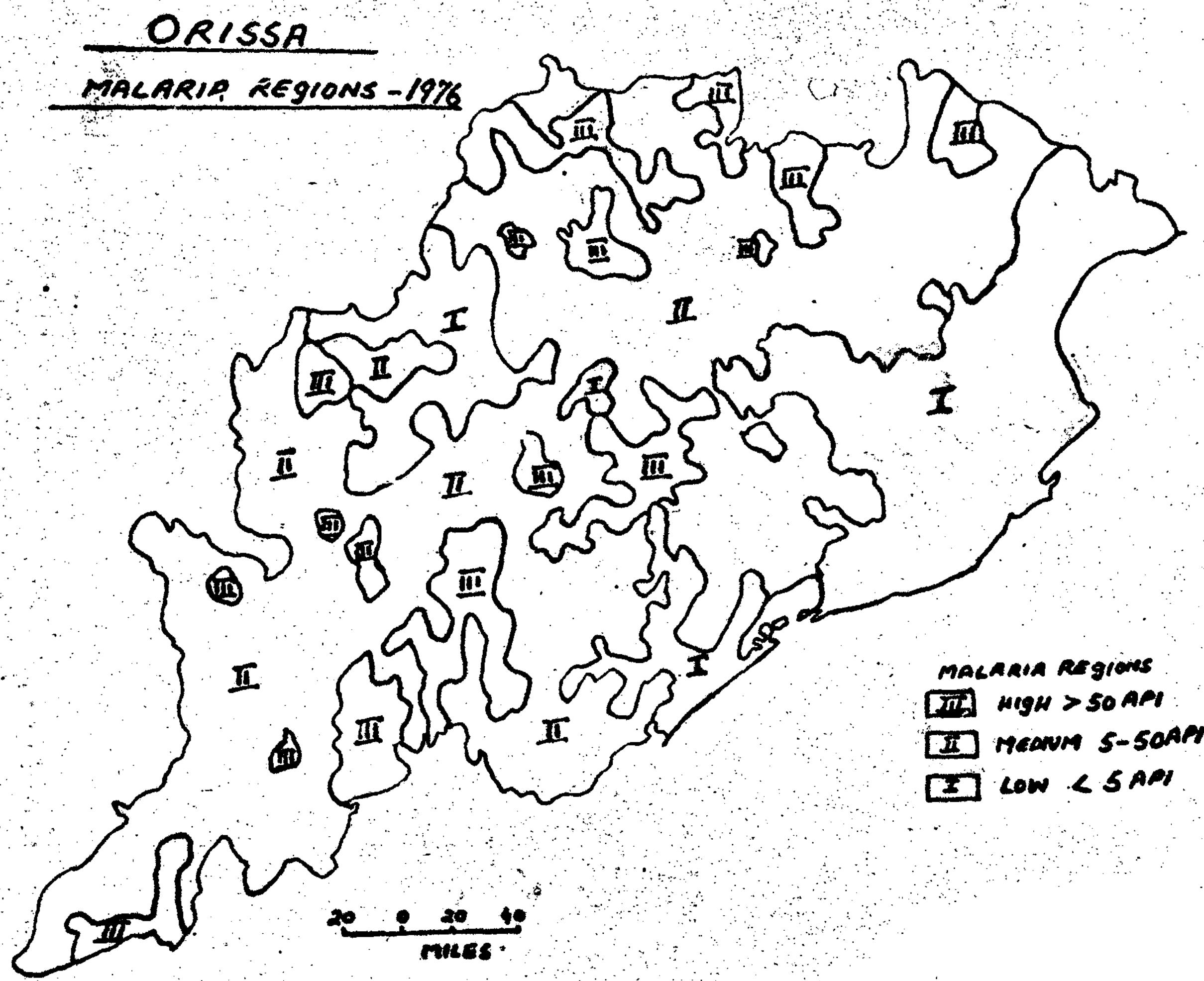
2 Ibid.


ORISSA
MALARIA REGIONS - 1976
MALARIA REGIONS
III HIGH > 50 API
II MEDIUM 5-50 API
I LOW < 5 API
20 0 20 40
MILES

MAP 9.1.

while areas of PF domination report high incidence. The emergence of falciparum malaria has serious undertones as this malaria is of a more virulent type with a higher mortality.

(21) Taking the incidence map of 1976 (Map 6.3) an attempt is made at identifying malaria regions of Orissa. The Map (No. 9.1) gives us a rough idea of the malaria regions of Orissa in terms of high, medium and low incidence. This regionalization has been done in order to bring out sharply the nature of malaria prevalence in the state, especially in terms of the high malaria incidence regions. It is hoped that in these regions identified efforts should be strengthened to control and check malaria.

Based on this study and on our findings certain questions emerge which need further research. These questions require a micro-level approach.

9.2 Some Questions Raised

The questions arising out of this study are:

(1) Does increasing human interaction with the environment lead to higher malaria incidence? Does agriculture favour malaria more than secondary or tertiary activity?

(2) What is the relationship between the annual agricultural calendar, including methods of watering of specific crops and incidence?

(3) How important is the role of migration movements of quasi-permanent nature, as in industrial and mining areas,

and of seasonal nature as in the "Rath Jatra festival of Puri, in the incidence of malaria?

(4) Why does Sundargarh record such a sharp rise between 1972 and 1976 when till 1972 the district had a low incidence?

(5) What are the reasons for Kalahandi having a lower rate of incidence of malaria and why has incidence here decreased considering Bhawanipatna unit had a high incidence till 1965?

(6) How can the high peaks of incidence in November in Bolangir and Kalahandi be explained? Why is there a smaller peak of incidences in April in many units? Why does Sundargarh have little seasonal variation in incidence when it has marked climatic variations?

(7) What are the micro-level factors that are responsible for the peak malarious tracts occurring between 300 and 600 metres?

(8) How far at micro-level situations do the poorly drained red soils and lateritic areas in Orissa, where worked out quarries entail stagnant pools of water, cause higher incidence?

(9) How far is the identified negative correlation between irrigation and malaria incidence due to anti-malaria measures?

(10) The peak incidence months of malaria occur in the post rainfall period which is the season of heavy agricultural activity in Orissa. What is the extent of economic loss in

terms of man hours by workers incapacitated by malaria? In assessing this economic loss, is it possible to argue that apart from the social obligation imposed in adopting anti-malaria measures, there is an element of economic viability in these measures?

(11) What is the role of improved health facilities in bringing down the incidence rate of malaria? Can the low incidence in the urban areas be explained through better health facilities?

It would be seen that the present study tries to correlate each aspect of the natural environment with malaria incidence. But in nature these factors operate by way of complex interactions and the malaria cycle constitutes an intrusion into the local ecosystem. As a further step to this study, it is necessary to seize out more important factors and measure their interaction. A rather ambitious factor analysis approach to selected sample areas is indicated. This should reveal a clearer picture of the malaria cycle and the causative and the restraining factors. The end product of such an exercise would test empirically its conformity to and deviations from a conceptual model of interaction presented later (Fig. 9.2).

Evidently this exercise would depend on the choice of the sample areas (having varying levels of incidence); availability of recorded data, generating data by field observations and enquiry including measurement of changes in natural aspects like soils, humidity and temperature, forests, drainage

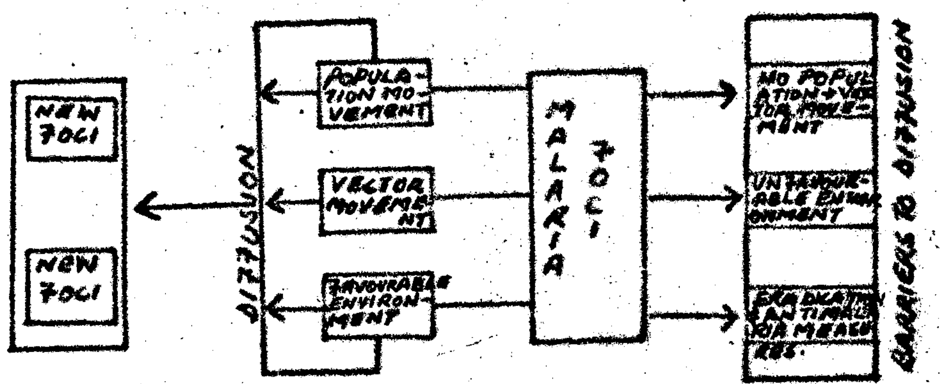


Fig. 91 A MODEL OF SPATIAL DIFFUSION OF MALARIA

characteristics and the local seasonal rhythm in the malaria cycle.

9.3 Some Theoretical Implications

9.3.1 Before concluding an attempt is made to present two spatial models based on the findings from the present study. The first is a simple spatial diffusion model which shows the nature of spread of malaria. An analysis of diffusion of disease affords an opportunity to consider how a variety of physical and cultural ecological factors may have influenced patterns of dispersal.[3]

From the study of Orissa, it was noted that a diffusion of malaria has taken place from 1968 to 1976. With the resurgence a spatial diffusion of malaria has occurred beginning with 1965 when the process was gradual but by 1976 it had diffused over most of the state. That a selection process of diffusion or spread of malaria seems to occur is evident from the fact that malaria in Orissa is largely found in dispersed clusters of population rather than in contiguous better populated areas. The process of diffusion is particularly seen in the tribal areas where the incidence has risen sharply in recent years.

For diffusion to take place there are certain required conditions. Firstly, there has to be an infected node or foci

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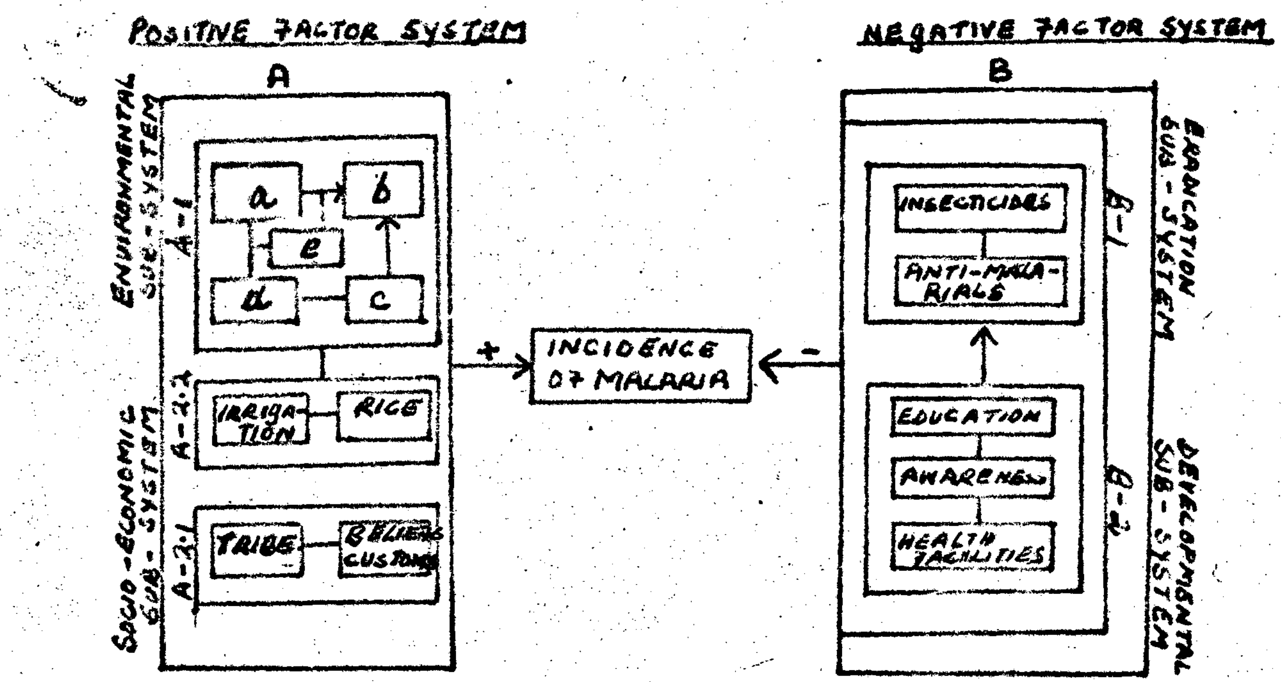
3 Such studies have been made, e.g., A.J. Ray, "Diffusion of Disease in Western Interior of Canada, 1830-1850", The Geographical Review, vol. 66, 1976, pp. 139-57.

and secondly, there has to be interaction among this and other regions through population movements. The migrant acts as a carrier and is significant in the diffusion process. Besides migration, if there is vector movement from the malaria foci to other regions diffusion may occur with the infected mosquito acting as the transmission agent. Besides these two factors, for diffusion to occur there should be suitable environmental and human conditions favouring malaria. Diffusion usually takes place from an endemic core to other areas which develop as smaller foci as seen from our study of Orissa.

The process of diffusion may be hindered due to some factors that act as barriers. If there is no interaction between a malaria foci area and other regions through migration then the process of diffusion gets checked as there are no carriers to spread the disease. If there is no vector movement then diffusion is not possible as the transmission agent is absent. In the process of diffusion of malaria there has to be either infected human or vector movements from the foci to other regions as these two are the channels of diffusion. For the transmission agent to be present and effective there are certain conditions required. When these conditions are unfavourable to the mosquito then diffusion is not possible. Another barrier to diffusion is man-made, namely, eradication, which implies the use of anti-malaria measures which prevent the spread of this disease by controlling the vector and parasite population.



a - UNDULATING RELIEF AND GRADUAL SLOPE
b - WATER STAGNATION
c - FORESTS
d - HOT-HUMID CLIMATE
e - POORLY DRAINED SOILS

Fig. 9.2. A MODEL OF INTERACTION

The main aspects of this model are highlighted in Fig. 9.1.

9.3.2 The second conceptual model presents the nature of interaction between incidence and the factors affecting it. Incidence is a function of two forces, the positive contributing variables and the negative set of contributors.

Incidence = Positive - Negative Forces

The diagram (Fig. 9.2) focusses on the main elements of this model. In our previous model we stated that there are certain conditions which favour malaria while there are some that do not. These factors are now elaborated upon. In the positive contributors to incidence, we consider certain environmental and socio-economic variables while among the negating contributors we include eradication and development. Among the positive environmental factors are undulating relief with a gradual slope of the land, high rainfall, humidity and temperature, water stagnation, poorly drained soils and forests. The socio-economic variables to be considered are irrigation, nature of agriculture especially rice cultivation, in-migration and beliefs and customs of the people. Each of these factors may over a specific time and space contribute towards the rise in incidence if an ideal combination of each of these factors exists. For example, steep slopes and an elevation of over 5,000 feet do not favour malaria rather gentle plateau surfances and a lower elevation are ideal.

Besides these factors another important contributing factor to incidence is the presence of the vector and the parasite. The presence of the vector or the female Anopheles mosquito is essential to the perpetuation and rise of malaria it being the transmission agent, while the parasite is the causative agent. The presence of this last stream is itself a function of the environmental and socio-economic conditions prevailing in a region.

Among the factors playing a negative role with regard to incidence, are eradication and developmental measures especially with regard to health facilities. Both these measures are responsible for controlling malaria. There does exist a positive correlation between malaria and underdevelopment and carefully organized development is necessary for its eradication.[4] It appears that some of the more direct interactions that humans have with their environment lead to a greater prevalence of malaria. Malaria is largely present in agriculture where primitive practises are used and there is poor land recovery. With a shift in the occupational structure from primary to secondary and tertiary activity there are chances of a decrease in malaria. Development, hence, plays a positive role in controlling malaria by creating an awareness of the problem and its solution and by providing better health facilities. Without proper development there can be no malaria eradication

4 G.D. de Bernis, "Some Considerations About Programme and Project Evaluation Techniques in the Field of Health", 1975.

as the masses need to be educated about the benefits of eradication.

Linked with development is the aspect of eradication. Eradication aims at attacking the vector and the parasite population and decreasing their numbers and effectiveness. This is achieved with the help of anti-malarials and spraying of insecticides. Eradication in turn plays a positive role in regional development and the difficulties of eradication are largely concerned with human ecology problems.

The incidence of malaria is therefore a result of these two sets of forces. When the positive forces are more dominant we have a higher incidence, whereas if the negative forces become stronger there is a decline in incidence. These forces operate over both time and space. In different parts of Orissa the role of these two forces varies resulting in spatial variations in incidence as seen from our study. There are temporal variations also in the role of these forces and in Orissa three phases can be identified. The early phase of high incidence prior to 1958 when the positive forces were strong; the phase from 1958 to 1965 when incidence fell with eradication measures being strong and lastly the phase of resurgence from 1965 onwards when the positive factors are again dominant (in this case the vector and parasite population) and eradication measures have become weak.

In the present study the spatial patterns of incidence have been identified. There are certain attributes of incidence in the form of positive and negative variables as seen from our study which have resulted in the variations in incidence and the spread of malaria. It is for the purposes of comparing the present study with similar studies of other regions in India and other malaria affected parts of the world, that the two conceptual models have been suggested - (1) the spatial model of diffusion and (2) the interaction model showing relationship between incidence and the factors affecting it.

These are mainly conceptual models derived as generalizations from the present study, and they require more precise testing at micro-level situations in Orissa. Such micro-level studies are likely to be seminal in understanding further - (a) the patterns and process of diffusion, (b) the role of barriers or suppressors to diffusion, (c) the critical focal points in the channels of diffusion where eradication measures may be concentrated, and (d) the importance of natural and human factors in malaria incidence.

Thus these approaches hold some promise in the theoretical aspects of spatial diffusion of a disease and in the practical applications towards its control and eradication.

In conclusion, it may be stated that this study is mainly centered on the spatial aspects of incidence and spread of malaria which has resurged in Orissa and on a search for causes of the patterns of malaria by way of spatial variations in environment. The clinical and physiological components are only marginally touched upon as they belong more properly to fields of Medicine, especially Environmental Medicine. Our attempt has been to show that significant patterns of malaria do exist and that the understanding of the incidence of malaria becomes more meaningful if the disease is also studied with reference to the spatial and environmental framework within which it operates. An understanding of these spatial environmental and human factors is vital in the implementation and success of eradication measures. This study makes no more claims than as an effort in identifying the spatial aspects and patterns of malaria in Orissa.

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