CONSERVATION AND SUSTAINABLE MANAGEMENT

OF

AVIFAUNAL DIVERSITY IN NORTHERN WESTERN GHATS, INDIA: A GEOGRAPHICAL PERSPECTIVE

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BY

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JUNE 2013

DECLARATION

I hereby declare that the thesis entitled "**CONSERVATION AND SUSTAINABLE MANAGEMENT OF AVIFAUNAL DIVERSITY IN NORTHERN WESTERN GHATS, INDIA: A GEOGRAPHICAL PERSPECTIVE"** completed and written by me has not previously been formed as the basis for the award of any degree or other similar title upon me of this or any other Vidyapeeth or examining body.

Sanjeev B Nalavade

Place: Pune

Date: June 2013

CERTIFICATE

This is to certify that the thesis entitled "**CONSERVATION AND SUSTAINABLE MANAGEMENT OF AVIFAUNAL DIVERSITY IN NORTHERN WESTERN GHATS, INDIA: A GEOGRAPHICAL PERSPECTIVE"** which is being submitted herewith for the award of the Degree of Vidyavachaspati (Ph.D.) in Geography of Tilak Maharashtra Vidyapeeth, Pune is the result of original research work completed by Shri Sanjeev B Nalavade under my supervision and guidance. To the best of my knowledge and belief the work incorporated in this thesis has not formed the basis for the award of any Degree or similar title of this or any other University or examining body upon him.

(Shrikant N. Karlekar)

Research Guide

Place: Pune
Date: June 2013

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ABSTRACT

Chapter 1: Study Area:

The present study is based on author's field experience, about wildlife in general and birds in particular, spanning more than three decades. The study area lies in northern Western Ghats. For the sake of convenience the study area is divided into two parts, one netted into another. The larger area covers more or less the 13 districts of western part of Maharashtra, including Konkan. The larger area is meant for general trend of distribution of the avifauna. The smaller area, which is a part of the larger area, is meant for specific studies, requiring more detailed enquiry. In a way this is the core of the study area.The core area covers four districts of Konkan (Thane, Mumabi city, Mumbai suburb, Raigad) and two districts of western Maharashtra (Pune & Satara). The main objective of the work is to study the avifauna from geographer's point of view-the patterns of distribution of various bird species and bird groups, the factors influencing the patterns, the faunal affinity and similarity between the study area and the rest of the country, changes taking place in the status of birds in the study area, impact of various drivers on the avifauna, etc.

Chapter 2: Methodology

One of the first steps was to prepare base maps & other maps. For this purpose NATMO, Collectorate maps, SOI topographical maps, Revenue & Forest maps, aerial photographs, satellite images from Wikimapia and Google Earth were used as the sources. Check-lists of birds belonging to different places, cities and districts within the study areas were collected. Birds were counted using various sample count techniques like the Line or belt transect

Point count and Block Count: Various methods were used for knowing the species richness, breeding status, seasonal Movements etc. of the birds. Foe developing bird maps, the bird locations were marked on maps using GPS points. A list of geographical factors, which influence the distribution of birds was prepared on the basis of available information. A lot of information was collected from people, the KIs(Knowledgeable individuals). For impact assessment, a list of impacting factors called 'drivers'

was prepared based on field data. List of equipments used (binocular,hand tally counter etc.) and, books and guides used are given at the end.

Chapter 3: History of Earlier study

The history of bird study in India, is divided into six periods on the basis of time-scale from ancient to modern. The six periods are i) Pre-Vedic Period ii) Vedic period (2000 BC-400 BC) iii) Post-Vedic period (1-1200 AD) iv) Moghul period (1525-1757) v) Colonial period (1800-1947) and vi) Post –Independence period (1947 onwards). The study is divided into two areas i) General bird surveys & studies and

ii) Zoogeographical studies. Studies done specially in the study area are highlighted separately.

Chapter 4: An Overview of the Bird Fauna

This chapter takes an overview of the avifauna of the study area. The study area has 484 species of birds. These are dealt with on the basis of 16 Orders and the families found therein. Birds from every family are briefly described along with the number of species found in the study area. Occasionally, there are comments on behavior and locational aspects.

Chapter 5: Factors influencing distribution of birds

Birds show certain patterns distribution. Some birds are quite common and are found everywhere. Some others are rare and are confined to small pockets in remote areas. Some species show continuous pattern of distribution, some other species are fragmented in their distribution. Some birds are concentrated around certain habitats, while some others are more or less evenly distributed. Why such patterns? A number of factors influences the distributional patterns of birds. These factors are listed group-wise as A) Evolutionary factors B) Innate factors

Environmental factors D) Geological factors and E) Human activities. Every group contains a number of sub-factors. Impact of every factor and sub-factor is discussed with suitable examples from the study area. The most important group is the environmental factors, which includes- Latitudinal

location**,** area, climate,(which includes rainfall, temperature , SW Monsoon wind, Monsoon season etc.), vegetation, food, and altitude. The Geological factors include cliff (escarpments), rocky features and soils. Human impact is the last but an important factor which influences birds through introduction of new species, habitat destruction and habitat changes etc.An overview of bird distribution of the area is discussed at the end with the help of GIS-based maps.

Chapter 6: Study Area: Faunal Affinity, Disjunct Distribution and Multiple-Route Theory

The study area lies in northern Western Ghats, which is part of the Peninsula India. The whole Indian subcontinent (except the higher Himalayas) is part of the Oriental zoogeographical region. To its north, is the Palearctic zoogeographical realm. The Ethiopian zoogeographical realm spreads up to the Arabian Peninsula. The flora and fauna of the whole region, including the bird fauna have evolved through time. It has been influenced by major geological, geomorphic, climatological & historical events which had taken place in the region during the last many million years, starting from the breaking up of the Gondwanaland, 200 million years ago to human activities of the recent times.The flora & fauna of India is influenced by the flora & fauna of 4 amphitheatres (centers of dispersal) viz. 1) Peninsular amphitheatre (native biodiversity) 2) Indo-Chinese & Malayan amphitheatres 3) Palearctic amphitheatre and 4) Ethiopian-Mediterranean amphitheatre. The faunal evolution of India has happened through receiving bird species from neighboring amphitheatres mentioned above. The major source has been the sub-regions, the Indo-Chinese and the Indo-Malayan of the Oriental region. The eastern fauna entered India through the Assam gateway and spread to different parts of the Peninsula via different dispersal routes.

A comparison of the avifauna of the study area with three other regions of India , namely: the north-western desert region, the Eastern Ghats and the north-east India, shows that the study area has the closest links to the Eastern Ghats, whereas it has the weakest link with the north-western desert region.

The disjunct (discontinuous) distribution of some species has been a key study area of Indian biogeography. Various hypotheses which have been put forth to explain it are discussed briefly. The most prominent of them, the Satpura hypothesis is dealt with in detail. The author has suggested a new entry route (Chittagong-Sundarbans route) of dispersal of the Eastern fauna into the Indian Peninsula.The author has also put forth a new thinking that the Eastern fauna (Indo-Chines & Malayan) may have used not one or two but many routes to disperse towards the South-western Ghats from Assam. This new thinking is called as 'The Multiple Route theory'.

Chapter 7: Patterns of Distribution

Every species has certain range of distribution. Every range of distribution has a certain pattern which can be best described on the basis of geometrical shapes. This chapter deals with various different types of patterns of distribution found in the study area.

The major patterns explained are 1) Continuous 2) Nucleated/Clustered/clumped 3) longated/Linear 4) Fragmented/Scattered/Dispersed 5) Disjunct/Discontinuous 6) Narrow endemic 7) Perforated 8) Spreading or Expanding 9) Reducing 10) Allopatric 11) Sympatric 12) Parapatric. Every pattern is discussed with suitable examples and the factors which are responsible for the patterns. Comparison of major distributional patterns shows that the Continuous distribution is the most dominant pattern, followed by Elongated, Uncertain Narrowly restricted, Fragmented and Perforated.

Chapter 8: The Changing status of birds in the Study Area

Every ecosystem, every habitat, every region keeps on changing with time. The physical environment changes first, which is then reflected on the biological environment. Biodiversity of an area also keeps on changing with time, and birds are no exception. The present chapter deals with the changes in bird status from the study area. The changes are with reference to population or range of distribution or both.

There are five possible trends i) Increase in population ii) Decline in population

iii) Stable population iv) Introduction of a new species. v) Extinction. Every trend is explained with suitable examples of bird species. The possible reasons behind the changes are also discussed. The case of house sparrow is discussed in detail. One positive aspect is that, no bird species has become extinct from the study area during the past 200 or so years.

Chapter 9: Threats to the avifauna and the impact assessment

The present chapter aims at assessing the impact of various man-made and man-induced activities on the avifauna of the region. The major impacting factors called drivers are identified as 1) Urbanization 2) Industrialization 3) Population growth 4) Transportation and traffic 5) Dams, reservoirs and multi-purpose projects 6) Recreational activities and tourism 7) Agricultural activities 8) Loss of and degradation of habitats 9) *Raab* practice and forest fires 10) MFP collection 11) Hunting, poaching and trapping of birds 12) roadkills and accidental deaths 13) Domestic cats and dogs menace 14) Explosive growth in scavenger bird population Pollution & 15) Mining and quarrying activities.

An Impact matrix is developed based on the impact scale ranging from 0 (No impact) to 5 (Very high Impact).Every driver is assigned a value based on its impact on birds.

Among all the drivers, Loss of and degradation of habitats , is the driver with the highest impact on birds, followed by Urbanization, Population growth, Industrialization, Recreational activities-tourism, Pollution, etc. The least impacting drivers are the Domestic cat/dog menace, MFP collection and growth in scavenger birds. The most impacted bird group in the study areas is the Urban birds. It is followed by Forest & woodland birds and Farmland birds. Aquatic & wetland birds and Scrub & grassland birds are the least impacted bird groups in the study area.

Chapter 10: Conclusion and Suggestions

This chapter at the outset discusses the importance of birds and the necessity to conserve them. It then goes on suggesting some innovative measures for conservation and management of the bird fauna of the study area. A four point conservation policy is recommended. The points are :

1) Preservation of existing habitats 2) Development of new habitats 3) Implementation of existing laws and 4) Environmental education, awareness and action

The priority list of existing habitats which need urgent attention is presented. For developing new habitats, a more innovative and practical approach is suggested. It includes developing smaller micro-areas, named here “Eco-spot”. An eco-spot may be a tree with a nest of a rare bird, a small pond, a banyan or bamboo complex or a heronry. Some new eco-spots are suggested with blue-prints. These are : Udyog van & Udyog taal (Industrial woodland and lake), Dakhkhan van (Deccan woodland),Quarry lake park, Private woodland and Deccan Eco-lake.It has been suggested that implementation of existing laws is one of the keys to the conservation.Conservation begins at home. Therefore conservation efforts at the individual level are emphasized. Efforts at the organizational and governmental levels are also listed.

Possible future projects are also listed at the end.

Chapter 1
INTRODUCTION

1.1 Origin of the Study

The present work has its origin in the author's interest in and association with birds which started way back in September 1975.The author was initiated into bird watching as a result of a chance encounter with a book on birds by late Dr.M.V.Apte, a veteran natural historian of the bygone era. The habit (or obsession?) of the author to maintain records in the form of written notes, diaries, news paper cuttings etc. piled up into voluminous data over a period of three decades. His subsequent interest and training in geography provided a different unique point of view for looking at birds. The present work is the culmination of studying birds through a pair of geographical glasses.

During the early days of this hobby the author visited nearby areas around Pune for getting familiar with birds. As his interest in wildlife in general and birds in particular developed further he expanded his geographical field farther into Western Ghats and Konkan. During these sojourns it was realized that sets of birds changed with changes in height, habitats, forest types and relative locations. When put on maps it was further realized that there were certain patterns of distribution, movements, contraction or expansion of ranges etc.

Thus though it started as a hobby, the project eventually evolved into an integrated geo-ecological and bigeographical study of the northern Western Ghats with birds as the core component of the study. As the study evolved further it was realized that it was possible to develop a conservation model for the northern Western Ghats as the basis of the present study. It is hoped that the model could be replicated elsewhere in the country with similar geographical and ecological situation.

1.2 Aims and Objectives

The area under study lies in one of the most urbanized regions of India and therefore the urban footprint is visible everywhere. Though there is a long history of bird study from the area there are many gaps also. Nobody has ever tried to study the birds from geographer's point of view. Hence this study is the first such attempt for the area concerned.

Though half a dozen different objectives have been defined, the final aim of the study is to develop a conservation model for the region. All the objectives lead towards the final aim.

The major objectives are:

- To determine the changing status and distribution of selected bird species.
- To identify distributional patterns of selected bird species.
- To study the effect of topography, climate and vegetation on the distribution of avifauna in general and individual species in particular.
- To determine the impact of anthropogenic activities including urbanization-the major player of the region.
- To suggest measures for conservation of birds and develop a model for conservation and management of the avifauna of the region.

1.3 Study Area

1.3.1 Choice of Study Area

The area of the present study lies in the northern Western Ghats of Maharashtra.There were certain reasons for choosing the northern Western Ghats as the study area .These were-

- The northern Western Ghats is the northern extension of one of the two biodiversity hotspots of India-the South-Western Ghats.
- It is part of the Satpuda highway of migration of the Indo-Malayan element into the South-West of India.
- Its north-south orientation, more or less parallel to the west coast is arranged in such a way that it obstructs the south-west monsoon, thereby creating a narrow heavy rainfall belt all along its western flank and the crest line and a rain shadow area towards the lee side.
- This north-south arrangement of isohyets has given rise to similar arrangement of vegetation belts parallel to the main range of the Ghats.
- The arrangement of vegetation has given rise a typical faunal pattern including birds
- The area under study has a long history of faunal study including the avifauna. This has made comparative time study possible.

No one has ever studied the avifauna of the area from geographer's point of view. This is the first such attempt. The author is based in Pune thereby making any place in the study area easily accessible that too within a short period of time. Even the farthest place in the area is within five hours traveling time by road.The author is "At home" with the area and has been visiting, studying and collecting wildlife related information for the last more than thirty years.The author has also been a witness to the rapid physical changes taking place in the region along with the changes in the fauna of the region.

It was therefore appropriate for author to select the northern Western Ghats as the area of study.

1.3.2 Types of Study Area

Two types of study areas were defined

1) General study area

2) Specific study area.

The former was chosen for identifying broad distributional patterns and general geographical factors affecting them. In bigeographical studies, larger the area, higher is the possibility of faunal and geographical diversity. The specific study area was chosen for more intensive and serious study of the subject with final aim of developing a conservation model.

The general study area stretches from Nashik Ghats in the north to the Warna basin in the south, a distance of about 400 km and from Mumbai-Alibaug-Srivardhan along the Arabian Sea coast in the west to Daund-Baramati in the east, a distance of about 200 km. The specific study area, which is within the general area, stretches from Bhimashankar in the north to Koynanagar in the south for about 150 km and from the coastline in the west to Purandar fort in the east for about 130 km. The total area of the general and specific study areas each is about 100,000 km^2 to 40,000 km^2 respectively. The general study area covers whole or part of eleven districts, viz.-Nashik, Thane,Mumbai city,Mumbai suburban, Ahmednagar, Pune, Raigad, Satara, Sangli, Kolhapur and Ratnagiri. The specific study area covers only six districts – Pune, Thane, Mumbai city, Mumbai suburban, Satara and Raigad.

The approximate latitudinal and longitudinal extents of the general study area is 16° N to 20° 30'N and the longitudinal extent is 72° 40' E to 76° E. The same for the specific area is 17° N to 19° 30' N and 72° 40' E to 74° 30' E.

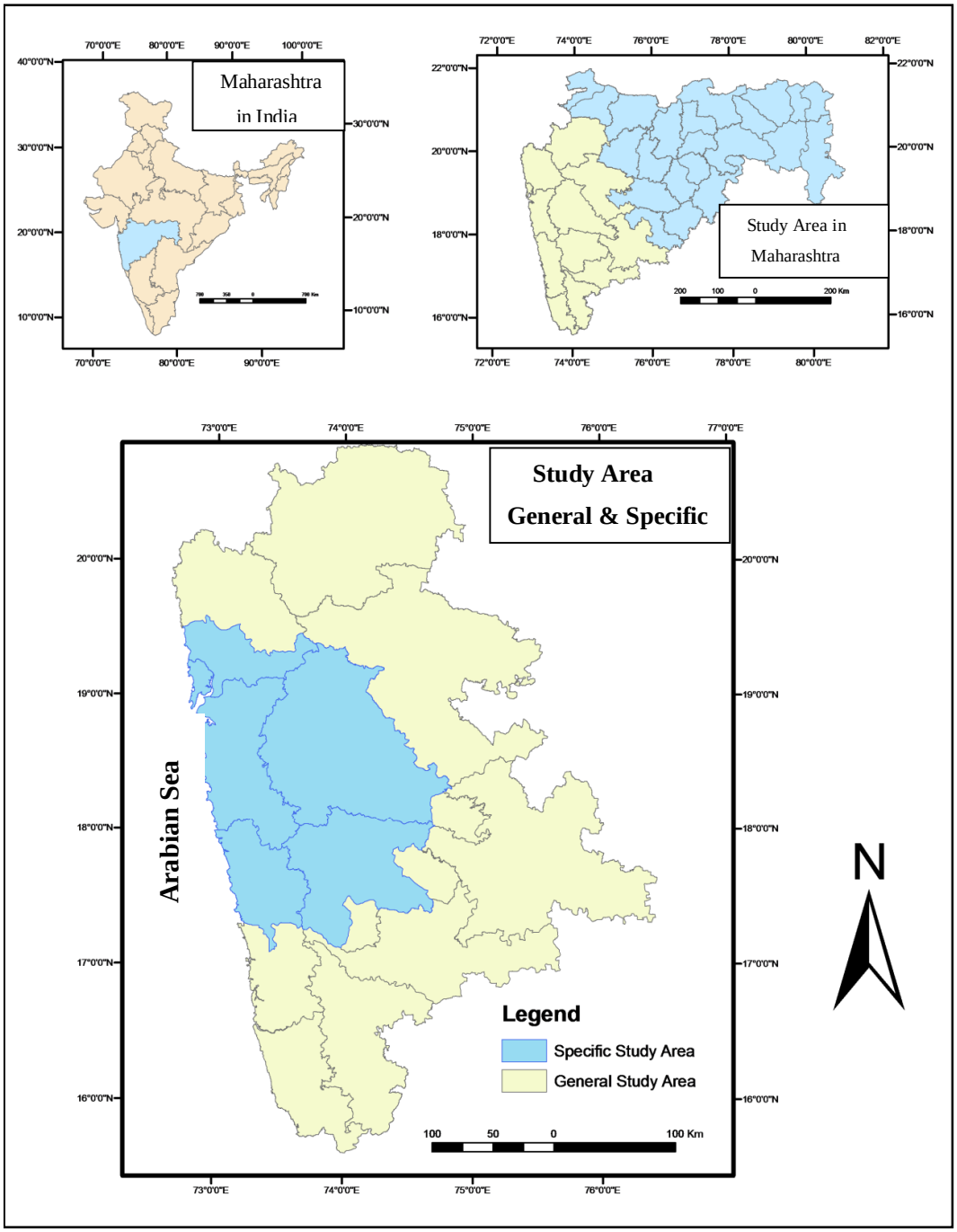


Fig.1.1 Location of Study Area

1.4 Topography

Most of the study area lies in the Western Ghats region. The study area can be divided into three broad physiographic divisions-

The coastal lowland

The Western Ghats or Sahyadri

The Upper Deccan plateau

The Coastal lowland:

This is a narrow belt of rugged topography. A number of rivers originating from the Sahyadri have carved out their valleys giving rise to flat-topped interfluves in between. The major rivers within the study area are Ulhas, Patalganga, Amba, Kundalika and Savitri. The interfluves are about 200 m high and support degraded vegetation. The overall height goes on increasing towards the foothill zone in the east and there are isolated hills towering above the surrounding valleys. These include Matheran (766 m), Manikgad (575 m), Sarasgad (750 m) and Raigad (868 m)

The Western Ghats:

This is the most important physical feature of the study area. In other words it can be said that almost eighty percent part of the study area is occupied by this feature. Though popularly known as mountains the Western Ghats are considered by many as the western edge of the Deccan plateau. (Dikshit 1986). Locally called Sahyadri this range extends within the study area from Nashik district to the north to the Warna basin in the south. Along its western edge the Sahyadri forms a long winding north-south line of cliff, the Western Ghats escarpment. This line of cliff, at places more than 600m high, descends down in steps and merges with the Konkan lowlands. The steps formed by the break in slope are mostly inaccessible and support good vegetation cover as at the Padarchi Wadi below Bhimashankar. Such isolated forest patches are good birding spots.

The average height of the crest line, locally called the Ghatmatha, is 700-900 m. The highest point in the Sahyadri, also of the study area, is the Kalsubai peak (1646 m) in the north. Other important peaks/high crest-line plateaus (north to south) are

Harishchandragad (1424 m)

Sinhagad (1314 m)

Torna (1400 m)

Rajgad (1400 m)

Raireshwar (1430 m)

Mahabaleshwar (1438 m)

Within the study area lie sources of many important plateau rivers like Triambakeshwar (R.Godavari), Bhandardara (R.Pravara), Bhimashankar (R.Bhima), and Mahabaleshwar (R.Krishna). From the main range of the Sahyadri a number of ridges run eastward forming a narrow hilly stretch to the immediate east of the main crest known as Maval. Pune urban area forms the eastern edge of the Maval.

The Upper Deccan Plateau: This area lies to the east of the Sahyadri proper. The plateau is formed of a series of alternating river valleys and interfluves. The interfluves are the eastern offshoots of the main Sahyadri range formed by the rivers rising in the Sahyadri and cutting their way through the plateau. From north to south the arrangement is shown in following figure.

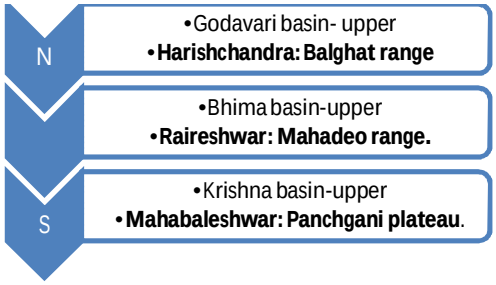


Fig.1.2 Eastern offshoots of Western Ghats (Sahyadri)

The average height of the plateau decreases from 650 m in the west, near Lonavala to 500 m in the east. The height of Pune city is 559 m. Pune is located in the Mula-Mutha basin,a twin tributary of the Bhima. The city is surrounded on all sides by low hill ridges. Its southern boundary is formed by the Sinhagd-Bhuleshwar range, Sinhagad forming the highest point (1314 m.) of the Pune urban area.

The geology of the area is mostly simple, the most important and dominating feature being the basaltic Deccan plateau. The rock basalt which forms the plateau is called the Deccan Trap. The basalts are overlain by alluvial deposits of recent origin in the river valleys. (Deshpande 1998)

The basalts have undergone chemical weathering in the high rainfall areas of the Sahyadri, in the process giving rise to laterite. Two sites with prominent laterite cover within the study area are Matheran and Mahabaleshwar, the popular hill stations.

An important micro-geological feature that was noted down in the present study was the layers of red bole or red bed. These relatively soft and brittle red layers are found as intertrappean beds all along the area especially in hilly districts and in the scarp zone. Being soft they weather and erode faster giving rise to cavities and caves, which are used as nesting sites by many cliff-nesting birds such as Long-billed vulture and kestrel.

The common soil type of the area is the reddish and yellowish brown soils of the Ghats country. The teak forests of the Ghats country are mostly found on these soils (Dikshit, 1986). Lateritic soils are mostly confined to Matheran and Mahabaleshwar plateaus. The medium deep black soils, also known as *regur*, are mostly found along the river valleys and flood plains of the Bhima basin.

1.5 Climate:

The overall climate of the study area is the same as in the surrounding country. It is best described as the tropical monsoon climate, the monsoon being the most dominating character. Two important features influencing the climate of the region are the close proximity of the Arabian Sea and the north-south orienting Western Ghats mountain chain. The Monsoon winds come from the south-west ,from over the Arabian Sea and are obstructed by the towering Sahyadri range along its path giving heavy orographic showers in the Konkan and in the Ghatmatha region. On the lee-side of the mountain the rain-shadow effect is visible with sudden drop in rainfall.

As in the rest of the country the study area also has three distinct seasons:
i) Hot weather season ii) Southwest Monsoon season iii) Cold weather season.

Hot weather season:

This season ranges from March to early June, April and May being the hottest months. The weather throughout the Ghats country is pleasant and the mean maximum temperature rarely rises above 30° C at Matheran and Mahabaleshwar. In the foothills belt and the lowlands to the west it is slightly above 30° C and sultrier, an impact of lower height and proximity to coast .At places like Nashik and Pune the mean maximum daily temperature is between 35° to 40° C. The relative humidity is low on the plateau, around 20 to 25 percent, but high (up to 50 %) in the Ghats country and the Konkan. There are occasional thunderstorms in the later part of the season which brings some thunder showers thereby ameliorating the heat.

Southwest Monsoon season:

The monsoon season stretches for four months from June to September. The season starts in the first week of June and the average onset date for Pune is around 7th June. The rainfall amount varies from 500 mm around Daund-Shirur to more than 6000 mm in the hilly Western Ghats. Most of the rains are received in the four monsoon months.

The rainfall increases as one move from the coast towards the Sahyadri due to the orographic effect. Whereas Alibaug gets around 2045 mm many foothill locations receive more than 3000 mm of rain. Some of the wettest places within the study area are Mahabaleshwar (6200 mm) and Matheran (5200 mm).

Towards the east of the Sahyadri there is a sudden drop in rainfall due to rain shadow impact. Lonavala located in the Ghatmatha (crest line) belt receives 4300 mm rains. Vadgaon, located hardly 24 km east of the crest line receives 1120 mm, whereas Pune at 50 km from Lonavala receives only 660 mm. (Dikshit, 1986). Most isohyets, especially those between 800 mm and 2800 mm run parallel to the main Sahyadri range. The relative humidity is around 70% to 90% in most areas. The Ghats country is fully clouded on most days during the rainy season. By the end of the Monsoon the greenery is at its peak. All kinds of grasses, herbs, and shrubs are found growing in profusion.

The Post-Monsoon period:

There is a short transition period between the Monsoon and the cold season. This season generally coincides with the month of October. During the first half of this month the withdrawal of the South-west monsoon starts. Some rainfall during this period is associated with thunderstorms. There is an increase in day temperature and herbs and grasses start drying.

The Cold Weather Season: This season stretches from November to February.

This is a fair weather season with cool & dry climate, gentle winds, and clear blue skies. The mean daily maximum temperature ranges from 28° C around Alibaug to 30° C inland. The mean daily temperature ranges from 20° C on the shore to 12° C around Pune. For a bird watcher this is the busy season with peaking activity, diversity and population of the winter migratory birds.

1.6 Vegetation:

Around 22 % land area in Maharashtra is under forest. Within the study area most of the plateau talukas in Pune district have 25 % area under forest, whereas in the

adjoining foothills areas of Raigad and Thane about 33% to 50 % land area is under forest. The Mahabaleshwar has more than 60 % area under forest. The forest in the study area falls under the following five categories. (Champion & Seth 1968).

Subtropical broadleaved evergreen hill

Tropical Semi-evergreen

Tropical moist deciduous

Tropical dry deciduous

Tropical thorn

Subtropical broadleaved evergreen hill forest:

Within the study area these forest are confined to the heavy rainfall areas of the Matheran and Mahabaleshwar plateaus. The forest is evergreen throughout the year because of high rainfall (more than 3200 mm) but show stunted growth because of edaphic impact. Steep slopes and a long dry season also keep them stunted.

The average height of the forest is 10 to 15 m. At favorable places like stream bank it may attain a 20 m height. There are generally two layers of vegetation. The upper story consists of taller trees of Jamun (*Syzygium cumini*), Pisa (*Actinodaphne angustifolia*) and Hirda (*Terminalia chebula*) while the middle storey is made of Anjan (*Memcylon umbellatum*), Gela (*Xeromphis spinosa*), and Parjambul (*Olea diocea*). The shrub & herb layer consists of Rameta (*Lasiosiphon eriocephalus*), Tambat (*Flacourtina latifolia*), Chimat (*Scutia circumcissa*), Papat (*Pavetta indica*), *Strobilanthus* sp. and a variety of ferns. Puri & Mahajan (1960) have identified three types of vegetation within this forest as i) Evergreen high forest ii) Evergreen scrub & Open treeless terraced areas. Such division is important for local bird study.

Tropical Semi-evergreen forest:

These forests occupy those areas where rainfall is 2500 to 3000 mm. These forests form the transition zone between the Tropical evergreen and the tropical moist deciduous forest. They are mostly confined to the Ghatmatha belt and within the study area are found around Khandala, Ambawane, Tamhini, Panshet catchments, Bhatghar catchments and Varandha Ghat area. The average height is 15 to 20 m. and the common trees found are-Mango (*Mangifera indica*),Umbar (*Ficus glomerata*),Ran Phanas (*Artocarpus hirsuta*),Nana (*Lagerstroemia lanceolata*) and Kadamb (*Anthocephalus cadamba*).Some deciduous species like the Silk cotton also start appearing here.

Tropical moist deciduous forest:

These forests are found in the areas with rainfall ranging from 1000 mm to 2500 mm. They are mostly seen on the either side of the crest line at relatively lower heights, at Bhimashankar, Varsai-Manikgad, Raigad and Rajgad-Torna ridge. The most important tree species here are Teak (*Tectona grandis*), Ain (*Terminalia tomentosa*), Silk cotton (*Bombax malabaricum*), Bondara (*Lagerstroemia parviflora*), Kusum (*Schleichera oleosa*), and Raan avla (*Embelica officinalis*). A variety of bamboos also grows in profusion in this forest.

Tropical Dry Deciduous forest:

These forests occur in those areas where the rainfall is relatively low- 1000 mm to 1250 mm. Within the study area they are confined to the Maval tract in Pune district mostly in the ravines surrounding the hill forests. Lohgad, Visapur, Tikona, Simhagad etc. The hill vegetation around Pune and Varsai also belongs to this category. The common trees are Teak (*Tectona grandis*), Dhavda (*Anogeissus latifoila*), Palas (*Butea monosperma*), Khair (*Acacia catechu*), Salai (*Boswellia serrata*), Moi (*Lannea grandis*), Shivan (*Gmelina arborea*) and Ain (*Terminalia tomentosa*). There are occasional bamboo clumps. These forests are heavily depleted because of withdrawal of fire wood from them.

Tropical Thorn forest:

This is the commonest forest type of the drought-prone area with less than 600 mm of rain. These forests are mostly confined to the eastern margin of the study area around Shirur, Jejuri and Dive Ghat on the eastern outskirts of Pune. The forest is thin and the trees are scattered. The main trees found here are Babhool (*Acacia nelotica*), Bor (*Zizyphus mauritiana*), Hivar (*Acacia leucophloea*), and Neem (*Azadirakta indica*). The last is a common roadside tree. Being hardy and drought resistant it is one of the most useful trees from the ecological point of view. Tarvad (*Cassia auriculata*) with its fine yellow flowers is the commonest shrub of the open "*maals*" (plain, rocky grass and scrub country). This is the most depleted forest of the area. Most of the trees mentioned above are used as fire wood. The dense urban shanties further increase the pressure. Furthermore this forest is making way for rapidly growing urban and semi-urban settlements, industrial estates, and SEZs.

Tidal forest:

The tidal forest is found on the inter-tidal zone along the creeks, estuaries and mouths of rivers along the Konkan coast.Thses are also called as the Mangrove forest.The plants here are well adopted to the saline environment created by rising and falling of tides.Some prominent mangrove patches within the study area are those at Vikhroli(Mumbai),Revas,Alibag,Revdanda and Rajapuri creek.The dominant species are Avicennia marina and A.ifficinalis.A few bird species like the Black-capped kingfisher (Halcyon pileata) are denizens of these forest.

1.7 Habitat Diversity:

The study area is washed by the Arabian sea along its western edge.It is more or less divided by the Western Ghats range into low lying humid Konkan to the west and the semi-arid, dry Deccan plateau to the east.The area therefore supports a variety of habitats.It includes a variety of forests types (from dense tropical evergreen to open thorn), a variety of wetland -rivers, lakes, ponds, paddy fields, monsoon puddles etc., The marine habitats include shallow sea,beaches, mud flats,sand bars, headlands with cliffs etc.The area is also rich in various different forms of rocky habitats-rocky shores,lateritic plateaus locally known as ‘sada’, rock fileds and tors of the upper Deccan,high cliffs and escarpment of the Ghats country etc.The human-managed habitats include farmlands,plantations,villages,towns,cities,industrial parks,etc.The diversity of habitat (Plate 1) therefore leads to diversity of birds.

PLATE 1.1 STUDY AREA: HABITAT DIVERSITY



COASTAL:
BEACHES, HEADLANDS, CREEKS (RATNAGIRI)



FRESH WATER:
KOYNA RESERVOIR (SATARA)



FOREST:
EVERGREEN TYPE BHIMASHANKR (PUNE)



GRASS & SCRUB:

BHULESHWAR RIDGE NEAR PUNE



LATERITE PLATEAU:

KAAS PLATEAU,NEAR SATARA



URBAN LANDSCAPE:

PUNE CITY

Chapter 2

Methodology

2.1 Introduction

Study of birds may be done with behavioral, ecological, demographical as well as geographical approaches depending upon the purpose and objective of the study. The methodology to be used depends a lot on the objectives. To achieve the already defined objectives the present study required to follow the following steps.

- Preparation of Base maps and other maps.
- Preparation of a master list of birds for the study area as a baseline document.
- Information about topography, geology, soil, vegetation, climate, water bodies etc which impact the bird distribution
- Information and survey about various aspects of birds such as geographical range, population and breeding status, abundance, species richness, migratory movements etc. Such information forms the basis for developing a conservation model.
- Land use study
- Vegetation study
- Human impact assessments

Table 2.1: An Overview of Methodology and Techniques used

Sr. No.	Objectives	Data/Information to be collected	Methodology used	Techniques used
1	Changing status and distribution of selected bird species.	Past & present location & demographic information about birds	a)Checklist & Inventorying b) Mapping	a)Secondary data collection b)Actual field data collection & Relevant map making techniques
		Bird population size	Sampling method	Line/belt transect Point count Block count
		Species richness Relative abundance	Sampling method	Timed Species Count

2	Distributional patterns of selected bird species	Past & present locational info. about birds	a) Checklist & Inventorying b) Mapping c) Information from people	a) Secondary data collection Actual field data collection b) Relevant map making techniques c) Interviews
3	Effect of geographical factors on the distribution	Data/Information about identified geographical factors	a)Secondary information from various sources b)Field data collection for filling gaps & updating	a)Secondary data collection b)Data collection through Field visits
		Topography Weather/ Climate Vegetation Wetlands	Toposheet study Primary data collection Primary/Secondary data collection Primary & Secondary data collection Use of maps Secondary data collection Primary data collection	Preliminary terrain analysis IMD data/Preliminary field notes Line Transect /Quadrate techniques Finding relative location Measurement of surface water area Info from irrigation dept. Field observations.
4	Impact of anthropogenic activities	Data/Info about identified major Human activities as impacting factor	a) Data/Information from secondary sources b) Field data collection	a) Secondary data collection b) Data collection through field visits c) Impact Matrix
5	Identify indicator species	a) Presence/absence and population changes of indicator species. b) Healthy/unhealthy Environmental changes	a) Past & present records/checklists Changes in species composition Comparison method b-1) Primary data collection	a) Secondary data collection a-1) Field study

2.2 Preparation of Base maps & other maps

Since the present study has a very strong geographical bias, use of maps was an integrated aspect of the study. The base-map was prepared to cover the entire study area. For preparation of the base-map following map sources were used.

- The Bombay sheet of the NATMO (National Atlas & Thematic Mapping Organization)
- Collectorate maps of six districts- Ahmednagar, Thane, Pune, Raigad, Satara, Sangli & Ratnagiri
- SOI topographical maps (one-inch maps of 47 F & 47 G series) for detail study.
- Revenue maps/cadastral maps used for some localities (for Bhimashankar, Matheran, Khandala and Mahabaleshwar)
- Forest maps
- Aerial photographs available for certain selected areas (mostly around Khandala) for knowing previous land use of the area.
- Satellite images for mega as well as micro-level studies. These are available on the available online on the Wikimapia (www.wikimapia.org) and the Google Earth (www.google.com) was also frequently used. These were used for knowing present day/latest land use changes. The Geotools on the Wikimapia were also used for calculating areas or for measuring distances. Many other maps were also prepared which show interrelationship/links between birds & their environment, range maps, migratory routes, threatscape etc.

2.3 Preparation of Master Bird List:

As per the objectives of the study we need to know the changing status of birds and past and present distributions of birds of the study area. We also hope to develop a conservation model for the birds. To achieve these objectives we need some basic information about some species,

Whether;

- The species is found in the study area
- Seen in the past, but no recent records
- Was never seen in the past but the species is seen/found presently, may be a new entrant in the region

For such information the main secondary source is the bird checklists of various places/regions .A checklist is an inventory of birds seen/found in an area. There are many shortcomings of checklist. Some of them are:

- It may cover most of the birds found in a given area-almost nearly a complete list or it may cover only a part of the total bird fauna.
- It may cover a small area, may be a bungalow compound or may cover a larger geographical area –a town, taluka, district or a province.
- There may just be one single checklist available for an area or there may be a series of updated checklists available for the same area over a long period of time.
- A checklist may just be a mere casual list of species seen at a place on a particular day, at a particular time or it may be a comprehensive list of birds based on work of many years along with status of each species.
- A checklist may have been prepared by a layman or non-expert and may contain wrong information or wrongly identified species.

In spite so many shortcomings a checklist is a very useful information tool in bird study. It is especially useful in knowing the past status of a bird or a group of birds. A comprehensive and reliable checklist may be used as baseline data. A reliable, comprehensive checklist for an area is a readymade document and saves our time, energy and efforts for collecting basic information from scratch. If such a list is not available for some places (which is very much possible) then one has to make one's own list based on field observations.

For the present study area more than 25 checklists are available as secondary data. The author has collection of bird information in the form of diary notes based on his own field observations. This voluminous data collected by the author for more than thirty years (from 1975 onwards till date) is placed in more than 150 plus diaries measuring many thousands of pages. The author developed a master checklist based on the available checklists and his own observations.

2.4 Bird Status:

For developing a conservation model for birds, the first prerequisite is to get information on the population of the listed bird species. One can get to know the population status of birds through

- Published work/checklists
- By physically censusing the birds in field.

There are two kinds of bird status a) Geographical status and b) Population status.

The status used in the present study is a simplified one based on Abdulali (1981), Kazmierzak (2000) and Grimett et al. (2011), rather it is a combination of what these three have used.

The geographical status includes following categories:

BR-Resident breeding

NBR- Resident Non-breeding

M- Winter migrant/visitor

S- Summer visitor

BR- Breeding migrant

LM-Local migrant

PM-Passage migrant

S- Stray or vagrant or accidental visitor

I-Introduced

?- Uncertain status

The categories under population status are:

Very common-VC

Common- C

Occasional- O

Uncommon or rare- U

Stray- S

Absent- A

2.5 Counting Birds:

Why count birds?

Knowing the approximate or exact number of birds is one of the basic aspects of bird study.Population data are one of the basic requirements of wildlife conservation and management. We require knowing bird population of different species or bird communities as a whole for the following reasons.

- The population size of those birds which are endangered or declining in numbers.
- The number of those birds which are pests/scavengers and whose population is rising.
- For comparing diversity of two different areas (e.g. between a highly disturbed and less disturbed forest habitats.
- For identifying important bird areas meant for conservation.
- For temporal comparison e.g. population size comparison between say 1970 and 2000 data. Such a comparison will decide whether the number of a certain species/bird community has increased, decreased or is stable.
- Routine periodic count for monitoring and managing protected sites or habitats.
- Population density is useful for understanding the ecology, behavior or pest aspect.

2.5.1 Field Techniques for Counting Birds.

There is no single technique that can be used for counting all types of birds. This is mainly because birds differ in terms of their size, behavior traits, habitat preferences etc. (Urfi, 2004). So a census method useful for one species or habitat is ineffective for another. In the ornithological literature, a variety of methods have been described.

Bird census methods are generally divided into two categories viz.

1) Direct and /or Total Count

2) Sampling Count

Direct or total count: Here an attempt is made to count all the animals (individuals) in a given area. This method works best when the area is very small (a few acres) or there is a congregation of birds. (Roosting birds, feeding colony, heronry, rookery etc.) The birds at roosting colonies are generally counted in the evening when most birds return to the roost. A congregation or flock of birds can also be photographed and individual birds can be counted later leisurely from the enlargements. Barring the count at few heronries and roosting colonies the present work did not attempt direct count. In fact it was not required.

Sampling count: It is not possible to count all birds in a given area and is also not required except for some large-sized, endangered, rare birds. Majority birds are

small in size, many of them have secretive habits & a large number of them have dispersed population. For such a situation sampling count is the only method. Generally a small part of the whole area is sampled and the findings are extrapolated for the larger area. Techniques of sampling count: Two techniques are widely used for monitoring birds in the field. These are

A) Line or belt transect
B) Point count.

A) The **Line or Belt Transect** is one of the popular techniques for sampling bird population. This involves recording the number of birds encountered/seen/observed along a definite length or line of habitat. This technique has certain advantages:

- It enables us to cover larger area.
- It is less cumbersome.
- It is very practical
- It is efficient
- It is relatively inexpensive

For the present study more than 200 transects were identified and monitored for the whole study area. While using this technique following standards were followed.

- The length of transect was different in different habitats. It was 200-500 m for urban areas, 800 m for forested habitats and 1000 m for open grass & scrub country.
- In case of fixed width transects the width was taken as 50 m for dense forest habitats and urban localities, 100 m for grass & scrub. A few open width transects (no fixed width limit) were also tried in degraded open forest and scrublands.
- The transects were chosen randomly on maps
- All transects were conducted in the morning and evening hours.
- Whenever and wherever transects were repeated, same length, width and time was maintained.

While monitoring birds along transects bird calls were also taken into consideration along with actual sightings. In case of unidentified calls ,the calls were syllabized/recorded in the field and identified later with the help of a bird call CD ("*Ga Vihangano*") published by Ruturang, Pune. This CD covers birds' calls mostly

from the Western Ghats of Maharashtra and Goa. In case of identifying difficult calls bird experts were consulted.

Most transects were monitored at least twice, first in winter (when local bird population is augmented due to migratory birds) and secondly in summer when most of the migratory birds have left.

B) Point Count is the most popular method for sampling bird population. This technique was frequently used during the present study. More than 600 point counts were conducted. The radii for most point counts differed from 20 m (in forest) to 100 m in open habitats. This technique involves the watcher to stand or sit at one place or spot and count the birds that are seen and heard in the surrounding. In other words a circular area around the watcher is studied. This technique is good in forest, scrublands and urban habitats. The count duration ranged from 5 minutes to 30 minutes depending upon the availability of time. The technique is good for finding relations between birds and habitats. The combination of both techniques gives better results.

C) Block Count involves counting a "block" of birds within a flock. A portion of the flock is imagined as a block and birds within that block are counted. A block can be of 10, 20, 50 or 100 birds depending upon the size of the flock. The count within one block is extrapolated for the whole flock. Suppose there are 50 birds counted in one block, imagine how many blocks would be required to cover the whole flock. If it is felt that six such blocks make the whole flock then the flock size would be 300 birds. (50 X 6). This method works well if the flock is homogeneous. It also requires lot of practice of rapid counting because a flock may be moving fast. This method can give estimates only, especially if the flock is very large. If the flock is heterogeneous a 2-person team works well in cooperation. Block count was used in the present study for counting flock birds like mynas, egrets, herons, parakeets, crows, sparrows, ducks, cormorants, rock pigeons and many kinds of waders. For counting birds in flocks a hand tally counter was used.

2.6 Method for Knowing Species Richness:

Many techniques for knowing species richness are known.These include

Encounter Rates technique,

McKinnon's Method,

Mist netting and

Timed Species count

The last method –Timed Species Count, developed by Pomery and Tengecho (1986) was used in the present study for calculating species richness. The method is quite logical and is based on the assumption that in a bird survey, common species are generally detected earlier than rarer forms. Therefore, a time taken to detect a bird becomes a measure of its abundance.

The technique is used like this-

The observer walks through the study area at a slow pace for one hour. This one hour observation period is divided into six 10-minute time period. All the species seen in the first 10-minute time period are recorded. In the next 10-minute slot of the remaining 50 minutes period, only those species not seen earlier are recorded. The idea is to record a species only once in its appropriate time period. In this way all the six columns are filled, taking care that species seen and recorded once are ignored in subsequent time periods. A minimum ten visits are suggested. It is suggested that during each visit the observer should cover about 1 sq.km.land area. All the species recorded are ranked according their time period. An index of relative abundance then can be calculated on this basis.

2.7 Breeding Status:

The breeding status of most of the birds is already known. But changes in breeding status do take place with changes in environment, e.g. creation of a reservoir. Breeding status does change when some new observations are added. Sometimes past data have some shortcomings or hastily drawn conclusions.

There are some established international criteria (Campbell & Lack referred in Urfi, 2004) to decide whether a bird species or a group of bird breeds in a given area or not. The same criteria were followed in the present study to decide the breeding status of some lesser known species.

Table 2.2: Criteria for knowing Breeding status of Birds

Standard observations	Remark on Breeding status
Species observed during breeding season	Possibly breeding
Species observed during breeding season in possible nesting habitat	Possibly breeding
Singing males/calls heard during breeding season	Possibly breeding
Pair observed in breeding season in suitable habitat	Probably breeding
Display & courtship observed	Probably breeding
Observed birds building nest/excavating holes	Probably breeding
Used nest / eggshells found	Confirmed breeding
Fledglings / chicks found	Confirmed breeding
Occupied nest found	Confirmed breeding
Adult carrying food observed	Confirmed breeding
Nest containing eggs found	Confirmed breeding
Nest with chicks found	Confirmed breeding

2.8 Seasonal Movements:

About one third bird species from the study area are migratory. Though migratory movement was not a major objective of the study, distributional studies always require knowing the emigrational movements. Most of the winter migrants arrive in August-September and leave in March. In other words they spend six to seven months in their winter quarters.

For every winter or summer migratory bird the **arrival and departure dates,** especially the first arrival dates and the last departure dates were noted down. In many cases previous dates/time of arrival & departure are available. Any **changes i**n these dates were noted down because such changes are closely associated with changes in climate or sudden weather changes in the neighboring regions.

Weekly or fortnightly records of some bird species (Pond heron, Black drongo, Roller etc.) at selected sites were also maintained for one year. In case of daily movement of some birds, their roosting sites were identified first. The birds were counted in the evening when they fly towards the roost in flocks. The direction/s of their daily outward flight was identified and the final destination of their daily migration was also identified by following them on motorbike.

2.9 Mapping Birds

Mapping birds has been an important aspect of the present study. Especially putting spot sightings on the map was an arduous task, because of the voluminous data about it. In most cases it was done manually, but in certain cases where the GPS locations were noted in the field and the coordinates read, the GPS records were uploaded on the Google Earth site to get the actual locations on maps.

Maps have been used to know

- Changes in distributional ranges of a species or group of related species
- Seasonal changes in distributional ranges of a species or group of related species
- Seasonal movements of some species
- Identifying threats to some species and their habitats.
- For comparing past range with present range of distribution.
- Daily migration routes

2.10 Geographical Factors:

A number of geographical factors influence the bird fauna of the area. These are: Topography, Climate, Vegetation, Wetland, Land use

Topography:

The study of topography includes;

i) General terrain aspect (hilly/plain/plateau/rocky)

ii) Slope aspect, especially steep slopes and cliff aspect was noted down. The horizontal and vertical extent of cliffs was noted down because many birds (Longbilled vulture, Laggar falcon, Kestrel nest on cliffs whereas many others are associated with it.) General geological aspects such as laterite plateaus and soil aspects such as color were also noted down for association of some birds with them. Altitude was considered since it was found that it influences the bird diversity to a certain extent.

Climate:

Information about temperature and rainfall distributions, dominant wind direction was derived from the secondary data available with the IMD and many web sites on weather and climate. Local weather conditions were noted down in the field at the time and place of observations.

Vegetation Study:

Vegetation is one of the basic elements of any system that influences the ecology, distribution and movement of birds. Any positive or negative change in vegetation is definite to affect the fauna in general and the bird fauna in particular. Following aspects of the vegetation were noted down-type/s, overall composition, height and layers, canopy cover, overall thickness, anthropogenic impact

Wetlands:

Wetlands play a very important role in the distribution of bird fauna in general and aquatic birds in particular of any area. The density of rivers & streams, reservoirs & canals, lakes & ponds, their perennial & non perennial nature, ecological stages (young/mature etc.) of reservoirs decide the diversity and abundance of many bird species The following aspects of wetlands were noted down:

- Type of wetland
- Area and shape
- Seasonal changes in water level
- Vegetation
- Level of ecological maturity
- Nature of shore/banks/channel/floor characteristics
- Bird fauna- Diversity, number, seasonal changes, nesting & breeding activities,
- Overview of fish and amphibian diversity

Human Activities

Land-Use Study:

Rapidly changing land use is the most crucial factor for ecology and fauna of the area in general and for the birds in particular. As the two prime growth centers viz. Mumbai and Pune lie on either side of the study area, land use changes due to and because of urban and industrial expansion is a vital area of study. To know the changes in land use/landscape, old maps of the study area were procured from various sources. These included past topographical maps of SOI, aerial photographs of some part around Khandala, urban land use maps (in case of Pune city) and land use maps published by NATMO. Old maps were used as base reference maps in the field while conducting survey for present land use.

2.11 Information from People:

A mountain of wildlife information is available with local people-the peasants, farmers, grazers, hunters, poachers, trappers, wood cutters and tribals. Such a person is known as KI –Knowledgeable Individual. Information was also collected from urban-based forest officials, wildlife experts, bird watchers, ornithologists and researchers.

Conversations and discussions with KIs provided information about

- Presence of a species/ past reporting or sightings.
- Changes in geographical /population status of birds
- Breeding records/information
- Possible reasons of increase or decrease in population.
- Past/previous land use

2.12 Impact Assessment:

A number of anthropogenic factors have been influencing the environment in general and the bird fauna in particular in the study area. For assessing the impact of these factors on the birds the Impact matrix method was used (Nalavade, 2003). Twelve major drivers impacting the ecosystems in general and bird fauna in particular were identified. Most of the drivers are responsible for

i) Reduction in habitat size

ii) Reduction in habitat quality

iii) Creation of a new habitat

iv) Reduction or increase in bird population size

The identified drivers for the study area are:

- Urbanization (including new hill towns)
- Industrialization
- Population growth
- Transportation and traffic
- Dams,reservoirs and multipurpose projects
- Mining & Quarrying
- Recreational activities and tourism
- Agricultural activities (including livestock culture)
- Loss and degradation of habitats
- *Raab* practice & forest/bush fires
- MFP collection

- Hunting, poaching & collection
- Domestic cats and dogs menace.
- Pollution
- Mining and quarrying activities

The bird fauna of the study area was categorized into five categories based on habitats.

These are;

- Urban birds.
- Forest & woodland birds
- Farmland birds
- Aquatic & wetland birds
- Scrub & grassland birds

The drivers were arranged against the birds on a matrix to identify the level of impact of drivers on concerned bird groups. The details of this technique are discussed in Chapter 9.

2.13 Equipments Used:

The following equipments were used for the field data gathering.

Binocular- Two different binoculars were used for watching birds. The 8 X 40 Task Optic for general use and 7 X 21 Olympus for use in urban habitats.

Hand Tally Counter- This instrument was used for counting birds especially when they were moving in flocks etc. This counter is 4-digit and counts up to 9999.

Compass- For finding and fixing directions a hand-held liquid filled orienteering compass with a circular moving disc was used.

Pedometer- For fixing short distances in paces a Casio digital pedometer (Model PDM-10 B) was used.

Thermometer- A digital hand-held battery operated non-branded thermometer was used for knowing temperatures in the field.

Camera- For field photography two cameras were used. Initially a Ricoh SLR with 52 mm normal and Tamron 70-300 zoom lense was used.In the later period a Canon SX 30 IS was used for overall and close-up photography.

GPS – On few occasions a GPS instrument (Garmin e-Trex H hand held receiver) was used.

2.14 Books and Field Guides:

For identification of birds in the field following illustrated guide-books were used

- The Book of Indian Birds-.Salim Ali (1973 & 1996 ed.)
- A Pictorial Guide to the Birds of the Indian Subcontinent- Salim Ali & S. Dillon Ripley (1983 ed.)
- Pocket Guide to the Birds of the Indian Subcontinent- Richard Grimmett, Carol Inskipp, Tim Inskipp (1999 ed.)
- Birds of the Indian Subcontinent-Richard Grimmet,Carol Inskipp and tim Inskipp(2011)

For further references following books were consulted-

- Compact Handbook of the Birds of India and Pakistan –Salim Ali & S.Dillon Ripley (1989 reprint)
- Popular Handbook of Indian Birds- Hugh Whistler (1986 reprint)



PLATE 2.1: White-throated fantail: A woodland bird, also seen in gardens

Chapter 3

History of Earlier Study

3.1 Introduction

The sages of ancient India were great lover of nature. They had a very acute sense of observation and had a fairly objective knowledge of animals, both domestic as well as wild. It seems that ancient people in India closely watched and studied the animal behavior with special attention to birds.

3.2 Bird Study- Historical Division:

The history of bird study in India can be better understood if we divide it into categories based on time period as follows-

- Pre-Vedic Period
- Vedic period (2000 BC-400 BC)
- Post-Vedic period (1-1200 AD)
- Moghul period (1525-1757)
- Colonial period (1800-1947)
- Post –Independence period (1947 onwards)

Pre-Vedic Period (10,000-2000 BC)

Bhela Samhita is one of the oldest treatises belonging to the pre-Vedic period (3000 BC) which prescribes the flesh of various birds for treatment of various human diseases. Besides this work there is no other work of repute from this period. But many artifacts belonging this period are available. Clay animals, sculptures, paintings, engravings on rock, pottery, clay tablets, figurines and seals etc. have been found at various excavations sites from Harappa to Inamgaon near Pune. These artifacts belong to various time periods ranging from 3rd millennium BC to 1000 AD. Though various different kinds of birds were represented, parrots (parakeets?) and peacock were the most common.(Dhavlikar 1976) The rock cave paintings from the central India, which are more than 10,000 years old also, depict a few birds.

Vedic Period (2000 BC – 400 BC)

The epics Ramayana and Mahabharata, the Puranas and the Smriti works have several references to animals including birds. Maharishi Valmiki is not only India's first poet, but is also regarded as the first bird watcher of India. The Chandogya

Upanishad has classified animals into three groups, one of which is that of birds. It further classifies animals into eight classes on the basis of habitats and feeding habits, the birds are put in the last two classes.

The well-known treatise of Ayurveda, the Charaksamhita and the Sushrut Samhita (1st cent.BC) have many references to birds. The former divides the birds into four groups as the peckers, scratchers, water birds and birds of prey. The treatise further describes the properties of their flesh for the use as medicines.

The Rig Veda mentions about 20 birds. The Vishnu Purana mentions returning of geese during winter. The Indo-Aryan were familiar with many birds and kept hill myna and parrots (parakeets !) as pet. They also knew parasiting habit of koel (Dave, 1980).

The 'Arthashastra' by Kautilya (4th cent BC) is a treatise on political science and governance. It recommends the protection of auspicious, pleasure and pet birds. It also mentions the use of royal homing pigeons for carrying news and messages. The work also discusses the use of flesh of various birds.

Panchatantra (3rd cent BC) is another treatise on political science and human moral conduct. It is recognized as the book of Indian folk wisdom. Most of the stories are told using various animals and birds as the actors in the stories.

Several *Smriti* works mention prohibitive rules against killing many birds.

Post-Vedic Period (300 BC-1200 AD)

Along with Sanskrit this period is dominated by Prakrit and Pali works. One of the greatest littérateurs, Kalidasa belongs to this period. He was an ardent nature lover and master of geography. His works have detailed accounts of mountains, rivers, forests and animals. His literature contains frequent references of to birds including peacock, parrots, pigeons, swans, geese and many other water and garden birds. His '*Raghuvansh*' mentions flocks of 'kadamb' (geese) visiting India from Manasarovar in Tibet across the Himalayas.

In the Jaina work, Tattvarthadhigama Umasvasti (40 AD) has attempted a classification of the animal kingdom on the basis of number of senses. Prasnavyakran (5th AD) mentions over 50 different kinds of birds. The Jataka tales (5th AD) are a series of books and many of them have bird titles like Tittiri (partridge) Jataka, Hansa (swan) Jataka, Baka (heron) Jataka etc. Many Jataka stories mention birds of various kinds.

This is also the period of the Sangam literature (4th to 7th cent AD). The treatises were produced in the Tamil country (present day Tamil Nadu).The work mentions a large variety of animals, both wild and domestic, including birds. There is a detailed discussion on birds with respect to their habits and ecological distribution. This is probably the first time that the distributional aspects are mentioned.

Two important works of the later part of this period are the Sandes Rasaka and Mriga Pakshi shashtra, both belonging to the 13th century. The former mentions changing birds as per the changing seasons. The latter written by Hamsadeva, a Jain sage, is the science of animals and birds. The work has two volumes; the first describes 27 mammals and the second 97 bird species.(Chitampalli & Bhatkhande 1993)

Moghul period (12-17th century)

Many Moghul emperors were keen naturalists. They were fond of hunting and maintained menageries .Their works include the memories of Babur (1494-1529), Akbar (1556-1605) and Jehangir (1605-1627). These were written either by them or by writers appointed by them. Most prominent among them is the '*Baburnama'*- memories of Babur. *Baburnama* mentions a large variety of game, garden and town birds as well those seen in the nearby jungles. The unique aspect of the memories is the Moghul paintings, which were quite realistic and depicted various animals and birds. These painting have made the memories more authentic. (Ali 1927)

The Marathi saints period (12-17th centuries) coincides with the Moghul period. Maharashtra has a very long and rich saints (sant) tradition ranging from Sant Dyaneshwar (13th century) to Sant Ramdas (17th century).Their treatise include references to animals and birds, with anecdotes describing their greatness and usefulness.

Colonial Period (1800-1947)

The colonial period was mostly the period of collection of information and specimens, for we had very scanty scientific information about our plants and animals." In the nineteenth century it was hard to study birds without killing them" (Haldane, 1959).This was the era when the Britain had started establishing their empire in every corner of the world. This was also the period when British biologists, scientists, civil and military officers and traders had undertaken the task of collecting

the information about natural resources including biological resources, because there were many gaps in the knowledge and collection became inevitable.. Collection was one of the chief ways of gathering information about India's little known flora and fauna. Many civil and military officers were keen naturalists and sportsmen. Most of the earlier works on India's natural and wildlife wealth have been contributed not by experts but amateur naturalists. Many geographical expeditions were carried out in different remote parts of the Indian peninsula by the British between 1868 and 1912. These expeditions were responsible for furthering our knowledge about the natural resources. The information thus collected was compiled by many experts to produce first fauna books. The first ever account of birds of the region dates back to 1830's when Lt.Col.Sykes of the Bombay Army wrote a catalogue of birds observed in the 'Dukhun' (Deccan). The overall beginning of the ornithological study in the country is credited to T.C.Jerdon. His pioneer work on the Indian birds-"The Birds of India" was published in 1862-64.Allan Octavian Hume (who also happened to be the founder of the Indian National Congress) edited the "Stray Feathers" (SF) - a periodical dedicated to bird study. Ten volumes of the "SF" were published between 1872 and 1888.The first bird list for any part of the present day Maharashtra appeared in the "SF" in 1876.It was contributed by S.B.Fairbank and covered the Sahyadri Mountains including Matheran & Mahabaleshwar. Many more articles about the birds from western Maharashtra also appeared in the "SF" which included Deccan (Davidson & Wenden,1878;Buttler 1881),South Konkan (G.W.Vidal 1880) and Western Khandesh (J.Davidson 1882,1886).The Deccan list included birds from the grass & scrub country from the eastern margin of the present study area.

The Journal of the Bombay Natural History Society, which started in 1886, has been regularly publishing ornithological papers, notes and checklists for different parts of India. The earlier issues of the journal contained Barne's articles on nesting birds of western India (1888,1889,1890) followed by Stuart-Baker's Ducks (1896,1897) and Betham's nesting accounts (1899,1900,1901,1903) of the Deccan birds.

The Gazetteer of the Bombay Presidency series which appeared in 1885 covered most districts of the then Bombay Presidency including all the districts within the present study area. Every gazetteer described fauna of the concerned district, some providing comprehensive bird list with brief descriptions. For example, The Poona District gazetteer, Vol.-I gives a brief description of game birds whereas volume III

provides a list of 55 water bird species (contributed by Wenden) seen at the Khadakwasla reservoir.

Blanford and Oates's "Fauna of British India-Bird Series" appeared in four parts from 1889 to 1898. Edward Hamilton Aitken, popularly known as 'EHA', was one of the greatest naturalists of his times. His 'Birds of Bombay' appeared in 1905.S.H.Prater and Charles McCann, two great natural historians of the subsequent era, also produced some good literature on birds. Trevenen (1922) mostly dealt with the game birds found in and around 'Poona'. E.C.Stuart-Baker's revised 'New Fauna of British India-Bird' volumes were published in 1922-30. The Popular Handbook' by Hugh Whistler-the first book for lay bird watcher was published in 1928.This book has been regarded as the one which popularized bird watching as a hobby among the Indian elites during thirties and forties.

Post-Independent Period:

Decades following 1940's were dominated by one man-Dr.Salim Ali, the Doyen of modern Indian ornithology. He started his real forays for birds while a resident of the Pali hill, in Mumbai in late twenties. Large tracts of what is now suburban Mumbai were covered with large forest patches interspersed with paddy fields and coastal marshes. The hills to the north and east were covered with good forest cover. Dr.Ali along with Prater, McCann and Abdulali made most of his earlier collections here. He also collected birds from nearby Western Ghats country.

Though his bird study started during the early part of the twentieth century and his land mark book 'The Book of Indian Birds' first appeared in 1944 ,his classic bird books appeared only during the post –Independent era.

Another keen naturalist and ornithologist of the contemporary era-Humayun Abdulali, Salim Ali's cousin and one time companion, had also started natural history studies around the same time. In the early thirties he collected birds for St.Xavier's college museum from Mumbai neighborhoods. This collection helped him in producing a series of papers jointly with Salim Ali, titled "Birds of Bombay and Salsette" which appeared in the journal of the BNHS in 1936-37.Since then Mr. Abdulali contributed on regular basis to the 'Journal' on birds of the oriental region in general and western India in particular. His notes dealt with every aspect of bird – nidification, nesting, molting, local movements, mortality, new occurrences, range extension and description of new races from Konkan and Western Ghats country. His

two checklists, one for the state as a whole (1973) and another for the Sanjay Gandhi (Borivli) National Park (1981) have been widely acclaimed and used.

Thanks to efforts by the duo, Salim Ali-H.Abdulali, bird watching started becoming popular past time among the educated middle class the in post-Independence era. As a result many amateur bird watchers came forward to study various aspects of bird behavior. Some of them made bird watching their profession. One among them V. C. Ambedkar, the first research student of Dr.Salim Ali, produced a landmark study on Baya weaver bird (1958, 1964, 1973), most of which was based in Pune. He also contributed a chapter on birds, along with D. N. Mathew to the FAUNA Gazetteer of Maharashtra State (1974).Another ardent conservator and keen bird observer from the Ali clan- Jaffer Futehally served the field of ornithology through the editorship of the 'Newsletter for Bird Watcher' since its inception in 1962 for the next four decades. The 'Newsletter' marshaled many from Maharashtra to document and write on local birds.

Bro. Navarro of St. Xavier, Mumbai made a brief collection of birds around Khandala in the sixties and seventies and wrote extensively about them (1965, 1967, 1975, 1976, 1978, 1979 & 1980) either on individual species or on the community as a whole. Stairmand D.A.also wrote about birds around Khandala around the same time (1970, 1971, and 1972). Gray Lincoln (1974) has been one of the first researchers to study the birdlife in introduced eucalyptus plantations in the state.

Among the local naturalists the most prominent was Dr.M.V.Apte, who as a doctor of a sanitarium at Lonavala spent almost twenty years there and wrote extensively about birds around Lonavala, Khandala and Pune. (1950, 1951, 1957). Another Pune-based naturalist, Prakash Gole initially wrote about common birds around Pune.(1972,1973). The first ever bird list for the city was contributed by P.Gole in 1972.His 'March Bird Count for Poona' (1981) was the first ever bird count not only for the city of Pune but for any city in Maharashtra. The bird census covered about 120 km^2 of the city area, enumerated about 55000 birds belonging to 130 species. He (1985) also studied the avifauna of the polluted stretches of the Mula-Mutha Rivers and identified some indicator species. He afterwards shifted his attention to Konkan and Western Ghats birds. His 'Birds of Western Ghats' is the only bird study for the region with some geographical bias. Purandare K. (1984) did a systematic year-long study of the breeding biology of Black-shouldered kite from a

riverside grove along river Mutha. Nalavade (1981) analyzed the birds of Pune area from geographer's point of view. A comprehensive checklist covering larger urban area of Pune was published by the Friends of Animals Society (Mundkur & Kelkar, 1981).The checklist covered area up to Simhagad and included about 250 species. Dr.Bharucha's (1986, 1987, 1988, and 1990) work mostly deals with wetlands and wetland birds around Pune. Ingalhallikar & T. Gole (1987) recorded 290 species for a slightly larger area. Bradbeer's (1987) list, which was published from London, described 295 bird species that he came across during his stay here in 1985-86. His list covered Pune and adjoining districts of Thane and Raigad. Taej Mundkur an internationally known figure on wetland birds started his career as an amateur bird watcher in Pune. Scores of his miscellaneous notes appeared in the 'Journal' and the 'Newsletter' during the eighties and nineties.

Dr Anil Mahabal (1990, 1992, and 1993) of the Zoological Survey of India has extensively worked on population, roosting behavior and social biology of communally roosting birds - mynas, parakeets, kites and crows. Most of his work is Pune-based. Mahabal & Lamba's (1987) systematic list of 329 species and subspecies covered the whole Pune district and was based largely on the bird specimens in possession of the Virus Research Institute and the Western Regional Station (WRS) of the Zoological Survey of India, Pune. Dr S.Naik (1988, 1990) mostly described arrivals of waders and cranes. T.Gole (1987) presented a brief account of owls around Pune followed by a similar account on the birds of prey by Ingalhallikar (1988). Purandare K.(1994) conducted another landmark study on the breeding biology of Whit-browed Wagtail along a stretch of Mutha river. He also provides a checklist of water birds found in the wagtail habitat. Dr.Watve (1989, 1994) worked on the nesting & hunting behavior of Bonelli's eagle.

Post -1970 passions for hiking and trekking along with bird watching had such an impact that every major town in the state saw formation of trekking groups, nature clubs or bird watching societies. This made the bird check-list a basic document of bird study. As a result many towns, cities, districts and protected areas got their own bird lists. Most of the bird lists were published privately. Some appeared as booklets, many others got published as book articles or in prominent journals and periodicals. Recently many bird lists have been uploaded on various websites, web groups or as bloggs. Some prominent bird lists from the study area other than Pune are: Karnala (Pandya 1982, Marathe 2001), Satara district (Bhate & Patankar 1998) and Konkan

(Katdare & Pande 1999). The last list covers a part of the study area from Raigad and Thane districts.

This surge in publication also saw many checklists coming out of and for Pune. Many of them covered smaller areas-a hill station, an educational campus or a lake such as Katraj lake (Singh 1984), Telco Lake (Mundkur 1988), Khamgaon & other lakes near Pune (Purandare R.1990), Pashan lake (Hollander 1994); Pune University campus (Goel 1976,Wadadekar 2000,Oberoi 2003), Fergusson College campus (Nalavade 1998), NCL Campus (2002) , Sinhagad environs (Ingalhallikar 2005).

An urban biodiversity survey of Pune by RANWA, a Pune-based NGO in 1998-2000, also covered the bird fauna (Ingalhallikar et al, 2001) of Pune urban area. .Kalpavriksha (2001) published a basic bird guide to cover the Pune district. The first decade of the 21st century saw many landmark studies by Dr. S. Pande. His work deals with various aspects of birds around Pune, Sahyadri and western coast. He is also the lead author of "The Birds of Western Ghats, Kokan and Malabar" (2003) and his pocket guide on birds of Khandala, as a co-author (2008) has become quite popular within a short period of time.

The Asian Waterfowl Census, which has been taking place on regular basis since 1987 covers many water bodies from Pune, Satara and Raigad districts. Many students while doing M. Sc. in Environmental Science or Biodiversity have chosen birds as a core study area for their dissertation. Such dissertations since 1989 have covered a wide range of subjects about birds and include such aspects as hill birds, wetland birds, bird movements, exotic flora & birds, important bird areas etc.

3.3 Zoogeographical Study

Biogeography has always been a neglected branch of both geography and biology. This has been true especially for India where we find very few workers and works on biogeography. Some fundamental aspects of biogeographical research in India are:

- There are few researchers who can be called as professional biogeographers.
- The discipline is looked upon with considerable misgivings.

- The volume of research on biogeographical aspects is very low compared to other branches of geography and ecology.
- The biogeographical research is mostly confined to dividing the country/subcontinent into bigeographical regions, sub regions, divisions and subdivisions.
- Many wildlife and /or ornithological studies look at geographical aspects (distribution etc.) as marginal area of study.

Many earlier workers including Jerdon (1862) dealt with the distributional aspects of birds as a small part of the whole description. Blanford (1870) was probably the first to divide the Indian subcontinent into major zoogeographical divisions. He made a valuable contribution to the zoo-geography of India in 1876, when he drew attention to the presence of African elements in our fauna. Many later workers like Elwes (1873),Wallace (1876), Newton (1893), Gadow (1893), Sclater (1899), Alcock (1910), Annandale (1911), Talbot (1939), Smith (1931,1935,1943), Mahendra (1939) and Prasad (1942) followed the footsteps of Blanford and tried to divide the Subcontinent into various zoogeographical divisions. Most of them made the divisions on the basis of distribution of mammals, reptiles, butterflies and fresh water crustaceans, with the exception of Gadow who used birds as basis for his zoogeographical division.

One of the most intriguing and fascinating aspects of the Indian biogeography is the general similarity in the character and composition of the animal and plant life of South- Western Ghats on the one hand and the North-east Himalayas & the South-east Asia on the other. This similarity has been noticed and commented upon by many successive workers including Salim Ali (1935). Many tried to explain this disjunct distributional pattern through various theories, but the one that stood out prominently and has been debated and challenged was the 'Satpuda Hypothesis' by Dr. S. L. Hora (1950). This theory considers the Satpuda range as the migration highway of the Indo-Chinese and the Malayan fauna (eastern elements) between the north-eastern Himalayas and the South-Western Ghats. Dr. Dillon Ripley tried to provide an alternate explanation through his 'Eastern Ghats hypotheses', for he considered the Eastern Ghats as the bird migration highway for carrying the eastern elements from the north-east to the south-west. He also discussed the zoo-geographical considerations of the Indian avifauna (1959). Dr.Salim Ali in fact should be

considered as one of the first zoogeographers of modern India. He was the first to discuss the Satpuda hypotheses from birds' point of view. He also tried to correlate 15 major forest types of India with their associated bird fauna. Many migration-based studies have strong zoogeography base. The most prominent work in this respect is the migration study of Common teal by Ambedkar & Daniel(1990).Gaston & Zacharias's (1996) account of distribution of endemic and disjunct birds of Kerala supported with a score of maps is an important zoogeographical work of the recent past ,the findings of which are useful for conservation of Kerala birds. There is hardly any notable work about the zoogeography of the northern Western Ghats. P.Gole (1998) was the first to deal with the geographical aspects of birds of the northern Western Ghats. Nalavade & Pande (2003) were probably the first to write about the ornitho-geography of the region. The present study is the first detailed and comprehensive account of the ornitho-geography of the region.

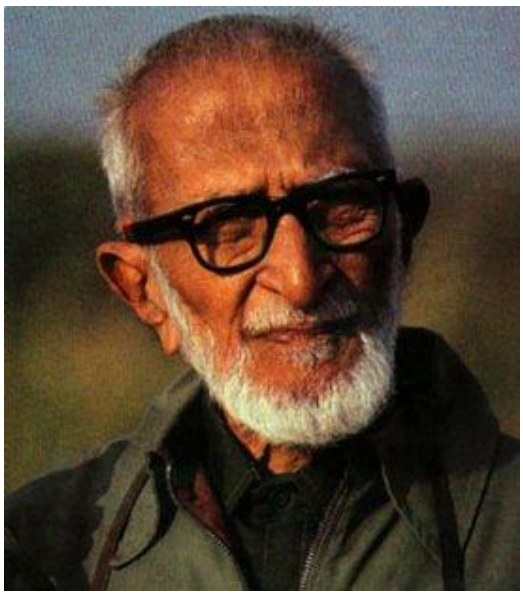


PLATE 3.1: Dr.Salim Ali, the doyen of Indian ornithology, was also a keen zoogeographer. (Source- www.google.co.in/images)

Chapter-4

An Overview of the Bird Fauna

4.1 Introduction

The study area has 484 species of birds. The number is quite substantial considering the size of the area. This is almost 93 per cent of the bird fauna of the whole state and 40 per cent of the bird fauna of the Subcontinent. The richness is partly because of the following factors.

- Almost all of the study area lies in the Western Ghats which is one of the biodiversity hotspots.
- Western margin of the study area lies close to the sea thereby adding marine bird diversity to the already rich bird inventory.

4.2 Overview:

The following description provides an overview of the bird fauna of the study area.

Order Galliformes: The Order Galliformes includes the single family Phasianidae which comprises 13 species of **Partridges** (Francolins), **Quails** and **Pheasants**. Except the Common quail, all the other species are resident. Whereas the Painted Partridge is found throughout the study area the Grey Partridge is confined mostly to the upper drier part. Most of the quails are confined to grass & scrub country as well as farmland.

The Grey jungle fowl is the common forest fowl of the Western Ghats, is locally common. Its northern counterpart the Red jungle fowl is not seen anywhere in the study area though there are two previous records of its existence, one from Khandala and the other from the jungle near Mumbai. The Peafowl is widespread in distribution, though declining in numbers everywhere. The two types of spur fowls – the Red & Painted are mostly confined to the Ghat country.

Order Anseriformes: Families Dendrocygnidae (**Whistling ducks**) and Anatidae (**Ducks & geese**).There are two species of whistling ducks- the Fulvous & Lasser. There is a lonely past record of Mute swan from near Pune. With 20 species the ducks & geese show a diverse group. This is partly because of the high density of dams &

reservoirs in the study area. More than half of ducks & geese are winter migratory. All the three goose species are rare or stray.

Order Turniformes: Family Turnicidae (**Buttonquails**).Apparently buttonquails look like true quails but lack a hind toe. They are less common compared to true quails but have widespread distribution.

Order Piciformes: The order is made of two families Picidae (**Wrynecks & Woodpeckers**) and Megalaimidae (**Asian barbets**).Woodpeckers are specialized hunters of insects found in tree bark. They therefore have very long sticky tongue for extracting insects from the crevices & cavities of rotten wood, also have a strong ,conical chisel-shaped bill and a stiff tail to support them for their upward journey over the bark. Almost all of the 10 species found in the area are resident. All of them are confined to forest, well wooded country or parks & gardens. Wryneck is a member of the woodpecker family but differs from them in habit. It is winter migratory & can descend to the ground for foraging insects. It is a rare bird.

Barbets are small to medium-sized arboreal birds dominantly green in color. They are mainly fruit-eaters go the four species found in Maharashtra three are found in the study area. The two larger types –the Brown-headed & the White-cheeked are mostly confined to the Ghat country whereas the Coppersmith barbet is the commonest of them all and is found everywhere.

Order Bucerotiformes: This order comprises **Hornbills**. They are large arboreal birds with long tails & large bills. Mostly frugivorous they travel long distances in search of fruiting trees. All the four species that are seen in the state are also found in the study area. Only the Indian grey hornbill is widespread.

Order Upupiformes: The order comprises only one family Upupidae & only one species the **Common Hoopoe**. This is a myna sized fawn colored bird with a prominent crest and black & white stripes on wings. It frequently forages on ground for insects etc. and is a local migratory bird.

Order Trogoniformes: Family Trogonidae is the only family that makes this order. The only species that occurs in the state & the study area is the Malabar trogon. **Trogons** are gorgeously colored, medium-sized forest birds. They are shy & rarely seen birds and the only species is confined the Ghat country and shows fragmented range.

Order Coraciformes: This order consists of a variety of birds belonging to five families, viz. Coraciidae (**Rollers**), Alcenidae (**Small Kingfishers**), Halcyonidae

(**Large Kingfishers**), Cerylidae (**Pied Kingfishers**) and Meropidae (**Bee-eaters**). Rollers are brightly colored Jay like birds. They prefer open country & farmlands and pounce on their prey on ground from a convenient lookout perch, preferably a cable or a pole of the two species found in the study area the Indian Roller is a common more or less resident bird seen almost everywhere, whereas the European Roller is a migratory species and has been reported only from a few places in Konkan & Ghat country. Of the six species of kingfishers found in the area, two are small, three large and one pied. The Common kingfisher is our commonest aquatic kingfisher and is seen attending almost every kind of water body large and small. The Oriental dwarf kingfisher is the smallest of them all, is rare and is confined to forest streams of the Konkan & the Ghats region of the larger ones the White-throated kingfisher is a commoner and is the one which can be seen away from water. The Pied kingfisher prefers non-turbid, clean waters.

Bee-eaters are slim birds with predominantly green plumage and projecting central tail feathers. Of the five species from the area only one-the Green bee-eater is common and wide-spread. The other species are rare and are mostly seen in the Ghat country.

Order Cuculiformes: The order consists of two families; the Cuculidae (**Old World cuckoos**) and Centropodidae (**Coucals**).Cuckoos are birds with rather elongated body & slightly decurved bill. Most of them are drab colored with occasional patterns. They are brood parasites and lay their eggs in hosts' nests. Koel is the only visibly common cuckoo that is heard everywhere during hot months. Many other species are breeding migrants and mostly arrive in late summer. Malkohas are larger in size and non-parasitic cuckoos. We have two species the Blue-face and Sirkeer which are less commonly seen. Greater coucal is the only member of the Centropidae family.It is a resident non-parasitic stout cuckoo, frequenting bush & grass country and gardens shrubbry. It is a great destroyer of eggs & chicks of other birds.

Order Psittaciformes: This order represents only one family, the Psittacidae which includes **Parrots** & **Hanging parrots**. Parrots are mostly tropical birds with vari colorful plumage. India does not have true parrots but parakeets the smaller slender version of the 14 species found in India, Maharashtra has five and all of them are found in the study area. The Rose-ringed parakeet is the commonest of them all and is a Commensal of humans and prefers to build its nest in human habitations. The

Hanging parrot, a related species, is quite smaller in size and is a woodland bird. Its name is an indication of its curious habit of sleeping upside down in trees.

Order Apodiformes: The order consists of two families the Apopidae (**Swifts**) and the Hemiprocnidae (**Treeswifts**). The Swifts are small drab-colored birds which spend most of their time in the air hawking for insects. Because of their weak feet & all four toes pointing forward, they cannot perch on wires. Of the four species seen in the study area two-the House Swift & the Palm Swift are quite common. There is only one species of tree swift found here, the Crested tree swift, which mostly keeps to the forested country.

Order Strigiformes: This order is made of four families' viz. Tytonidae (**Barn owls**), Strigidae (**Typical Owls**), Batrachostomidae (**Asian Frogmouths**) and Caprimulgidae (**Nightjars**). Owls are birds of prey with roundish face, large eyes, short beak & neck. Most owls are nocturnal and live on any type of animal that they can get hold of. Of the 28 owls species found in India and 15 in Maharashtra, 14 have been listed for the study area, including the Barn owl, the only representative of the family. The Barn owl, and the Spotted owlet, the smallest of owls, are the only two types which are commonly seen everywhere. The other owls are more or less is either occasional or rare. Most of the owls are widely distributed in all the three distinct zones of the study area. Owls play an agriculturally vital role by destroying rats & mice, which do so much damage to the crops. Asian frogmouth is the only representative of the Batrachostomidae. Frogmouths are nocturnal birds with large head and broad heavy bill. They are mainly forest birds, and rare in the state. The only record of this species from the area is from the Phansad wildlife sanctuary near Alibag (birdsofbombay@yahoogroups.com). Nightjars are crepuscular & nocturnal birds with large eyes, huge gape for catching insects & dark plumage of the seven species recorded in India, six occurs in the state and all the six are recorded in the study area. But only two of them, the Indian & the Grey are quite common and widespread.

Order Columbiformes: The order consists of one family Columbodae which represents **Doves & Pigeons**. The family is quite large and has a cosmopolitan distribution. There are about 290 species found throughout the world, of which 36 occur in India and 15 in Maharashtra. The study area supports 11 of them. These are medium-sized birds with compact head and short beak. They are largely granivorous and/or frugivorous. The Blue rock pigeon is the commonest pigeon with cosmopolitan distribution and is seen everywhere from rocky cliffs of Western Ghats to the busy

central wards of Pune city of the remaining types ,six are forest birds while the rest mostly prefer agricultural habitats surrounded by grass & scrub country.

Order Gruiformes: This order has three families –Otididae (Bustards), Gruidae (Cranes) and Rallidae.

Family Otididae: There two species of **bustards** recorded within the area-the Great bustard & the Lesser florican. The former is a large bird of open grassland habitat & was persecuted in the past for its meat. It is an endangered bird today & a few sightings have recorded from the eastern periphery (Jejuri etc.) of the study area. The Lesser florican is another bird that is highly threatened. It is of the size of poultry, & has been recorded from Konkan, the Ghat country & the Upper Deccan plateau. It is also a rare bird.

Family Gruidae: Cranes are among the largest birds with long necks and legs. They generally prefer marshy areas in plain country. They are known for their loud trumpeting calls of the three species recorded so far from the study area the Demoiselle crane is more or less a regular visitor, though in declining numbers. The Common crane has always been rare whereas there is only one record of Saras crane, probably a stray bird.

Family Rallidae: Rails, crakes and Gallinules- These are small to medium marshland birds with a short cocky tail. Most of them are shy and live in waterside vegetation of the 11 species found in the area, the White-brested water hen, Purple swamp hen & the Common moorhen are quite common & widespread while others are rare, less common or recorded at certain localities only. Coot is the only gallinule found in the area. It is a common water bird at every reasonably large water body in the study area.

Order Ciconiiformes: This is a large order of **aquatic or marsh birds** as well as **birds of prey**. This order represents 161 species of 22 families in the study area. The families & the birds therein are Pteroclidae (Sandgrouse), Scolopacidae (Woodcock, Snipes, Godwits, Sandpipers & Curlews), Rostratulidae (Painted Snipe), Jacanidae (Jacanas), Burhinidae (Thick-Knees), Charadriidae (Oystercatcher, Avocet, Stilt, Plovers & Lapwings), Glareolidae (Crab Plover, Pratincoles & Coursers), Laridae (Skuas, Jaegers, Skimmer, Gulls & Terns), Accipitridae (Osprey, Bazas, Kites, Hawks, Eagles, Buzzards, Harriers & Vultures), Falconidae (Falcons), Podicipedidae (Grebes), Phaethontidae (Tropicbirds), Sulidae (Boobies), Anhingidae (Darters), Phalcrocoracidae (Cormorants), Ardeidae (Herons, Egrets & Bitterns),

Phoenicopteridae (Flamingos), Threskiornithidae (Ibises & Spoonbills), Pelecanidae (Pelicans), Ciconiidae (Storks), Fregatidae (Frigatebirds) & Poecellariidae (Shearwaters & Strom-petrels).

Family Pteroclidae: Sandgrouse are medium-sized birds resembling pigeons with drab-colored plumage. Terrestrial & gregarious in nature, their drab color blends them with their arid and semi-arid habitats. Only two species are found in the area, both of them confined to the dry upper plateau region.

Family Scolopacidae: This family consists of 26 species in the area more than half are sandpipers. The Eurasian Woodcock is a stray bird. Of the 5 snipe species that occur in the study area, only the Common snipe is common. Godwits are wading birds with slightly up curved bill of the two species, the Black-tailed godwit is common and widespread whereas the Bar-tailed is rare and restricted to a few places around Mumbai. Sandpipers are small to medium sized olive brown waders with whitish under parts. They are known for their high pitched piping calls. Shanks, Tringa sandpipers, Stints, Sanderling etc. all belong to this family. In all there are 16 species. They generally prefer mudflats, river and lake banks. Curlew & whimbrel are medium sized waders with have down curved bills. Both the species are rare, while the first bird has widespread range; the other has restricted range along the coast.

Family Rostratulidae: The family has only one species-the **Painted snipe**. They apparently look like snipes but have more prominent plumage. This bird is relatively common.

Family Jacanidae: The **Jacanas** are light-bodied water birds with enormously elongated feet which enable them to walk on floating lily leaves of the two species the Pheasant-tailed Jacana is common whereas its smaller cousin, the Bronzewinged Jacana is rare.

Family Burhinidae: The **Thick-knees** are having strong, thick legs, thick bill and large head with huge eyes. Both, the Eurasian thick-knee & the Great thick-knee prefer dry country and dry sandy river beds former is occasional while the later is rare.

Family Charadriidae: This is a large family containing 14 species of **Oystercatcher, Avocet, Stilt, Plovers and Lapwings**. Oystercatcher is a large black and white wading bird with red legs and bill. It is winter migratory and is occasionally seen only along the Konkan coast. Both, the Pied Avocet and Black winged stilts are long-legged waders with black & white plumage. The former has prominently up-

curved bill, is winter migratory, rare and confined to the coast only. The latter is one of the commonest waders and is present at almost every wetland. Plovers are short-billed small wading birds. Except the Ringed plover all the other species are migratory. Plovers prefer mudflats, sea shores and river banks. Lapwings are medium-sized waders with long legs and upright stature. Of the 5 species found in the area, the Red-wattled is the commonest of them all. The Yellow-wattled is less common. The former is generally seen near water, while the latter is generally seen in dry land countryside. All the other species are rare.

Family Glareolidae: This family consists of **Crab plover, Pratincoles and Coursers.** The crab plover is a whitish wader with black wing tips and bill. This is a bird of coastal mudflats and reefs and is uncommon in the area. Pratincoles are swallow-like plovers with short legs and forked tail of the three species found in the area, only one, the Small pratincole, is relatively common. The other two are uncommon. The Indian courser is a plover-like ground bird that prefers fallow land in semi-arid country. It is common across the “maals” around Pune, especially towards the east.

Family Laridae: This family consists of a few species of **Skua, Jaegers and Skimmer** and many species of **Gulls and Terns**. Skuas and Jaegers are medium-sized ocean birds. They are more or less piratical in habit and rob other birds of their food. They mostly stray to our coast during monsoon months.

Skimmer is tern-like bird .It has a prominent red bill with elongated lower mandible. It ploughs the surface of water with open bill and lower mandible immersing into it, ready to catch fish.

Gulls are medium-sized seabirds with webbed feet and strong flight. Of the 19 species that occur in Maharashtra, only 7 occur in the study area. Most of them are winter visitor and occur along the coastal waters. One or two species are occasionally seen around Pune.

Terns apparently are similar to gulls but are smaller and slimmer, with a slender bill. They generally feed by flying or diving. Eleven tern species have been found in the study area. Like gulls, most of them are confined to the coastal waters. Only three species are seen around Pune. They are the gull-billed, the river and the whiskered terns. Except two species all the terns are migratory.

Family Accipitridae: The family consists of **Birds of prey**. The birds can be easily distinguished from others with their strong hooked bills and sharp claws. All of

them live on fish or other vertebrates. The family includes osprey, bazas, kites, hawks, eagles, buzzards, harriers and vultures. Osprey, the winter migratory fish-hawk, is confined to coastal waters & large inland water bodies. The black baza is a forest hawk, is rare in our area with a record from Bhimashankar. Of the three species of kites, the black kite is the commonest hawk of the area. It is a scavenger bird, commensal of man and is seen hovering over the city sky in umpteen number. The black-shouldered kite is mostly seen over grass & scrub country on the outskirts. The Brahminy kite is rare around Pune, but is frequently sighted around Alibaug.

Of the 5 Accipiters species, the shikra is the commonest hawk which inhabits open woodlands around human habitations. Fourteen species of eagle have been found in the area. Some are resident, some are migratory. Some are forest birds, others hunt over grasslands. A few scavenge near garbage dumps. Of the three buzzard species two are resident, one migratory.

Harriers are slim, medium-sized long-tailed raptors seen around open country. Of the four harrier species seen in the area, one keeps itself to marshes. All the harriers are winter migratory.

Vultures are large birds of prey with hooked beaks and naked neck. They exclusively feed on dead animals. All the six species found in the area are now rare. Two of them-the white-rumped and the long-billed were some of the commonest birds about two decades ago. The Eurasian griffon and the cinereous are stray.

Family Falconidae: Falcons are small to medium-sized raptors with long wings. They mostly inhabit open grass & scrub country with cultivation. Of the 8 species found here. The common kestrel is the commonest falcon, which prefers open grassland and Crestline plateaus. The other falcons are either rare or uncommon.

Family Podicipedidae: Grebes are aquatic birds with webbed feet and short tail. They feed by diving and build floating nests. Of the three species only one, the little grebe, is resident and common and is seen in almost every water body of any size.

Family Phaethontidae: This family consists of **Tropicbirds**, which are oceanic birds with long streamer tail. The only species found in the stray area.

Family Sulidae: Boobies are another oceanic bird with pied plumage & streamlined body.the only species that is found in the stray area is masked booby.

Family Anhingidae: The family is represented by only one species in the study area, the **Darter** or snakebird. The darter, a close relative of cormorant, has a very long, slender neck, which it uses to spear fish. It is rare throughout the area.

Family Phalacrocoracidae: The **Cormorant** family is represented by three species in India and all the three are found in the study area. They are the little cormorant, the Indian cormorant and the great cormorant. These are aquatic birds and are seen on rivers, lakes & reservoirs. The first one is common whereas the other two are seen occasionally.

Family Ardeidae: This family is made of **Egrets, Herons and Bitterns**. Egrets & herons are wading birds with long legs & neck. Fifteen species of the family are found in Maharashtra and all of them have been found in the study area. Only one, the reef heron, is confined to the coastal waters, the others are widespread. Except bitterns most herons & egrets are common and seen in flocks. The bitterns are mostly confined to marshy areas and lead a concealed life.

Family Phoenicopteridae: Flamingos are large gregarious birds with very long neck & legs. They are monsoon migratory. Of the two species recorded from the area, the greater flamingo is relatively familiar bird and arrives in large flock to spend the non-breeding season at selected reservoirs. The lesser flamingo is uncommon.

Family Threskiornithidae:Ibises & spoonbills- An ibis is closely related of stork. It has a long, down curved bill. All the three species found in the area are more or less common & widespread.

Spoonbills are stork-like waders with spoon-shaped bill. Asian spoonbill is the only species found in the area.

Family Pelecanidae: Pelicans are large aquatic birds with a very large pouched bill. Only one individual of spot-billed pelican has so far been recorded from around Pune. It is clear that this was a stray bird.

Family Ciconidae: Storks are large waders with long legs and long neck with heavy bills. Out of the eight species found in India, seven are seen in Maharashtra, all of them in the study area. Three of them are winter migratory, three are resident and/or local migratory and one is stray.

Family Fregatidae: Frigatebirds are large oceanic birds with webbed feet and a large hooked beak. Only two species occur in the area, the greater and the lesser. Both of them are stray.

Family Poecellariidae: Shearwaters & Storm-petrels are oceanic birds with distinct tubular nostrils. Of the three species occurring along our coast, only two, the Wilson's storm petrel and the Persian shearwater have been recorded from the area. Both of them are uncommon.

Order Passerifomes: This is the largest order of birds comprising more than half the total number of living bird species. In the study area ,this order is represented by 19 families, as follows- Pittidae (Pitas), Irenidae (Fairy bluebird & leafbirds),Laniidae(True shrikes),Corvidae (Crows, woodswallows, orioles, cuckoshrikes, minivets,flycatcher-shikes, fantails, drongos, monarchs,ioras & woodshrikes), Muscicapidae (thrushes, flycatchers & chats), Sturnidae (starlings & mynas), Sittidae (nuthatches), Certhiidae (tree creepers), Paridae (tits), Hirundinidae (swallows & martins), Pycnonotidae (bulbuls), Hypocolidae (hypocolius), Cisticolidae (cisticolas & prinias), Zosteropidae (white-eyes), Sylviidae (Warbles, grassbirds & babblers), Alaudidae (Larks), Nectariniidae (flowerpeckers & sunbirds), Passeridae (sparrows, wagtails, pipits, weavers & munias), and Fringillidae (finches & buntings).

Family Pittidae: Pittas. Indian pitta is the only species of this family found in the area. It is a brightly colored myna-sized bird with long legs and short tail. It is monsoon visitor. Family Irenidae-Fairy bluebirds and leaf birds: As the name suggests, the fairy bluebirds are blue and black colored forest birds. Asian fairy bluebird is the only species found in the area and so far has been seen around Bhimashankar.

Leaf birds are bulbul-sized birds with bright green, yellow and blue colors. They mostly prefer dense forest canopy. Blue-winged leaf bird has widespread distribution while the golden-fronted is confined to the Ghat country.

Family Laniidae: True shrikes. Shrikes are large birds with hooked beaks and long claws. They kill small mammals, birds, other vertebrates and insects and impale them on thorns to be devoured later. Of the five species from the study area, three are resident and widespread while the remaining two are migratory and uncommon.-Most shrikes prefer open scrub and grass country.

Family Corvidae: Crows, Treepies, Orioles, and Drongos etc. The newly reorganized Corvidae family contains twenty species in the study area. These include treepies, crows, woodswallows, orioles, cuckooshrikes, minivets, flycatcher shrikes,

fantails, drongos, monarchs, ioras and wood shrikes. Corvids are small to large-sized birds with generally strong bills and legs. Most corvids are omnivorous.

Treepies are reddish brown birds with long tails. They generally prefer wooded areas, scrub country and gardens. Rufous treepie is the only species occurring in the area which is common as well as widespread.

Crows are among the most familiar birds. They are large sized, strongly built birds with dominantly black plumage. The house crow is the one of the most common birds around human habitations. The large-billed crow, a slightly larger and robust species prefers marginal habitats around human habitations. Both the species are abundant and widespread throughout the study area.

Wood-swallows are small birds with triangular wings and short conical beaks. They are gregarious and catch insect on wings. Ashy wood-swallow is the only species that occurs in the area. It is relatively common in Konkan.

Orioles are myna-sized birds with bright yellow and black plumage. They are mostly arboreal. Of the four species occurring in India, three occur in Maharashtra as well as in the study area. The Eurasian golden oriole is common throughout and prefers open well-wooded areas and gardens. The black-hooded species though widespread is less common, whereas the black-naped is rare winter migrant.

Cuckoo-shrikes are moderate-sized birds with grey plumage and barred under parts. Of the three species that occur in the area, the large and the black-headed cuckoo-shrikes are resident birds with widespread ranges. The third species, the black-winged is winter migratory and uncommon.

Minivets are either pied or brightly colored birds with slim bodies and long tails. They often move in small flocks. Of the six species that occur here only the small Minivet is common and widespread. Two species, the white-bellied and the scarlet minivets are occasionally seen, whereas three, the rosy, ahsy and long-tailed, are stray.

Flycatcher-shrikes are small black and white birds with arboreal habit. They mostly catch flies. The bar-winged flycatcher-shrike is the only species of this group that is mostly confined to forests of the Ghat country.

Fantails are sparrow-sized flycatchers with predominantly ashy-brown plumage and prominent white supercilium. These restless birds are known for fanning their tails. Species, the white-throated and the white-browed that occur in the area are common and widely distributed. Both prefer well wooded country and gardens.

Drongos are slim-bodied birds with predominantly shiny black plumage and long mostly forked tails. Of the 20 species of drongos that occur in the world, six occur in Maharashtra as well as in the study area. Black drongo is the commonest of them all and has wide range. It mostly prefers open country and is frequently seen perching on telegraph wires. Another species, the Ashy drongo, is always confused with the former, but has less shiny plumage and is winter visitor. All the other drongos are mostly confined to forested areas of the Ghats and Konkan.

Monarchs are a group of flycatchers with bright blue plumage and white abdomen. Blacknaped monarch is the only species occurring in the well-wooded parts of the area .Though widely distributed; this is a rather uncommon flycatcher. Ioras are sparrow-sized yellow and black birds. They mostly prefer open forest, village groves and gardens. The common iora is a fairly common species whereas the Marshall's iora is a stray bird.

Woodshrikes are medium-sized grayish brown birds with a dark strip below eyes. They largely consume insects and are arboreal. Of the two species, the common woodshrike is widely seen in all the well-wooded areas, and the large woodshrike is mostly stray around Mumbai.

Family Muscicapidae: Thrushes, Old World flycatchers and Chats: The thrushes are small to medium sized song birds with black, blue or grey plumage. Seven species occur in the area.

Blue rock thrush, a common winter migrant, is generally seen around rocky hill slopes, cliffs and ruins. Malabar whistling thrush, orange-headed thrush and Eurasian blackbird are mostly forest birds and are frequently seen in the jungles of Konkan and the Ghat country.

Nine species of old World flycatchers have been observed in the area. Most of them are winter migratory. Among the migratory ones, the red-throated is the commonest, seen in gardens and groves, flitting among branches with cocked tail. Among the resident flycatchers, the Tickell's blue is common and is present in every open forest patch.

Ten species of chats and wheatear occur in the area. The commonest of them all is the magpie robin, a familiar black and white song bird of our parks and gardens. Indian robin, another equally familiar robin, is sparrow- sized with almost all black plumage and prefers more open country. White-rumped shama is a forest cousin of magpie robin and differs from it with more chestnut plumage rather than white. It is

one of our best songsters. Black redstart is widespread in parks and gardens during winter. The common stonechat and the pied bush chat are common in open country; the former is a winter visitor. Both the wheatears are also rare winter visitors.

Family Sturnidae: Starlings and Mynas. These are medium-sized birds with straight or slightly curved beaks. They are gregarious and build their nests in buildings. They are omnivorous. Of the 19 found in India, 9 species are found in Maharashtra, all of them occur in the study area. Almost all the mynas are commensal of humans and therefore commonly seen and widely distributed. Hill myna is a rare forest myna from the Western Ghats. The common starling is stray whereas the pied starling is confined to the vicinity of Mumbai, where it is an escaped bird.

Family Sittidae: Nuthatches and creepers. Nuthatches are small sparrow-sized, stocky song birds that creep up and down the trunks. The two species that occur in the area are confined to the narrow Ghat belt only.

Family Certhiidae: Treecreepers. These are small insectivorous birds with a long beak. The only species that is recorded in the area is the spotted creeper, has more spotted under parts and longer tail. It is a rare bird.

Family Paridae: Tits. These are small, mostly arboreal birds with short beaks. Of the 35 species found in India, Maharashtra has only two, both of which also occur in the study area. The great tit and the black-lored tit are woodland and garden birds; the later is confined to the Ghat country.

Family Hirundinidae: Swallows and Martins. These are small, slim insectivorous birds with triangular beak, short weak feet and long forked tail. They are gregarious. Swallows have longer tails than martins. In all 4 swallow and 6 martin species occur in the area. Almost all the hirundines are resident, common and widely distributed. They are frequently seen perching on roadside telegraph wires. Eurasian crag martin is the only migratory species. Sand, pale and house martin are uncommon.

Family Pycnonotidae: Bulbuls. These are medium-sized singing birds with short wings and bills. Many species have crests of the 19 species found in India, 6 are recorded from Maharashtra as well the study area. The red-vented and the red whiskered bulbuls are the commonest of them all. These two are familiar garden birds. Both, the Black bulbul and the yellow-browed bulbuls are forest birds, the later are found south of Mahabaleshwar.

Family Hypcoliidae: Hypocolius. Grey hypocolius is the only member of this family. This bulbul-like sooty-brown bird has slim body, long tail and crest. This is an uncommon bird and there is only one record from near Mumbai.

Family Cisticolidae: Cisticolas and Prinias. Prinias are a kind of small warblers with short wings and long graduated tails. Cisticolas are small warblers with streaked upper parts. Most of them are drab-coloured. Of the 92 species recorded in India, 29 are found in Maharashtra and seven in the study area. Of the five Prinia species, four are common and widespread, Ashy prinia being a familiar backyard bird. Of the two cisticolas, the Zitting is common, the Bright-headed rare.

Family Zosteropidae: White-eyes. These are small agile yellowish birds with short legs and a distinct white ring around eye. They are arboreal and move in small flocks. Oriental white-eye is the only species found here. It is resident and cosmopolitan in distribution.

Family Sylviidae: Warblers, Grass birds, Babblers and Sylvia warblers. Warblers are small insectivorous songbirds with drab colored upper plumage and lighter under parts. Warblers are put into various groups on the basis of their habitats and subtle physical characteristics. Hence we have Bush warblers, Grasshopper warblers, Scrub warblers, Grass birds, Reed warblers, Tree warblers, Sylvia warblers etc. Eighteen species of warblers occur in the study area. Almost all the warblers are winter visitors except the Tailorbird, which a familiar backyard bird. Warblers are difficult to differentiate in the field. Many of them can be differentiated by their distinct calls. They mostly keep to some kind of vegetation-bushes, shrubbery, tree canopy, grassy patches etc. Some warblers are extremely common throughout (e.g. Blyth's reed warbler, Greenish leaf warbler etc.) whereas others are occasional or rare (e.g. Bristled grass bird, Orphean warbler etc.)

Babblers are small to medium sized birds with overall dull plumage. They generally move in small flocks and are very noisy. They are mostly sedentary and keep to the lower strata of vegetation. All the nine species that occur in the area are resident. Some of them are local migratory. The Large grey babbler, Jungle babbler and Yellow-eyed babbler are the commonest of them all and have wide distributional ranges. Scimitar babbler is the forest babbler of the Ghat country. It is more heard than seen. The Common babbler is uncommon in the study area.

Family Alaudidae: Larks. These are small brown birds with broad wings and short tails. They nest on the ground and are good singers. All inhabit open country

intermixed with cultivation and barren wastes. Of the seven species that occur here, only the Greater short-toed lark is winter visitor, all the others are resident. The Ashy crowned sparrow lark, Rufous-tailed lark, Oriental skylark and Syke's lark are familiar species. Malabar lark, with a distinct crest, is confined to the Ghat country.

Family Nectariniidae: Flowerpeckers and sunbirds. Flower-peckers are small olive-brown birds with short beaks and tails. They are seen flying restlessly from tree to tree in search of berries and nectar. Of the 14 species found in India, three are recorded in the State as well in the study area. The Thick-billed and the Pale-billed flower-peckers are common and mostly affect village groves, orchards, plantations and gardens. The third species, the Plain Flower-pecker mostly keeps to dense forest of the Ghat country and is a common bird of Matheran and Mahabaleshwar.

Sunbirds are small birds with short wings and long decurved bill. They are always seen hovering in front of flowers. The males are usually brightly colored, the females are dull. Of the 27 species found in India, five are seen in the state and the study area. All the sunbirds are resident birds. The Purple and the Purple-rumped sunbirds are our common garden birds. The remaining three species are woodland birds.

Family Passeridae: Sparrows, Wagtails, Pipits, Weavers and Munias.

This family consists of birds belonging to various different groups. Sparrows and petronias are small short-beaked seed-eating birds. They are mostly drab colored and live in flocks. The House-sparrow is the commensal of man and is therefore the most familiar bird of our towns, cities and the countryside. Another common sparrow, the Chestnut-shouldered petronia, prefers open grass and scrub country, farmland and thin forest.

Weavers are sparrow-like bird's heavy conical bills. The birds are called weavers because of elaborate woven nests that many of these species build. During the breeding season (which coincides with the monsoon), the males attain a bright yellow and black plumage. Three species of these birds have been noted from the study area. The Baya weaver is the commonest weaverbird of the area. It's hanging nests in colonies, usually near water, is a familiar picture of the country side during rainy months. Two other weaver species, the Black-breasted and the Streaked are uncommon and recorded only from around Mumbai.

Munias are another group of sparrow-like birds with thick conical bills and short tails. Some of them are strongly plumaged while others are drab colored.

Most munias prefer open cultivated country. They build large globular nest of plant fibers in trees. They are usually seen in small flocks. Some 15 types are found in India, 6 are recorded in Maharashtra, and the same number is recorded in the study area. All the munias except the Green Avadavat have wide distributional ranges. The Indian silverbill and the Scaly-breasted munia are commonly seen around grass and scrublands. The Red avadavat generally prefers wet grassland.

Wagtails are small birds with long tails, long legs and slender bills. They mostly feed on ground and frequently wag their tails up and down. They generally have light and dark contrasting plumage. India has some 18 species, Maharashtra has 9, and the study area has 6 species. All the wagtails except one are winter visitors. The White-browed wagtail is the only resident species that lives around fresh wetlands. Forest wagtail is the one which affects forest of the Western Ghats.

Pipits resemble larks but have more slender body, longer legs and tail. They have sandy-brown plumage with streaks and spots. Birds in some species wag their tails up and down. Of the 8 species that occur in the study area, six are winter visitors. Blyth's pipit is uncommon. The resident species include the Paddy field and the Long-billed pipits. Pipits generally prefer open country and feed mostly on the ground.

Family Fringillidae: Finches and Buntings. Finches are small sparrow-like birds with short thick swollen beaks and notched tails. Of the 61 species found in India, only one species, the Common Rosefinch occurs in Maharashtra and in the study area. This finch is winter visitor to our area and is partial to hilly bamboo forest. It is always seen in small flocks.

Buntings resemble finches but have thinner beaks and longer tails. Some 20 kinds are found in India with six of them occurring in Maharashtra and the study area. All the buntings except one are winter visitors. The Crested bunting is the only resident bunting and prefers open stone-covered hill sides. They mostly feed on the ground.

PLATE: 4.1

PLATE 1: SOME AQUATIC BIRDS



WOOLLY-NECKED STORK (L) & PAINTED STORK (R)



GREY HERON



BLACK-WINGED STILT



LITTLE GREBE (F) AND COMMON COOT (B)



RUDDY SHELDUCK



PURPLE SWAMPHEN

PLATE 4.2

PLATE 2: PROMINENT URBAN SCAVENGER BIRDS



HOUSE CROW



LARGE-BILLED CROW



COMMON MYNA



BLACK KITE



ROCK PIGEON



HOUSE SPARROW

PLATE 4.3

PLATE 3: GARDEN & WOODLAND BIRDS



MAGPIE ROBIN



INDIAN PEAFOWL



RUFOUS TREEPIE



YELLOW-CROWNED WWODPECKER



PLUM-HEADED PARAKEET



COMMON WOODSHRIKE

PLATE 4.4

PLATE 4: OPEN COUNTRY BIRDS



GREEN BEE-EATER



PIED BUSHCHAT (MALE)



RED-WATTLED LAPWING



WIRE-TAILED SWALLOW



LAUGHING DOVE



BLACK-WINGED KITE

Chapter- 5

Factors Influencing Distribution of Birds

5.1 Introduction:

Distribution has been the core of all the geographical sciences and Biogeography is no exception. One of the tasks of biogeography is to try to explain 'why organisms, are distributed in the way that they are'. (Robinson, 1972) Biogeography studies 'the patterns of distribution of organisms in space and time '(Cox et al, 1977). The present world of biologists, bio-geographers & ecologists is not satisfied with the mere description of these patterns. They are more interested into the factors that determine or limit the distribution of species. The present patterns of distribution of any species are the outcome of the physical environment surrounding the species, the evolutionary history of the species and its bio-ecology. Generally the range of a species' distribution is surrounded by areas where the species cannot maintain a population because physical conditions or lack of food resources are too different to permit survival. These so called hostile areas are viewed as "barriers" (Cox et al., 1977). A species has to cross such barriers if it is to disperse to other favorable places. Climatic factors, topography, lack of food & water resources etc. may act as barriers. Whereas there are some factors which favor the species/group of species to settle & sustain in a territory. In other words there are many factors which influence & impact the presence, absence & level of abundance of a species in an area. Detailed knowledge of distributional patterns, as well as factors influencing those patterns is essential information for conservation and management of any organism including birds.

5.2 Factors Influencing Distribution:

Robinson (1972) gives the following five sets of factors which may be said to account for the "natural" distribution of plants and animals. These are

- Evolutionary factors
- Innate factors
- Environmental factors
- Geological factor
- Human activities

5.2.1: Evolutionary Factors:

The distribution of a species or group of organisms is influenced by the time and place of its origin. Very few organisms have survived through the geological period. In fact many of them have died out as a result of geological, climatic, ecological & human-impacted changes. The age of a group of organism is of some significance in the extent of its present geographical range. Generally greater the geological age, wider is the distribution of the concerned organisms. That is why the families of invertebrates have much greater ranges than those of vertebrates. Among the vertebrates, the birds have appeared on the earth quite late. The first birds are said to have appeared near the end of the Jurassic Period, about 140 million years ago (Stanley, 1986)

As per Mani (1974), the origin & evolution of the present day biogeographical characters of the Indian peninsula is dominated by the following factors:

- Evolutionary history
- Senile topography
- Its physical relations to the Himalayas
- Monsoon rainfall pattern &
- Extensive destruction of natural habitats by humans within historical times.

According to Mani (1974) the present day character fauna belongs to two groups

- The derivatives of the Gondwana fauna
- The derivatives of the younger fauna

The Gondwana fauna mostly consists of the peninsular autochthonous (native) elements and represent the true Indian component. Most of the endemic elements belong to this group.(Mani,1974) The Gondwana fauna does not include birds,since most of the present day birds evolved during the post-Gondwana period.The 2nd group consists mostly the intrusive elements and comprises fauna from the Indo-Chinese and Malayan sub-regions on one hand and African-Mediterranean elements on the other hand. The former mostly show discontinuous distribution and form geographical relicts. A small section of the intrusive fauna is derived from the Himalayas, Euro-Siberian and Turkmenian sub regions as Pleistocene relicts. These also show

discontinuous distributions. A large portion of the intrusive fauna also belongs to the Ethiopian element, many of which show continuous distribution. The birds are the derivatives of the younger fauna. Issues related to evolutionary aspects are discussed separately in the next chapter (Chapter 6) in detail.

5.2.2: Innate Factors:

Innate means belonging to or existing from birth, the inherent factors. Organisms become adapted to specific environmental conditions through the anatomical, physiological and behavioral specialization. If they are forced out of that specific environment they either perish or have great difficulties adjusting themselves to it. In this way innate factors may restrict the distribution of species (Robinson,1972).Birds along with mammals, differ from reptiles and amphibians, in possessing an internal mechanism which helps them to maintain a constant body temperature irrespective of thermal changes in the environment, i.e. they are homeotherms. As a result, birds (and mammals) are better able to withstand lower temperatures and are to be found in latitudes too cold for reptiles and amphibians. Birds' ability to fly has also made their dispersal possible worldwide. The present study avoids discussion of the innate factors for the obvious reasons –they are purely biological and therefore too technical to deal with.

5.2.3: Environmental Factors:

Major physical environmental factors that affect the dispersal, diversity and distribution of birds are latitudinal location, configuration of land and sea, accessibility, area, climate and soil. Indian subcontinent has rich bird fauna for its size, is partly because of its location within the tropics, it's very large land area, the arrangement of land & water in such a way that has given birth to the Monsoonal system of climate, the peninsular aspect, the geological history of the region etc. Some of these factors are taken care of in the next chapter (No.6).

A) Latitudinal Location:

There is progressive latitudinal increase in number of species per unit area from the Arctic to the tropics. Such a trend is found in most groups of both plants and animals (Kendeigh,1975).In other words ,species diversity is higher in the tropics and it goes on decreasing as one moves away from the equator towards the poles.

The number of species of birds breeding in North and Central America goes on increasing as one moves from Alaska(222 species) to Panama(667 species) (Cox et al,1977).The similar trend is observed along the Western Ghats. The number of

resident forest birds goes on decreasing from south to north as is shown by the following table:

Table 5.1: Northward Impoverishment of Resident forest Birds in Northern Western Ghats

Area	**Latitude**	**No.of resident forest species**
Sawantwad—Amboli	15° 58’ 04.6” N	182
Mahabaleshwar-Koyna	17° 55” 28.3” N	168
Khandala	18° 45’ 15.2” N	166
Igatpuri-Nashik Ghats	19° 41’ 44.2” N	142

The possible reasons for this bird diversity from north to south along the Western Ghats are:

- The Southern Western Ghats has more complex and diverse topography & habitats.
- The area has higher elevation range (0-2600m.) against 0-1400 m. in the north, of which the study area is a part.
- The southern part of the Western Ghats also has higher vegetation diversity with wider variety of niches.(seven vegetation types against five in the north)
- The region receives higher rainfall amount & has longer (5 to 6 months) rainy season, against 4 months long rainy season in the north.(Rainfall generally goes on decreasing from south to north)
- Higher overall biomass productivity
- The region is at the receiving end of the incoming fauna.
- There is climatic stability with reference to the rainfall. The frequency of drought is higher in the north.

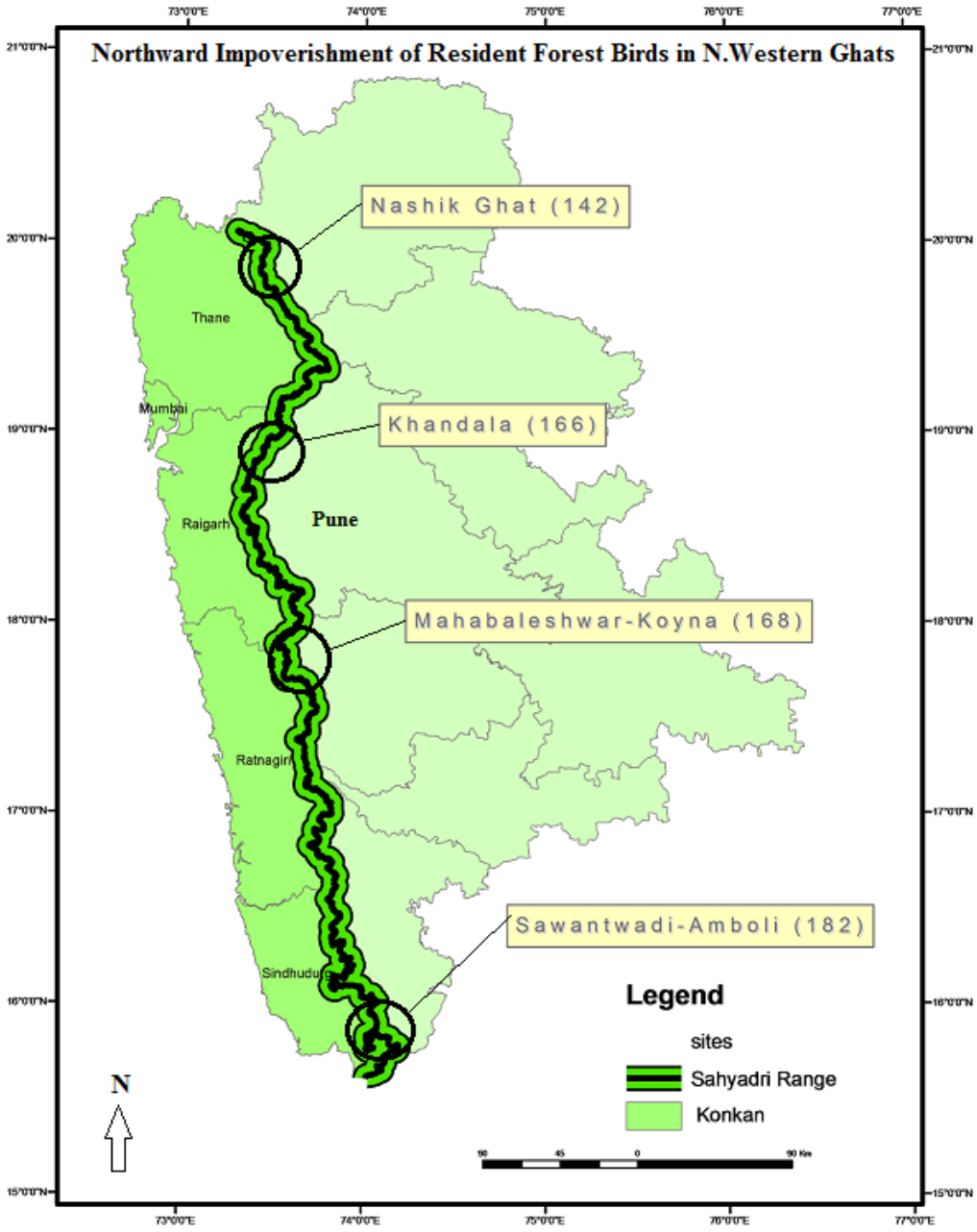


Fig. 5.1: Northward Impoverishment of Resident Forest Birds in N. Western Ghats

B) Area:

The larger the area, assuming other conditions to be equal, the richer is the fauna (Robinson, 1972).It is now a known fact that there is a definite relationship between geographical area and number of species. A larger area is likely to support more species than a smaller area. Preston (1962) an early investigator of the theory, has stated two types of Species-Area relationship (SAR)-

a) Samples

b) Isolates.

The 'sample' type is a census of a contiguous habitat that grows in census area from the smallest unit to larger unit in a nested pattern. The "isolate" is a census of discontinuous habitats, such as island, also called "island" SAR. The present study obviously uses the former sample type.

To get the SAR curve for the study area, only the resident/local migratory birds were taken into consideration. The addition of winter migratory birds may have given a wrong picture. The following data were used. The smallest unit chosen was 1 sq.km around a residential bungalow colony. The largest unit was the western part of the state, with 100000 km^2 area, including the whole study area.

Table 5.2: Increasing Bird diversity with increase in Area

Area.No.	**Selected areas**	**Size (Sq.km.) (A)**	**Number of bird species (S) enumerated for the area(1975-2010)**	**Number of basic habitat types**
1	Rajaram Society environs	1.0	94	03
2	Bibwewadi ward	6.60	134	08
3	Pune city (old limit)	173	148	09
4	Pune urban area	2000	215	12
5	W.Pune district (under study area)	10700	251	14
6	Study area(part)	22000	260	14
7	Wn.Maharashtra(Upland)	100000	281	15

Calculation of the SAR Equation:

The equation for SAR is: **$S = z \ln(A) + C$**

Where S = species number, z = slope of species-area relationship, A = Habitat area, C = constant.

For arriving at the SAC Equation following steps were followed.

i) Log value for the area was arrived at

ii) The constant was fixed at 94 (The number of species found in an unit area of 1 sq.km.)

iii) Z values were calculated with this formula: z= S-C/ln(A), where S = Number of species found in concerned area , C = constant (here 94), ln(A)=Log of area value.

iv) Z values were also calculated using Median & Mode.

v) The best fitted Z value was chosen using a hypothetical area figure

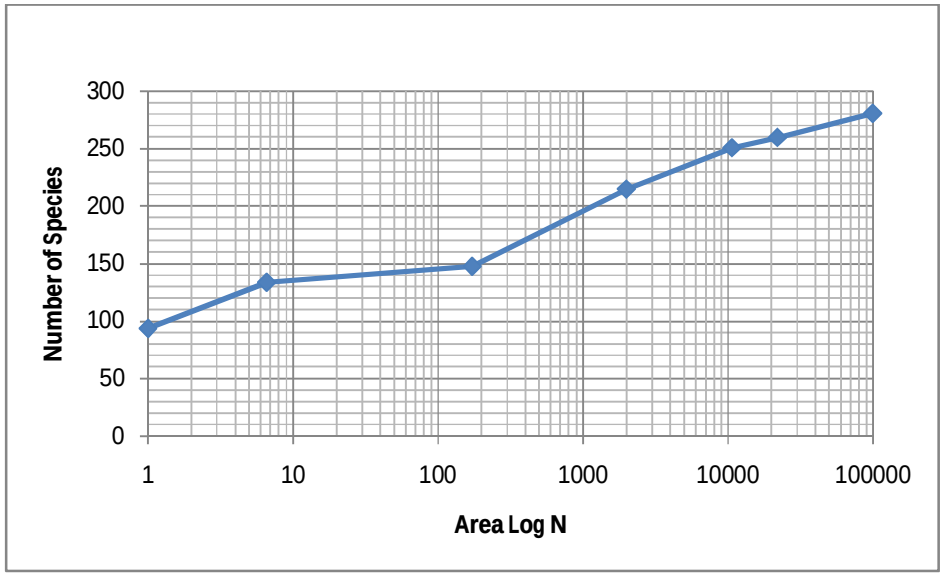


Fig. 5.2 Bird diversity versus Area

a) Calculation of Z value using formula: The table 5.3 provides Z value by using formula.

Table 5.3: Calculation of Z value

Area No.	Area A (km^2)	n(A)	Species number (S)	(S-C)	Z value
1	1.0	0.0	94	0	0.0
2	6.6	1.887	134	40	21.20
3	173	5.153	148	54	10.48
4	2000	7.60	215	121	15.92
5	10700	9.278	251	157	16.92
6	22000	9.998	260	166	16.60
	50000 (hypothetical area X)	0.82	266	----	------
7	100000	1.513	281	187	16.24
					$\sum Z$=97.3595
	Z value				**Z= 13.90**

Thus the Z value using the formula is: **Z = 13.90**

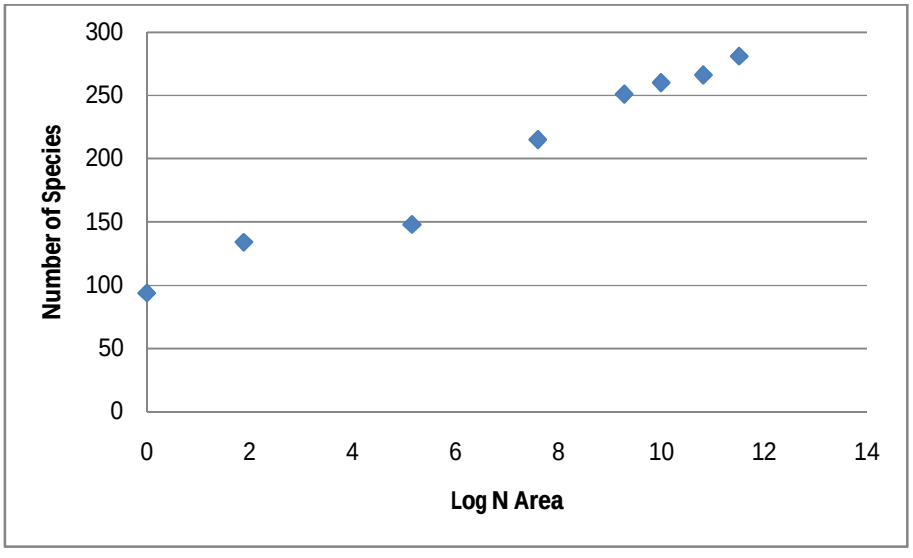


Fig. 5.3: Species-Area curve

Table 5.4: Estimated values

Sr.No.	Species No.	Area (sq.km.)	ln(A)	Estimated (A)
1	94	1.0	0.0	1.67
2	134	6.6	1.89	18.36
3	148	173	5.15	42.52
4	21	2000	7.60	2368.5
5	251	10700	9.23	20537.3
6	260	22000	9.99	35242.2
7	281	100000	11.51	124243.7

b) Calculation of Z value using Median method:

The first step is to arrange the values in ascending order.

Thus the order is: 0, 10.48, 15.92, **16.24**, 16.60, 16.92, and 21.20

Z = Size of (N+1)/2 the item

= (7+1)/2= 4th item

Value of 4th item = 16.24

Z = 16.24

c) Calculation of Z value using mode (empirical relation among mean, median & mode)

Z = 3 Median – 2 Mean

= (3X 16.24) – (2X13.9)

= (48.72) – (27.8)

Z = 20.92

We thus have three Z values. 1) 13.90 2) 16.24 3) 20.92

We arrive at the best fit value by using all the three Z values in the formula

S= Z* ln(A) + 94 with an hypothetical area figure of 50000 sq.km.

Case 1: Z value 13.90 S= 13.90*10.82+94

S=244.34

Case 2: Z value 15.92 S= 15.92*10.82+94

S=266.25

Case 3: Z value 20.92 S= 20.92*10.82+94

S=320.35

Thus we have three S values (rounded off): 244, 266 & 320.

The correct S value is 266. This gives us 15.92 as the best fitted value.

The formula for this Species –Area ratio thus becomes:

$$S = 15.92 \ln(A) + 94$$

If replaced with X and Y, this formula can be rewritten as:

$$\mathbf{Y = 15.92 \ln(X) + 94}$$

Interpretation

The following table provides the ratios between two consecutive area values and the corresponding species ratios.

Table 5.5: Consecutive area and species ratios

Area equation (Next larger/Smaller)	**Area ratio**	**Species ratio**
1 /2	6.6	1.42
2 / 3	26.21	1.10
3 / 4	11.56	1.45
4 / 5	5.35	1.16
5 / 6	2.06	1.03
6/ Hypothetical area X	2.27	1.02
Hypothetical area X / 7	2.0	1.05
7 / Hypothetical area Y	1.3	1.0

Area no.2 is 6.6 times the area no. 1 ,but the increase in bird diversity is only 1.42 times.

Area no. 3 is 26.21 times in size the area 2, but the bird diversity ratio of 1.10 shows a marginal increase.

There is sudden rise in bird diversity between area 3 & 4 (Species ratio: 1.45). Area 3 is Pune city (old limit), whereas area 4 is Pune urban area. Area wise area 4 is 11.56 times the area 3. The sudden rise in species diversity is solely due to addition of the Sinhagad area as a part of Pune urban area. The Sinhagad area is a local biodiversity hotspot. (Ingalhalikar, 2005)

After area 6, the species number seems to even out.

The species ratio becomes 1.0 when we reach the threshold value of 130000 km^2. In other words any increase in the area after this value may not add any new species.

C) Climate:

Climate is one of the fundamental factors affecting animal life including birds. The climate generally decides the diversity, population, abundance & distribution of birds. The impact of climate is twofold, direct and indirect. Temperature, winds, seasons affect species distribution directly, while it has indirect impact through forest, soil etc. There seems to be a correlation between climate and number of species. Areas, which are climatically favorable to life, support many species. The study area falls under two types of climatic zones as per the Koppen's classification 1) Tropical wet and dry 2) Semi-arid. A high degree of warmth and moisture seems, generally, to encourage prolific life (Robinson, 1973). There is clearly recognizable decrease in the number of species of both flora and fauna (including bird fauna) between the wet Konkan-Sahyadri and dry upper Deccan. Similarly there is more varied bird fauna on the high level lateritic plateau grasslands than the upper Deccan scrub & grass table lands. This is simply because the former area is more humid than the later.

The impact of climate is reflected through a) rainfall b) temperature c) SW Monsoon wind and d) Monsoon season etc.

a) Rainfall:

Ranges of many bird species are confined by isohyets of a particular value. Most of these birds have elongated & linear patterns of distribution along the Western Ghats. Since almost all the isohyets are more or less parallel to the main range of the Ghats, the ranges of many birds & isohyets patterns run parallel. The easternmost boundaries of the distribution of many bird species are enclosed by particular isohyets. There is no direct link between the birds' ranges and the distribution of isohyets. The rainfall distribution influences the distribution of vegetation, which further impacts the distribution of birds.

Many birds show north-south elongated distribution. Two patterns usually emerge,

i) The one is with wider east-west range covering Konkan as well as the Ghats country. The western boundaries of their ranges coincide more or less with

2400 mm isohyets. But the eastern boundaries are enclosed by different isohyets. There are 28 species with this pattern. Three species (Lesser Yellownape, White-bellied woodpecker, White-cheeked Barbet has their western limit coinciding with 2800 mm isohyets.

In another pattern the ranges are mostly confined to the narrow north-south belt along the Ghats country. Such a distributional pattern is enclosed on either side by isohyets. There are six species with this pattern. (Fig. 5.4)

Table 5.6: Isohyte patterns and associated Bird Species

Easternmost limit of range (Isohyte in mm)	**Number of species**	**List of Species**	**Places (Where reported during present study)**
2000	17	Rufous woodpecker, Malabar Grey Hornbill, Great Hornbill ,Malabar Trogon, Blue-bearded Bee-eater, Vernal Hanging parrot Green Imperial pigeon, Pompadour Green pigeon, Scarlet Minivet ,Bronzed Drongo ,Spangled Drongo ,Blue-capped Rock-thrush ,Yellow-browed Bulbul, Plain Flowerpecker, Forest Wagtail, Lesser Yellownape ,White-bellied woodpecker, White-cheeked Barbet	Bhimashankar Khandala Ambavane Tamhini Ghat Mahabaleshwar
1000 mm	13	Heart-spotted woodpecker, Brown Wood Owl, Nilgiri Wood pigeon, Golden-fronted leafbird, Orange-headed thrush, Malabar Whistling thrush,White-rumped Shama, Black Bulbul, Puff-throated Babbler, Indian Scimitar Babbler, Drongo Cuckoo, Eurasian Blackbird	Purandar, Sinhagad Panchgani
600 mm	04	Brown Hawk owl, Jungle Myna, Malabar Lark, Banded Bay cuckoo	Pune, Purandar (fort)

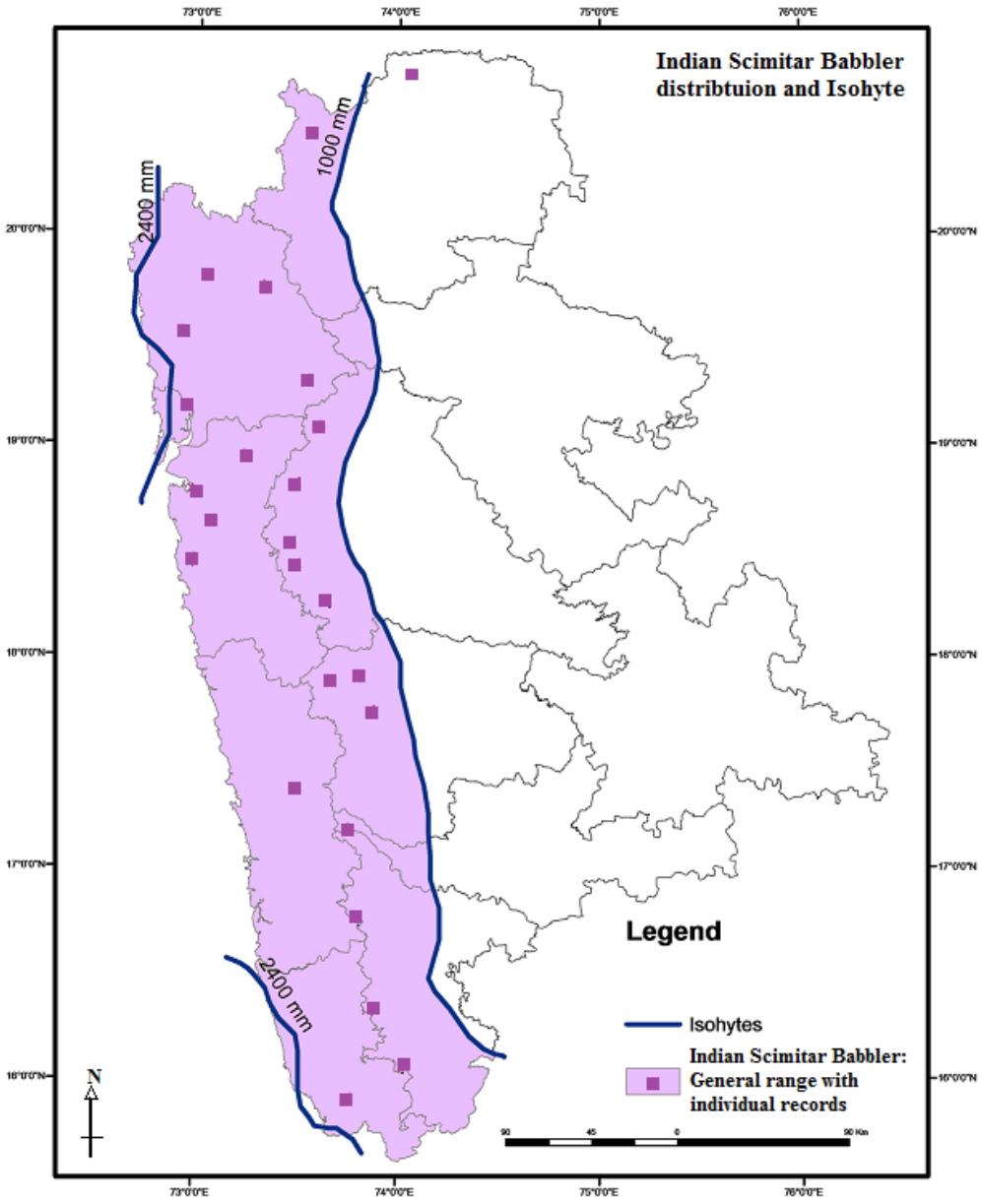


Fig.5.4: The distribution of Indian Scimitar Babbler and the position of 1000 mm isohyte.

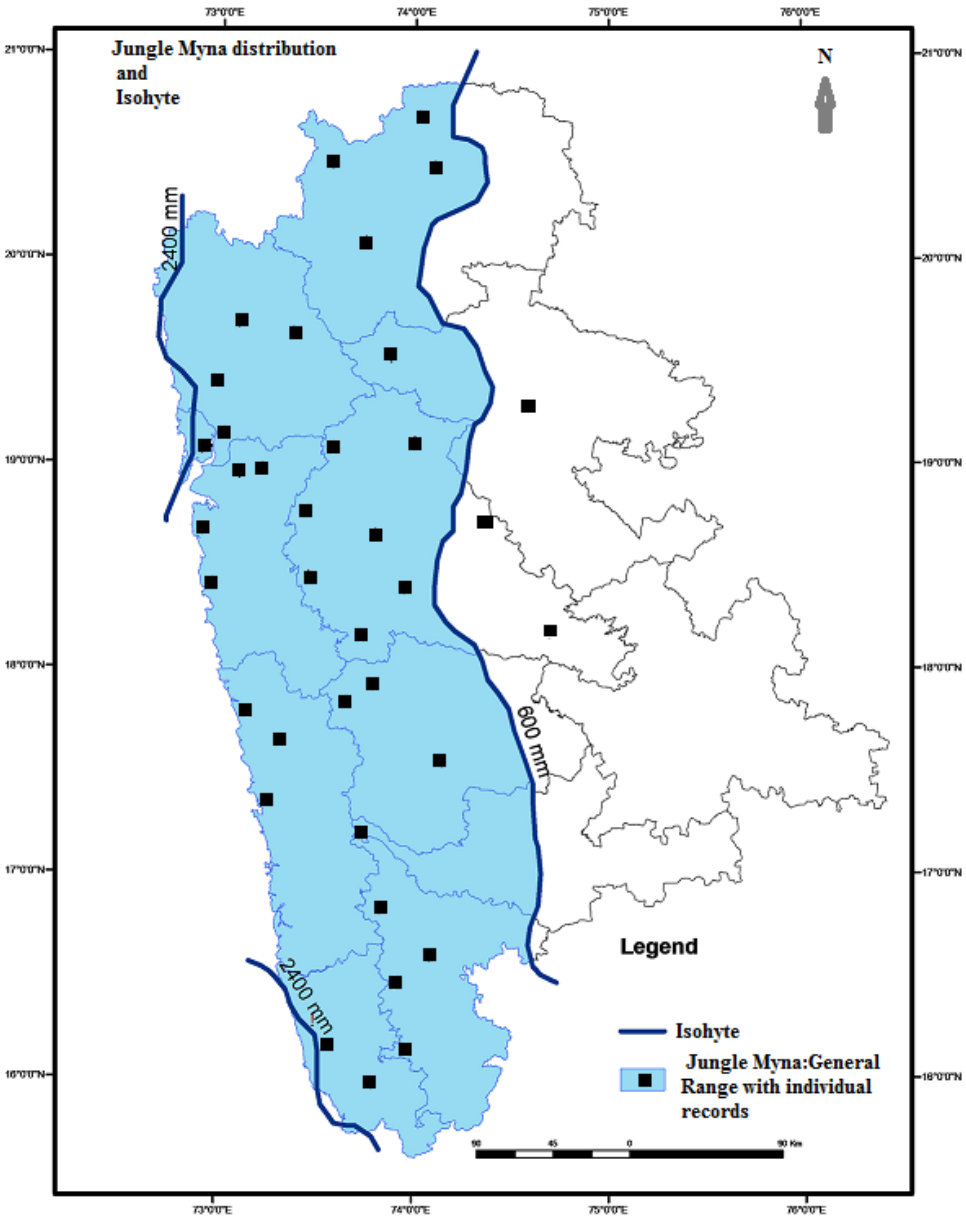


Fig.5.5: The distribution of Rufous woodpecker and the position of 2000 mm isohyte.

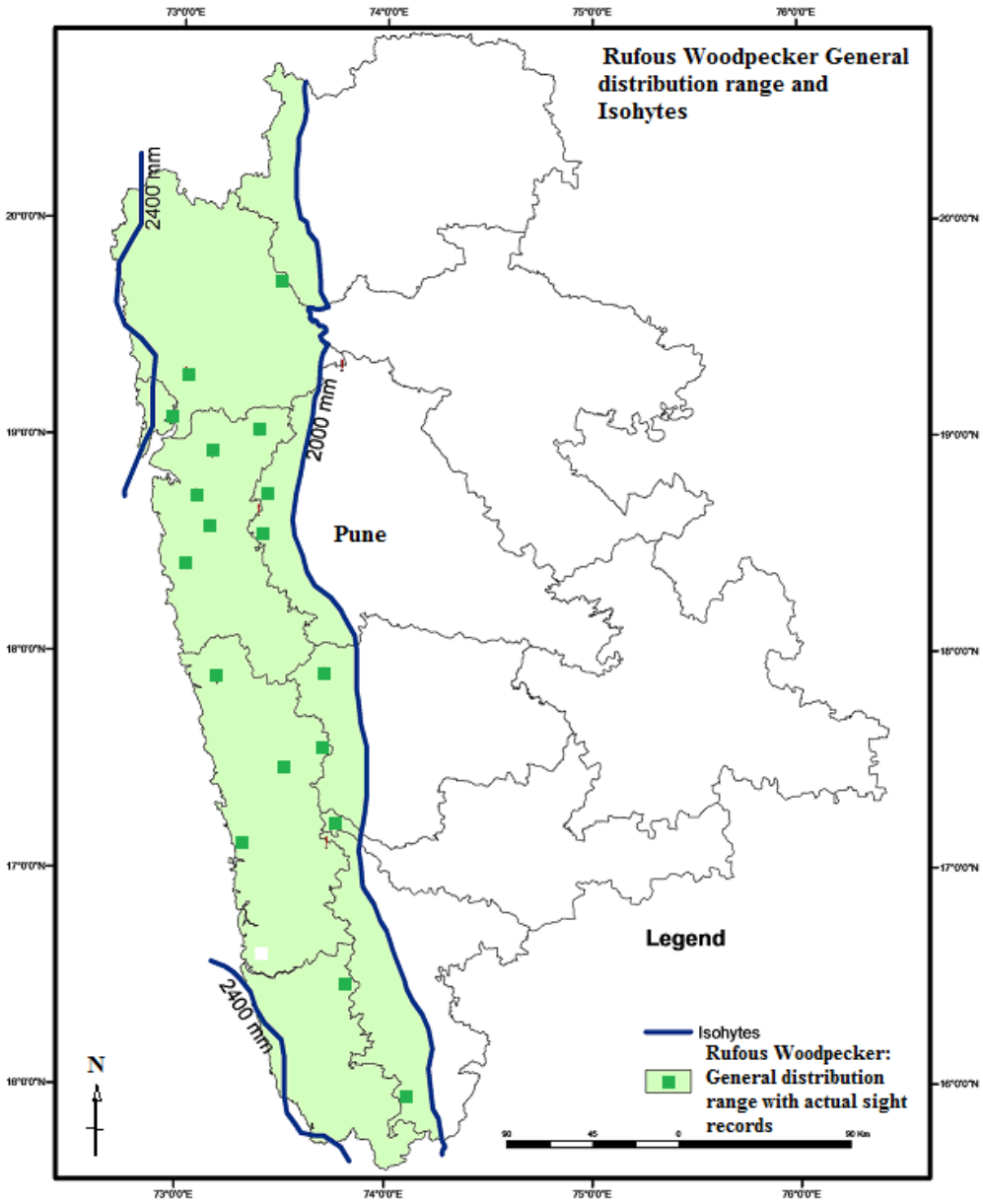


Fig.5.6: The distribution of Jungle Myna and the position of 600 mm isohyte.

Interpretation:

The 17 bird species with their easternmost distributional limit enclosed by 2000 mm isohyets are humid forest species. The 2000 mm isohyet runs more or less parallel to the crest line of the Western Ghats and is also the easternmost limit of the Tropical moist deciduous forest. **More than the isohyets, it is the forest type that defines the distributional ranges of most bird species.**

Birds with wider tolerance are found over a wider area with larger ranges lying across many habitats. The 13 species whose ranges of distribution on the east are bound by 1000 mm isohyets are the ones with wider tolerance range. They can be seen in various different forest types from Tropical evergreen (Mahabaleshwar), through Tropical semi-evergreen to Tropical moist deciduous (Sinhagad).

Four species here show the widest ranges of them all. The easternmost limit of their ranges is bound by 600 mm isohyets. They almost grade into Tropical thorn type of vegetation.

b) The South-west Monsoon Wind:

i) The sighting of pelagic birds & monsoon wind:

The South-west monsoon starts blowing towards the Indian peninsula from May end (Lal, 2004). The Arabian Sea branch follows a certain route over the northern Indian ocean-Arabian Sea. The winds blow over the Reunion, Mauritius, Rodriguez, Seychelles Islands & Chagos archipelago before they cross the Equator. After crossing the Equator the winds turn towards the north-east and blow over Socotra, the Maldives & the Lakshdweep islands as the South-west monsoon before landing on the west coast of India. The winds are so strong that they force many pelagic (deep open sea) birds from the central, western and northern Indian Ocean/Arabian Sea towards the west coast of India. During the monsoon months (June to September), especially during the onset and/or earlier we receive many pelagic birds.

Such birds are occasionally but regularly blown on to the western Indian seaboard during monsoon gales. While writing about the wandering habit of pelagic birds, del Hoyo remarked that," No regular migration is undertaken, although individuals can undergo extensive dispersal out to sea" (del Hoyo et al. 1992).

Some pelagic/oceanic birds reported from the coastal belt of /off the study area (Period: 1890-2010)

Table 5.7: Sighting records of pelagic bird species- Western coast of Maharashtra

Pelagic species-→ Months ↓	**Masked booby**	**Tropicbird**	**Frigatebird (2 sp.)**	**Brown Noddy**	**Persian Shearwater**	**Storm Petrel**	**Sooty Tern**	**Total**
January								
February		01						01
March	01							01
April								
May	02	01						03
June	06		06	03		01	01	17
July	08	02	10	01	03		01	25
August	06		01			01		08
September							01	01
October						01		
November								
December								
Total sightings (for individual species)	23	04	17	04	03	03	03	57

All of these species breed on various islands and/or coastal areas around the Indian Ocean, especially in the western & south-central part of the ocean (Ali & Ripley,1987) All of these are occasionally but regularly blown in on the western seaboard during the monsoon gales.

Of the 57 sighting records available for 8 pelagic species, 51 sighting records (89.47%) are from the four monsoon months (June to September).This clearly shows the influence of monsoon winds on pushing the pelagic birds towards the west coast of India. Every monsoon, there are regular reports in local newspapers about arrival and rescue of pelagic birds. Masked booby (Sula dactylatra) breeds on a number of islands in central, western and north-western Indian ocean.Its' breeding season is confined to the early months (February-June) of each year.Every year a few masked boobies are force-landed on the western shore of India during the rainy season by the Monsoon winds. (**Fig.5.7**) There are eight pelagic bird species which breed on various island in the Indian ocean and are blown towards the Indian coast during the monsoon months. Table 5.8 provides information about some pelagic birds and their breeding places in the Indian Ocean.

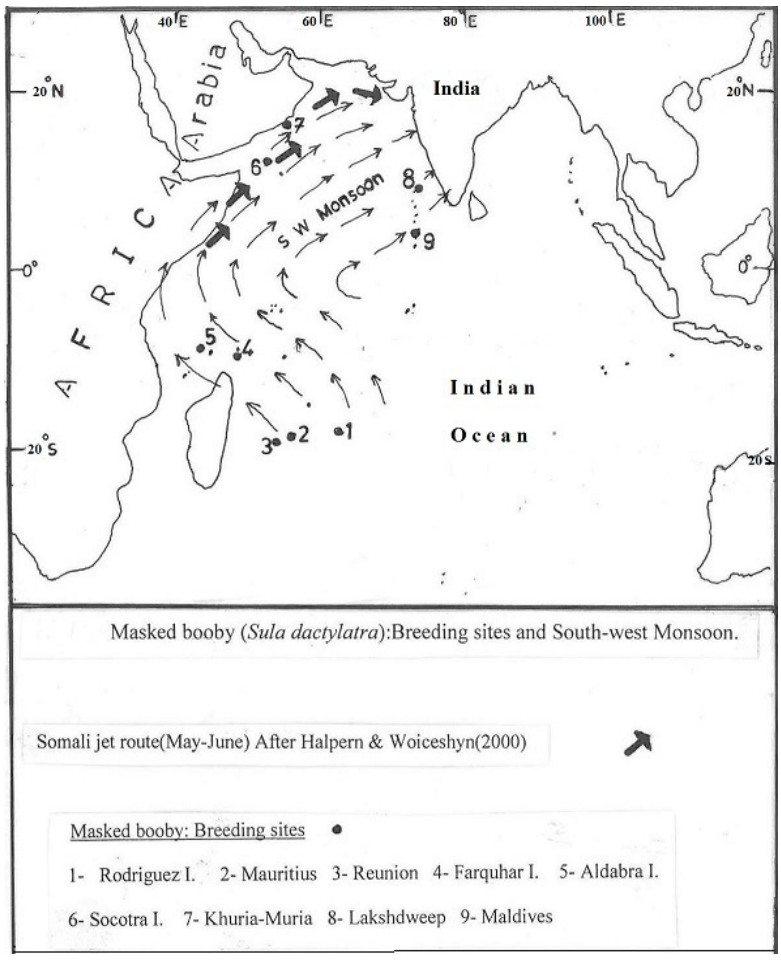


Fig.5.7: Breeding sites of Masked Booby (*Sula dactylatra*) in the Indian Ocean and the impact of South-west Monsoon on its dispersal

Table 5.8: Breeding places of some pelagic birds from the Indian Ocean which are washed ashore the Indian coast during Monsoon months

Sr. No.	Species	Breeding places	Breeding season
01	Masked Booby (*Sula dactylatra*)	Socotra I. Mait & other islands off Somali coast Rodriguez & Farquhar islands nr.Mauritius. Seychelles I. Perhaps Kuria Muria group of islands off Oman coast (S.Ali, 1983). Possibly Lakshadweep & Maldives	February to August
02	Red-billed Tropicbird (*Phaethon aethereus*)	Islands off Somali coast, in Strait of Bab-el-Mandeb & off Persian Gulf	?
03	Great frigatebird (*Fregata minor*)	Seychelles I. Aldabra I.	?
04	Lesser Frigatebird (*F.ariel*)	Aldabra I.nr Madagascar Also some atolls in Maldives	October & November (Maldives)
05	Persian Shearwater (*Puffinus persicus*)	Possibly off Makran Coast	?
06	Wilson's Storm-petrel (*Oceanites oceanicus*)	Antarctic & subantarctic islands	?
07	Brown Noddy (*Anous minutus*)	Lakshadweep, Seychelles, Madagascar & Christmas I.	February (Lakshadweep) April to September (Seychelles, Christmas)
08	Sooty Tern (*Sterna fuscata*)	Vengurla Rocks off Konkan, Lakshadweep, Maldives Islands	April-September (Vengurla Rock) December-May (Lakshadweep)

The South-west Monsoon, Somali jet and the case of Pied Cuckoo.

Almost all of the pelagic species are treated as vagrant or straggler birds i.e. they breed elsewhere and visit Indian shore as vagrants. But there is one species of bird which is a summer (monsoon) breeding migrant to India and is said to come from Africa. This is the Pied Cuckoo (*Clamator jacobinus*). This bird has three subspecies/geographical races (Freidmann, 1964) as follows:

Clamator jacobinus pica-This is the migratory race,the popular rain visitor ,which arrives here from Africa in late May/early June and occupies large areas of northern & western India.This race spends its non-breeding time in eastern and north-eastern Africa(Kenya, Ethiopia & Somalia).

Clamtor jacobinus jacobinus-The resident race of Sri Lanka and southern India (south of 15° N).This race breeds in January to March. This race disperses widely during the monsoon and may intermingle with migratory ones.

Clamator jacobinus serratus-This race is resident over a large part of tropical Africa south of Sahara.

Some facts about the Pied Cuckoo:

- The migratory Pied cuckoos (PCs) are mostly confined to the northern and western part of the Peninsula. The migratory PC population that arrives in India generally occurs north of 15° N latitude.
- The mean period of the arrival of the migratory Pied cuckoo population to India is last week of May and the first week of June (Ali & Ripley, 1987)
- The arrival dates of the PCs are earlier by one week along the Konkan coast than in Gujarat.
- The arrival dates are also earlier for the coastal location than the interior places. So far as the arrival dates of the pied cuckoo are concerned this is what experts have to say

Kinnear's remark- "every year in the latter part of the hot weather there appears to be a large influx of Pied-Crested Cuckoos into Bombay and the surrounding district. They generally made themselves noticeable about the first week in June. (Editors, 1910)

There is some ambiguity over the exact migratory route of the migratory race from Africa to India. It is said that they take an Arabian Sea route along the shores of the Arabian Peninsula. Some watchers (Jamdar, 2005) suspect role of the Somali jet

(a fast stream of air over the Arabian sea) in carrying the migratory population from Africa to south Asia. The author feels that not only the Cuckoo but all the pelagic birds that stray towards the Indian shore are carried here by the Somali jet. Since this needs further confirmation, this role is discussed here in detail.

The role of Somali jet in transporting Pied cuckoo and the pelagic birds from E. Africa/Western Indian Ocean to India.

What is the Somali jet?

The Somali jet is a low level jet stream that forms in the northern summer over the western part of the Indian Ocean off the Madagascar coast. It is part of the monsoon weather system that is also formed in the same region.

The south-west monsoon is born out of a high pressure area called "Mascarenas High" (Named after the island with the same name).The moisture-laden winds from the high pressure area travel northward towards the east African coast as south-easterlies. On the way they pass the islands of Rodriguez, Mauritius, Reunion, Farquhar group, Madagascar, Aldabra & Seychelles. When they reach the shores of east Africa they are deflected by the East African Highlands initially towards the north while crossing the Equator. When the system reaches the Somali coast it is further deflected towards the east as the south-westerlies. (Barry & Chorley, 1976; Lal, 2004)

The Somali jet after formation in April off the Mauritius coast also moves north-eastward towards northern Madagascar and then towards the Kenyan coast about 3° south. Subsequently it runs over the plains of Kenya, Somalia & southern Ethiopia during May, before it strikes the coast again about 9° N the non-breeding range of Pied Cuckoo in Africa that migrates to India. The Jet which reappears over the Socotra then traverses the northern part of the Arabian Sea, before reaching the Indian shore in June. The Jet is up to 15 km deep and attains speed of 25-30 ms^{-1} (Findlater, 1969) at just 1 to 1.5 km. This branch of the Jet later becomes the low-level monsoon westerlies (Krishnamurti & Bhalme,1976).The Jet which begins to develop in April is strongest during the month of July (Chakraborty et al.,2008) .**This is probably the reason why we have maximum number of pelagic birds visiting us in the month of July.** The Somali jet which is almost 200 km wide (Halpern & Woiceshyn, 1999) reaches the Indian shore like a front. It mostly strikes western

shore north of 10° N hence probably the migratory Pied cuckoos are mostly confined to the northern part of the Peninsula.

The route of the South-west Monsoon system & that of the Somali jet follows those islands of the Indian Ocean which are main breeding grounds of the eight pelagic species that straggles the western shores of India.(T:5.10) (Ali, 1983; Keith & Gooders, 1980; Grimmet et al.,1998)

The average period of the arrivals of the migratory pied cuckoo race to India is last week of May and the first week of June. This is the formative period of the Somali jet, so that the winds are still to be established. Fleux and Stommel (1977) reported that 25 May (with a ± 5-day uncertainty) is the average date of onset of monsoon winds in the Arabian Sea about 500 km. north-east of Somalia.(off the Oman coast).But this is the time of arrival of first pied-crested cuckoos on the western shores of India. There are weak Somali jet currents in later part of May and/or early June. The Pied Crested Cuckoo, being a myna-sized slim bird (body length-33 cm), and a weak flyer, it is quite possible that it prefers the weak initial streams of the Somali jet to reach India. Hence its early arrival in May/June. The streamlines of the approaching monsoon wind during the period, 25 May-9 June are also aligned in such a way that they have the tail over eastern Africa, middle portion over the Arabian Sea and head along the western coast of India (Singh & Ranade, 2010).This is the most probable migratory route of the pied cuckoo from Africa to India.

It seems that the PCC uses the landward section of the Somali Jet stream which moves close to the Arabian shoreline.

The Somali jet/South-west monsoon system moves as a front towards the western shore of India. It seems that the front first touches the Konkan coast and then moves towards Gujarat. **This may be the reason why the arrival dates of the PC are earlier by one week along the Konkan coast than in Gujarat**. It is quite possible that the migratory flocks of Pied-crested cuckoo fly as a front within the Somali jet, a front about 200 to 400 km wide across. The advancing tongue of the front must be touching the Mumbai coast first and the Gujarat coast later. This is probably the reason why the arrival dates of the PC are earlier in Konkan than in Gujarat.

The migratory PC population that arrives in India generally occurs north of 15° N latitude. This is probably due to following reasons-According to Miller & Keshavamurthy (1968), the southwest monsoon current in the lower 5 km. near India

consists of two main branches, which are the Bay of Bengal branch,…and the Arabian Sea branch. The latter branch can be further divided into two separate currents. One part of the main low-level current flows northward across the equator and then, turning northeast, flows over the Arabian Sea, crossing the Konkan coast north of 15° N.(Lockwood,1979)

The strongest Somali jet, with maximum wind speed, is generally experienced in July. This is the period when we receive maximum numbers of pelagic birds. It must be remembered that almost all the pelagic birds are vagrant and not a regular migrant like the Pied cuckoo. **It seems their arrival coincides with stormy weather phenomena.**

The birds it seems arrive first on the coastal locations and spread in the interior in due course of time later as is shown by the sequence of dates for coastal locations (Alibaug, Mumbai etc.) and interior locations (Pune, Nashik, Solapur etc.)

The sightings of Wilson's storm petrel, Tropicbirds, Shearwaters & Masked boobies in the off-shore waters of the passage from the Gulf of Aden to Karachi between 1st and 7th July (Phillips, 1945) is an indication that the migration/straying route of the pelagic birds in the northern Indian Ocean passes through the northern Arabian Sea, the route that is channeled by the Somali jet/South-westerly monsoon system.

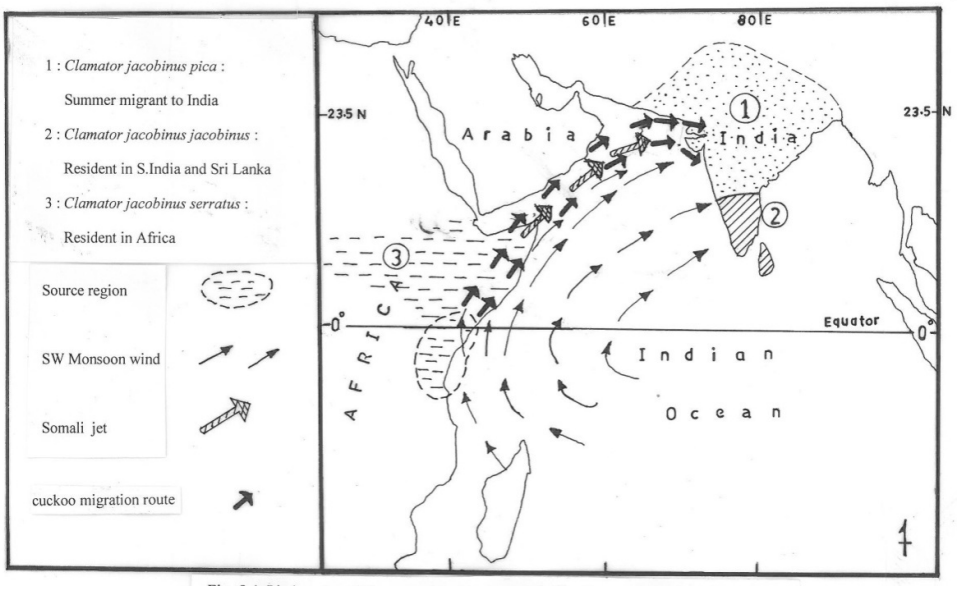


Fig.5.8: Pied cuckoo: Migratory route from Africa to India, coincides with the Somali jet and the SW.Monsoon wind routes

c) Monsoon Season and Bird Distributions:

Monsoon also guides the local movements of birds. With the onset of Monsoon in Konkan & the Ghat region many birds from these areas move towards less humid eastern belt of the study area. This movement is generally west-east.

This is evident in

a) Sudden appearance of some Ghats birds around Pune

b) Increase in the number of some familiar birds around Pune.

This movement was referred to as early as 1905 by Aitken. He once expressed in his inimitable style that "the common kites go to Poona, with the Government, for the monsoon months"(Aitken,1947).Three types of birds have been found to move from heavy rainfall Konkan & Ghats country towards less wet, relatively dry upper Deccan country. These are:

- Common urban birds such as black kites
- Common open area birds such as drongos & rollers.
- Some forest species such as ground thrushes.

Common kites from around Mumbai & coastal towns of Alibag seem to move towards the east during the heavy monsoon months. It is not known for want of reliable ringing data whether the Mumbai kites go to Nashik or Pune. Though Aitken (1947) commented them to go to "Poona" from" Bombay" ,if one studies the monsoon wind pattern then the kites that we receive in Pune must be coming either from the Ghat country of south-west Pune district or southern Raigad (Mahad, Mhasla etc.) and northern Ratnagiri area. Mumbai kites must be moving towards Nashik region. The only proof of kites coming to Pune from outside is the drastic increase in their number.The point counts at five different localities in Pune viz.i) Vaikuntha crematorium ii) Fergusson college campus iii) Shivaji market (Pune camp) iv) Yeravada & v) Uruli Devachi garbage dump during the monsoon months show the average population almost double the summer months population.

The population of common drongo & Indian roller around Lonavla & Tamhini decreases during the monsoon months. Against this the population of both the species around Pune increases. The increase changes from place to place and is from 10 pc to 25 pc.

Many typical Konkan birds arrive in the forests and woodlands around Pune during the monsoon season. **(Fig.5.9)**

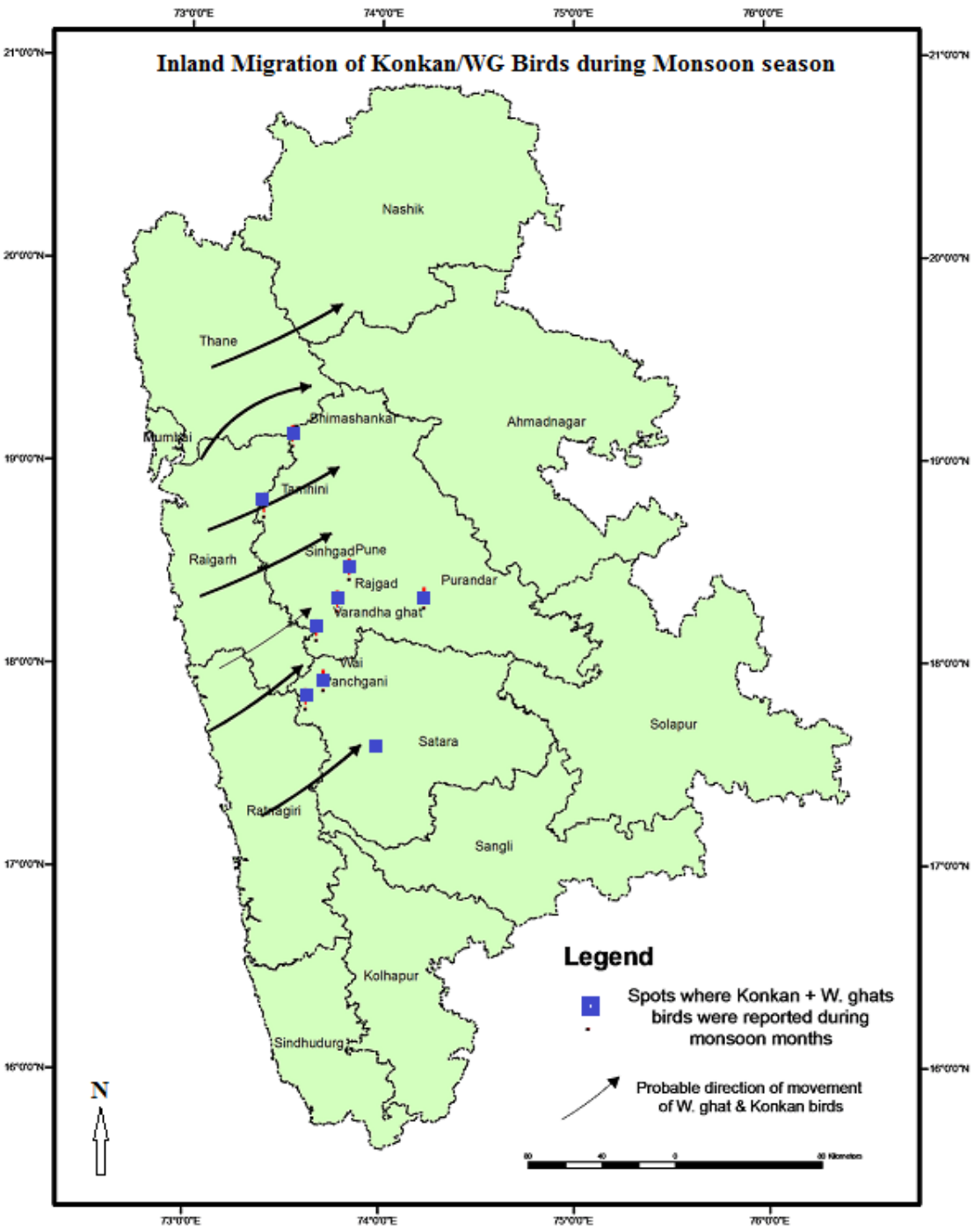


Fig. 5.9: Inland Migration of Konkan/WG Birds during Monsoon Season

Table 5.9: Konkan birds moving inland to the Ghats country & upper Deccan area during Monsoon

Species	Time of arrival	Places where sighted	Reported dates during the present study
Malabar Pied Hornbill	Late June	Bhimashankar WLS	Occasionally seen
Great Hornbill	Late June/Early July	Tamhini	Late May 2009
Vernal Hanging Parrot	Early July	Varandha Ghat/Tamhini	
Malabar Parakeet	July-August	Rajgad/Sinhagad	Frequently sighted during monsoon
Nilgiri Wood pigeon	July-August	Sinhagad	August 2006
Pompadour Green Pigeon	July-August	Purandar	Regularly sighted from early June
Black Eagle	Late June-Early July	Bhimashankar WLS	July 2006
Bronzed Drongo	Late June-Early July	Panchgani	June 2005
Malabar Whistling Thrush	Mid-June/Early July	Panchgani/Sinhagad/Purandar	Regularly seen
Orange-headed thrush	Late June-Early July	Sinhagad/Purandar	Frequently from 2001
Black Bulbul	Late June-Early July	Panchgani	June 2005

Expansion and Contraction of ranges due to Monsoon:

Some birds expand their ranges while the ranges of some other birds get contracted with the arrival of Monsoon .The expansion of the ranges is largely due to formation, availability and expansion of wetland habitat .Most of the rails, crakes and water hens show this behavior. The best example is the white-breasted water hen. During the dry season the hen is mostly confined to overgrown water-side bushy vegetation. The water hen "wanders considerably afield in the monsoon when low-lying tracts become water-logged" (Ali, 1979). A flock of White-breasted water hen monitored at Pashan lake area for three years (2001-2004) revealed an interesting fact. At the height of summer (last week of April/first week of May), the flock of the Water hen was found to be confined to a narrow 500 m long belt near the tail end of the lake and along the Ramnadi. The farthest points/places where the flock or member of the flock was sighted was noted down. It was found that the water hens always preferred vegetative part of the tail-end of Pashan Lake. Some hens were seen wandering upstream along the Ramnadi and the defense compounds of the nearby establishments. The total area covered by White-breasted water hens during the summer months was found to be from about 30 to 35 hectare. After the beginning of the monsoon, the water hens started spreading to neighboring compounds and streams in upstream direction. In July they had maximum spread, which covered all of Pashan lake, all the neighboring compounds & campuses. All the rainy season sightings put together, the composite range of Pashan flock comes to around 160 ha. This clearly shows that the composite monsoon range of WBW is at least five times larger than its summer range.

Monsoon is the breeding season for most herons, egrets & cormorants. During the monsoon season most herons & egrets disappear from around Pune. There is drastic drop in population of Pond heron. Cattle egrets also become almost absent. The five species of egrets and herons viz. Pond heron, Large egret, Median egret, Small egret and Cattle egret seem to move towards the west, to either Mawal or Konkan region for breeding. **(Fig.5.10)**

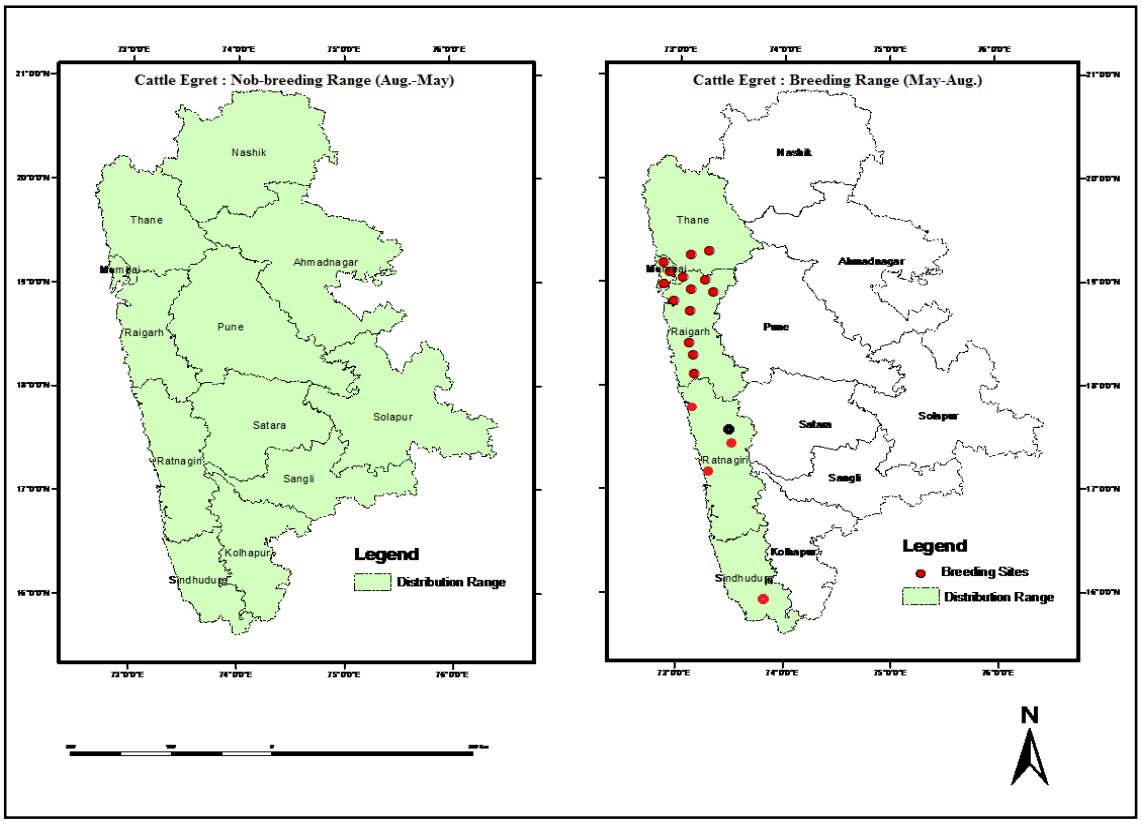


Fig. 5.10: Expanding (non-breeding) and contracting (breeding) range of Cattle egret as an impact of SW.Monsoon

Some evidences of this movement are:

- Most egrets and herons mentioned above are seen moving westward of Pune in flocks by May-end or beginning of June.
- Almost all the known heronries belonging to these five species are confined to Raigad and Thane districts (Mahabal,1990;Present study).
- A few heronries are also reported from Mawal and Mulshi talukas of Pune districts.(Present study).
- There are scattered & isolated nesting sites of these five species around Pune. Most of the sites belong to pond heron (Peshwe Park in Pune)
- There are many heronries along the Pune-Solapur highway. Most of these belong to i) Grey heron ii) Painted stork and iii) Little cormorant .The location of heronry seem to be influenced by four factors a) Creeks & estuaries b) Paddy fields, c) Reservoirs and d) Protection.

Table 5.10: Locations of heronries from the study area (past & present)

Sr. No.	District	Location	Species	Nearest wetland (Distance in km.)	Surrounding Habitats	Source
1	Mumbai	Vihar lake islets (U)	Night herons	Lake (K) (100 m)	Urban settlement	Barns
2		Elephanta islands (R)	Night herons	Sea (K) (500 m)	Creek	Barns
3		Jijamata Udyan(Victoria Gardens) (U)	Pond heron	Sea(K) (2)	Urban settlement	(SA+HA,1941)
4		Bandra Rly.Stn. (U)	Cattle egret/Pond heron	Sea(K) (1.8)Creek (735 m)	Urban settlement	---Do---
5		Andheri Bazar(U)	Cattle egret/Pond heron	Sea(K) (3)	Urban settlement	---Do---
6		Borivli village(U)	Cattle egret/Pond heron	Creek(K) (1.7)	Urban settlement	---Do---
7		Borivli (W)(U)	Night Heron	Creek (K) (1.7)	Urban settlement	BOB
8		Mahalaxmi (U)	Cattle egret/Pond heron	Sea(K) (730 m)	Urban settlement	---Do---
9		Kandivli (U)	Cattle egret/Little cormorant/Intermediate egret/Night heron	Creek(K) (5)	Urban settlement	Naik(?)
10	Thane	Thane town (U)	Pond heron/Night heron	Creek(K) (1)	Urban settlement	(SA+HA,1941)/ Present study
11		---Do---(U)	Little cormorants/Night heron	Creek(K) (1)	Urban settlement	---Do---
12		Vasind (R)	Smaller egrets	(K) River(1)	Paddy field	---Do---
13		Vasind Rly.Stn. (R)	Large/Smaller/Little/Cattle egrets/Pond heron	(K) River(1)	Paddy field	Barns
14		Vajrabai hot spring (R)		River(K) (352 m)	Paddy field	---Do---
15	-	Khadkali (U)	Little cormorant/Cattle egret/	-Lake(K) (50m)/ Creek (5)	Urban settlement	Present study
16		Navi Mumbai (U) (DAK City-	Egrets/Herons/Cormorants	(K) Creek(1.3)	Urban settlement	RajeshKumar(2009)

		Koparkhairne)				
17	Raigad	Panvel town (04)(U)	Cattle egret/Pond heron/Little egret/Median egret	Lakes/Creek(K) (4)	Urban settlement	Mahabal(1987)/ Present study
18		Shirdhon village (R)	Cattle egret/Pond heron/Little egret	(K) Creek-(10.2) Lake(12.3)	Paddy field	Mahabal(1987)
19		Palaspe village (R)	Cattle egret/Pond heron/Little egret	(K) Lake(9) Creek(10.7)	Paddy field	Mahabal(1987)/ Present study
20		Apta villge (R)	Cattle egret/Pond heron/Little egret/Median egret	(K) Creek(9) Lake(12.8)	Paddy field	Mahabal(1987)/ Present study
21		Karjat town (U)	Cattle egret /Little egret/Median egret	River (K) River(300) Lake(5)	Paddy field	Mahabal(1987)
22		Karjat (U)	Large/Smaller/Little egrets/Pond heron	River (K) River(300 m) Lake(5)	Paddy field	(SH+HA,1941)
23		Neral town (U)	Cattle egret /Little egret/Median egret	River (K)(1.4)	Paddy field	Mahabal(1987)/ Present study
24		Uran town(U)	Cattle egret /Little egret/Median egret	Sea/Creek (K) (1.7)	Urban settlement	Mahabal(1987)
25		Pen town(U)	Cattle egret/Pond heron /Median egret	River (K) Creek(7.6) Lake(9.3)	Paddy field	Mahabal(1987)/ Present study
26		Varsai (R)	Cattle egret/Pond heron	River (K) River(125 m) Lake(5.8)	Paddy field	Present study
27		Alibaug (U)		Sea (K) (1)	Creek	
28		Shahbaj village (R)	Cattle egret/Pond heron/Little egret	Creek (K) (2.4)	Paddy field	Mahabal(1987)
29		Roha town (U)	Cattleegret/Pond heron/Little egret/Median egret	Creek/River (K) (650 m)	Paddy field	Mahabal(1987)
30		Kolad village(R)	Cattle egret/Pond	River (K) (236 m)	Paddy field	Mahabal(1987)

			heron/Little egret			
31		Nagothane village (R)	Cattle egret/Pond heron/Little egret	River (K) (9.9)	Paddy field	Mahabal(1987)
32		Mangaon town (U)	Cattle egret/Pond heron/Little egret	Creek/River (K) (703 m)	Paddy field	Mahabal(1987)
33	Pune	Indapur (U)	Grey herons/White & Black ibises/Painted stork	Reservoir (D) (3.9)	Farmland	K.Purandare(1990)/ Present study
34		Bhadalwadi (R)	Painted stork	Lake(D) (0 m)	Farmland	Present study
35		Telco lake (U)	Greyherons/Painted stork	Lake/Pond (D) (0 m)	Urban settlement	Present study
36		CME lake (U)	Grey herons/Purple herons	Lake/Pond (D)(0 m)	Urban settlement	Present study
37		Kasurdi nr.Yewat (R)	Grey herons	Reservoir (D)(0 m)	Farmland	C.Rajarshi(2011)
38		Urali Kanchan (R)	Grey herons/Little cormorants	River (D) (4)	Farmland	K.Purandare(2011)/ Present study
39		Ramdara nr.Loni (R)	Egrets	Pond (D) Lake(3.3) River(5.7)	Farmland	Present study (19/06/2002)
40		Kamla Nehru Park (U)	Night heron	Stream/Odha (D) River(850 m) Lake(5.1)	Urban settlement	Present study (Jan-Feb.1998)
41		Thube Park (U)	Night heron	Stream/River (D) (546 m)	Urban settlement	Present study
42		Daund (U)	Grey herons	River (D) (1.4)	Farmland	Present study
43		Patas (R)	Grey herons	Lake/pond(D) (500 m)	Farmland	Present study
44	Satara	Mhaswad tank (R)	Spoonbill/Smaller egret/Indian shag/Black ibis	Tank (D) River (616 m)	Farmland	Present study
45		Khatpal(26 km E.of Mhaswad) (R)	Painted stork	(D) Lake	Farmland	Present study

Observations:

a. Geographical distribution:-

Out of the 45 heronries from the study area, 32(71.11%) were from the Konkan region, whereas only 12 (28.89%) were from the Deccan plateau area. Not a single heronry was reported from the Ghatmatha (crestline) area.

b. Urban-Rural division:

Sixty per cent (27 heronries) were reported from the urban areas, whereas 40% (18 heronries) were reported from the rural area.

c. Distance of nearest water body/wetland:

Almost 42.22% (19 heronries) were found to be within 1 km. radius of the nearest wetland, 71.11% (32) lie within 3 km. 88.88 % (40) within 6 km. and 97.77% were within 10 km of the nearest wetland/water body. Only one heronry was reported just beyond 10 km of the nearest wetland/water body.

d. Wetland affinity:

About one-third heronries (15) prefer to be near rivers/streams followed by Creeks and lakes/reservoirs (26.67% each) and sea shore (13.33%).

e. Species composition:

There were 11 single-species heronries, 11 two-species heronries and 19 multiple-species (more than three species) heronries. Most of the single species heronries belonged to either night heron or grey heron. Almost all the heronries in the Konkan region belonged to smaller and medium-sized herons (Pond heron, Cattle, Smaller and Medium egrets and Night herons) whereas most of the heronries in the Deccan area belonged to larger herons (Grey & Purple herons) as well as little cormorants, Asian spoonbills, Painted stork etc.

f. Dominant habitat of the hinterland (within 10 km.):

Urban settlement (18 sites/40%) and paddy field (16 sites/35.55%) are the most dominant habitats within 10 km of the heronry sites. Other less dominant habitats are farmland (9 sites/20%), and creeks (2 sites/4.44%)

Explanation:

a. More than 67 % heronries were recorded from the Konkan region. This is largely due to its paddy cultivation (the major feeding ground of all the egrets and herons), and a dense network of streams, creeks and estuaries. The breeding season of most smaller and medium-sized egrets and herons in the study area falls

during the monsoon season, which is also the sowing & growing season of rice(paddy).

b. More than 70 p.c. heronries are reported from the urban area. This shows that the egrets and herons prefer security in the company of humans over many other aspects. In fact many heronries are located in densely crowded localities in the heart of cities.(e.g. the Jijamata Udyan)

c. Five to ten kilometer from the nearest wetland seems to be the optimum distance for selection of site for heronries. Observations at the Urali Kanchan heronry near Pune showed that herons travel at a speed of about 30 to 40 km per hour. Every heron on an average took around 6 to 8 minutes, one way, to reach the nearest river located 4 km away. On average every bird spent around 30 minutes at the wetland before collecting enough food (fishes, frogs etc.) and return to the nest for feeding the young. With this frequency one bird brings food about 10 to 12 times a day. To maintain this frequency and the food supply, the 5 to 10 km optimum distance from the nearest wetland sounds quite logical.

d. The wetland affinity seems to be equally divided among sea shore habitat and streams/rivers habitat, followed by creeks and estuarine habitat.

e. It is interesting to note that smaller medium-sized egrets & herons prefer the Konkan region for establishing their heronries whereas larger grey herons prefer wetland on the Deccan plateau for the same. The early nesting of grey herons (Jan-April) seems to be the deciding factor of their choosing the Deccan plateau wetlands when most of the paddy fields in Konkan are dry. Most heronries along the Pune-Solapur highway are recent. They have come up during the last 10 to 30 years after completion of new dams, especially the Ujani reservoir. (eg. the Indapur heronry) **Distribution of heronries is controlled by a single factor-the wetland.**

f. Paddy field as dominant habitat is obvious.Urban settlements provide security,nesting trees and food from nearby reservoirs

F) Temperature and birds

About a quarter of the bird fauna of the study area is winter migratory. Some of these birds are mostly confined to the northern and central parts of the country and Pune or the study area forms the southernmost boundary of their winter range. In this

case it is not the isohyets but an isotherm that forms its southernmost boundary. Some prominent examples are:

Table: 5.11: Some bird distribution ranges bound by January isotherms

Southernmost boundary (January Isotherm in C°)	No. of species	Bird species list	Places/spots where seen
22.5°	2	Tufted Duck Oriental Turtle Dove	Pashan,Veer Saswad-Daund line
21.5°	4	Eurasian Wryneck Steppe Eagle Bank Myna Rufous-fronted Prinia	i) Khandal-Pune-Baramati ii)Khandal-Pune-Baramati iii)Mumba-Pune line iv)Mumbai-Pune-Shirur line

A few species are confined to southern part of the Peninsula or the Western Ghats. Pune or the study area is its northernmost limit. These limits again coincide with some particular isotherms.

Table: 5.12: Isotherms and northernmost limit of bird ranges.

Northernmost boundary (January isotherm in C°)	No. of species	Bird species list	Places/spots where seen
22° C	1	Brown shrike Jerdon's Nightjar,	Mahabaleshwar
21.5° C	2	i)Black-headed Munia, ii)Chestnut-tailed Starling	
21° C	2	i)Blyth's Reed Warbler	Mumbai-Pune line

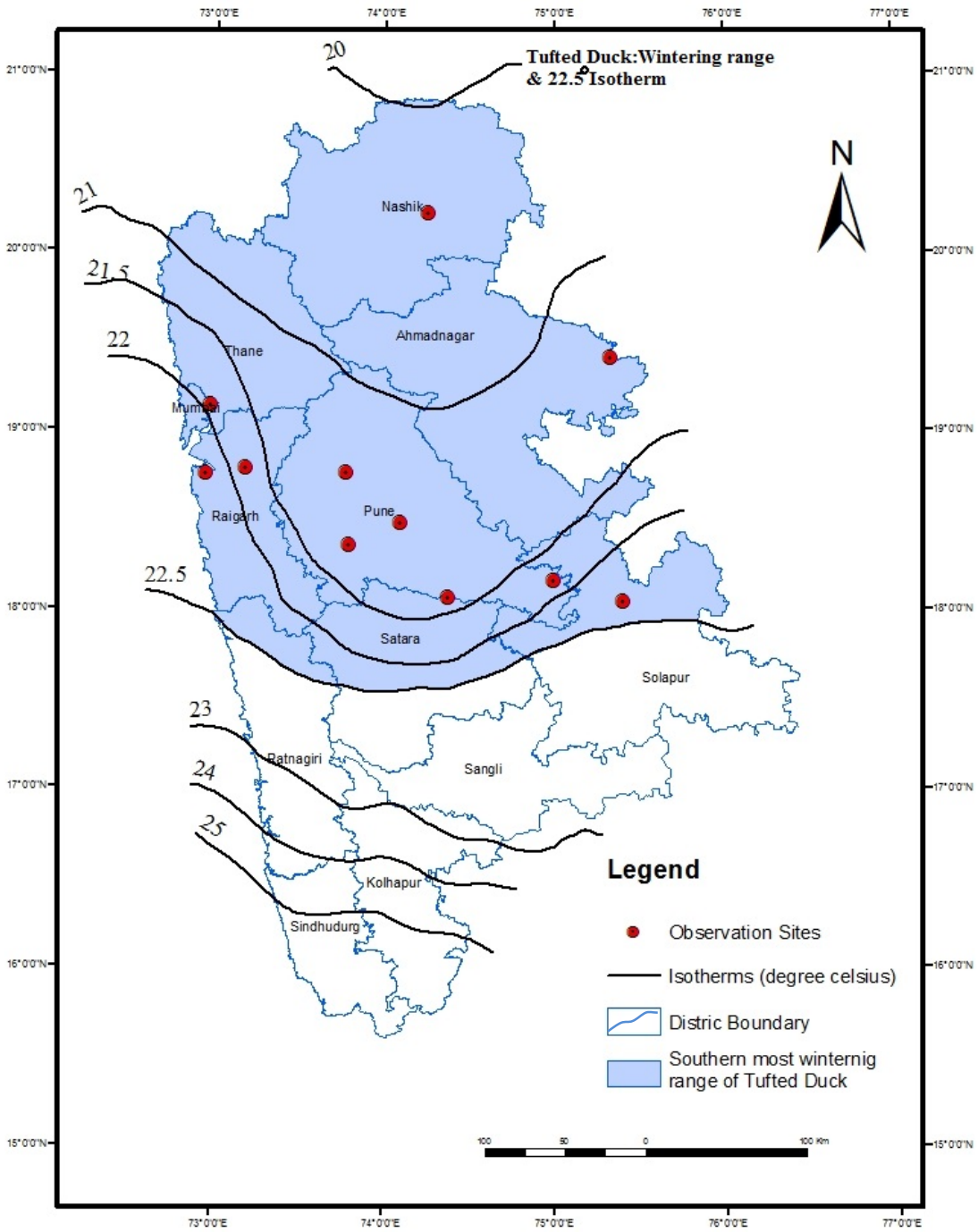


Fig.5.11: Tufted duck-Its southern wintering range is approximately bound by 22.5° C. January isotherm

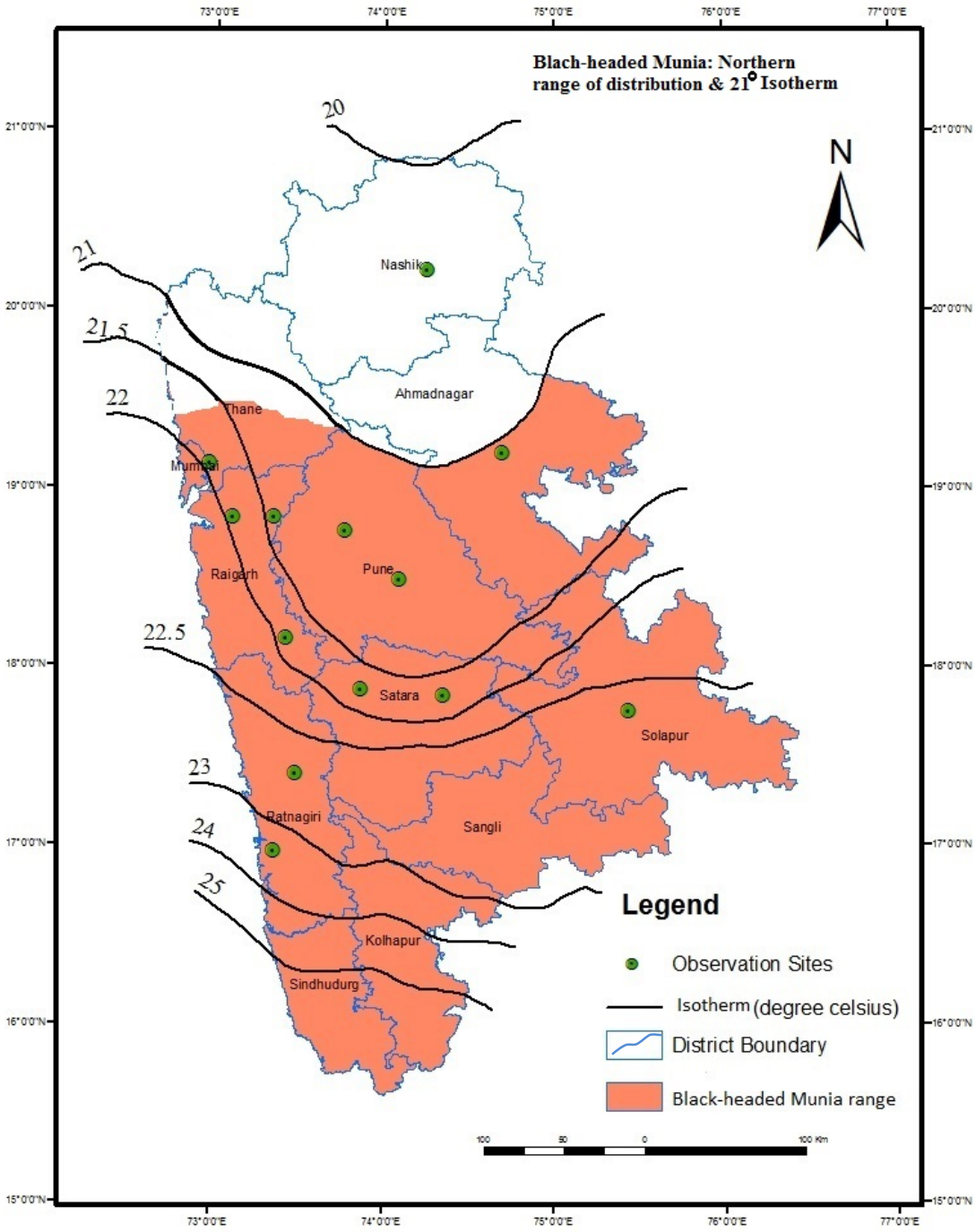


Fig.5.12: Black-hesded munia-Its northern range is approximately bound by 21° C. January isotherm

5.2.3.4: Vegetation & Forest types

The amount of rainfall is directly reflected in the vegetation of the study area. The following table states the relation between rainfall and vegetation type in the study area.

Table: 5.13: Annual Rainfall range and Forest types

Annual Rainfall range (mm)	Temperature Range(mean annual)-C°	Forest type	Areas under the type	Remark
2000-2500	26	Tropical semi-evergreen	Slopes below Bhimashankar (Thane)/Hill top plateaus & sheltered ravines in Mawal, Mulshi, Velhe & Bhor talukas (Pune), Ravines below Mahabaleshwar & Upper Koyna area.	
2000	24-27	Tropical moist deciduous	Slopes of Sahyadri	Low hills to 820 m.
850-1900	26	Tropical dry deciduous	Eastern slopes of Sahyadri	Low undulating hills up to 650 m.
Up to 750	25	Tropical thorn	Dry tracts of Upper Deccan ,mostly east of Pune	
1500-6600	18-24	Subtropical Broad leaved hill	Mahabaleshwar, Matheran,	1000-1400 m.
Up to 2670	26	Tidal swamp	Rajpuri, Revdanda & Dharamtar creeks	

(Based on Champion & Seth 1968)

There have been many studies on relationship between forest/vegetation and bird diversity-distribution. These studies deal with various aspects of forest as affecting the diversity/population/distribution of birds in general and some specific birds in particular. The aspects of forest/vegetation include vegetation composition and structure (Goldstein,et.al.,1986),size of forest patch(McIntyre,1995), forest fragmentation (Marini,2001), pre- & post logging impact(MacDonald,2005),and forest structure (Verschuyl et al., 2008).Most of these works deal with micro issues

and micro-areas with ecological approach. There are very few works which deal with larger areas with geographical approach. Salim Ali (1981) was one of the earliest to discuss the relationship of forest types and birds, when he wrote- "It is worth considering some fifteen or so forest types found in India and pointing out how closely birds are related to these environmental conditions."

In the earlier discussion, especially under the climate and elevation factors, it was clear that it is the vegetation rather than temperature, precipitation, altitude or slope, which affects the bird diversity and distribution.

Of the six types of vegetation found in the study area, every vegetation type has a specific set of birds which are confined to that vegetation type only and are rarely seen outside the vegetation type. In other words the distribution of these specialized birds is governed by the forest/vegetation type they live in. The forest types and associated bird species are as follows:

Tidal Swamp(Mangrove forest): Within the study area tidal forest is mostly found in small patches along creeks and lower courses of some rivers such as Ulhas river/Thane creek; Patalganga/Amba rivers and Dharamtar creek; Kundalika river/Roha creek and Rajpuri creek. Certain species were reported primarily from this habitat only.

Table 5.14: Bird Species confined to Tidal forest Habitat

Sr.No.	Bird species	Places/spots reported from	Remark
1	Black-capped kingfisher	Thane-Mumbra Durshet nr. Pen Salav along Roha creek	Present study
2	Common babbler	Thane creek,Uran	The babbler is found throughout most of India but is uncommon on the Maharashtra plateau.It is rare in Konkan and all the few records are from around Mumbai; from tidal forest areas only.**This is not a tidal forest bird.**
3	Western Reef Egret	Most creeks between Thane & Bankot	
4	Greater Flamingo	Thane creek(Airoli, Vashi, Shivdi)	Both the species can be seen inland, but in limited numbers. birdsofbombay@yahoogroups.com
5	Lesser Flamingo	Shivdi	birdsofbombay@yahoogroups.com

Tropical Thorn Forest: This is low open forest having species adapted to dry climatic and edaphic conditions. Dominated by various types of Acacia species, the trees are stunted and widely scattered with patches of thorny shrubs and grasses. The western limit of the forest more or less coincide with 800 mm isohyets, though at places isolated stands of this forest type are found up to 1000 mm isohyets. The belt falling between 1000 and 1200 mm is the transition zone between tropical thorn and tropical dry deciduous forest and runs more or less parallel east of the main range of the Western Ghats. There are six species which prefer tropical thorn forest as their major habitat and whose westernmost boundary of the distributional ranges more or less coincides with the westernmost extent of the tropical thorn forest. In that sense these species can be called as dry land species. (Table 5.4)

Table 15: Some Dry land Birds and the western limit of their normal ranges enclosed by selected Isohyets

Bird species	**Western boundary limit (Isohyets in mm)**	**Westernmost limit of normal range**
Grey Francolin	1000-1200 mm	Pokhari(Nr.Bhimashankar) Lonavla, Tamhini, Bhor, Wai
Painted Spurfowl	600-700 mm	Vadgaon Mawal, Wai
Indian Grey Hornbill	800-1000 mm	Dimbhe(Nr.Bhimashankar), Lonavla, Tamhini, Panchgani (Recently reported from Thane)
Brown Crake	600-700 mm	Vadgaon Mawal
Indian Bushlark	1000-1200 mm	Pokhari plateau, Lonavla, Tamhini, Bhor
Indian Bustard	600-700 mm	Jejuri (present study)
Lesser Florican	600-700 mm	Pune
Painted Sandgrouse	600-700 mm	Pune

There are many other species which show greater affinity for the tropical thorn vegetation zone, though they are also found in other vegetation types. These include many larks, pipits and bunting species.

Tropical Dry Deciduous forest: This forest is confined to a narrow belt along the eastern slopes of the Western Ghats and is generally encountered within the range of 850 to 1900 mm. rainfall zone. Towards its eastern boundary it merges with the tropical thorn vegetation and on the west with tropical moist deciduous type. This zone shows rich bird diversity because of its transitional location between the moist

deciduous/semi-evergreen type on one side and tropical thorn type on the other. It obviously attracts birds from both the vegetation types. Katraj: 147 species (Present study), Simhagad: 172 species (Ingalhallikar, 2005), Katar Khadak-Andhale: 157 species (Present study), Andeshe-Mulshi: 153 species (Present study) are some places which lie within the transition zone and were monitored during the present study. There is no specific bird which is known to live exclusively in this type of vegetation but there are a dozen or so species which show affinity for this type of vegetation.

These are:

Red spurfowl, Yellow-crowned woodpecker, Indian nightjar, Red collared dove, Yellow-footed green pigeon, Rufous treepie, Black-headed cuckooshrike, Whitebellied Minivet, White-bellied drongo, Common woodshrike, Tickell's blue flycatcher, Jungle myna, Jungle babbler, Chestnut-shouldered petronia

Moist Forest types: The tropical moist deciduous and the tropical semi-evergreen forest lie side by side in the study area along the western slopes and crest line plateaus of the Ghats country. At places they appear to merge into each other as around Bhimashankar, Khandala, and Varandh Ghat area. The semi-evergreen type merges into the sub-tropical broad-leaved hill forest as around Matheran and Mahabaleshwar. The bird fauna of all the three types of vegetation is more or less same, and simply be called as **moist forest bird fauna,** hence this clubbing together of all the three types. At least 71 species show strong affinity for moist forests. Their geographical ranges which appear to be continuous pass across all the three vegetation types under moist forest category.

These include [bird group (species)]: woodpeckers(08), barbets(03), hornbills(03), trogon(01) kingfisher(01), cuckoos(07), parakeets(02), owls(08), nighjars(02), pigeons & doves(04), woodcock(01), Baza(01), eagles(04), pitta(01), Fairy bluebird (01), Leafbird(02), Orioles(02), Scarlet minivet(01), Flycatcher shrike(01), Drongos(03), Black-naped monarch(01), Blackbird(01), Flycatchers(04), Bulbuls(02), Chats(02), Tytler's leaf-warbler(01), Babblers(04), Sunbirds(03), Flowerpeckers(02), and Forest wagtail(01).

Some of these birds are confined to more humid sections of the forest such as Malabar parakeet, Nilgiri woodpigeon, Green imperial pigeon, Emerald dove, Black eagle, Asian fairy bluebird, Bronzed and Spangled drongo, Eurasian blackbird, and Yellow-browed bulbul.

The areas where various moist forest types , and moist & dry vegetation types meet and merge, the bird diversity(aquatic birds deleted) is very high as reflected at Matheran:195 sp.(Present study),Lonavla-Khandala:254 sp.(Pande et.al.,2008, Present study), Bhimashankar: 252 sp. (Present study), Mahabaleshwar-Panchgani: 258 sp. (Present study)

5.23.5: Food:

One of the most important biological barriers is the non-availability of food. Many animal species have limited distributions that are associated with the distribution of plants or other animals on which they feed. (Cox et. al.1977)

Species with very narrow food preferences (*stenophagus* species) are much more likely to be limited in their distribution by their food than are species with very broad food preferences (*euryphagus* species).

For example seed eaters (rock pigeons) will have wider distributional ranges than the fruit eaters (Green pigeons).Similarly flesh/carrion eaters (Birds of prey) have wider ranges compare to the fish eaters (e.g Osprey). Omnivorous (e.g.Crows) generally are cosmopolitan in distribution and are found almost everywhere.

Plant food & distribution:

The example of Malabar pied hornbill is quite interesting. The food of this hornbill consists of figs of banyan & peepul trees.It also consumes fruits of Nutmeg (*Myristica* sp.) & berries of *Melanoxylon* species. But this hornbill voraciously consumes the fruits of the Strichnine tree (*Strychnos nux-vomica*.) (Dixon, 1894).The tree is found wild in south Konkan. It is found scattered in forests, along streams as well as on the coasts. The tree is common in the south Konkan districts (Cooke, 1958), it is infrequent in Raigad district (Kothari & Moorthy, 1993) and almost absent in Thane district. The hornbill is relatively common in the south Konkan districts of Sindhudurg and Ratnagiri, but is rare in its northernmost range in the Raigad, and absent from the Thane district. This distribution perfectly coincides with the distribution of *Strychnos* tree.

Fruits of *Myristica* trees also form a part of hornbill diet, especially that of the Great hornbill (*Buceros bicornis)*. Two *Myristica* species are found in the forest of Konkan and the Ghats country. These are *M.malabarica* and *M.attenuata*.The later is also reported from ravines around Matheran and Khandala, where Great hornbill has also been reported from.

Rufous woodpecker and the *Crematogaster* ants: Rufous woodpecker (Micropternus brachyurus) is a myna-sized woodpecker found in open deciduous forests of the Konkan, the Ghats country & upper Deccan. Its main food consists of the eggs, pupae and adults of *Crematogaster* tree ants. (Ali, 1979) The ants build a carton-liked globular nest of papery material high up in trees. Another interesting aspect in this relationship is that the woodpecker carves out a hole in the live globular nest of the ants. Nine Crematogaster species are said to occur in the state (Nadkarni,1974).In the southern & western Peninsula, the Rufous woodpecker(RW here afterwards) chooses following three species to build its nest-i) *Crematogaster rothneyi* ii) *C.wroughtoni* & iii) *C.ebenina*.(Narendra,2003). All the three species are found in western Maharashtra.

The crematogaster nests are a common site in the forest of the Konkan and the Ghat country. The woodpecker is a fairly common resident in Konkan but is rare or occasional in the Ghats. It has been reported from many places including Yeoor (Thane), Bhimashankar, Khandala, Tamhini, Karnala, Mahabaleshwar & Koyna area under the present study. But finding the nest is a difficult task and so far only six nests have been reported. But there are many sightings of the woodpecker and the ants' nests been found in the same locality.

To find out how far the two species are associated, a statistical technique called **Test of Association (Two species case)** was used. The study area has been divided into 81 grids (SUs-sampling units) each of size 10 km. x 10 km. The presence and absence of both the species throughout the study area was put into a 2X2 matrix with four cells- a, b, c, & d. For each pair of species we obtain the following:

Step 1:

These two species are treated here as Species A (*Crematogaste*r ants) and Species B (Rufous woodpecker). The squares a, b, c, & d are assigned actual observational values as follows:

a = Number of SUs (Sample units) where both the species occur

b= Number of SUs where species A occurs, but not B.

c= Number of SUs where species B occurs, but not A.

d= Number of SUs where neither A nor B occurs.

N= Total number of SUs (N= a + b + c + d)

The above information is summarized in the form of a 2 x 2 matrix (in table format)

Table 5.16: The 2x2 matrix (species association table)-Standard format

		Species B (Woodpecker)		
Species A (Ants)		Present	Absent	
	Present	a	B	m= a + b
	Absent	c	D	n= c + d
		r= a + c	s= b + d	N= a +b + c + d

Here,

a= 17, b=36, c=01, d=25

After putting actual values, the matrix looks like this

Table 5.17: The 2x2 matrix –Ants Vs.Woodpecker

		Species B (Woodpecker)		
Species A (Ants)		Present	Absent	
	Present	17	36	m=53
	Absent	01	25	n=26
		r=18	s=61	N=79

After adding the rows & columns we get following values-

m=53, n=26, r=18, s=61 & N=79.

The m*n*r*s value is 1,513,044

The expected frequency of occurrence of species A and B in the SUs, are represented as f (A) & f (B), are given by

f(A)= a + b/N

And

f(B)= a + c/N

Thus we get the following values:

Species A: f(A) = a+b/N=53/79 = 0.67

Species B: f(B) = a+c/N=18/79 = 0.2278

Is assumed that both species occur in at least one SU in the data collection, that is, f (A) and f(B) are greater than 0.

Step 2:

Hypothesis: The null hypothesis is defined that "the species are independent ". (i.e., there is no association between them)

Step 3:

Computation- The 2x2 table contains observed values (a, b, c, d).To test for association, we need to compute the expected values for each cell .The expected values are based on the assumption that species A and B occur independent of each other. A chi-square test statistic is used here to test the null hypothesis of independence in the 2x2 table.

The chi-square test is computed as follows:

$\chi^2 = \sum (\text{observed-expected})^2/\text{expected}$

This is a summation over the four cells of the 2x2 table.

The expected value for cell is given as:

E(a)= (a + b)(a + c)/N= rm/N

Similarly expected values for cells b, c, and d are :

E(b)=ms/N, E(c)= rn/N, E(d)= sn/N

Thus we get expected values for each cell as follows:

E(a)= rm/N= 12.07

E(b)=ms/N= 40.92

E(c)=rn/N= 5.92

E(d)=sn/N= 20.07

Table 5.18: Expected frequency values

Species B

	P	**A**
	12.07	40.92
	5.42	20.07

A simple equation was used to get the chi-square test statistic.

χ^2 = N(ad-bc)²/mnrs

χ^2 test was calculated using two methods:

Method 1:

χ^2 = N(ad-bc)²/mnrs

= 79(425-36)²/1513044 = 25(1225)/6600

= 79*151321/151304

χ^2 = 7.90

Method 2:

χ^2 = [a-E(a)]²/E(a)+ ….+….+ [d-E(d)]²/E(d)

= [17-12.07]²/12.07 + [36-40.92]²/40.92 + [1-5.92]²/5.92 + [25-20.08]²/20.08

= 2.0136+0.5915+4.0889+1.2076

χ^2 = 7.90

The significance of the chi-square test statistic was determined by comparing it to the theoretical chi-square distribution. The 2x2 contingency table has one degree of freedom (df), since contingency table with r rows and c columns has value for 1 df at the 5% probability level is 3.84. **If $\chi^2 > 3.84$, we reject the null hypothesis that the co-occurrence of species A and B is independent and conclude that they are associated.**

Since χ^2 value 7.90 is greater than 3.84, the null hypothesis is rejected and it is proved that both the species are closely associated with each other.

If the observed a > E (a) then the association is positive.(Ludwig & Reynolds,1988). Here observed a (17) is greater than E (a) ,which is here 12.076.

According to Zar (1974) the statistic is biased if

Any cell in the 2x2 table has an expected frequency < 1 or

If more than two of the table cells have expected frequencies < 5.

Since both the conditions are not fulfilled here, the statistic is not biased.

The result is that both the Rufous woodpecker and the *Crematogaster* ants are associated and one (the ants) is likely to influence the distribution of the other (the woodpecker).

Vultures & carrion:

All most all the vultures are carrion feeders .Today vultures are highly endangered birds. (IUCN Report, 2009) But till mid-1980's they were one of the commonest birds of the country side. Though they showed wide & continuous range, they would be seen more frequently in certain localities only. Till 1990 vultures would always be found in the south-eastern wards of the Pune city, especially around Vanawadi, Kondhva and Bibwewadi. The main reason was the bone-crushing factory located at that time on the outskirts of Kondhwa. This factory with its small bone-crushing unit and a huge flesh dumping and drying yard would always attract hundreds of vultures-mostly White-backed and Long-billed varieties and occasional Red-necked and scavenger vultures. Another factor that made vultures roost and spend most of their time around this ward was the Parsi Tower of Silence that was located nearby, on top of the Kondhwa hill- it is still there. The Tower of Silence is the cemetery of Parsis. While writing about one such located at the Malabar Hill, Mumbai, more than a hundred years ago, Forrest (1903) wrote," on the other(side) stands out the Towers of Silence, where the Parsis deposit their dead, to be devoured by vultures. On the trees and on the walls scores of these hideous birds can be seen." Writing about the same towers Urwick (1885) stated that "Each tower possesses usually an extraordinary coping, not of dead stone but of living vultures." Phatak (1981) also mentions that vultures used to be seen around Parsi cemeteries only. He further adds that they would also been in large numbers sitting on roofs of a butchery at Bandra. When the vultures were abundant till 1980's, the author happened to stay in the vicinity of the Tower and frequently visited the environs of the Tower and the bone-crushing factory. The frequency sighting of the vultures in that part of the city was 100 pc between 1976 and 1985, the years the author lived there, whereas it was 70 to 90 pc in other parts of the city. There was sudden reduction in the number of vultures around Kondhwa after the bone-crushing factory was closed in late 1980's.

The sudden decline in Gyps vultures since mid-1990s has always been attributed to the poisoning by the drug Diclofenac used in livestock (Shultz, 2004). The new rule by the Maharashtra state government of banning open dumping of animal carcasses may have been partly responsible for the decline of vultures.

5.23.6: Altitude and Bird Diversity:

The altitudinal range in the study area is from zero (sea level) to 1419 m.(Mahabaleshwar).This height is just enough to influence the vegetation, though certain altitudinal variations are seen among the vegetation especially around Mahabaleshwar and certain hill forts above 1000 m. height. Santapau (1968) sees altitude as a dominant factor influencing vegetation patterns of some Deccan hill forts lying above 1000 m. To understand the correlation between altitude and bird diversity, an east-west broad cross-sectional area was selected. The line joining Uran to Shrivardhan is the westernmost boundary of the area and this boundary coincides with mean sea level (near zero m. elevation).The eastern most boundary of the cross-sectional area is the line joining Lonavla to Mahabaleshwar on the crest of the Ghats, reaching the height of 1400 m at Mahabaleshwar. The total number of species found in the study area is around 500.For the purpose of elevation-bird relationship study only 241 indicative species were selected. These were selected on the basis of the following criteria.

- Birds which are resident and /or local migratory.
- Birds that spend at least four continuous months in the Ghats country.
- All the water bird species were deleted, for the simple reason that their distribution is strongly guided by water bodies rather than elevation.
- All the stray, vagrant birds and birds with isolated records were deleted. Their presence hardly has any connection with altitude.
- Birds whose definite altitudinal range, either lower or higher, is not known were also deleted.
- The selected area was divided into three altitudinal zones from msl (0 m.) to the highest level (1400 m.) as follows:

  Lower altitudinal zone (0-300 m)
  Middle altitudinal zone (300-800 m)
  Higher altitudinal zone (800-1400 m)

Table 5.19: Altitudinal zones and Associated Forest types

Altitudinal Zone	Height class (ASL) (m.)	Associated forest type
Lower Altitude Zone	0-300	Mangrove (upto 50 m), Tropical moist deciduous forest (50 to 300 m)
Middle Altitude Zone	300-800	Tropical moist deciduous forest
Higher Altitude Zone	800-1400	Tropical semi-evergreen forest (800-1000 m). Sub-tropical broad leaved hill forest (1000-1400 m)

The lower altitude zone mostly consists of low lying areas close to the coast, estuarine plains of Ulhas, Patalganga, Kundalika, and Savitri rivers, and flat-topped low interfluves and low hill ridges and spurs.In the Ulhas basin this zone almost reaches the foot of the Western Ghats, across Karjat.

The middle altitudinal zone consists of alternate land facets of plains (depressions) and hill ranges. The hills range from 300 to 500 m. and occasionally have peaks and plateaus on top. Some prominent examples are Matheran (766 m.), Manikgad (575 m.), Sarasgad (618 m.), Mahal Mira (570 m.) and Raigad (869 m.). The zone also includes foothills of Western Ghats, low-level terraces (most of which are under paddy cultivation) and enclosed ravines, most of which under good forest cover.

The higher altitude zone mostly consists of middle & higher slopes of the Western Ghats, with terraced slopes, cliff lines and escarpments and high Crestline plateaus like Mahabaleashwar and Panchgani.

The analysis based on elevation revealed the following facts.

Low altitude zone birds: Only four species were found to confine to lower altitude. These include White-eared bulbul (0-100 m.), two species of weaver birds (the Black-breasted and Streaked), and the Sri Lanka frogmouth (0-300 m.). Though the last species is reported from higher altitudes elsewhere, like Amboli (900 m.) (Purandare K.,Pers.Com.), the Sri Lanka frogmouth has so far been reported only at lower elevations (Phansad sanctuary and the Sanjay Gandhi National park,50 m.) within the limits of the study area.

Middle Altitude zone birds: There is not a single species which can truly be described as the middle altitude zone bird.

Lower and Middle Altitude zone birds: There are thirteen species whose ranges start around the sea level and extend into the middle zone right up to 800 m. These can better be described as birds belonging to both the lower and the middle altitudinal zones.

Middle and Higher Altitude zones birds: There is another group of birds constituting of 20 species, whose lowermost range limits start within the middle altitudinal zone and extent in to the higher altitudinal zone across 800 m. The birds belonging to this group may be described as birds of middle and higher altitudinal zones.

Higher Altitude zone birds: There is only one species, the Yellow-browed bulbul, which truly belongs to this category. It ranges from 900 to 1400 m.

Altitudinally Cosmopolitan birds: There are 204 species whose distribution ranges from or near the sea level and extend all the way to higher altitudes up to or above 1000 m. (There are 122 species whose altitudinal range covers the whole height spectrum of 0 to 1400 m.) In other words 84 % of the total bird fauna of the selected area is attitudinally cosmopolitan in distribution and height above sea level, does not seem to play any major role in their distribution.

Height classes and bird species diversity

The elevation-bird relationship is discussed at the larger areal level, for an area measuring around 100 km (N-S) by 65 km (E-W), covering approximately 6500 km².

The selected area was divided into 14 height classes, each of 100 m value. The total number of bird species found within each height class is given below.

Table5.20: Altitude and Bird diversity

Height Class (ASL) (m)	No.of species found within the class
0-100	221
100-200	223
200-300	233
300-400	236
400-500	236
500-600	237
600-700	**240 #**
700-800	238

800-900	229
900-1000	230
1000-1100	199
1100-1200	199
1200-1300	164
1300-1400	**141***

Highest bird diversity.

* Lowest bird diveristy

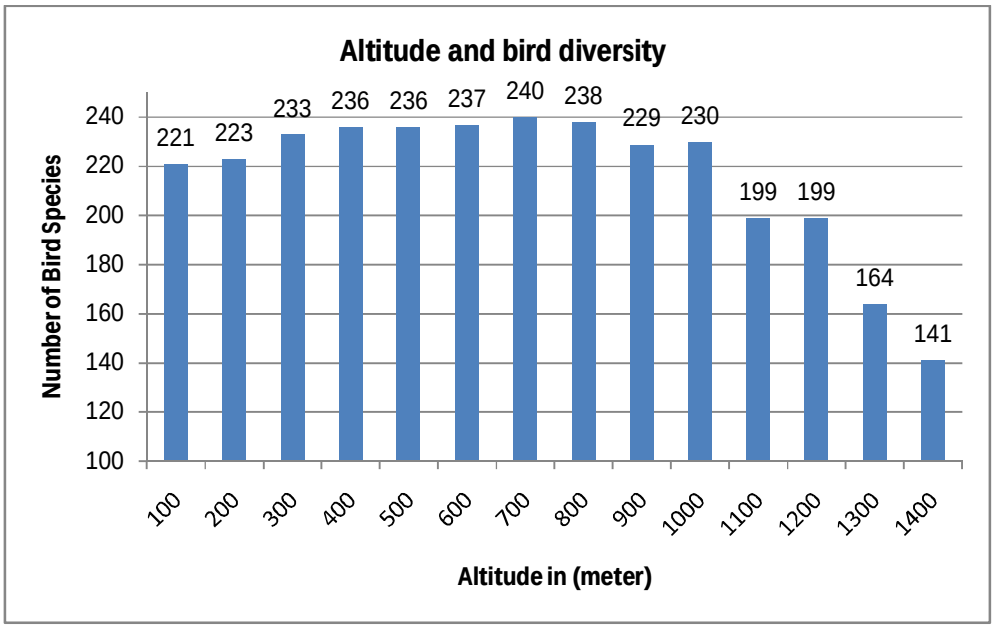


Fig.5.13: Konkan & northern Western Ghats: Altitude and bird diversity

Observations:

i) There is a gradual rise in bird diversity with rise in altitude from the sea level up to the middle level .(700 m)

ii) Height classes from 300-400 to 700-800 show more or less same level of bird diversity with a plateau effect

iii) There is a gradual decrease in diversity after 700 m.

iv) There is a sudden drop in diversity after 1000 m.

v) The highest bird diversity is in the height class 600-700.(240 species)

vi) The lowest bird diversity is in the height class 1300-1400 (141 species)

Interpretation:

i) The gradual rise in bird diversity from the sea level towards the 700 m contour is partly due to addition of newer habitats like grass & scrub country over the interfluves, river-side vegetation stands and beginning of moist deciduous forest from 50 to 100 m upwards. Initially at the lower levels the forest is largely degraded (as around Karjat, Varsai, Pali & Nagothane) But this is enough to add a few bird species through the forest edge effect.

ii) The stabilization of the level of bird diversity from 300 to 800 m.(between 236 and 238)is largely due to the more or less similar composition of habitats- forested ridge tops, terraced farms surrounded by forested ravines, and forest mostly belonging to one single type-the moist deciduous forest.

iii) From 800 to 1000 m there is an arrangement of cliff lines alternated by flat terraces clothed with moist deciduous forest and intermittent burnt patches under 'kumri', the practice of shifting cultivation. Towards the higher slopes, the moist deciduous forest gradually merges into the semi-evergreen forest. These are some of the possible reasons of slight drop in bird species diversity.

iv) The sudden drop in bird diversity after 1000 m may be due partly to replacement of moist deciduous forest with semi-evergreen type, more and more land coming under steep slope and appearance of large barren Crestline plateaus and hill forts, barring the exception of Mahabaleshwar. The land area also decreases with height.

v) The highest bird diversity around 600 to 700 m is largely due to the best moist deciduous forest cover, mostly in relatively isolated ravines (e.g. the Plus or Cross valley near Tamhini) with minimum human activity and large grassy patches on the upper slopes.

vi) The lowest bird diversity between 1300 and 1400 m is largely attributable to the barren Crestline plateaus which are few in numbers and limited in area. The overall land area available as bird habitat gets reduced. Barring the exception of Mahabaleshwar most of these plateaus are small in areal extent, hardly support any vegetation except scrub and grassland, are mostly under laterite and are very windy during monsoon months.

In other words it can be said that **in the northern Western Ghats the elevation influences the distribution& diversity of birds to a limited extent only.** Most of altitudinal influence is indirect, through vegetation. The limited

height range of 1400 m in the present case also seems to matter. Hence we do not see prominent impact of height as is seen in the South western Ghats (Height difference 0-2600 m) (Ali, 1984) or in the Himalayas (Height difference, 0--7000 m plus) (Sharma, 1994)

Height (ASL) as a Local Impacting factor:

For assessing the local impact of elevation on bird diversity and distribution, Simhagad fort near Pune was selected. This is a hill fort situated on an eastern offshoot of the Western Ghats. Its foothills lie at the height of 700 m whereas its topmost point is at 1318 m. The fort top is also reasonably extensive (W-E.: 1.0 km, N.-S.: 0.753 m.) (Khare, 1948).The height from 700 m to 1300 is reached within a short distance of 3.0 km making it an ideal spot for such an exercise.

For the purpose of the study a 3.0 km long transect was defined. Transect started near the bus stand at Atkarwadi, a hamlet at the foot of the fort. Transect followed the footpath leading to the fort .The end point of Transect was the Balekilla, the highest point on the fort.

Six readings, two for each season, spread across one year (2007-08) were taken. One set of two readings each, covered one season. During each visit the data were collected on the basis of bird species, number of individuals, height at which birds seen and habitat of the place. In all twelve point-count surveys were conducted along the transect as-

- **Base:** Atkarwadi village (4 point counts) (Height- 700 to 750 m)
- **Lowe Slope:** Plain ground & second bend, (2 point-counts). (750 to 1000 m)
- **Upper slope:** Sadkeche met and End of path (2 point-counts) (1000-1250 m)
- **Top:** Pune gate no.1 to Balekilla (4 point-counts) (1250-1318 m)

Every point count was conducted for a period of 30 minutes each and covered an area up to 100 m visible radius from the observation point. Height and location coordinates were noted down with the help of GPS. The final results were as follows:

Table 5.21: Sinhagad fort-Altitude and Bird diversity

Height class	Height (m.)	Summer	Monsoon	Winter	Annual
Base	700-750	37	35	45	52
Lower slope	750-1000	10	12	18	28
Upper slope	1000-1250	09	12	17	22
Top	1250-1300	09	12	22	24

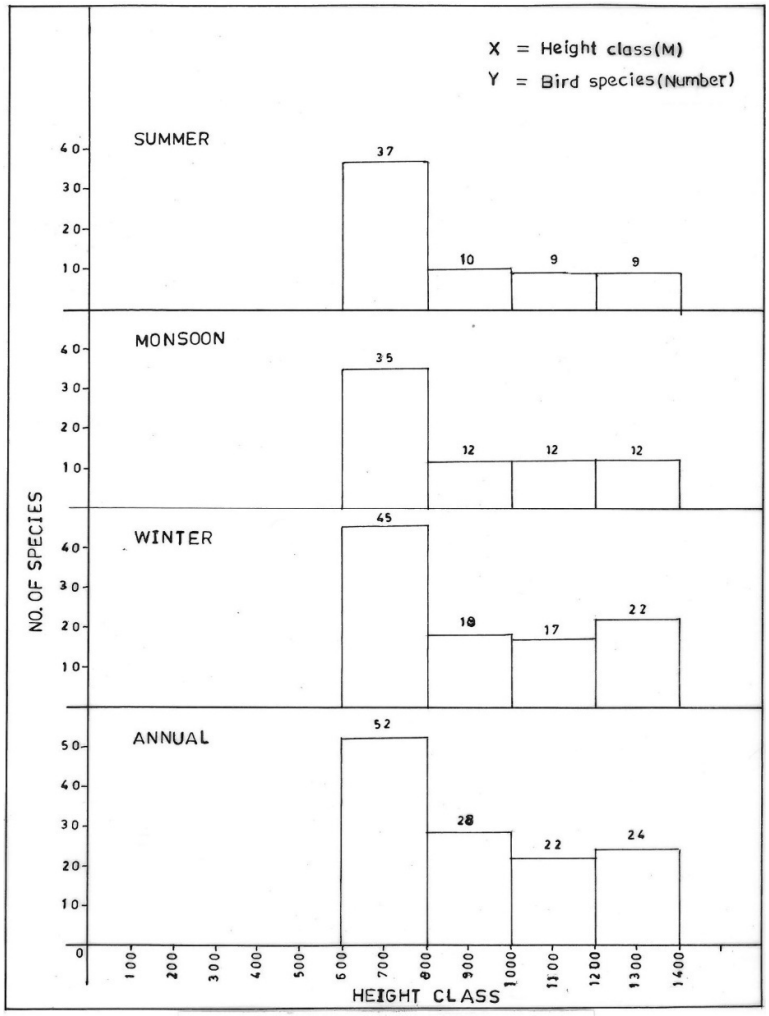


Fig. 5.14: Sinhagad fort-Altitude and Bird diversity

Observations:

i) The highest bird diversity is in the Base zone.

ii) There is sudden drop in diversity with the beginning of the next zone, the Lower slope zone.

iii) There is slight drop in diversity as one move from Lower to Upper slope section.

iv) The diversity at the top is slightly higher for annual data, higher during winter season and remains same in the summer & monsoon months.

Interpretation:

i) The highest diversity in the Base zone is due to habitat diversity found around the Atkarwadi village, which includes village gaothan (settlement), farmlands, plantations and forested ravines. Most of the ravine vegetation is dominated by tree flora, though we also have luxuriant growth of shrubs, bushes, herbs & grasses during the monsoon months.

ii) The sudden drop in diversity after 750 to 800 m height is due partly to ceasing of farmland habitat, (the highest farm along the slope is at 830 m height) and stunted open forest which replaces the relatively dense ravine & foothill forest.

iii) With further rise in height, the slopes become steeper, open forest becomes more open and stunted and is gradually replaced by Karvi (*Carvia callosa*) stands and grass & scrub patches of the higher slopes, with some reduction in bird diversity.

iv) The slight increase in diversity on the Top of the fort is largely due to its relatively flat terrain, easy availability of water throughout the years thanks to the dozens of rock cut tanks, and abundant trash food thanks to the scores of eateries that have come up on the top.

Ingalhallikar (2005) in his comprehensive list of birds of Sinhagad, similarly divides the birds into three categories as- seen at base, slope and top. On the basis of the categories his bird species count comes to 94 (Base), 48 (Slope) and 30 species (Top).

This clearly shows that the bird species diversity decreases with height around a hill fort.

5.23.7: Cliff (Escarpments), Rocky features and Soils:

Cliffs and Birds:

The Long-billed vulture (Gyps indicus) was till recently one of the commonest vultures of the study area. Since mid-1990s the number has gone down drastically. But the population seems to be reviving since 2005 (present study).

This vulture builds its nest on ledges of precipitous cliffs and hill forts (Ali, 1981). The author managed to collect information about 18 nesting sites of the vulture, out of which three are extinct. (See table) The distribution of the sites is as follows- Konkan (08), Crestline region (04), & Deccan Plateau (06)

All the sites were located in crevices & cavities on exposed cliff faces 100 to 300 m from the base. Lithology seems to have played a major role in site selection on cliff, for at least nine nesting sites are located in the cavities made out of the red bole horizon, an intertrappean bed found in the Deccan Trap .Since the bole horizon is softer, it weathers and erodes readily giving rise to cavities, caverns and crevices, which are widely used by vultures as their nesting sites.

There are 15 sight records of the vulture from the study area, without any mention of their nests. But there is some connection between the sight records and the nesting sites. Vultures are birds which roam long distances in search of their food, the carrion."They spend most of the day scouting the countryside for food, covering immense distances in the quest."(Ali, 1983).There is no data available for how long the Indian vultures roam in search of food, the foraging range. But a lot of work in this regard has been done in other countries. Moreno-Opo et.al (2010) found linear flight routes of cinereous vultures, ranging from 7.9 km. to 342 km in a study done in central Spain. The Cape vultures (*Gyps coprotheres*) travel up to 100 km or more in search of their food. Stavros et al (2009) gives 15 km and 29.9 km as the mean and mean maximum foraging ranges for Eurasian griffon vulture (Gyps fulvus). Martin et al(2007) give individual home-ranges of Asian Gyps vulture as ranging from 1824 km^2 (42 km X 42 km.) to 68930 km^2 (262 km X 262 km). In the present study, the author used the crude "physical chase' method to decide the foraging range. For this purpose the vultures of the nesting colony at Garud Machi near Tamhini (Mulshi taluka, Pune dist.) were selected. This is the largest active nesting site of the long-billed vulture in the northern Western Ghats. Every year between 12 to 21 active nests are seen on the cliffs above Garud Machi. The colony is located on a towering scarp facing north-west. (November to March is their breeding season) It was observed that they take to the air 9generally between 10 and 11 am during the winter months, when

rising thermal currents start developing. All the birds do not take to the air at the same time. One bird is followed by another in a leisurely manner. The birds on wings spend some time (15 to 30 minutes) gliding over the ravines below or around the cliffs before heading to west/north-west (Konkan side) for foraging. Most birds were seen heading towards the direction of Nagothane and Roha. The vultures were monitored at Nagothane next day. They were found to move further west of Nagothane, towards the direction of Alibaug. It is suspected that the Long-billed vultures seen around Alibaug may have been from the Garud Machi nesting site, because there is no other prominent knownnesting sites in northern half of Raigad district. (There are two isolated nests, one each on Sagargad & Sudhagd near Pali.) The straight-line distance between Garud Machi site and Alibaug is 53.6 km. **The 50 km is therefore taken as the maximum foraging range of the vulture.** This seems to hold true. There is an interesting correlation between Long-billed vulture sighting records and their nesting sites. All the sighting records are within 50 km of the nearest nesting site/s. (Table 5.22) (Map 5.15)

The eastern-most nest in the study area is at Purandar fort. The long-billed vultures are extremely rare to the east of line joining Shirur to Morgaon. (Morgaon is 50 km. east of Purandar, the maximum foraging range of the vultures)

Table 5.22: Long-billed Vulture nesting sites

Sr. No.	District	Site	No. of nest (Birds)	* Reference	Remark
1	Thane	Mumbra pinnacle	Extinct (?)	Aitken(1905), SA/HA(1941) Present study (2000-02)	Konkan
2		Mahuli fort	? (2)	Mare(2007)	Konkan
3	Raigad	Manikgad	02	Present study (1985-2000)	Konkan
4		Sarasgad	03 (2)	Present study (2007/2010)	Konkan
5		Sagargad nr. Alibaug	01 (1)	Viabhav(2004), Present study(2007)	Konkan
6		Durshet nr Khopoli	?	K.Singh(2002)	Konkan
7		Matheran	01	Present study (2007)	Konkan
8		Raigad fort	03 (06)	Present study (1997 & 2007)	Konkan
9	Pune	Lonavla (Cliffs nr INS Shivaji	? (20)	Singh(2002)	Crestline region
10		Lonavla (Cliffs on way to Rajmachi)	03	Present study (2002)	Crestline region
11		Lohogad	?	Present study (2002)	Deccan Plat.
12		Kamshet(Nr. Nilashi/ Andhra lake)	02	A.Bhavnani (2004)	Deccan Plat.
13		Tamhini (Garud Machi)	21 (50+)	Present study (1997-todate)	Crestline region
14		Simhagad fort (Sn.cliffs)	05 (Extinct)	Present study (1980-todate)	Deccan Plat.
15		Purandar fort	06 (Extinct)	Present study (1997-2007)	Deccan Plat.
16		Rajgad fort		Present study (1997-2012)	Deccan Plat.
17	Satara	Panchgani	?	Present study (1990/1997/2006)	Crestline region

*Most references taken from birdsofbombay@yahoogroups.com. The regionwise distribution of nesting sites is : Konkan: 08,Crestline region: 04, & Deccan Plat.:05

The following table gives only sighting records of the Long-billed Vulture:

Table 5.23: Long-billed Vulture-Sighting records

Sr. No.	District	Site	Nearest cliff (Straight-line Dist in km.)	References	Remark
1	Thane	Kohoj nr.Wada	Tungareshwar(15.0)	R.Vaidynathan (?)	
2	Raigad	Nr. Alibaug	Kunkeshwar(4.0) Sagargad(15.0)	Viabhav (2004)	2
3		Nr. Alibaug	---Do---	Viabhav (2004)	7
4		Nr. Alibaug	----Do----	Vaibhav (2010)	
5		Panvel	Matheran(17.8) Manikgad (23.7)	N.Pathak (2007)	
6		Roha	Sarasgad(15.5)/ Sudhagad(23.5)/ Tamhini (28.3)	N.Pathak (2007)	
7		Sagargad	Sagargad(0), Main scarp(1)	R.Vaidynathan, Vaibhav (2004) Present study (2007-8)	
8		Sagargad	Sagargad(0),		2
9		Hill Nr.Alibaug	Kunkeshwar(4.0) Sagargad(15.0)	Vaibhav (2010)	
10		Raigad fort	Raigad(0)/Main scarp (2)	Present study (2000)	4-5 over fort
11	Pune	Kamshet	Kamshet (0)	K.Singh (2005)	
12		Tamhini Devrai	Tamhini (Garudmachi) (02)	V.Bhagwat(2009) Present study (1997-2011)	
13		Mulshi dam	Mulshi hill (0)	S.Barve(2006) Present study (1997-2011)	18 birds seen, probable nesting site
14		Bhukum	Sinhagad (5.0)	S.Tapaswi(2010)	

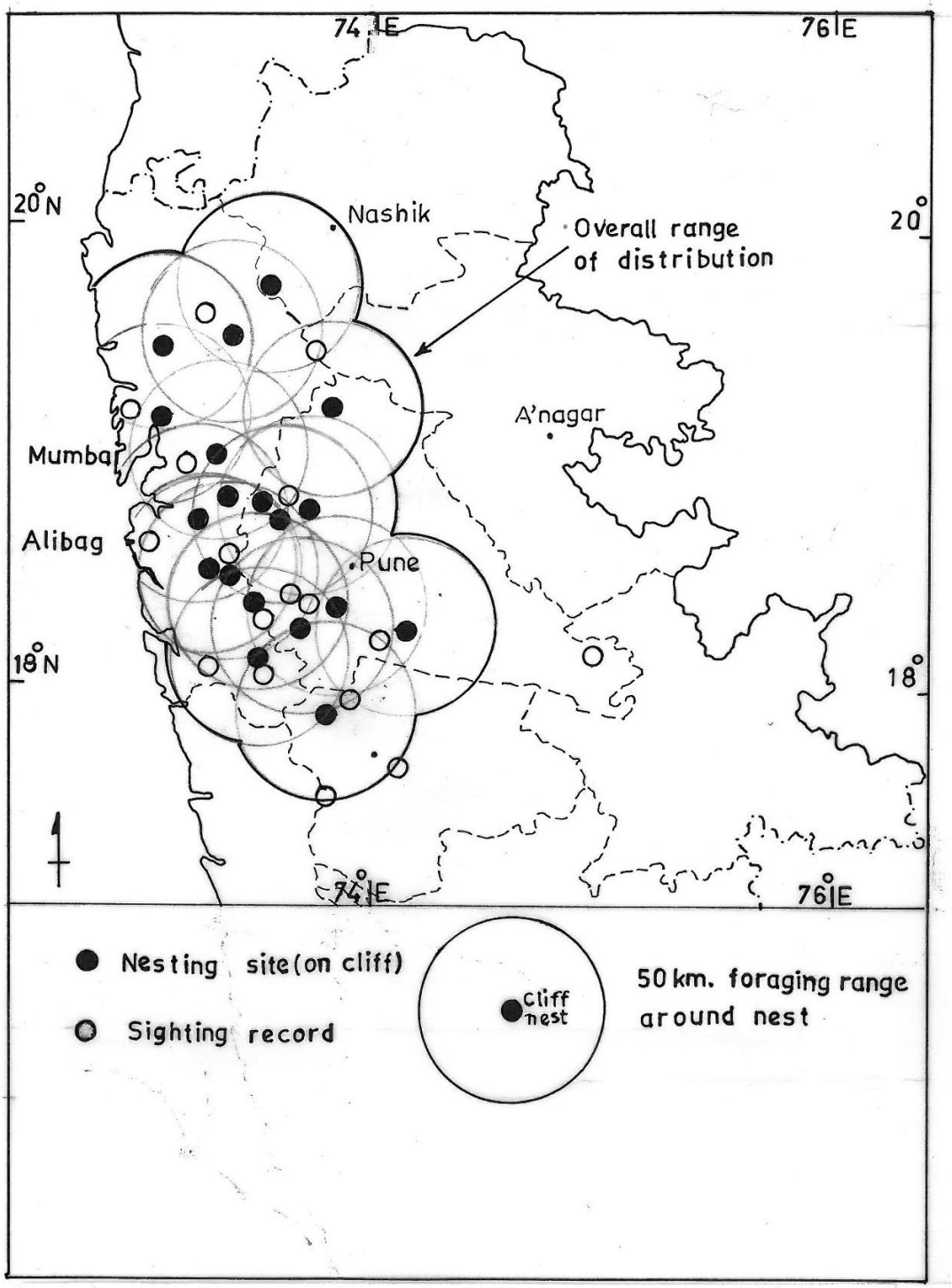


Fig.5.15: Long-billed Vulture: Relation between Nesting sites, Foraging Range and Overall range of distribution

Figure 5.11 indicates that **most of the Long-billed vulture sightings are within the 50 km. (foraging limit) of the birds' cliff nesting sites.**

Some other birds associated with cliffs & rocky features:

Some species associated with cliffs are Alpine swift, Peregrine falcon, Eurasian crag martin, Northern house martin, House swift, Rock pigeon & Cliff swallows. Most of these birds are frequently seen around the hill forts. Another bird that is very closely associated with rock faces is the Blue rock thrush. This bird is winter migratory and is seen around cliffs (Sinhagd), abandoned stone quarries (Vetal hill) & rock fields (around Yewat).

The Eurasian eagle owl builds its nest mostly on ledges of cliff. All the five nesting sites of this bird known from around Pune are on cliff ledges. The bird is therefore frequently sighted around rocky ravines, cliffs & abandoned quarries. Malabar whistling thrush is a typical bird of rocky hill streams with good streamside vegetation.It is therefore mostly confined to the boulder-strewn shady streams of the Western Ghats country.

Out of the seven species of lark found in the study area, the distribution of five species is fully or partly controlled by rocky features-stony grass & scrub, stubbles, stone outcrops and rock fields. The rock fields & tors along the Pune-Solapur highway are the heaven for larks where all the five species associated with rock are found. Another bird that is associated with stony hill side is the Crested bunting. An interesting observation about this bird is that it seems to prefer stony road cuttings along the many ghat roads that pass through the study area. Along a 55 km transect line that follows the ridge joining Simhagad to Bhuleshwar, 7 out of 10 crested bunting records are from the rocky ghat road sections.

5.2.3.8: Soils and birds:

There seem to be very weak connection between soils and birds. The only example of soil influencing distribution of birds to some extent is the two species of crested larks, the Malabar crested and the Syke's crested larks. The former has lighter plumage, the latter darker. The former is confined to Konkan and the Crestline area of the Ghats country, the later towards the drier plateau country east of the Ghats. The general range of the Malabar lark coincides with the red lateritic and the reddish/yellowish brown soils of Konkan and the Ghats country whereas the general range of the Syke's lark coincides with the black *regur* soil of the Deccan plateau.

Both the species are found side by side in the Maval tract where both the black and the reddish/yellowish soils merge. **(Fig. 5.15)**

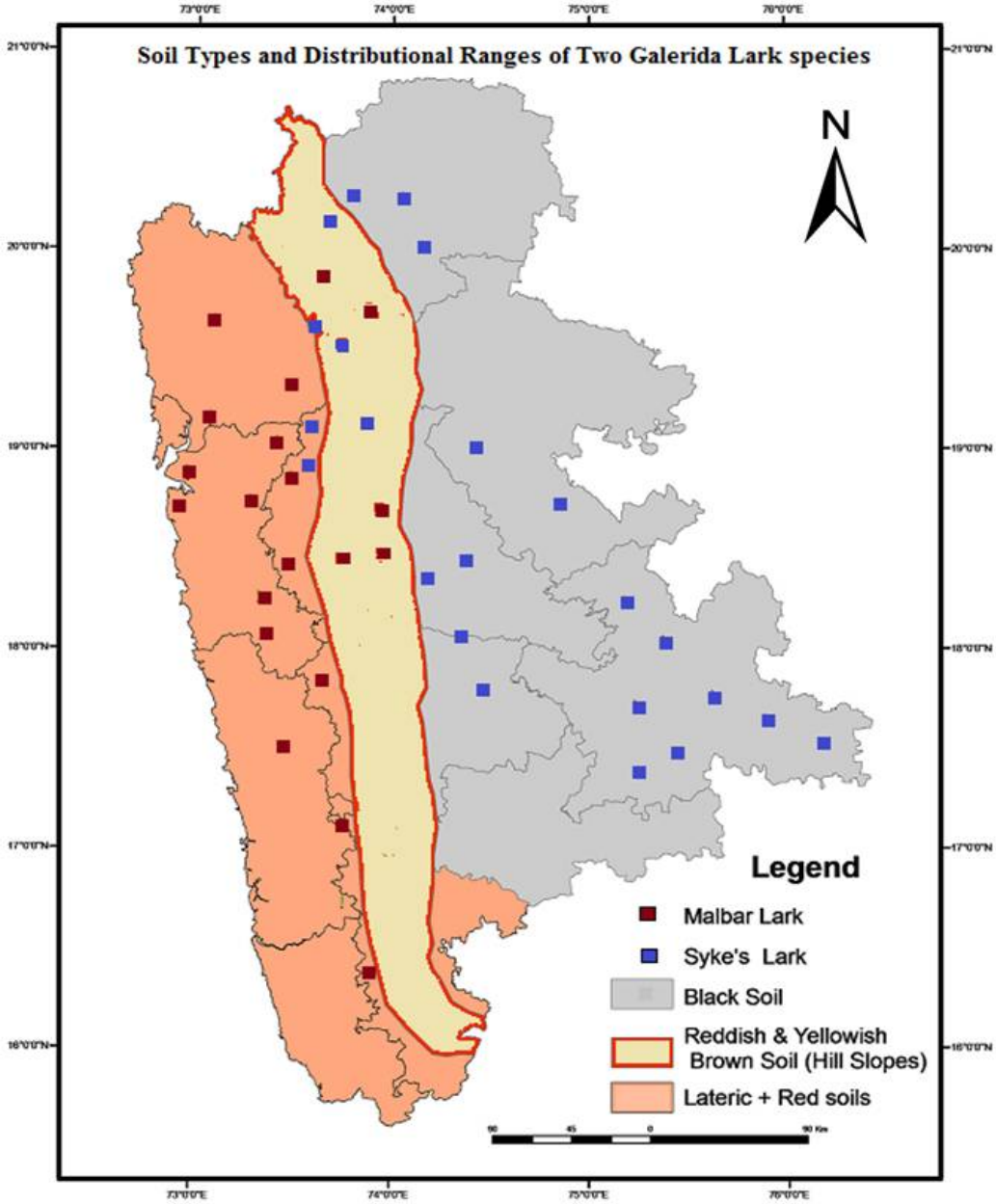


Fig.5.16: Soil types and Distributional Ranges of Two Galerida Lark Species

5.23.9: Human impact:

Human manipulation of the environment has influenced and modified the geographical distribution of thousands of species of animals and plants. (Cox et.al, 1977) A few broad patterns that have been recognized (Elton, 1958) are;

- **Plants and animals deliberately taken by man with him around the world:**

Most of these animals were domesticated and useful as raw materials for food, transport, or hunting. Some of them were taken as pet or for some sentimental reasons. Domestic fowl (Gallus domestics) is the only species found in the study area which belongs to this category.

- **Species that have been accidently spread by man:**

Human beings have been responsible for spreading of creatures since early times."Many creatures have been introduced into far-distant lands through the agency of man. While some were accidental or chance introductions, many were deliberate."(Robinson, 1978) There are a few species in this category from the study area. The most prominent example is that of the Asian pied starling (a kind of myna). The normal range of distribution of this starling is northern and eastern India (Ali 1979; Kazmierczak 2000; Grimmett et. al. 2011). A few pairs brought to Mumbai as pet, may have escaped accidently in the past. The bird thus got introduced in suburban Mumbai probably as an escaped bird in 1939 (Ali & Abdulali, 1940).Since then the bird has established itself initially as a Mumbai bird (Abdulali & Ali,1953; George,1971; Naik,1985; Ali & Ripley,1987). In due course of time the number multiplied and spread along the Western and Central Railway suburbs, the spread along the Central Railway line being gradual and continuous. It is interesting that the birds used suburban railway lines as dispersal pathway. The farthest places where the pied starling is seen nesting today are Dahanu along the Ahmedabad line, TItwala along the Kasara line, Badlapur along the Karjat line and Panvel along the Mumbai-Pune Highway. **(Fig.5.12)** The bird is commensal of man and proliferates around garbage dumps, which provide easy and abundant food. The bird, has established itself as a breeding resident bird of Mumbai long ago (Abdulali & Ali, 1953; George, 1970) and spreading northward (Naik, 1985).

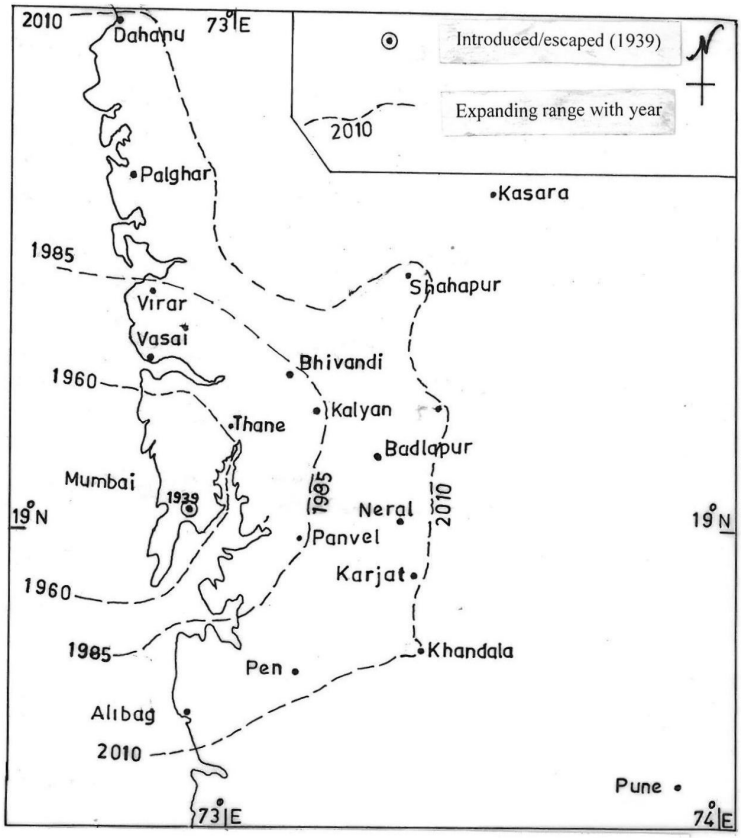


Fig 5.17: Dispersal of Asian pied Starling (1939-2010)

The present study found the starling breeding at many places within the range mentioned above and has been found to be successfully competing with the common myna in the urban areas of suburban Mumbai, Thane, Kalyan and Navi Mumbai. In May-June 2007, 13 pied starling nests were found in Kharigaon alone, a suburb of Thane. With the present rate of dispersal, the starling may one day cross the Ghats country and establish itself on the Plateau region towards Pune and Nashik. The process seems to have already started for there is a stray record of this bird from Lonavla-Khandala (Pande et.al. 2008). The rate of dispersal of the starling along the railway lines comes to about 1.36 km per year.

Another example of an escaped bird establishing in a new area is the Alexandrine parakeet. Its natural range is mostly northern, central & north-eastern India (Grimmett et al., 2011).In the state of Maharashtra, the birds' range is confined to northern, central & eastern Maharashtra. It is almost absent in western Maharashtra. But few escaped pairs have established themselves in the cities like

Mumbai, Thane and Pune. A flock of 4 birds have made the Fergusson College campus, Pune their permanent residence since 2006.One of the birds has a ring bound around its lower tarsus, clearly indicating that the bird is an escapee. A pair of Alexandrine parakeet was found nesting in a hole on an abandoned building off the Prabhat road in Pune in 2011.

Species that have been made rarer or extinct as a result of man's activities:

The various activities carried out by man include-hunting, poaching, over-collection, modification of habitats as a result of agricultural and industrial practices and the process of urbanization have been responsible for changes in bird population and habitats. A detailed discussion of the impact of human activities on birds is carried out in chapter 9.

5.3: An overview of specific distribution:

A study of grid maps of the study area throw light on many interesting facts about the overall distributional patterns of birds. The whole study area, divided as it is, into 81 grids, each of size 10 x 10 km. Every grid as assigned a value depicting the highest number of bird species within the grid. Two such maps were developed one for the Resident & local migratory birds and the other for winter migratory birds. The data were used to develop two types of maps i) Species contour maps & ii) Species choropleth maps.

Residential & Local migratory birds:

The map for residential & local migratory bird species has range of bird species from 174 to 240.

The range was divided into four classes with 20 interval viz.

(1) 160-180

(2) 181-200

(3) 201-220 &

(4) 221-240.

The choropleth map which assumes discrete nature of observations shows highest diversity (221-240) in two belts, the coastal belt and the Western Ghats belt. In case of coastal areas the higher diversity is due to diversity of coastal habitats: beaches, headlands, creeks & estuaries, green compounds in the form of 'wadis' (wadi-privately owned house surrounded by plantations & gardens), some areas with good forest cover (e.g. the Sanjay Gandhi national park & the Phansad wildlife

sanctuary) and patches of paddy fields. The rich diversity is part forest/woodland, part aquatic Western Ghats is one of the biodiversity hotspots (?) All the grids with highest species diversity perfectly follow the Western Ghat. The grids with highest avian diversity are Bhimashankar (240), Simhagad (237), Raigad-Torna (236), Upper Savitri (236) and Mahabaleshar (235). Bhimashankar & Mahabaleshwar are on the crestline (ghatmatha) of the Ghats, Raigad-Torna is part foothill-part Crestline, Upper Savitri is along the western slopes of the Ghat country whereas Simhagad is an eastern offshoot of the Western Ghats range. The extensive Crestline plateaus with grassy slopes, the intergrading of evergreen-moist deciduous forest, relatively protected forested ravines, terraced paddy fields, a series of dams & reservoirs: all together have given rise to a variety of habitats & niches for forest, woodland & aquatic birds converting these spots into local biodiversity hotspots. The higher diversity at Bhimashankar & Simhagad surpassing even Mahabaleshwar is partly due to better & frequent coverage of the former places with good bird database, compare to Mahabaleshwar. The author is of the opinion that a better, wider coverage & deeper bird surveys around Mahabaleshwar may add many more species making Mahabaleshwar surpass the previous top spots. The area between these two belts has moderately high diversity (201-220). The diversity drops towards the east of the Ghats country. The area immediately to the east of the Ghats country has moderate diversity (181-200).This is the rain shadow region of the Western Ghats, with tropical thorn the dominant vegetation. Most of the vegetation here is depleted. The lowest diversity belt (160-180) lies further east with still lower rainfall, with extensive patches of scrub & grass country & barren rocky fields.

The bird species isopleth (bird species contour) map is even finer with seven classes as follows: Isoline map assumes the continuity in the distributions.

(1) Less than 180

(2) 181-190

(3) 191-200

(4) 201-210

(5) 211-220

(6) 221-230 &

(7) 231 and above.

The area with highest diversity (230 & above) lies along the Ghats country. The diversity goes on decreasing on the either side. The gradient is steeper towards

the east, the diversity dropping from 230 to 180 within forty kilometers at places (e.g. Mahabaleshwar to Wathar). The whole drought-prone eastern belt Pune & Satara districts showing poor diversity(less than 180).The diversity slightly increases towards the coast, towards Mumbai & Alibaug ,for the obvious reasons –the addition of coastal & aquatic habitats and two protected areas.

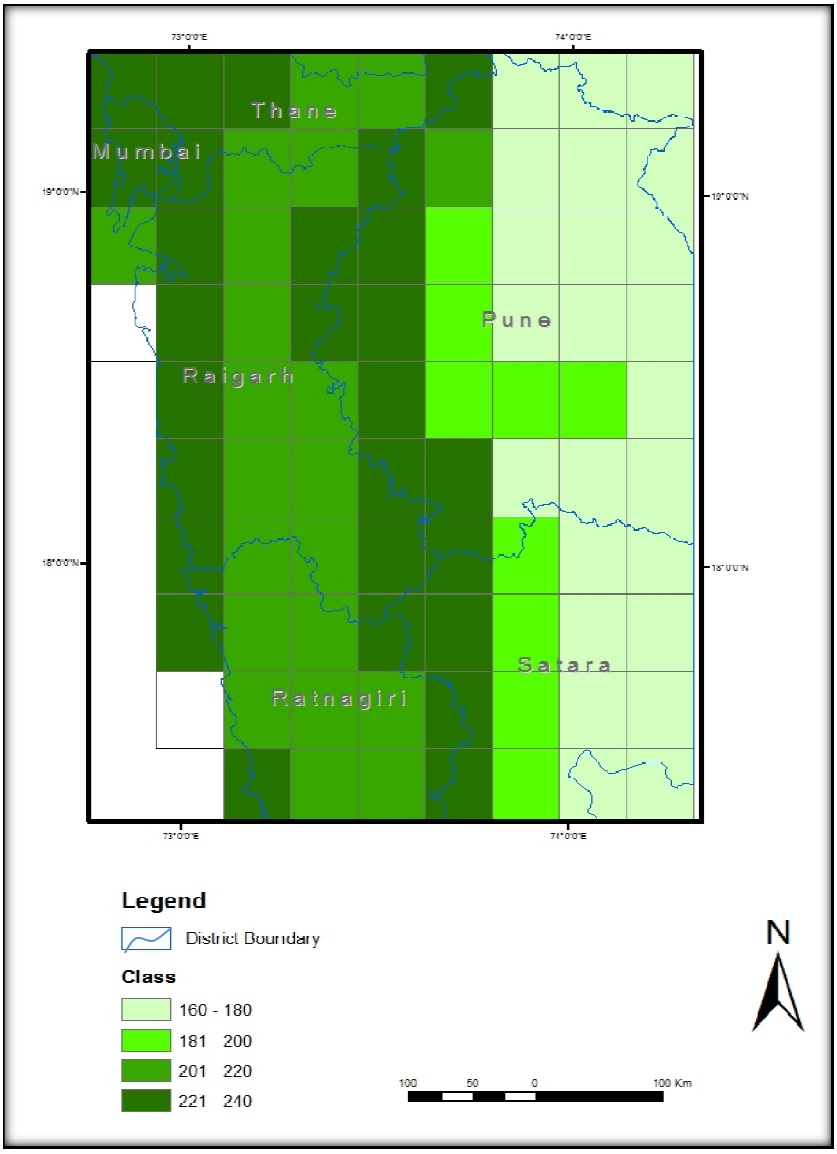


Fig.5.18: Gradient of species distribution-Breeding resident birds (The class represents number of birds) (Choropleth map)

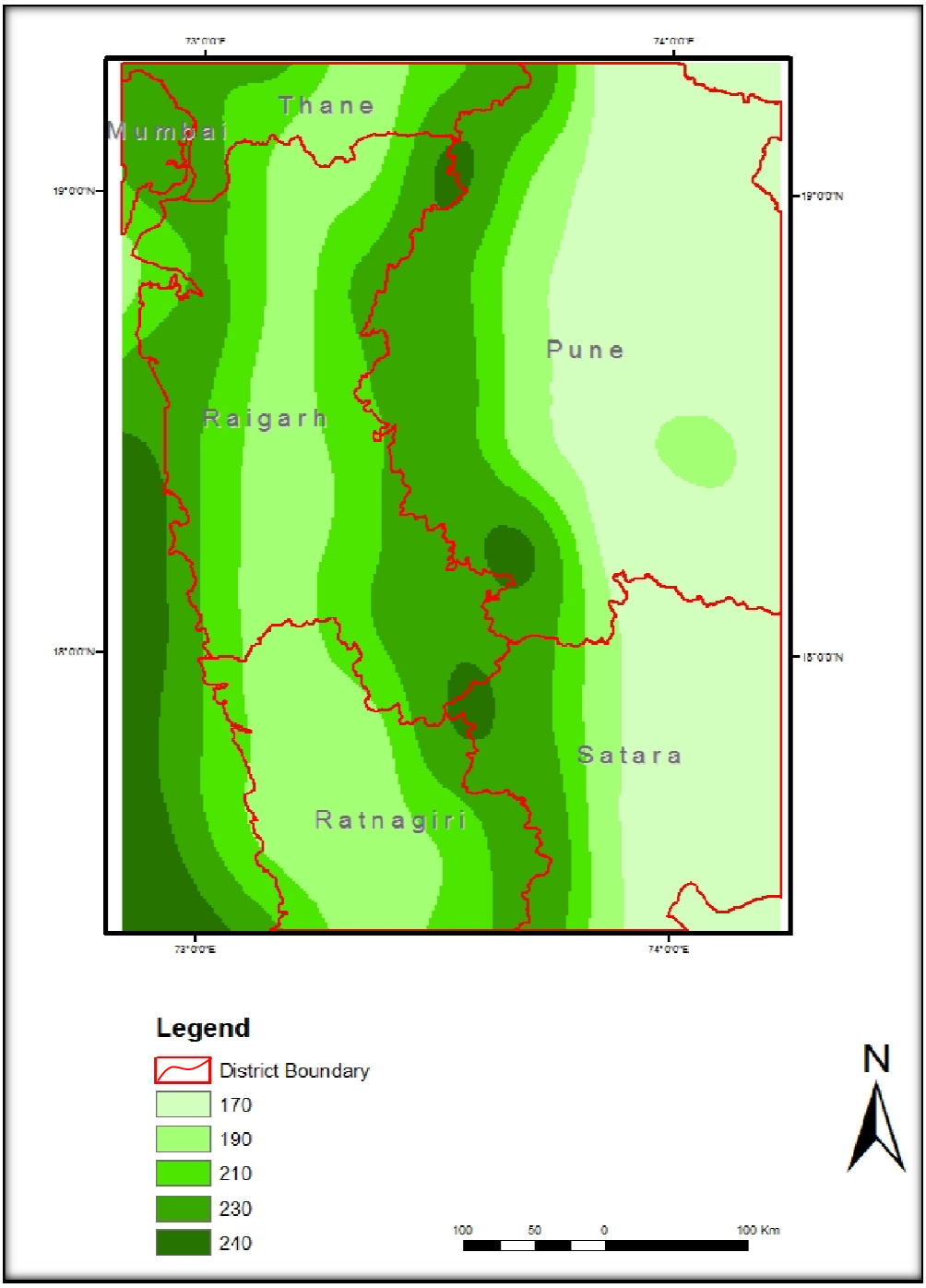


Fig.5.19: Bird species contour (Isopleth map)- Breeding resident birds

(The figures are number of birds)

Distribution of Wintering Birds:

The map showing distribution of winter migratory birds are even more interesting. The data range from 49 to 75. There are six classes with interval 5 as follows:

71-75
66-70
61-65
56-60
51-55
Less than 50

There are two areas with highest winter bird diversity: the Mumbai suburban (west) and the Ujani backwater. The former is a coastal location with two creeks, the later a man-made reservoir. It must be noted that 55 of the 75 winter migratory bird species (73.33%) seen in the study area are aquatic. Mumbai suburban west in fact is the richest spot with highest number of winter migratory birds. This is partly due to its coastal location, availability of abundant food, and better monitoring and data gathering. The Ujani reservoir is located in the heart of the drought-prone area of Pune-Solapur-Ahmednagar districts. It is the largest water body (reservoir area: 357 Km^2) within a hundred kilometer radius, obviously making it a point of attraction for wintering birds. It is also frequently visited & monitored by Pune birders, with tons of data available. An east-west belt, of which Ujani is a part, shows high diversity of wintering birds. This belt starts near Pune and ends at Ujani, almost 120 km long. This belt runs more or less parallel to the Pune-Solapur highway. A number of lakes & reservoirs are located along the belt (there are 7 medium-sized lakes & one, the Ujani, very large Lake). Every lake attracts thousands of birds of hundreds of species. Ujani alone supports 160 species, 65 of them migratory (Bharucha & Gogte, 1991), whereas Khamgaon, Kasurdi & Khutbav lakes together support 246 species,71 of them migratory (Purandare R.,1992). A single day visit to any of these lakes during winter months yields around 45 to 50 species, most of them winter migratory(Purandare K.,1997).A third biodiversity hotspot is around Khopoli-Khandala with 65-70 species,a combination of migratory aquatic & forest birds. Otherwise most of the remaining area lies within low diversity categories(less than 50, 50-55 & 55-60).In other words almost half of the study area shows more or less same winter bird diversity.

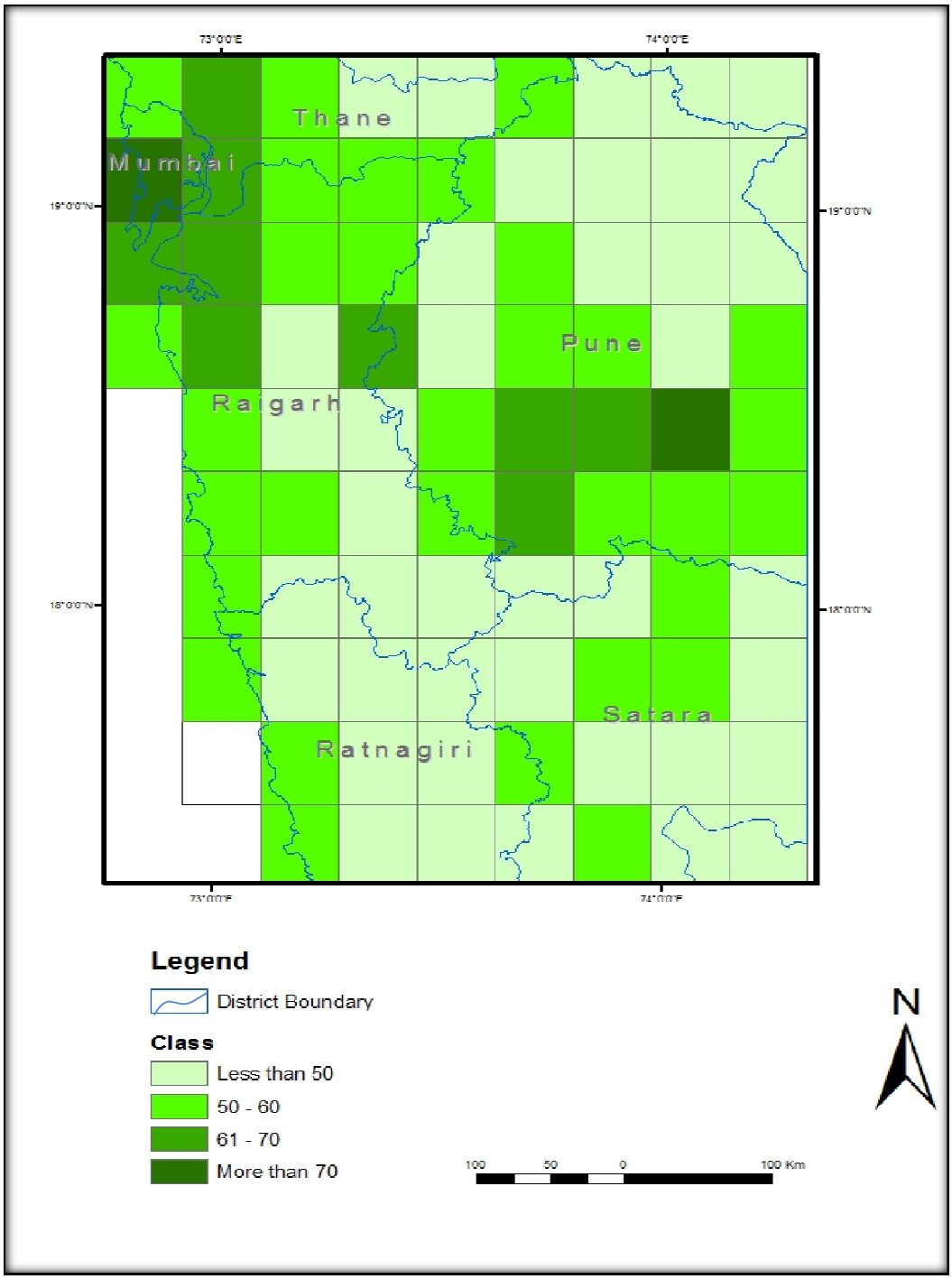


Fig.5.20: Gradient of species distribution-Winter migratory birds (The class represents number of birds) (Choropleth map)

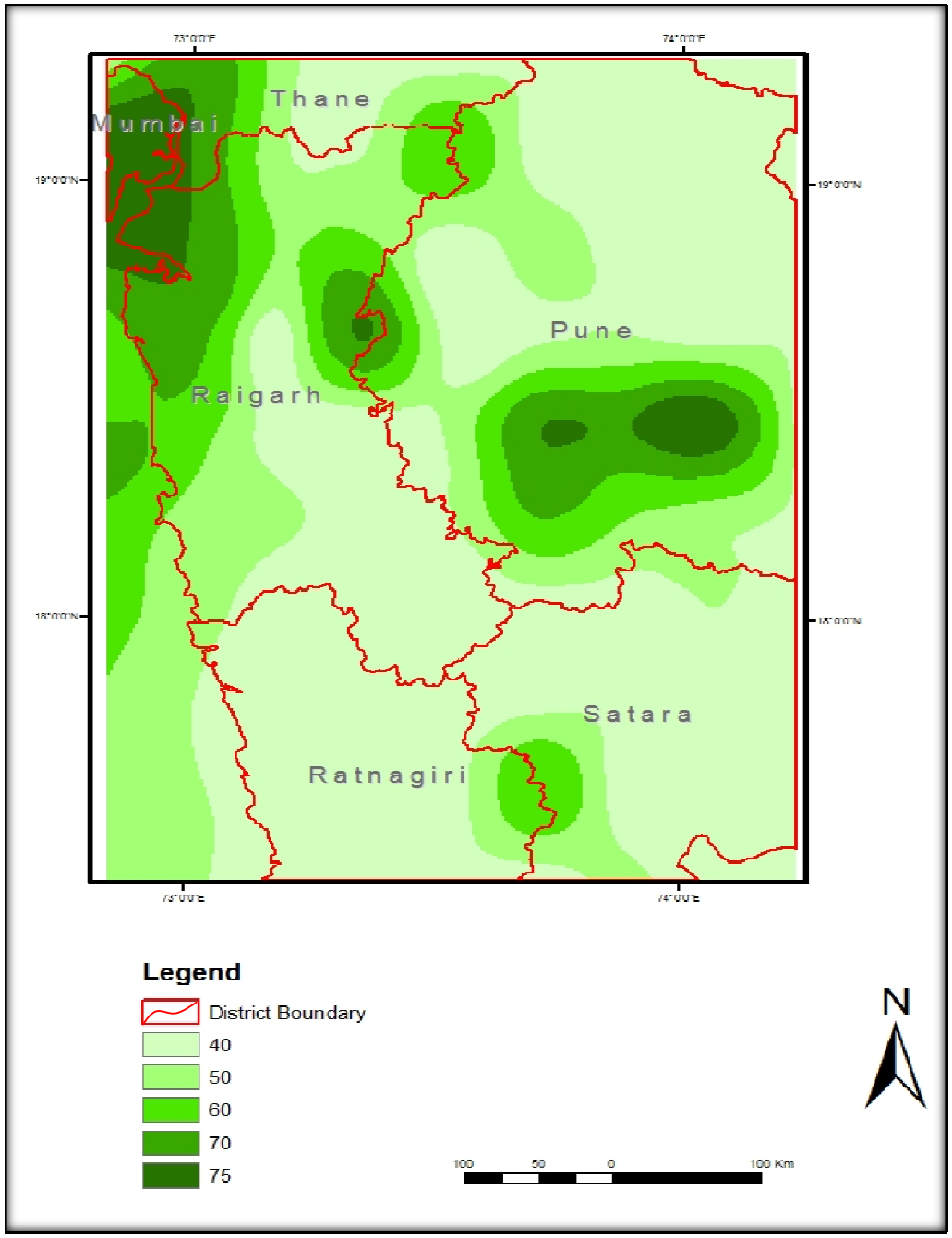


Fig.5.21: Bird Species Contour (Isopleth map) - Winter migratory Birds

(The figures represent number of birds)

Chapter 6:

Study Area: Faunal Affinity, Disjunction Distribution and Multiple-Route Theory

6.1 Introduction

"Present is the key to the past."

Present day bio-geographical characters of a region are the outcome of gradual and continuous modifications of past ones. The bio-geographical evolution consists of continuous changes in composition, ecological characters, affinities and associations of flora & fauna, & distributional patterns (Mani, 1974).The bio-geographical evolution involves not only biotic elements of the region but also the abiotic ones-land, water, climate etc. Both the factors merge into each other as a whole and evolve as one system. The distribution of organisms (plants or animals), is a dynamic phenomenon and it includes the whole history of origin, spread & establishment of species or group of species, in a region.

6.1.1 Species Range

A species range is the area where a particular species can be found during its lifetime. Species range includes areas where individuals or communities may breed migrate or hibernate. Every living species on the earth has its own unique geographical range. Frogmouths, for example, live only in the Oriental region, in South, South-eastern Asia and the western Pacific region.

There are 13 species of forest birds. Some bird species have a wide range, while others live in a very limited area. For example, the global range of the Barn Swallow (*Hirundo rustica*) encompasses about 25 million square kilometers across North America, Europe, Africa and Asia. (www.eol.org). At the other end of the scale, we have the Jerdon's Courser (Rhinoptilus bitorquatus), a supposedly extinct bird, rediscovered during 1980's. It has such a limited range that it is confined to a small corner of southern Andhra Pradesh with a limited range of about 100km^2

Species with ranges that cover most of the Earth are said to have a cosmopolitan distribution. The House sparrow was basically confined to Eurasia and northern Africa. It was introduced to other parts of the world by humans. Its present distribution covering all the six continents is cosmopolitan. Black-crowned night heron, House crow, Osprey, Cattle egret, Rock pigeons are some other birds with

cosmopolitan distribution. The Jerdon's courser is said to have endemic distribution range.

Species with two or more ranges that do not connect with each other have a disjunct distribution. Mountain ranges, deserts, or oceans sometimes separate the ranges of these species. Around 55 bird species show more or less disjunct distribution in India.The most prominent examples are the Great hornbill (*Buceros bicornis*), Frogmouth species (*Batrachostomus* sp.) and Asian fairy bluebird (*Irena puella*).

6.1.2 Species distribution is the manner in which a species or a group of species is spatially arranged. Some characteristic features of distributional range are:

- Distribution is dynamic
- Range changes slowly
- Changes are complicated
- Distributional range either expands or contracts in time
- Range may be shifted, temporarily or permanently.
- Range may be separated from larger area
- Range may break up into isolated patches
- Fragmented ranges may coalesce into a larger unit.

The geographical evolution of a range is closely linked to and influenced by the geological and geomorphic evolution of the region. A meaningful interpretation of Indian biogeography is possible only if we take into consideration the geological development. Present day patterns of distribution are product of the geological & evolutionary history of the region. Even the present distribution is not static & is undergoing continuous changes.

6.2 Zoogeographical Realms & Regions of the World:

The land areas of the earth, have been divided into a number of major areas based on their characteristic fauna (especially mammals).These are called **zoogeographical realms**. One of the earliest classifications of such regions was by Alfred Wallace in 1876.

As per his classification there are six regions

- Palaearctic (Eurasia minus South & South-east Asia)
- Neotropical (Central & South America)
- Nearctic (North America north of Mexico)

- Ethiopian(Sub-Saharan Africa & south-western Arabia)
- Oriental (South & South-east Asia)
- Australian.

These are also called the faunal regions. India forms part of two faunal regions –the Oriental & the Palearctic. The Oriental region extends from Baluchistan (Pakistan) in the west, through most of India (except the north-western Himalayas), Myanmar, S. China, SE Asia to the western half of the Indonesian archipelago (Robinson, 1972). Part of Jammu & Kashmir and the higher Himalayas, form the southern boundary of the Palearctic region.

Holt et al.(2013) have come out with a new classification of zoogeographical regions based on data on distribution & phylogenetic (evolutionary) relationship of 21037 species of amphibian, birds & mammals. This classification has 11 larger realms & 20 zoogeographical regions.

The newly defined 11 zoogeographical realms are:

Nearctic (North America north of Mexico)
Panamanian (Central America)
Neotropical (South America)
Palearctic (Europe, central & northern Asia)
Saharo-Arabian (Northern Africa & west Asia)
Afrotropical (Africa south of Sahara)
Madagascan (Madagascar)
Oriental (South & south-east Asia)
Sino-Japanese(Part of China including Tibet ,& Japan)
Australian (Australia & New Zealand)
Oceanian (Islands in west & central Pacific Ocean)

As per this new classification India forms part not two but three regions. As usual 90% of the subcontinent is part of the Oriental zoogeographical realm. Large part of Jammu & Kashmir is easternmost boundary of the Saharo-Arabian faunal region, whereas most of the Higher Himalayas forms southern edge of the Sino-Japanese region. **The study area is part of the Oriental realm under both the classifications.**

6.3 Faunal Evolution of India:

According to Mani (1974) the flora & fauna of India is influenced by the flora & fauna of 4 amphitheatres (centers of dispersal) viz.

1) Peninsular amphitheatre (native biodiversity)
2) Indo-Chinese & Malayan amphitheatres
3) Palearctic amphitheatre
4) Ethiopian-Mediterranean amphitheatre

In other words India lies at the meeting point of many faunas and shares faunal affinity with three regions (No.2,3 & 4 as mentioned above).For the purpose of simplicity & convenience ,the faunal elements are simply renamed as:

1) Native elements (Indian Peninsula)
2) Eastern elements (Indo-Chinese & Malayan)
3) Northern elements (Palearctic)
4) Western elements (Ethiopian, Mediterranean & west Asian)

The major geological, geomorphic, climatological & historical events which had deeper & wider impacts on the flora & fauna (including birds) of the region are:

1. Breaking up of the Gondwanaland
2. Drifting of the Indian plate from original location near the present day Antarctic
3. Deccan volcanic eruption
4. Contact of the Indian plate with the Asian landmass
5. Rising of the Himalayas & the Tibetan plateau
6. Uplifting of the Western Ghats country & subsequent erosion of the Konkan lowland
7. Development of Monsoon weather system
8. Pleistocene Ice age
9. Humanization of the region

Some explanation:

Points 1 & 2:

A hypothetical supercontinent called Pangaea existed around 200 m. years ago as per the Wegener's theory. The supercontinent started breaking up initially into two large landmasses called Laurasia (northern component) & Gondwanland (southern component) about 120 m. years ago(Emiliani,1997) The

Gondwanaland comprised of S. America, Africa, India, Madagascar, Antarctica & Australia. All these landmasses after separating from the Gondwana drifted to different directions. The Indian mass drifted towards the north-northeast and moved towards the Asian mass.

Point 3:

While drifting towards the Asian landmass the Indian landmass on the way hit the volcanic hotspot of the Reunion island (presently part of the central Indian ocean) giving rise to the volcanic eruptions which formed the Deccan plateau(Late Cretacious-Early Eocene: About 650 m. years ago).

Point 4:

Finally the Indian landmass moved closer & collided with the much larger Asian landmass. This gave rise to formation of the Himalayas as a fold mountain. The first contact between the Indian & the Asian landmasses was established in the Assam area. This connection between India & the rest of Asia in Assam provided a land bridge which was later used by eastern floras & faunas to get an entry into the Indian subcontinent. Some native Indian flora & fauna also escaped into south-eastern Asia using the same route (Mani, 1974).

Point 5:

The result of the collision of the two landmasses was the rising of the Himalayas around 45 m. years ago as a fold mountain. The Himalayas have been the highest mountain chain of the world with many peaks towering over 7000 m. This sheer height of the Himalayas made it into a physical barrier making it almost impossible for any plant or animal species to cross over from the northern side & vice versa. This physical barrier has isolated the Indian subcontinent from the rest of Asia into an independent geographical unit. This isolation was responsible for the development of native flora & fauna (Mani, 1974). The uplift of Tibetan plateau has been the major factor driving the Indian monsoon circulation (Stokes, 2000)

Point 6:

The Peninsular Deccan was uplifted during Mio-Pliocene period. This movement formed the Deccan plateau. This was followed by a very long period of erosive activity giving rise to the long scarp facing west & the Konkan lowland (Deshpande, 1998).

Point 7:

The present Monsoon system is said to be about 8 to 10 million years old. It is said to be strengthened around 4.5 to 5.0 million years ago (Srinivasan, 2000). The Monsoon climate has been responsible for three distinct seasons viz. hot - dry, hot-wet & cold. The uneven topography & latitudinal differences have made monsoon rainfall highly variable, ranging from 12 cm in west Rajastan to 1000 cm & above in the Meghalaya hills. (Sharma,2007).In Maharashtra this difference ranges from 747 cm. (Amboli) in southern Sahyadri to less than 50 cm.in drought-prone central Maharahstra (Dikshit,1986).Within the study area the rainfall amount ranges from 622 cm.(Mahabaleshwar) to less than 50 cm. in the dry eastern talukas of Pune district(Deshpande,1971). This has given rise to various types of forest. The north-south orientation of the Western Ghats along the western coast of India has created a high rainfall zone along the Konkan coast & the Ghats country. Further east across the Ghats, a large part of the Upper Deccan has become rain-shadow region. The outcome of this arrangement is the north-south narrow belts of different forest types based on rainfall amount. The forest type changes here within a short distance of few kilometers. The change of gradient in rainfall and forest type is very steep, which has reflected in bird diversity of the region also.

Point 8:

Pleistocene Ice ages: Quaternary is the geological period which represents the last approximately 2.5 million years. It is further subdivided into two periods-the Pleistocene, first 1.99 million years and the Holocene, last about 10 to 12 thousand years. The Pleistocene is marked by repeated glacial periods called the ice ages. The evidence suggests that there were at least 20 ice ages during the period, occurring after every 100000 year. During the ice age period the climates were cool and dry, deserts expanded, sea levels were lower by 120 m. than the present level. At this time many seas around India-the Persian Gulf, the Java Sea etc. were exposed. Many straits were dry lands, which acted as land corridors for a variety of land fauna (including birds) to cross over, or provided short cut routes for dispersal. The African-Mediterranean elements in the Indian fauna may have used the Persian Gulf route to reach India. The weaker monsoon was also responsible for dry conditions (Stokes, 2000).The last glacial period culminated about 18000 years ago. With the retreating of ice began the warmer and wetter periods. Maximum wetness in arid and semi-arid regions was experience around 9000 years ago, the period of intensive monsoonal

rainfall. Enormous environmental changes that took place every 100000 years during the Pleistocene period were responsible for dispersal, fragmentation and isolation of all kinds of biological populations, leading to speciation and evolution (Emiliani, 1997).It is possible that whatever speciation among birds happened in India, must have happened during the glaciated periods of late Pleistocene. The beginning of warmer & wetter period during the Holocene may have replaced the ice-covered lower Himalayan slopes with coniferous and deciduous forest. (Emiliani, 1992)

Point 9:

The oldest fossilized record of a hominin (ancient human being) in India dates back to about Middle to Late Pleistocene (around 0.5 million years) (Sankhyani et al., 2012). Similar fossils were also discovered in western Maharashtra (Sankalia, 1976) and Kerala (Rajenrdan, 2001), but the antiquity of both records is uncertain. Stone-age tools belonging to the stone-age man have been discovered in different parts of Maharashtra, dating back to 100000 to 150000 years BP (Sankalia, 1976). The most authenticated early human remains in South Asia is relatively recent. Two remains, one from Afghanistan & another from Sri Lanka are 30000 & 37000 years old respectively (Singh, 2008). Stone Age tools from the middle stone age (20000 to 30000 years BP) have also been found in Maharashtra (Sankalia, 1976). The earliest agricultural settlements in western Maharashtra date back to 2000 to 1500 BC. (Sankalia, 1976) The megalithic culture in western India dates back to 2000 BC to 1000 BC (Clutton-Brock, 1965). The known history of the region is about 2000 years old. This history starts with Satvahana, through Rashtrakutas, Wakatakas, Chalukyas, Yadavas, Bahamanis, Moghuls, Marathas & finally the British. The present population of the study area is about 30 million & the region is one of the most urbanized regions of the country.

The following table depicts the major events mentioned above & their correlation with bird fauna.

Table 6.1: Major environmental events and development of bird fauna of the area

Major event*	Geological period	Period of the event	Relation with bird fauna
Breaking up the Gondwanaland	Jurrasic	120 mya@	Primitive birds gradually replaces pterosaurs(flying reptiles).Break up leads to rapid diversification process
Drifting of the Indian plate	Cretaceous	100 mya - 4.5 mya	
Deccan volcanic eruption	Eocene	80 mya – 48 mya	Modern bird families (Neornithes)evolved
Collision of the Indian subcontinent with the Asian landmass	Eocene-Oligocene	55 mya	Eastern (Indo-Chinese & Malayan) faunal elements, including birds, enter the Subcontinent post Assam link.
Rise of the Himalayas & the Tibetan plateau	Miocene	52 to 48 mya	Indian subcontinent becomes isolated from rest of Asia. Native bird fauna develops
Uplifting of the Western Ghats country & the Deccan plateau& subsequent erosion of the region	Tertiary-Quaternary Miocene Pliocene	20-5 mya	Formation of windward & leeward belts giving rise to N-S rainfall zones from high (west) to low (east) & subsequent corresponding vegetation types.This boosts diversity of bird fauna in the region.
Development of Monsoon weather system	Late Terciary	4.5 -5.0 mya	----------Do----------
Humanization of the region	Quaternary/ Holocene	150000 BP to the present	Impact of human activities on bird fauna. Most intense during the last 100 years.

@ mya: million years ago

Fossilized Bird Records:

Bird fossils are rare compared to fossils from other vertebrates. Bird bones are lighter & softer. They can therefore be easily weathered. This seems to be the major reason as to why bird fossils are relatively rare to be found. Among the vertebrates, most records belong to fishes, reptiles & mammals. Records of animal fossils are limited from the Deccan plateau region, mainly because of its igneous petrology. Records of fossilized birds are few & far between. Of the Deccan Trap fauna, the vertebrate animal remains mostly belong to reptiles, fish & frogs. (Wadia, 1989) The Siwalik fauna (Middle Miocene to Lower Pleistocene) is mostly dominated by mammals. But the Lower Siwalik deposit contains a few bird fossils belonging to the

following genera: *Phalacrocorax* (Cormorants), *Pelecanus* (Pelicans), *Mergus* (Ducks) & *Struthio* (Ostriches) (Wadia, 1989). Quaternary deposits from the Godavari valley contain fossils of mammals (elephants, hippopotamus, wild ass, cattle, etc) and reptiles (crocodiles), but not birds. (Sankalia, 1976)

According to Daniels (1997),"Bird life in Southwestern India apparently came into existence only after India merged with the Asian mainland about 45 million years ago."

The Western Ghats of India is an interesting region from the bio-geographical point of view. This so called mountain chain which in fact is the western edge of the Deccan plateau runs north-south along the western coast of India. It forms a link between the South-western Ghats & the Satpura mountains of Central India. It is proposed that this was the migration route for the Eastern fauna (Indo-Chinese & Malayan) between Assam and the South-west of India. The Western Ghats is one of the three biodiversity hotspots in India. The other two are the North-eastern Himalayas and the Andaman & Nicobar island group.

6.4 The Avifaunal Composition:

Though Western Ghats is one of the biodiversity hotspots in the world, it is moderately rich in its avifauna. In fact Daniels (1997) considers it to be poor compared to many other tropical areas. Out of the total 508 species reported for the whole Western Ghats region, only 15 are endemic. A large part of the study area falls under the Western Ghats.

Of a total of 96 families & 277 genera of birds listed for India, 76 families (79%) and 244 genera (88%) are found in the study area. The avifauna of the study area is a mixture of Peninsular, Eastern, and Western & Northern elements. A comparative study of the avifauna of the study area with other major regions in the country would be of some help in solving such issues as the present composition, past distribution, migratory routes etc. For this purpose three distinct areas from three corners of the country are selected on the basis of climate, location & relation with the study area.

These are (1) North-western India (2) Eastern Ghats & (3) North-eastern India

The North-western India mostly includes the arid & semi-arid parts of Rajasthan & Gujarat. Comparative data of the topography, climate & forest types of the regions is given in Table-

Table 6.2: Comparative chart of major physical factors of four regions

Physical factors	Study Area	NW India	Eastern Ghats	NE India
Location	Tropical	Subtropical	Tropical	Subtropical
Dominant topography	Mountain, coast & plateau	Desert with occasional ridges	Mountain & coast	High mountains & river valley.
Rainfall	Moderate to heavy	Scanty	Moderate	Heavy
Relative humidity	Moderate to high	Low	Moderate to high	High
Range of diurnal temperature	Moderate	Extremes	Moderate	Low
Dominant forest type	Tropical Moist & dry deciduous	Tropical Desert ,thorn & scrub	Tropical Moist & dry deciduous	Tropical Evergreen & semi-evergreen
Minimum distance between the study area & the other region (Km.)	----------	615	590	1570

(Modified after Kurup, 1974)

6.4.1 Faunal similarity:

Let us now have an overview of the avifauna of the four regions on the basis of orders, families & genera & how the study area is related to the other three.

Table: 6.3 Comparitive chart of the bird fauna of four regions

Group of Taxa	India	Study Area	NW India	E. Ghats	NE India
Orders	21	17	17	18	18
Families	96	76	69	73	82
Genera	277	244	208	222	249
Species(Resident)	855	344	299	311	494

Table: 6.4 Number of bird families, genera & species (resident birds) of three regions as compared to the study area

	N.W. India		E. Ghats		N.E. India	
Group of taxa	**Total**	**Common to Study area**	**Total**	**Common to Study area**	**Total**	**Common to Study area**
Orders	17	17	18	17	18	17
Families	69	67	73	72	82	73
Genera	208	200	222	220	249	216
Species (resident birds)	299	208	311	222	494	249

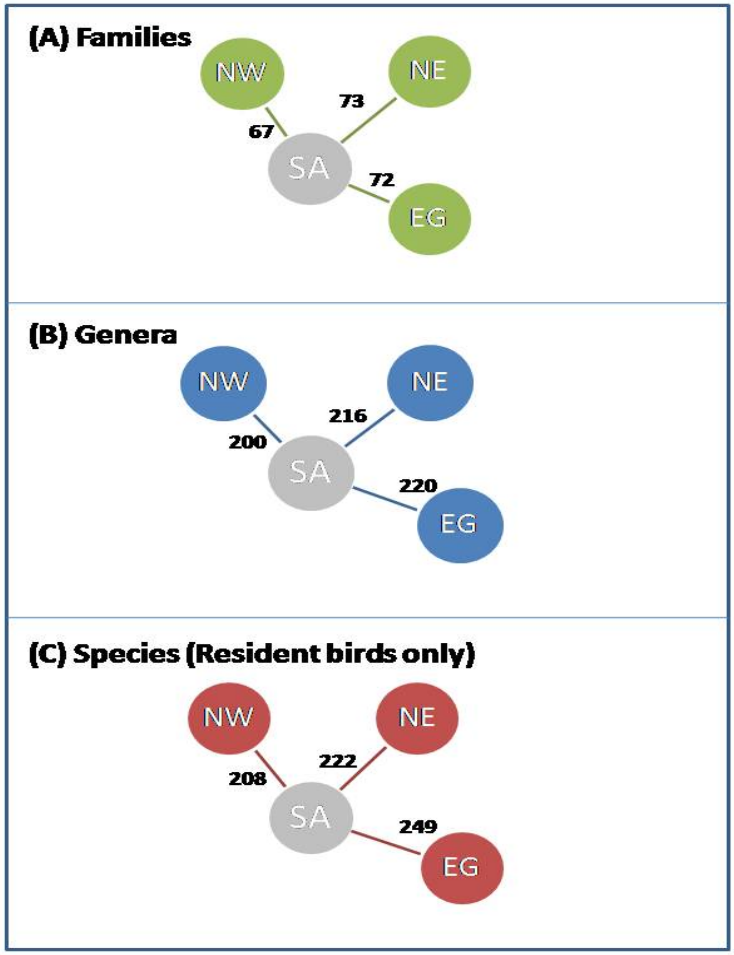


Fig. 6.1: Avifaunal Relationship of the Study area with three other Regions

SA= Study area, **NW**= North-west India, **NE**=North-east India, **EG**= Eastern Ghats

Avifaunal Relationship of the study area with three other selected regions is compared on the basisi of number of families, genera and resident species common between the study area and three other regions.

The avifaunal resemblance of the study area to the other three regions may be expressed statistically by

Simpson's index S=C/NI * 100.

(The proportion of the species in smaller fauna as compared to the larger one in percentage)

On this basis the faunal similarity of the study area with each of the three regions is as follows:

Table 6.5: Avifaunal resemblance (C/NI*100) of the Study area with Other three regions of India

Taxon group	NW India	En Ghats	NE India
Orders	100	94.44	94.44
Families	97.10	98.63	89.00
Genera	96.15	99.00	86.75
Species(Resident)	69.56	71.38	50.40

The above table clearly shows that the Study area has closer avifaunal affinity with the En Ghats, followed by the NW India & NE India The faunal similarity of the Study area with E. Ghats(98.63% families, 99 % genera & 71.38% resident species in common) is obvious because of location, climatic & vegetation similarity between them. The Eastern Ghats is the nearest of the three regions to the Study area (proximity). Besides both the regions are physically connected to each other through the Nilgiri mountain chain in the south making dispersal (faunal exchange) a close reality. White-spotted fantail, Indian scimitar babbler, Brown-cheeked fulvetta, White-bellied woodpecker, Heart-spotted woodpecker, Malabar trogon, Painted Bushquail, Malabar pied hornbill are some species exclusively shared by both the regions. Next closest region in line to the Study area is NW India. In spite of location, climatic & topographical differences this region's share with the study area is quite high (97.10% families, 96.15% genera & 69.56% resident species in common). This is partly due to the inclusion of the semi-arid upper Deccan within the study area which shares many open area birds with the NW India like Great Indian bustard,

Indian courser, Syke's nightjar, & white-eared bulbul. The Study area shares the weakest link with the North-east. The Study area shares 89% families, 86.75% genera & only 50.40% resident species with the Northeast. The Northeastern region is closely linked to the Eastern faunal elements (Indo-Chinese & Malayan) and therefore is dominated by many eastern families, genera & species which are not to be found in the Northern Western Ghats.

The following families are confined only to the Northeast:

Heliornithidae (Finfoots), Indicatoridae (Honeyguides), Eurylaimidae (Broadbills), Aegithalidae (Long-taile tits), Troglodytidae (Wrens), Cinclidae (Dippers), and Prunellidae (Accentors).

The Northeast also has additional 33 bird genera & a whopping 245 species of its own, which are not found in the Study area. Lying as it is, at a distance of 1590 km. from the Study area, it is also the farthest region among all the three. The Study area shares 249 bird species with northeast, most of which are commoner birds of India. Some unique birds exclusively shared by both regions are mostly the Eastern elements (Indo-Chinese & Malayan) which had their origin in the south-east Asia & have entered the Indian subcontinent through the Assam faunal gateway. Many of these birds show disjunct distribution. In other words birds with disjunct distribution show discontinuous pattern of distribution whereby we have two populations of the same species ,one confined to the Western Ghats ,the other to the Northeast, separated by hundreds of kilometers of intervening territory, where the species does not occur at all.

Some birds with such distribution are: Slaty-breasted rail, Rudy-breasted crake, Mountain Imperial pigeon, Great hornbill, Black bulbul, Asian fairy bluebird, Crimson sunbird, and crested bunting.

A similar study on mammals by Kurup (1974) showed similar faunal similarity between the Western Ghats & the Eastern Ghats, and similar lack of affinity between the Western Ghats & Assam (the North-east).

6.4.2 Faunal Interchanges:

Faunal interchange is one of the most dynamic and potent factors underlying changes in the faunal composition in a given region (Kurup, 1974).So far as the Peninsular Indian birds are concerned two substantial faunal inflows have happened

during the late Pleistocene around 250000 years ago (Daniels, 1997).A maximum number of bird species that are found today invaded the Peninsula from Africa & South-east Asia. These species entered the region from the north-west & the north-east (Assam) respectively. These early entrants colonized newer habitats & started evolving into newer species. This process probably continued till the retreat of the last ice age about 18000 years ago. Those who had arrived in the earlier period evolved into a full species. Whereas those who entered late did not find enough time to evolve into a full species. Such late entrants are therefore found as a subspecies or geographical race of some full species living in South-east Asia or Africa-west Asia. In other words the avifauna of the time was modified by the influx of the eastern as well as western elements. As a result there are 50 subspecies exclusive to the South-western Ghats region (Daniels, 1997). One of the possible fall-outs has been that there are only 15 endemic species of birds in the Western Ghats.

The quantum of interchange (QI) is expressed as follows:

QI= 100* Genera common between study area & any one other region/ Total no. of genera present in India.

Genus is the most suitable standard unit for the study of faunal resemblance and interchange (Kurup, 1974), hence its frequent use in the present topic. After the calculation, the QI values arrived at for each region against the Study area are as follows:

Table: 6.6: Quantum Interchange of Bird fauna between Study area and Other regions

Region	**QI value (%)**
North-west India	72.20
Eastern Ghats	79.42
North-eastern India	77.97

From the above figures it is clear that the quantum of avifaunal interchange between the study area and the two regions viz. the Eastern Ghats & the North-east is almost same, though the interchange is slightly more in case of the Eastern Ghats. The interchange between the study area and the North-west is relatively low compare to the other two regions. The maximum interchange between the study area and Eastern Ghats is obvious because of their geographical proximity & similarity in latitudinal

location, climate and vegetation. The more or less similar QI values suggest that the climate of peninsular India in the past (Late Pleistocene) may have been more or less the same, making the dispersal of birds from one region to other possible.

6.4.3 Avifaunal Affinities of the Study area:

For the sake of deciding the avifaunal affinity of the study area, it was necessary to categorize the birds into different faunal affinity categories. Six main categories were therefore identified as follows:

- Eastern elements (Indo-Chinese & Malayan)
- Northern elements (Palearctic)
- Western elements (Ethiopian, Mediterranean & west Asian)
- Endemic (to study area)
- Cosmopolitan(Having world-wide distribution)
- Uncertain affinity

While developing the list the following bird groups were not taken into consideration for the obvious reasons.

1. Stray & vagrant birds
2. Extinct birds

The faunal affinity was assigned on the basis of

a. Available proof that the species' origin lies in a certain region
b. A large portion of its distributional range lays in the source regions.
c. Most subspecies are found in the source region.

Table 6.7: Avifaunal affinity of the Study area

Faunal affinity (Source region)	**Number of Species #**	**Affinity (%)**
Eastern elements (Indo-Chinese & Malayan)	121	26.65
Northern elements (Palearctic)	101	22.25
Western elements (Ethiopian/Mediterranean/West Asian)	52	11.45
Endemic to study area	14	03.08
Endemic to the Indian subcontinent	66	14.54
Cosmopolitan	06	01.32
Uncertain affinity	86	18.94
Pelagic (Oceanic)	08	01.76
Total	**454 #**	**100.00**

(*# some doubtful records not included.*)

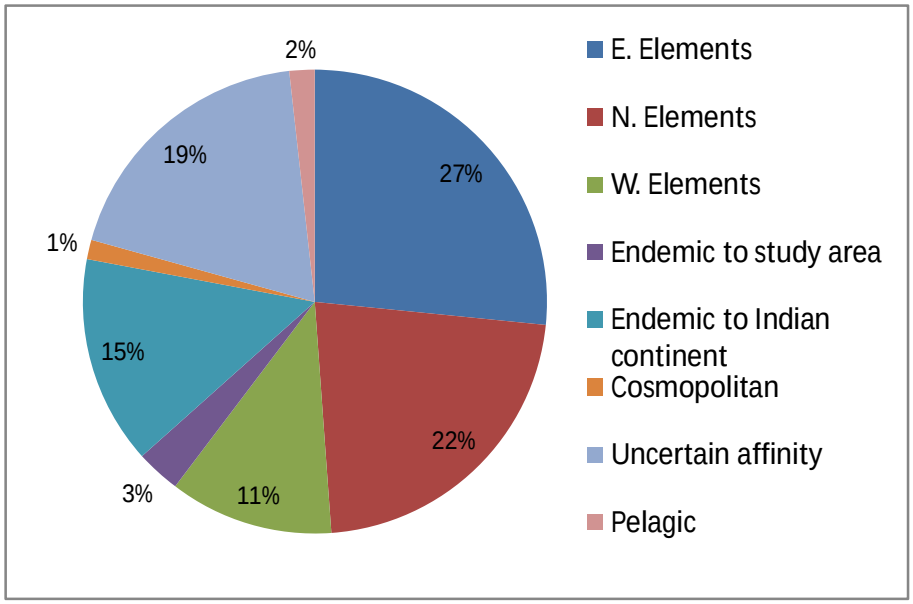


Fig 6.2: Avifaunal affinity of the Study area

6.4.4 Interpretation

a. The Eastern element (Indo-Chinese & Malayan) is dominant in the avifauna of the Study area, sharing 26.65% affinity value. Most of these are forest birds.
b. The Northern (Palearctic) element is the next dominant group with 22.25% affinity value. Most of these are winter migratory species.
c. The Western (African-Mediterranean-west Asian) elements share only 11.45 % of the avifauna. This is possibly due to the humid climate of the study area, since most birds with African /west Asian affinity are scrub & grassland birds.
d. The local endemicity is very low with only 14 endemic species (3.0%).
e. About 14.54% birds (66 species) of the Area are endemic to the Subcontinent, besides the 14 mentioned under point (d).
f. A large proportion (18.94%-86 species) of birds are uncertain in origin & therefore in affinity.
g. A small proportion of birds are cosmopolitan (6 species-1.32%) and pelagic (8 species-1.76%)

The above -mentioned trend agrees with Mani (1974) who stated that the main bio-geographical components of the flora & fauna of India is based on /derived from four major sources such as;

1. Peninsular autochthonous elements (Endemic fauna in the above table)

2. Indo-Chinese & Malayan intrusive (Eastern element)
3. Palearctic element (Northern element)
4. Ethiopian & Mediterranean element (Western element)

Characteristic features of the source regions & the faunas:

Eastern element (Indo-Chinese & Malayan)

- The Indo-Chinese zoogeographical sub region contains southern China & most of South-east Asia, whereas the Malayan sub region contains the Malayan peninsula & western half of the Indonesian archipelago. Both the sub regions meet & merge in northern Myanmar & north-eastern India.
- South-east Asia has been a region of faunal radiation.
- The region is rich in forest insects, snakes, birds & higher mammals (Mani,1974)
- The fauna is relatively younger, diversified & belongs to the Pliocene & Pleistocene periods.
- The fauna entered India through the Assam gateway, long after the contact was established between the Asian mainland & the Indian subcontinent.
- After entering through the Assam gateway, the fauna dispersed to different parts of the Subcontinent (including the Study area)using various routes such as the Himalayan highway, the Satpura highway, the Eastern Ghats highway etc.

Northern element (Palearctic)

- The Palearctic realm covers Europe & Asia(minus west & south Asia)
- The Turkestan sub region (C. Asia) of the Palearctic is the southern edge of the 'Realm', bordering & at places passing through the Himalayan ranges.
- Central Asia has been the centre of faunal differentiation & radiation.
- The fauna is the youngest, & highly adaptive & specialized.
- The region is rich in Steppe elements especially invertebrates, but poor in fishes, amphibian & reptiles. (Mani,1974) The region is moderately rich in birds most of which are steppe/grassland/mountain species.
- Most winter migratory birds that visit our area are Palearctic in affinity.

Western element :(Ethiopian & Mediterranean)

- The Ethiopian realm covers sub-Saharan Africa and part of south-western Arabian Peninsula. The Mediterranean subregion is a part of the Palearctic realm & covers most of west Asia.
- The fauna is relatively ancient & stable.
- The region is rich in tropical desert, scrub & grassland species
- The Western fauna entered the Indian Subcontinent through the north-west, through Iran & Pakistan.
- Most of the Western fauna is confined to north western & western India till Maharashtra.

6.5 Disjunct distribution, dispersal and the Satpura Hypothesis:

One of the most significant aspects of the Indian biogeography is the discontinuity in distribution shown by many wet-zone species of plants and animals from India.(Here the wet-zone limit is taken as those regions receiving 250 cm. or more rainfall. The wet-zone supports moist tropical forest with four distinct forest types:-Tropical wet evergreen, Tropical moist semi-evergreen, Tropical moist deciduous & Tidal forest.), (Sharma, 2007). The disjunct species have one population residing in the Western Ghats and another nearest population living thousands of kilometers away in the north-east of India.(Fig.6.3).Take for example Asian fairy bluebird(AFB). This birds has one population confined all along the Western Ghats from the southern tip all the way to Bheemshankar (part of study area) in the north. The bird is found nowhere in the peninsular India. The nearest population of the AFB from Bheemashankar is Badampahar in northeastern Odisha about 1400 km away. Off course this outlier of the AFB, and the main population lies further east in the north-east 500 km. across. In other words the AFB is distributed in two widely separated areas: the Western Ghats & the Northeastern Peninsula. Such a distribution is known as "**Disjunct distribution**". Most cases of disjunct distribution are with reference to the Indo-Chinese & Malayan elements of the Indian biodiversity. It is a fact that these species may have followed some route for dispersal into the Peninsula.

Dispersal is the spread of individuals away from their original homes. Dispersal movements are generally slow, and cover short distances in the life time of an individual. The cumulative result of short dispersals by successive generations,

however, may become conspicuous in the course of years, decades, centuries or even millennia, when it constitutes range expansion of the species into a new habitat or area. (Kendeigh, 1975)

Researchers have been trying to explain the geographical discontinuity in the distributional ranges of many species. Hooker & Thomson were probably the first to draw attention to the similarity in vegetation between the southwestern Ghats & the northeast of India. (Ali, 1948)

Since mid-19th centuary Wallace(1859), Blanford (1876), Ali(1949), Hora (1949,1953), Abdulali (1949), Ripley (1949), Digler (1952, in Karanth 2003), Mani (1974), Ripley & Beehler (1990), Daniels (2001), Karanth (2003) etc. have tried their best to explain the disjunct patterns of distribution of various taxa.

6.5.1 Major theories explaining the disjunct distribution are

Since the times of Medlicott & Blanford (1879), many experts have tried their best to explain the reasons behind the disjunct distribution of some species in India. Medlicott & Blanford comments mostly on the disjunct distribution of the temperate flora & fauna between the Himalayas & the south Indian hills. Various different theories have been put forward since then. Some of the important theories are:

Deccan Traps Theory:

The distribution of many plants & animals were continuous in the period before the formation of the Deccan lava province. The Deccan lava eruption took place during the late Cretaceous & early Ecocene period. The volcanic activity happened over a very large area, finally creating the Deccan plateau covering about 60000 km^2. of area in the central –western part of the continent. Many species of plants, insects & lower vertebrates who enjoyed a continuous distributional range from north to south, before the eruption the Deccan lava, became separated due to volcanic activity into southern population and northern/north-eastern populations. (Sarasin in Hora, 1949) This theory does not apply to birds because most of the present bird fauna of the Peninsula (including the one in the study area) has evolved in late Pleistocene period (Daniels, 1997), many million years after the formation & stabilization of the Deccan plateau.

Himalayan Glaciations Theory:

This theory was postulated by Medlicott and Blanford in 1879.A large part of central Asia; most of the Himalayas & a part of northern India were under glaciations many times in the geological past. The last time when this region was under

glaciations was in late Pleistocene. The cooler conditions thus created, provided corridors & ideal situation for the Himalayan temperate flora & fauna to move southward into the Peninsula. When the glacial period was over , the glaciers retreated ,climate over most of the Peninsula became warmer & humid and the temperate species in the south(who had all the way migrated to the south during the ice age) had to retreat to the highland & peaks of the southern mountainous areas, where conditions were cooler(and still are the same). A few rhododendron (Alpine plants) species, the Nilgiri Tahr (a mountain goat), & the Nilgiri marten(a small carnivore) are some prominent examples. But this theory does not & cannot explain the disjunct distribution of birds. Because most birds showing disjunct distribution are not Alpine/mountain birds but tropical forest species.

Southern Route Theory:

While writing about the similarity between the earthworm fauna of the Indian subcontinent, South-east Asia and Australia, Michaelsen (1904) opined about a possible former land connection between India & Australia across the Bay of Bengal. According to him, some species may have migrated using this land bridge from Australia to southern Asia. But there is no geological evidence to support this view.

Continuous Range Theory:

As per this theory, the wet-zone species, which today show fragmented or disjunct distribution, had in the past, continuous distribution, throughout the Peninsula. The continuity of distribution was disrupted mostly by climatic changes, especially increased dryness of the climate. This theory has been widely accepted as one of the most logical explanations of the disjunct distribution.

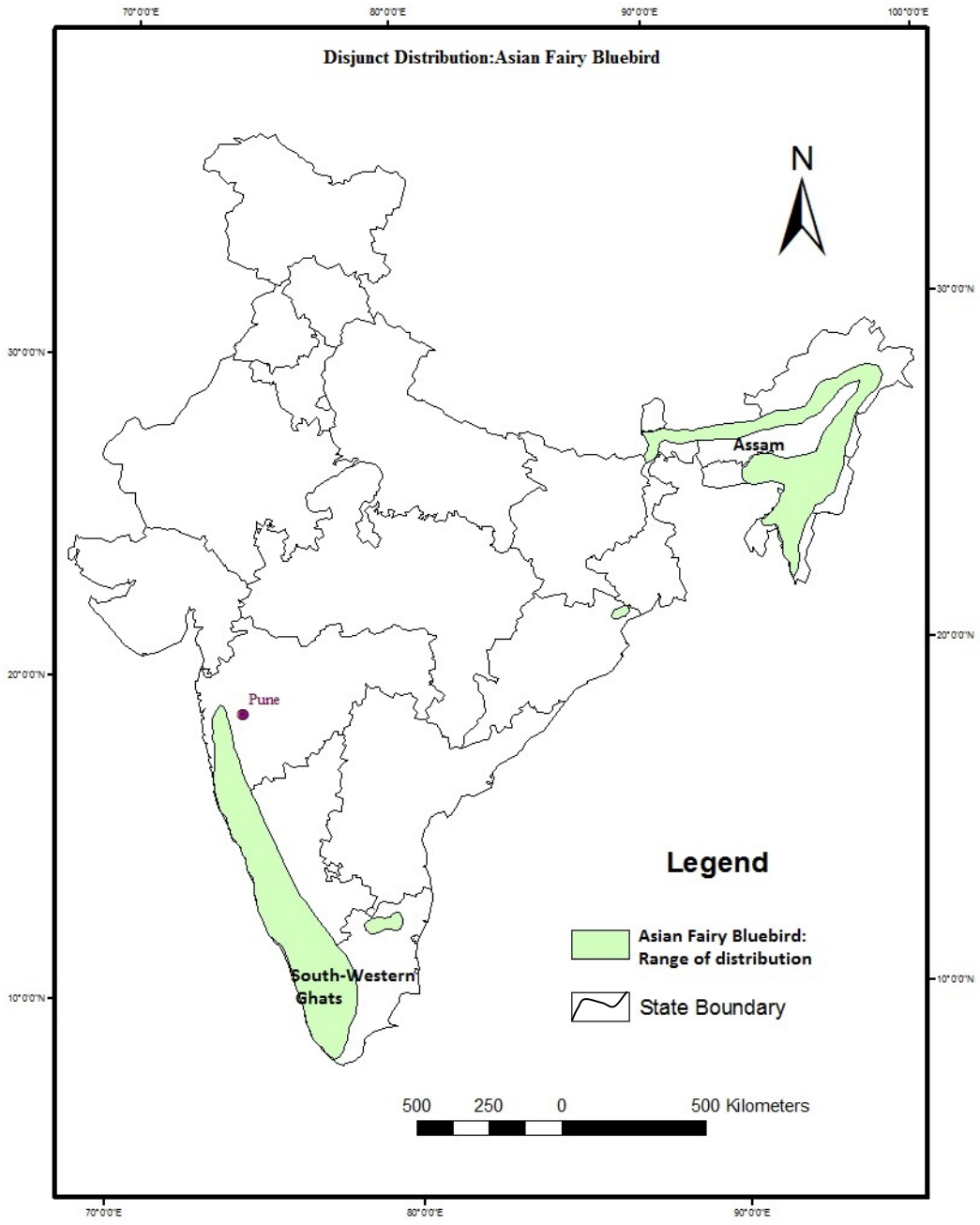


Fig.6.3: Disjunct distribution- Asian fairy bluebird

Eastern Ghats hypothesis:

As per this hypothesis, the route of migration of the eastern elements into South-western Ghats was via the Eastern Ghats and not via the Satpura range as proposed in the next theory. (Ripley 1949) It is possible that for some species the Eastern Ghats was the main migration route.

Satpura Hypothesis:

Dr. Sundar Lal Hora of the Zoological Survey of India, proposed this very well known hypothesis in 1949.Many species of hill stream fishes of Eastern origin (Indo-Chinese & Malayan) are found in the Western Ghats. While putting his hypothesis, Dr. Hora had following assumptions:

a) During the Pleistocene times, the Satpura-Vindhyan chain of mountain was higher up to 2000 m.

b) Both mountains formed a continuous chain between the Western Ghats in the west & the Himalayas to the east.(According Dr. Hora, the present day gap through which the Ganga & Bhrahmaputra flow was not there. Both the rivers flew westward as one single river called 'Indo-Brahm', and the present gap had a ridge connecting the Garo-Khansi hills with the Rajmahal hills across the Chhota Nagpur plateau, thereby making the continuous movement of flora & fauna from Assam towards the west of the Peninsula possible through the Satpura corridor. But this view did not have geological support, since we never had a connecting ridge as envisaged by Hora)

c) The North-east, the Satpura-Vindhyan range & the Western Ghats formed a continuous ecological belt with rainfall over 250 cm.

d) The dispersal of flora & fauna took place along the eco-belt from east to west along the Satpura-Vindhyan range and from north to south along the Western Ghats. **(Fig.6.4)**

Dispersal model: A large part of Peninsular India was under humid forest ,which was continuous throughout the Peninsula.(wet period of Quaternary phase) After the change in climate towards the dryness especially during the late Pleistocene/early Holocene, the continuity of the humid forest was broken into small patches across the central & eastern India. According to Karanth, some wet-zone species from the south-east Asia arrived in India (through the Assam corridor) after 'the establishment of dry zone' in the interior of the Peninsular India. These species used the then fragmented wet-zone forest as stepping stones to reach the Western Ghats.

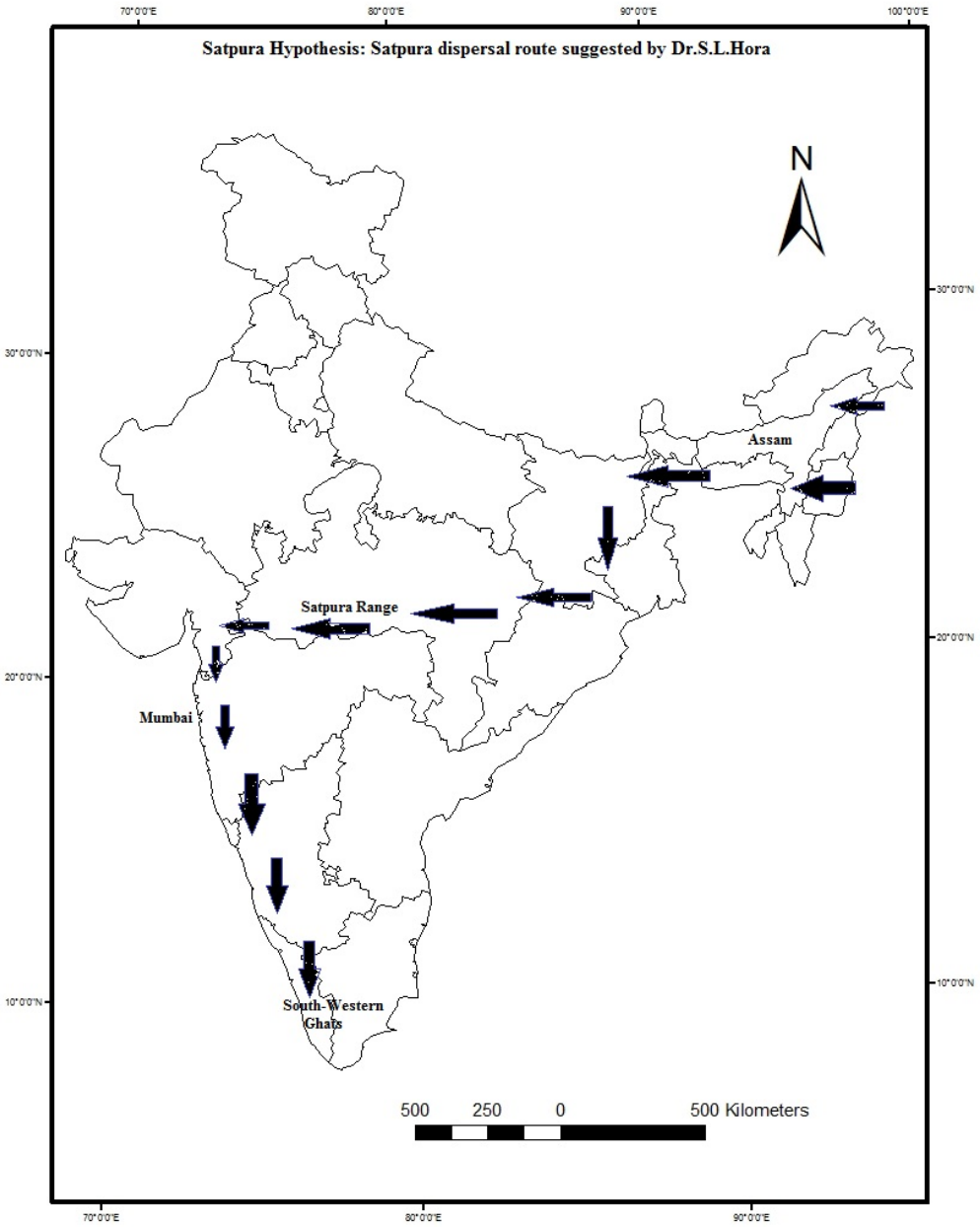


Fig.6.4: Satpura Hypothesis-Satpura dispersal route as suggested by Dr.Hora

Vicariance model: The separation or division of a group of organisms by a physiographic barrier, such as a mountain range or a body of water, resulting in differentiation of the original group into new varieties or species. Under the Indian scenario, the wet-zone species arrive in India before the establishment of the dry zone and were isolated from their counterparts in the north-east India due to subsequent fragmentation of the wet-zone forest.

Convergence model: According to Roonwal and Nath (1949), similarity of environments in the two areas (Western Ghats and the north-eastern India) might be the cause of the independent origin of similar forms from a common ancestral form. In other words, two different species (of the same family) living in two different areas with similar ecological conditions, evolved independent of each other into morphologically similar forms. These two forms were wrongly treated as one single species, making their distribution apparently disjunct. To explain the case Karanth, provides example of flowerpeckers (family Dicaeidae) of peninsular India. The species *Dicaeum concolor* (Nilgiri/Plain flowerpecker) has discontinuous distribution. In the subcontinent it is confined to the Western Ghats and the north-eastern states. The intermediate dry zone is inhabited by another species *D.erythrorhynchos* (Pale-billed flowerpecker). As per Karanth,it is plausible that *D.concolor* of peninsular India is more closely related to the neighbouring dry-zone species, *D.erythrorhynchos*, than it is to *D.concolor* of the north-east. During the drying up of the climate of the peninsular India,the *D.concolor* from the intermediate region may have been converted into *D.erythrorhynchos* apparently giving *D.concolor*,a disjunct distribution.

6.6 The Multiple Route Theory:

The author is more interested in the Dispersal and vicariance models mentioned above. Experts have already suggested four routes of dispersal of the Eastern elements into the South-west of India. These are

- Aravali route (Abdulali 1949)
- Satpura-Vindhya route (Hora 1949)
- Braj route (Digler 1952, in Karanth 2003)
- Eastern Ghats route (Ripley 1959)

Since Dr. Hora was an ichthyologist, his work mostly focused on hill stream fishes commonly found in the Western Ghats & the North-east of India.

While analyzing various hypotheses about the disjunct distribution, Karanth (2003) has put forth three models:

The author here tries to suggest that there may have been more than four routes of dispersal. The suggestion is based on present distribution of some wet-zone bird species. The various routes are defined on the basis of present distribution of

forest & woodland species in the Peninsular India with Indo-Chinese/Malayan affinities. It is possible that the present distribution of these species may be the relict distribution of the former wider range. The present (relict) distribution of the species is obviously the most favored distribution, since the species has been exterminated from the surrounding region due to increasing dryness of the climate.

* Every new species that enters a region from outside/neighboring areas generally follows the most favorable route for spreading in the new region.

* The species initially settles down along the most favorable routes.

* After it has established itself in the most favorable areas, it then starts spreading to the surrounding areas which may be comparatively less qualitative than the most favorable regions. Let us call such regions less favorable (comparatively, but still habitable by the species) regions.

When climate starts changing and becomes more and more dry the less favorable habitats are the first to be affected.Such areas become so dry that it becomes almost impossible for a woodland species to sustain here. The population of the species therefore retreats back to the most favorable areas, which by virtue of their topography (more height etc.) and climate (higher rainfall) are least affected by the drying up of climate. In this case the species is now a relict one and the relict distribution is nothing but its one time migration route.

On the basis of this logic the researcher tries to identify the possible routes of migration of the eastern avifauna within the country.

6.6.1 Secondary Gateways:

Assam has always been treated as the "Gate-way" to India for the Indochinese/Malayan flora & fauna.

The author renames it as the Primary gateway. After entering through this gateway, the avifaunal species has to negotiate secondary routes to make further entry into the peninsular region. The author has thus identified four secondary entry points. He calls them "**Secondary gateway**". There are four such secondary gateways:

1. Chittagong hills-Sundarbans
2. Garo hills-Rajmahal hills
3. Darjiling hills –Rajmahal hills
4. Himalyan-Aravli range.

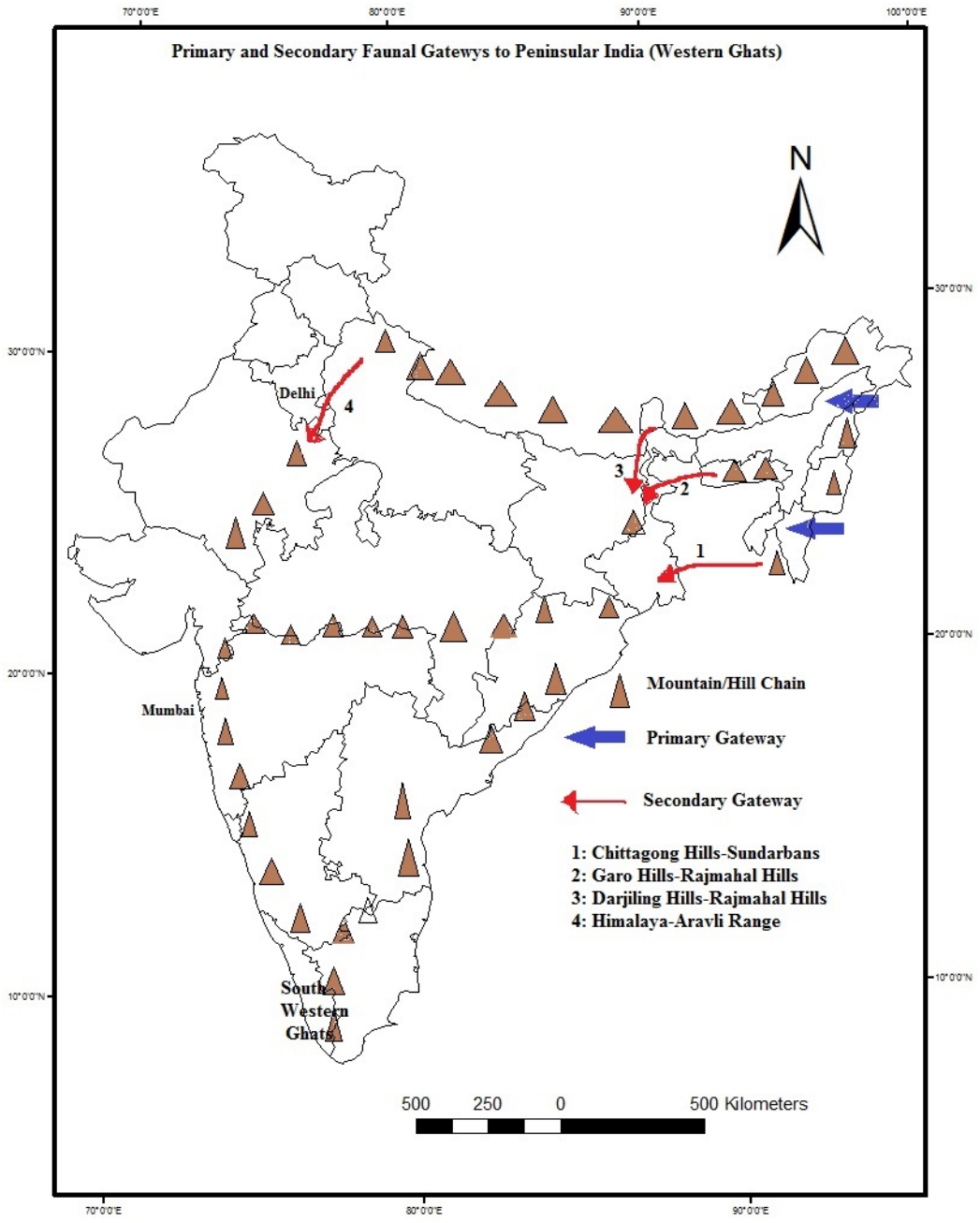


Fig.6.5: Primary and Secondary faunal gateways to peninsular India.

1. Chittagong hills-Sundarbans gateway:

This gateway runs along the southern coast of Bangladesh. The Chittagong hills in the east are the only hilly part of Bangladesh. It adjoins Myanmar & India. In the recent past the area was heavily forested, though only a part remains. The rest is brought under cultivation. On the other side of this route is the Sundarbans, the largest

delta & mangrove forest in the world. The present gap (open area without forest) between the Chittagong hill tract and the Sundarbans is around 250 km., most of which is under paddy cultivation and is densely populated. Most of the Sudarbans delta is under mangrove forest. The delta is of late Pleistocene origin and the vegetation is around 20000 years old. The evidence suggests that the delta was larger in extent in the past. It is possible that during the late Pleistocene, when the humid period was on & the rainfall was higher, the whole gap supported humid forest from the Chittagong hills across to the Sundarbans. The Sundarban National Park has 248 species of birds found today, one third of them are forest species. (Green pigeons/Indian scimitar babbler/ Flowerpeckers/ Sunbirds/ Babblers/ Bulbuls etc.).The Park also supports such forest animals as tiger, Axis deer, Barking deer, Wild boar etc.(De,1990) The distributional ranges of many forest birds from the region show that at least 15 species may have used this gateway to enter the Indian subcontinent. **This is for the first time that this gateway has been identified as an entry corridor.**

2. Garo Hill-Rajmahal hill gateway:

This is the well-known Garo-Rajmahal gap made famous by the Satpura hypothesis.Dr.Hora imagined a hill ridge in this gap. It was via this imaginative hill ridge that his Malayan hill stream fishes dispersed from Assam into the Peninsula to follow the Satpura range later to reach the Western Ghats. Geological evidences suggest that we never had any ridge here. The present gap is around 240 km. wide and has been made by the Ganga & Brahmaputra Rivers, which presently flow through it. At present there are the Garo hills to the east of the gap. The Garo hills are the easternmost extension of the Shillong plateau with average height of 600 m, though several peaks are above 1500 m. The region is covered with dense tropical forest. (Das, et. al. 1995).The Rajmahal hill across the gap is the north-eastern extension of the Chotanagpur plateau. It almost touches river Ganga. With average height of 330-450 m ,and some peaks rising above 500 m.(Singh,1995). Though the area today support dry deciduous forest with occasional moist stands of the Sal forest, in every likelihood the region supported moist forest during the late Pleistocene when the climate was humid. The Gap,in all probability, was also covered with humid forest during the Late Pleistocene, providing a perfect corridor for migration for birds. Because of the excessive attention & emphasize given to this Gap in the Satpura Hypothesis, the general impression is that this must be the prime route of migration

for all the fauna entering the Peninsula from Assam. The present study shows that only two species of birds-Lineated barbet & Alexandrine parakeet show a continuous distribution across the Gap. It seems that most birds have avoided this Gap as a corridor for entering the Peninsula. Presently 82 species of forest birds show very interesting distributional ranges. The Himalayan ranges in the Far East bend towards south with an acute angle and form a series of hill ranges. While one branch goes southward through Nagaland, Manipur to Mizoram, another range branches off towards the west into Meghalaya to form Mikir, Khansi, Jaintiya & Garo hills. Many forest birds which are found in the main Himalayan range are also found in these branched off hills. Their distributional ranges are therefore shaped by the hills they are found in.(Map) Eighty two species ,which are found in the Himalayas ,are also found in the Mikir-Garo hills complex. They are distributed in such a way that their distribution ranges end at the western tip of the Garo hills. It is interesting to note that most of these species are also found in the Darjiling hills across the Assam valley. Why only two bird species have crossed the Garo-Rajmahal gap, and why remaining 82 species have not crossed it is difficult to answer. Instead of using the Gap, they have preferred the main Hiamalayan range to disperse towards the west. This clearly shows that the Garo-Rajmahal gap is not at all the preferred highway of dispersal at least not for birds.

3. **Darjiling-Rajmahal hills gateway:**

Darjiling is part of the Sikkim Himalaya and is located at a height of about 2000 m. Rajmahal is to its south at a distance of 180 km across the Gap. The foothill region here, lying as it is, below 1000 m. is called the Duars & is under dense tropical evergreen forest (Bose, 1979). Six present species show distributional ranges across this gap. This seems to be a more preferred crossing for birds than the previous one.

4. **The Himalayan Range:**

This is the main route of dispersal of birds from the north-east to the north-west into Nepal, Uttarakhand, Himachal Pradesh, Jammu & Kashmir etc. About 160 bird species, starting from the north-east have their distributional range all along the Himalayas. But only two species (of bush quails) have used the Himalayan-Aravali corridor to penetrate into the west & south of India. The importance of this route for the Western Ghats as a whole & for the study area in particular is not much.

Importance of the gateways:

It is possible to arrive at the relative importance of these gateways on the basis of the number of bird species having their present distribution across these gateways. We have dropped the Himalayan gateway for the obvious reason. An interesting fact is that 13 species have used multiples routes/gates for entering into the Peninsula. Five of these have used all the three routes, whereas the remaining seven have used two routes.

Table 6.8: Relative Importance of Secondary Gateways

Gateway/Route	No. of species with cross distribution	% of species
Chittagong-Sundarbans	15	41.66
Garo hill-Rajmahal hill	02	5.55
Darjeeling hill-Rajmahal hill	06	16.66
Multiple routes	13	36.11

From the above data it is clear that the Chittagong-Sundarban route is likely to be the most preferred route of entry (41.66%), followed by the Darjeeling Rajmahal route (16.66%). The Garo-Rajmahal seems to be the least preferred route (5.55%) of entry. It is quite logical that 36.11% bird species may have used multiple routes to enter the Peninsula. Among the multiple route users, four species have used the Sundarban route, three have used Darjeeling-Rajmahal route whereas only two have used the Garo-Rajmahal route. This more or less agrees with the individual routes result.

6.6.2 Peninsular Highways of dispersal

A lot has been written about the possible corridors of dispersal /dispersal pathways.within the Peninsula. So far researchers have identified four corridors:

1. Satpura (Hora,1949)
2. Eastern Ghats (Ripley 1959)
3. Aravali (Abdulali 1949)
4. Braj (Digler 1952, in Karanth 2003)

According to the present work

a. There may be a few more corridors than mentioned earlier.
b. All the previous theories of dispersal have emphasized only mountain chains/hill ranges/highlands as the corridor of dispersal.According to the

present work, not only mountains/hill ridges but forest corridors & river basins have also played equally important role in dispersing the avifauna of the Peninsula.

c. It is possible that a single species has used more than one route for dispersal.
d. The drier Deccan plateau region has always acted as the main barrier of dispersal for the incoming species and forced them to move towards the more favorable Satpura and Eastern Ghats routes.

There seems to be five main corridors of dispersal **(Fig.6.6):**

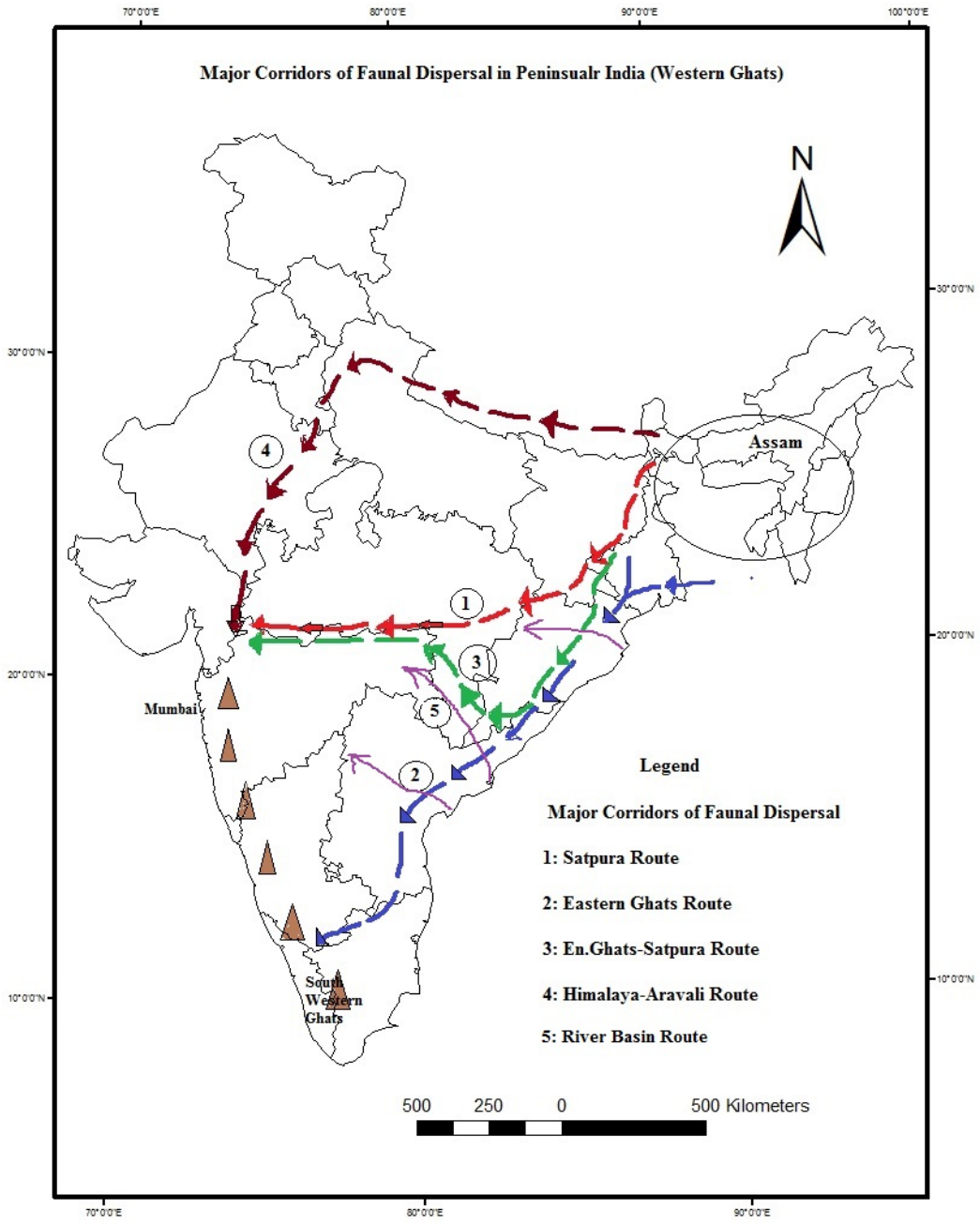
1. Rajmahal hills-Chotanagpur plateau-Maikal range-Satpura-Vindhya ranges-W.Ghats
2. Rajmahal hills-Chotanagpur plateau-Badam Pahar-En.Ghats-Nilgiri mountain-Wn.Ghats.
3. Rajmahal hills-Chotanagpur plateau-En Ghats-Bastar hills-Maikal range-Satpura-Wn.Ghats.
4. Himalayan range-Aravali hills-Malwa plateau-Satpura-Wn.Ghats.
5. Peninsular river basins route

1. Rajmahal hills-Chotanagpur plateau-Maikal range-Satpura-Vindhya ranges-W. Ghats:

This is the well-known Satpura highway of Dr. Hora. In all 59 species apparently show disjunct distributional pattern. The distributional ranges of these species were studied further to identify the dispersal routes. Only six species show that they have most likely used the Satpura highway for dispersal. In fact the process of westward dispersal is still going on as is evidenced in case of the Malabar pied hornbill (Wagh et.al, 2011). These species are generally distributed with two distributional arms, one along the Western Ghats, and the other along the Satpura range, a clear cut indication that they may have used the Satpura highway for westward dispersal.

2. Rajmahal hills-Chotanagpur plateau-Badam Pahar-En.Ghats-Nilgiri mountain-W. Ghats:

This is the Eastern Ghats highway of Dillon Ripley. This seems to be the most favorable route of dispersal. Sixteen species may have used this highway for reaching the Western Ghats. Out of these sixteen species, seven are confined to central and southern Western Ghats, 5 have isolated



populations in Eastern Ghats and the remaining have clear cut Eastern Ghats-Nilgiri-Western Ghats distribution.

Fig. 6.6: Major corridors (routes) of faunal dispersal in peninsular India

3. **Rajmahal hills-Chotanagpur plateau-En Ghats-Bastar hills-Maikal range-Satpura-W. Ghats:**

This route is suggested for the first time. These species follow the Eastern Ghats till about the Vishakhapatnam-Koraput highland and then turn northwards through the Bastar-Chhattisgarh hills till they reach the Maikal-Satpura ranges. Here the distribution moves westward till the Western Ghats is reached. Sometimes instead of continuous distribution the species have isolated population along the route, an evidence of its once continuous range. In all 12 species may have used this totally new route of dispersal.

4. **Himalaya-Aravali route:**

This route radiates out from the Himalayas around Uttarakhand and moves towards Delhi across Ganga & Yamuna –a gap of 200km.It then follows the trend of Aravali till the Panch Mahals-west Malwa plateau to reach Satpura-Western Ghats.Only four species –Jungle and Rock Bushquails, Pericrocotus minivet and Great tit may have taken this route.

5. **Peninsular river basins route:**

Another new route is being suggested here. Distributional ranges of some species have the Eastern Ghats as their main base of distribution. The range moves inland from the Eastern Ghats as the base. If the ranges of distribution of these species are superimposed in the basins of Mahanadi, Godavari & Krishna, it appears that the birds have moved inland by following the rivers and their tributaries. The middle & upper basins of Mahanadi & the middle basin of the Godavari are already densely forested. In case of intermittent open patches stream-side vegetation may have been used to disperse inland. At least four species may have moved inland from the baseline of Eastern Ghats using river courses /river basins as dispersal routes. These are 1) Ashy Wood swallow 2) Scarlet minivet 3) Spangled drongo & 4) White-rumped shama.Ripley and Beehler (1990) found range boundaries of birds 20 species associated with major river systems in India.

Twin route users:

There are 16 species, which in all probability may have used both, the Satpura & the Eastern Ghats routes to reach the Western Ghats. We can call them ‘twin routers’. Five species among the twin routers have such a

distribution that their ranges are cut short in central India. In other words they have not reached the Western Ghats yet.

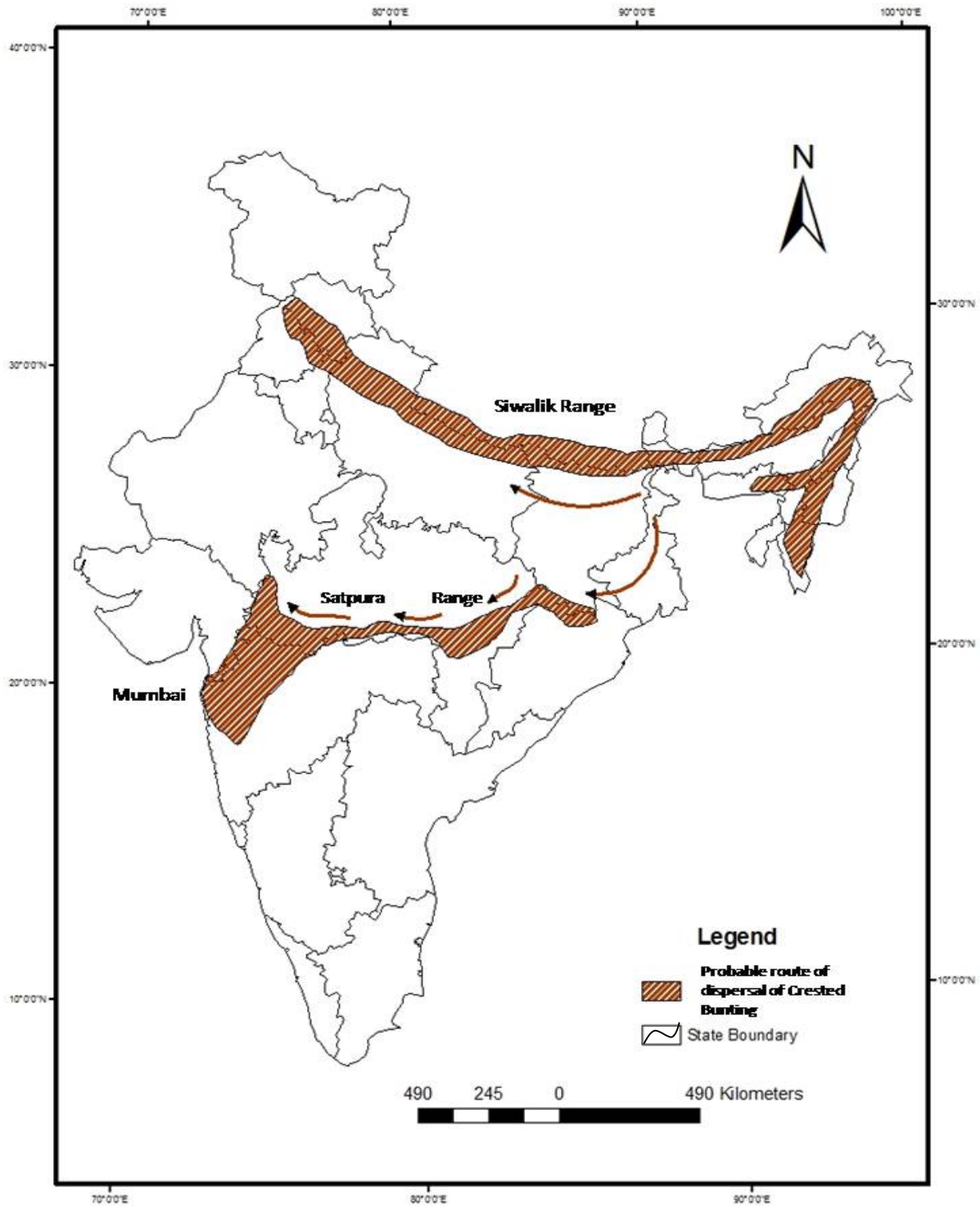


Fig. 6.7: Satpura route of dispersal, probably used by Crested Bunting

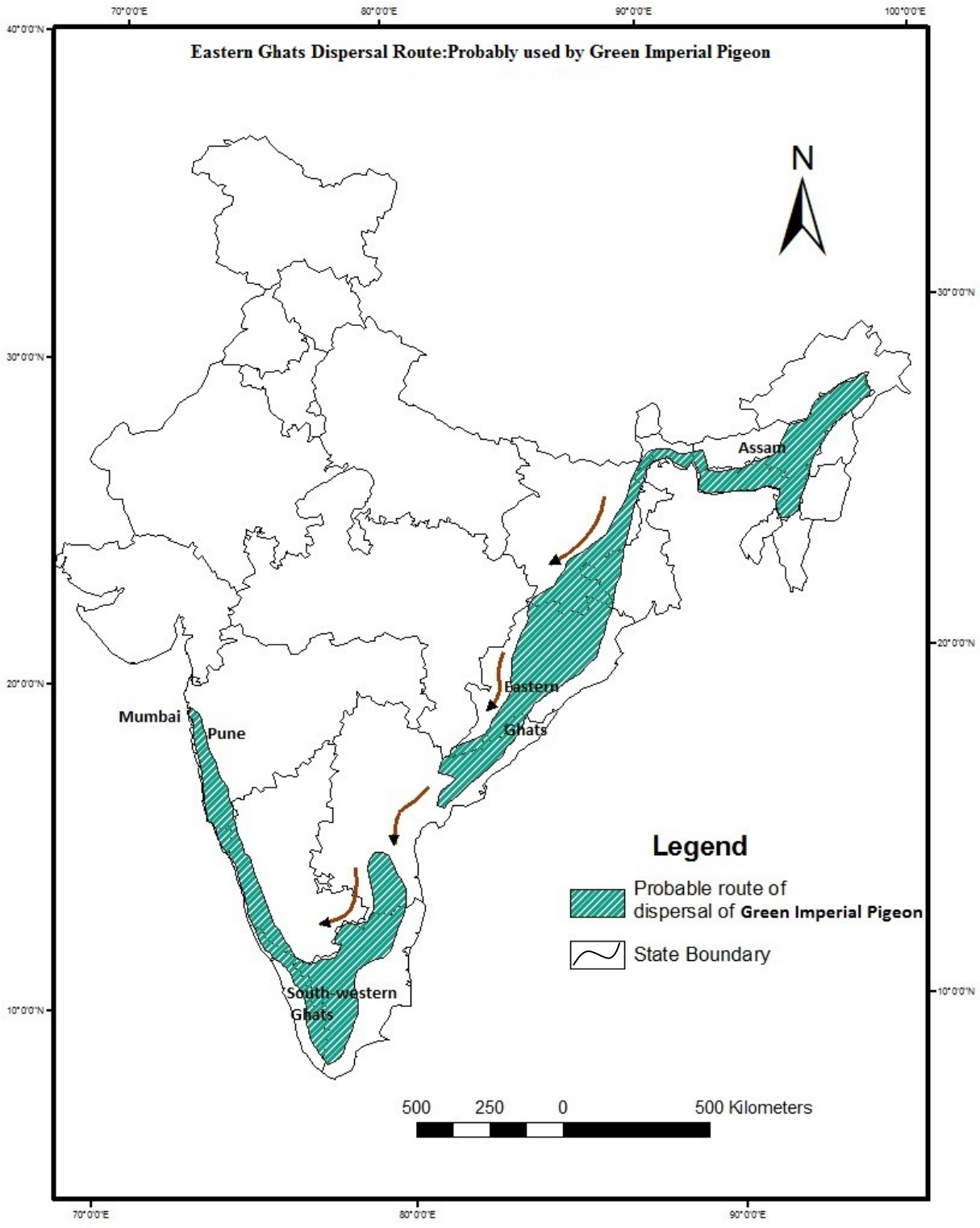


Fig.6.8: Eastern Ghats dispersal route-probably used by Green imperial pigeon

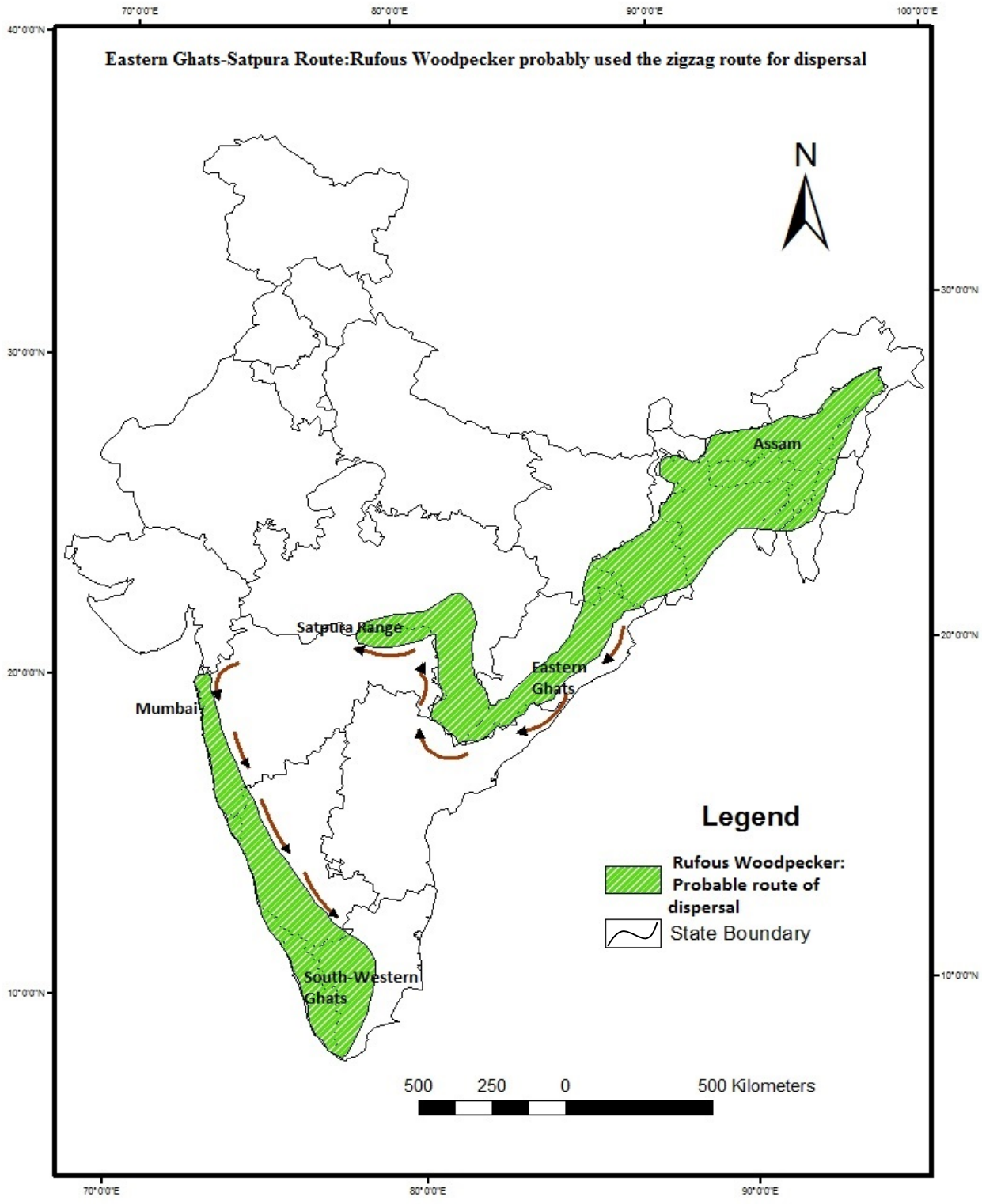


Fig.6.9: En.Ghats-Satpura route:-Popbably used by Rufous woodpecker

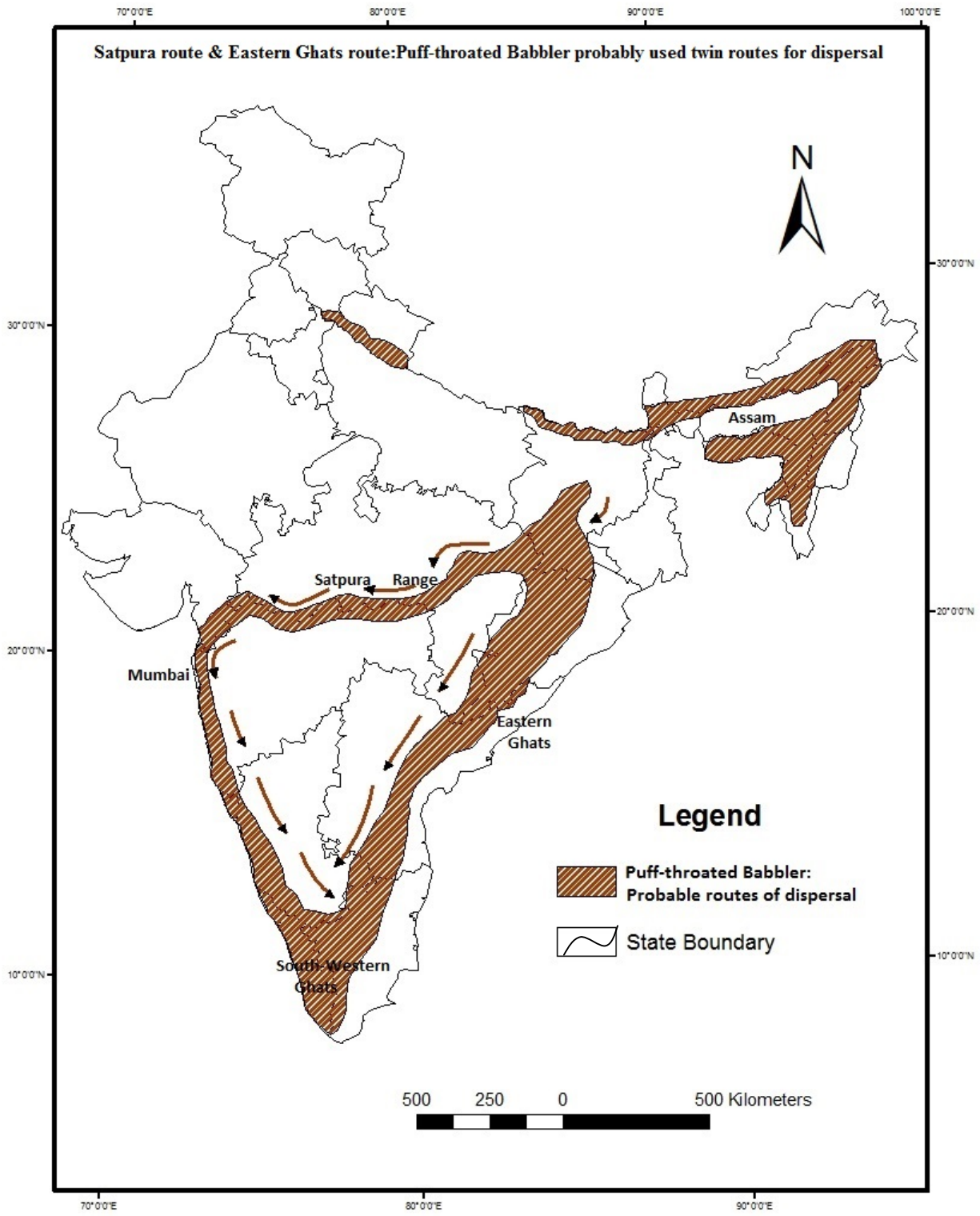


Fig.6.10: Puff-throated babbler-probably used two routes (Satpura & En.Ghats) for dispersal.

Use of multiple routes by one species:

It seems that some bird genera have used more than one route to reach the Western Ghats. Dendrocitta species (Treepies) and Pycnonotus species (Bulbuls) have probably used all the four routes for dispersal.

Uncertainty about routes of some species:

Some bird species show true disjunct distribution. These are 1) Great hornbill 2) Black bulbul 3) White-bellied blue flycatchers 4) Frogmouth species & 5) Asian fairy bluebird. The main problem with these species is that they do not have isolated populations anywhere in the intervening region.

Their distributional ranges along the Western Ghats are such that both ends of their range are equidistant from the source region (Here the north-east India).In other words whether they followed the Satpura route or the Eastern Ghats route; they had to cover the same distance.

6.6.3 Highway comparison:

Comparison of different dispersal highways mentioned above throws light on the relative importance of the highways. It was realized that 59 species show more or less disjunct distribution.

Which is the most popular highway of dispersal?

Table: 6.9: Different Dispersal highways and Possible Bird users

Dispersal Highway	No. of species who may have used the route.	% Users
Satpura	06	10.16
Eastern Ghats	16	27.11
E. Ghats-Satpura	12	20.33
Aravali	04	6.78
Twin Highways	16	27.11
Uncertain status	05	8.47

Of the 59 species which show partial or complete trend of disjunct distribution, 16 species seem to have used the Eastern Ghats as dispersal highway to reach the Western Ghats and/or South India. With 27.11% share the Eastern Ghats

obviously is the most favorable single dispersal route for birds with Indo-Chinese/Malayan affinities to reach the Western Ghats/South India. The next most favorable routes are the Eastern Ghats-Satpura (20.33%), the Satpura (10.16%) and the Aravli route (6.78%). Another interesting point is that 16 species (27.11%), same as those which used the Eastern Ghats, probably used two routes the Eastern Ghats and the Satpura to reach the south of India. If we go by the sheer number of species, using these highways, 44 species have (fully or partly) used the Eastern Ghats highway, whereas 34 species have used the Satpura highway.

6.6.4 Conclusion:

1. The Eastern Ghats seems to be the most preferred dispersal highway by birds of Indo-Chinese/Malayan affinity.
2. The Satpura highway is the next preferred dispersal highway after the Eastern Ghats.
3. A quarter of the species seem to have used two routes for dispersal.
4. A few species are likely to have used more than two routes for dispersal.
5. The Aravali seems to be the least preferred dispersal highway.

Chapter 7:
Patterns of Distribution

7.1 Introduction:

Biogeography not only gives a description of the species distribution, but also a geographical explanation for the distribution of particular species. If all the spots where an animal is seen are marked on a map, we get its range of distribution. Every range of distribution has a certain pattern which can be best described on the basis of geometrical shapes. Clustered, fragmented, elongated are just some examples. While writing about these distributional patterns, Darlington (1957) raises three questions:

1. What is the main pattern of animal distribution?
2. How has this pattern been formed?
3. Why has the pattern been formed?

The present patterns are the product of the evolutionary history of the region and the species, proximity to the centre of dispersal, arrangement of barriers and migratory routes, location of the region, climate, & human impact. **Most distribution patterns used here for analysis are based on Grimmett et. al. (2011)**

7.2 Patterns of Distribution:

The major patterns of distribution identified for the study area are:

1. Continuous:
2. Nucleated/Clustered/clumped:
3. Elongated/Linear
4. Fragmented/Scattered/Dispersed
5. Disjunct/Discontinuous
6. Narrow endemic
7. Perforated
8. Spreading or Expanding
9. Reducing
10. Allopatric
11. Sympatric
12. Parapatric

1. Continuous distribution:

Continuous means connected or unbroken or uninterrupted. A species with continuous distribution has continuous range of distribution without any gap in its range. The area of study is divided into 81 grids of size 10 km x 10 km. If a species is reported in each & every grid, it is said to have continuous distribution. The possible reasons for continuous distribution are:

1. The species may be relatively common
2. The species may be abundant,
3. The species may be evenly distributed.
4. The species is likely to have wider tolerance range, so that it occupies different habitats across the range.

In all 129 species show continuous distribution pattern, out of which 33 species are winter migratory. **(Fig.7.1)**

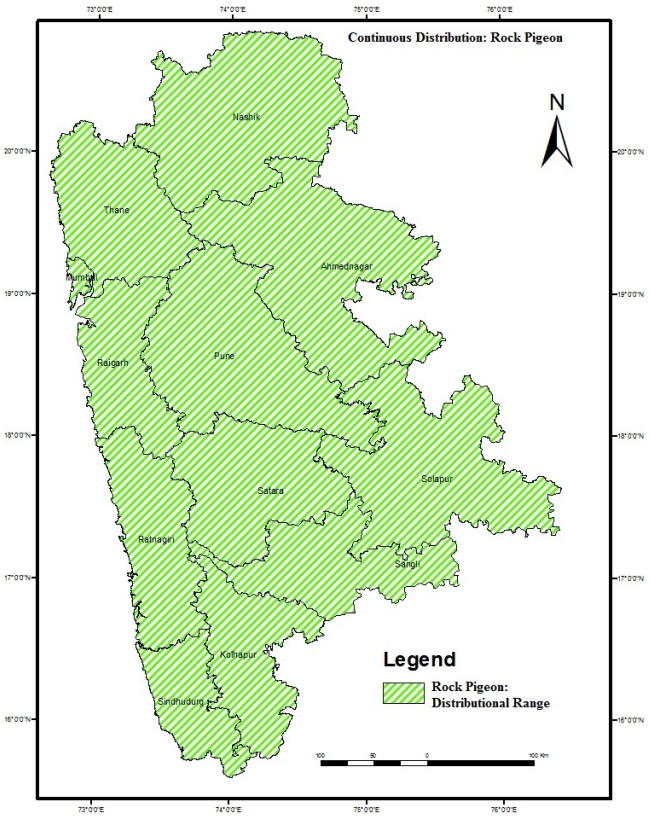


Fig.7.1: Continuous distribution pattern- Rock Pigeon

2. Clumped distribution:

Clumped distribution is also called as nucleated or clustered distribution. It is one of the most common types of distribution found in nature. In this type, the individuals of a species are packed together. In other words the distance between neighboring individuals is minimal. Individuals are closer together than they would be if they were randomly or evenly distributed. **(Fig.7.2)**

Reasons for clumped distribution are:

a) Clustered distribution of food, water, shelter and other resources.

Some resources, on which the birds depend upon, become scarce during certain seasons, thereby forcing birds to clump around the scarce resources. The most well-known example is that of aquatic birds. At the height of summer, when most water bodies are dried up, remaining few water bodies attract large number of water birds. Heronries in Konkan show clumped pattern. Monsoon is the breeding season for most of herons and egrets. The heronries are found clustered around creeks, lakes and paddy fields. There can be hundreds of herons and egrets in a locality centered on a heronry, whereas on the Deccan plateau, one does not find a single heronry for scores of kilometers.

b) Communally roosting and nesting birds show clumped distribution. Besides, the herons and egrets, crows, mynas and parakeets which otherwise have continuous distribution, many times show clustered pattern around food resources such as garbage dumps. Many times House crows build a number of nests in a single tree. Such a tree with crow nests is called rookery.

c) Flocking behavior: -Individuals might be clustered together in an area due to social factors such as family groups. Crows, mynas, pigeons, kites, house sparrows and parakeets show flocking behavior.

d) Security and protection: Clumping together is a possible strategy for protection to avoid predators.Clustering of rock pigeons and house sparrows is most probably for confusing predators like shikra (*Accipiter badius*) and Eurasian sparrow hawk (*A.nisus*).

e) Literally tens of thousands of water birds, belonging to 100+ species visit us every winter. They generally start arriving in August-September and leave by March. During their stay here they congregate in and around water bodies-river courses, lakes and reservoirs, ponds, and other wetlands. Some local migratory birds also augment the population by migrating from less favorable areas to more favorable areas (like the water bodies around Pune). Pune-Solapur highway has more than a dozen prominent water bodies, which attract thousands of aquatic birds and waders during the winter season. This is nothing but clumping of wintering birds around the water bodies. The following table presents data about density of water birds, as indication of clumping, during winter and summer months at four water bodies around Pune between 2001 & 2005.

Table 7.1: Seasonal clumping of Water Birds at four water bodies around Pune (2001-2005)

Water body	**No. of water bird species (Winter) @**	**Bird density per Ha. (Winter)**	**No. of water bird species (Summer) $**	**Bird density per Ha. (Summer)**
Mula-Mutha (river course)	28	47.16	14	2.35
Kavadi (river course)	40	51.55	18	5.05
Pashan (reservoir)	29	39.8	12	4.83
Matoba (reservoir)	46	22.62	11	2.67

@ : December and January *$: April and May*

Species diversity ratio and winter-summer population ratio further corroborates the clumping behavior of birds at certain localities during certain season/s. Both the ratios are calculated as-

Species diversity ratio SDR= Number of species seen during winter season/ Number of species seen during summer season

Winter-summer population ratio (WSPR) = Total winter population count / Total summer population count

Table 7.2: Species diversity ratio (SDR) and Winter-summer population ratio (WSPR)

Waterbody	Species diversity ratio (SDR)	Winter-summer Population ratio (WSPR)
Mula-Mutha bird sanctuary	2.00	20.01
Kavadi (river stretch)	2.22	10.19
Pashan lake	2.42	8.23
Matoba lake	4.18	5.58
Varvand lake	2.63	5.12
Shindavane lake	3.14	6.41
Ujani backwater	2.00	NA
Average	2.65	9.25

During winter months, the water bodies are full of water birds, waterfowls and waders. The species diversity is also very high. The average Species diversity ratio (SDR) between the winter and summer months is 2.65,that is, the winter bird diversity of the water bodies is 2.65 times higher to the summer water bird diversity. The SDR ranges from 2.00 (Mula-Mutha bird sanctuary) to 4.18 (Matoba lake).

The average Winter-summer population ratio (WSPR) is 9.25, that is, the winter bird population is 9.25 times higher to the summer bird population. The WSPR ranges from 5.12 (Varvand lake) to 20.01 (Mula-Mutha bird sanctuary). The figures are enough to explain the clumping of wintering birds

3. Elongated distribution:

Also called as linear distribution, the range of distribution is long and narrow. For a distribution to be called elongated, the length of the range has to be 5 to 6 times the width. The major reason for elongated distribution is that the species is confined along an elongated physical feature-a mountain range, a river course, a coastline, a forest patch etc. That makes the range of concerned species elongated. There are 97 species within the study area which show this pattern of distribution. There are two sub-patterns: (i) Broadly elongated and (ii) Narrowly elongated or linear.

The birds with broadly elongated sub-pattern are found in Konkan as well as in the Ghats country. The average width of range in this case is about 65 to 125 km. In all 48 species show such a pattern. These species are relatively tolerant and are found

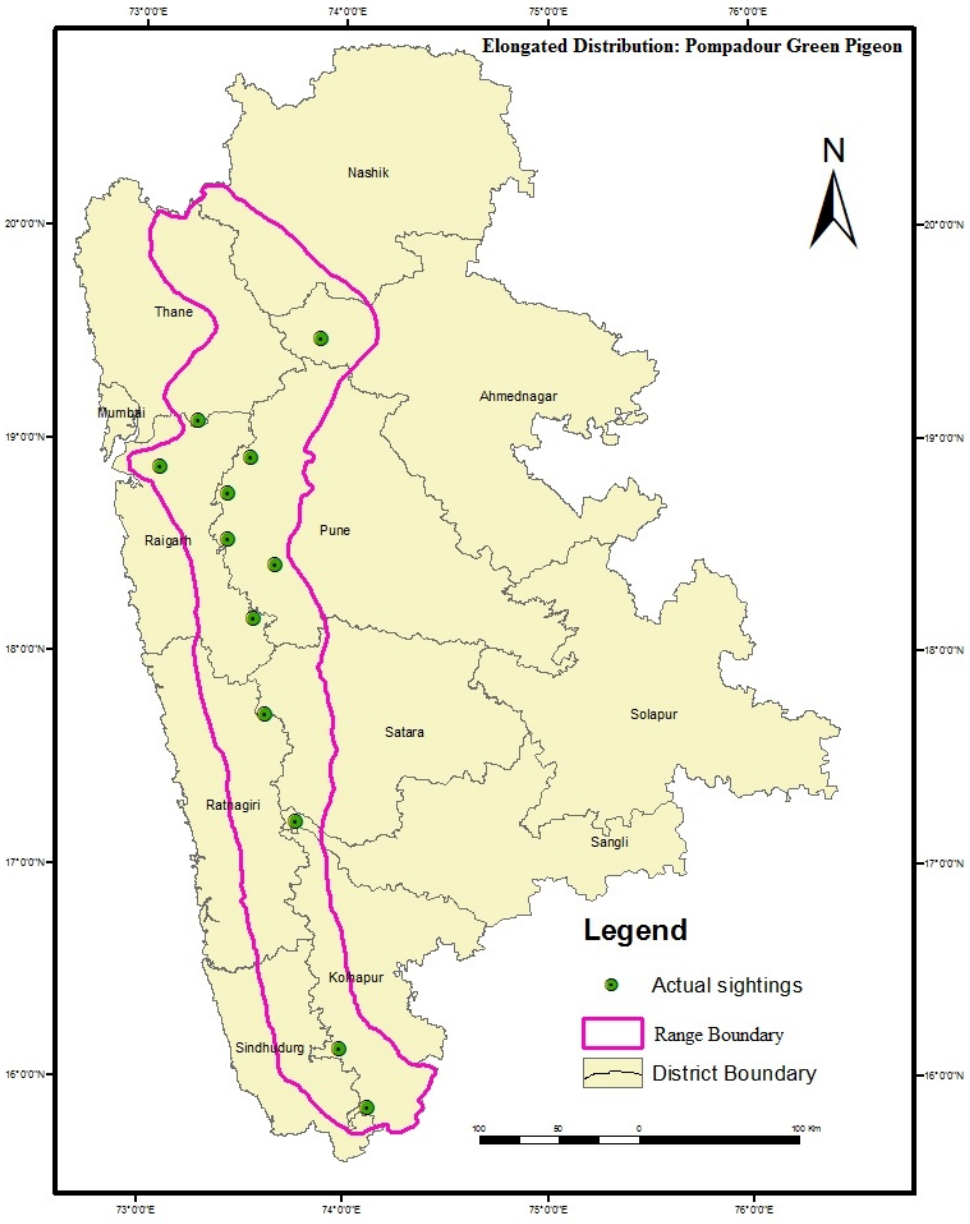


Fig.7.3: Elongated distribution pattern: Pompadour green pigeon.

in evergreen, semi-evergreen, moist deciduous and plantation forest. Some prominent species with this distributional pattern are: Malabar grey, Malabar pied and great pied hornbills, Malabar lark, Black bulbul, Jungle myna, White-rumped shama, Asian fairy bluebird, Indian scimitar babbler and Forest wagtail etc.(The last species is winter migratory. There are 7 species which are winter migratory and show broadly elongated pattern).

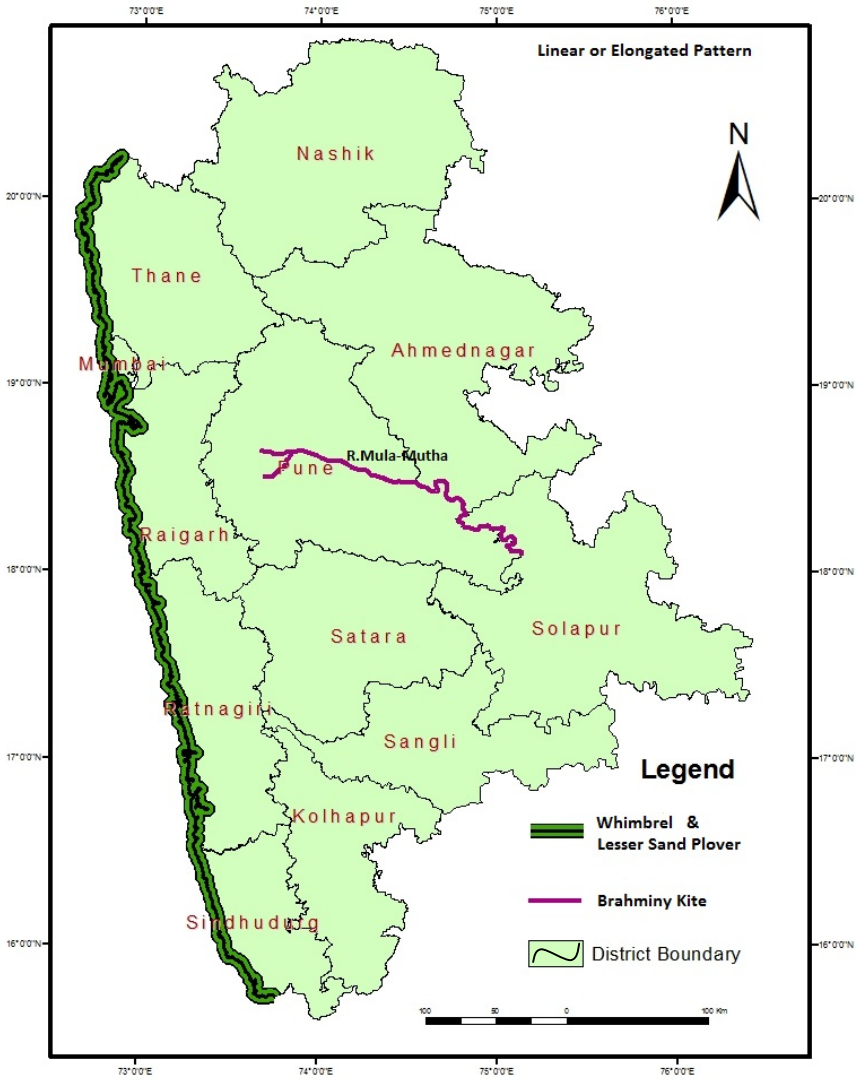


Fig.7.4: Linear distribution pattern: Whimbrel, Lr. Sand plover & Brahminy kite.

Narrowly elongated distribution is the one where the birds are either confined only to the crestline of the Western Ghats or along the narrow belt of coastline. (Fig7.3 and 7.4) The average width of ranges in this case is only about 60 km. or less. On the map this distribution appears as a line, hence another name-linear distribution. There are 49 species which show narrowly elongated/linear distributional pattern. Out of which 29 are coastal species and are confined to a narrow shoreline area, another 20 species are moist forest species and are confined to the crest line forest of the Western Ghats, While most coastline species are winter migratory, most crest line

species are resident ones and narrowly tolerant, (Fig 7.1), hence their range is dictated by the narrow moist tropical forest belt running north to south all along the Ghats country.

4. Fragmented distribution:

A species is seen only in a few grids with its absence from intermediate grids. Its distribution appears patchy on map (Fig 7.1). It is in fragments, hence the name. In other words, its range is divided into separate pieces or patches. The reasons for such type of pattern is-

a) It is quite likely that the distribution was continuous in the past but has become fragmentary due to habitats loss (removal of continuous habitat) or due to changing environmental conditions. Great bustard once showed continuous distribution but its present distribution is fragmentary.
b) The favorable habitats are found in scattered manner. The larks found on lateritic flats show fragmented distribution because the flats themselves are found discontinuously. Fragmented distribution of water bodies or mango topes may be responsible for the fragmented distributional pattern of water birds and woodland birds respectively.
c) Food is found in fragmented manner.

Twelve species from the study area show fragmented pattern of distribution. Six of them are winter migratory. Some prominent resident species among them are: Black eagle, Chestnut-headed bee-eater, White-bellied woodpecker, White-bellied blue flycatcher, Black-bellied tern and Oriental pratincole. The Black eagle *(Ictinaetus malayensis*) is a beautiful deep blackish brown eagle, resident of hill forest. Its distribution is patchy and scattered. It is reported from Bhimashankar, Mahabaleshwar-Koyna, Khandala, Simhagad (Western Ghats), SGNP, Karnala, & Phansad (Konkan).The winter migratory birds with fragmentary distribution are: Northern goshawk, Black-naped oriole, Tawny pipit, Striolated bunting and Wood snipe.

It is difficult to explain as to why certain species show fragmentary distributional pattern in spite of their habitats found over a large, continuous region, for example, White-bellied blue flycatcher and Striolated bunting.(**Fig. 7.5)**

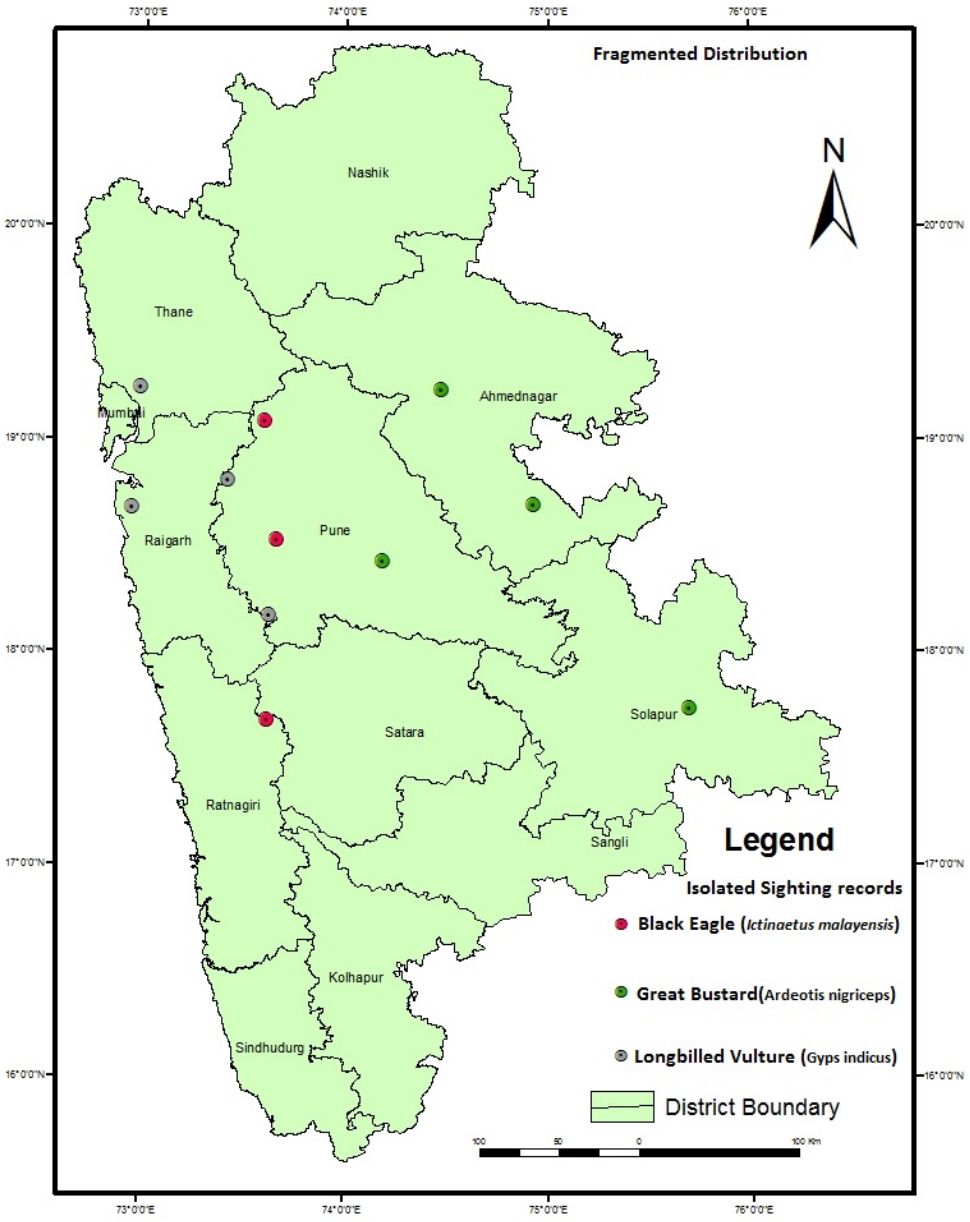


Fig.7.5: Fragmented distribution pattern-Black eagle, Great bustard & Longbilled vulture.

5. Disjunct/Discontinuous distribution:

A species is said to have disjunct distribution if it has two populations found in two pockets separated by a vast tract where the species is absent. There are 55 species in India, which show complete or partial disjunct distribution. The best examples are

the Great Hornbill and White-rumped shama. Disjunct distribution is already discussed at length in chapter 6. **(Fig.6.3)**

6. Narrowly restricted:

To quote Robinson (1972), the narrow endemic species are those, "which are very closely confined in their range, often to merely a few square miles and sometimes to but a few acres." Though he makes this remark for plants, it is applicable to animals also. In case of narrowly restricted species, the species may or may not be endemic, but have very narrow range of distribution.

Such species have such a limited tolerance range that, the most suitable conditions for them are found over a very small, limited area. The most prominent example of a narrow endemic from the study area is the Sri Lanka frogmouth (*Batrachostomus moniliger*).The bird has an overall disjunct distribution with one population confined to South-western Ghats and the other to Sri Lanka. This particular species is endemic to India. Its northernmost range along the Western Ghats was believed to be 'North Kanara' (Ali, 1984), but recently it has been found to be spreading northwards along the Western Ghats. In spite its spreading pattern (which is discussed under spreading distribution in detail) the present distribution of the bird can best be described as narrow endemic.

7. Perforated distribution:

Perforated distribution has a very interesting pattern. A species has a continuous distribution with perforations (gaps) in the middle of its distributional range. **(Fig 7.6).** We have only one species showing such a distribution-the Ashy-crowned sparrow- lark (*Eremopterix griseus*).The species is found on the either side of the main Western Ghats but avoids the crest-line of the Ghats country. The bird prefers open grass and scrub country and fallow lands around cultivation on the Deccan plateau, whereas across the Ghats in Konkan, it prefers low lateritic plateaus and dry tidal mudflats. It probably avoids the heavy rainfall narrow belt along the crest-line of the mountain giving it the perfect perforated pattern of distribution.

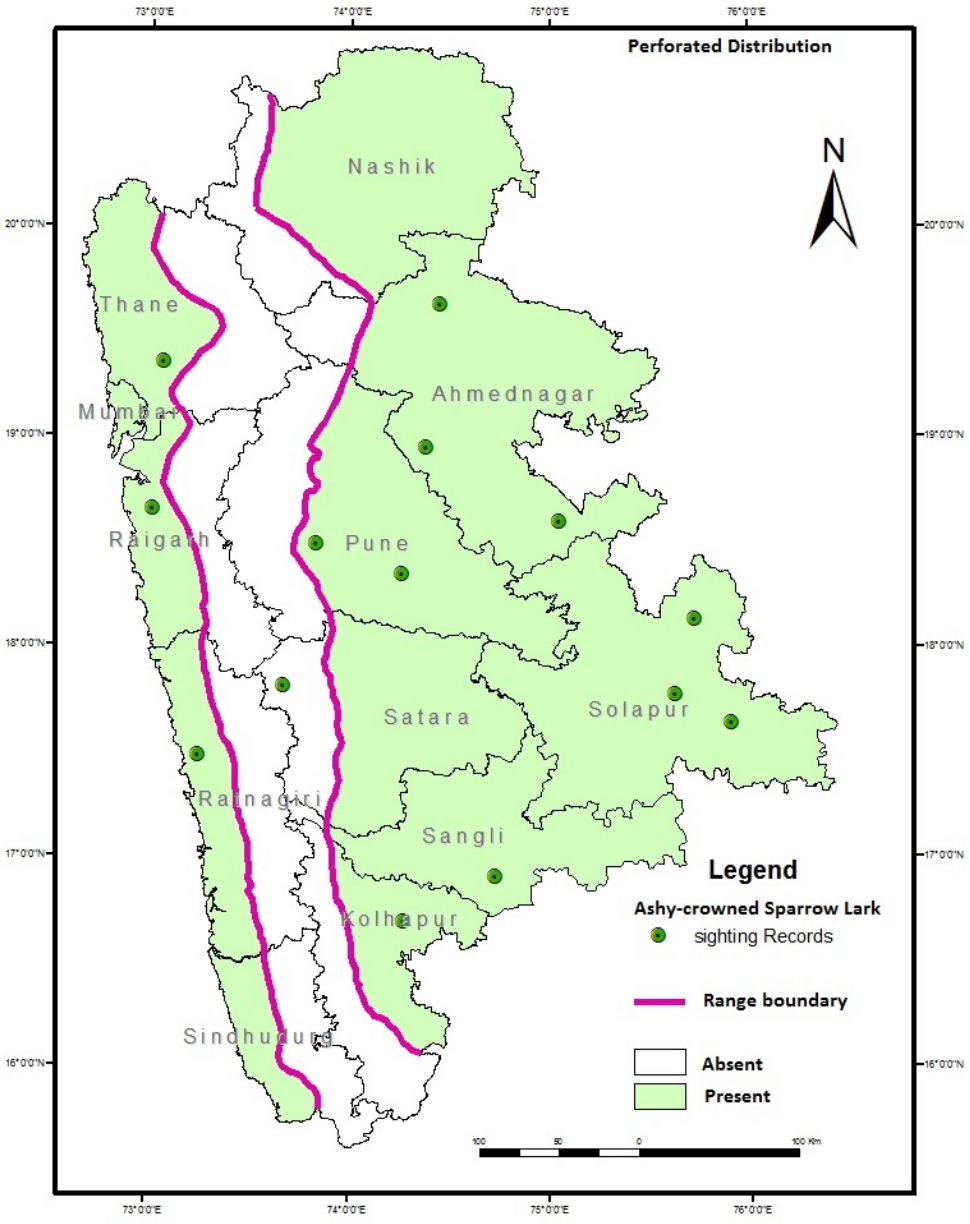


Fig.7.6: Perforated distribution pattern- Ashy-crowned sparrowlark.

Thebird is almost absent from the humid core of the Western Ghats, but is found on the either side of the crestline.

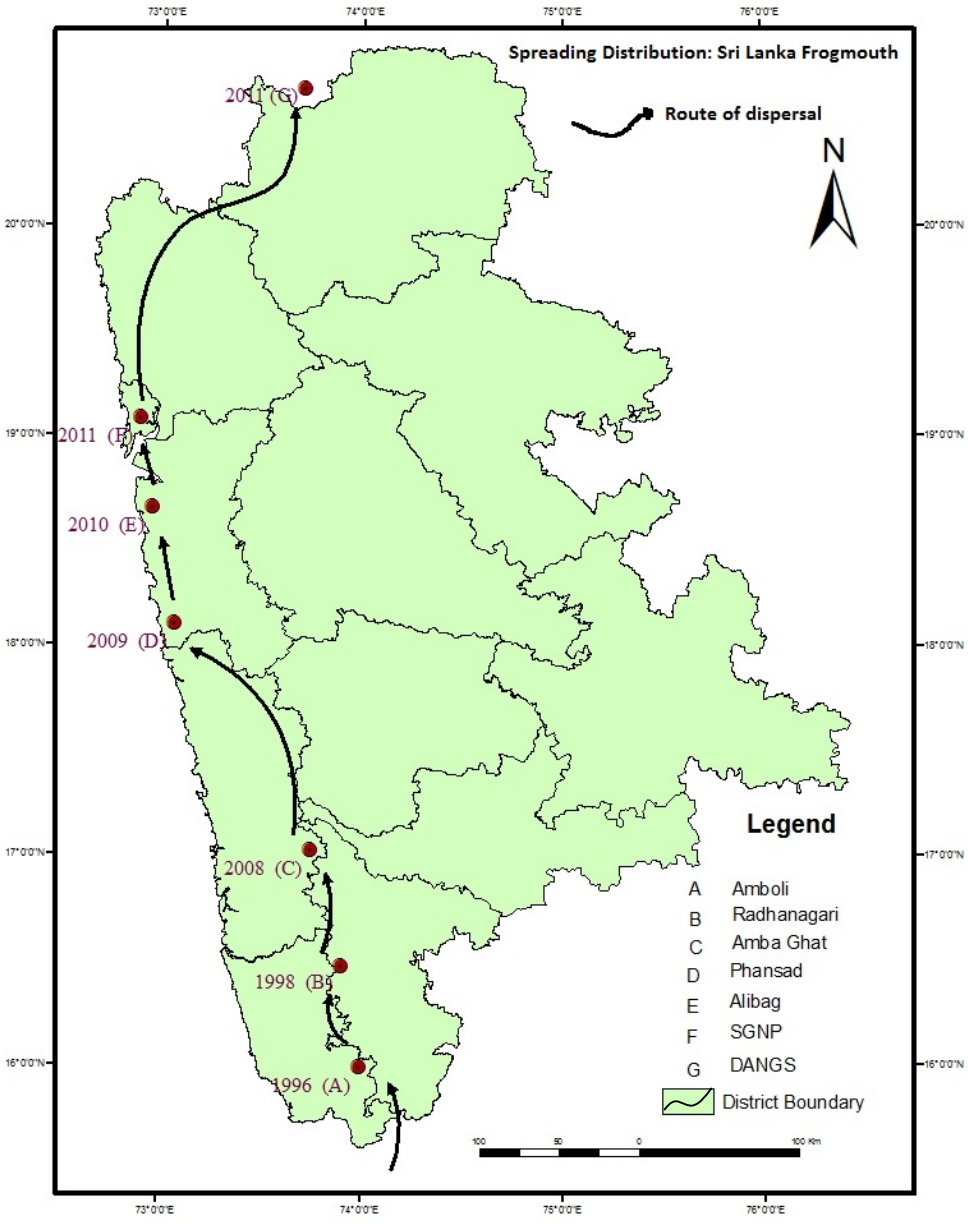


Fig.7.7: Spreading distribution pattern-Sri Lanka frogmouth.

8. Spreading or Expanding distribution:

Many species have wider ranges of tolerance and are found across many habitat types. Many of them are commensal to man and spread after him. Spreading happens in two ways.

a. The species spreads out from their parent (source) area to other adjoining regions.
b. The species spread out from the place where it is newly introduced most probably by humans.

In the first case we have two examples-the Sri Lanka frogmouth (*Batrachostomus moniliger*) and the Asian fairy bluebird (*Irena puella*). It seems both species are spreading northward along the Konkan-Sahyadri belt. The frogmouth was previously regarded as having its northern most range up to 'North Kanara' (presently Uttar Kannada) (Ali, 1984; Ali & Ripley, 1994). It seems that the species was not reported from Maharashtra till 1981 (Abdulali, 1981) or from Konkan till 1999 (Katdare & Pande, 1999).There are some recent records of its progressive sightings to the north of 'North Kanara'/Goa limit.

Table 7.3: Northward dispersal of Sri Lanka Frogmouth

Area/place of reporting	**Year of reporting**	**References ***
Amboli	1996	Purandare Kiran (Pers.com.)
Radhanagari	1998	Giri,2002
Amba ghat	2008	Giri,2009
Phansad	2009	Shivkar,2009
Alibag	2010	Vaibhav,2010
Sanjay Gandhi,Mumbai	2011	Kasambe,2011
Dang(Gujarat)	2011	Srivastava,2011

*birdsofbombay@yahoogroups.com

There seems to be a progressive dispersion of the species, Goa northward, during the last two decades. According some observers, the "extreme elusive behavior "of the bird has made it remain hidden from the bird watchers (Shivkar, 2009).Whether this is spreading or under-reporting?

Another species showing similar dispersal pattern is Asian fairy bluebird (*Irena puella*). This species was once regarded as having its northernmost limit up to Savantwadi (Vidal.1880) and Goa (Ali, 1984). Since then it has been regularly reported from many areas north of this limit.

Table 7.4: Northward dispersal of Asian fairy Bluebird

Area/place of reporting	1st Year of Reporting	References
Mahabaleshar	1981	Abdulali,1981
Bhimashankar	1988	Borges,1988
Vasota(Satara)	1998	Gole,1998
Raigad (No specific location)	1999	Katdare & Pande,1999
Phansad WLS	2000 ?	Monga,2006
Karnala	2006	Monga,2006

The bird was not included in the bird list of Karnala (Pandya, 1982; Kakodkar et. al., 2001).But there are frequent sighting records from the place since 2002.The fairy bluebird is not an elusive bird like the frogmouth. It is a diurnal myna-sized bird, lives in small flocks and quite noisy, hence easily seen/heard. So it does under recording can be ruled out. It is therefore clear that the bird has spread from Goa (its former limit) northwards up to Bhimashankar during the last 40 years. The straight line distance between Savantvadi-Goa borders to Bhimashankar is about 360 km. The rate of dispersal comes to about 9 km. per year.

The three other species showing spreading distribution pattern are Black Baza (*Aviceda leuphotes*), White-bellied blue flycatcher (*Cyornis pallipes*) and Indian grey hornbill (*Ocyceros birostris*).The Baza is a bird of evergreen forest and is largely confine to the South-Western Ghats (Ali, 1984).In the later years there have been isolated records of its occurrence from Goa (Dennis, 1999, www.wordtwitch.com), and Bhimashankar (Rane & Borges, 1987).

Till about 1950, Belgaum was regarded as the northernmost limit of the distributional range of White-bellied flycatcher (Ali, 1949). The first record north of this limit was reported from Bhimashankar (Ali, 1951).Since then many records have been reported from intermediate areas on regular basis.

Table 7.5: Dispersal of White-bellied blue flycatcher along the Western Ghats

Area/place of reporting	Year of reporting	Reference
Mahabaleshwar	1968 1983 1985	Pande et al.,1968 Ali & Ripley,1983 Abdulali,1985
Panshet	1988	Gole,1988
Matheran	1998	Gole,1998
Lonavla-Khandala	2002	KBSingh,2005*
Sinhagad	2002	AP (Pers.com.)*
Phansad WLS	2003	KBSingh,2005*
Koyna WLS	2003	VS,2003*
Tungareshwar WLS	2005	Yuva,2005*
Mahuli	2008	Pravin,2008*

*birdsofbombay@yahoogroups.com

It seems that the species has been slowly spreading northward along the Ghats country and Konkan.

B) There are two cases of introduced species spreading from the center where they were introduced/ escaped accidently. These are Asian Pied starling (*Gracupica contra*) and Alexandrine parakeet (*Psittacula eupatria*) whose cases already discussed at length in chapter 5.

9. Reducing Distribution:

The distributional ranges of many species have been shrinking. The present ranges of distribution are quite small compared to their previous distributions. The main cause of shrinking ranges is destruction, depletion and reduction in habitats. The main culprit is the human beings and their activities. The best example of shrinkage in range is the Great Indian bustard (*Ardeotis nigriceps*).This is a bird of dry grassland with low scrub. About 60 years ago the birds occupied a very large distributional range covering Rajastan, Haryana, West Uttar Pradesh, Gujarat, plateau Maharashtra and drier portions of Karnataka, A.P.& Tamil Nadu(Ali & Ripley,1987).Presently the bird is confined to a few protected patches across its former range. The same is the case in Maharashtra. Its former range (around 1930) in Maharashtra included 12 districts of western Maharashtra and Marathwada covering almost 60000 km^2. Its present range covers only five districts of Solapur, Ahmednagar, Nashik, Aurangabad and Pune, that too patchily.

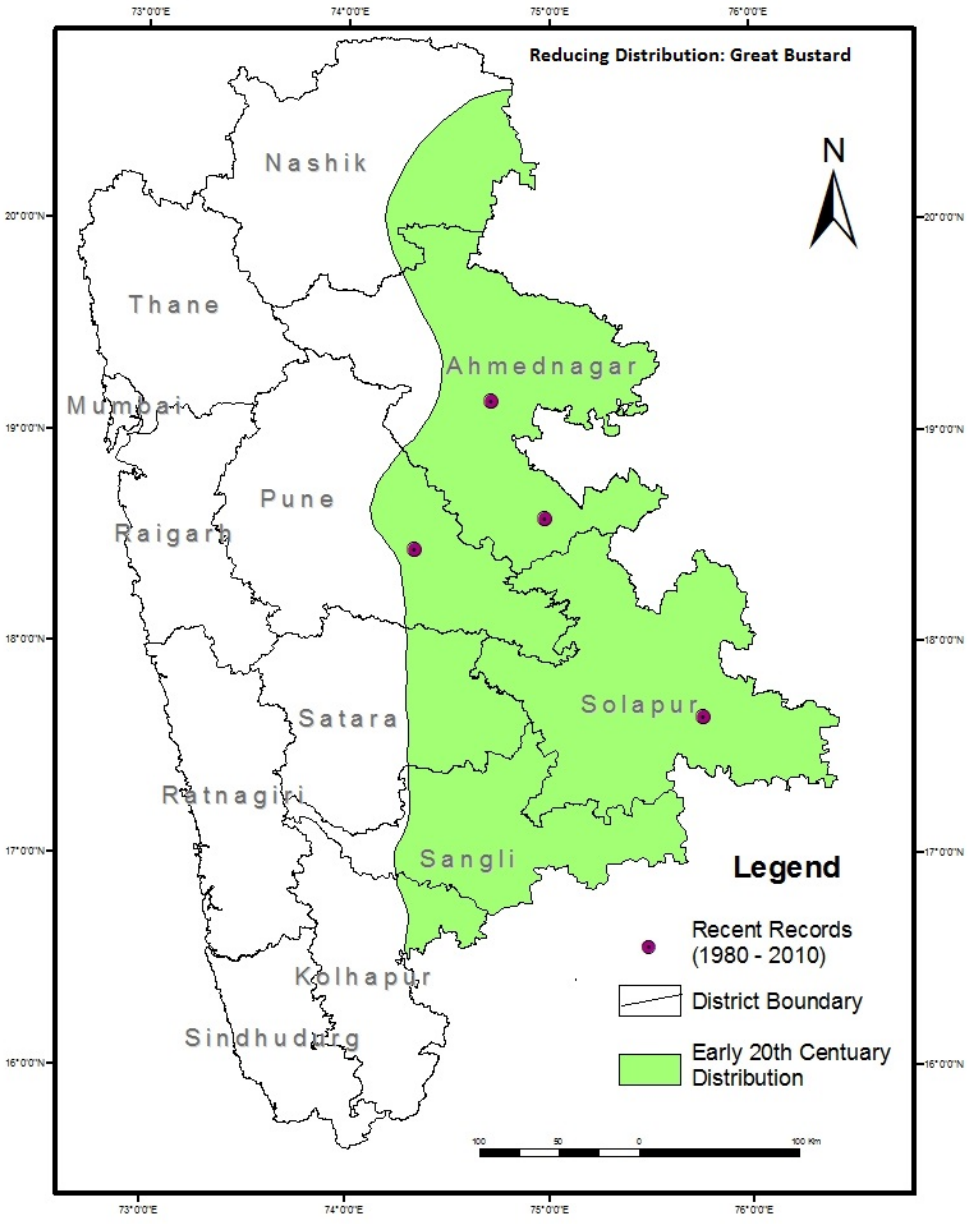


Fig.7.8: Reducing distribution pattern- Great Bustard

The extent of present range is just about 3000 km², which is mere 5% of its past range. **(Fig.7.8)** Most *Gyps* vultures are also showing reducing distributional trend.

10. Allopatric distribution: Allopatric (geographic) speciation occurs when biological populations of the same species become geographically isolated from each other, that there is no genetic interchange between them. In allopatric speciation, long-term geographical isolation generates reproductively isolated and spatially segregated descendant species. The major causes leading to allopatric speciation are-

a. Dispersal of population leading to separation.
b. Geological changes such as formation of mountain, island, rift valley etc. which act as barriers for dispersal.
c. Climatic changes such as drying up of climate in the intermediate regions.
d. Human activities which create man-made barriers through habitat destruction.

The separated populations over time may evolve into separate species. The species' ranges are entirely separate and they generally do not find together along the boundaries of their ranges. Such neighboring species are generally sister species, that is, they belong to the same genus. Allopatric isolation is a key factor in speciation and a common process by which new species arise. The only example of the allopatric distribution from the area is that of Indian Grey Hornbill (*Ocyceros birostris*) & Malabar Grey Hornbill (*Ocyceros griseus*).

Both the hornbills prefer open forest as their favorite habitat. The IGH is found over a large area covering almost the whole country, from Punjab to Kerala and from Gujarat to Bihar (Grimmet et al, 2011) and inhabits "lightly-wooded country with groves of ancient trees" whereas the MGH "affects open evergreen and moist deciduous forests abounding in *Ficus* trees" (Ali,1979) along the Western Ghats. Within the study area the IGH is found in SGNP, Thane, Ghats country and upper Deccan. The MGH is confined to the Konkan & Ghats country south of SGNP (Monga, 2003).There are few places where both the species are seen together. These include the SGNP, Karnala (Monga, 2001, Pers.comm.), Phansad (BK, 2002), Bhimashankar (Bradbeer, 1987), Khandala (Abdulali, 1952; Navarro, 1978), and Chiplun (Kanade, 1997).The sightings of IGH around Mumbai (since 1945) and north Konkan is a recent phenomenon (Prasad, 2003). It seems the bird is spreading in Konkan region also. The boundary that apparently separates the two species seems to be the Crestline of the Western Ghats.

11. Sympatric distribution:

Sympatric speciation is the process through which new species evolves from a single ancestral species while inhabiting the same geographic region. Species which are closely related, that is, they are sister species (means they belong to the same genus) and whose distributional ranges are identical or overlap to some extent are said to have sympatric distribution. A growing body of phylogenetic and experimental data suggests that closely related species often occur in sympatry (Doebeli & Dieckmann, 2003). It is interesting to note that there are within the study area, 43 cases involving 69 species which apparently show sympatric distribution pattern. Some prominent examples are: Jungle bush quail (*Perdicula asiatica*) and Rock bush quail (*P.argoondah*), Red spufowl (*Galloperdix spadicea*) and Painted spurfowl (*G.lunulata*), Redwattled lapwing (*Vanellus indicus*) and Wellow-wattled lapwing (V.malabaricus), Chestnut-bellied sandgrouse (*Pterocles exustus*) and Painted sandgrouse (*P.indicus*), Black drongo (*Dicrurus macrocerus*) and White-bellied drongo (*D.caerulescens*), Red-vented Bulbul (*Pycnonotus cafer*) and Red-whiskered Bulbul (*P.jocosus*), Rose-ringed parakeet (*Psittacula krameri*) and Alexandrine parakeet (*P.eupatria*), Indian nightjar (*Caprimulgus asiaticus*) and Savanna nightjar (*C.affinis*), Small minivet (*Pericrocotus cinnamomeus*) and White-bellied minivet (*P.erythropygius*), Jerdon's Leafbird (*Chloropsis jerdoni*) and Gold-fronted Leafbird (*C.aurifrons*), Purple-rumped sunbird (*Leptocoma zeylonica*) and Crimson-backed sunbird (*L.minima*), Scaly-breasted munia (*Lonchura punctulata*) and White-rumped munia (*L.striata*) etc**.**

12. Parapatric distribution:

In biogeography, **parapatry** is the relationship between two species whose ranges are touching each other and the ranges overlap marginally, that is, they only occur together in a narrow contact zone. This narrow contact zone may be the result of unequal dispersal, and porous physical barriers. Only one case in the study area shows this type of distribution-The Malabar lark (*Galerida malabarica*) and the Syke's lark (*G.deva*). The Malabar lark inhabits the Western Ghats and Konkan region whereas the Syke's lark is confined to semi-arid Deccan plateau. But both the species are found together at many localities along their boundary line with each other. They are found together in the Maval tract, which is a transition belt between the humid Ghats country and semi-arid Deccan region. The case of both the larks is discussed in detail in Chapter 5. (**Fig. 5.15)**

7.3 Comparison of distributional patterns:

A comparison of seven patterns for which definite data are available shows that continuous distribution is the most dominant pattern (47.60%), followed by elongated pattern (35.79%), Uncertain pattern (7.38%), Narrowly restricted (4.43%), Fragmented (4.43%) and Perforated (0.37%). The domination of continuous pattern shows that the proportion of species with wide tolerance is high in the avifauna of the region. A high proportion of species showing elongated pattern, indicates the role played by the coastline and the Western Ghats range, in dictating the distributional pattern. Both, the coastline and the Ghats range are north-south in orientation, are almost parallel and close to each other and more or less straight. Together they form an elongated territory, making the distributional range of any species confined to them showing elongated pattern.



PLATE 7.1: Malabar Lark, one of two lark species showing Parapatric distribution

Chapter 8:

Changing Status of Birds in the Study Area

8.1: Introduction:

One of the basic characteristic features of any environment is the 'change'. Every element of environment, physical as well as biological, every habitat, every region keeps on changing with time and location. The changing physical environment then influences the biological environment, including the flora and fauna of the region. Changes in flora and vegetation further affect the fauna including the avifauna. Birds are good indicators of environmental changes. General presence or absence of a species, rising or falling number of a species, sudden appearance or disappearance of a species, indicates some subtle change in the local and/or regional environment. The changes may be positive (increasing greenery) or negative (degradation of habitat). With the changing environment, bird species and their population also keeps on changing.

To realize that some changes in bird fauna have taken place, one needs to have some baseline data. Prediction of any change in bird fauna is not possible without availability of past data that is reliable and covers a long time span. Fortunately for the study area, many past bird records have been available. The data are spread over a reasonable wide time scale (1832 to the present), with frequent data available for certain pockets, like for example, Mumbai and Pune environs and the northern Western Ghats. The past records are mostly in the form of bird surveys done by British civil and military officers during the mid and late 19th century and the early 20th century. Another set of surveys is from 1930s through 1970s, when Dr. Salim Ali, the doyen of Indian ornithology, and Humayun Abdulali, his cousin are the main contributors. The period of information is from 1950's onwards, starting with V. M. Apte (1952, 1957) and Prakash Gole (1970's and 1980's) to the present day web groups on the Facebook etc.

The major contributors during the 19th century are: W. H. Sykes (1832-33), T. C. Jerdon (1839-40), WHO Burgess (1854-55), W. T. Blanford (1869 & 1894) E. H. Aitken (1875-1897), S. B. Fairbank (1876), J. Davidson (1874-1898), A. O. Hume (1876-1879), Hume & Oates (1889-90), E. A. Butler (1877-1881), J. Davidson & H. Wenden (1878), G. W. Vidal (1879-1898), J.D.Inverarity (1879 & 1887), Keswal/Sinclair, W.F (1886-98), H. E. Barness (1988-91), E. Comber (1896-1901),

and R. M. Betham (1899-1904). Most of these contributions appeared either in "Stray Feathers" (1872-1899) or in the BNHS Journal(1886 onwards).W. B. Trevenen's short notes (1922-23) on Pune's fauna is the only major contribution of the early 20th century. The four decades from 1930's onwards, belong to two prominent figures of the Indian ornithology- Dr. Salim Ali & Humayun Abdulali. S. Ali (1934-1980), Abdulali (1934-1990), Ali & Whistler(1933-42),Ali & Abdulali (1936-1868) contributed tremendously to the ornithology of India in general and the region in particular' The Newsletter for Birdwatcher', which was founded by Jaffer Futtehally, in 1960,contributed widely to the cause of birding for the next five decades. The birders and researchers who contributed a lot for the Pune region are: M.V. Apte (1950,1957), A. Navarro (1962-1981), T. Gay (1970-79), P. Gole (197196), S. Ingalhalikar (1977-2005), T. Mundkur (1981-86), Mahabal & Lamba (1987) and Mahabal (1989-90), R.Purandare (1996-98), K. Purandare (1999-2002) & S. Pande (2003-08). **Most historical records especially those from 19th centuary, discussed here are refered from Prasad, (2003)**

The major problem with the exercise is that it is mostly qualitative in approach. The description of population status of birds in most past works is qualitative, like-abundant, very common, rare, absent etc. These are all relative terms and need to be used carefully. For the sake of convenience the same terms have been retained, so that temporal comparison is possible. The standard population status terms used for timely comparison are:

Table 8.1: Standard population status of birds

Population status used by past workers	**Standardized status used in the present study for comparison**
Very abundant/extremely common/very common	Very common
Fairly common/ common/not uncommon/not rare/tolerably common/moderately common/occurs in numbers/Rather common/Moderately numerous/Numerous/	Common
Not common/By no means common/seen intermittently/less common	Occasional
Rare/Rare straggler/Seldom obtained/Scarce/Decidedly scarce/Straggler/Once/Uncommon/Occurs sparingly/Sparingly scattered/Decidedly uncommon/Only two specimens in three years etc./Very sporadic/Small numbers/scattered	Uncommon
Stray/Vagrant	Stray
Unrecorded/Not recorded/Unknown in an area	Absent

Hence we have the following standard terms modified after Abdulali (1982)

- Very common: Seen in very large numbers, over very wide area and seen almost daily.
- Common: Seen in large numbers, over wide area, very frequently.
- Occasional: Seen intermittently and less frequently
- Uncommon: Seen rarely, in very small numbers/may be ones and twos/ patchily
- Stray: Seen outside its normal range of distribution.
- Absent
- Extinct/Locally extinct

The terms are arranged in descending order, from most numerous and widespread (i) to non-existent (vii).

8.2 Changes in Population status:

There are five possible changes in the population of any bird species/groups for any area. They are:

a. Increase in population
b. Decline in population
c. Stable population (No apparent change)
d. Introduction of a new species. (Through human agency and through natural process)
e. Extinction

There are 238 species for which definite past and present status data are available. The changes are mostly for the species found in Pune area.

a) Increase in population:

Any change in status from any lower level status to any upper level status is treated as 'increase in population'. In other words, up-gradation in status needs to be treated as 'increase in population', because any status up-gradation means rise in population number and/or expansion of range. For example, from absent to stray, stray to rare, occasional to common etc.

There are 49 species which show such a trend. A group wise overview follows:

Cormorants: The number of great cormorant and little cormorant has increased over the years. Both the species used to be rare around Pune during early 1970's (Gole, 1972/1973). Today both of them are common, seen in large flocks, on almost all the major water bodies, almost throughout the year. (present study)

Egrets & herons: Both, the Grey heron (*Ardea cinerea*) and the Purple heron (*A.purpurea*) were uncommon till 1970's (Mahabal & Lamba, 1987), becoming common in 1980's (Bradbeer, 1987) and reasonably common today (present study). Great egret (*Casmerodius albus*) and Intermediate egret (*Mesophoyx intermedia*) were rare in 1970's (Mahabal & Lamba,1987) but have become reasonably common today, and are met with on almost each visit to any large wetland.

Storks, Ibises and spoonbill: The Painted stork (*Mycteria leucocephala*) seems to have increased during the last 40 or so years. It was not mentioned in the Pune checklist (Mundkur & Kelkar, 1981). When the author started watching birds in mid-1970's Painted stork was a rare treat. Today, they are seen regularly in large flocks of up to 40 birds, at all the major water bodies around Pune. Woolley-necked stork (*Ciconia epicsopus*) has also increased from uncommon (Mahabal & Lamba, 1987) to common bird of the winter, it being a local migratory species. Glossy ibis (*Plegadis falcinellus*) was treated as 'stray' by Mundkur & Kelkar (1991), whereas today it is a common bird. Eurasian spoonbill (*Platalea leucorodia*) was also not recorded around Pune till early 1980's (Mundkur & Kelkar, 1981) & (Mahabal & Lamba, 1987). Presently small flocks, of about 5 to 12 birds,are regularly seen at all the major water bodies.

Flamingos: Greater flamingo (*Phoenicopterus ruber*) and lesser flamingo (*P.minor*) were considered to be rare (Davidson & Wenden 1878, Vidal 1880, Butler 1881, Aitken 1900) and stray (Ali & Abdulali 1941, Abdulali 1981) respectively. Both the species are seen regularly at Sewri flats near Mumbai, literally in thousands (birdofbombay@yahoogroups.com) for the last 10 years or so. The greater flaminogs are also a regular visitor to large water bodies around Pune (Ujani & Veer reservoirs etc.) since 1980's (present study).

Ducks & geese: Five species of this group show increasing tendency. The Bar-headed goose (*Anser indicus*) was not mentioned earlier (Mundkur & Kelkar, 1981), but is seen regularly in small numbers (pairs etc.) at Ujani, Veer etc. (present study). The Common pochard (*Aythya ferina*) was 'not so common' near Pune (Mahabal & Lamba, 1987) but has become occasional now. The Comb duck

(*Sarkidiornis melanotos*) used to be rare in the past around Pune (Trevenen 1922) (Mahabal & Lamba 1987), but is now regularly reported from the water bodies along the Pune-Solapur highway.

Birds of prey: The Black kite (*Milvus migrans*) is one of the commonest birds of the Indian towns and cities. It was reported as RBC (Resident/Breeding/Common) in the past (Mundkur & Kelkar 1981), (Mahabal & Lamba, 1987).It has become so more common today than it used to be three decades ago. Its present status can best be described as 'Resident/Breeding/Abundant'. Any casual observation at any place in Pune city easily shows 25 to 50 kites soaring at a time, in the overhead sky. The concentration is highest around the garbage depot at Uruli Devachi on the outskirts of Pune, where thousands are seen at one go. This explosive increase is partly due easily availability of food in the form of garbage. Short-toed snake-eagle (*Circaetus gallicus*), once reported as rare & uncommon (Mahabal & Lamba, 1987) has increased apparently in numbers, the reason behind the increase is unknown.

Waders: The Purple swamphen (*Porphyrio porphyrio*) which is so common a sight today, at every water body of considerable size around Pune, was once a rare & uncommon bird (Mahabal & Lamba, 1987). The Pheasant-tailed jacana (*Hydrophasianus chirurgus*) shows similar trend from 'occurring sparingly' (Wenden 1878, Butler 1881) to present day common status. Small pratincole (*Glareola lactea*) used be 'occasional' in the past (Mundkur & Kelkar 1981), is presently quite common, and there are many breeding records from around Pune (Bharucha et.al.1988). There were no sighting records for Kentish plover (*Charadrius alexandrinus*) from the Deccan in the 19th century (Sykes 1832, Butler 1881, Bethham 1899), but the species appears to be common today at many lakes along the Pune-Solapur highway. Black-tailed godwit (*Limosa limosa*) was unrecorded in the 19th century, but reported as 'stray' by Mundkur & Kelkar (1981) and its present status can best be described as 'occasional'. Common redshank (*Tringa totanus*), has changed from rare (Davidson & Wenden 1878) to very common winter visitor today (present study).The Ruff (*Philomachus pugnax*) was a rare bird in the 19th century (Davidson & Wenden 1878).Abdulali (1981) listed it as 'occasional'. Bradbeer (1987) found it common around Pune. The present status is between 'common' and 'occasional'. The Whiskered tern (*Chlidonias hybridus*) was reported as 'rare' not common' in the 19th century(Davidson & Wenden 1878,Butler 1881) but was returned as common around Ujani (Bharucha & Gogte 1990).The present study found

it quite common at many wetlands around Pune. The River tern (*Sterna aurantia*) was unrecorded in the Deccan area by Davidson & Wenden (1878). Today it is a common resident bird and there are breeding records from at least three places around Pune (Prasad 2003)

Some common urban birds: Rock pigeon (Columba livia), a cosmopolitan bird with worldwide distribution, has gone up from common to abundant level. In fact it is treated as a pest in most cities. Within the study area, it is one of the commonest birds in Mumbai, Thane and Pune. Another bird that is flourishing with urbanization is the Rose ringed parakeet (*Psittacula krameri*). It has also become 'more common' from just 'common'. The Asian koel (*Eudynamys scolopacea*) has also been flourishing along with crows. It is a resident parasitic cuckoo and its normal hosts are the House crow and the Large-billed crow. It lays its eggs in the crows' nests. With both the species of crows-the House & the Large-billed flourishing in urban areas, the Koel is not far behind and has been spreading along with them. A distant cousin of Koel, the Grey-bellied cuckoo (*Cacomantis passerines*), was unrecorded in the Deccan area by Davidson & Wenden (1878). But the present study found it very common around Pune, and parts of Raigad district (Pen-Varsai etc.). Another common city bird is the House swift (*Apus affinis*). It is such a common bird that it is seen and heard almost every day throughout the year. It is surprising that this species was reported as rare by Sykes (1832) and Jerdon (quoted in Prasad, 2003). The Indian grey hornbill (*Ocyceros birostris*) is a common bird and is easily seen wherever there are woodlands and groves with Ficus trees. It was not reported by Fairbank (1876) and Butler (1881) in upper Deccan. It was reported 'rare' around Mumbai in 1940's (Ali & Abdulali 1945),but since then has become quite common and expanding its range towards the south. (Prasad 2003)

Lesser goldenback (*Dinopium benghalense*, a beautiful woodpecker, was uncommon around Pune (Mahabal & Lamba 1987, Bradbeer 1987), but has become reasonably common since then. The Indian Pitta (*Pitta brachyura*) is a passage migrant around Pune.It breeds in Konkan and the Ghats country. It was returned as 'occasional', by Mundkur & Kelkar (1981), but there have been regular sightings (mostly in June) since 1985. Between 1985 and 2005 there were 18 records from around Pune alone. A 'harassed-by-crows' pitta was rescued by the author himself in June 1988 from the Vetal hill area of Pune. The Greater short-toed lark (*Calandrella brachydactyla*) is a winter visitor to our area. The bird was unrecorded by Davidson

& Wenden (1876) in upper Deccan. But large flocks have been observed on 'maals'(grass & scrub plain country) along the Pune-Solapur highway, especially around Yewat and Bhuleshwar (present study).It can treated as common winter visitor. Dusky crag martin (*Hirundo concolor*) is a tiny sparrow-sized, ashy brown bird found around cliffs, forts, old buildings and dams. It has been a common bird, but is becoming more common, rather abundant with every new apartment house that is added in the vicinity of Pune. Every new building that comes up has its quota of dusky crag martins. Common myna (*Acridotheres tristis*), House crow (*Corvus splendens*), and Large-billed crow (*C.macrorhynchos*) is another set of birds, that is flourishing with urbanization. All the three species are conformed scavengers and have made urban areas their true home. They live mostly on leftover food that is so abundant in urban areas. All the three species are very common or abundant around Pune. The house crow and the large-billed crow were reported as 'hardly seen' and 'rare' respectively by Shroff (1949) at Mahabaleshwar, whereas today both the species are reasonably common (present study). The two bulbul species-the Red vented (*Pycnonotus cafer*) and the Redwhiskered (*P. Jocosus*), though reported common in the past by almost every collector and watcher, today has become abundant, on the lines of mynas and crows. The red-whiskered bulbul was reported 'rare' around Pune by Apte (1957).

Another city dweller, the Oriental magpie robin (*Copsychus saularis*), is also doing well against the urban background. It was reported as rare by Fairbank (1876) and 'less common', by Butler (1881) in the Deccan. Two flycatcher species have been expanding their ranges, one is spreading from south to north (White-bellied blue flycatcher: *Cyornis pallipes*), another from north to south (Grey-headed canary flycatcher: *Culicicapa ceylonensis*), along the Western Ghats. Both the species were unreported from around Pune (Mundkur and Kelkar,1981).But reported as rare from the Ghats country (Mahabal & Lamba,1987).The present status is occasional. Another species that is spreading northward is the Black-headed munia (*Lonchura malacca*). The bird was reported from south Konkan in the late 19th century (Vidal 1880, Butler 1881). It was reported 'absent' in northern part of the Ghats country (Ali & Ripley 1983). The bird has been regularly reported from around Mumbai and Pune since 1965. (Abdulali 1966, Mundkur & Kelkar 1981, Mahabal & Lamba 1987, Monga 2003) Its present status is 'occasional', though Prasad (2003) describes it as 'fairly common'. The desert wheatear is a winter migratory bird. It was rare in the late 19th

century (Butler 1881). It was not reported by Mundkur & Kelkar (1981) in Pune list, though Mahabal & Lamba (1987) called it 'uncommon'.

b) Stable population:

The species in which there is no change in the past and present population status is said to have stable population. Either the population or the range is stable or both are stable. A species which was rare in the 19th century is still rare or a species which was common five decades ago is still common in the same area, are examples of stable population. It is interesting to note that there are 145 species in the study area that show stable population status.

Table 8.2: Trend of Stability status

Trend of stability status	No. of species	% of species
Common to Common(C2C)	119	82.06
Occasional to occasional(O2O)	13	8.96
Rare to rare (R2R)	13	8.96
Total	145	100.00

It is interesting to note that majority (82 %) of the birds in the category show C2C (common to common) trend. These are such common bird species as –Indian pond heron(*Ardeola grayii*),Cattle egret (*Bubulcus ibis*), Spotbill duck (*Anas poecilorhyncha*), Shikra (*Accipiter badius*), Common peafowl (*Pavo cristatus*), Common moorhen (*Gallinula chloropus*), Common coot (*Fulica atra*), Blackwinged stilt(*Himantopus himantopus*), Red and Yellow-wattled lapwings (*Vanellus indicus* and *V.malabaricus* respectively), Spotted & laughing doves (*Streptopelia chinensis* and *S.senegalensis* respectively), Spotted owlet (*Athene brama*), Greater coucal (*Centropus sinensis*), Common & White-throated kingfishers(*Alcedo atthis* and *Halcyon smyrnensis*), Coppersmith barbet (*Megalaima haemacephala*), Wiretailed swallow(*Hirundo smithii*), Eurasian golden oriole (*Oriolus oriolus*), Black drongo (*Dicrurus macrocercus*), Common woodshrike (*Tephrodornis pondicerianus*), Common iora (*Aegithina tiphia*), Large grey babbler (*Turdoides malcolmi*), Zitting cisticola (*Cisticola juncidis*), Greenish warbler (*Phylloscopus trochiloides*), Pied bushchat (*Saxicola caprata*), Indian robin (*Saxicoloides fulicata*), Great tit (*Parus major*), White-browed wagtail (*Motacilla maderaspatensis*), Purple & Purple-rumped sunbirds (*Nectarinia asiatica* and *N.zeylonica* respectively), Baya weaver (*Ploceus philippinus*) etc.

The prominent species under the O2O category are: Asian openbill(*Anastomus oscitans*), Black ibis (*Pseudibis papillosa*), Barred buttonquail (*Turnix suscitator*), Barn owl (*Tyto alba*), Alpine swift (*Tachymarptis melba*), Asian palm swift (*Cypsiurus balasiensis*), White-cheeked barbet (*Megalaima viridis*), Syke's lark (*Galerida deva*), Barn swallow (*Hirundo rustica*), Lesser whitethroat (*Sylvia curruca*), Common chiffchaff (*Phylloscopus tytleri*), White-rumped shama (*Copsychus malabaricus*), Eurasian blackbird (*Turdus merula*), Richard's pipit (*Anthus richardi*), and Crested bunting (*Melophus lathami*).

Under the R2R category, we have 13 species: Black stork (*Ciconia nigra*), Black-headed ibis (*Threskiornis melanocephalus*), Black eagle (*Ictinaetus malayensis*), Egyptian vulture (*Neophron percnopterus*), lesser florican (*Sypheotides indica*), Bronze-winged jacana (*Metopidius indicus*), Greater thicknee (*Esacus recurvirostris*), Emerald dove (*Chalcophaps indica*), and Crested tree swift (*Hemiprocne coronate*), and Forest wagtail (*Dendronanthus indicus*).

Why such a large number of species are stable?

- The category is dominated by common birds (82%).
- Most common birds have continuous distributional ranges.
- Most common birds show wider tolerance range, and hence are found across many habitats, from semi-arid to woodland to forest.
- Most common birds seem to adjust rapidly to the changing environment, including the urban sprawl.
- Twenty eight species are winter migratory. In spite of being winter migratory, they seem to show higher level of tolerance to the rapid changes taking place in their wintering quarters and hence are holding their own.
- Most R2R category species today show fragmented distributional pattern, which has been unchanged for the last one hundred and fifty or so years. So their population status (rare) has remained the same.

c) Decreasing population trend:

There are 36 species in the study area which have been showing declining trend. The trend statistics is as follows:

Table 8.3: Overview of Declining population changes

Change in status(from- to)	No. of species showing the trend	% of species showing the trend
Common to Rare	24	66.66
Abundant to Common	01	2.77
Common to Occasional	09	25.00
Rare to Near-threatened	02	5.55
Total	**36**	**100.00**

Almost two third species (66.66%) show 'Common to Rare' change, followed by another 25% showing 'Common to Occasional' trend. Both the categories between them share almost 92% of the declining trend. One species has declined slightly from 'Abundant to Common', whereas two species are showing 'Rare to Near-threatened' trend.

Discussion on the declining trend:

Darter (*Anhinhga melanogaster*) used to be common in Konkan and upper Deccan between 1880 and 1900(Vidal 1880, Butler 1881, Davidson 1882, Keswal 1886, Aitken 1900 & 1905).It was also reported as 'locally common' around Pune and often seen at 'Mulshi & Khadakwasla lakes'. (Mahabal & Lamba 1987).But its status during the last three decades (1980 onwards) can be best described as 'rare'. There are hardly two or three records of its sighting during the present study.

Little heron (*Butorides striatus*): A' very common' river-side bird in the late 19th century of the 'above Ghats' country (Davidson & Wenden 1878, Butler 1881), has become very rare in the same region today. There are not more than six records of the bird from the study area, during the period 1987 to 2002.

Ducks: The Red-crested pochard (*Rhodonessa rufina*) is a wintering duck of our area. A 'rare' duck of the Deccan area about 180 years ago (Sykes 1833), probably became more common during 1970s & 80s (Mahabal & Lamba 1987), but has become extremely rare since then.

The Tufted duck (*Aythya fuligata*) used to be so common at all the major water bodies around Pune in 1980's that they would be seen in large flocks. The author himself has seen their large flocks at the Pashan Lake regularly in the early 1980's. Presently they are rarely sighted and uncommonly reported even on the 'bird of Pune' group at the '*yahoogroups.com*'.

Birds of Prey: Brahmany kite (*Haliastur* i*ndus*), the kite of rivers, creek and lakes, used to be frequently seen along all the Pune rivers in 1970s and 1980s. Mahabal & Lamba (1987) also called her 'fairly common'. It has become quite uncommon today and is rarely sighted. Another raptor, the **White-eyed buzzard** (*Butastur teesa*) used to be 'common' in the past (Butler 1881) but is no more common. Aitken (1947) found it "everywhere" on the Deccan in 1905. The author used to see this raptor frequently sitting on top of every second or third telegraph pole, alongside the Pune-Solapur railway line, during his frequent visits to Solapur in 1970's.The raptor is rare today even along that route. The population of another raptor has been dramatically dropped (Prasad 2003) from 'extremely abundant' in the late 19th century (Davidson & Wenden 1878) to 'fairly uncommon'. This is the Tawny eagle (*Aquila rapax*). The population of all the three species of vulture has declined rapidly and considerably during the last two decades. Both the White-rumped vulture (*Gyps bengalensis*) and the Indian vulture (*G.indicus*) were regarded as one the most common birds of the country side till about mid-1990s.According to the BNHS, the population of *G.indicus* has declined by about 99.7 per cent between 1992 and 2003 (Rastogi 2007). The decline is blamed on the use of diclofenac, a commonly used painkiller for cattle, which would then pass on to the vultures through the livestock carcasses which is their food. Another possible reason is that the practice of dumping livestock carcasses on to the open ground is now prohibited by law for the health reasons.

This has made the availability of food (flesh) for vultures not only difficult, but almost impossible. This along with the impact of diclofenac has been a double blow for the vultures, thereby bringing their population down to such a dangerous level that they have been declared as 'Near Threatened' by the IUCN. The Red-headed vulture, which was rare in the past (1970's and 1980's.) has also become more rare, and is accorded the same 'Near Threatened 'status by the IUCN (IUCN Red list 2010). While writing about the **Egyptian vulture** (*Neophron percnopterus*), Aitken (1905) remarked:"It is one of the commonest birds about Poona and everywhere on

the plains of the Deccan". Mundkur and Kelkar (1981) also reported it as 'occasional' around Pune. The author has always found this vulture "uncommon" around Pune since 1975.

The Laggar falcon: (*Falco jugger*) used to be so common till 1980's that it would be sighted around every hill and cliff-face around Pune regularly. The author found a pair attempting a nest building on the ledges of the abandoned stone quarry at the Hanuman hill in the heart of the city in February 1983.There is not a single record of its sighting since mid-1990's.Its definitely a rare bird now. The Red-necked falcon (*F.chicquera*) used to be common in the Deccan (Sykes 1832,Davidson & Wenden 1878, Butler 1881).Both Mundkur and Kelkar (1981) and Ingalhalikar (2005) found it to be 'occasional'. Common Kestrel (*F.tinnunculus*), a small, beautiful falcon, nests in the Western Ghats country. During the present study, it was found nesting at Pratapgad near Mahabaleshwar, in 1993. Sykes (1832) recorded it to be 'very abundant', in the Deccan. It was reported as 'common' by Mundkur & Kelkar (1981) around Pune. Its population has declined slightly since 1990 and the falcon is seen occasionally around Pune, though it is still common at places like Mahabaleshwar and Panchgani.

Partridges and quails: Painted francolin (*Francolinus pictus*), used to be 'abundant' (Sykes 1832) and 'common' (Davidson & Wenden 1878) in the Deccan. It declined in numbers around Mumbai, due to trapping and poaching (Ali & Abdulali, 1938). It is presently uncommon around Pune. The Rain quail (*Coturnix coromandelica*) was 'very abundant' (Sykes 1832) and 'very common' (Davidson & Wenden 1878) in the Deccan. It was reported as 'common', by Mundkur & Kelkar (1981). It has progressively declined since then. Its present overall status is 'occasional'. Painted bush quail (*Perdicula erythrorhyncha*), one of the most beautiful of our quails, is confined to the Ghats country only. It was reported as 'abundant' (Sykes 1832) and 'not uncommon' (Butler 1881) in the past.Mundkur & Kelkar (1981) do not include it in the Pune checklist. Ingalhalikar (2005) does not mention it for Sinhagd either. The author has only a few records of this stubby quail, all of them from Mahabaleshwar and Panchagani. It is definitely an uncommon bird for the area. Another quail with similar situation is the Small buttonquail (*Turnix sylvatica*). This quail was also reported as 'common' by Davidson & Wenden (1882). Trevenen (1922) included it in his list of game birds shot around Pune. This species is not

mentioned either by Mundkur & Kelkar (1981) and Ingalhalikar (2005) in their respective lists for Pune and Sinhagad. It's an uncommon bird now.

Cranes: Both the crane species, the Common crane (*Grus grus*) and the Demoiselle crane (*G.virgo*) are treated as 'uncommon winter visitor'(Prasad 2003) for the Deccan region. The common crane was returned as 'tolerably common' by Davidson & Wenden (1878) and 'not uncommon' by Butler (1881), whereas 'immense flocks' of the Demoiselle crane were reported by Davidson & Wenden (1878). Both the species are not included in the Pune checklist (Mundkur & Kelkar 1981). For the last thirty years, the author has seen the former species only twice. The later is relatively more common.Large flocks of Demoiselle crane have been reported from Veer and Ujani backwaters.But the number has been declining gradually since around 2000.

Crakes: Two crake species are showing declining trend:the Baillon's crake(*Porzana pusilla*) and the Spotted crake (*P.porzana*). Both are winter visitors. The former was recorded as 'common' around Mumbai by Ali and Abdulali (1939), where presently it is an 'uncommon' bird (Monga 2003). The later was also reported as 'fairly common' around Mumbai in late 19th century by Inverarity (1887) and 'not rare' in the Deccan by Davidson & Wenden (1878). There are not more than a dozen records of this crake from western Maharashtra for the last fifty years. The author has never come across this species around Pune for the last 35 years.

The case of Indian Bustard (*Ardeotis nigriceps*) is already discussed in chapter 7.The birds population status has been depleted from 'common' to 'rare', during the last century or so.

The Indian courser (*Cursorius coromandelicus*), which used to be so common on most 'maals'(waste and fallowlands) around Pune till 1990s(present study),has now become relatively less common, thanks to the rapid urbanization that has taken place around Pune since 1990 or so. Their preferred habitat-the waste and fallow lands, has been encroached upon and converted into urban habitats-housing colonies, townships, industrial estates and educational complexes, thereby pushing them away from the City. The status of the bird in the vicinity of Pune can best be described as 'occasional'.

The Black-bellied tern (*Sterna acuticauda*) is one of the uncommon terns in the study area. During the 19th century, in the Deccan area, the bird was reported as 'common' (Sykes 1832),and 'very common'(Davidson & Wenden 1878).Mahabal &

Lamba(1987) described it as 'often seen' on the Mula-Mutha rivers, whereas Bharucha & Gogte found it 'common' at Ujani in 1989.

Painted sandgrouse (*Pterocles indicus*) is a bird of semi-arid country and prefers grass & scrub country with rocky areas. The bird has a patchy distribution and was 'abundant' at places in the Deccan (Davidson & Wenden 1878).Since 1980's the sighting records of the bird are few and far between. They are also geographically scattered. It's an uncommon bird now.

The Red collared dove (*Streptopelia tranquebarica*) is another bird of the open country side. It is 'the least common of the doves' (Ali 1984).Davidson & Wenden (1878) found them 'common' in the Deccan region. Abdulali returns it as 'occasional' (1981). Mundkur and Kelkar (1981) also describe its status as 'occasional' around Pune. Throughout the present study, the bird was found to be 'uncommon' in the vicinity of Pune.

The Malabar parakeet (*Psittacula columboides*)is an endemic of the Western Ghats country. In the 19th century, the bird was described as 'tolerably common' near Mahabaleshar by Davidson and Wenden (1978), 'moderately common' in the Ghats by Vidal (1880), and 'not uncommon' by Butler (1881) in the Ghats. It is returned as 'uncommon' by Abdulali (1981) and Monga (2003) around Mumbai. Nalavade (1981) also found it rare in the Ghats country of Pune district. It is presently a rare bird at Mahabaleshwar and Panchgani (R.Purandare, Pers.comm.).

The Eurasian eagle owl (*Bubo bubo*) is a widely distributed owl. There are records of its presence from almost every grid of the study area. All the 19th century reports from the Deccan, mark it as 'very common' (Sykes 1832) or 'common' (Davidson & Wenden 1878). Abdulali (1981) assigns it the 'occasional' status for the whole state, whereas Mundkur & Kelkar (1981) treat it as 'uncommon' for the entire Pune city area. The present study shows that the sighting and calls of this particular owl has become progressively less and less frequent around Pune, since1990.It's major habitat around the city has been the abandoned stone quarries and rock faces. Many of these quarries have either been filled in and reclaimed (for example the one near the Paud phata), encroached upon by slums (the one behind the Dahanukar colony at Kothrud) or disturbed with increasing human activities (Vetal hill quarry).The present study found that the owl which used to be frequently seen at all of these places up till 1990's has almost been exterminated now. According to author's

own observations, Sinhagad used to be the place where this owl was common till 1990s. As recently as 2005, Ingalhalikar reported it to be 'occasional' there.

The Grey nightjar (*Caprimulgus indicus*) is another nocturnal bird that is widely recorded from various places from Konkan ,the Ghats country and the upper Deccan. Abdulali (1981) described it as 'occasional' for the whole region. Mundkur and Kelkar (1981) also found it occasional around Pune, though Monga (2003) calls it 'fairly common' from around Mumbai. This nightjar has become either 'uncommon' or 'occasional' in the hills around Pune. Another species,the Indian nightjar (*C.asiaticus*),once frequently seen and heard on every hill and fallow land around Pune has declined in numbers during the last 10 to 12 years.

The Pied kingfisher (*Ceryle rudis*) is one of our commonest kingfishers. It frequents rivers, reservoirs and estuaries. Once a common bird of the Mula and Mutha rivers, it has now dwindled in numbers. It finds its food by remaining 'stationary' in the air above water and 'dropping down' upon the quarry (fish) swimming near the surface of water. For this to attain, it requires crystal clear water. The increasing turbidity and pollution of both the rivers has made 'hunting' almost impossible for this kingfisher, thereby pushing it away and out of the city. It has become 'occasional' or 'uncommon' on both the rivers.

The **Yellow-crowned woodpecker** (*Dendrocopos mahrattensis*) is one of our commonest woodpeckers. The author found it very common in the Pimpri-Chinchwad town during 1983-1997.Recent visits revealed that the bird has declined there in numbers due to rapid urbanization and is now confined only to small woodland pockets around the Tata lakes area and the Durgamata hill plantations. It has also declined in numbers from the 'hill plantations' around Pune, though still common at Sinhagad (Ingalhalikar 2005). While writing about the status of this woodpecker around Mumbai, Monga (2003) remarks that "Nos fallen considerably since early-1990s".Another woodpecker, the **Greater flameback** (*Chrysocolaptes lucidus*) has also shown declining trend over the years. Butler (1881) and Davidson & Wenden (1878) found it 'not uncommon' along the Ghats country. Abdulali (1981) returns it as 'uncommon'. This bird is also not mentioned in the Pune list (Mundkur & Kelkar 1981).It is also not recorded by Monga (2003) as a Mumbai bird or by Pande et al. (2008) for Lonavla and Khandala. The nearest place where this bird was reported was at Koyna in 1990s and Karnala around 2000 (Prasad 2003).

Ashy woodswallow (*Artamus fuscus*) is a bulbul-sized dull grey bird associated with Palmyra palm, hence confined mostly to the Konkan region. The bird was reported as common around Mumbai by Ali & Abdulali (1937).The author also found it common at many places (Yeoor, Parsik hill etc.) around Thane between 1980 and 1995. According to Monga (2003) the' Nos declined considerably since early 1990's' around Mumbai.

Another species that has reduced in number around Mumbai is Black-headed cuckooshrike (*Coracina melanoptera*). Its status has changed from 'not uncommon' in 1930's (Ali & Abdulali 1937) to 'uncommon' in the new millennium (Monga 2003).

The White-browed fantail (*Rhipidura aureola*) is widely distributed over western part of the Peninsula. It was reported as 'common', 'tolerably common', and 'very common' from various parts of the upper Deccan (Butler 1881, Davidson & Wenden 1878, Betham 1899). Abdulali (1981) returns it as 'uncommon'. Mundkdur & Kelkar (1981) calls it as 'occasional' near Pune.

Case study of House sparrow (*Passer domesticus*):

The last but not the least is the House sparrow (*Passer domesticus*). Once regarded as one of the commonest birds of the human settlements, it is now reduced so fast that it has reached to a highly critical situation. Various different theories and reasons have been put forth to explain the decline of house sparrow. So far as Pune city is concerned these are the possible reasons for reduction in house sparrow population:

- **a.** Conversion of 'wada' type structure into modern apartment buildings
- **b.** Removal/Disappearance of hedges and hedge plants
- **c.** Disappearance of horse stables and cattle sheds
- **d.** Increasing use of packed grains
- **e.** Increase in scavenger birds
- **f.** Reduction in dusty patches
- **g.** Predation by domestic cats
- **h.** Threat from mobile towers
- **i.** Mushrooming of bird nonfriendly architecture

a. Conversion of 'wada' type structure into modern apartment buildings:

The 'wada' (a residential mansion) has been a part of Pune's cultural heritage. A traditional wada is a square-shaped; two story brick structure, with an open space (front, central or backyard) and few garden / hedge plants and trees. The brick walls with its innumerable holes, ledges and cavities provided ideal nesting sites for sparrows and other birds.

b. Removal/Disappearance of hedges and hedge plants:

Pune has many bungalow colonies especially in the suburban areas. Most bungalows had (and some still have) hedge fences. The hedges provided night roosting sites for the sparrows. Most hedges have been removed to make way for stone-wall/barbed wire compounds, thereby reducing the night roosting sites for sparrows.

c. Disappearance of horse stables and cattle sheds:

Pune was once known for its *tongas*, the horse drawn carriage. There used to be hundreds of tongas in Pune, till about 1960's.Pune therefore also had many horse stables. The horses would be fed with grains and cereals of various type (bajra, oat, gram, sorghum, millets, wheat etc.). The leftover grains and spilled over livestock feed would provide enough food for sparrows. Most horse stables therefore attracted hundreds of house sparrows. In 1950 there were 1152 tongas and victorias and 1375 bullock carts in Pune city, Pune and Khadaki cantonments together (Poona District Gazetteer 1954). This number came down to 200 tongas in 1985 (Potdar 1985). The estimated number of bullock carts in the city at present is around 50 only. With tongas and bullock carts gone there are hardly any stables and cattle sheds left in the city. The house sparrows lost not only nesting and roosting sites but also the main source of food supply.

d. Increasing use of packed grains:

In the past most people purchased loose grains from grocery shops. The grains would have to be sorted out for they contained lot of impurities and small pebbles. To make them usable they required sorting and sieving. Most women at that time were house wives. They would gather in the central courtyard in the afternoon for sorting and sieving of grains. This was the time when a pinch of the grain would be thrown on to the ground for the birds (especially sparrows) to feed upon. With the wadas, house wives and the practice of feeding sparrows gone, sparrow lost another source of easy food.

e. Increase in scavenger birds:

The urban scavenger birds include: Crows (2 species), mynas (3 species), rock pigeon (1 species), Common kite (1 species). (Plate 4.2) As a part of rapid urbanization, new apartment buildings are coming up in every ward of Pune city. Every new building (especially the central enclosed duct) provides ideal niches for rock pigeons to build nest etc. The rock pigeons are therefore breeding prolifically. The common myna, jungle myna and the Brahmany starling have also taken advantage of the urban sprawl and competing with pigeons for nesting sites on buildings. The new apartment buildings also provide some nesting and roosting sites to sparrows. But there is heavy competition for such sites among these species and the best sites have gone to rock pigeons, common and jungle mynas and brahmany starlings with less suitable and more vulnerable sites (for example gaps behind electric switch boards etc.) left to sparrows. The crows-both the house and the large-billed are a great threat to smaller birds. According to Ali (1979), "eggs or fledgling birds pilfered from nests" by crows. He further adds that the crow is "also a great bully and therefore a serious menace to defenseless ornamental bird species in urban areas." The present study found that it is not only the ornamental birds but the other smaller birds in our cities as well –the Prinias, robins, fantails, tits, bulbuls, sparrows, mynas etc. which are being bullied by the cunning and audacious crows. On various occasions the reseacher has seen the whole clutch of smaller birds being destroyed by crows in one go. The house sparrows in fact are at the receiving end, and the present study found that the death cause of one in five sparrow chicks is 'robbery by crows'. The explosive increase in crow population in urban areas has been one of the greatest threats to smaller birds including the house sparrow. Common kites have also been found to occasionally lift young sparrows. Shikra, which is a major predator of sparrows, is also maintaining a constant population in urban areas.

The following table provides data about changes in population of some scavenger birds in Pune (old limit)

Table: 8.4: Changes in population of some Scavenger Birds in Pune

Scavenger species	Population (Mahabal , ,1975-78)	Population(Approximate) (present study,2008-10)	% change (+ or -) in population
Crows (2 species)	16000	25000	+156.25
Mynas(3 species)	32000	48000	+150
Kite	600	3600	+600
Rock pigeon	8000	146000	+1825
Rose-ringed parakeet	6000	7300	+121.66
House sparrow	50000	20000	-40

The population of two crow species and three myna species has multiplied by 150 per cent within about three decades. The population of Rose-ringed parakeet has increased by about 122 per cent .The highest growth is found in Rock pigeons and kites. The pigeons have grown by staggering 1825 per cent, whereas the kites have grown by 600 per cent. It seems that the population of pigeons, returned as 8000 in 1975-78 is in all probability an under counting and the real population may have been a few time more than the actual figure of 8000.In one way, it is fact that the population of rock pigeons has grown at explosive rate. Compared to all other scavenger species the population of house sparrows has decreased by 40 per cent during the same period.

f. Reduction in dusty patches:

Sparrows, like many other birds, have a habit of dust bathing on open ground. This they do to get rid of insect pest living on their bodies. For this they require open dusty patches. In the past, the courtyards in wadas provided such open grounds. In the modern housing colonies, almost every inch of ground is covered with tiles, interlocking blocks, tar or concrete. Where is the place left for dust bathing?

g. Predation by domestic cats:

This seems to be a global problem. The domestic cat density in urban areas is always very high. The domestic cat density in the UK ranges from 132 cats per sq.km. (Sims et al, 2008) to 200 cats per sq.km.(Baker et al,2008). In Kothrud, a suburb of Pune, where the author has been staying for the last 25 years, the domestic cat density ranges from around 80 to 100 cats per sq.km. Cats are a great threat to smaller birds. Birds which nest low in bushes and hedges (tailorbird and *Prinia* species), and on ground (Indian robin), birds which feed on ground (house sparrows, mynas and

pigeons) are in fact highly vulnerable. The author has observed a full clutch of five chicks of house sparrow being killed and eaten by a pair of cats within three days in the summer of 2007.

h. Threat from mobile towers:

Various studies around the world show that mobile towers are threat to sparrows. The study in Kollam taluka of Kerala by environmentalist group Kerala Environmental Researchers Association (KERA) in 2009 claims that the number of sparrow is going down largely due to proliferation of mobile towers. But the present study shows otherwise. A study in Kothrud showed that the number of house sparrow has been stable in spite of three mobile towers within 100 meters of each other. There are two sparrow roosts within the triangle made by the three mobile towers. One roost is a large babool tree (*Acacia nelotica*) which houses more than 1000 sparrows. The other roost is a complex of Indian cork tree and Bougainvillea plant, where about 600 plus sparrows roost for night. The second roost is hardly 50 m. away from the nearest mobile tower. The roosts are minimum 10 years old whereas the mobile towers were erected in 2008-09.There does not seem to be any visible impact of the towers on the two sparrow roosts, where the sparrow population has been stable throughout.

i. Mushrooming of bird nonfriendly architecture: This includes the buildings with glass façade, fully air-conditioned closed-buildings and tall tower buildings. Such buildings have mushroomed in all the suburbs of Pune. The density of such buildings is higher in western Pune, along the S.B.road, Hinjawadi and the Katraj byepass. The density of house sparrows is higher in those suburbs where there is prevalence of bungalow and chawl type houses (for example Sinhagad road and Paud road), whereas house sparrows are almost absent in Hinjawadi IT park, where the modern structures with glass façade are dominantly found. The average population density of house sparrow within the old limit of the City was 136.98 individuals per one sq.km.(2008-10).In Shivtirthnagar, a housing suburb of Kothrud, the density is high:2000 individuals per km^2. This locality is a mixture of apartment buildings, bungalows and hutment colonies. In the Hinjawadi IT Park, the density has been found to be very low: only 39 birds per km^2

(Use of garden pesticides: The author is unable to make any comment on this issue, since he did not find time to work on this aspect.)

8.3: Introduction of new species. (Through human agency and through natural process)

a) A new species may be added into the avifauna of a region through i) Human agency & ii) through natural process of dispersal. So far six species have been introduced in the study area through human agency during the last 80 years**. (Table: 8.5):** Most of these are descendants of escaped or released stock.

Table 8.5: Introduced Bird species in the Study area

Introduced species	**Possible year of introduction and place of introduction**	**Reference**
Southern hill myna	1924 , Pali hill, Mumbai	Ali & Abdulali(1937)
Red jungle fowl	1929 , Borivli, Mumbai	Ali & Abdulali(1938)
Alexandrine parakeet	1938 , Mumbai	Ali & Abdulali(1938)
Asian pied starling	1939 , Mumbai suburbs	Ali & Abdulali(1938)
Lesser adjutant	1985 , Pimpri-Chinchwad near Pune	Present study
Red-breasted parakeet	1994 , Andheri, Mumbai	Andheria (1998)

Out of the six species only two, the Alexandrine parakeet and the Asian pied starling are doing well and have established themselves and naturalized ,in the Mumbai-Pune urban belt.

Eleven species have been newly added to the avifauna of the region, since 1930's. These were mostly due to the natural extension of range from parent area into new area or straying out of the normal range of distribution. The species addition to the avifauna of the region is:

Table 8.6: Addition of new species in the Study area

Sr.No.	**Species added**	**Possible year of 1st reported sighting and place of addition**	**Reference**
1	Imperial eagle	1939, Bombay (?)	BirdLife International 2001 in Prasad (2003)
2	White-bellied blue	1951 ,	Ali (1951)

	flycatcher	Bhimashankar(Pune)	
3	Ashy minivet	1965 , Karnala (Raigad)	Navarro (1965) in Prasad 2003
4	Asian fairy bluebird	1981 , Mahabaleshwar(Satara)	Abdulali (1981)
5	Black baza	1988 ,Bhimashankar(Pune)	Rane & Borges(1986)
6	Rufoubellied eagle	1993 , Mula-Mutha,Pune	Prasad (2003)
7	Cinereous vulture	1993 , Pali near Satara	Prasad (2003)
8	Spot-bellied eagle-owl	2000 , Bhimashankar (Pune)	Gole (2000) in Prasad 2003
9	Ortolan bunting	2000 , Pashan, Pune	Ingalhalikar et al.(2000-01)
10	Sri Lanka frogmouth	2009 , Phansad (Raigad)	Shivkar (2009)*
11	Grey-headed lapwing	2011, CME lake, Pune	Baindur (2011)*

*birdsofbombay@yahoogroups.com

Out of the eleven species that has been added into the avifauna of the region through natural process of dispersal, only two-the Asian fairy bluebird and White-bellied blue flycatcher are doing well and are frequently seen in their respective habitats, while other species have remained elusive. Not a single species from the study area has become extinct in the last century or so.

8.4: Changes in Dissemination of Bird Information:

There has been a progressive increase in the number of bird species reported from Pune city region. The first ever list of the city birds was prepared by Prakash Gole in 1972.This list included 153 species. The Pune checklist prepared by Mundkur & Kelkar (1981) included 250 species. The most comprehensive list about the region was published in 2001 by Kalpavriksh & the CEE, which included 303 bird species. The present study slightly fatten the list to 310 species.This clearly shows that the bird species number is now almost stabilized, though a few new species may still be added. The rise in number is not due to addition of new bird species per se, but due to

better recording and coverage of the avifauna of the region, by more and more trained and skilled, enthusiastic bird watchers.

Table 8.7: Reported Bird species (1972-2010)

Year of reporting	Number of species	Reference
1972	153	Gole(1972)
1981	250	Mundkur & Kelkar(1981)
2001	303	Kalpavriksha & CEE (2001)
2010	310	Present study(2005-10)

Till about 1980, the number of birdwatchers in Pune was limited. Very few could afford cameras with telephoto-lenses, which has now become so common thanks to digital technology. Photographing a bird for identification has become so easy and fast. There are better illustrated birding guides available today. According to Gole (pers.comm.) there were not more than a dozen bird watchers in Pune around 1970.Presently the 'Birds of Pune' group on the Facebook has 2436 members as on 18th May 2013.

Table 8.8: Birdwatching-related Information (Pune city)

Item	1970	2012
Nos. of birdwatchers	About a dozen(1970) P.Gole (pers.com.)	3000+ (Present study)
Nos. of field guides available in market	03	13
No. of published checklists (study area)	Nil	10
No. of nature clubs/Bird-watching groups	Nil	50 +

The above data clearly recognizes the importance of information and rising awareness in bird study.

8.5: An Overview:

a. It is a good indication that out of the 238 species for which definite trends are available 147 species (61.76%) show stable population trend. One of the

possible reasons is that barring the Mumbai-Pune belt, the remaining part of the study area has not changed drastically.

b. In all 49 species (20.58%) show increasing trend. Most of these are commensal of man, are scavengers, and have easily adapted to rapidly changing urban environment. Many of them are aquatic species which have been flourishing further, with the addition of every new reservoir and lake in the study area.
c. Thirty six species (15.12%) are showing declining population trend. Eleven of them are open country species, another 11 species are aquatic species,6 are birds of prey and 8 are forest/ woodland species. In other words the decline has happened in all the major habitat types.
d. The number of bird-watchers, birders and bird-experts has multiplied by almost 250 times between 1970 and 2012.
e. The availability of literature meant for studying birds is also very high today, with 13 multicolored guidebooks easily available in the market.

Table 8.9: Changes in Population status, Species wise.

Changing population status	**Number of species**	**% of species ineach category**
Increase in population	49	20.58
Decline in population	36	15.12
Stable population	147	61.76
Introduced species	06	2.52
Extinct/locally extinct species	--	----
Total	**238**	**99.98**
Addition of new species	11	

Chapter 9

Threats to Avifauna and Impact Assessment

9.1 Introduction:

The study area has two most important cities of India at the two ends, Mumbai and Pune. Though these two cities are separated by the Western Ghats ranges, the impact of the cities is felt throughout.

Though there is a long history of human civilization in the study area, the major impact ensued only after the takeover of the region by the British during 1810s'. The major events that took place in the study area and that have impact on the wildlife in general and the avifauna in particular are;

- The arrival of and the establishment of the British rule in the region during the late 18^{th} and the early 19^{th} centuries
- The development of the Mumbai as a major port, trade and industrial city.
- The building of the Panvel-Pune road was built in the last decade of the 18^{th} and the 1^{st} two decades of the 19^{th} centuries, by the British.
- Establishment of the military station at Pune.
- Pune being made the monsoon capital of the then Bombay Presidency.
- The first railway line in India was opened between Mumbai and Thane in 1853.This line was further extended into the inland areas of the Peninsula through the ghat section of Kasara and Khandala. The Khandala-Pune line was opened for traffic in 1858. (Gazetteer of Bombay Presidency: Poona District, Vol. XVII,Pt-II,Pg.159).
- Development of Pune as a major education hub, following the establishment of many educational and research institutes and universities (1830's onwards, till day)
- Establishment of hill stations and hill towns in the region, starting with Mahabaleshwar (1829), through Lonavla-Khandal (1820's-30's), Matheran (1850), Amby valley (1990's) and Lavasa (2000 onwards)
- Establishment of Pune as 'Pensioners' city'. (1920's onwards)
- Development of dams, canals and multi-purpose projects, especially in the Ghats country (starting with the Khadakwasla dam and the Mutha canal system in 1878)

- Development of manufacturing industries and industrial estates around Pune(1960s onwards)
- Development of IT industry around Pune (1990s onwards)
- Explosive urbanization of the region (Mumbai, Thane, Navi Mumbai, Pimpri-Chinchwad, Pune etc.)
- Recreational activities including religious visits, trekking and hiking, hill station tourism etc.
- Farm-housing culture (1980s onwards)

9.2 Impacting Factors:

The present chapter aims at assessing the impact of various man-made and man-induced activities including climate change; on the avifauna of the region .The purpose is to identify major and minor impacting factors. This information will be useful in planning and conservation of the wildlife in general and the avifauna in particular, especially in mitigation planning.

The major impacting factors:

The major impacting factors called drivers (modified after Nalavade 2003) have been identified as follows:

a. Urbanization
b. Industrialization
c. Population growth
d. Transportation and traffic
e. Dams, reservoirs and multi-purpose projects
f. Recreational activities and tourism
g. Agricultural activities (including livestock culture)
h. Loss of and degradation of habitats
i. *Raab* practice and forest fires
j. MFP collection
k. Hunting, poaching and trapping of birds, road kills and accidental deaths
l. Domestic cats and dogs menace
m. Explosive growth in scavenger bird population
n. Pollution
o. Mining and quarrying activities

a. **Urbanization:** The Mumbai-Pune belt is one of the most urbanized regions of India. Out of the 21 municipal corporations in Maharashtra, 10 municipal corporations lie in the study area.

The urban sprawl of Pune city was mere 5 sq.km.in 1817.In 1997,it had grown to about 700 km.(Nalavade 2000-01).The population of Pune urban area also grew from 1.64 lakhs in 1901 to more than 42 lakhs in 2001(Nalavade 2000-01).The area notified under the proposed Pune Metropolitan Area is 9220 sq.km., which is 58.94% of the total district area. Mumbai Metropolitan Region also covers 4355 sq.km.

b. **Industrialization:** The Mumbai-Pune belt is one of the most industrialized regions of the country. The industrialization in the region started ay back in 1850's when the first cotton started in Mumbai (Sharma & Coutinho 1977). The other manufacturing industries developed there in 1940s and 1950s, whereas industrial development around Pune began in 1960's. Today out of the total 229 industrial areas developed by the MIDC, 42 (18.34%)are in the study area. Pune alone has 18 industrial areas whereas Thane and Raigad together have another 18 industrial areas.

c. **Population growth:** The study area covers six districts of Mumbai city, Mumbai suburbs, Thane Raigad, Pune and Satara. The total population of all the districts was 1,07,60,574 (1.07 crores) in 1961 (Census of India 1961,Vol.X,part II-A). (In 1961 Mumbai city and Mumbai suburb were one district of Greater Bombay).The population of the same area as per the 2011 census is 3,85,98,853 (3.85 crores) (www.censusindia.gov.in/2011). The population of the region has multiplied 3.58 times within the last 50 years .The population density of Greater Bombay in 1961 was 9480 persons per sq.km. The population density figures for both Mumbai city and Mumbai suburb as per the 2011 population census were 20038 and 20925 persons per sq.km. The population density of Thane has gone up from 180 (in 1961) to 1157 persons per.sq.km.in 2011.The figures for Pune district are 158 in 1961 to 603 in 2011.Large,rising population always exert pressure on natural resources like land, water, forest and wildlife etc.

d. **Transportation and traffic:** The first railway line in India was opened between Mumbai and Thane in 1853.This line was further extended into

the inland areas of the Peninsula through the ghat section of Kasara and Khandala. The Khandala-Pune line was opened for traffic in 1858. (Gazetteer of Bombay Presidency: Poona District, 1885.Vol XVII,Pt-II,Pg.159). The building of the Panvel-Pune road was built in the last decade of the 18th and the 1st two decades of the 19th centuries, by the British (Ibid, 1885). In due course of time, after independence, new third railway line was added between Khandala and Karjat.The Pune-Mumbai Express highway was opened to traffic in 2000.As on today the Express highway handles about 43000 PCUs (Passenger Car Unit) every day. Six national highways: Mumbai-Pune-Bangaluru (NH-4), Mumbai-Ahmedabad-Delhi (N.H.8), Panvel (Mumbai)-Goa-Mangalore (N.H.17), Mumbai-Agra (N.H.3), Pune-Solapur-Hydrabad (N.H.9) and Pune-Nashik (N.H.50) pass through the study area.Pune-Mumbai corridor is served by two major arteries 1) The old Mumbai-Pune highway(part of NH 4) and the Mumbai-Pune Expressway.

e. **Dams, reservoirs and multi-purpose projects:** During the British era, eight major dam projects were completed, out of which four are in the study area. All of them are in the Ghats country. During the five-year plan period, 12 major projects were completed.4 of which are in the study area. Of the 34 on-going projects in the state, 14 are in the study area. (Dastane 2004).Koyna, the largest hydel-power project in the state, is on the periphery of the study area. While all dam projects have been responsible for clearing and submerging natural forest, grassland and farmland worth millions of hectares, some reservoirs have provided wetland habitats and have attracted thousands of waterfowls and wetland birds belonging to hundreds of species. There are a series of dams and reservoirs along the Pune-Solpaur highway, which are hotspots of wintering and wetland birds.(For example Ujani)

f. **Recreational activities and tourism:** The history of religious tourism is many centuries old. The study area houses one of the 12 Jyotirlingams (Bhimashankar). It also houses all the eight ‘Ashtavinayak’ places. The most sacred places of the ‘Varkari samprday’, Alandi and Dehu, are part of Pune urban area. Scores of beaches along the Thane, Mumbai and Raigad districts attract millions of tourists every year. Out of the 34 groups of

rock-cut caves (lene in Marathi) in Maharashtra, 25 groups (about 1000 caves out of 1200) are within the limits of the study area (Joglekar 1952).Similarly out of the 351 forts that lie in western Maharashtra, about 110 forts (31.34%)lie within 18° N to 19.5° N, which more or less coincides with the study area. Trekking is so popular in the belt that there are 200 trekking clubs in Pune alone (G. Sapkal, pers. comm.) Some hill stations from the study area (for example Mahabaleshwar and Khandala), date back to 1820s.The only two new hill towns of the state, that have come up during the recent times (Amby valley and Lavasa) are in the heart of the study area. There is one national park, and six wildlife sanctuaries within the study area. The wildlife tourism, especially the bird tourism is quite a popular activity. The membership of the following groups on the Facebook (as on 21st May 2013) shows how popular bird-watching, bird study and bird photography are in the study area: Birds of Mumbai (1060 members), Birds of Thane & Raigad (1054 members) and Pune Birds (2456 members).

g. **Agricultural activities (including livestock culture):** In spite of heavy industrialization, agriculture is still the major economic activity of the region. Mumbai city and suburban districts are without any gross-cropped area (GCA). The total area of Pune, Thane, and Raigad and Satara districts is 42406 km2 out of which 22835 km2. (53.84%) is gross cropped area. District wise, Pune has highest percentage (73.68%) under GCA, followed by Satara (62.99%), Raigad (31.37%) and Thane (26.84%) (www.mahaagri.gov.in). The higher proportion in Pune and Satara district is largely due to flat terrain, good quality farmland soil and better irrigation facilities. The lower percentage in Thane and Raigad is partly due to rugged terrain, lower soil fertility (dominated by laterite) and high rate of conversion of agricultural areas into non-agricultural land use.

The total bovine population (cattle + buffaloes) of the four concerned districts is 2696838 (2.69 million) as per 2007 livestock census (dahd.nic.in).This comes to 63.59 bovines per sq.km. The data show that the bovine population has been decreasing. Raigad had 4,88,880 bovines in 1955-56, which came down to 3,65,606 in 2007 (25.21% reduction in about 50 years).Satara also returned 760204 bovines in 1956 (Satara

District Gazetteer, 1963 Revised edition),which got reduced to 540812 in 2007, a 28.86% reduction in 50 years.

h. Loss of and degradation of habitats: Urbanization, industrialization, transportation development, tourism etc. have either reduced or degraded various different habitats in the area. Some changes in vegetation and flora of the region are:

1) Loss of native plants and increasing proportion of exotic species: Some prominent examples of replacement of native species with exotic species are shown in following table.

Table 9.1: Replacement of Native plant species with Exotic species

Native plant species	**Exotic plant species which replaced the native plant**	**Places where the change was observed**
Pan-kanis (Typha angustata)	Besharmi (Ipomea aquatic)	Pashan lake
Takla (Cassia tora)	I (Parthenium sp.)	Most hills around Pune, open plots, railway track
Karanda (Carissa carandas)	Tantani (Lantana sp.)	Mostly in the Maval belt, Sinhagad

2) Loss of orchard from the fringe areas of the City: The adjoining talukas and the outskirts of the city were once known for guava, lemon and fig orchards, most of which are now totally replaced.

3) Disappearance of banyan avenues: All the major roads, including the highways which started from Pune, were once lined with Ficus and neem trees on the either side. The canopy of the trees formed green tunnels all along. The trees were removed in late 1970s and early 1980s, when the roads were widened for further development.

4) Disappearance of babul bans / karanj rai / mango topes (Aamrai) / shindi bans (clumps): All of these are native trees. They once dominated the vegetation of the city. Following table shows the changes.

Table 9.2: Major Disappearing Habitats from around Pune

Types of groves/clumps	Places where found in the past	Reference
Babul bans (Acacia nelotica groves)	Open grass & scrub country on the eastern outskirts.(Ahmednagar and Solapur highways) Hill tops (Parvati-Panchgaon till 1970s)	
Karanj rais(Pongamia pinnata groves)	Mostly along rivers , streams and canals Some old Pongamia trees still survives as remnants of old groves along the presently filled-in Mutha right bank canal	Present study
Aamrais (Mango topes)	On the city outskirts. Many along the Pune-Sinhagad road till 1970's	Present study
Shindi bans (Wild-date palm groves)	Along rivers and streams .Ambil odha banks till 1970s.	Present study

5) Loss of "*paars*": A '*paar*' is tree with round or square-shaped platform built around it. Pune city was once known for its paars. Almost every ward had a paar around old, tall trees, mostly belonging to Ficus species (Banian, Peepul, Umbar etc.), Tamarind, Mango etc. Pune once had more than 40 paars (S.D.Mahajan, pers. comm.). Today hardly about a dozen *paars* survive. *Paars* functioned like micro-sanctuaries and attracted as many as 35 bird species for feeding, resting, roosting, nesting etc.

6) Conversion of 'wada' (traditional mansion) type house into an apartment building has changed the micro-ecology of the city. While wadas provided niches (holes, cavities, cracks, ledges, hedges etc.) for insects, reptiles, small mammals and birds, modern apartment buildings provide limited niches. The present study found that a wada could support 28 species of birds; a modern apartment building can support only about 15 species of birds.

7) 'Kumri' practice of cultivation: Kumri is a type of shifting cultivation found all along the Western Ghats of Maharashtra. It was common in the past, but has become less important now-a-days partly because of

legal ban on it and partly because better farmland practices are available. It is still marginally practiced at Bhimashankar, Panshet and Koyna areas in the study area.

i) **Raab practice and forest fires:** Molesworth's dictionary (1986 reprint) describes 'raab' as follows-Ground burned in preparation for the seed: also the crop raised on ground so prepared: also lopping, leaves, grass, rubbish used in burning the ground. Raab is a farming practice commonly followed in western Maharashtra. It " involves lopping and burning of branches, leaves, grass etc. and its layered burning in the field-a precursor for preparation on the seed" (Nalavade,2003). Lopping of branches, twigs, leaves etc. is partly responsible for degradation of forest in the environs. Sometimes fire in the field goes out of control and is responsible for large forest fires. Ground fires are responsible for destruction of ground flora and fauna, including eggs and chicks of ground nesting birds like quails, partridges, pipits, larks, lapwings etc. A survey done in parts of Maval taluka of Pune district revealed that 75 to 90 per cent hill-slopes were affected by forest fires. (Nalavade, 2003). A study about Pune Metropolitan area (Nalavade 2000-01) revealed that between 1967 and 1998, the area under settlement increased 2.36 times, whereas areas under agriculture and grass & scrub country decreased by 31.26% and 39.24% respectively.

j. MFP collection: The MFP (Minor Forest Collection) includes collection of firewood, fruits, nuts, seeds, leaves, bark, gum, medicinal plants etc. (Table 9.3)

Table 9.3: MFP (Minor Forest Produce) Collection

MFP type	Places where collected	Remark
Firewood	Almost every village in the study area, Practiced in slums and hutment colonies located around hills in Pune	Main flows of firewood trade(Nalavade 2003) a) Karjat-Neral to Kalyan and Thane b) Khandala Ghats-Lonavla-Malavli to Vadgaon Maval and Pimpri
Hirda nuts (Terminalia chebula)	Bhimashankar region	Collected on individual basis and also by cooperative societies.
Karvi (Carvia callossa) sticks	Matheran, Bhimashankar and Mahabaleshwar	Used as packaging material
Jamun (Syzygium cumini) and Karvand(Carissa carandas) berries	Lonavla-Khandala and Matheran environs	Mostly collected by local tribals meant for selling to tourists and visitors.
Medicinal plants	Matheran, Bhimashankar and Mahabaleshwar	Collected by city-based traders through tribals etc.

It was found that about 750 tons of firewood was traded every year at the Vadgaon Maval market (Nalavade 2003), whereas the annual trade at Mahabaleshwar was worth 1200 tons (Nalavade 1986).

k. Hunting, poaching and trapping of birds, roadkills and accidental deaths: During the British times hunting was a major past time of British civil and military officers as well as Indian rajahs, maharajahs and nababs. Common people from remote rural and forested areas would also hunt occasionally. Hunting has been totally banned in India since 1970. But poaching (illegal hunting) continues in every nook and corner of the state, except a few protected areas. Hunting and poaching data collected from various sources including interviews with former hunters, revealed 93 cases of bird hunting and poaching. (Table 9.4)

Table 9.4: Hunting and Poaching data

Bird group/family hunted-poached	No. of species	Details of species under the group	% of cases	Remark
Phasianids birds	12 species	Peafowls, junglefowls, spurfowls, partridges, quails etc.	40.86%	Partridges top the list followed by peafowl our national bird.
Waterfowls waders and wetland birds	36 species	Egrets, herons, waterhens, grebe. Shanks, flamingoes, storks, cranes cormorants, etc.	34.40%	Most persecuted are the ducks followed by snipes, waterhens & herons
Doves and pigeons	9 species	Doves, pigeons, green pigeons	15%	The single largest group to be hunted
Other miscellaneous birds	12 species	Sandgrouse, great bustard,owls, hawks, kingfishers etc.	9.67%	2 species of Sandgrouse most hunted
		Total	**99.93%**	

Most of the birds mentioned in the table are killed for meat. Very few like owls are killed for black magic etc.

In spite of legal ban a large number of birds belonging to more than 100 species are still traded across the country. Mumbai has been one of the six major bird markets in the country (the other five being Kolkata, Delhi, Hyderabad, Chennai and Bangalore).Birds which are traded here are mostly pet birds. These include parakeets, munias, mynas and starlings, finches, sparrows and weaverbirds, quails and partridges. Most of these birds are trapped in northern and north-eastern parts of the country. A limited trapping is also done in Maharashtra, especially in Vidarbha. There are few instances of bird trappings from the study area also.

Other threats include road kills, poisoning, killed by kite-string. Compare to reptiles and mammals, very few birds have been found to be involved in road accidents. That is mainly because of their flying ability which saves them from being run over or hit by passing vehicles. Birds which have been involved in road kills/accidents are: rock pigeons, house sparrows, munias, prinias, mynas, sunbirds and an occasional coucal and crows. Poisoning and electrocution are rare causes of death among birds in the study area.

Injury from kite-string has been a rising cause of concern, especially in urban areas. Fortunately for birds, kite-flying is not a year-round activity and is confined to a few auspicious days (like Sankranti day) only. Also it is celebrated only in Mumbai and to some extent in Pune, where most injury cases are reported from. A detailed report, about injuries to birds on kite-flying day, which appeared in 'Pudhari', a local vernacular newspaper on 15th January 2010, revealed that there were 116 cases of bird injuries treated by some NGOs in Mumbai on one single day. Out of the 116 cases, 102 happened to be the rock pigeons, the commonest bird of Mumbai. Other injured species included rose-ringed parakeet, kites, koel, mynas, owls, house sparrows, and an occasional crow.

l. **Domestic cats and dogs menace:** The role of stray cats is already been discussed in chapter 8. So far as stray dogs are concerned, it is serious a problem as that of cats. As per the statistics provided by the Pune Municipal Corporation health department, there were approximately 40000 stray dogs in Pune in 2011.The number had gone up from 35000 in 2008.The dog population density for the whole city was then 162.6 dogs per one km2 or 1.62.dogs per hectare in 2010-11.Stray dogs are a threat to ground nesting birds, their eggs and chicks. The menace of stray dogs is evident at the Bhamburda (Vetal hill) and Parvati-Panchgaon forest parks. Both the parks are on hill top. Both of them have adjoining slum areas. Because of open dumping and improper management of garbage, the leftover food is easily available. The result is very high dog density. In a hutment colony adjoining the Vetal hill the dog density in 2012 was found to be 3.33 dogs per hectare, twice the average city density. At the Vetal hill stray dogs have been found to consume peafowl eggs and chicks on regular basis. In spite full protection, the peafowl population at the Vetal hill has declined since

1990. Around 1990, there used to be about 300 plus peafowls at the Park, today (2012) the number has gone down to about 100.The author suspects that this decline has been largely due to strays. The same is the case with other ground nesting birds like pipits, larks, Indian robin, yellow-wattled and red-wattled lapwings etc.

m. **Explosive growth in scavenger bird population:** This issue too was discussed in chapter 8 with length.

n. **Pollution:** The Mumbai-Pune belt is a heavily polluted region of the state. It is high on every type of pollution-air, water, soil, sound. Pollution is a composite outcome of urbanization, industrialization, modern agriculture, tourism, vehicular traffic, raab practice etc. The rivers (Mula-Mutha and Pawna), and the creeks (Thane and Dharamtar), are heavily polluted. Mumbai is 4th city in India in production of hazardous plastic waste. As per the combined survey by the CPCB and IIT-Delhi in 2011 of 88 industrial clusters in India, Dombivli is the 14th among the most polluted industrial clusters in the country and 2st in the state after Chandrapur (cpbc.nic.in).More than air pollution, it is the water pollution that affects the birds most. Water pollution depletes fish fauna, which in turn impacts the bird diversity and population. The levels of sound pollution are also very high in Mumbai and Pune, with many traffic junctions showing noise level of more than 80 dcbl. The bursting of fire crackers, which in the past was confined to Diwali days only, has become an year-round activity. Most birds are disturbed by bursting of firecrackers. The garbage generated per day is about 5000 tons in Mumbai and 1200 tons in Pune (PMC-ESR, 2007-08). Rising garbage quantity has been responsible for rapid increase in scavenger birds' population.

o. **Mining and quarrying activities:** The Mumbai-Pune belt is not known for any minerals except stone metal. The stone quarries, functional and abandoned are a common feature of the region. In Navi Mumbai, hill after hills are quarried for stone. Around Pune, Pashan and Chinchwad are the areas known for stone quarries. Some abandoned quarries, like the one at the Vetal hill, has now been converted into an ecosystem which is part rocky, part wetland and therefore attracts a diversity of water birds and rock-associated species.

The major impacted elements:

The above-listed drivers impact birds as a group or birds on species level. If birds are grouped into convenient categories, the impact of drivers can be understood clearly. The bird groups categorized are:

1. Forest and woodland birds
2. Scrub and grassland birds
3. Aquatic and wetland birds
4. Urban birds
5. Farmland birds

9.3 Impact Matrix:

The impact of the drivers on the bird group categories was achieved through a matrix. A matrix was arranged with drivers on one axis and the bird groups on the other axis. Each bird group was judged against each driver. The intensity of impact was arrived at by assigning a certain score (weightage) to each bird group. The range of score is expressed numerically on a scale ranging from 0 to 5. [modified after Nalavade(2003)] Where:

0: No impact.

1: Insignificant impact: There is very weak relation between driver and bird group.

2: Low impact: The Impact may not be clearly recognizable to a layman unless observed /watched carefully.

3: Moderate impact: The impact is visible but not threatening to the birds/bird group.

4: High Impact: The impact level is such that the diversity and population level of the species/group of species is likely to suffer.

5: Very high Impact: The impact level is so intense; the species/group of species concerned is already threatened or is likely to become critical in the near future.

The drivers (impactee) are arranged on the Y-axis and the impacted (bird groups) are arranged on X-axis. In all there are 15 drivers and five bird groups. The impact of each driver on the concerned bird group is judged on the basis of actual field observations, field experience of the author supported by some primary and secondary data collected during the study period. Thus every square was assigned a

score on this basis. Total score for every driver (columns total) and every bird group (row total) was also calculated (Table 9.5). On the basis of the total score two separate matrices were developed, one for the drivers (Table 9.6), another for the bird groups (Table 9.7). If two or more drivers show the same score, then they were ranked on the basis of the personal perception of the author.

Table 9.5: Impact of drivers on Bird groups

Bird groups ---→ Impacting | Drivers | V	**Forest & woodland birds**	**Scrub & grassland birds**	**Aquatic & wetland birds**	**Urban birds**	**Farmland birds**	**Total score**
Urbanization	4	5	4	3	4	20
Industrialization	3	3	4	4	3	17
Population growth	3	3	4	4	3	17
Transportation and traffic	2	2	1	4	3	12
Dams, reservoirs and multi-purpose projects	4	1	1	1	3	10
Recreational activities and tourism	4	1	4	4	3	16
Agricultural activities (including livestock culture)	3	3	3	1	1	11
Loss of and degradation of habitats	5	5	4	4	4	22
Raab practice and forest fires	4	4	0	1	5	14
MFP collection	3	1	0	1	2	07
Hunting, poaching and trapping of birds, roadkills and accidental deaths	3	3	4	1	3	14
Explosive growth in scavenger bird population	0	1	1	4	0	06
Domestic cats and dogs menace	0	1	1	4	2	08
Pollution	1	2	4	4	3	14
Mining and quarrying activities	2	2	3	3	1	11
Total	**41**	**37**	**38**	**43**	**40**	**199**

After arranging the above data in descending order on the basis of rank, we get the following figures.

Table 9.6: Ranking of drivers

Driver	**Rank**	**Score**	**% score**
Loss of and degradation of habitats	1	22	11.05
Urbanization	2	20	10.05
Population growth	3	17	8.54
Industrialization	4	17	8.54
Recreational activities and tourism	5	16	8.04
Pollution	6	14	7.03
Raab practice and forest fires	7	14	7.03
Hunting, poaching and trapping of birds, road kills and accidental deaths	8	14	7.03
Transportation and traffic	9	12	6.03
Agricultural activities (including livestock culture)	10	11	5.52
Mining and quarrying activities	11	11	5.52
Dams, reservoirs and multi-purpose projects	12	10	5.02
Domestic cats and dogs menace	13	08	4.02
MFP collection	14	07	3.51
Explosive growth in scavenger bird population	15	06	3.01
Total score		**199**	**99.94**

On the basis of level of impact we can further classify the drivers into three impact categories

- High impact category: Impact score 17 to 22
- Moderate impact category: Impact score 11 to 16
- Low impact category: Impact score 5 to 10

Table 9.7: Grouping of drivers on the basis of Impact level

Impact category	Driver	% contribution
High	Loss of and degradation of habitats Urbanization Population growth Industrialization	38.18
Moderate	Recreational activities and tourism Pollution *Raab* practice and forest fires Hunting, poaching and trapping of birds, roadkills and accidental deaths Transportation and traffic Agricultural activities Mining and quarrying activities	46.20
Low	Dams, reservoirs and multi-purpose projects Domestic cats and dogs menace MFP collection Explosive growth in scavenger bird population	15.56
		99.94

Table 9.8: Ranking of Bird groups according to Impact

Bird group	Ranking	Score	% score
Urban birds	1	43	21.60
Forest & Woodland birds	2	41	20.60
Farmland birds	3	40	20.10
Aquatic & wetland birds	4	38	19.09
Scrub & grassland birds	5	37	18.59
Total		**199**	**99.98**

9.4 Interpretation:

The resultant matrices throw some light on the relative importance and impact of the drivers and relative effect on the bird groups.

a. Among all the drivers, Loss of and degradation of habitats , is the driver with the highest impact score (22) followed by Urbanization (20), Population growth (17), Industrialization (17), Recreational activities-tourism (16), Pollution (14), *Raab* practice-forest fires (14), Hunting-poaching etc(14),

Transportation and traffic (12), Agricultural activities(11),Mining-Quarrying (11), Dams etc. (10), Domestic cat/dog menace (08), MFP collection (07) and growth in scavenger birds (06).

b. It is obvious that habitat loss and degradation, urbanization, population explosion, industrialization and recreational activities are the top most five influential drivers.

c. On the basis of impact category, four drivers fall under the High Impact category (38.18%), seven in Moderate Impact category (46.20%) and four in Low Impact category (15.56%).**From conservation point of view ,the situation is still within control, and we still have chance to save and preserve most species.**

d. All the drivers can be conveniently grouped into three categories as

1) Urban drivers
2) Rural drivers
3) Rural-urban drivers.

Six drivers: Urbanization, Population growth, Industrialization, Pollution, Domestic cats-dogs menace and growth of scavenger birds, are dominantly urban. Five drivers: *Raab* practice & forest fires, Hunting-poaching etc., Agricultural activities, Dams, reservoirs etc., and MFP collection are dominantly rural. Four drivers, found in both urban and rural areas, hence called 'Rural-urban', are: Loss of & degradation of habitats, Recreational activities & tourism, Transportation & traffic and Mining-quarrying activities.

e. If we go by the percentage impact, the urban drivers are the ones with the highest impact (41.19%), followed by 'rural-urban' drivers (30.64%) and rural drivers (28.11%).The combined score of the urban and rural-urban drivers is 71.83%. This is obvious considering the dominantly urban and semi-urban character of the study area.

f. The lowest score (<10) is shown by three drivers viz. domestic cats-dogs menace (08), MFP collection (07) and growth of scavenger birds06). Domestic cats-dogs menace and scavenger bird problem are mostly confined to urban areas of Pune & Mumbai, hence the low impact score. Except Thane rural, and Raigad south, the study area has very low percentage of forest cover ranging from 12 to 16 per cent. (Pune-13.29%., Satara-14.71%, Southern Thane-16%)

(www.mahaforest.nic.in). the forest in the study area is already highly degraded.

g. The most impacted bird group is the urban birds for the obvious reasons. The area is already highly urbanized and rate of growth of urban population has been high. The decadal growth rate (2001-11) of urban population for Pune has been 22.64% for Pune municipal corporation area and staggeringly high 63.11% for Pimpri-Chinchwad municipal corporation area. Thane city for the same period has shown 44.18% population increase (www.censusindia.gov.in) The urban changes are rapid and have deeper impact on the environment. Urban birds have to adapt to the faster changes. The next group is the Forest & woodland birds. The Ghats country, which forms the core of the study area, once supported dense forest. For various reasons discussed under habitat loss & degradation, the forest cover here has reduced drastically. The continuity of the forest cover has been breached by transport lines, expanding hill stations, new hill towns and farm houses. The result has been fragmentation of contiguous forest habitat. The once peaceful ambience is a history now. Millions of tourist, trekkers, hikers, wildfires, and pilgrims visit the Ghats country every year. So there is some pressure on forest birds. They are either moving away from hill stations or are reduced in numbers, as is shown by their lowering frequency of sighting. Farmland birds are next in the line of impact. Farmlands and agricultural areas around all the towns and cities in the study area have been making way for new suburbs, housing colonies, hutment colonies, roads and other urban features. With this conversion in land use, the farmland birds have also made way for urban birds. Aquatic & wetland birds and Scrub & grassland birds are the least impacted bird groups in the study area. In spite some wetlands being reclaimed and many being heavily polluted, this negative impact was offset by addition of many ponds, lakes and reservoirs in the area. The major addition being the Ujani backwaters in 1980.The surface area of the reservoir is 370 km^2 most of which is shallow. The lake area supports 160 bird species, 85 of which are aquatic (Bharucha & Gogte 1990).It is amazing to note that within 10 years of its inception, the lake started attracting 80 plus aquatic birds. Many such small and medium-sized lakes have come up in the region, most of which attract and support resident as well wintering aquatic birds. Many lakes are owned privately (Tata Lake at

Pimpri) or belong to defense ministry (CME lakes at Dapodi). This automatically provides protection to the birds, the level of poaching at the government lakes is also low to moderate. Frequent visits and presence of bird-watchers and bird photographers also make them partially immune from poachers. This is why aquatic birds are least affected. Another set of birds, which is least affected are the scrub & grassland birds. Pune region lies in the transition zone between the humid Ghats country and the drought-prone Deccan plateau. Most area to the east of Pune is semi-arid with grass & scrub as the dominant vegetation. In spite of large areas of 'maalraan' brought under cultivation, housing, settlement and industries near Pune, areas worth hundreds of kilometers are still under grass & scrub type of country in Purandar, Shirur and Daund talukas of Pune district. They still support pipits, larks, lapwings, courser, thick-knees, harriers and eagles.

9.5 Impact of climate change and global warming:

Various different studies have already been done, or are still going on, world over, on the possible impact of global warming on biodiversity and wildlife in general and birds in particular. Why the present study does not take into consideration this factor?

The reasons are:

- Climate change and global warming is still a nascent and highly debatable science.
- So many different scenarios and models have been predicted, that it becomes difficult to choose one close to reality.
- For India as a whole, the predictions, for example, range from marginal increase to marginal decrease in monsoon.
- There are many different possible scenarios/models predicted for the northern Western Ghats. Which one is the correct model to work on?

PLATE 9.1 : MAJOR THREATS TO BIRDS



HABITAT DESTRUCTION & DEGRADATION:

FOREST THINNING NEAR VARSAI, DIST.RAIGAD



URBAIZATION

EXPLOSIVE GROWTH OF PUNE URBAN AREA



RECREATIONAL ACTIVITIES: BEACH TOURISM, GANAPTI PULE, RATNAGIRI



POLLUTION: GARBAGE DUMPING INSIDE FOREST PARK, P.PANCHGAON, PUNE



FOREST FIRE: BHIMASHANKAR WILDLIFE SANCTUARY, PUNE-THANE



EXPLOSIVE GROWTH OF SCAVENGER BIRDS: CROWS DOMINATING A STREET

Chapter 10

Conclusion and Suggestions

10.1 Introduction:

In its simplest meaning, conservation is the protection of the natural resources. As per Jones and others (1990),"Conservation is the management, protection and preservation of the earth's natural resources and environment." The final aim of conservation is to achieve long-term sustainability. This is achieved through active, little or no (deliberate absence of) management.

Preservation and restoration are part of conservation. Preservation involves maintaining something-an ancient man-made structure, an endangered natural habitat, a unique geological landform etc. in its original state. Restoration involves returning a natural habitat to its previous condition, through reestablishing ecological processes and functions.

10.2 What is Wildlife Management?

Management is the first step in conservation. Presently both the 'wildlife conservation' and 'wildlife management' are used as synonymous terms. Many scientists now prefer to use 'wildlife management'. Leopold (1933, quoted by Shaw 1985) was one of the earliest to define wildlife management. He used the term 'game' instead of 'wildlife'. As per Leopold -"Game management is the art of making land produce sustained annual crops of wild game for recreational use". According to Olson (1980) wildlife conservation (management) is "The science and art of making decisions and taking actions to manipulate the structure, dynamics, and relations of wild animal populations, habitats, and people to achieve specific human benefits from the wildlife resource." A more simple definition is given by White (2004) (www.afrc.uamont.edu) which reads-"Wildlife management is the science and art of managing wildlife, their habitats, and ecosystems for long term human benefits."

10.2.1 Aims of wildlife management.

a. To lessen the loss of biodiversity
b. To preserve and improve habitats
c. To balance the needs of wildlife with those of people
d. To maintain wildlife population at sustainable level.

10.3 A Conclusive Overview:

A. Bird Diversity:

- The study area has 484 species of birds. This is almost 93 per cent of the bird fauna of the whole state and 40 per cent of the bird fauna of the Indian Subcontinent.
- Highest bird diversity is found in two belts, the coastal belt and the Western Ghats belt.
- The bird diversity drops towards the east of the Ghats country.
- There are two areas with the highest winter bird diversity: the Mumbai suburban (west) and the Ujani backwater.
- The number of resident forest birds goes on decreasing from south to north along the Western Ghats.

B. Distributional Aspect:

- The Monsoon wind and the Somali jet stream play an important role in transporting pied cuckoo and the pelagic birds from Eastern Africa/western Indian Ocean to India.
- Among all the factors affecting distribution of birds-Climate, vegetation and human impact seem to be the most impacting and deciding factors.

C. Faunal Affinity and Interchange:

- The Study area has closer **avifaunal affinity** with the Eastern Ghats, followed by the NW India & NE India.
- The quantum of **avifaunal interchange** between the study area and the two regions viz. the Eastern Ghats & the North-east is almost same, though the interchange is slightly more in case of the Eastern Ghats. The interchange between the study area and the North-west is relatively low compare to the other two regions. The maximum interchange between the study area and Eastern Ghats is obvious because of their geographical proximity & similarity in latitudinal location, climate and vegetation.

- The Eastern element (Indo-Chinese & Malayan) is dominant in the avifauna of the Study area, (Most of which are forest birds). The Northern (Palearctic) element is the next dominant group (Most of which are winter migratory).The Western (African-Mediterranean-west Asian) elements share least of all the foreign element.
- The local endemicity is very low with only 14 endemic species (3.0%).A large proportion (18.94%-86 species) of birds are uncertain in origin & therefore in affinity. A small proportion of birds are cosmopolitan (6 species-1.32%) and pelagic (8 species-1.76%).

D. Dispersal Highways:

- There are four secondary gateways for the eastern faunal element to enter and spread to the peninsular India
    1. Chittagong hills-Sundarbans
    2. Garo hills-Rajmahal hills
    3. Darjiling hills –Rajmahal hills
    4. Himalyan-Aravli range.

- The Eastern Ghats seems to be the most preferred dispersal highway by birds of Indo-Chinese/Malayan affinity. The Satpura highway is the next preferred dispersal highway after the Eastern Ghats.
- A quarter of the species seem to have used two routes for dispersal.
- A few species are likely to have used more than two routes for dispersal.
- The Aravali seems to be the least preferred dispersal highway.
- The study area shows 12 different patterns of distribution.

E. Patterns of Distribution:

- A comparison of seven patterns for which definite data are available shows that continuous distribution is the most dominant pattern (47.60%), followed by elongated pattern (35.79%), Uncertain pattern(7.38%), Narrowly restricted (4.43%), Fragmented (4.43%) and Perforated (0.37%). The domination of continuous pattern shows that

the proportion of species with wide tolerance is high in the avifauna of the region. A high proportion of species showing elongated pattern, indicates the role played by the coastline and the Western Ghats range, in dictating the distributional pattern.

F. Changes in Avifauna:

- So far six species have been introduced in the study area through human agency during the last 80 years. (since 1930s)
- Eleven species that have been added into the avifauna of the region through natural process of dispersal,
- There has been a progressive increase in the number of bird species reported from Pune city region. The number goes up from 153 species in 1972 to 310 species in 2010.
- Out of the 238 species for which definite trends are available 147 species (61.76%) show stable population trend.
- In all 49 species (20.58%) show increasing trend. Most of these are commensal of man, are scavengers, and have easily adapted to rapidly changing urban environment.
- Thirty six species (15.12%) are showing declining population trend. The decline has happened in all the major habitat types.

G. Threats & Impacts:

- Habitat loss and degradation, urbanization, population explosion, industrialization and recreational activities are the top most five influential drivers threatening the avifauna of the area.
- Domestic cat/dog menace, MFP collection and growth in scavenger birds are the least impacting drivers.
- The most impacted bird group is the urban birds. The Forest & woodland birds, and the Farmland birds are the next impacted.
- The least impacted bird groups are the Aquatic & wetland birds and the Scrub & grassland birds.
- In spite of high impact it is possible to protect and conserve 90% of the bird fauna of the study area.

10.4 Why conserve birds?

Birds are an important fundamental element of the environment. Over the last 200 or so years, many animals including birds have become extinct or rare, thanks to human activities. It is the moral and ethical responsibility of human beings that they save many species from becoming extinct.

Wildlife in general and birds in particular, are important from the economic and other points of view. Wildlife (including birds) carries positive as well as negative values (Shaw 1985).

A) The positive values are:

I. Aesthetic values
II. Recreational values
III. Ecological values
IV. Educational and scientific values
V. Utilitarian values (Food for man)
VI. Commercial values

B) Negative values are:

I. Accidents
II. Crop damage
III. Disease reservoirs.

A) Positive Values:

I. **Aesthetic values:** These values are concerned with natural beauty and its appreciation. These are largely psychological, and therefore difficult to measure or compare. Emotionally they carry a very high value, and play major role in conservation. Many birds carry beautiful plumage (peafowl), move gracefully (Asian paradise flycatcher moving through branches, peregrine falcon diving on prey, vultures gliding in the sky), either sing or utter beautiful notes (white-rumped shama, Malabar whistling thrush, fantails etc.). Birds are subject of art and painting.

II. **Recreational values:** These include those values which are related to sports and hobbies. Hunting has been one of the oldest recreational activities of humans. Hunting is totally banned in India since 1970. But before that date, hunting used to be a common pastime of many elite Indians. The types of birds hunted is already discussed in

chapter 9.Hunting has been replaced by bird-watching now, another very popular recreational activity. According to one estimate (Purandare & Khare, pers .comm.) there may be around 10,000 birdwatchers in Pune alone.

III. **Ecological values:** Every bird species plays a specific role within its biological community or ecosystem. These include control of prey population (sparrow-hawk and shikra maintain sparrow population; owl does the same during night by keeping control over rodent population.) Many insectivorous birds maintain the balance by consuming tons of insects. Scavenger birds like vultures, kites and crows "speedily and effectively dispose of carcasses of cattle and other refuse dumped in the precincts of our village that would otherwise putrefy and befoul the air and become veritable culture beds of disease" (Ali,1979). Many species of birds (for example sunbirds) are responsible for cross-pollination of flowers. Ali (1979) noted 60 bird species as cross-pollinating agents. Many birds also play the role of seed dispersal. Many exotic plants have been dispersed in India by our native birds; the best example is the spread of *Lantana* by bulbuls, and *Loranthus* by flowerpeckers. Many smaller birds are food for larger birds, reptiles or mammals.

IV. **Educational and scientific values:** These values are important in teaching and learning about nature. While learning ecological principles, like prey-predator relationship, changes in population, migratory behavior etc. birds are frequently quoted as ideal examples. For example, the winter migration of birds that happens at the global level.

V. **Utilitarian values:** These include practical uses of birds-the main being food (meat and eggs) for humans (for example poultry).Fortunately most birds do not have any medicinal properties. They are also rarely used in bio-medical research compare to mammals. Many birds are ecological and geographical indicators. Canaries were used in coalmines in the past as indicators for presence of poisonous gases. Absence of pied kingfisher from a water-body is an indication that the water-body has been polluted.

VI. **Commercial values:** These values involve some economic returns. Bird as a source of food is already quoted. For some tribes living in forest, some birds (junglefowls, spurfowls, partridges, quails etc.) still form a part of their diet. Kathkaris from the study area still lead a nomadic life and hunt some birds for food. About a century ago, trapping and killing white egrets was a common practice in parts of the then Bombay Presidency. This was done for their feathers which would be exported to Western Europe to be used as decoration material in ladies' garments (Ali 1979).

B) Negative values:

I. **Accidents:** Birds have been responsible for accidents involving aircrafts. Birdhit is one of the major causes of concern around airports in India. It is a serious threat at the Mumbai's Chhatrapati Shivaji International airport, surrounded as it, by slums. Birds are partly destructive to factory equipment and machinery. Crows have been found to be responsible for short-circuiting of power distribution network. In a locality in Kothrud, a suburb of Pune, there was 24 instances of power blackout in one year (2009) thanks to crows' interference in the system.

II. **Crop damage:** At least 30 different species of birds:-sparrows, buntings, munias, pigeons, starlings and mynas, have been held responsible for damaging crops. The rose-colored starling, a passage migrant to our area, has been known to plunder jowar, a local millet.(In the past it used to be called as 'jowar bird')

III. **Disease reservoirs:** Birds are known to carry over sixty transmissible diseases. Bird droppings are responsible for spreading disease when fecal spores from birds nesting on buildings (for example, rock pigeons) enter homes. Besides being direct carriers of disease, pest birds are associated with over 50 kinds of **ectoparasites**. Many of them may infest houses and bite humans (www.bird-x.com).

The above discussion makes it clear as to why birds need to be conserved. Bird management is generally done with following aims:

a. Management for harvest
b. Management for preserving avian diversity
c. Management for solving specific problems such as explosive growth scavenger birds, problems created by exotic birds, problems associated with diseases and parasites, protection of a habitat etc.

In the present discussion, management for harvest is not considered, because it is banned in India. Therefore all the suggestions and recommendations are with reference to preserving bird diversity and solving bird related problems.

10.5 Suggestions and Recommendations:

The very basis of suggestions and recommendations, presented here are that they should be

- Practical
- Feasible
- Simple to implement
- Require limited budget
- Possible as individual, group and public level activity

10.5.1 A five point conservation policy is recommended.

1. Preservation of existing habitats (In-situ conservation)
2. Development of new habitats
3. Implementation of existing laws
4. Environmental education, awareness and action
5. Ex-situ conservation

1. Preservation of existing habitats:

This is the key to conservation, because most existing habitats are natural.It is possible to conserve most birds through preserving their habitats. Fortunately,barring few exeptionsMany of the habitats have been changed, modified and are partly or fully degraded. These habitats may be preserved through the singular and/or collaborative efforts of individuals, NGOs, *grampanchayats*, forest department etc. The list of key habitats to be preserved and protected is given below. The habitats are arranged on the basis of eco-geographical zones as follows:

A. Narrow coastal belt

B. Hinterland Konkan Ghats country and *Maval* tract

C. Dry Deccan plains (*maals* etc.)

D. Urban areas

Table 10.1: Eco-geographical Zones and Sensitive habitats

Group	Eco-geographical zone	Sensitive Habitats requiring management intervention	Remark
A- Narrow coastal belt		Mud flats & intertidal zones	Feeding sites of waders/reef herons, egrets, flamingos
		Mangrove vegetation	Feeding and nesting sites of waders/reef herons, egrets, kingfishers, Breeding site of a number of fishes (food for many birds)
		Shore platforms	Feeding & sunning sites of waders/herons, egrets
		Casuarina/Silver oak plantations behind beaches	Nest sites of sea-eagle
		Wadi compounds (house with plantation garden surrounding it)	Almost every *wadi* is a micro sanctuary Supports a variety of woodland & garden birds
		Tidal mouths of estuaries	A meeting point of aquatic and maritime birds
B-Hinterland Konkan (excluding coastal tract)		Low-level lateritic plateaus (‘*Sada’*)	One of the few open habitats. Habitat of larks, pipits, Birds of prey, lapwings.
		Ravine vegetation (A mixture of natural and planted vegetation)	Habitat of forest and woodland birds. (Compensates the barrenness of lateritic plateaus)
		Middle courses of streams(estuaries) with shady bank vegetation	Habitat of herons, egrets, bitterns, king fishers, fishing eagles
C Ghats country and *Maval* tract		Ravines with dense vegetation/ Upper courses of streams	Ulhas valley near Khandala Home to many forest birds including White-rumped shama, Great hornbill
		Sacred groves(*Devrais*)	Green islands of biodiversity (Including bird diversity). Requires urgent protection.

	Pools of dense forest patches	Remnants of once continuous Forest corridors.
	Lakes and reservoirs	Most of them are deep. Therefore attract only diving birds (diving ducks, cormorants, Snake bird, little grebe etc.) Needs to maintain fish stock
D **Dry Deccan plains**	'*Maals'* (dry grass & scrub plain country)	Home to dryland birds-larks, pipits, lapwings, courser, thick-knees, Birds of prey (harriers,eagles, black-shouldered kite etc.)
	Babul bans(groves)	Shelter for dryland and scrubland birds.Doves and pigeons,shrikes,babblers)
	Rock fields and tors	Shelter for dryland and scrubland birds Also rock thrush, Indian robin
	Lakes & reservoirs	Most are shallow with shore vegetation. Even a small sized reservoir like Matoba & Khamgaon support high bird diversity. (91 wetland species reported by Purandare ,1990)
E **Urban areas**	River-side vegetation	Mostly removed-very few patches remaining. Mutha bank in Nanded village (Pune)
	Green campuses	Pune university, College of Agriculture, ILS Law college, Fergusson college, College of Military Engineering(Pune), IIT, Powai; Film City (Mumbai) Every campus is a micro-sanctuary. 98 bird species reported by Nalavade (1998) In Fergusson College campus in Pune.
	Lakes and ponds	Peshwe Park pond,Katraj & Pashan lakes (Pune), Masunda lake(Thane) Tulsi,Powai,& Vihar lakes(Mumbai)
	Abandoned stone quarries	Vetal hill, Pashan,Dhanori, Chinchwad (Pune) Parsik hill (Navi Mumbai-Thane)

2. Development of new habitats

Some of the already existing habitats are so much degraded and threatened that preservation and restoration is difficult. Under such conditions instead of trying to preserve the whole habitat, the best policy is to conserve the relevant micro units of the habitat. The micro units are here introduced as a new way of preserving at least some species and/or groups. The micro-unit is here christened as **Eco-spot**. The concept is a possible answer to the traditional conservation view of protecting a whole area.

2.1 'Eco-spot' concept:

Spot also means a place. Eco-spot (ES) is a short form of Ecological spot. It means a very small place which supports a micro-ecosystem. *This is a new concept introduced here*.

a. The basic characteristic features of an eco-spot are:
b. Eco-spot ranges from a single tree to a clump/grove of trees covering a few hectares.
c. The maximum area for an eco-spot is recommended to be 10 hectares.
d. The area around an eco-spot is generally humanized: inhabited, settled, populated, hostile, barren, under crops etc.
e. An eco-spot can also be located inside a dense forest. For example, nesting tree of Great hornbill in the heart of a forest.
f. The eco-spot should be-
    - A place(tree etc.) with nest of a rare animal(here bird) species
    - Nesting colony of any animal (bird) species-common or rare
    - Roosting colony of any animal (bird) species-common or rare
    - A major source of food for the life in the environs
    - Resting place of a rare animal (bird) species.
    - Resting spot along a migratory route of (bird) species.
    - Watering spot along a migratory route for animals, birds.
    - Congregation point of passage migratory birds.
    - A shelter with shade, cavities, holes, cracks
    - A rare plant/ tree

Eco-spot may include following entities. (The list may not be complete)

- Heronry: A place (tree or grove) where herons, egrets, storks, cranes, cormorants etc. come for nesting.
- Rookery: A colony or breeding place of rooks (a crow-like bird).In the present case place /nesting colony of crows.
- Nesting tree (nest of a rare species or colony)
- Roosting tree/colony
- Flying fox tree (Just an example. It's a mammal)
- Banyan complex
- Mango tope
- Babul(*Acacia nelotica*) grove
- Bamboo complex (called bamboo *bet*)(bet=island in Marathi)
- '*Paar*' around a tree
- Vulture colony (In a tree or on cliff, ledge etc.)
- Mid-stream islet
- Pond
- Tor/hillock
- Lateritic flat
- Sand bank/mud flat /mangrove patch

Why an eco-spot?

One of the traditional ways of protecting wildlife and wildlife habitats has been to declare an area as a wildlife sanctuary or national park. But this is not always easy in a densely populated country like India. It is even more difficult in the present study area, which is one of the most urbanized, industrialized and densely populated regions of India. The hurdles for declaring protected area in such an area are:

- No large wild area to be declared as a sanctuary is available in the study area.
- The human pressure very high.
- People in the region have already undergone the bad experience of loosing land to/likely to lose land to, various development projects- Scores of dam projects, the Mumbai-Pune Express highway, hill towns

of Amby valley and Lavasa, Karjat-Panvel railway line, proposed international airports near Pune and Navi Mumbai etc. They are now politically more aware and motivated than before and therefore do not want to lose any more land for any project, definitely not for a sanctuary, which curtails their traditional rights.

- Already existing sanctuaries are not properly managed for various reasons: under- staffing, ill-equipped and non-motivated staff, funding problems, bureaucratic way of administration, non-cooperation from local people, all leading to problems such as poaching, encroachment, forest fires etc.
- Large size, whether a district, a municipal corporation or a sanctuary, has no more remained an efficient unit of governance.
- 'Small is beautiful', seems to be a good motto for bird conservation. The most successful example being the Karnala Bird sanctuary in Raigad district. The Sanctuary is just 4.48 km^2. (448 hectares) in area, has preserved and maintained the forest habitat and still supports more than 200 bird species, in spite of the urban and industrial pressures in the immediate vicinity.
- With the help of PPP (Private-Public-Participation) model, it is possible to implement small scale conservation projects on smaller areas of few square kilometers or few hectares with achievable objectives like protecting a vulture nesting tree or a heronry.
- With every nook and corner being humanized, there are left very few areas, which can be truly called wild. Most of such areas are either in the north-east of India or in the South-western Ghats. Northern part of the Western Ghats has very few, smaller so called wild areas.
- Under such scenario, the best strategy would be to give protection to as many micro spots as possible. Hence this concept of **Eco-spot**!

PLATE 10.1: SOME ECO-SPOTS



BANYAN GROVE-PUNE UNIVERSITY CAMPUS



POND ATTRACTING WATERBIRDS (NR PUNE)



GREEN COMPOUND OF AN INSTITUTE, PUNE



ROOSTING TREE: CORMORANTS (NR PUNE)



NESTING TREE: WHITEBELLIED SEA EAGLE

NR.MALGUND (RATNAGIRI)



KALKAI DEVRAI (SACRED GROVE)
(PUNE-RAIGAD)

Table 10.2: Some recognized eco-spots from the Study area

Type of eco-spot	Suggested examples from the area (with district)	Remark
Heronry	*Scores from Raigad district *A few from Pune district (Uruli Kanchan, Bhadalwadi lake and Indapur)	
Rookery	Many in Mumbai and Pune	Crows are prominent scavenger birds. Their population needs to be controlled; hence every rookery does not need protection. Only a few would.
Nesting tree (nest of a rare species or a colony)	Great hornbill nest site at Oazrde rai near Koynanagar (Satara)	
Roosting tree/colony	Vaikuth crematorium in Pune	The largest roosting colony of communally roosting birds in Pune.(23 species, about 4000 birds)
Banyan complex	*Pune university campus, near old canteen *Pemgiri complex(1.5 hectare) (Junnar,Pune)	Pemgiri-Largest banyan complex in Maharashtra (P.K.Ghanekar,pers.com.)
Mango tope	Baneshwar near Pune	One of the ancient mango topes around Pune, dates back to the Peshwa period(18^{th} century)
Babul(*Acacia nelotica*) grove	*Mastani talav(tank) near Dive ghat(Pune) *Jejuri (Pune)	Babul groves are still seen in the eastern part of Pune district.
Bamboo complex	*Tamhini (near the temple)(Pune) *Ravine on the way to Rajmachi fort(Pune) *Mogarwadi near Sinhagad(Pune)	
'*Paar*' around a tree	Last 10 remaining in Pune city (Once there were 40)	New '*paars*' can be developed on educational institute campuses, in cantonment areas, on hill tops
Vulture colony	Cliff near Garud Machi camp site, Tamhini ghats	Largest nesting colony of Longbilled vulture in northern Western Ghats(21 nests in 2010)

	(Pune-Raigad)	
Mid-stream islet	*Naik bet(islet) near the Mula-Mutha sangam(confluence) *Chaskaman reservoir (Pune)	Privately owned. Breeding colony of river tern (*Sterna aurantia*).
Pond	Peshwe Park(Pune) Khandala pond (Khandala, Pune) Varsai pond (Pen, Raigad) Kihim pond (Kihim,Raigad)	In Konkan, almost every village has a village pond. Every pond is a micro bird-sanctuary. Such ponds need urgent management intervention, because many of them have become garbage dumping ground.
Tors/hillock	Many along the Pune-Solapur highway:- around Yewat, Choufula, Patas.	Favorite habitat of bushchats, rock thrush, bush quail, buntings
Lateritic flat	Wilson point and Connaught Peak (Mahabaleshwar, Satara)	Home to hundreds of larks, pipits, birds of prey (harriers etc.)
Sand bank/mud flat	Sewri flats(Mumbai)	Thousands of flamingos gather here every winter. The number ranges from 2000 to 5000 (birdofbombay@yahoogroups.com)

Developing some innovative eco-spots:

1. Udyog van (Industrial forest) and Udyog taal (Factory lake):

Some industries have large land areas under their possession, which runs into scores of hectare. Every inch is not required for industrial purpose. The factory can reserve a part of the land for green activities, preferably tree plantation. Tata Motors Ltd. (Telco) at Pimpri near Pune has shown a green path to other industries by developing a dense tree cover (woodland) and a pair of lakes within its campus. The whole 320 ha (800 acre) plot, when allotted to the company in 1964, was almost rocky, barren with scattered thorny bushes and occasional trees. Today the factory campus has more than 150000 trees, belonging to 188 species (110 of which are indigenous). A part of it is 'urban forest' (or industrial forest?) with two man-made lakes. The lakes are supplied with water that is used in factory, and reprocessed. Fish have been introduced, which have attracted water birds. When last visited in January 2007(the entry is restricted), the author noted 50 bird species in one visit, and half of

them were aquatic. He also saw 46 nests of Grey herons and about 20 nests of Painted stork. This place is probably the largest grey heron nesting colony around Pune.

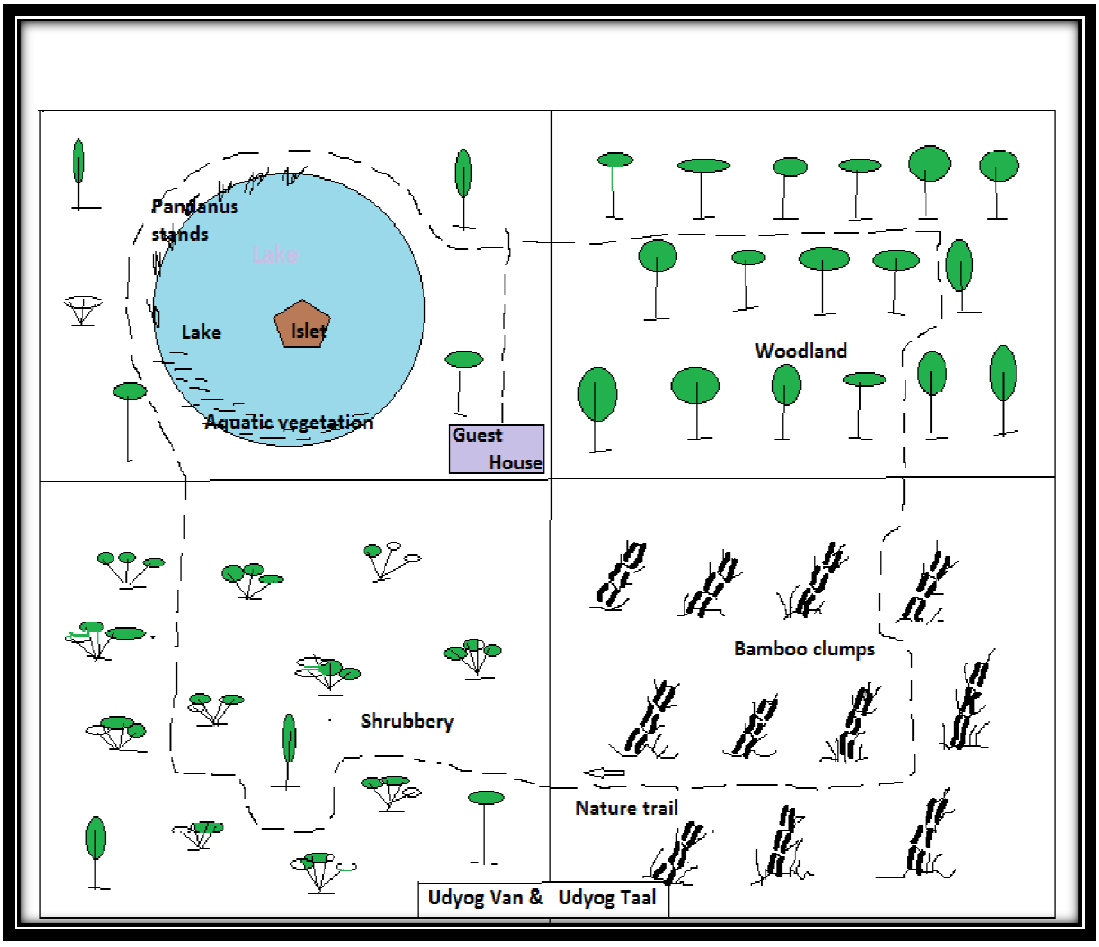


Fig. 10.1: A plan of Udyog Van (Industrial woodland)

Udyog Van model: Characteristic features:-

- For industries/factories with large plot under their possession.
- Maximum recommended size 10 ha. (25 acres).
- The woodland is to be developed along with a water body (pond).
- The tree species may be a mixture of native tree species (80%) and exotic tree species (20%)
- The recommended shape is square or rectangle.
- The plot is to be divided into four sections as S-1, S-2, S-3.S-4. **(See fig.)**

- Every section is reserved for a certain type of green entity.
- Four green entities to be developed are 1) Pond or lake 2) Woodland dominated by trees 3) Shrubbery and bushes 4) Bamboo
- Pond/lake will have aquatic plants in a graded manner (submerged, floating, emerging, bank)
- *Pandanus* clumps may be developed on the bank
- There may be an islet in the middle of the pond.
- There will be natural/bird trails touching all the four sections.

II. Quarry Lake Park

There are many abandoned stone quarries around Pune. Some of them may be developed into a quarry lake park. Quarries are man-made depressions made into a rocky area. By going down man has made available certain habitats for wildlife in general and birds in particular. These are i) Pond ii) Rocky pools iii) Shallow marshes iv) Vertical rock faces.

The Bird Valley Park (Chinchwad, Pune) is developed by the Pimpri-Chinchwad Municipal Corporation (PCMC) at Chinchwad (Pune) by converting an abandoned quarry. It has a large lake, boating facilities, jogging track and bird watching facilities. The uniqueness of the park is that it is developed in an abandoned stone quarry, covering about 10.40 hectares. It is developed on the basis of BOT (Build-Operate-Transfer) basis. There is a watch tower with a pavilion that gives a panoramic view of the lake. A small coconut grove is developed out of transplanted trees is also developed near the lake. The other facilities include: artificial beach, children's park, amphitheatre, skating ground and a 1.5-km-long jogging track. About 25 different species of migratory birds visit the lake on regular basis every winter.

Other abandoned stone quarries observed are: Vetal hill, Fergusson college hill, Baner hill, Parvati-Panchgaon hill.

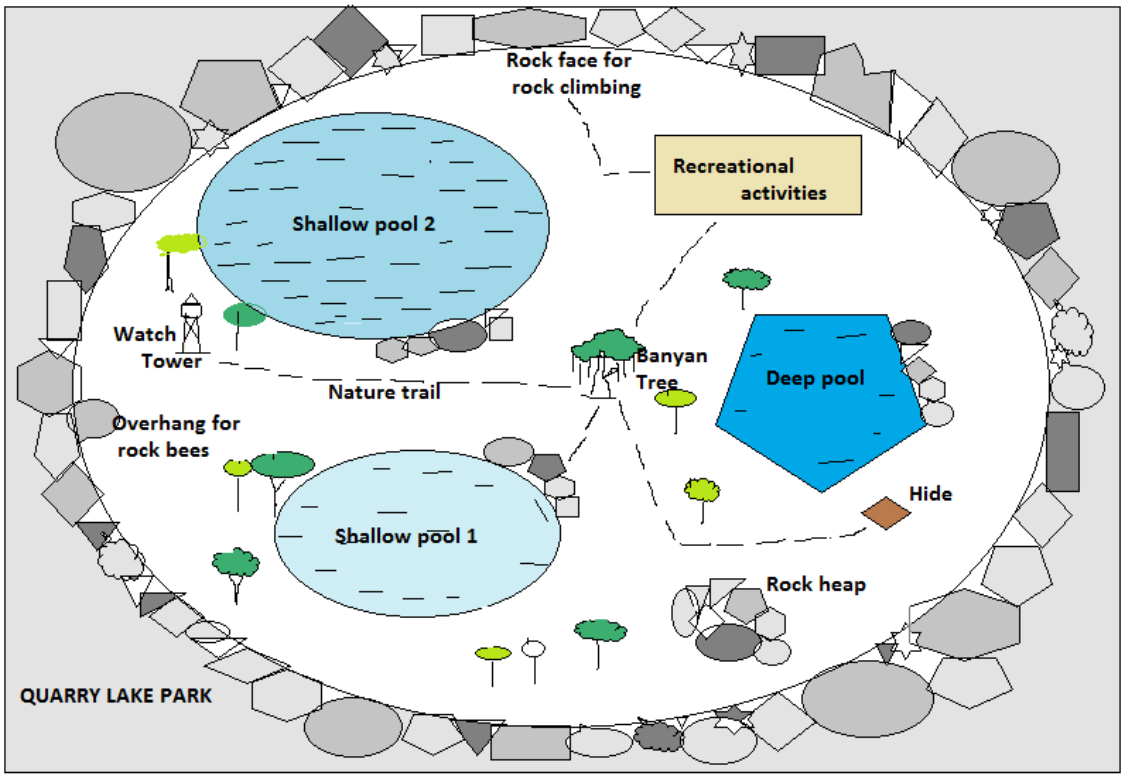


Fig.10.2: A plan of Quarry Lake Park (on abandoned quarry site)

Quarry Lake Park: Characteristic features:

- Part rocky, part freshwater habitat
- Deep pool/s with native fish
- Shallow ponds with aquatic vegetation
- Rocky heaps
- Vertical rock face(cliff)
- An overhanging face for rock bees
- A corner reserved for garden and other recreational activities
- Sheds & watch tower for watching birds
- Hide for watching and photographing birds at close quarter.
- Jogging track, planned in such a way that it least troubles the birds
- If the quarry is large, a few trees (Banyan, peepul, tamarind) may be planted.
- A rock face may be reserved for rock climbing/rappelling activity

iii. Dakhkhan Van (Deccan Grove):

Dakhkhan is Urdu for Deccan. This model is meant for the dry scrubby, rocky plains of the Deccan to the east of Pune. The area is a drought-prone country, with rolling topography.

These are vast dry grass and scrub plains interspersed with farms. There are low ridges on the margin with occasional rocky areas. Water scarcity is a major issue, where irrigation is not available.

Dakhkhan *Van*: Characteristic features

- Recommended location: barren countryside, especially near a spring.
- Recommended size : 4 hectare
- Shape –square or rectangular
- Center of the plot to have a banyan (*Ficus benghalensis*) tree
- The plot is divided into four sectors: S-1,S-2,S-3,S-4
- Every sector reserved for a specific green entity.
- Sector 1 reserved for grove of mixed trees led by *umbar* (*Ficus glomerata*). Other trees recommended –kala umbar (*Ficus hispida*), neem
- Sector 2 reserved for grass & scrub vegetation interspersed with babul (*Acacia nilotica*) trees.
- Sector 3 reserved for artificial tor structure (heap of stones etc.).If natural tor is already there, the *Van* can be planned around it.
- Sector 4 to have a pond or tank
- The pond to be developed mainly for drinking, bathing purpose of birds.
- If possible pisciculture may be introduced here.
- Management by: gram panchayat, NGO ,Joint venture of Forest Department (FD) and Grampanchayat or FD and NGO. May be privately owned

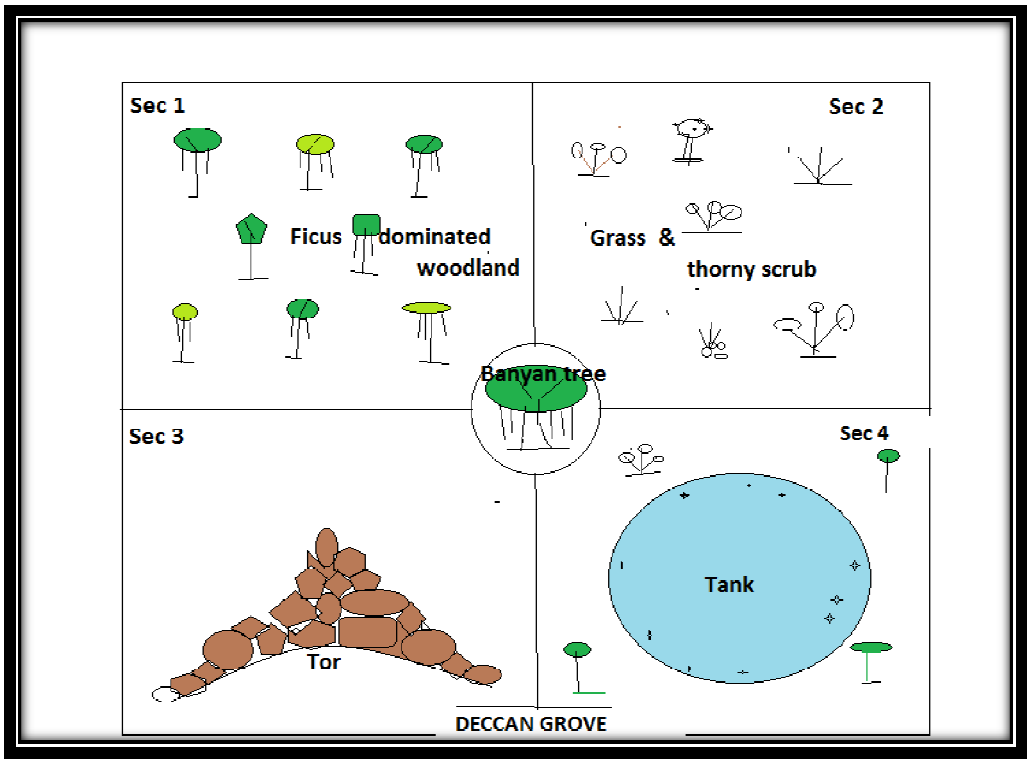


Fig. 10.3: A plan of Dakhkhan Van (Deccan grove)

iv. Deccan Eco-lake:

We have ponds, lakes, tanks etc. in every part of the study area. They differ in size, shape, depth, perenniality, diversity of life etc. Most lakes were built for human use. Over the period they have matured into an aquatic system and started attracting life-aquatic vegetation, aquatic invertebrates, fish, reptiles and birds. But the basic purpose remained to be human use. Here is a model lake, with ecology as the main purpose.

Eco-lake: Characteristic features

- Location-Recommended mostly for the dry plateau east of Pune
- Size: ranging from 1 ha. To 10 ha.
- Shape: Preferably circular. May be square or rectangle
- A natural depression is preferred
- The water body to be divided into four sections: S-1, S-2, S-3, S-4.

- **Section-1:** Deep pool (depth to range from 3 to 6 m.) (For diving birds including deep diving ducks, cormorants, snake bird etc. High bank with rocky patches.
- **Section-2:** Shallow part ,depth to range from few cm. to 1 m(3 feet).For shallow water waders :-storks, cranes, flamingos, herons. Adjoining bank: Flat land with grass & scrub patches.
- **Section-3:** Mud flats, aquatic vegetation, water lily, reed beds, *Typha* clumps for egrets, herons, waterhens. Gradation of aquatic vegetation from submerged-floating-emergent to bank vegetation. A mixed vegetation on adjoining bank-babul, wild date palm, karanj, screw pine, umbar
- **Section-4:** A mid-lake islet. For resting, roosting of birds. Adjoining bank:-Watch tower, hide, camping site, visitors' resting shed, equipment & laboratory room, parking space at appropriate locations.
- A few perching poles to be erected in water/on mudflats for birds.
- The pond/lake to be stocked with fish, preferably native fish species.
- Fencing recommended
- Management by Grampanchayat, NGO, private party, state forest department or jointly by any of these parties.
- Can be a CCA (Community Conserved Area)
- Such a lake will benefit other animals also, especially wild mammals in the vicinity

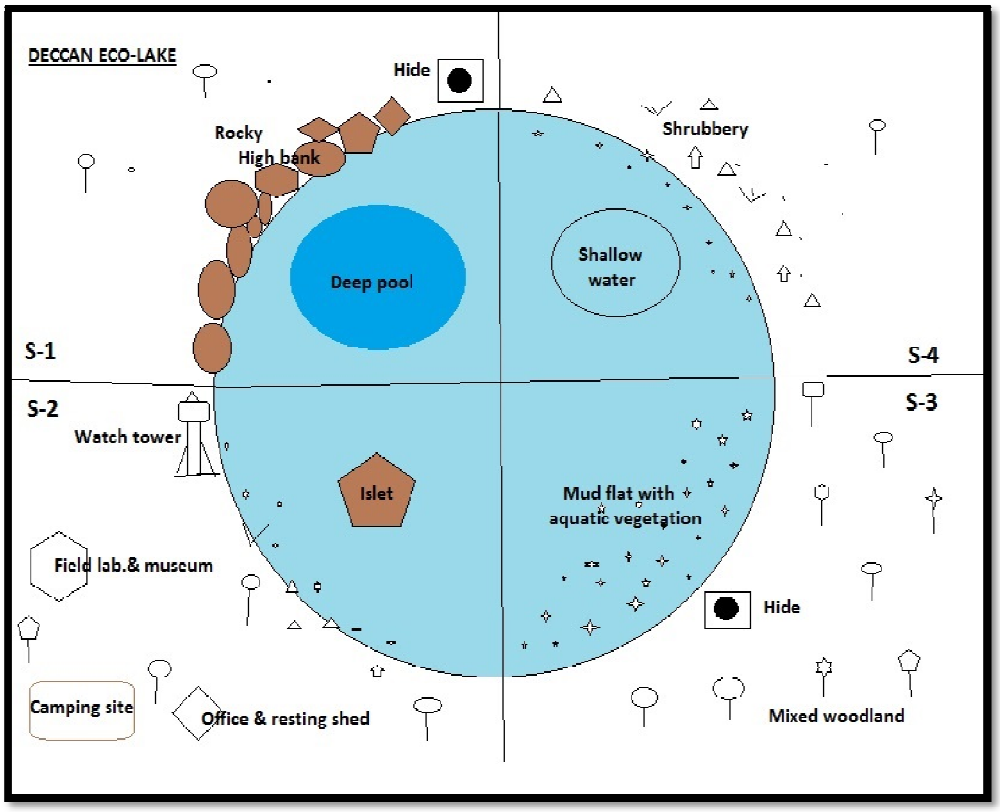


Fig.10.4: A plan of Deccan Eco-Lake

Some other models:

v. Private Forest & Woodland:

Many citizens now go for second home or weekend home. They generally purchase a farm house plot on the outskirt of the city or at a far away location in Konkan or Ghats country. Many of these plot holders are nature lovers and some of the plots are quite large in size admeasuring many hectares. Some of the owners can develop a private woodland or forest on such plots.

Suggestions for developing a private forest/woodland

- Decide whether to develop the woodland covering the whole plot or a part of it.
- Fencing is mandatory. That is the better way of protecting trees.
- As far as possible, plant native varieties of trees and shrubs.
- Grow a hedge. Hedge is one the habitats that is fast disappearing from everywhere, including study area. It is one of the possible reasons of disappearance of house sparrows.

- The density of trees would depend upon whether one wishes to develop dense woodland or an open one. 400 trees per hectare is an average density, which gives relatively dense woodland.
- The species to be selected should be a combination of fruit trees, flowering trees, trees that grow straight and those that spread like umbrella.
- An ideal example of a private woodland is the one developed by late Shri Pramod Nargolkar, on a 8 ha plot at the foot of Sinhagd. When the researcher visited the place in 2002, it had 14000 plants (1750 plants per ha.) belonging to 600 species. A part of it was kept open, while most of the remaining plot had two story vegetation, (shrub & tree layers). An early morning bird watching session at the site, yielded more than 35 species of birds. The list included such woodland birds as Asian paradise flycatcher, Tickell's blue flycatcher, jungle babbler, yellow-crowned woodpecker, and spotted dove.

vi. Roadside , railway side and canal-side tree plantations:

The Social Forestry department is already working on the project of planting trees along a) Highways and roads, b) Canals, c) Railway lines. Initially (1970, s and 1980s) most trees planted such, were exotic and dominated by Eucalyptus, *subabul* (*Leucaena leucocephala*), and Australian acacia. There is a dichotomy here. About 30 years ago most major roads and highways passed through a green tunnel made by intermingling canopies of trees planted on either side of roads. Most of these trees were native (mostly *Ficus* sp.) All this is history now. The tree cover was removed when the roads were widened. This removal affected woodland birds, especially green pigeons (*Treron* sp.) and hornbills. The new trees that were planted belonged mostly to exotic varieties, and therefore failed to attract birds. This can be compensated by planting native varieties along the widened roads, canal banks and railway tracks. The total length of railway track in Pune district is 311 km. If the track length worth 111 km. which passes through densely populated urban areas is deducted, we still get worth 200 km of railway track which can be utilized for planting trees on the side margin. The required width for plantation would be 10 m. (5 m. on either side).This makes available around 200 hectares of land just for plantation. Plantation to be done in such a way that local biodiversity (including birds) is maintained and enriched.

vii. Temple forest and woodland:

Indians are a highly religious people. They are fond of constructing temples. Temples, mosques and other place of worship, belonging to every period (ancient, medieval, modern etc.) are found in the country and the state. Many temples have large precincts and backyards with some ancient trees and temple pool. Some classic examples of temples surrounded with woodland in urban surroundings are: The Ganesh temple at Saras baug, Changa Vateshwar temple at Saswad, Ramdara temples near Uruli Kanchan, Shiva temple at Baneshwar (Pune),the Shiva temple at Khidkali (Thane) (The list does not include temples which are already in forested country and are therefore surrounded by forest .For example Bhimashankar). This temple woodland attracts hundreds of birds belonging to scores of species. These are roosting colonies of communally rooting birds. Some of them have heronries. (Khidkali, Ramdara). There are some negative stories also. Two well known temples in southern Pune the Pdamavati and the Aranyeshwar, were once (1960s) known for the groves surrounding them. Today both the temples are surrounded by buildings, apartment houses and housing colonies, making them almost impossible to find out.

A survey during the present study in one drought-prone taluka near Pune (The Purandar) revealed that there were 55 temples in the taluka alone, where compound tree plantation is possible. The total area available for such a plantation and woodland would be around 40 to 50 ha. The estimated figure for the whole district comes to about 680 to 700 ha.

3) Implementation of existing laws:

There is no need for additional laws for conservation of wildlife in India or Maharashtra, study area included. We have enough number of conservation laws with stringent measures. But the main problem is their implementation. While highlighting this issue, this is what Justice Kuldip Singh (1998) had to say- “There are plenty of laws in the environmental field. The pity is that there is no will on the part of the government and its machinery to implement the same”.The major las and conventions in practice today are mentioned in table 10.3.

Table 10.3: List of major Laws protecting Environment, Forest and Wildlife

Category of Law	Title of the Law	Basic purpose of the law	Remark
Forest	The Indian Forest Act,1927	To manage forest resources and regulate movement and transit of forest produce	Concerned most about commercial utilization of forest
	Forest(Conservation) Act,1980,(amended 1988) Forest(Conservation) Rules,1981 (amended 1992)	Conservation of forest	
	National Forest Policy,1988		
Wildlife	The Wildlife (Protection) Act,1972(amended 1992)	Protection and conservation of wildlife	A scheduled list threatened birds included
	The Wildlife (Transactions and Taxidermy)Rules,1973		
	The Wildlife (Stock Declaration) Central Rules,1973		
	The Wildlife (Protection) Licensing (Additional Matters for Consideration) Rules,1983		
Wildlife trade	CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora), 1973. An international agreement (ratified by India)	To ensure that international trade in wild animals and plants does not threaten their survival.	Useful for controlling illegal trade in wild birds
Cruelty to animals'	The Prevention of Cruelty to Animals Act,1960(amended 1982)	To ensure that animals are fairly treated.	
	Transport of Animal Rules,1978	---Do---	
	The Prevention of Cruelty to Animals(Application of Fines) Rules,1978	---Do---	

	The Prevention of Cruelty(Capture of Animal) Rules,1972	---Do---	
Environment	Environment (Protection) Act,1986	Protection and improvement of environmet	
	Environment (Protection) Rules,1986	---Do---	
	The National Environment Tribunal Act,1995	To provide for strict liability for damage arising out of any accident wrt. hazardous substances	
Import-Export	Import-Export Policy (2002)	Regulation on import and export items	Negative list of import and export contain prohibited items (wild animals & their parts), restricted items (animal, birds, reptiles for research, zoo etc.)
Coastal environment	Coastal Regulation Zone Act 2011	Preservation, management and conservation of coastal environment	Preservation of many bird habitats possible
Forest rights of scheduled tribes & other forest dwellers	The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006"	Recognition and vesting the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers	Environmentalists opposed the law. It may lead to depletion of the country's forest cover. It is contrary to the Rio Declaration,1992
Biodiversity	Biological Diversity Act (2002).	Conservation & use of biological resources and associated knowledge	Applicable to all biodiversity including birds
	The Convention on Biological Diversity (CBD) ,1992 (International Convention under UN, Ratified by India))	To develop national strategies for the conservation and sustainable use of biological	

		diversity.	
Wetlands	The Ramsar Convention (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat):An international treaty,1971(amended 1982 & 1987)	Conservation and sustainable utilization of wetlands	There are 26 Ramsar sites in India, unfortunately none in Maharashtra (www.ramsar.org)
Environment tribunal	The National Green Tribunal Bill,2009	Effective and fast redressal of case related to environmental protection and conservation of natural resources and forests.	Pune has a bench for Maharashtra and Goa

The above table shows that we have enough number of laws and regulations to cover every aspects of environment-forest, wildlife, biodiversity, wildlife trade, tribal's rights etc. The implementation is the main hurdle. That's why in spite of one of the best wildlife protection acts in the world, we still have very high rate of poaching.

Poaching cannot be stopped completely, but can be controlled to a certain extent.

3) Poaching: Some of the measures suggested for poaching -

a. Legal measures
b. Special task force
c. Reformation of poachers
d. Education and awareness
e. Information sharing & use of modern technology

a. Legal measures: Legal measures include formation, amendment and implementation of laws. As already discussed we have best environmental laws. But most people are not aware about them. Even those who are aware about these laws do not bother to respect them. A kind of 'law-breaking' culture prevails in the country, and Maharashtra is no exception to that. Most people feel proud of

disrespecting and breaking laws. This attitude is reflected in poaching also. Poachers belong to three categories i) Elite urbanites and celebrities ii) Those with strong political connection iii) People from lower social and economic class- tribal, native forest dwellers, peasants etc. Many elite urbanites are involved in poaching around our hill stations. Prosecuting those belonging to the 1st category is difficult in our country.

b. **Special task force:** The level of poaching is moderate to high in the study area. The bird poaching is confined to two groups of birds-aquatic and forest .What species are poached is already discussed under chapter 9. Remote forest parts (Bhimashankar, Ulhas valley near Khandala, Tamhini, upper Koyna valley below Mahabaleshwar, forest below Manikgad, Sinhagad environs are some areas where birds are trapped and shot. Whereas many lakes along the Pune-Solapur highway are known for illegal water fowl hunting. A special task force made of forest department officials and wildlife volunteers may be formed to monitor poaching activities. Involving volunteers from local NGOs would be more practical. For example, for monitoring Ujani backwaters, NGOs from Bhigvan or Indapur (nearest towns) can be involved.

c. **Reformation of poachers:** A new social thinking is that at least some poachers be pardoned with mild punishment and be involved in protecting wildlife. It is interesting to note that the author came face to face with some former poachers at the Ghana-Bharatpur National park, a birdwatchers' Mecca in Rajasthan, when he visited that place in November 2012.The former poachers were working as birding guides for tourists. This transformation was done through a scheme launched by the Rajasthan Forest department with the help of some NGOs working in the field of conservation. What was possible in Rajasthan may also be possible in Maharashtra.

d. **Education and awareness**: Thank to the efforts attempted by the state forest, environment and educational department, and NGOs, the level of awareness about the environment in general and the specific issues in particular, are quite high. Cruelty to animals has

slightly declined. There is greater awareness about dealing with injured birds and animals. There is also greater understanding and knowledge about common birds among the young generation. But some things have changed little. One such aspect is superstitions. Traditional medicine, blind faith and superstition are rapidly causing depletion in the various species of wildlife, including birds. Superstitious beliefs have been responsible for killing of thousands of animals (including birds) every year. This has led to certain species (of owls, for example) to the brink of extinction. It is not that only rural people nurture superstitions, even the so called educated urbanites from cities like Mumbai and Pune also have strong faith in traditional medicines and support superstitions. Some superstitions about birds are:

- Auspicious signs: Sighting of coucal, Indian roller, peafowl- considered good omen. But hearing any shrill call or sound of a bird (including peafowl) is considered bad omen. Sighting or hearing the hooting calls of owls is considered bad omen. Cawing of crow on one's house forecasts the arrival of guests. A house sparrow building its nest in a newly built house is considered as good fortune. Bird droppings landing on one's head or car is good luck.
- Sacrifice/killing of birds: Patients suffering from paralysis are advised to rub fresh blood of wild rock pigeons. Owls are also sacrificed on various so called auspicious days throughout the year by those who practice black magic. Owls are also killed for their eyes, which are used in talisman or amulet. In our area three species, viz. Barn owl (*Tyto alba*), Spotted owlet (*Athene brama*) and Eurasian eagle owl (*Bubo bubo*) are largely used for this purpose. It is a herculean task to remove these superstitions. Only through proper education it may be possible to remove such faiths.

e. **Information sharing & use of modern technology**: The main problem with poaching is lack of information. Most of the times

poaching takes place during night time, in remote areas with scattered population. Absence of trekkers, forest guards etc. emboldens poachers to commit the crime. Information sharing is very vital in poaching related crimes. If proper information is shared by villagers, tribals, graziers, trekkers, birdwatchers, wildlifers, with forest and police officers beforehand, it is possible to prevent poaching from taking place or even capture poachers' red handed. Use of walky-talky, ham radio, mobile phones etc for fast communication, camera traps, CCTV, mobile phone cameras for secret footage, using GPS for exact crime location etc., sharing of information on web groups, Facebook ,Twitter, computerized data building, sharing of data at the inter-state and international levels. Poaching should be dealt with at war-footing and be treated like an 'All-out- war'.

4) Environmental education, awareness and action

This can be achieved at three levels

4.1) Individual efforts

4.2) Organization/Instituion/Group level efforts

4.3) Government level efforts

4.1) Individual efforts:

"Conservation begins at home." is a famous conservation tagline. Another popular tagline is *"I too can make a difference."* In other words conservation efforts can begin at home and an individual is the first person who can take an initiative towards conservation. When many like-minded persons come together, it becomes a public movement. An individual effort does carry a weight. There is a standard transformation: a birdwatcher in due course of time becomes a bird student. While studying nature for some time, a student gradually gets converted into a nature conservator, either part time or full time.

Various activities that can be done at the individual level can be grouped under different categories as follows:

a. Activity: This includes

- Installing nest box/boxes in garden, on terrace, wall, tree trunk etc.,
- Erecting a bird table (only during the scarcity season)
- Hanging netted seed bags
- Developing a bird bath in garden.
- Developing an ornamental pool or eco-pond in garden or in backyard.
- Planting and nurturing a bird friendly plant or tree

Making bird box, bird table or simple bird bath is easy, not expensive, can be made from recycled material. Hundreds of designs are available on scores of websites. is a green activity. Many activities mentioned here are ideal for children.

b. Education, research and awareness: One never knows when a bird watching hobby is changed into an educational activity.
   - Maintaining bird dairy with records about various aspects of birds: their food, feeding, breeding, nesting habits, relation with other organisms etc.
   - Every unique bird record kept by an individual, who may be a layman, is equally important as kept by professional ornithologists.
   - Bird-watchers' diaries have been an important document and played a vital role in conservation of a species or group of species.
   - Writing popular articles, report sighting of new species in news papers or on web groups, write about places which are rich birding spots.
   - Individuals can photograph or video-shoot birds and develop an album-document. Photo-exhibition is an effective way of popularizing bird/nature related activities.
   - By working on conservation projects it is possible to find out solution on some conservation issues.

c. Action: Action means some conservation action.
   - Reporting or treating an injured or sick bird, carrying the sick bird to nearby veterinary doctor or hospital, rescuing a bird in

trouble; putting a chick ,fallen out of its nest, back into the nest; repairing a damaging nest, etc.

- Reporting poaching,
- writing a protest letter,
- writing an FIR against some illegal activity,
- filing a case in the court of law etc.,
- taking part in planning process,
- Financially support a conservation activity,
- Work as volunteer, guarding nest to prevent robbing of eggs' - the list is unending.
- Developing a private sanctuary (micro sanctuary)
- Avoid and discourage feeding pigeons
- Help manage organic garbage to control scavenger bird population

4.2) Organization/Institutes/Group level efforts:

'Union is strength', is a universal truth. An action becomes more effective, more powerful, more widespread-if it becomes a public movement.

- Group bird watching is in fact the first organizational activity.
- Public actions such as rallies, protest or support marches, agitations, sit outs, can be aimed at achieving some conservation goals.
- Cleaning a bird-friendly habitat, campus, river banks, fort etc. by collecting garbage, removal of weeds,
- organizing bird photography/painting exhibitions, bird fest/bird races, celebrating bird watching weeks, forming teams of volunteers to look after birds injured by kite-string during kite festivals,
- Organizing ornithology courses, lecture series on birds, bird banding camps, running & being an active member of bird-related web groups, running bird hospital, the list goes on.
- Educational institutes with large green campuses (for example- Pune University campus: 165 ha.), can develop bird trails,

display bird information boards with photographs at appropriate places.

- There are five Facebook birding groups in the study area, based at Mumbai (02), Thane(01), Pune(01) and Satara(01),with combined total membership of about 4000. There are specialized groups devoted to one species or a group of species. These are: great Indian bustard (05), house sparrows(04), vultures(02) and ducks(01). Besides there are some all India groups like **Indian Birds** (13953 members on 23/05/2013), **Indian Bird Conservation Network** (IBCN), and the **Sanctuary Asia** group (A magazine dedicated to wildlife conservation in India)
- Bird Data bank: Data deficiency has been a major shortcoming in wildlife management in India. It is unfortunate that we do not have enough data about such common birds as the house sparrow. We also have scanty data about some groups like the migratory birds, forest birds etc. Geographical coverage is also very low. Out of the 35 districts in Maharashtra, only 12 districts have bird checklists available. Most of these checklists were published long ago and have not been updated since then. The same applies to town and cities in the region. Of the 15 major towns from western Maharashtra, only 8 have their bird checklists published, that too at least 10 years ago. The Biological Diversity Act 2002, demands that every village, taluka, district, and city should have biodiversity committees and they should maintain biodiversity registers. This has unfortunately not happened, except formation of the state level biodiversity board. The process for formation of biodiversity committee for Pune city is underway.

  Though building biodiversity data bank is a herculean task, it is possible by involving school and college students, tribals, farmers, NGOs, enthusiasts, experts etc. led by forest department.

There can be web groups and social net-working sites groups for reporting, organization, presentation, discussion, and analysis of bird data. The web groups can be area-based (city, taluka, district, sanctuary, national park, lake etc.) or theme-based (forest birds, marine birds, threatened birds, scavenger birds, winter migratory birds etc.) or taxonomy based (ducks, vultures, Indian peafowl, India bustard etc.). There can be mapping groups, conservation or issue-oriented groups or poaching reporting group.

About half a dozen TV channels are dedicated to nature and wildlife (Discovery, National Geographic, Animal Planet etc.). All these channels are foreign-based, and telecast programs preferably in English, though occasional Hindi versions are available. Is it possible to telecast some programs in vernacular? Why do we not have a Mumbai or Pune-based wildlife channel, telecasting preferably in Marathi and showing films and documentaries made by local enthusiasts?

- It is strongly recommended that private sanctuaries be promoted. According to Gooders (2004), 'Owning a land is the first step towards conservation. Land ownership by Conservation bodies is the key." Most Eco-spots suggested above can function as private sanctuaries. **No environmental act in India today allows private sanctuaries**. We will have to make efforts for incorporating private sanctuary bill under any of the wildlife or forest acts.

4.3 Government level efforts:

These include

- Formulation and amendments of conservation laws
- Establishment and management of small-sized (4 sq.km.to 8 sq.km.) bird reserves.

- Establishment of natural history museums, botanical & zoological gardens, aviaries, animal orphanage etc. at least one per district
- Budgeting and funding
- Controlling of illegal activities through legislation, proper infrastructure and man power.
- Infrastructure development (including conservation infrastructure)
- Intensive Awareness campaigns
- Collaboration with private sector/NGOs/other governmental departments.
- Collaboration at international level (as with International Crane Foundation)
- Forming Biodiversity Boards at village, city, district and state levels and maintaining biodiversity registers (mandatory by Biological Diversity Act,2002)
- Bringing more wetland under the Ramsar Convention. The one recommended from the study area is the Ujani reservoir (Pune-Solapur districts).

Every measure, whether small or big, aimed at conserving birds will also be beneficial for conserving other life forms-mammals, reptiles, frogs, fishes, insects etc. A private forest developed near Sinhagad not only attracted birds, but was also found providing shelter to small mammals (mongoos, striped squirrels, field rats & mice, hare, shrews, bats etc,), reptiles (lizards, snakes, skinks etc.), frogs; insects (butterflies, moths, bugs and beetles etc.). In other words **"Conserving birds are like conserving the whole nature".**

Ex-situ Conservation:

Pune has one of the best zoological parks in India, the Rajiv Gandhi Zoological Park and Wildlife Research station.It also houses an animal orphanage with experienced staff. It is recommended that a breeding center for rare birds can be esatblised here.Vultures are already threatened birds.We do not have a vulture breeding center in this part of the country.A vulture conservation breeding centre on

the lines of Pinjor(Haryana) may be established here.A state-of-art animal hospital is also recommended.

What next?

Time, work and financial constraints restricted this work to certain limited aspects only. This work obviously does not end here. It can be extended further into various fields and directions. There are many possible themes to which this work can be taken further. I hope to work on the following possible themes in the future:

- Extending the study area to cover the whole state of Maharashtra.
- Building a future scenario of the **possible impact of climate change and global warming** on the avifauna of the northern Western Ghats.
- Developing a conservation model (for Konkan and Western Ghats) of micro and meso-sized bird preserves, based on Karnala bird sanctuary.
- Developing an '**Integrated conservation model'**, for semi-arid upper Deccan area of meso-sized (8 to 20 sq.km.) bird preserve. This model can incorporate the habitable area and area under farmland. Local farmers and graziers to be involved as the managers of the preserve.
- Developing a detailed '**Bird Atlas'** initially for Pune district(as a pilot project) and extending it further to include larger area,may be the whole state of Maharashtra.

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*Jr.Bom.Nat.Hist.Soc.= Journal, Bombay Natural History Society

APPENDIX I

List of Threatened birds from the Study area (2012)

The International Union for Conservation of Nature (IUCN) is the world's leading authority to decide the conservation status of species. It publishes list of threatened species on the basis of criteria that decides the risk of a species, which if ignored are likely to become extinct in the future. The list is also called as the 'Red Data List'. There are 38 species from the study area in the Red Data Book of the IUCN. There are seven categories as follows:

The first three categories are together treated as 'Threatened'.

CR- Critically Endangered
EN- Endangered
VU- Vulnerable
NT- Near Threatened
DD- Data Deficient
C- Least Concern
Unlisted

Sr.No.	Common name	Species name	IUCN status (2012)	Status in study area
1	Great Bustard	*Ardeotis nigriceps*	CR	U
2	Lesser Florican	*Sypheotides indicus*	EN	U
3	Sociable Lapwing	*Vanellus gregarius*	CR	Stray
4	White-rumped Vulture	*Gyps bengalensis*	CR	U
5	Red-headed Vulture	*Sarcogyps calvus*	CR	U
6	Indian Vulture	*Gyps indicus*	CR	U
7	Cinereous Vulture	*Aegypius monachus*	NT	U
8	Egyptian Vulture	*Neophron percnopterus*	EN	U
9	Pallas's Fish-eagle	Haliaeetus leucoryphus	VU	U
10	Greater Spotted Eagle	*Aquila clanga*	VU	U
11	Grey-headed Fish-eagle	*Ichthyophaga ichthyaetus*	NT	U
12	Indian Spotted Eagle	*Aquila hastata*	VU	?
13	Pallid Harrier	*Circus macrourus*	NT	U
14	Laggar Falcon	*Falco jugger*	NT	U
5	Black-bellied Tern	*Sterna acuticauda*	EN	U
16	River Tern	*Sterna aurantia*	NT	C

17	Marbled Teal	*Marmaronetta angustirostris*	VU	S
18	Ferruginous Duck	*Aythya nyroca*	NT	U
19	Great Knot	*Calidris tenuirostris*	VU	U
20	Oriental Darter	*Anhinga melanogaster*	NT	U
21	Lesser Flaingo	*Phoeniconaias minor*	NT	U
22	Black-headed Ibis	*Threskiornis melanocephalus*	NT	O
23	Spot-billedPelican	*Pelecanus philippensis*	NT	S
24	Painted Stork	*Mycteria leucocephala*	NT	C
25	Black-necked Stork	*Ephippiorhynchus asiaticus*	NT	U
26	Black-tailed Godwit	*Limosa limosa*	NT	O
27	Eurasian Curlew	*Numenius arquata*		O
28	Sarus Crane	Grus antigone	VU	S
29	Wood Snipe	Gallinago nemoricola	VU	?
30	Indian Skimmer	Rynchops albicllis	VU	S
31	Nilgiri Wood-pigeon	*Columba elphinstonii*	VU	U
32	European Roller	*Coracias garrulus*	NT	U
33	Kashmir Flycatcher	*Ficedula subrubra*	VU	?
34	White-browed Bushchat	*Saxicola macrorhynchus*	VU	C
35	Malabar Pied Hornbill	*Anthracoceros coronatus*	NT	O
36	Great Hornbill	*Buceros bicornis*	NT	U
37	Tytler's Leaf-warbler	*Phylloscopus tytleri*		O
38	Bristled Grassbird	*Chaetornis striata*	VU	?

The status of the same species for the study area is also given in the last column. These status categories are: C=Common, O=Occasional, U=Uncommon, S= Stray, ? = Uncertain.

APPENDIX II

List of trees and plants (native and exotic) beneficial for birds

(Recommended for plantation in the study area)

The list of native trees/plants contains 63 species, whereas the list of exotic trees/plants contains 25 species. The reason as to why the exotic plants are included is that, the present study found that **the diversity of birds in habitats with a fine mixture (80:20)of native and exotic trees is high compare to a stand of pure native trees.** This was a surprising finding. Some so called exotic plants have been here for the last many hundreds of years and have been naturalized here. Baobab is the best example, which has been here for the past 700 years(Mahajan,2011) Many native birds have adapted to such trees/plants. For example, 21 bird species have been observed to be associated with the yellow oleander plant (*Thevetia peruviana*), in Pune. This plant is native to Latin America. Almost 7 out of 10 nest holes of coppersmith barbet around Pune, have been found in Gulmohor tree (*Delonix regia*), an African tree, naturalized in India.

The following tables include, besides the common, vernacular and taxonomic names, the information about the subregions of the study area, where the listed plant species are found growing naturally or are fit to be planted there. The subregions are numbered 1, 2 and 3 and represent Konkan, the Ghats country and the upper Deccan respectively. The use includes some short forms such as FR/FL/NST & RST. The meaning of the short form is:

FR=fruit .The plant provides fruits/nuts/berries as food to birds.

FL= flower. The plant provides flowers as a source of nectar for the birds.

NST= nest building. The plant/tree is useful as a nest building site, provides nest building material, safety etc.

RST= roosting/resting. The plant provides protection, coolness and shelter, from weather and predators alike, so that birds roost/rest in it during noon time or during night time.

Some plants provide only one function, while many other provide more than one.

The plants listed here are recommended for plantation in Dakhkhan van, Udyog van, Deccan eco-lake vicinity, private woodland areas (mentioned in chapter 10), and farm houses, educational campuses etc. Planting, nurturing and maintaining

these plants will definitely maintain and enrich the bird diversity and the population of an area.

Table A: List of native plant/tree species useful for birds in the study area

Sr.No.	Common English name	Vernacular name	Taxonomical name	Use
1		*Nandruk*	*Ficus microcarpa*	FR
2		*Bhui umbar*	*F.hispida*	FR
3	Pipal /Bo tree	*Pimpal*	*F.religiosa*	FR/NST/RST
4	Banyan	*Vad*	*F.benghalensis*	FR/NST/RST
5	India rubber tree	*Rabarache zaad*	*F.elstica*	FR/RST
6	Java fig	*Java umbar*	*F.comosa*	FR
7	Red silk cotton	*Katesawar*	*Bombax ceiba*	FL
8	Silk cotton	*Saur*	*B.insigne*	FL
9	Indian tulip tree	*Raanbhend*	*Thespesia populnea*	FL/RST
10	Colored sterculia	*Kaushi*	*Sterculia colorata*	FL
11		*Kakad*	*Garuga pinnata*	FL
12	Drumstick	*Shevga*	*Moringa oleifera*	FL
13	Indian coral	*Pangara*	*Erythrina indica*	FL
14	---Do---	*Raanpangara*	*E.stricta*	FL
15	---Do---	*Booch pangara*	*E.suberosa*	FL
16	Flame of forest	*Palas*	*Butea monosperma*	FL
17	Babul	*Babhool*	*Acacia nilotica*	FL/NST
18	White-barked acacia	*Hivar*	*A.leucophloea*	NST
19	Purple Bauhinia	*Rakt-kanchan*	*Bauhinia purpurea*	FL
20		*Apta*	*B.racemosa*	FL
21	Fire-flamebush	*Dhaiti*	*Woodfordia fruticosa*	FL
22		*Ukshi*	*Calycopteris floribunda*	FL

23	Indian milkweed	*Rui*	*Calotropis procera*	FL
24	Malabar nut	*Adulsa*	*Justicia adhatoda*	FL
25	White teak	*Shivan*	*Gmelina arborea*	FL
26		*Bandgul*	*Loranthus sp.*	FL
27	Coconut	*Naral*	*Cocos nucifera*	FL/NST
28	Wild date palm	*Shindi*	*Phoenix sylvestris*	FR
29	Fish-tail palm	*Bherli maad*	*Caryota urens*	FL/FR/NST/RST
30	Palmyra palm	*Tad*	*Borassus flabellifer*	NST/RST
31		*Kunti*	*Murraya paniculata*	FL
32		*Charoli*	*Buchanania cochinchinensis*	FL/FR
33	Queen of flowers	*Taman*	*Lagerstroemia reginae*	FL
34		*Durangi babhool*	*Dichrostachys cinerea*	NST
35		*Dhaman*	*Grewia tilaefolia*	FL/FR
36		*Nepti*	*Capparis decidua*	FR/RST
37		*Pachunda*	*C.grandis*	FR/RST
38	Ivory tree	*Pandhara kuda*	*Holarhhena pubescens*	FL/RST
39		*Phanashi*	*Dalbergia lanceolaria*	FL/RST
40	Indian laburnum	*Bahava*	*Cassia fistula*	FL
41		*Bibba*	*Semecarpus anacardium*	FR
42	Indian jujube	*Bor*	*Zizyphus jujuba*	FR/RST/NST
43		*Moi*	*Lannea coromandelica*	FL/FR
44		*Karmal*	*Dillenia pentagyna*	FL/FR/RST
45		*Moha*	*Madhuka longifolia*	FL
46		*Vanrukh*	*Solanum erianthum*	FR

47	Monkey biscuit tree	*Vaval*	*Holoptelea integrifolia*	FR/RST
48	Sacred barna	*Vayvarna*	*Crataeva nurvala*	FL/FR
49	Parrot tree	*Shirish*	*Albizzia lebbeck*	FL/FR
50	Devil's tree	*Satvin*	*Alstonia scholaris*	FL/RST
51	Yellow silk cotton	*Ganer*	*Cochlospermum religiosum*	FL
52	Dinner plate tree	*Muchkund*	*Pterospermum acerifolium*	FL/NST/RST
53		*Bhokar*	*Cordia dichotoma*	FL/FR
54	Indian meddler	*Bakul*	*Mimusops elengi*	FL/NST/RST
55	Child life tree	*Putranjiva*	*Drypetes roxberghii*	NST/RST
56	River ebony	*Temru*	*Diospyros malabarica*	FR
57	Ceylon ironwood	*Khirni*	*Manilkara hexandra*	FR
58	Wild mangosteen	*Kokam*	*Garcinia indica*	FR
59	Lac tree	*Kusumb*	*Schleichera oleosa*	FL/FR
60	White siris	*Kinai*	*Albizzia procera*	NST/RST
61	Male bamboo	*Vans*	*Dendrocalamus strictus*	NST/RST
62	Pickle berry	*Karvand*	*Carissa congesta*	FR/NST/RST
63	Tamarind tree	*Chinch*	*Tamarindus indica*	FR/NST/RST

Table B: List of exotic plant/tree species useful for birds in the study area

Sr.No.	Common name	Vernacular name	Taxonomical name	Use
1	Tiger bamboo	*Vansa kulluka*	*Bambusa vulgaris*	NST/RST
2	Hibiscus	*Jaswand*	*Hibiscus rosa-sinensis*	FL
3	Flamboyant tree	*Gulmohor*	*Delonix regia*	FL/NST
4	Peacock flower	*Shankasur*	*Caesalpina pulcherima*	FL
5	Sesban tree	*?*	*Sesbania grandiflora*	FL
6	Firecracker plant	*?*	*Russelia juncea*	FL
7	Indian cork tree	*Booch*	*Milingtonia hartensis*	FL
8	Scarlet-Bell tree	*Ghantapatra*	*Spathodea campanulata*	FL/FR
9	Golden dew drop	*Duranti*	*Duranta plumier*	FL/RST
10	Paper flower	*Boganvel*	*Bougainvillea sp.*	NST/RST
11	Yellow oleander	*Bitti/Pivali kanher*	*Thevetia peruviana*	FL/FR
12	Baobab tree	*Gorakhchinch*	*Adansonia digitata*	NST/RST
13	Rose apple tree	*Jam*	*Syzigium jambos*	FR
14	Rain tree	*Parjanya vruksha*	*Albizia saman*	RST
15	Copper pod	*Shimbi*	*Peltophorum pterocarpum*	NST/RST
16	Beef-wood tree	*Khadsherni/Suru*	*Casuarina equisetifolia*	NST/RST
17	Christmas tree	*Natal vruksh*	*Araucaria sp.*	NST/RST
18	Mesquite tree	*Vedi babool*	*Prosopis juliflora*	NST/RST
19	Pink cassia	*Gulabi cashia*	*Cassia sp.*	NST/RST
20	Kapok tree	*Pandhari sawar*	*Ceiba pentandra*	FL
21	East Indian almond	*Khota badam*	*Terminalia catappa*	FL/NST/RST

22	Mulberry	*Tuti*	*Morus alba*	FR
23	Mast tree	*Khota ashok*	*Polyalthia longifolia*	FL/NST/RST
24	Singapore cherry	*Singapur cheri*	*Muntingia calabura*	FR
25	Chinese thuja	*Morpankhi*	*Platycladus orientalis*	NST/RST