

**PRELIMINARY STUDY ON BEHAVIOR, DIURNAL ACTIVITY
AND
TERRITORIALITY OF BLACK ROBIN
IN BUTTALA**

By

M. SANDUN JAYALAL PERERA

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Faculty of Applied Sciences,
Sabaragamuwa University of Sri Lanka,
Buttala, Sri Lanka.

DECLARATION

The work described in this thesis was carried out by me at the Faculty of Applied Sciences under the supervision of Prof. S.W. Kotagama and Dr. R.L.R. Chandrajith. A report on this has not been submitted to any other University for another degree.

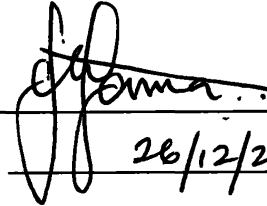


M. Sandun Jayalal Perera

Date : 26/12/2000

Certified by,

Prof. S.W. Kotagama,
External supervisor,
Professor in Environmental Sciences,
Department of Zoology,
Faculty of Science,
University of Colombo,
Colombo,
Sri Lanka.



Date : 26/12/2000

Dr. R.L.R. Chandrajith,
Internal supervisor,
Senior Lecturer,
Department of Natural Resources,
Faculty of Applied Sciences,
Sabaragamuwa University of Sri Lanka,
Buttala,
Sri Lanka.



Date : 26/12/2000

Mr. K.P.L. Nishantha,
Course coordinator / Natural Resources,
Department of Natural Resources,
Faculty of Applied Sciences,
Sabaragamuwa University of Sri Lanka,
Buttala,
Sri Lanka.



Date : 2000/12/26

AFFECTIONATELY
DEDICATED TO
MY
EVERLOVING PARENTS
AND
TEACHERS

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ABSTRACT

A preliminary study of behavior, diurnal activity and territoriality of black robin (*Saxicoloides fulicata leucoptera*) was carried out at the university premises, Buttala, within the intermediate zone of Sri Lanka, during the period of July through October 2000, within the dry season.

Ad-libitum, focal-animal and instantaneous behavior sampling methods were used for the study of behavior and diurnal activity. Population studies were carried out using the total count sampling method. Birds captured using mist nets and color tagged using plastic rings, were mapped and territories were demarcated using distinct cluster registrations.

This study recorded a total of 64 behaviors, which were categorized into 14 categories. Generally black robin spent much of its time budget on locomotion. Activity of black robin was low in midday than that of morning and evening. The peak activity was recorded around 17:30 hrs and, the activity had an inverse relationship with the environmental temperature. A direct relationship between the relative humidity and the activity of black robin were also observed.

It was evident that there was no significant difference between the activity of male and female of black robins.

A population of 29.2 ± 4.76 birds was recorded at a population density of 1.667 individuals per hectare. Almost all birds occupy a territory, which had an average size of 1.18 ± 0.34 ha with an activity center of 22.573% of the total area in average. Territories were distributed in open or sparse woodlands and grass or scrubland. The key feature of distribution of the black robin was concluded as the density of the undergrowth and human influence and maintenance of the habitat.

The number of black robins occupy a territory varied between two and six, and there was no correlation between the territory size and the number occupied. The territories overlapped at their boundaries with an overlapping area of 8.964% of the total area in average.

A checklist of 68 birds species were recorded from the study area, which can be concluded as a remarkable site for bird studies, and requires a careful conservation and management.

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CHAPTER 1

INTRODUCTION

1.1 Introduction to the study

The black robin (*Saxicoloides fulicata leucoptera*) belongs to the family Muscicapidae and sub family Turdinae of order Passeriformes.

It is a common bird through out the island especially in the dry and intermediate zones of Sri Lanka. It prefers open scrubland or gardens and eschews heavy forest (Henry 1998). Black robin is a highly territorial bird that defends a territory as a couple or family.

A preliminary study of behavior, diurnal activity and territoriality of black robin was carried out at the university premises in Buttala. The research was done for 15 weeks during July-October 2000 in the dry season.

Most of the dry zone of Sri Lanka is covered by secondary forests and open grass or scrubland. Since black robin is a common, readily identifiable bird which is mostly unique to the mentioned habitat it can be considered as an ~~indicator~~ indicator species for the conservation of open grass/scrub land vegetation in the dry and intermediate zones. Therefore information on behavior, diurnal activity and territoriality of this bird can be used for better management and conservation of such habitats and populations.

1.2 Objectives of the study

Objectives of the study was

1. To identify behavior patterns of black robin in order to construct an *ethogram* and to study the diurnal variation of its behavior
2. To determine the percentage time expenditure on major behavior patterns and to see whether there is a significant difference between time expenditure of male and female black robins.

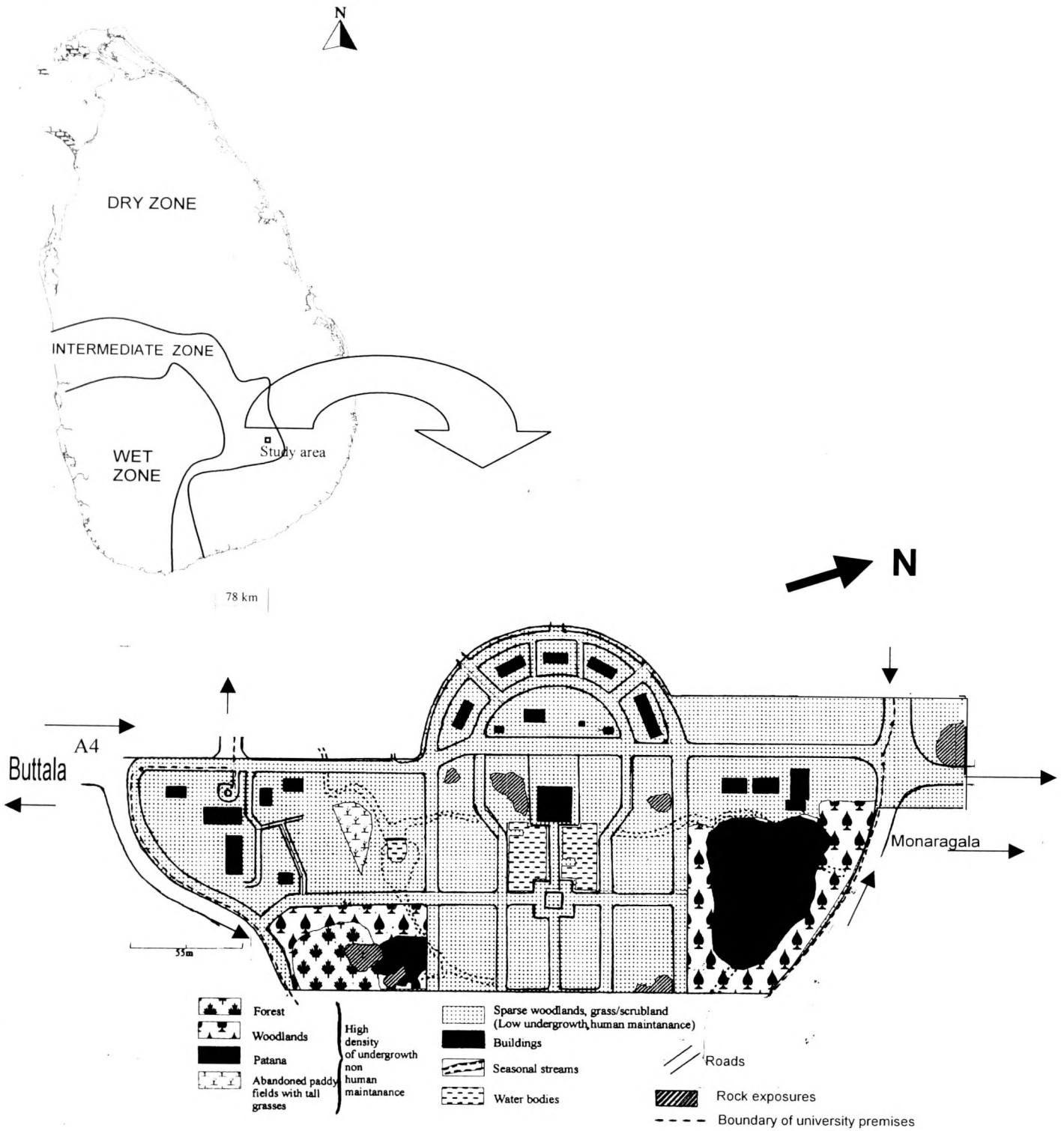
3. To estimate the population of black robins with in the study area and their territory occupation.
4. To demarcate the distribution of black robins territories with the vegetation and to find the average size of territories and activity centers.

1.3 Study Area

The study area of the research lies inside premises of the Faculty of Applied Sciences of the Sabaragamuwa University of Sri Lanka. It is about 1.5 Km away from the Buttala junction on the right side of the Colombo-Pothuvil main road (A4) and belongs to Buttala A.G.A.division in Monaragala district in the Uva province of Sri Lanka. It is situated on a valley between two ridges along North – East direction. They are Rahathangala from East and Andampahura Kanda from *North*. The University premises covers an area including human habitations, well wooded home gardens, grasslands (Patana), scrublands and forest patches within which 17.5 ha was selected as the study area of the research project.

The study area was situated within the intermediate zone of Sri Lanka and the floristic region of Eastern Intermediate Lowlands according to the map prepared by Ashton and Gunatilleke (1987).

Figure 1.1: Map of the study area



CHAPTER 2

LITERATURE REVIEW

2.1 Birds of the World and Sri Lanka

A Bird has been described as a 'Feathered Biped'. This description is apt and precise, and can apply to no other animal (Ali, 1996). Birds are at once the most beautiful, most widely admired, most entertaining and most studied group of animals on earth. In capturing our imagination they reign supreme and thus have done more to promote wildlife conservation and care of the environment than all other creatures put together (Martin, 1987).

Birds are vertebrate warm-blooded animals, i.e. whose temperature remains more or less constant and independent of the surrounding temperature. This is in contradistinction to Reptiles, Amphibians and Fishes, which are cold-blooded. To assist in maintaining an even temperature, the body of a bird is covered with non-conducting feathers, which is the chief characteristic of a bird. The body temperature of birds, 38°C-44°C, is higher than that of mammals. Assisted by their non-conducting covering of feathers birds are able to withstand great extremes of climate. Their rate of metabolism is higher than that of mammals and they lack sweat glands (Ali, 1996).

Birds as a class possess certain well-marked characteristics, which equip them pre-eminently for a life in the air. The forelimbs of birds have been evolved to serve as perfect organs of propulsion through the air. Many of their larger bones are hollow and often have air sacs running into them, which functions principally as accessory respiratory organs. Modifications in the structure of the breast bone, pectoral girdle and other parts of the skeleton, and the enormously developed breast muscles enables a bird to fly in the air. As a whole the perfectly streamlined spindle-shaped body of a bird is designed to offer the minimum resistance to the wind. On account of all these characters nature has endowed them, birds enjoy a wider distribution on the earth than any other class of animals (Ali, 1996).

There are thought to be between 8600 and 9016 bird species in the world. A precise figure could never be given for new species continue to be discovered in remote or little known areas while the others is very vague, some times bordering on extinction (Martin, 1987). If subspecies or geographical races are taken into account the figure would rise to nearly 30000 (Ali, 1996).

The vast Indian subcontinent with its extensive coastline, affords suitable living conditions to a great variety of feathered inhabitants. FAUNA OF BRITISH INDIA series of birds enumerated some 2400 forms (species and subspecies). The latest checklist, A SYNOPSIS OF THE BIRDS OF INDIA AND PAKISTAN lists 2061 forms of which over 300 are winter visitors, chiefly from the Palaearctic Region of the north. The Indian subcontinent as a whole falls in to the zoogeographical division of the earth known as the Oriental Region. For the sake of convenience it has been split up into 5 primary subdivisions as given below (Ali, 1996).

1. The Indo-Gangetic Plain
2. Peninsular India
3. Sri Lanka
4. The Himalayas
5. Assam

Sri Lanka's Avifauna is one of the richest in the whole of Asia. It contains 435 species, comprising 331 regular species found within the land boundary of the country – including the 23 confirmed endemic species – 68 irregular species recorded over years, and 36 oceanic species (Kotagama and Wijayasingha, 1998).

Harrison (1999) say that the island has its own avian specialists – more than 20 endemic species and over 70 races found in Sri Lanka, add to these the species shared with the nearby India and beyond, the migrants, plus 80 or so vagrants and Sri Lanka have an official checklist of some 426 species.

2.2 The black Robin (*Saxicoloides fulicata leucoptera*)

2.2.1 Classification

Kingdom	- Animalia
Phylum	- Chordata
Class	- Aves
Order	- Passeriformes
Family	- Muscicapidae (Babblers, Flycatchers, Warblers, Thrushes, etc.)
Sub-family	- Turdinae (Thrushes and Chats)
Genus	- <i>Saxicoloides</i>
Species	- <i>Saxicoloides fulicata</i>
Sub-species / Geographical race	- <i>Saxicoloides fulicata leucoptera</i> (Lesson) (Race peculiar to Sri Lanka)

2.2.2 Nomenclature

Evolution of the scientific name

Motacilla fulicata, Linn. (1766)

Sylvia fulicata, Lath. (1821)

Thamnobia fulicata (Jerdon, 1839 ; Blyth, 1849 ; Kelaart, 1852 ; Layard, 1853 ; Horsf & Moore, 1845 ; Jerdon, 1863 ; Hodds, 1872 ; Hume, 1874 ; Legge, 1875 ; Davidson & Wender, 1877 ; Legge, 1880)

Saxicoloides fullcata fullcata (Phillips, 1951 ; Wait, 1931 ; Stuart and Baker, 1933)

Saxicoloides fullcata leucoptera, Lesson

English name - The Black Robin

Other English names - Rusty-vented Thrush (Latham)

Sooty Warbler (Latham, Kelaart)

Indian Robin (Jerdon)

Blue Rock Thrush (Legge)

Sri Lanka Black Robin, Sri Lanka Black-backed Robin
(Kotagama and Perera, 1983)

Black-backed Robin (Harrison, 1999 ; Phillips, 1951 ; Wait, 1931 ;
Stuart and Baker, 1933)

Indian Chat (Grimmett *et al.*, 1998)

Ceylon Black Robin, Indian Robin (Harrison, 1999)

Sinhala names - Kalu Polkichcha, Kalu-kichcha, Meechcha
Lanka Kalu-kichcha (Kotagama and Perera, 1983)

Tamil names - Kari-kuruvi ("Black Bird" in Tamil)
Kaddukari-kuruvi

2.2.3 Morphology

Black robin (*Saxicoloides fulicata*) is a Sparrow-sized bird, but with fuller plumage than a sparrow (Henry, 1998). According to Legge (1983) measurements of an adult male are, length 6.2 to 6.4 inches; wing 3.0 inches; tail 2.5 inches; tarsus 1.0 inches; mid toe and claw 0.8 inches; bill to gape 0.7 inches and a female have a length of 6.2 inches and wing length of 2.8 inches.

Male black robin is glossy blue-black, with white lesser wing -coverts and chestnut under tail -coverts. The female is dark grayish brown, with chestnut under tail-coverts, and no white in the wing (Henry, 1998). Young ones are blackish brown with upper tail-coverts and tail black; beneath dark brown, with a dusky fulvous stripe down the throat, and rufous under tail-coverts (Legge, 1983).

2.2.4 Distribution

Black robin is a very common bird throughout the low country and hills, ascending the latter to 5,000 feet on the drier, north-easterly aspect; less high in damper districts. It prefers open scrub land or gardens, and eschews heavy forest (Henry, 1998). Legge (1983) say that it is very numerous in the dry parts of Ceylon, and affects by choice , the maritime districts of them viz. from Chilaw northward to Jaffna and the adjacent islands, and then down the whole east coast round to Tangalla on the south. It is less common in the Western Province

and South Western districts. It was more numerous in the Galle district than "in the Western Province, appearing as if it increased gradually towards the south-east coast, where it is extremely abundant. It inhabits the southern ranges and the lower hills of the Kandyan Province, is found in coffee-district of considerable altitude on the north and west of the main range, being not uncommon as high up as Maturata on one side and Lindula on the other. Its limit is abruptly defined by the high spur which culminates in the mountain of Mahacoudagalla, to the south of which it does not seem to pass, being immediately replaced on the Elephant Plains by the Hill Stonechat, *Prantincola bicolor*. It again reappears in Uva, extending from Badulla eastwards to Madulsima, and thence in to the low country, in the interior of which, as well as to the south of Haputale, it is common. Phillips (1951), say that it rarely ascends the hills above 5,000 feet where in the grass-country, its place is taken by the pied bushchat (*Saxicola caprata atrata*). It is not however uncommon in some of the tea growing districts at nearly that altitude.

Black robin is a resident endemic to the Indian Sub-continent where It occurs throughout except the northeast, Himalayas and part of the northwest. It is found common and widespread in India, Pakistan and Sri Lanka, Uncommon and rare in the center and east of Nepal, former resident in Bangladesh (No recent records), Rare in Bhutan and vagrant in Maldives (Grimmet *et al.*, 1998).

According to Jerdon, this species is found in India as far north as Taptee on the west and the Godaverri on the east, and is tolerably common in the south. It does not appear to frequent in regions of any elevation, as it is not recorded from Travancore, and in the Palanis only from the eastern base (Legge, 1983).

2.2.5 Habitat

Black robin is a general household favorite in Ceylon, frequenting the vicinity of human dwellings, perching on walls and roofs, and resorting even to the verandahs of bungalows. It seems to covert the companionship of man. It is found in all open rocky places, in newly burnt clearings and in cultivated chenas; and in the Central Province it affects stony patanas and bare hill sides (Legge, 1983).

2.2.6 Habits

This merry little bird spends most of its time on the ground where it runs actively, searching for small insects, amongst which it shows a marked preference for termites (Henry, 1998). It is most animated in its movements, carrying its tail erect and jerking it up with a corresponding strutting down of its wings when giving out its pretty warble, and moving hither and thither with a short jerky flight. It consorts in pairs; but the young brood remain a long time with their parents, thus forming a little troop of three or four, after the breeding - season (Legge, 1983).

In assessing territorial rights -against a rival robin, the male adopts a remarkable attitude; he stretches his neck, pointing the bill vertically up, puffs out the breast feathers, white wing-coverts and chestnut under tail-coverts, and elevates the tail until it touches the back of his head: all the while he runs about, pouring out a flood of rather creaky, squeaky song (Henry, 1998).

2.2.7 Breeding

The black robin breeds during the months of March, April, May, and June in the Central , Western, and Southern Provinces, the majority of nests being built at the end of April. A hollow in the ground under the shelter of a rock or stone is another favorite spot, and not infrequently the nest is constructed on the top of a low outhouse wall, or in the side or against the beam of a roof. It is loosely constructed, and varies in size according to the locality; those which are built in niches or holes are made so as to fill the cavity and are constructed of dry roots and grass-stalks of various sizes, being lined with finer materials of the same sort (Legge, 1983). But, according to Henry (1998), the breeding season lasts from March to September. Stuart and Baker states that the breeding season in Ceylon may be said to be all the year round (Phillips, 1951).

Plate 2.1: The black Robin (*Saxicoloides fulicata leucoptera*)

The male



The female



1st year male



Juvenile



2.3 Animal Behavior

2.3.1 Introduction to Animal Behavior

Behavior essentially is what an organism does in an environment (Gopal 1992). The basic tenet of behaviorist is that animal behavior consists of an animal's responses reactions or adjustments to stimuli or complexes of stimuli (Drickamer *et al.*, 1996).

We can broadly classify the forms of behavior in to two (Lehner, 1996; Welty, 1964; Manning, 1967),

1. Innate behavior – A response of an animal to an external stimulus, it is more or less stereotyped and most similar in each individual of the population.
2. Learned behavior – Adaptive changes in individual behavior as a result of experience

Most of animal's behavior is categorized into two groups using durational time of behavior (Lehner, 1996). They are:

1. State – The behavior an animal is engaged in or ongoing behavior.
2. Event – A change of status, it approaches an instantaneous occurrence.

According to Altmann (1974) events are instantaneous; states has appreciable durations. Of course, in reality, the performance of any kind of behavior takes some amount of time, however brief. But if we consider behaviors at the moment of their onset, or at any other single defining instant, then we are recording events.

2.3.2 Significance of Behavior Studies

By studying animals, we can learn about the relationships between them and their environments and about the internal processes that govern their behavior (Drickamer *et al.*, 1996). Behavioral analysis can be used for the discovery of natural groups and new species (Brown, 1975). According to Kotagama and Fernando (1994) instinctive behavior or habits are good clues for the identification of several groups or species of birds.

For the management of animal population in a given area their behavior and habitat requirements must be known (Suratissa, 1995). Scientists investigate behavioral processes of animals to conserve and protect endangered species and many researches use their

knowledge about behavior to control economically costly animal pests (Drickamer *et al.*, 1996).

Wildlife management could be made efficient by behavioral studies. One of the greatest uses of animal behavior for wildlife management is that it helps one to identify the abnormal behaviors shown by certain animals (Emlen, 1955). Their study is very essential for understanding the interspecific and intraspecific relationships existing in animal populations (Gopal 1992).

According to Jasinghe (1995) behavior studies are important because,

- It gives record of units of animal or human behavior.
- Continuous record will eventually show a pattern of animal or human behavior.
- Patterns of animal behavior are important for Zoo management and Wildlife management.
- Animal behavior is used to maintain and preserve the environment in order to save endangered species.
- Animal behavior is used to control economically costly environmental or agricultural pests.

2.3.3 Study of Animal Behavior

All animals, including humans, are involved in complex and vital relationships with members of our own species, with members of other species and with the environment. Our survival, like that of all animals, depends on our ability to procure food and shelter, to find mates and produce offspring, and to protect ourselves from the elements and predators. Thus, we should not be surprised to learn that people have been interested in animal behavior for a long time (Drickamer *et al.*, 1996).

The scientific study of animal behavior has its origins in the work of eighteenth century naturalists such as Gilbert White (1770-1793) and Charles Leroy (1723-1789). Charles Darwin (1809-1882) is regarded as the father of the scientific study of animal behavior (Mc Ferland, 1993). The rigorous scientific study of animal behavior did not begin until the later part of the nineteenth century (Drickamer *et al.*, 1996). The modern approach to this includes many features derived from both the behaviorists and early ethological views. Konard Lorenz and Niķo Tinbergen are generally regarded as the founders of modern ethology. While

evolutionary biologists seek functional accounts of behavior, and psychologists seek explanations in terms of proximate causes or mechanisms, ethologists should aim to answer the questions of the causation, development survival value and evolution of any behavior pattern under study (Mc Ferland, 1993).

Animal Behavior can be studied in the natural environment and in the laboratory. In the natural environment animal is free to express its full range of behavior. This is discovered preliminary through the observations. Direct visual observation is the traditional approach, but in recent years this has been supplemented by indirect methods, which rely on technological development such as audio recording, radio-telemetry, etc (Mc Ferland, 1993). Until recent decades, many animal behaviorists focused on 'how' questions: those involving the ways in which behavior is directly produced and regulated or proximate factors. The recent development of the fields of behavioral ecology and sociobiology has given an impetus to the investigation of 'why' questions those involving the ultimate factors that have influenced the evolution of behavior patterns (Drickamer *et al.*, 1996).

Behavior study is an activity to 'systematically' gather information on animal or human behavior. Behavior is an activity that can be observed, recorded and measured, this includes what living organisms do, their movement in space. It also includes physiological or bodily changes, such as changes in blood pressure or brain waves (Jasinghe, 1995).

2.3.4 Approaches to the Study of Animal Behavior

The scientific study of animal behavior involves a variety of approaches; Behavior can be explained in terms of its evolutionary history, In terms of the benefits that it brings to the animal and in terms of physiological mechanisms (Mc Ferland, 1993). The ideas, methods and theories established during the later part of the nineteenth century form the foundation of today's experimental approaches to the study of animal behavior (Drickamer *et al.*, 1996).

2.3.4.1 Ethological Approach

The systematic study of the function and evolution of behavior, called ethology, is now a little over a century old. One of its most important principles is that behavioral traits can be studied from the evolutionary viewpoint (Drickamer *et al.*, 1996). An ethological study of animal behavior begins with an ethogram – a complete inventory of an animal's behavior. An

ethogram can be compiled for all behaviors or for only selected aspects of behavior. In the ethological approach animals are studied in their natural habitat, their functional relationships are more readily discerned, and this approach deals with problems from an evolutionary perspective (Jasinghe, 1995). After making observations of an organism's behavior, ethologists then formulate specific questions about the adaptiveness and function of particular behavioral patterns (Drickamer *et al.*, 1996).

2.3.4.2 Approach of Comparative Psychology

Comparative psychology is the study of different animals behavior patterns in order to determine the general principles that explain their actions (Drickamer *et al.*, 1996). This approach begins with classification and comparison of behavior of different species or individuals in order to discover relationships between them. In this approach, experiments have a high degree of control over both test subject and environmental conditions; one or more variables are manipulated while others are kept constant (Jasinghe, 1995).

2.3.4.3 Approach of Behavioral Ecology

In the past few decades, a third approach to the study of animal behavior has emerged. Behavioral ecology, with origins in zoology, examines the way in which animals interact with their environment and the survival value of behavior (Drickamer *et al.*, 1996; Morse, 1980; Krebs and Davies, 1987). Behavioral ecologists are concerned with both ultimate and proximate questions about behavior, for example, a study on behavior and habitat selection of an animal (Jasinghe, 1995).

2.3.4.4 Approach of Sociobiology

The study of animal behavior reached maturity in 1975 with the publication of Sociobiology. Sociobiology applies principals of evolutionary biology to the study of social behavior of animals. It is a hybrid of behavioral biology from the ethological perspective, with an emphasis on ultimate question, and population biology, with an ecological perspective (Drickamer *et al.*, 1996; Wittenberger, 1981; Trivers, 1985).

Animal behavior has been largely resolved during recent years. Ethologists believed that much of animal's behavior was instinctive or preprogrammed and was not affected to any extent by experience. Psychologists claimed that learning and experience were the major determinants of behavior. Today, most animal behaviorists accept that neither of these

viewpoints is entirely correct. The current focus is on the interactions of genotype, physiology and experience as determination of behavior and on how the degree of genetic and experimental determination of observed behavior patterns differs among animal species (Drickamer, 1992).

2.3.5 Sampling methods commonly used in behavior studies

Seven major types of sampling for observational studies of social behavior have been found in the literature. These methods differ considerably in their suitability for providing unbiased data of various kinds (Altmann, 1975).

Those sampling methods for use in direct observation of spontaneous social behaviors are given below,

1. *Ad libitum* sampling
2. Sociometric matrix completion
3. Focal – animal sampling
4. Sampling all occurrences of selected behaviors
5. Sequence sampling
6. One – zero sampling
7. Instantaneous and Scan sampling

2.3.5.1 *Ad libitum* sampling

This is the most common form of behavior records and consists of what is called 'typical field notes' in the field, or in laboratory by means of non-systematic sampling or informal observations. Such records are the results of unconscious sampling decisions, often with the observer recording 'as much as he can' or whatever is most readily observed. In any field study some data probably will consist of such records, which may be of considerable use as illustrative material and because of their heuristic value in searching for ideas and in planning systematic sampling (Altmann, 1975).

Ad libitum sampling is used during early reconnaissance observations and when you are developing an *ethogram*. This type of sampling is also commonly used in descriptive research (Lehner, 1996).

2.3.5.2 Focal-animal sampling

The term focal-animal sampling is used to refer to any sampling method in which,

- i) all occurrences of specified (inter)actions of an individual or special group of individuals, are recorded during each sample period, and
- ii) a record is made of the length of each sample period and, for each focal individual, the amount of time during the sample that it is actually in view.

Once chosen, a focal individual is followed to whatever extent possible during each of his sample periods (Altmann, 1975).

With focal animal sampling, one individual (pair, group) is the focus of observations during a particular sampling period. With this method you can accurately measure several behaviors in selected individuals by observing only one (focal-animal) at a time (Lehner, 1996).

2.3.5.3 Instantaneous sampling

Instantaneous sampling is a special type of time sampling in which the observer scores an animal's behavior at predetermined 'points' in time. This method has been called 'time sampling' by Hutt and Hutt (1974), 'point sampling' by Dunbar (1976) and 'on-the-dot sampling' by Slater (1978). The major benefit of instantaneous sampling is the relative ease of recording data versus all occurrences sampling. This method work well with behavioral states, but it is not recommended for use with events. Behavioral events and the sampling points are both instantaneous; hence the probability of them occurring together is remote (Lehner, 1996).

In an ideal instantaneous sample, each individual's state would be instantly noted. If, in addition, the state of the entire group is of interest (as in studies of subgroups or of synchrony), then ideally the state of every individual in the group would be noted at the same moment in time: the scan should be instantaneous (Altmann, 1975).

2.3.5.4 Scan sampling

Scan sampling is simply a form of instantaneous sampling in which several individuals are 'scanned' at predetermined points in time and their behavioral states are scored: that is, instantaneous samples are taken on several individuals at the same time. This allows the observer to record relatively accurate data on a few behaviors for a relatively large number of animals (Lehner, 1996).

2.3.5.5 Estimating percent of time

A primary use of instantaneous sampling is in studies of estimating percent of time that individuals devote on various activities. Percent of time is estimated from the percent of samples in which a given activity (state) was recorded. In most of the studies, instantaneous sampling was used to obtain such estimates. Smith and Connolly (1972) explicitly chose instantaneous sampling over one-zero sampling for this purpose (Altmann, 1975).

Table 2.1: Sampling methods commonly used in behavioral sciences and recommended uses

SAMPLING METHOD	DEFINITIONS (SYNONYMS)	STATE OR EVENT SAMPLING	PRINCIPAL TYPES OF INFORMATION	ADVANTAGES
<i>Ad Libitum</i>	Non systematic, informal observations (Field notes)	Either	Non systematic	Rare, unusual events
Focal-animal	Change in behavior recorded continuously per animal	Either	Duration, participants in interaction, frequency, rate, sequence	Complete data record per individual
All occurrences of Selected behaviors	All occurrences of selected behaviors in members of a group are recorded	Usually event	Synchrony, rates	Can concentrate on specific behaviors of individuals in a group
Sequence	A chain is focused upon from onset to termination in the order of occurrence	Either	Sequence, frequency	Detailed sequential information
Scan / Instantaneous	Behavior is sampled at regular periodic interval (fixed interval time point, time sampling)	State	Estimate of time spent, synchrony	Easiest way to estimate % of time
One / Zero	A predetermined interval is established; if behavior occurs during the interval, given the score one; if not scored as zero (Fixed interval time span modified frequency, checklist, Hansen frequency)	Usually state	Modified frequency	High inter-observer reliability; easy to use

Source: J. Altmann (1974), Sackett (1978), Lehner (1979), Kat Moan (1985)

2.4 Territory and Territorial Behavior

During the breeding season many species are territorial. Especially among passerines, territories are often marked by conspicuous song, display and periodic disputes with neighbors (Bibby *et al.*, 1992)

Each breeding male establishes itself an area whose limits gradually become more clearly defined. It defends the zone around itself within which living space it will tolerate no other member of the species. The study of such defensive and offensive behavior patterns has led to the definition of bird territory. In 1868 Altum in '*Der Vogel und sein Leben*' defined the concept scientifically. However the concept is much wider than that and it is better to give it a more general definition, agreeing with ornithologists such as Noble and Nice that the territory is the whole area defended by a bird at a given moment in its life. In contrast, an area which is regularly used by a bird, but which it does not defend, is not a territory and called their living space (Dorst, 1974). Perrins and Middleton (1985) in their encyclopedia of birds defines the territory as the area that animal or animals consider their own and defend against intruders.

The earliest reference to food territory in birds was given by Aristotle in his *Historia Animalium*. The fact is that a pair of eagles demands an extensive space for its maintenance (Lack, 1953).

2.4.1 Particulars of territory

Territories are not always contiguous and may be separated by neutral zones at least in certain species, or where the population is not very dense – in other situations they form a continuous mosaic with clearly marked lines. More often however the boundaries follow much more complex lines, being established in relation to the nature and topography of the terrain (Dorst, 1974).

There is a rough correlation between the size of bird and the mean area of territory; and especially between the diet and this area in relation to the amount of specific foodstuffs available. The kind of habitat also has an important effect, territories being generally larger in open environments than in closed ones. This is no doubt due to their reduced productivity and behavioral differences between birds of different habitats. Ethological factors also affect

the size of the territory through differences in the competitiveness and aggressive behavior of the birds. There is a seasonal variation of territories. Territories tend to be larger at the beginning of the breeding season and to be successively reduces as further males arrive. A territory defended by a pair will be larger the sparser the food supply, so as to assure a sufficiency to themselves and their brood. The territories of young males are generally smaller than those of males, which have already nested. Young birds are often displaced in to marginal areas, which do not fully meet the ecological needs of the species. This competition is under the control of the male hormones whose quantity in a sense determines the size of the territories, as well as the position in the social hierarchy (Dorst, 1974).

Claiming and defending the territory is generally a male prerogative, which to some extent forms part of the breeding behavior and displays. At later stages of breeding the female may take an active part in the defense of the territory, which thus becomes truly the property of the pair, with the female often defending especially the approaches to the nest. However, in most species in which the sexes are conspicuously different it is the male alone, which undertakes the defense of the territory (Dorst, 1974).

2.4.2 The significance of territory

Territory is of indisputable ecological importance. Situated as it is within the habitat best adapted for the species, it must provide everything necessary to the bird to remain alive and ensure food for the pair and its young. The availability of nesting sites markedly influences the density of birds, and consequently the size of their territories (Dorst, 1974).

Territory has survival value for two main reasons, first the acquiring and retention of a mate, and secondly the ensuring of a food supply for the young (Lack, 1953). Knowledge of the terrain allows the territorial birds to escape its enemies effectively. Predation is markedly more intense on birds, especially game birds, when they show non-territorial behavior (Dorst, 1974).

The value of territory in pair-formation has not been disputed since Howard enunciated it. Territorial behavior spaces the males out over the countryside, and males which are unmated sing more loudly than those which have acquired mates. Since in many species, like the robin, the territory is also defended after pair-formation, Howard suggested that it has the subsidiary function of helping to maintain the pair once formed, since they have a definite headquarters and rivals are driven out (Lack, 1953).

Territory and associated behavior are essential to the males of many species for certain psychological factors in the maturation of the gonads because of the dominance, which they show on their own ground. Males, which are subordinate or lack territory, cannot reproduce successfully (Dorst, 1974).

The division of the habitat into territories brings about the optimal use of its natural resources. It avoids local overpopulation, which would otherwise arise. In most cases the area of each territory cannot fall below a minimum, so that even if food is abundant to the point of surplus many birds (especially among the passerines) cannot tolerate the close neighborhood of their own species. This necessarily involves a mutual withdrawal, and hence keeps the population below a definite level (Dorst, 1974). The idea that birds regulate their own population density in accordance with food supply is picturesque, and has from the time of Aristotle caught the imagination of part of zoological public. However, there is no real evidence to support it (Lack, 1953).

Furthermore, by dispersing the population and avoiding local concentrations, territory hinders the spread of diseases and parasites harmful to the species (Dorst, 1974).

2.4.3 Types of territory

Of the various classifications of the territory, which have been proposed, Nice's (1941) seems the best and seven categories can be distinguished (Dorst, 1974).

1. Territory is the scene of all reproductive behavior, including pairing and sexual displays and all feeding behavior. Male first establishes himself at the start of the breeding season, attracts a female by his audible and visible behavior, build their nest and raise their young. All the food required by the family is taken within the defended boundary and this is the most widely distributed type.
2. Territory has only a sexual significance. All reproductive behavior takes place within this area, which the male, vigorously defend by aggressive behavior. Territory has no significance for feeding.
3. Territory consists of a simple display ground, often termed a *lek*. These are only found among birds whose females alone devote themselves to the young, while the males are sexually promiscuous and spend their time in communal displays. Territory has no significance in other reproductive behavior and feeding.

4. Territory encloses nothing but the nest and its immediate surroundings. Sometimes it is no longer than the area, which the bird can defend with its bill while in the nest. This type is found among gregarious birds which nest in dense colonies.
5. Some birds have two territories, spatially separated but defended equally vigorously, one devoted to nesting and the other to food gathering. Very few birds have territories of this type.
6. Non- migratory birds general defend territories only during the breeding season, outside which they scarcely show any territorial instincts. Territorial instincts of migrants mostly disappear during migration, when birds, which have been intolerant of others during the breeding season, become gregarious.
7. The last category comprises the roosts and resting places used by birds outside the breeding season. Many birds return nightly to the same place and use the same perch.

2.4.4 Territorial behavior and defence of territory

The essence of territorial behavior, defence of a particular space, shows itself in a series of aggressive activities: threats and pursuits leading up to real fighting. The objects of this defence are the nest, the mate and the young, and a number of localities such as the song posts which are scattered throughout the territory and mark out its limits (Dorst, 1974).

Among passerines song plays an important part in defence, the male advertising its rights to a territory and defending it from rivals mainly by audible display. Display behavior providing optical stimuli also plays a part in the defence of territory. These stereotyped species-specific movements act primarily by showing off specific colored patches (Dorst, 1974). Lack (1943) states in 'The Life of Robins' that the song, fighting and display of the robin all center round the acquiring and maintenance of a territory.

Where natural territory boundaries do not exist, the territorial limits are still fairly sharply defined, and are determined by encounters with neighbors (Lack, 1953). When two holders of territory come into actual conflict, the one on whose ground the fight takes place usually wins. It is effectively dominant within its own territory, and the intruder is submissive as though showing an 'inferiority complex'. Aggression is generally shown only between individuals of the same species, and is obviously under the time influence of the sex hormones, varying with the quantity secreted from beginning to the end of the breeding season (Dorst, 1974).

2.4.5 Territories of robins

The second reference ever recorded for territoriality was by Olina for the robin. No recent literature has been found about the territories of robins, except 'The Life of robins' by David Lack (1953). This data on the British robin is also less relevant to the situation of the black robin (*Saxicoloides fulicata leucoptera*) in Sri Lanka.

Lack (1953) states that the robin spends so much of its life acquiring and maintaining a territory, and the territory is so definite, that it is reasonable to suppose that it has a value.

Although the robin is efficient in keeping out mating rivals, it is inefficient in preserving its territory from food trespassers. Poaching robins retreat when attacked, but often return unobtrusively after a few minutes. Indeed, feeding is the only one of its activities for which the robin seems to perform beyond the boundaries of its own territory (Lack, 1953).

The average size of a robin's territory at Dartington was about 1.5 acres. Burkitt obtained the same figure in Ireland. Detailed study shows that the territory size is not fixed for the species. At Dartington the larger robin territories were about two acres in size; indeed, pairs some times held over three acres for a short time, after a neighbor has left or died, but they did not maintain such large areas for long. On the other hand, the smallest breeding territories were only 0.4 acres. These seem nothing peculiar about the makeup of these small territories, which were in woodland similar to that of the large territories. According to available information (Lack, 1953).

In song birds breeding territories are the rule, the possession of an autumn territory is very uncommon. The autumn territory of robin is an individual territory held by a male or less commonly by a female with the average size of 0.75 acres (Lack, 1953). But, this type of seasonal territories are not found in any Sri Lankan bird as well as the black robin.

2.4.6 Territory mapping method

The territory mapping method discussed below is described by Bibby et al (1992) in the book 'Bird Census Techniques'.

The method has formed the basis of the British Trust of Ornithology (BTO)'s Common bird Census since 1962 (e.g. Williamson, 1964) and has been widely used elsewhere (william,

1936; Kendeigh, 1944; Enemar, 1959). The mapping approach relies on locating all the territorial signs on a series of visits and using them to estimate locations and numbers of clusters or territories. There are rules for mapping census work set out by the International Bird Census Committee (1969). The mapping method is the most time consuming of the general bird count methods for a fixed number of birds finally counted. In this sense, it is inefficient (Bibby et al., 1992).

The study plot

The location of plots need careful consideration depending on the objective of the study. A study plot needs to be adequately mapped at a scale of about 1:2500. It is important that birds are mapped accurately and, at this stage, symbols can be positioned to within about 10-20 m, which is probably comparable to the error to be expected in map reading. In open or uniform areas, it is essential to mark selected stones or trees, or other features on the ground and on the map so that any bird can be located accurately. It is necessary to walk the boundaries of the plot. To make the most of a mapped plot, it is necessary to describe its vegetation in some way. This allows a variety of further analysis on the habitat utilization.

Time and route of visits

The results of a mapping census can be influenced by the number of visits. It might be thought that more visits would be better, but infact they can add confusion rather than clarity. The Common Bird Census (CBC) had adopted 10 visits as the standard. Ideally they would be spread fairly uniformly at about weekly intervals. Early morning is the best time for visiting, but some evening visits might be helpful. It is best to avoid the first hour of activity before dawn.

Bird Recording

The identity and activity of all birds are mapped with small and tidy writing in pencil. It is helpful to use a standard list of codes for bird species and activities.

It is necessary to map records outside the plot. In the field, this is accomplished by recording everything detected from the boundary without walking outside the plot. The field maps therefore need to extend by about 100 m in all directions beyond the plot.

Following variations of the method can be applied in order to get accurate results.

1. Restricting the list of species covered

The CBC and Bird Community studies include all species, or at least as many as possible. If the purpose of the study is more restricted, the first variation is to map fewer species.

2. Eliciting responses

The observer can increase the chance of finding birds and obtaining simultaneous registrations by using a tape to play snatches of songs of the target species and recording any responses.

3. Consecutive flush

Another way to make birds respond is to try to chase them to their territory boundaries. They will often fly readily within the territory but be reluctant to go beyond it.

4. Nest-finding

In a study of a single species, the location of nests may be needed in territory mapping. For some species with weak signs of territorial behavior, nest finding is the only really good way of counting them.

5. Marked birds

Much of the difficulty in interpreting maps comes from the problem of knowing which records refer to the same individual and which to different ones. This problem becomes much simpler if birds are uniquely color marked or radio tagged.

6. The full study

If marking and nest finding are used, and all efforts made to maximize the critical records for a mapping study, there is a chance that the results will give a good picture of the absolute number of birds using an area in a season.

Interpretation of results is a complicated process, which includes several steps and assumptions. It can be summarized as transporting the field data into fixed maps, interpreting the species maps using minimum requirements for a cluster, dotted, solid or question marked solid lines, multiple sightings, superfluous registrations, large or defused clusters, spurious clusters, and edge clusters.

Assumptions made in the process of territory mapping are,

- The observer is good at finding and identifying birds.
- Records are plotted accurately.
- The standard rules are used, or broken selectively.
- Birds live in pairs in fixed, discrete and non-overlapping ranges.
- There is a reasonable chance of detecting a territory holder.

CHAPTER 3

MATERIALS AND METHODS

3.1 Methodology

Observations were made during a period of 57 days in Buttala in between 0630 and 1830 hrs. Data was collected in the dry season and few days with showers within the study period were purposely eliminated. Several preliminary *ad-libitum* observations were done prior to the detailed study.

Ad-libitum behavior sampling described by Altman (1975) was done throughout the research period in order to construct the *ethogram*. Focal animal sampling method (Altman, 1975) was also used to support above data.

For the study of diurnal activity and behavior instantaneous and scan sampling method (Altman, 1995) was used. 84 instantaneous behavior samples were recorded for 7 days within the data-gathering period. Sampling was done in the morning between 0630 and 0830 hrs, mid day 1130 to 1330 hrs and evening 1630 to 1830 hrs. Four instantaneous samples of 15 minutes each were taken during the two-hour period at 15-second intervals.

The total count sampling method described by Caughley, 1980 and Verner, 1985 was used to determine the population of black robins in the study area.

Territorial mapping was done using the method described by Bibby et al. (1992) in order to identify the different territories of black robin. Selected individuals of black robins were marked using colored plastic rings, prior to the mapping, for identification purpose. These birds were captured using mist nets placed across their activity centers of the territory, and using a hand net while they were roosting at night. Different markings of the plumage of some black robins were also used in individual identification.

The study area was mapped at a scale of 1:550 using a base map of the university premises, which had been prepared at the above scale with an error of 0.9% and it was divided into six study plots. Several copies of each an every plot map were produced, one for each field visit. This scale was used because it is hard to mark birds, whose activities are some times limited to a small area for the whole mapping period, in a much larger scale. Therefore, in order to reduce the error to be expected in mapping of birds in a map of

smaller scale, it was done very carefully with the help of roads and pathways on the base map and other features such as trees and rock exposures which were marked on the map prior to territory mapping. A grid system was not used since the base map provided a good network of roads and pathways.

Territorial mapping was done while regularly traversing the study plot. Each black robin encountered was followed recording the locations and activities of the bird. Field maps were generated for each visit in this way. Birds were recorded using codes developed with the help of standard BTO (British Trust for Ornithology) codes used for territorial mapping (*Appendix V*). All field maps of different visits to the same study plot were copied on to a single map and finally maps of different plots were copied on to the area map. All possible territories were identified on the basis of distinct clusters of registration.

Territorial behavior of black robin was recorded using a separate data sheet. Whenever black robins were encountered engaged in territorial disputes following data were recorded.

1. Date and Time
2. Location
3. Numbers of Individuals
4. Individual sex and Identification
5. Duration of dispute
6. Behavior activities involved

3.2 Equipment used

1. Pair of binoculars 7X50 (Super zenith)
2. Pentax P 30 Camera with
 - 35 mm - 70 mm zoom lens
 - 70 mm - 200 mm zoom lens
 - 2X Converter
3. Stop watch
4. Wet and Dry Bulb Thermometer
5. Mist net
6. Plastic rings and a spoon

Plate 3.1: Equipment used



Plate 3.2: Usage of mist net in capturing of black robin



Plate 3.3: A ringed juvenile black robin



3.3 Data Analysis Techniques

Ad libitum behavior data was analyzed manually in order to construct the *ethogram*, and behavior descriptions.

For the study of diurnal activity, percentage time spent on each behavior type was calculated using all 84 instantaneous behavior samples collected during the study period.

The student's *t*-test was used to determine the significance of the difference between percentage time expenditure in two different sexes of black robins for each type of behavior as shown in the appendix I.

The total population of black robin within the study area is computed using data from five total-count samples according to the calculations of standard deviation and coefficient of variance given in appendix II.

Correlation analysis was done to examine the relationship between the territory size and the number of individuals occupy the territory. Pearson correlation coefficients were found using the statistical computer package 'SAS' from the program given in appendix III, at the acceptable level of significance $p = 0.05$.

Territory maps were analyzed in order to demarcate distinct territories of black robin. The territories were defined based on distinct clusters of registrations and they were marked joining the outermost locations of registrations in each cluster. The sizes of territories, activity centers and areas of overlapping were measured using a 1 cm X 1 cm grid overlaid on the map. Those readings were computed according to the scale of map and expressed in hectares.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Behavior of black robin

Black robin is an active bird and shows a great variety of behaviors. The bird was very much alert, always keep searching around the habitat, and aggressive in its behavior. Different behavior patterns were identified during the course of study and categorized in to major behavior patterns for the easiness of analysis.

4.1.1 Ethogram

Following *ethogram* was constructed using observations made on behavior of black robin.

Table 4.1: Ethogram

Major Category	Type of behavior or event
I. Locomotion patterns	<ol style="list-style-type: none">1. Hopping2. Running3. Standing alert while locomotion4. Standing alert and jerking tail5. Jumping on the land6. Jumping up7. Jumping down8. Flying9. Short flight10. Flying up11 Gliding down
II. Ingestion pattern	<ol style="list-style-type: none">12. Picking13. Darting on insects14. Continuous feeding15. Feeding while holding food with a foot16. Feeding from clay mounts17. Kill and feed

Major Category	Type of behavior or event
	18. Playing with food 19. Turn over leaves 20. Feeding from grass leaves 21. Searching for food 22. Drinking water
III. Elimination patterns	23. Defecation
IV. Perching	24. Perching 25. Perching with the beak open 26. Perching in pairs 27. Perching with call / song
V. Cleaning patterns	28. Cleaning the beak 29. Preening 30. Puffing the plumage 31. Stretching wings 32. Direct scratching 33. Bathing
VI. Resting patterns	34. Standing on land 35. Look out 36. Look out while calling 37. Look out in pairs 38. Hiding 39. Roosting
VII. Posture patterns	40. Sitting on land 41. Sitting at a height
VIII. Territorial behavior patterns	42. Territorial song 43. Territorial display 44. Look out at the territory boundary 45. Tail show 46. Territorial attack
IX. Nidification patterns	47. Nest building 48. Using nests of other species 49. Laying and incubation of eggs 50. Nest guarding 51. Nest cleaning 52. Child caring

Major Category	Type of behavior or event
	53. Feeding the brood
X. Intra-specific interactions	54. Quarreling 55. Driving one another on land 56. Chasing one another in flight 57. Supplanting attack
XI. Interaction with other species	58. Attacking 59. Withdrawal 60. Alertness
XII. Searching patterns	61. Searching
XIII. Communication patterns	62. Vocal sounds 63. Alarming
XIV. Thermoregulation	64. Sunbathing

451.2 Description of behavior patterns

4.1.2.1 Locomotion patterns

Hopping - This is the regular pattern of locomotion of black robin. Hopping is associated with several other events to make the whole locomotion pattern. They are running being alert on land and jumping.

Running - This is similar to bipedal locomotion, But very fast. Bipedal locomotion of black robin can be categorized as running, but not as walking, since it is done in high speed.

Standing alert while locomotion - This is performed in the interval between few hops or short runs. This event lasts a very short time and performed repeatedly during the locomotion on land. Body of the bird is kept straight, neck is starched and it seems very watchful. The tail can be erected up or down (Plate 4.1).

Standing alert and jerking tail – The black robin jerks its tail frequently while standing alert at intervals while locomotion.

Jumping on land – This behavior was shown when the bird is excited or afraid of something on the land. The birds suddenly jump away from one location to another, sometimes associated with an alarm call.

Jumping up - This was shown when the bird needs to jump up to a lookout post or some other height. It gets the propulsive force to jump up by bending the legs and stretching them quickly. This is not associated with movements of wings.

Jumping down - This behavior was shown when the birds need to come down from a look out post, termite mount, etc. The bird leaps down from the height and lands. No use of wings.

Flying - Flying is done in order to move within two places apart from each other. The black robin showed this behavior commonly, but it is not the major locomotion pattern, since it is a terrestrial bird. Flying take place between 2-8 feet height range and rarely exceed ten feet, only when it perches on a high song post after the flight. Flight of this bird is not very long and usually last for few seconds (The maximum distance recorded for one flight was approximately 100 m). Black Robin use short and rapid wing stork in performing its jerky flight. Black robin is able to change the flying direction very rapidly and it was capable of escaping the mist net by reducing flying speed and reversing the flight in a split of seconds even after it touches the net.

Short flight - This is the flight that black robin shows when exited. A short flight is performed with an alarm call or loud song. It lasts only about two seconds and movement is only 1-2 meters.

Flying up - When it needs to climb up to a branch with a height of more than 0.5m approximately it flies up by the propulsion got from bending and stretching legs and using of wings.

Gliding down - When the bird move down from a perch it show gliding down. The wings are stretched, but not moved or used. After it comes near the land, wing movements before landing controls the speed.

The locomotion on land is a complex behavior pattern, which is associated with several events such as hoping, running, being alert, tail jerking, jumping and sudden changes of direction. Above events are practiced with out an order, very rapidly and continuously. For most of the time, land locomotion is associated with feeding, especially picking.

4.1.2.2 Ingestion patterns

Picking - This is the most widely used method of feeding. It is used to feed from soil, dead or fresh grass, grass roots, leaves and litter. Picking is shown while locomotion on land. It is done also when feeding from termite mounds and tree barks (Plate 4.1).

Darting on insects - Usually done to catch fast moving insects on land. The bird charges against insects for 1-2 seconds and picks up it (Plate 4.1).

Continuous feeding - When a quality food is found the bird feeds on it continuously for duration of 15 seconds to 1 minute. Normally the bird does not mind about the surrounding environment when performing this behavior.

Feeding while holding foods with feet - This is shown when the food material is something large or when the bird feeds on insects or some other food attached to a stick or any object.

Feeding from termite mounds - Black robins feed on termites, from fresh ends of termite mounds. It makes a hole on the wall of termites mount and feed on termites coming out or picks termites inside the mound by the beak. This behavior was observed continuing for more than 10 minutes (Plate 4.1).

Kill and feed - Black robins feed on worms, caterpillars and some larger creatures too. They catch those creatures from the soil or grass and brought on to a rock. The bird will kill the prey by rubbing and hitting it against a rock using its beak. Few pieces of the prey is fed after killing and the rest is kept away.

Playing with food - When the birds capture a prey like worm, usually it plays with the prey before killing. It throws the prey up and again hit it against a rock while jumping and playing.

Turn over leaves - This is the behavior of searching for insects under leaf litter. Sometimes it turns over all the leaves and even sticks and finds insects.

Feeding from grass leaves - This is shown when the bird searches food which is attached to leaves of grass. It was observed that the robin places grass leaves between its beak and drawn along the beak.

Searching for food - Black robins search for foods with a stretched neck, sometimes the neck and head is tilted in order to search the gaps between grasses and other debris on land.

Drinking water - This behavior was observed only once during this whole study. Black robin do not often drink water even in the dry season. It is hard to explain the reason for this because its food material does not contain a high moisture content and the bird lives in a very hot and dry environment. The bird lowers the bill in to the water and head is titled upwards in order to swallow water. This pattern is repeated several times (Plate 4.1).

Black robin shows a marked preference on termites and other insects as food material. It was once observed that black robins catch and eat swarming termites. Grasshoppers and other small insects including ants are darted frequently during the feeding sessions. It generally feeds on ground, singly or in pairs, hopping, running, tail jerking and being alert are associated with feeding behavior.

Feeding activity of black robin can be also considered as a social interaction where the family of birds feeds together within their territory. It was once observed that a female black robin fed on a termite mound for more than 10 minutes with three juveniles. Black robin is sharing the same feeding habitat and foods with red-vented bulbuls, common mynahs and some other birds.

After capturing several insects and when the bird is satisfied it settles on a perch and clean the beak and the body. Verbeek, (1972) states in his study on yellow billed magpies (*pica nuttalli*) that while feeding in grass lands, magpies frequently flee to near by trees in response to predators or to alarm calls from other birds. This results in an intermittent pattern of feeding, flying and resting, as occurs in other species that feed in grassland, such as starlings (*Sturnus vulgaris*)^{and} Brewer's Black birds (*Euphagus cyanocephalus*). The black robin also show the same behavior sequence.

4.1.2.3 Elimination patterns

Defecation - Defecation is the major elimination pattern of the black robin. It defecates while standing on land with jerking the tail up wards, while perching on tree branches and even while flying. The droppings are rather watery with blackish green center and white watery surroundings.

4.1.2.4 Perching

Perching - This can also be considered as a resting behavior pattern but in the case of black robin, perching has a territorial significance because they use known and definite perches within their territory. This is usually performed after a feeding session. When perching in warm weather the birds often seek shade in the territory and fall silent. Normally feathers of the breast are puffed. Sometimes it was observed they close their eyes frequently when they perch for a long time (Plate 4.1).

Perching with the beak open - It was noted that in very hot midday periods the bird perches with the beak open.

Perching in pairs - Perching of male and female together play a major role in pair bonding of black robins. It was observed that the pair remains perching together under the shade in hot middays, for a long period of time.

Perching with call / song - Sometimes perching is associated with calling or singing. This has significance as a territorial behavior too. Singing while perching was shown by both males and females intermitatnly.

Black robins usually perch at a height range of 1-6 feet, and rarely exceed 10 feet. Most frequently used trees were 'Kohomba' (*Azadirachta indica*), 'Ipil ipil' (*Leucaena leucocephala*), 'Pera' (*Psidium guajava*) and it shows a marked preference on 'Bougainvillea' bushes. It was clearly observed that the cleaning behavior is mostly associated with perching.

4.1.2.5 Cleaning patterns

Cleaning the beak - This is the first activity black robin show after perching on a tree branch after a feeding session. It rubs the beak against the tree branch and cleans the beak (Plate 4.3). Once a bird was observed, rubbing its beak an also the face on a rock.

Preening – Feathers are drawn through the beak very fast. Preening can again be divided in to several events according to the part of the body preened. (Plate 4.3). For preening the inside of the wing, the wing is stretched a little up and approached from underneath, rump and back abdomen area is preened by approaching from above after wing is dropped, Wing

outer surface is preened without any movement of the wing (as described by Suratissa, 1995 in the study of purple coot and Delias, 1969 in his study of skylarks), and the breast and the abdomen are some times cleaned by bending the neck down. The backside is preened by bending the neck back.

Preening is usually associated with shaking the body and occurs during rest periods or perching. All parts of the plumage are preened except the head and upper throat. Allopreening which is the term used when a bird preens the plumage of another bird (Cullen 1963) has never recorded from black robin.

Puffing the plumage – The black robin puffs its plumage several times while other cleaning events are performed. Sometimes after preening, scratching and stretching it rests some time with the puffed feathers, especially the breast feathers. This is observed to be done when there is a fair wind, which automatically puff feathers.

Direct scratching - Scratching with one foot over the wing is used in order to clean the head and upper throat. The bird usually closes its eyes while scratching.

Indirect scratching which was described by Pearson (1994) where the scratching foot is lifted beneath the stretched wing (Suratissa, 1995), has not been observed in black robin during the study.

Stretching wings - Stretching movements occur at intervals during cleaning and rest periods. The bird stretch out and again fold wings one by one.

Wing stretching occurs at high frequency often when bird is perched. It is a maintenance activity associated with preening (Burkley, 1968).

Bathing – Bathing is a rare behavior observed only twice. I could not observe any black robin bathing from a natural water body. A robin was once observed bathing by dipping the body in water accumulated in a gutter, In the same rainy afternoon another robin was recorded bathing from the rainwater. It was exposed to the rain with a puffed plumage, and cleaned feathers using the beak followed by puffing feathers again.

Cleaning occur much in the midday as it is associated with perching, and perching have a high proportion of time budget of the midday. But cleaning has considerable percentage of time spent in the morning and afternoon too where the bird is more active.

4.1.2.6 Resting

Standing on land - Here, the bird is standing on the same position for a long time. Once a juvenile robin was observed to stand at the same place for 7 minutes without any movement, in a shady place on grass.

Look out - Look out behavior can be categorized as a resting pattern as the bird's activity is low. But this is some times done at intervals while locomotion. During the locomotion it jumps up to a place with a height between the range of 1-2 feet and being alert and watchful for sometime (for about 1-2 minutes). But the same behavior is shown for about 10-15 minutes on its famous look out posts or on walls (Plate 4.1).

Look out in pairs - Sometimes look out is also shown as a pair. Once I observed a pair of black robins looking out on a termite mount. Same behavior has been observed on walls too.

Hiding - This was observed in a hot sunny midday. Where a couple of black robins were hiding inside a stack of discarded bamboo. Sometimes they came out for little while, look out and again hide inside. This behavior was again observed at a time of raining, where a robin was hiding in order to escape from the rain.

Roosting - This is the common behavior of black robin at night. The birds settle on a suitable place and stay still. Even though they are sleeping they open their eyes even with a little disturbance. The time of going to sleep and of wakening adhere closely to the sunset and sunrise.

Roosting places of black robin are unusual with compared to the other birds. Usual roosting places of black robin are associated with man-made structures. They roost on corners of buildings, edges of walls inside houses etc. This is a good example that shows the relation of black robins to human habitations.

4.1.2.7 Posture patterns

Sitting on land - This is a very rare behavior pattern. This was observed only once on a grassland under the shade. This behavior was performed by a juvenile robin.

Sitting at a height - This is the common posture pattern of black robin. It sits on a place above the ground on a tree branch or on a roof of a building. In this behavior normally the birds bends its legs and places its ventral side on the object it is sitting on. Normally it uses a corner with an angle of 90-120⁰ and perform the behavior as shown in plate 4.1.

4.1.2.8 Territorial behavior patterns

Lack (1953) states in 'The Life of Robins' that the song, fighting and display of the robin all center round the acquiring and maintenance of a territory. It was observed that male black robins only defend their territories. In the case of females, even they are stucked to one territory they do not defend it except performing the territorial song.

Territorial song - The song play a major role in announcing the territory of black robins. It uses several trees or any other song posts along the boundary of its territory to perform the territorial song. In the morning and afternoon periods male black robins announce their territory boundaries by singing continuously for a long time. Some times I observed robins flying all around the territory with intermittent perching on song posts for singing. It was also observed that the male and female both perch at once on a song post and sing one after the other. Some times male black robins are observed singing simultaneously on song posts on either sides of the territory boundary.

Territorial display - The male robin adopts a remarkable attitude against a rival robin; he stretches his neck, pointing the bill vertically up, puffs out the breast feathers, white wing-coverts and chestnut under tail coverts, and elevates the tail until it touches the back of his head (Henry, 1998).

Black robins show a peculiar territorial display. This is performed only in territory overlaps, between two male black robins of consecutive territories. Both birds are looking at each other with stretched neck and, puffed breast. The tail is elevated up to an acute angle. Then they elevate and lower the neck several times, then walk against each other with lowered and stretched neck (Tail down for most of the time). Sometimes they walk around each other and show their white wing patch and chestnut under tail patch to the other bird. Showing the color patches has been described also by Lack (1953) as a method of robins used in territory defending. After walking for few steps they stop for a while and show their puffed breast.

Sequence of events in the typical territorial display of black robin is illustrated in plate 4.2. This sequence can be changed in certain occasions.

Look out at the territory boundary - It was sometimes observed that male black robins perform look out behavior for some time on look out posts, rocks or any other physical barrier like a wall along the territory boundary. Normally they look at the territory next to their one.

Tail show - It was observed performing this special behavior, carrying the tail erect and jerking it up with a corresponding strutting down of its wings when giving out the warble as explained by Legge(1880), this was performed usually at the boundary of the territory, but sometimes without the presence of rival robin.

Territorial attack – This attacks are followed after the territorial display if the rival robin is not returning back or performed when the territory owner see a rival robin entering their territory. Normally supplanting attacks take place at territory boundaries, which is described later in the text. These attacks can be seen often and usually the rival robin flees back to its territory after the attack.

Black robins seems to maintain its territory all the year-round. Territorial encounters are spread out more evenly throughout the morning and afternoon. But a high percentage of territorial disputes have been recorded in the afternoon than morning. There is no any record of territorial disputes in midday.

Territorial disputes are performed only for a short time period. It ranges from a minimum of 10 seconds to a maximum of 2 minutes. Most of the time 2 to 4 individuals are involved in territorial disputes. Much of them are males. Even if females are involved they do not show any territorial behavior, and be a part looking at the dispute some times with puffed feathers.

Robins must frequently be dispossessed of their territories and such birds are rarely killed according to Lack (1953). The time period of my study was not enough to study such dispossessions or establishment on new territories by young birds.

4.1.2.9 Nidification patterns

Nest building - Black robins make their nest for a period of about two weeks. *Both males and females are* engaged in building the nest. *But, mainly male* black robins collect the nesting material and place

them to form the nest in some kind of a cavity. Nesting material was the same as given in the literature survey and using of artificial material such as wires were also observed. Several nests of black robin were found and they were placed on various locations such as in a hole of a bamboo, inside an old bucket, in a hollow on a vertical cut of land, inside a wall bracket, on the upper surface edge of a wall and on the edge of a closed window. It should be noted that much of black robin nests are unprotected and exposed to predators (Plate 4.1).

Using the nests of other species - It was once found that the black robin goes in and come out from a nest of White-backed munia. Later I found that it has laid eggs inside that. Normally black robins build their nests in some kind of a hollow or cavity. Therefore, old munia nest could give a good cavity for robin to make its nest. Another nest was found in a cavity created by a nest of Red-rumped swallow, which was broken at its mouth.

Laying and incubation of eggs - The incubation is done only by the female robin. The bird bends its legs and comes to a low position while keeping the back lifted up wards. The thoracic region rests on the nest for incubation (Plate 4.1).

Nest guarding - Male always keeps moving around the nest while the female is incubating inside. It fly between perches near the nest (about 1-5 m away) and keeps singing. When ever a threat occur it gives a loud note or an alarm call and attacks predators. It was observed that male and female both attacking skinks, lizards and even land monitors in the vicinity of the nest with eggs. After the alarm call is given by the male, the female robin also come out of the nest to guard it.

Nest cleaning - Droppings of broods are taken away from the nest by parents using their beak.

Feeding the broods - The broods are fed by both parents until they grow up to the size of adults, for more than one month after birth. When broods are in the nest, male and female bring food materials alternatively and feed the broods. Broods are fed very frequently as 15 times during 70 minutes in an afternoon. The female fed brood 7 times and male 8 times. It was also observed that feeding the brood is much frequent in the morning and afternoon. Feeding the broods was continuoued even after they fly out of the nest. An adult male was observed feeding a brood 3 times during 15 minutes. The juvenile was standing on land and hopping for few feet while adult male finds food and feeds the brood. It was also noted that feeding the brood reduces with the maturation of young ones (Plate 4.1).

The chief nesting season of black robin in Sri Lanka has been recorded as March till September by Henry (1998). But, I have found nests with broods even in October in Buttala.

Phillips (1951) states that the eggs usually number two only, but sometimes three are laid. All the nests I came across during the study had a clutch size of two eggs.

I have recorded that black robins make more than one nest in each breeding season. Bird occupying the territory number three made three consecutive nests during the study period of four months, after first two nests were failed.

4.1.2.10 Intraspecific interactions (Social behavior)

Quarrelling – Intra specific quarreling of black robins was a rare behavior pattern. It seemed to be a sexual battle between two males, where the battle become more aggressive when the female comes near. Two quarrels were recorded which occur approximately for 35 seconds and 75 seconds.

In vigorous fights, the tendency seems to be to get above the other and strike down upon it. The stronger robin attacks the other while in short flights, when the weaker one collapse on land the other lands on its body and attack several time from the beak. The stronger wins and the winner stand above the looser that lies on land in an upright position for some time.

Driving one another on land - This behavior is shown when there is conflict between individuals of the same territory. It can be described as running around following each other. The fittest of the two birds drive away the other. It was not clear whether they are playing or performing an aggressive behavior.

Chasing one another in flight – Chasing one another was observed in between two males and also in between a female and a first year male. It was clearly an aggressive behavior associated with quarreling in the case of two male robins and associated with supplanting attack in the case of male and female. Occasional attacks were also done by the beak while chasing.

Supplanting attack - This behavior was described by Trillmich(1996) and Brockway (1964) as flying in to or on to another individual. The bird flies straight at the place where another is feeding or resting on land. The attacked bird evades by flying off immediately. Flying in to or on to another individual can be seen in between the birds occupying the same territory. This

type of aggressive encounters were observed frequently between the dominant female and the first year male of the territory number 01.

4.1.2.11 Interactions with other species

Attacking - Black robin normally attacks small birds who feed within the same territory such as bush larks. It seems to attack reptiles such as cobras and rat snakes. Once a male black robin try to drive away a cobra by continuous alarm calls, and jumping around the snake, but it did not attacked the snake. On another occasion a pair of black robins attacked a rat snake and they were able to drive away it until the snake go out from the territory. They attacked to the body of snake with their beak. Also they attacked skinks, lizards and even land monitors when they are defending the nest.

Withdrawal - It was observed that red-vented bulbuls always come to an encounter with black robins while feeding. Whenever a robin founds a quality foods red-vented bulbuls quickly fly on to it and drive away the black robin. Black robins attacked the red-vented bulbuls very rarely but mostly it withdraws and gives red-vented bulbul the chance of consuming the food.

Lack (1953) states that the robins, like other territorial species, make no serious attempts to eject food competitors of other species. The later one attacked only sporadically, and visually for reasons, which have no connection with territory. This statement exactly matches with the situation of black robin that is always associated with red-vented bulbul (*Pycnonotus cafer cafer*) common mynahs (*Acridotheres melanosturnus*), spotted dove (*Strptopelia chinensis ceylonensis*) and rarely with bush larks (*Mirafra affinis*).

Alertness - The black robin do not show any interspecific behavior against some species of animals. But, being alert about the movement of the animal. This behavior was observed against a land-monitor and a mongoose. Black robin looked alert at the animal till it go beyond the territory boundary.

The principal enemies of the black robin are certain reptiles like rat snake, cobra and land monitor, and mammals like cats. It was never observed, any bird species becoming an enemy of black robin.

4.1.2.12 Searching

searching - The black robin is a watchful and enthusiastic bird as well as being a household favorite. It is always aware of every thing happening in and around its territory. It searches every thing in the territory in a great enthusiasm. It was observed that whenever something new has been placed in their territory they approach it very carefully and if they feel safe they search every thing they can. On several occasions when a bicycle was placed in their territory they were observed searching in pairs or groups.

4.1.2.13 Communication patterns

Vocal sounds – communication is a rather difficult term to define. But in general it is the process where the behavior of one animal alters the probability of some behavior in another. During communication information is passed between animals by signaling, but it is not enough to merely detect the signal (Catchpole, 1979).

Normal song note of the black robins sounds like 'Qui keee', 'Qui kew keee' or 'Qui kew kew keee ka'. The usual singing of black robin consists of continuously repeated song notes and occasional alarming note.

Alarming - Moynihan (1955) defines alarm displays and calls as those functioning to alert others to the presence of potential predators (Buckley, 1968). Black robin always gives an alarm call when there is a danger. It sounds like 'Krrrrrk' or 'Krrrrsh'.

4.1.2.14 Thermoregulation

Sunbathing - This is a rare behavior observed only two times during the study. The bird lies on land stretching the wings apart under the direct sunlight, on an open land, most preferably on sandy land. First it clears the ground with feet and wings. Then, it lies on land in a way that its abdomen touches the land with puffed plumage. It did not last for more than 45 seconds to 1 minute in both observations.

Sunbathing is directly associated with feather care as heat is important in restoring and maintaining the shape of flight feathers, sunlight is important ^{for} the synthesis of vitamin D, warmth of sun spreads off preening oils and also it helps to remove flies and mites. Sunbathing is also important in temperature control (Brook and Birkhead, 1991)

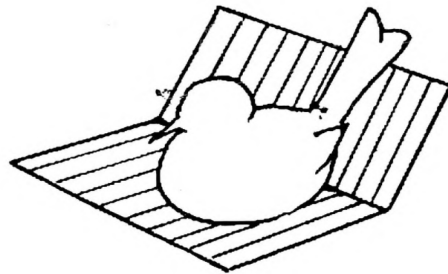
Plate 4.1: Some behaviors of black robin



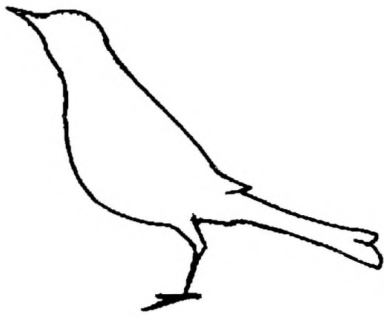
Lookout



Sitting (on a rock)



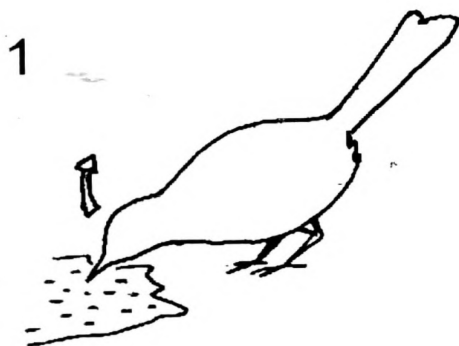
Sitting (on a roof)



Standing alert



Perching

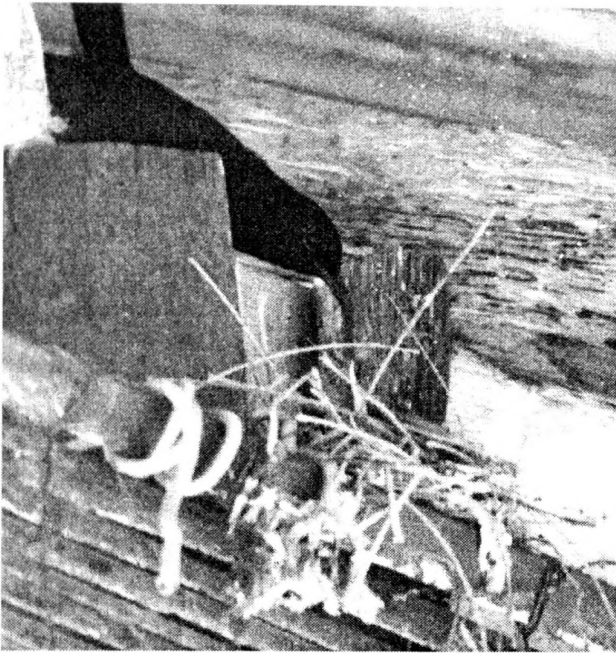


Drinking

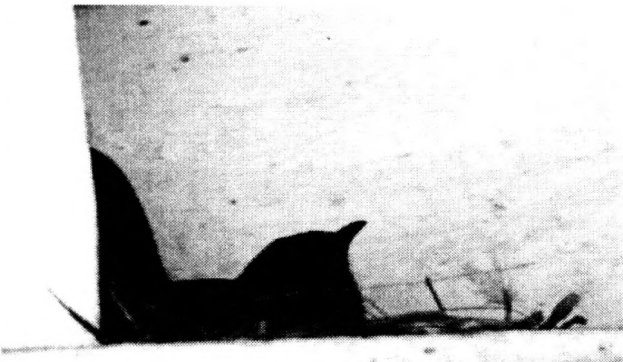


Water

Plate 4.1 (Contd.): Some behaviors of black robin



Nest building (Male)



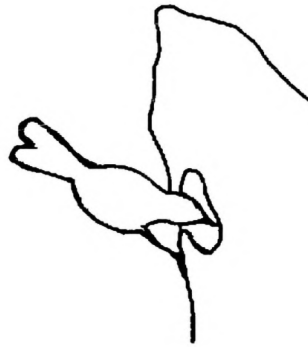
Incubating (Female)



Feeding the brood



Picking

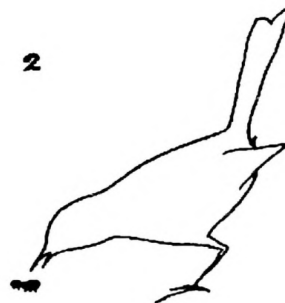


Feeding from termite mounds



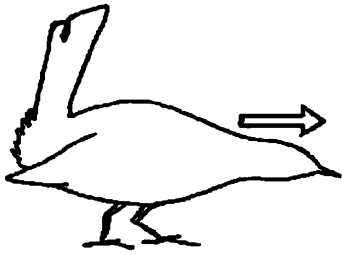
1

2



Darting on insects

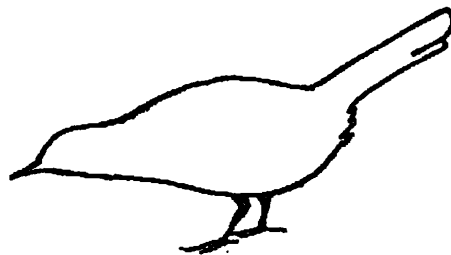
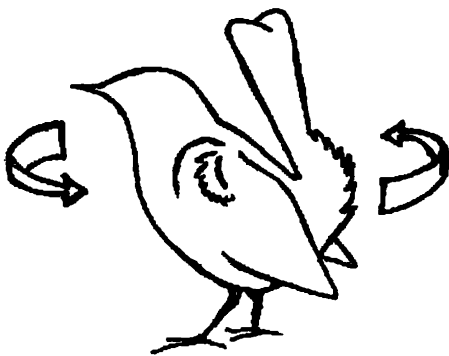
Plate 4.2: Sequence of events in territorial display of black robin



Walk against each other with stretched neck and pointed beak



Elevate and lower the stretched neck



**Showing the color patches
(White wing coverts and chestnut under tail coverts)**



Show their puffed breast to each other with elevated tail and head

Plate 4.3: Some events of the cleaning behavior



**Preening inside the wing
Approached from underneath**



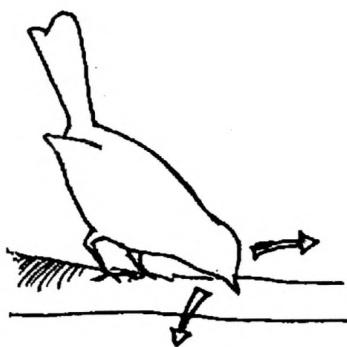
**Preening the back
Approached from above**



**Preening inside the wing
Approached from underneath**



**Preening the rump area
Approached from above**

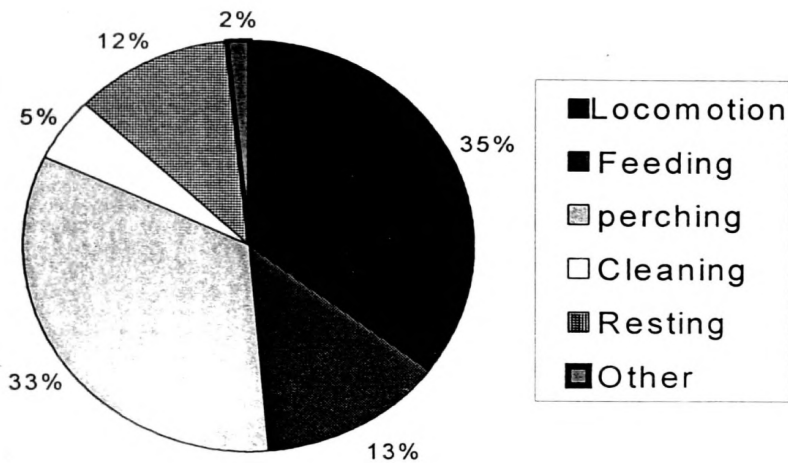


Cleaning the beak

4.1.3 Percentage time expenditure

The percentage time spent on each behavior was calculated using 84 instantaneous behavior samples for 7 days. Results are given below.

Figure 4.1: Percentage time expenditure of black robin



Percentage time expenditure of black robin for morning midday and evening are illustrated below.

Table 4.2: Percentage time expenditure for morning

Date	Feeding%	Locomotion%	Resting%	Perching%	Cleaning%	Other%
1	12.92	38.7	14.58	32.08	0.42	1.25
2	19.58	45.4	10.83	21.67	1.67	0.83
3	21.67	35.8	6.25	26.25	10	0
4	16.25	48.3	12.08	18.33	4.58	0.42
5	12.92	41.2	13.75	23.33	7.92	0.83
6	21.25	32.0	13.33	31.67	1.67	0
7	21.25	23.7	18.33	28.75	7.08	0.83
Total	125.84	265.	89.15	182.08	33.34	4.16
Avg	17.977	37.91	12.736	26.011	4.763	0.594

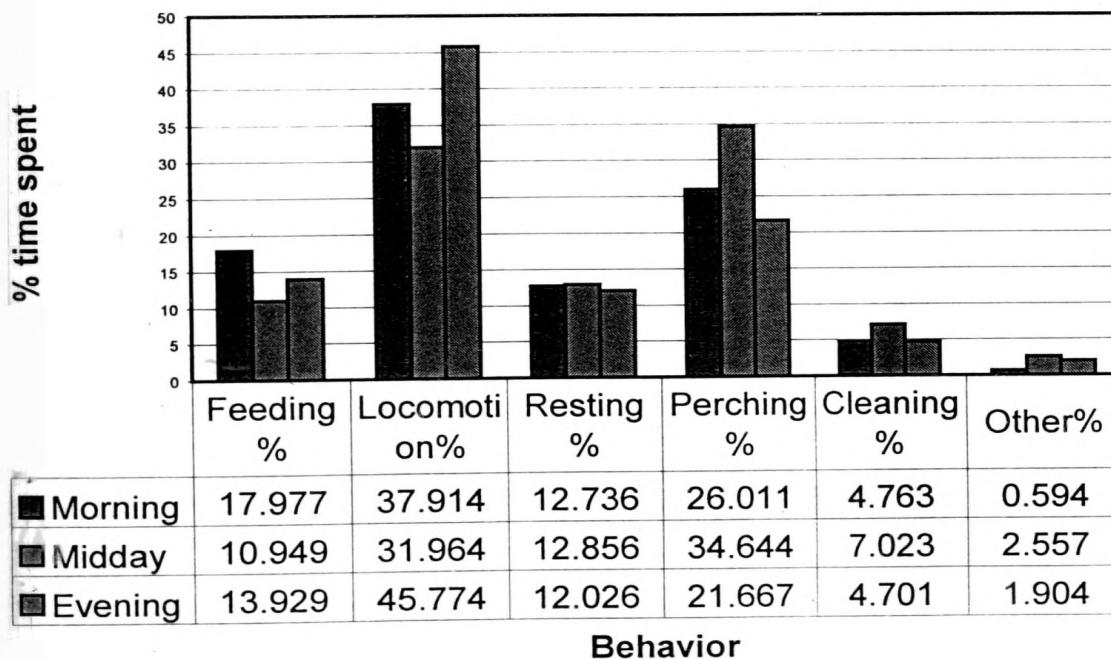
Table 4.3: Percentage time expenditure for midday

Date	Feeding%	Locomotion%	Resting%	Perching%	Cleaning%	Other%
1	2.08	10.8	22.08	59.17	5.83	0
2	8.33	35.4	19.58	27.5	9.17	0
3	10.83	41.2	15.83	24.17	2.08	5.83
4	13.33	43.7	7.5	24.58	5	5.83
5	13.75	28.3	3.33	49.17	3.33	2.08
6	10.41	22.	7.5	37.5	20	2.08
7	17.91	41.6	14.17	20.42	3.75	2.08
Total	76.64	223.7	89.99	242.51	49.16	17.9
Avg	10.949	31.96	12.856	34.644	7.023	2.557

Table 4.4: Percentage time expenditure for evening.

Date	Feeding%	Locomotion%	Resting%	Perching%	Cleaning%	Other%
1	2.08	10.8	22.08	59.17	5.83	0
2	8.33	35.4	19.58	27.5	9.17	0
3	10.83	41.2	15.83	24.17	2.08	5.83
4	13.33	43.7	7.5	24.58	5	5.83
5	13.75	28.3	3.33	49.17	3.33	2.08
6	10.41	22.	7.5	37.5	20	2.08
7	17.91	41.6	14.17	20.42	3.75	2.08
Total	76.64	223.7	89.99	242.51	49.16	17.9
Avg	10.949	31.96	12.856	34.644	7.023	2.557

Figure 4.2: Percentage time expenditure for morning, midday and evening for each behavior



Higher portions of the black robins time budget is occupied by locomotion (35%). It clearly describes the active behavior of black robin who always move from place to place with a great hurry.

Feeding also occupies a large part of time budget (13%). The distribution of time spent on feeding varies with the time of the day. Much time is spent on locomotion and feeding in the morning and evening than in the midday, where warm climatic conditions reduces the activity of birds.

Resting behavior shows an even distribution, while the time spent on perching become high in the midday than morning and evening. Cleaning shows the same distribution since cleaning is mostly performed while perching.

But, figure 4.2 show that the order of time allocation for various behavior patterns is fairly similar throughout the day because lines joining the top of bars for morning, midday and evening have a similar pattern.

When we look at the overall time budget of black robin it can be suggested as a very active bird, that spends much of the time in feeding and locomotion. Even black robin is a terrestrial bird whose locomotion mostly take place on land, it uses trees and branches for perching which has 33% in time budget, associated with 5% of cleaning. Resting which occupies 12% of the time budget, is mostly done on land.

From the figure 4.2, we can see a diurnal pattern of variation of activity, which will be further discussed later.

4.1.4 Significance of the difference of percentage time expenditure in two different sexes

Results obtained using 84 instantaneous behavior samples are given below in tables 4.5, 4.6, and 4.7 For morning midday and evening respectively.

Table 4.5: Difference of % time expenditure in two different sexes for morning

Day	Feeding%		Locomotion%		Resting%		Perching%		Cleaning%		Other%	
	M	F	M	F	M	F	M	F	M	F	M	F
1	13.88	10.00	37.78	41.67	5.0	43.33	41.11	5.00	0.55	0.00	1.67	0.00
2	16.67	22.50	44.17	46.67	20.0	1.67	15.00	28.33	3.33	0.00	0.83	0.83
3	12.50	30.83	27.50	44.17	6.6	5.83	35.00	17.50	18.33	1.67	0.00	0.00
4	16.67	15.00	48.89	46.67	0.0	18.33	17.78	20.00	6.11	0.00	0.55	0.00
5	13.30	11.67	39.44	46.67	17.7	1.67	20.55	31.67	7.78	8.33	1.11	0.00
6	19.17	23.33	25.00	39.17	10.0	16.67	42.55	20.83	3.33	0.00	0.00	0.00
7	21.00	10.00	27.78	11.67	19.4	15.00	22.78	46.67	3.89	16.67	1.11	0.00
Total	113.19	123.33	250.56	276.69	78.8	102.50	194.77	170.00	43.32	26.67	5.27	0.83
Avg.	16.17	17.62	35.79	39.53	11.2	14.64	27.82	24.29	6.19	3.81	0.75	0.12
Std	3.16	8.06	9.21	12.62	7.9	14.46	11.46	13.04	5.82	6.43	0.62	0.31
S ₂	9.96	64.89	84.74	159.23	62.4	209.17	131.43	170.04	33.90	41.41	0.38	0.10
Std _{pool}	6.1176		11.0445		11.6529		12.2773		6.1361		0.4888	
Se _{pool}	1.6350		2.9518		3.1144		3.2813		1.6400		0.1306	
T _{cal}	-0.8860		-1.2646		-1.0830		1.0784		1.4504		4.8550	
T _{tab}	2.179		2.179		2.179		2.179		2.179		2.179	
Signif.	n.s.		n.s.		n.s.		n.s.		n.s.		*	

Table 4.6: Difference of % time expenditure in two different sexes for midday

Day	Feeding%		Locomotion%		Resting%		Perching%		Cleaning%		Other%	
	M	F	M	F	M	F	M	F	M	F	M	F
1	4.17	0.00	17.50	4.17	0.83	43.33	73.33	45.0	4.17	7.50	0.00	0.00
2	9.17	7.50	55.83	15.00	1.67	37.50	33.33	21.6	0.00	18.33	0.00	0.00
3	6.67	5.00	43.33	39.17	6.67	25.00	24.17	24.1	0.83	3.33	8.33	3.33
4	15.55	6.67	48.89	28.33	9.44	1.67	16.11	50.0	6.11	1.67	3.89	11.67
5	4.16	23.33	16.67	40.00	4.17	2.50	69.17	29.1	3.33	3.33	2.50	1.67
6	6.67	14.17	23.33	21.67	11.67	3.33	42.50	32.5	11.67	28.33	4.17	0.00
7	14.16	21.67	36.67	46.67	20.00	8.33	25.83	15.0	2.50	5.00	0.83	3.33
Total	60.55	78.34	242.22	195.01	54.45	121.66	284.44	217.5	28.61	67.49	19.72	20.00
Avg.	8.65	11.19	34.60	27.86	7.78	17.38	40.63	31.0	4.09	9.64	2.82	2.86
Std	4.59	8.79	15.69	15.24	6.67	17.72	22.48	12.6	3.92	9.95	2.98	4.16
S2	21.05	77.28	246.05	232.37	44.52	313.97	505.30	158.7	15.33	99.02	8.88	17.34
Std _{pool}	7.0118		15.4665		13.3882		18.2210		7.5614		3.6206	
Se _{pool}	1.8740		4.1336		3.5781		4.8698		2.0209		0.9677	
T _{cal}	-1.3562		1.6316		-2.6834		1.9634		-2.7485		-0.0413	
T _{tab}	2.179		2.179		2.179		2.179		2.179		2.179	
Signif.	n.s.		n.s.		n.s.		n.s.		n.s.		n.s.	

Table 4.7: Difference of % time expenditure in two different sexes for evening.

Day	Feeding%		Locomotion%		Resting%		Perching%		Cleaning%		Other%	
	M	F	M	F	M	F	M	F	M	F	M	F
1	17.22	30.00	56.1	53.33	1.67	1.67	24.44	13.3	0.55	1.67	0.00	0.00
2	6.67	3.33	35.0	21.67	16.67	29.17	39.17	30.0	0.00	13.33	2.50	2.50
3	12.50	3.33	30.0	26.67	3.33	30.00	38.33	24.1	15.83	15.83	0.00	0.00
4	15.55	15.00	62.7	75.00	8.33	1.67	12.78	8.3	0.00	0.00	0.55	0.00
5	13.33	16.67	55.0	56.67	13.33	8.33	13.89	18.3	4.44	0.00	0.00	0.00
6	15.00	10.00	43.8	55.00	7.78	8.33	21.11	23.3	4.44	3.33	7.78	0.00
7	8.33	33.33	32.5	48.33	15.83	16.67	30.83	0.8	3.33	0.83	9.17	0.00
Total	88.60	111.66	315.2	336.67	66.94	95.84	180.55	118.3	28.59	34.99	20.00	2.50
Avg.	12.66	15.95	45.0	48.10	9.56	13.69	25.79	16.9	4.08	5.00	2.86	0.36
Std	3.87	11.94	13.0	18.39	5.91	11.98	10.77	10.1	5.55	6.68	3.96	0.94
S2	14.95	142.47	170.3	338.31	34.97	143.49	116.05	102.0	30.77	44.66	15.67	0.89
Std _{pool}	8.8720		15.9475		9.4462		10.4425		6.1413		2.8778	
Se _{pool}	2.3711		4.2622		2.5246		2.7909		1.6413		0.7691	
T _{cal}	-1.3893		-0.7169		-1.6353		3.1854		-0.5570		3.2504	
T _{tab}	2.179		2.179		2.179		2.179		2.179		2.179	
Signif.	n.s.		n.s.		n.s.		*		n.s.		*	

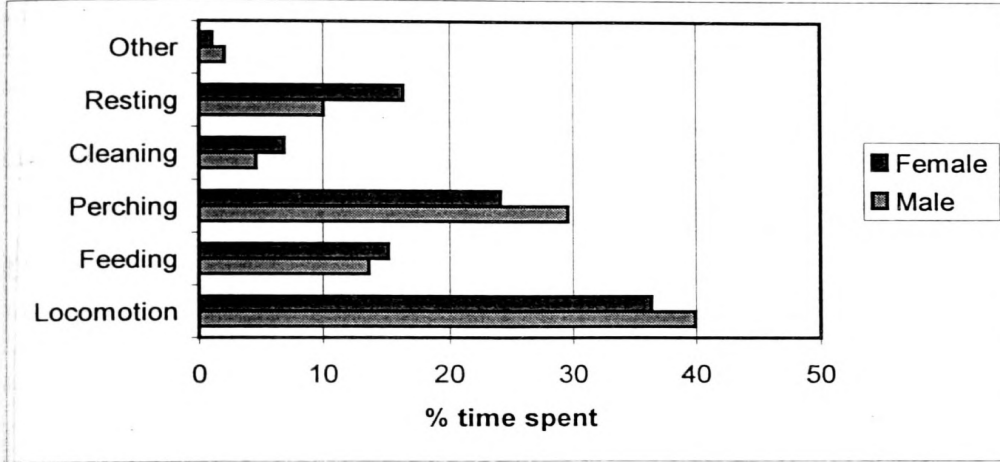
Note : * = Significant

n.s. = Non significant

These results show that there is a no significant difference between the activity of male and female black robins except perching behavior in the evening.

Overall percentage time expenditure for two different sexes can be illustrated as follows.

Figure 4.3: Percentage time expenditure for male and female



There is no difference^{cp} in the order of the proportion of time budgeted for each behavior. Males and females both spend much of their time for locomotion and follow the same order locomotion, perching and resting and then cleaning. It can be explained that male occupy a longer portion of time budget than female in locomotion and perching and vice versa in resting, cleaning and feeding. Since locomotion is the most active behavior pattern it can be concluded that the male is somewhat active than the female. That statement is also supported by the higher percentage time of the female spent on resting. But, this difference of the activity should not be very high according to the results of t-test.

4.1.5 Diurnal variation of activity

Diurnal variation of the activity was detected using 42 instantaneous behavior samples of male black robins for 7 days of observations within the dry season at Buttala. Results are given below.

Table 4.8: Diurnal variation of activity

Day (sample)	06:30-07:30			07:30-08:30			11:30-12:30		
	1	2	3	1	2	3	1	2	3
1	41.67	10.00	43.33	10.00	1.67	88.33	31.67	8.33	55.00
2	33.33	20.00	40.00	55.00	13.33	30.00	41.67	6.67	51.67
3	30.00	20.00	35.00	25.00	5.00	48.33	40.00	20.00	38.33
4	31.67	21.67	46.67	45.00	13.33	21.67	45.00	15.00	31.67
5	26.67	6.67	60.00	35.00	21.67	43.33	28.33	6.67	55.00
6	26.67	13.33	58.33	30.00	25.00	46.67	16.67	6.67	55.00
7	35.00	28.33	33.33	21.67	21.67	51.67	40.00	13.33	40.00
Average	32.144	17.143	45.237	31.667	14.524	47.143	34.763	10.953	46.667

Day (sample)	12:30-13:30			16:30-17:30			17:30-18:30		
	1	2	3	1	2	3	1	2	3
1	3.33	0.00	93.33	75.00	16.67	6.67	56.67	20.00	23.33
2	70.00	1.67	18.33	43.33	5.00	46.67	26.67	8.33	65.00
3	46.67	13.33	23.33	23.33	15.00	31.67	36.67	10.00	51.67
4	51.67	5.00	43.33	60.00	16.67	23.33	71.67	20.00	6.67
5	5.00	1.67	91.67	58.33	11.67	20.00	46.67	11.67	40.00
6	28.33	6.67	53.33	53.33	11.67	31.67	25.00	11.67	51.67
7	33.33	15.00	51.67	33.33	3.33	43.33	31.67	13.33	50.00
Average	34.047	6.191	53.570	49.521	11.430	29.049	42.146	13.571	41.191

Where,

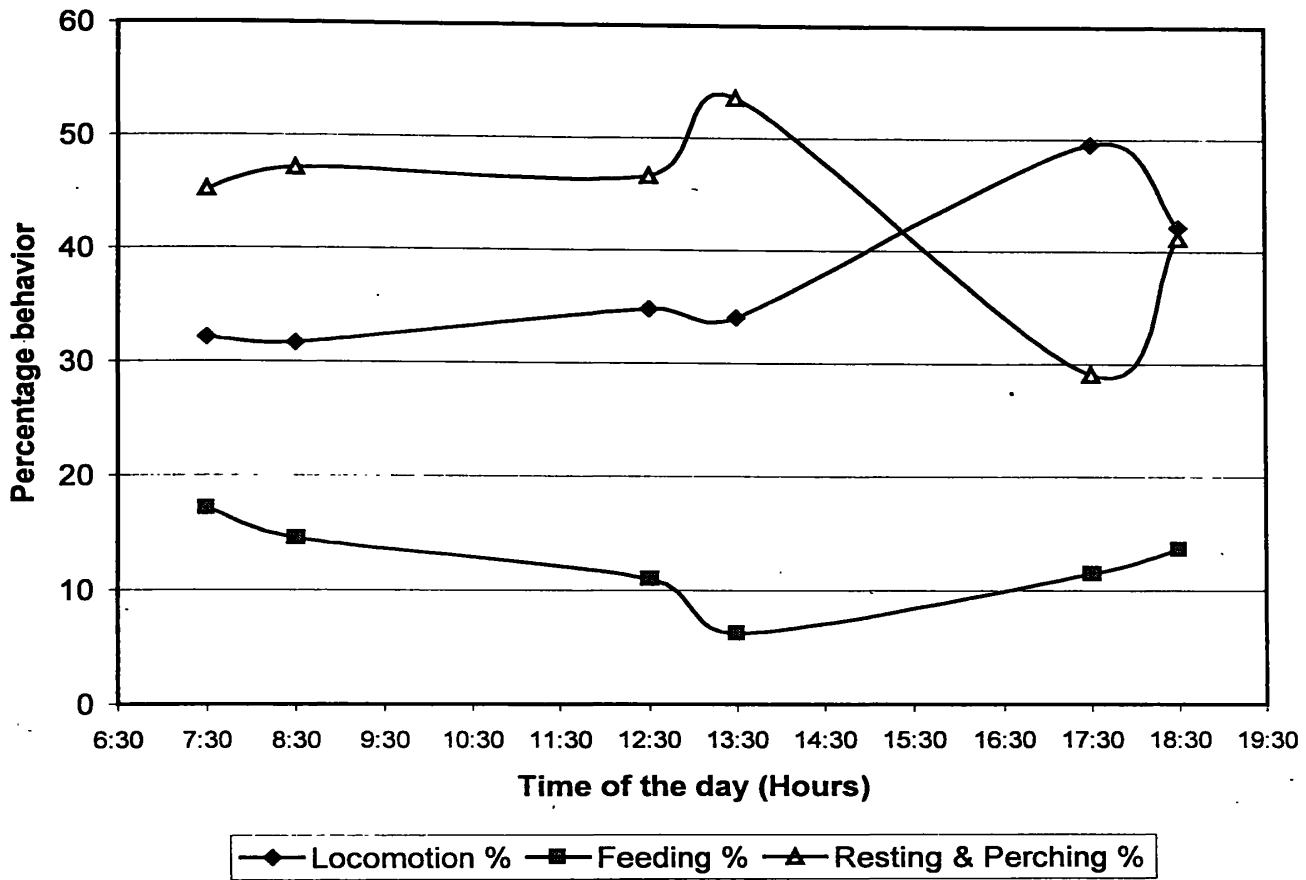
1 = % time spent on locomotion

2 = % time spent on feeding

3 = % time spent on resting and perching

Variation of activity with time of the day is illustrated as in the figure 4.4.

Figure 4.4: Diurnal variation of locomotion, feeding, resting and perching



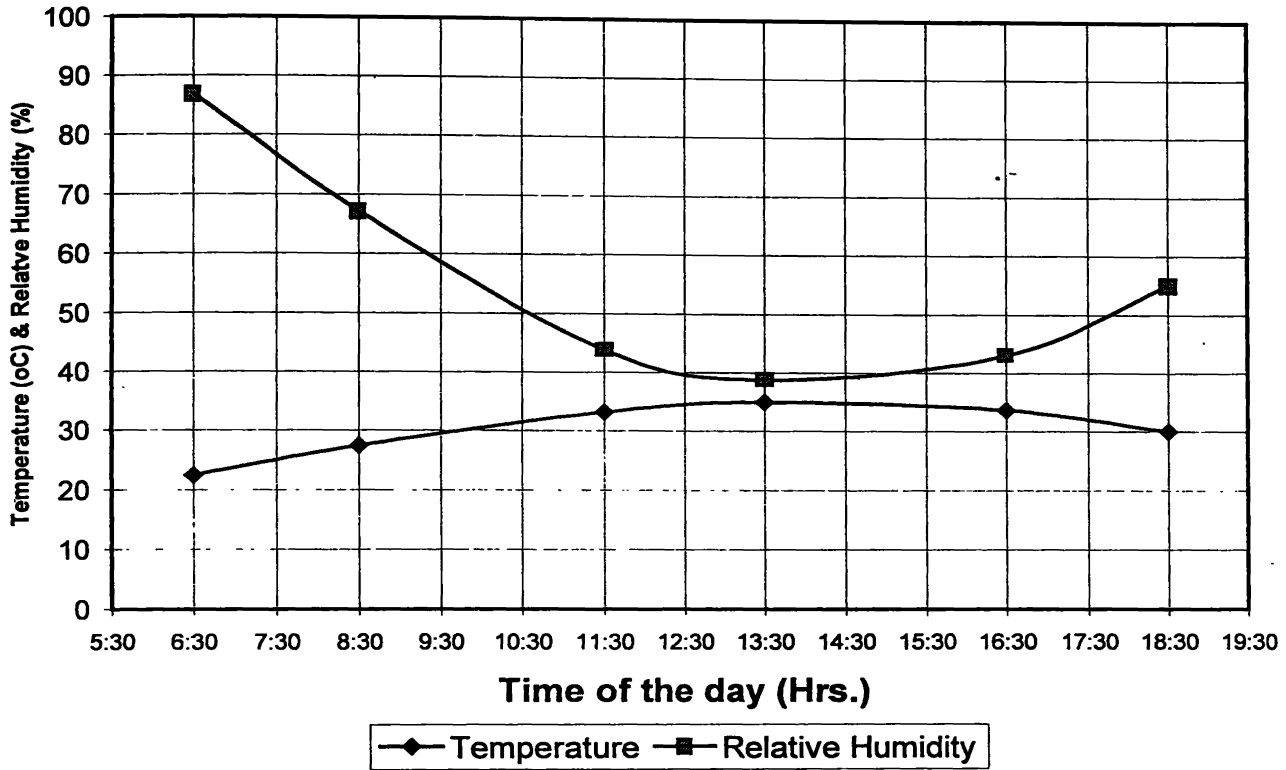
Variation of locomotion shows a continuous increase from morning to evening. Percentage time spent on feeding has decreased from morning to midday and again increased in the evening, and resting and perching is vice versa.

Locomotion and feeding are considered as active behaviors, and so resting and perching are inactive. According to the results illustrated above it can be conducted that the overall activity of black robin decreases from morning to midday and again increases towards evening. The highest activity has been recorded in the evening.

Figure 4.4 show that the peak activity was recorded around 17:30 hrs. where locomotion is maximum and perching is minimum. The least activity was recorded around 13:30 hrs. which is the hottest hour of the day (Average temperature of 34.9 °C and 38.7% relative humidity).

Diurnal variation of Temperature and Relative Humidity was also recorded for 10 days within the period of behavior study and has been illustrated below.

Figure 4.5: Diurnal variation of Temperature and Relative humidity



Diurnal variation of activity (Figure 4.4) has an inverse relationship with the Diurnal variation of Temperature (Figure 4.5) and a direct relationship with Relative Humidity (Figure 4.5). It can be concluded that Environmental Temperature and Relative Humidity as two external factors that determine the activity of black robin.

4.2 Population of black robin within the study area

Population estimation within the study area was done using 5 total count samples.

Table 4.9: Population estimation

Day	Total population	#Male	# Female	# Juvenile	# 1 st year Male
1	26	11	10	2	3
2	28	14	9	3	2
3	25	14	7	1	3
4	30	11	14	1	4
5	37	15	12	4	6
Total	146	65	52	11	18
X	29.2	13	10.4	2.2	3.6
Std	4.76	1.87	2.7	1.3	1.52
CV	16.3	14.4	26	59.3	42.1

The population of black robin within the study area can be given as

Adult male	= 13.0 ± 1.87 , with 14.4 coefficient of variance
Adult female	= 10.4 ± 2.70 , with 26.0 coefficient of variance
Juvenile	= 2.2 ± 1.30 , with 59.3 coefficient of variance
1 st year male	= 3.6 ± 1.52 , with 42.1 coefficient of variance
Total population	= 29.2 ± 4.76 , with 16.3 coefficient of variance

Population of the black robin shows a distribution of 44.52% males and 35.62% females. The number of juveniles observed has a very low number. This low number cannot be given a precise explanation based on the observations done during the study. But, it was clearly observed that the mortality rate of broods and the destruction and predation on nests was very high. It can be given as a major reason for the lowering of survival rate of juvenile black robins.

4.3 Territoriality of black robin

4.3.1 Distribution of territories and habitat preference of black robin

Territories of black robin were distributed all over the study area and dispersed over the suitable habitats within the range. Especially they prefer open or space woodlands and grass or scrub lands where, there is a good supply of termites, insects and other food material they look for. Much of the territories were overlapping at their boundaries.

Within the 17.5 ha study area eight territories had been identified and studied. Five more territories were found which extend away from the study area and they were not studied intensively.

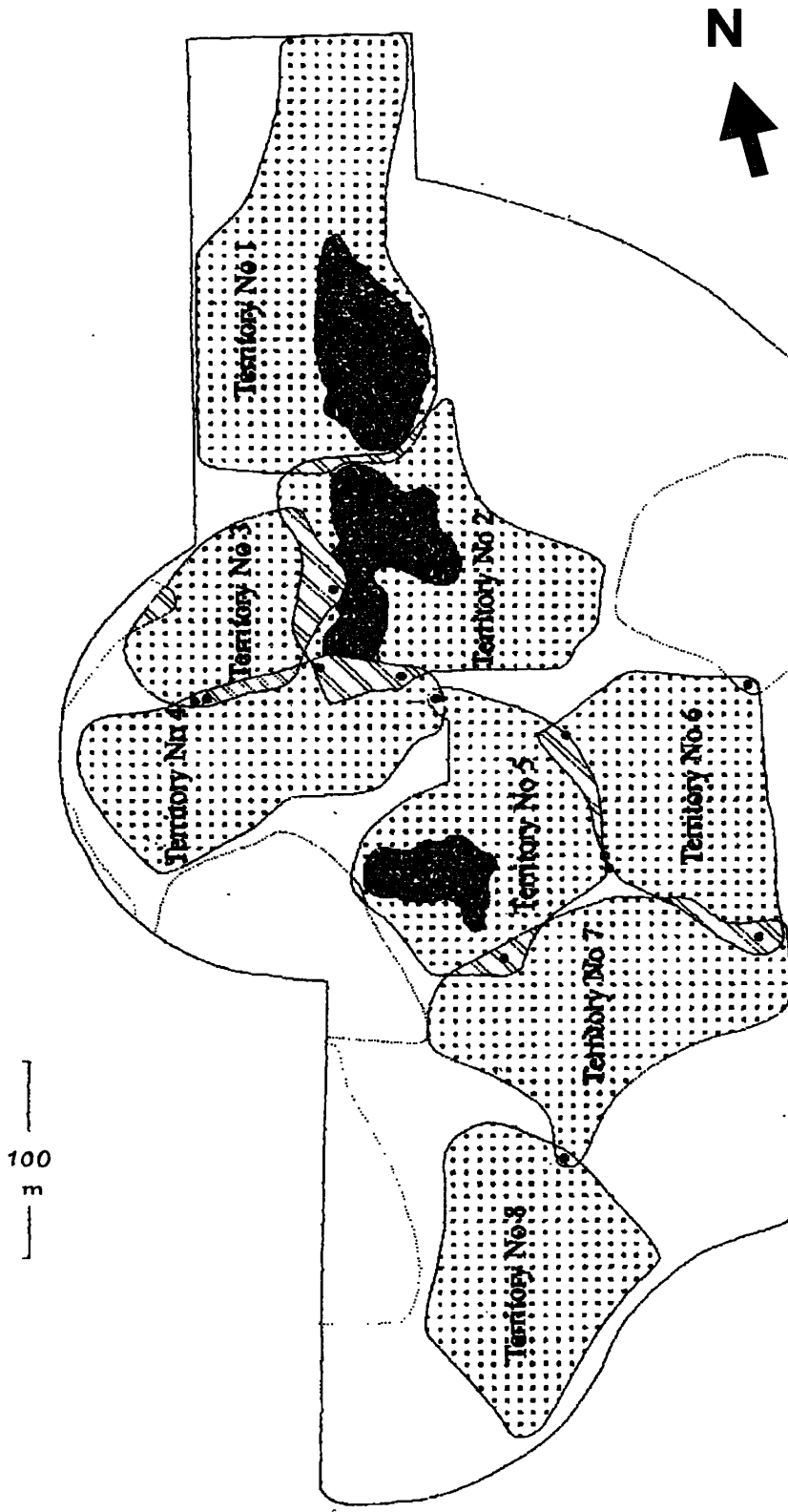
Distribution of black robin territories (Figure 4.6) with the distribution of vegetation within the study area (Figure 4.7) is illustrated later. It will be noted that territories are restricted to those areas without dense vegetation, usually in open grassland, scrubland and sparse woodlands without high undergrowth. Their distribution was mostly limited to the areas which were continuously maintained by man. When the grasses are kept shorter by regular cutting the birds had an easiness of catching insects from land.

In areas covered by forest, woodlands with high grass undergrowth and patana grasslands (dense high grass) black robins do not establish their territories. Also an abandoned rice field which is covered by dense grass grow up to about 0.5 m was not used by black robins. But, it used the adjacent area, where the grass is regularly cut and maintained by man.

Considering all above data we can conclude that key features of the distribution of black robin are the density of vegetation in the undergrowth and the human influence and maintenance of the habitat.

Howerd (1920) explained territories are maintained in order to facilitate pair formation. This is exactly correct in the case of black robin where the pair once formed lasts a very longer period. The book 'The life of birds' emphasized the importance of knowledge of terrain in escape from predators, as one of the major advantages of territoriality. It is clearly observed during the study period where the black robin seems to familiar very well with each and every object within its territory. Black robin territory also plays a major role in reproduction where copulation, nesting and nursing of young is always done inside the boundary.

Figure 4.6: Distribution of black robin territories



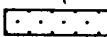




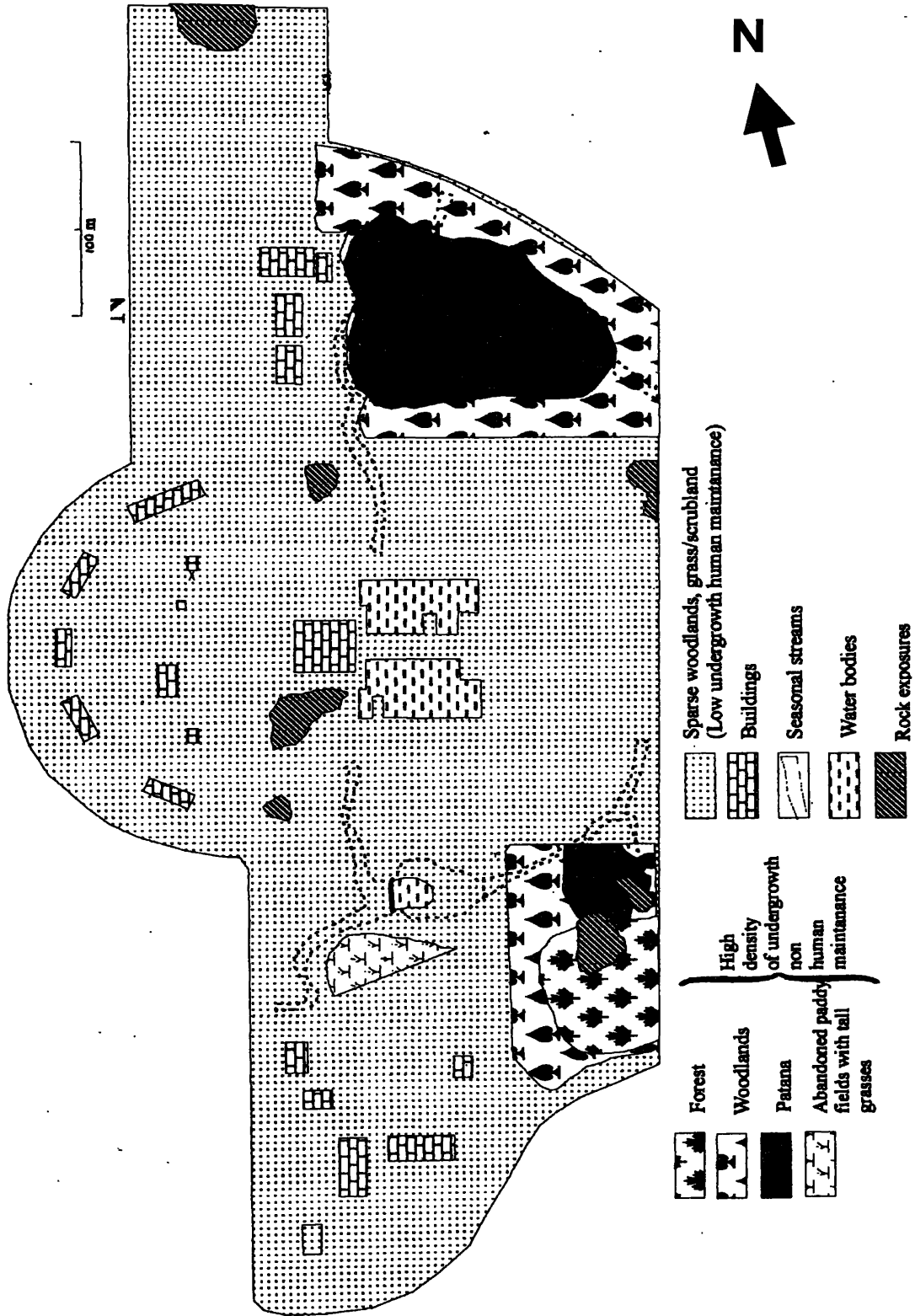
-  Territories
-  Activity centers
-  Territory overlaps
-  Territories which were not studied
-  Points where territorial disputes were recorded

Figure 4.7: Distribution of vegetation



It was observed that all the parts of the territory were not utilized equally. Black robins spent different proportions of their time in different sections of their territories. This unequal utilization is related with uneven distribution of food supply, termite mounds and features such as song posts and rocky outcrops especially for males.

It was also observed that when any thing new is kept inside the territory the bird quickly approach it carefully and search it in a great enthusiasm.

4.3.2 Average size of Black Robin territories and activity centers

Sizes of eight territories which were studied are tabulated in the following table.

Table 4.10: Sizes of Black Robin territories

Territory No.	Size (ha)
01	1.8525
02	1.3875
03	0.675
04	1.0825
05	1.11
06	1.035
07	1.235
08	1.065

Average size of a black robin territories in Buttala was 1.1803 ha. Data on territory size had a standard deviation of 0.3385 And coefficient of variance of 28.679.

Three territories were studied intensively (More than ten territory maps were made) and activity centers were identified in each of those territories. Details of activity centers are given in table 4.11.

Table 4.11: Sizes of black robin territories and their activity centers.

Territory no.	Size of the territory (ha)	Size of the activity center (ha)	Size of the activity center as% of territory size
1	1.1825	0.400	21.592
2	1.3875	0.402	29.009
5	1.110	0.190	17.117
Average	1.2267	0.3307	22.573

Average size of the activity centers of black robin territory is 0.3307 ha. It is 22.573% of the total area of the territory in average.

Although territory size varied considerably, the cause of this variation remains unknown. It could not be explained using habitat parameters since all the territories are distributed in some types of habitat, suggesting that differences in territory size did not come about because of variation in habitat quality. In the case of robin Lack (1953) has explained the same as their seemed nothing peculiar about the make-up of small territories, which where in woodland similar to that of the large territories.

It can be suggested that the territories, which are distributed in areas with no human activities, are likely to be smaller than other. It is clear that almost all the territories except one were associated with some sort of manmade structure or building out of 8 territories.

Territories surrounded on all sides by those of others were smaller than those in which part of the boundary was formed by the edge of the habitat and so did not have to be defended (Lack, 1953).

4.3.3 Overlapping of territories

Almost all the black robin territories were overlapping at their boundaries. Aggressive territorial disputes are commonly observed within these overlapping areas. An overlapping area usually occur at the territory boundaries, where area beyond the boundary is occupied by another robin. This overlapping area gives a definite limit to the territory. But, when the territory boundary is on no-man's land, it is not clearly defined. The overlapping areas were studied in all 8 territories and the data is tabulated in the table 4.12.

Table 4.12: Sizes of Black Robin territories and their overlapping areas.

Territory no.	Size of the territory (ha)	Size of the overlapping area (ha)	Size of the overlap as% of territory size
1	1.8525	0.023	1.268
2	1.3875	0.193	13.945
3	0.675	0.126	18.696
4	1.0825	0.116	10.734
5	1.110	0.092	8.288
6	1.035	0.097	9.372
7	1.235	0.109	8.826
8	1.065	0.0062	0.582
Average	1.1803	0.0952	8.964

The overlapping area has an average value of 0.0952 ha and 8.964% as the percentage of the total area of the territory.

It is also noted that the territories which are surrounded by other territories has more overlapping area than the territories with indefinite boundaries, which are not limited by other territories. It can also be stated that in general small territories has a higher percentage of the overlapping area. That can be the reason for the smaller size of those territories.

4.3.4 Territory occupation of black robins

Out of the population mean of 29.2 ± 4.76 birds 30 individuals has been recorded to occupy the 8 territories which were studied as shown in table 4.13.

Table 4.13: Territory occupation of black robins

Territory No.	No. of Birds	Description
01	3	Adult male, Adult female and First year male
02	5	Adult male, Adult female, First year male, Juvenile Male and Juvenile Female
03	3	2 Adult males and Adult female
04	4	2 Adult males, Adult female and Juvenile Female
05	3	Adult male, Adult female and Juvenile Female
06	2	Adult male and Adult female
07	4	Adult male, Adult female, First year male and Juvenile Female
08	6	2 Adult males, Adult female, First year male, Juvenile Male and Juvenile Female

Note : 1st year males – Male black robins that do not have the glossy black color all over the body. They have brownish black patches in various parts of the body, and it was observed that they gradually become glossy black.

Population studies and territory occupation of birds show that almost all the black robins are occupying territories. Most black robins establish breeding territories, which is very important in pair formation. Normally a family of birds occupies a territory of black robin where an adult male dominates. Legge (1880) has described that black robins consorts in pairs; but the young brood remain a long time with their parents, thus forming after the breeding-season a little troop of three or four.

4.3.5 Correlation between the territory size and the number of individuals occupy the territory

Correlation between the size of territory and the number of individuals occupy each territory was analyzed using 'SAS' statistical computer package. Results are as follows,

Table 4.14: Pearson Correlation Coefficients between the territory size and number of individuals occupy the territory

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 8

	SIZE	NUM
SIZE	1.00000 0.0	0.05618 0.8949
NUM	0.05618 0.8949	1.00000 0.0

Note : 2 'VAR' Variables: SIZE - Size of the territory

NUM - Number of individuals occupy the territory

Using the above correlation analysis and probability values we can conclude that there is no correlation between the size of territory and the number of individuals occupy each territory. A variation of ~~1.85~~ ha maximum and ~~0.675~~ ha minimum has been recorded from the black robin territories. The reason for this variation is difficult to explain with the number of individuals occupies the territory, or availability of food. There was no difference between the habitat in smaller territories and larger ones. Similar variation occurs in other songbirds, including several like robin, song thrush in Finland, song sparrow in Ohio, and wren-tit in California (Lack, 1953). He also states that these variations were not related to the food supply, but to the length of defended border, where territories defended by all sides were smaller than others. This explanation can be applied to the situation of black robin in Buttala too. The territory distribution map prepared from the data collected during the study (Figure 4.6) show that black robin territories defended by all sides were smaller than others.

4.4 Bird species recorded from the study area

A checklist of 67 birds species were recorded from the study area, which can be considered as a remarkable site for bird studies, and requires a careful conservation and management. This checklist included many endemic species such as Sri Lanka lorikeet, Sri Lanka gray hornbill, Spotted munia and rare winter visitors such as Orange-headed ground thrush. The sirkeer malkoha, which is a rare and peculiar species to 'patana' grassland habitat, can also be found with many other rarer species.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A study on behavior, diurnal activity and territoriality of black robin has obtained the results discussed in chapter 4. Following conclusions were made using above results.

The ethogram has come up with 64 types of behaviors or events, which can be categorized in to 14 major categories of behavior patterns. They are locomotion, ingestion, elimination, perching, cleaning, resting, posture, searching, nidification, communication, thermoregulation and territorial behavior patterns, plus inter and intra specific interactions. With all these results it can be concluded that black robin has a higher activity rate than many other species of birds. The behavior of black robin is typical of that of the order Passeriformes.

Territorial behavior of black robin was very interesting to study and it is comparable with the typical territorial behavior of songbirds with the territorial song, display and attacks. Territorial display of black robin included several features peculiar to it such as the following.

- Stretching the neck, pointing at a rival robin, and elevating and lowering of it. This was performed intermittently with walking against the other with the lowered and stretched neck.
- In-between above two behaviors it waits for few seconds, puff the breast and erect the tail until it touches the head, which is elevated up vertically.
- Carrying the tail erected and jerking it up with a corresponding strutting down of its wings.

These displays were associated with territorial song, supplanting attacks at the boundary of the territory and showing off color patches (White wing coverts and chestnut undertail coverts) to each other.

The time budget of black robin has the highest proportion of time involved in locomotion and then perching, feeding, resting and cleaning. This supports the conclusion that the black robin is very active.

It was evident that, there was no significant difference between the activity of male and female of black robins.

Diurnal activity of male robins shows a variation with time. Bird's activity was low in midday than that of morning and evening. Highest activity was recorded in the evening around 17:30 hrs and the least activity was recorded around 13:30 hrs. Environmental temperature and relative humidity can be concluded as two external factors that determine the activity of black robins. Activity is directly proportional to relative humidity and inversely proportional to the temperature.

The population of black robin within the study area of 17.5 ha was estimated as 29.2 ± 4.76 , thus had a population density of 1.667 individuals per hectare.

Territories of black robin had an average size of 1.1803 ± 0.34 ha with an activity center of, 22.57% of the total area in average. The territories were overlapped at their boundaries and had an overlapping area of, 8.964% of the total area in average.

Almost all the territories were distributed in open or scarce woodlands and grass or scrublands (mostly in habitats maintained by man), not in Patana grasslands, forests, and woodlands with dense grass (*Panicum* sp.) undergrowth. Therefore the key features of the distribution of black robin territories can be considered as the density of vegetation in the undergrowth and human influence and maintenance of habitat.

The number of black robins occupy a territory varied between two and six and there was no correlation between the territory size and that number.

5.2 Recommendations

I could recommend that a comprehensive further study on biology, ecology and behavior of black robin could gather much more new and valuable information for the conservation of this bird and its habitat. Even it is still a common bird in the dry zone of Sri Lanka, data gathered on black robin can be used to reduce the population decline of it as well as many other more rarer species.

Further studies have to be done on following aspects related to my topic.

- Behavior of black robin in the wet season.
- The procedure, a young black robin follows in establishing a new territory.
- The difference between behavior of black robin in a habitat associated with human activities and maintenance as Buttala and a scrubland where human influence is negligible.
- Breeding behavior, nidification behavior, and mortality of broods of black robin.
- Predation on the black robin, etc.

The study area within which I conducted my research (University premises at Buttala) can be considered as a remarkable site for bird studies with a very good checklist of birds including rare and endemic species. I could recommend that this site also needs a strategy of careful conservation and management.

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APPENDIX I

Significance of the difference between means

The standard deviation of the pool (Std_{pool}) is calculated as,

$$Std_{pool} = \sqrt{\frac{S_1^2 + S_2^2}{2}}$$

Where, S_1^2 & S_2^2 = Sample variance

The standard error of the pool (Se_{pool}) is computed according to the following formula.

$$Se_{pool} = \frac{Std_{pool}}{\sqrt{n_1 + n_2}}$$

Where, Std_{pool} = Standard deviation of the pool
 n_1 & n_2 = No of samples

Calculated t value (t_{cal}) is computed using the following formula,

$$t_{cal} = \frac{\bar{x}_1 - \bar{x}_2}{Se_{pool}}$$

Where, \bar{x}_1 & \bar{x}_2 = Sample means
 Se_{pool} = Standard error of the pool

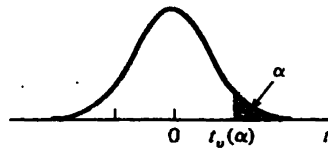
Tabulated t value (t_{tab}) is obtained from the t table (Table :I.1) annexed to the appendix I, at a confidence level of 95% and $2n-2$ (12) degrees of freedom.

If $t_{cal} > t_{tab}$ There is a significant difference between means of two samples at a confidence level of 95%.

If $t_{cal} < t_{tab}$ There is no significant difference.

Table :I.1

Student's t – distribution critical points



d.f. ν	.250	.100	.050	α .025	.010	.00833	.00625	.005
1	1.000	3.078	6.314	12.706	31.821	38.190	50.923	63.657
2	.816	1.886	2.920	4.303	6.965	7.649	8.860	9.925
3	.765	1.638	2.353	3.182	4.541	4.857	5.392	5.841
4	.741	1.533	2.132	2.776	3.747	3.961	4.315	4.604
5	.727	1.476	2.015	2.571	3.365	3.534	3.810	4.032
6	.718	1.440	1.943	2.447	3.143	3.287	3.521	3.707
7	.711	1.415	1.895	2.365	2.998	3.128	3.335	3.499
8	.706	1.397	1.860	2.306	2.896	3.016	3.206	3.355
9	.703	1.383	1.833	2.262	2.821	2.933	3.111	3.250
10	.700	1.372	1.812	2.228	2.764	2.870	3.038	3.169
11	.697	1.363	1.796	2.201	2.718	2.820	2.981	3.106
12	.695	1.356	1.782	2.179	2.681	2.779	2.934	3.055
13	.694	1.350	1.771	2.160	2.650	2.746	2.896	3.012
14	.692	1.345	1.761	2.145	2.624	2.718	2.864	2.977
15	.691	1.341	1.753	2.131	2.602	2.694	2.837	2.947
16	.690	1.337	1.746	2.120	2.583	2.673	2.813	2.921
17	.689	1.333	1.740	2.110	2.567	2.655	2.793	2.898
18	.688	1.330	1.734	2.101	2.552	2.639	2.775	2.878
19	.688	1.328	1.729	2.093	2.539	2.625	2.759	2.861
20	.687	1.325	1.725	2.086	2.528	2.613	2.744	2.845
21	.686	1.323	1.721	2.080	2.518	2.601	2.732	2.831
22	.686	1.321	1.717	2.074	2.508	2.591	2.720	2.819
23	.685	1.319	1.714	2.069	2.500	2.582	2.710	2.807
24	.685	1.318	1.711	2.064	2.492	2.574	2.700	2.797
25	.684	1.316	1.708	2.060	2.485	2.566	2.692	2.787
26	.684	1.315	1.706	2.056	2.479	2.559	2.684	2.779
27	.684	1.314	1.703	2.052	2.473	2.552	2.676	2.771
28	.683	1.313	1.701	2.048	2.467	2.546	2.669	2.762
29	.683	1.311	1.699	2.045	2.462	2.541	2.663	2.756
30	.683	1.310	1.697	2.042	2.457	2.536	2.657	2.750
40	.681	1.303	1.684	2.021	2.423	2.499	2.616	2.704
60	.679	1.296	1.671	2.000	2.390	2.463	2.575	2.660
120	.677	1.289	1.658	1.980	2.358	2.428	2.536	2.617
∞	.674	1.282	1.645	1.960	2.326	2.394	2.498	2.576

APPENDIX II

Calculation of Standard deviation - (std)

$$\text{Std} = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

Where, \bar{x} = Population mean

n = No. of observations

Calculation of efficient of variance (CV)

$$\text{CV} = \frac{\text{Std}}{\bar{x}} * 100$$

Where, \bar{x} = Population mean

APPENDIX III

Correlation analysis – Pearson correlation

Following 'SAS' program was used for correlation analysis.

```

Data core;
input size num;
cards;
1.8525 3
1.3875 5
0.675 3
1.0825 4
1.11 3
1.035 2
1.235 4
1.065 6
run;
proc corr;
var size num;
run;
□
    
```

Results of the above program was as follows,

CORRELATION ANALYSIS

2 'VAR' Variables: SIZE - Size of the territory
 NUM - Number of individuals occupy the territory

Simple Statistics Variable	N	Mean	Std Dev	Sum
SIZE	8	1.180313	0.338488	9.442500
NUM	8	3.75000	1.28174	30.00000

Simple Statistics Variable	Minimum	Maximum
SIZE	0.67500	1.85250
NUM	2.00000	6.00000

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 8

	SIZE	NUM
SIZE	1.00000 0.0	0.05618 0.8949
NUM	0.05618 0.8949	1.00000 0.0

APPENDIX IV

Behavior categories and abbreviations used in sampling

01. Locomotion Patterns

- 01.1 Flying- Including fly up, fly down etc. - **FI**
- 01.2 Short flight- **SFI**
- 01.3 Gliding down from a tree - **GI**
- 01.4 Hopping - **Hp**
- 01.5 Running - **Rn**
- 01.6 Standing alert while locomotion (tail down / tail up) - **Alt**
- 01.7 Standing alert and jerking tail while locomotion - **Jrk**
- 01.8 Jump on the land - **Jmp**
- 01.9 Hop / jump on tree, branches, walls roots, etc. - **Ju**
- 01.10 Jump up (to a lookout post) - **Ju up**
- 01.11 Jump down (from a lookout post) - **Judn**

Ingestion Patterns

- 02.1 Feeding (all types of feeding including searching for food) -**Fd**
- 02.2 Drinking water - **DW**

Perching

- 03.1 Perching on tree branches - **P[]** (with height of perch in brackets) - Including perching with beak open
- 03.2 Perching in pairs (with the opposite sex) - **P¹[]**
- 03.3 Perching with call/song - **PC[]**

Cleaning Patterns

- 04.1 Cleaning the plumage with beak (including preening) - **CI** - Including oiling
- 04.2 Cleaning the beak - **CIB**
- 04.3 Puffing the plumage - **Fluf**
- 04.4 Stretching wings - **St**
- 04.5 Scratching (Direct) - **Sc**

Resting Patterns

- 05.1 Resting on land (Standing at the same place for a long time) - **Rst**
- 05.2 Look out (a little height above the land) - **WO []** (with the height in brackets)
- 05.3 Look out in pairs (with the opposite sex) **WO¹[]**
- 05.4 Look out with call / song - **WOC []**
- 05.5 Hiding - Inside bushes or corners of buildings - **Hid**
- 05.6 Roosting - On the walls of buildings and inside bushes - In the night - **Roo**

Posture Patterns

- 06.1 Sitting - On trees branches, walls of buildings, roots, rocks, etc.- **Sit**
- 06.2 Sitting on land - **SitL** (only observed in juveniles)

Thermoregulation

- 07.1 Sun bathing - **Su**

Territorial Behavior Patterns

- 08.1 All territorial disputes (including attacks, neck stretching, breast forward etc.) - **Tr**
- 08.2 Tail show - **Ts**

Inter and intraspecific Interactions

- 09.1 Fighting with each other - **Ft**
- 09.2 Chasing one another - **Dr** (on land)
- 09.3 Chasing one another while flying - **DrFI**
- 09.4 Attack individuals of other species - **At []** (with the other species in brackets)

10. Nidifications Patterns

- 10.1 Nest building - **Nst**
- 10.2 Incubating eggs -**In**
- 10.3 Child caring - **Ch**
- 10.4 Feeding the brood - **FdY**
- 10.5 Stealing nests of other species - **Stl []** (with the species which the nest belong to in brackets)

APPENDIX V

Standard codes used for territory mapping (Including standard BTO codes)

- R - Black robin - Male
- r - Black robin - Female
- R_{fam} - Juvenile black robins and parents together

 - Black robin giving vocal signals

R - Perching black robin

 - Black robin on land

 - A flying black robin (Seen only the flight)

 - Perched then flying away

 - Black robin flying in and then perch (First seen in flight)

 - Moving between perches

 - Moving from perch to land

 - Moving from land to perch

 - Same bird at two different places

 - Aggressive territorial encounter between two individuals

 - Two individuals singing at the same time

 - Black robin feeding while locomotion on land

APPENDIX VI

The data on diurnal variation of temperature and relative humidity

Time	630		830		1130		1330		1630		1830	
Day	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH
1	23	83	28	64	33	43	37	36	34.5	32	31.5	41
2	25.5	69	27.5	63	33	46	33	46	32	44	29	52
3	23	87	28.5	68	33.5	43	34	41	33	46	31.5	52
4	21	91	27	70	34.5	41	36	43	33	51	29	64
5	21	91	26	69	33	45	34	41	33	45	29.5	56
6	21.5	91	26	76	33	45	35	34	35	38	31	55
7	21	95	29.5	62	33.5	43	34.5	38	34	43	30	59
8	22	91	28	64	32.5	39	34.5	32	33.5	43	30	53
9	22	91	26.5	70	32	44	36	38	34	45	29.5	59
10	24	79	27	66	33	48	35	38	33.5	43	29.5	59
Total	224	868	274	672	331	437	349	387	336	430	301	550
Avg.	22.4	86.8	27.4	67.2	33.1	43.7	34.9	38.7	33.6	43	30.1	55

APPENDIX VII

Checklist of bird species recorded from the study area

1. Crested Serpent Eagle
2. Crested Hawk Eagle
3. Shikra
4. Blue-breasted Quail
5. Barred Button-quail
6. White-breasted Waterhen
7. Red-wattled Lapwing
8. Spotted dove
9. Pompadour Green Pigeon
10. Sri Lanka Lorikeet
11. Alexandrine Parakeet
12. Rose-ringed Parakeet
13. Sirkeer Malkoha
14. Common Coucal
15. Crested Tree Swift
16. Palm swifts
17. White-breasted Kingfisher
18. Common Kingfisher
19. Stork-billed Kingfisher
20. Three Toad Kingfisher
21. Green Bee-eater
22. Chestnut-headed Bee-eater
23. Indian Roller
24. Sri Lanka Gray Hornbill
25. Malabar Pied Hornbill
26. Brown-headed Barbet
27. Crimson-breasted Barbet
28. Brown-caped Pigmy Woodpecker
29. Yellow-fronted Pied Woodpecker
30. Rufous Woodpecker
31. Red-backed Woodpecker
32. Indian Pitta

33. Red-rumped swallow
34. East asian swallow
35. Black-headed Oriole
36. White-vented Drongo
37. Common Mynah
38. Black Crow
39. Large Cuckoo-shrike
40. Black-headed Cuckoo-shrike
41. Common Wood-shrike
42. Little minivet
43. Common Iora
44. Jerdon's Cloropsis
45. Red-vented Bulbul
46. Common Babbler
47. Yellow-eyed Babbler
48. White-browed Fantail Flycatcher
49. Paradise Flycatcher
50. Ashy Prinia
51. Large Prinia
52. White-browed Prinia
53. Grey-breasted Prinia
54. Common Tailorbird
55. Orange-headed Ground Thrush
56. Magpie Robin
57. Black Robin
58. Forest Wagtail
59. Small Flowerpecker
60. Thick-billed flowerpecker
61. Loten's Sunbird
62. Purple Sunbird
63. Purple-rumped Sunbird
64. Small White-eye
65. Baya Weaver
66. White-backed Munia
67. Spotted Munia
68. Black-headed Munia

APPENDIX VIII

Tabulated results of 84 instantaneous behaviour samples

Day	1												2											
	Morning				Midday				Evening				Morning				Midday				Evening			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Sample no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Gender	M	F	M	M	M	F	M	F	F	M	M	M	M	F	F	M	M	F	M	F	F	M	M	M
FI	6	2	5	1	1				2				4	8	5	6	4	1	1	1	2	4	6	7
SFI																								
GI																								
Hp	8	6		12	4			2	5	4	3	5	6	5	5	12	5	1	3	8	2	2	3	3
Rn	2			2	1				3	7	2	5	2	1	2				2					3
Alt	5	14	1	20	12	1		2	19	26	11	16	8	15	15	11	13	2	8	26	4	10	12	5
Jrk	3	3		2	1		1		3	8	2				2	1			2	4			2	1
Jmp																1			1					
Ju	1										1						3				1	1		
Ju up																								
Ju dn																								
Fd	6	6	1	18	5				18	10	9	12	12	8	19	8	4	5	4	7		4	3	5
Dw																								
P	21	3	32	2	32	44	56	3	8	2	12	13	9	19	12	9	31	25	1	9	22	4	17	9
P0																								
PC	2		17			7					17			3							10			21
Cl				1	2	8	2	1	1	1			4					16	6		15	1		
CIB																								
Fluf																								
St																								
Sc					1																			
Rst	3																							
WO	3	2	4	2	1			1	1	2		1	12	2		7					1	34	11	8
W00																								
WOC	21												3			2								1
Hid																								
Roo								51																
Sit																								
SitL																								
Su																								
Tr	2															1								
TS																								
Ft																1								1
Dr																								
DrFl																								
At																								
En	1																							1
Nst																								
In																								
Ch																								
FdY																					3			1
Sit																								
Total	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60

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