Status and ecology of the Nilgiri Pipit in the Western Ghats

Thesis submitted to the
Bharathiar University, Coimbatore

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in
ZOOLOGY

by
Uma J Vinod

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March 2007

CERTIFICATE

This is to certify that the thesis, entitled "**Status and ecology of the Nilgiri Pipit in the Western Ghats**" submitted to the Bharathiar University, in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Zoology is a record of original research work done by **Ms. Uma J Vinod** during the period August 2002 to February 2007 of her study in the Department of Zoology at Sálim Ali Centre for Ornithology and Natural History under my supervision and guidance and the thesis has not formed the basis for the award of any Degree /Diploma /Associateship /Fellowship or other similar title to any candidate of any University.

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DECLARATION

I, **Uma J Vinod** hereby declare that the thesis, entitled "**Status and ecology of the Nilgiri Pipit in the Western Ghats**" submitted to the Bharathiar University, in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Zoology is a record of original and independent research work done by me during August 2002 to February 2007 under the supervision and guidance of **Dr. Lalitha Vijayan, Department of Zoology** at Sálim Ali Centre for Ornithology and Natural History and it has not formed the basis for the award of any Degree/Diploma/Associateship/Fellowship or other similar title to any candidate in any University.

Uma

Signature of the candidate

This work is dedicated to… ….
My Mom, Dad, Teacher E. Kunhikrishnan
and my Uncle,
Mr. R. Jayadevan… … … … … … … ….

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Uma J Vinod

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Chapter I
Introduction

1. 1. General

The verdant grass covered undulating hills interspersed with shola forests embracing the folds of hills in the Upper Nilgiris present a unique ecosystem with a variety of endemic plants and animals. These forms are specialists which could survive only in that specific ambience with least fluctuations. Hence, any perturbation to the ecosystem would lead to catastrophic effects on these specialists. However, the shola - grassland ecosystem of the higher altitudes have been subjected to sizeable anthropogenic threats ever since the colonization in the early 19th century (Sukumar 1990, Prabhakar and Gadgil 1994); most grasslands and sholas have been converted into plantations of various kinds, transforming the landscape of once massive stretches of grasslands into smaller bits and, most of the pristine sholas into obliteration. Changes they ushered in the faunistic elements, however, have not been documented adequately. Birds are considered to be ideal for this, as they are indicators of the ecosystem changes and ecosystem health (Morrison 1987, Newton 1995, Lawton 1996); mainly because they occupy a top position in the trophic structure and that they provide adequate data to illustrate the consequences of human activities in a given ecosystem. Such bird-born data have been keys for many global environmental issues (Lack 1968, Perrins 1970, Murton and Westwood 1977, Cockrem 1995, Gwinner 1996, Hahn and Mader 1997)

Endemic species are more vulnerable to habitat alternations. The Nilgiri hills, generally the Western Ghats, are known for its high endemism. Those species, which have restricted range of distribution, have more chances of getting endangered or extinct (Lee *et al.* 2005). The populations of many grassland birds have declined sharply (Noss *et al.* 1995), mainly because of the loss and degradation of grassland habitat. As a group, grassland birds have experienced "steeper, more consistent and more geographically widespread declines than any other behavioural or ecological guild" (Knopf 1994).

Hence, it is thought prudent to document the basic ecological requirements of a species which inhabit invariably the grasslands – the Nilgiri Pipit.

India has a rich avifauna of over 1295 species with 69 endemics concentrated in areas of high rainfall (Inskip *et al.* 1996, MoEF 1999). 16 endemic species are restricted to the Western Ghats (Stattersfield *et al.* 1998). According to Birdlife International (2001), nine of them are Threatened, namely the Nilgiri Laughing Thrush, Nilgiri Wood Pigeon, White-bellied Shortwing, Broad-tailed Grassbird, White-rumped Vulture, Spotbilled Pelican, Lesser Adjutant, Wood Snipe and Kashmir Flycatcher of which the first four are endemic. Apart from this, there are 13 Near Threatened species, namely Grey-headed Fish Eagle, Red-headed Vulture, Pale Harrier, Malabar Pied Hornbill, Great Hornbill, Oriental Darter, Black-headed Ibis, Painted Stork, Great Snipe, Grey-breasted Laughing Thrush, and Black-and-Orange Flycatcher, Nilgiri Pipit, and Nilgiri Flycatcher of which the last five are endemic. Nilgiri Pipit and Nilgiri Flycatcher have been included under Vulnerable by Islam and Rahmani (2004) and the Grey-headed Bulbul is proposed as vulnerable by Vijayan and Balakrishnan (2005). Among the 16 endemics, those confined to the high altitude grasslands are Broadtailed Grassbird and Nilgiri Pipit. The former frequents tall grass thickets, whereas the latter short grasslands (Ali and Ripley 1987).

1. 2. Literature review

1. 2. 1. Studies on pipits outside India

The Meadow Pipit *Anthus pratensis* has been extensively studied. Hötker (1988) studied the lifetime reproductive out put of male and female in Northwestern Germany during 1975-1986, Seel and Walton (1979) breeding population in mountain farm grassland in North Wales, Coulson (1956) the mortality and egg production with reference to altitude, Bureö and Pavel (1997) the effect on nesting condition on risk-taking, Dougall (1993) the post-juvenile moult and dispersal and, Spaepen (1988) the survival rates.

Halupka (1994, 1998 a,b,c and d) did a detailed study on Meadow Pipit; the effects of incubation-feeding on activity budget of the female pipits, nest-site selection and, the extension of predation costs of vocal begging by nestlings. He found that the intensity of vocal begging by broods did not influence their survival, despite the fact that the proportion of time that parents sacrificed to nest guarding declined with increased begging. Halupka and Halupka (1997, 1998) studied the nest defense and the reaction of chick on alarm calls.

The species of pipit which attracted the attention of a larger number of ornithologists is the Water Pipit *Anthus spinoletta*. Rehsteiner *et al.* (1998) studied singing and mating success in Water Pipits and found that 'Snarr' element of the song determines the mating success of the male Water Pipit. Hendricks (1987) found the nesting Water Pipit forage where they have the greatest probability of encountering preferred sizes and types of prey. Miller and Green (1987) reported the distribution, status, and origin of Water Pipit breeding in California. Sutton and Parmelee (1954) discussed the survival problems of the species in Baffin Island. Drury (1961) and Verbeek (1970) reported that the important features of the breeding ground for Water Pipit is snow-free early in season, having rough features, such as tussocks, rocks and eroded areas. Bent (1950) and Verbeek (1970) described the display behaviour of the Water Pipit. Frey *et al.* (1995) evaluated the relations between food conditions, foraging behaviour and reproductive performance and found that yearly variation of food reduces reproductive success. Bollmann (1996) investigated the mating system in a variable environment and the reasons for the monogamy in the Alpine Water Pipit. Territory quality and reproductive success of this pipit was also given in detail (Bollmann *et al.* 1997). Reyer *et al.* (1997) reported the ecological determinants of extra-pair fertilizations and egg dumping, Rauter and Reyer (1997) the incubation pattern and foraging effort of the female, Brodmann *et al.* (1997) and Brodmann and Reyer (1999) nestling provisioning and reproductive performance and, Rauter *et al.* (2000, 2002) provisioning behaviour in detail and its relation to nest site characteristics and breeding times.

Harris (1933) observed a nest and Hendricks (1991) studied the site fidelity and re-nesting of female American Pipit, while McConnell *et al.* (1993) recorded breeding and Sutter *et al.* (1996) the re-nesting intervals. Sutter (1997) looked at the nest-site selection and nest-entrance orientation while Robbins (1998) studied the display behaviour of male.

Breeding biology (Garoche *et al.* 1997), agonistic behaviour and strategy (Elfström 1997), feeding habits and territory (Gibb 1956), and food and territory size (Arvidsson *et al.* 1997) of the Rock Pipits have also been reported.

Various ecological aspects of the Sprague' Pipits were studied. Dale (1983), Madden (1996) and, Sutter and Brigham (1998), concluded that intermediate height and sparse to intermediate vegetation density of grasslands are the suitable habitat for Sprague's Pipit. Habitat selection and prairie drought in relation to nesting ecology (Sutter 1996) and, nest-site selection and nest entrance orientation in mixed grazed mixed-grass prairie (Sutter 1997) were reported. Robbins (1998) found male breeding territories on ridge tops with short grass and low sedge and forbs density in Northwestern North Dakota. Breeding season, phenology and site-fidelity were studied by Robbins (1998), Sutter (1996), and Sutter *et al.* (1996). Response of the Sprague's Pipit to prairie management such as burning and haying (Maher 1973, Stewart 1975) and, grazing during the breeding season (Davies *et al.* 1989, Bock *et al.* 1993, Anstey *et al.* 1995) have been documented.

Ecological studies on Richard Pipits or Grassveld Pipits or African Pipits *Anthus cinnamomeus* were done extensively. The African Pipit inhabits most grasslands including open fringes near pans (including saline pans) and lightly wooded savanna (Keith *et al.* 1992, Maclean 1993, Clancey 1997). They forage primarily from ground or low perches, occasionally leaping or making short pursuit flights to obtain prey and, largely consume insects and other arthropods (Borrett & Wilson 1970, McDonald 1974, Keith *et al.* 1992). Breeding biology of the African Pipit was also extensively documented (Tait 1991, Keith *et al.* 1992, Clancey 1997). The eggs are subjected to predation from rats and other ground predators, and also to trampling by stock and game (Van Someren 1956, Steyn 1980). They make specific calls for individual purpose (Dowsett-Lemaire 1989, Keith *et al.* 1992 and Maclean 1993). Movement pattern of the species also have been documented (Clancey 1990, Keith *et al.* 1992, Clancey 1997, Tarboton 2001).

1. 2. 2. Studies in India

In India, basic information on the ecology of many of the bird species have been documented (Ali and Ripley 1987). Detailed quantitative ecological studies on the endemics of the Western Ghats have been done only for four species, namely the Black-and-Orange Flycatcher (Khan 1978 a and b), Nilgiri Laughing Thrush and Greybreasted Laughing Thrush (Islam 1985) and, Nilgiri Wood Pigeon (Somasundaram 2006). No such studies on the high altitude grassland birds of the Western Ghats have been reported. Studies on pipits in India are confined mainly to site records, a list of which is given in Chapter III where the status and distribution are discussed. Vijayan *et al.* (1999) and Vijayan and Gokula (2006) reported the decline of the Nilgiri Pipit with the expansion of plantation in the Nilgiris. Mitra (1978a) reported the display of Richard's Pipit and Nair (1996b) observed Pipit (*Anthus* sp.) preying on leeches. Unnithan (1995) reviewed the collection of Motacillidae in Bombay Natural History Society.

While ecological studies on some of the large prominent grassland birds in the North India such as the Great Indian Bustard (Rahmani and Manakadan 1986); Lesser Florican and Bengal Florican (Narayan *et al.* 1989, Sankaran *et al.* 1992, Sankaran, 1996), Swamp Francolin (Iqubal *et al.* 2003) were undertaken, no such work has been done to find out the ecological requirements of any of the grassland species in the South. However, grassland ecology of the Western Ghats has been studied Zarri *et al.* (2004). In this background a detailed study was undertaken on the Nilgiri Pipit with the following main objectives: a) determine the status, b) unravel the ecology, and, c) identify the key factors affecting the survival of the Nilgiri Pipit and suggest management options.

Chapter II

Study area and species

2. 1. Study area

Distribution and status of the Nilgiri Pipit were studied in select areas in the Western Ghats, whereas the intensive studies were in the Upper Bhavani area of the Nilgiris.

2. 1. 1. Western Ghats

The Western Ghats, the most important topographic feature of the peninsular India, is a chain of highlands running along the West Coast forming a practically unbroken relief for almost 1600 km with a latitudinal range of more than 10 degree. It extends from the mouth of the River Tapti (21^0 N) to the tip of South India (about 8^0 N). It is distributed narrowly between 73^0 and 77^0 E and is less than 100 km wide over most of its length; widest being in the Anamalai and Nilgiri ranges. Along its length, it bears various names, including the Nilgiri Hills, the Anamalai Hills, the High Ranges, the Cardamom Hills, the Highwavy Mountains, and the Ashambu Hills (Figure 2.1).

The only gap in the chain of mountains is the 30 km wide Palghat Gap. North of it towards $11^0 30'$ N, the Western Ghats rise abruptly in the Nilgiris constituting an elevated plateau which attains a maximum height of 2636 m at Doddabetta. South of the Palghat Gap, the Ghats reappear abruptly as the Anaimudi-Palani block whose high plateau attains a height of 2695 m in the Anaimudi peak, the highest point in South India. Almost at the Southern tip of India, where it is more rugged, it has another peak, the Agasthyamudi peak around 1869 m.

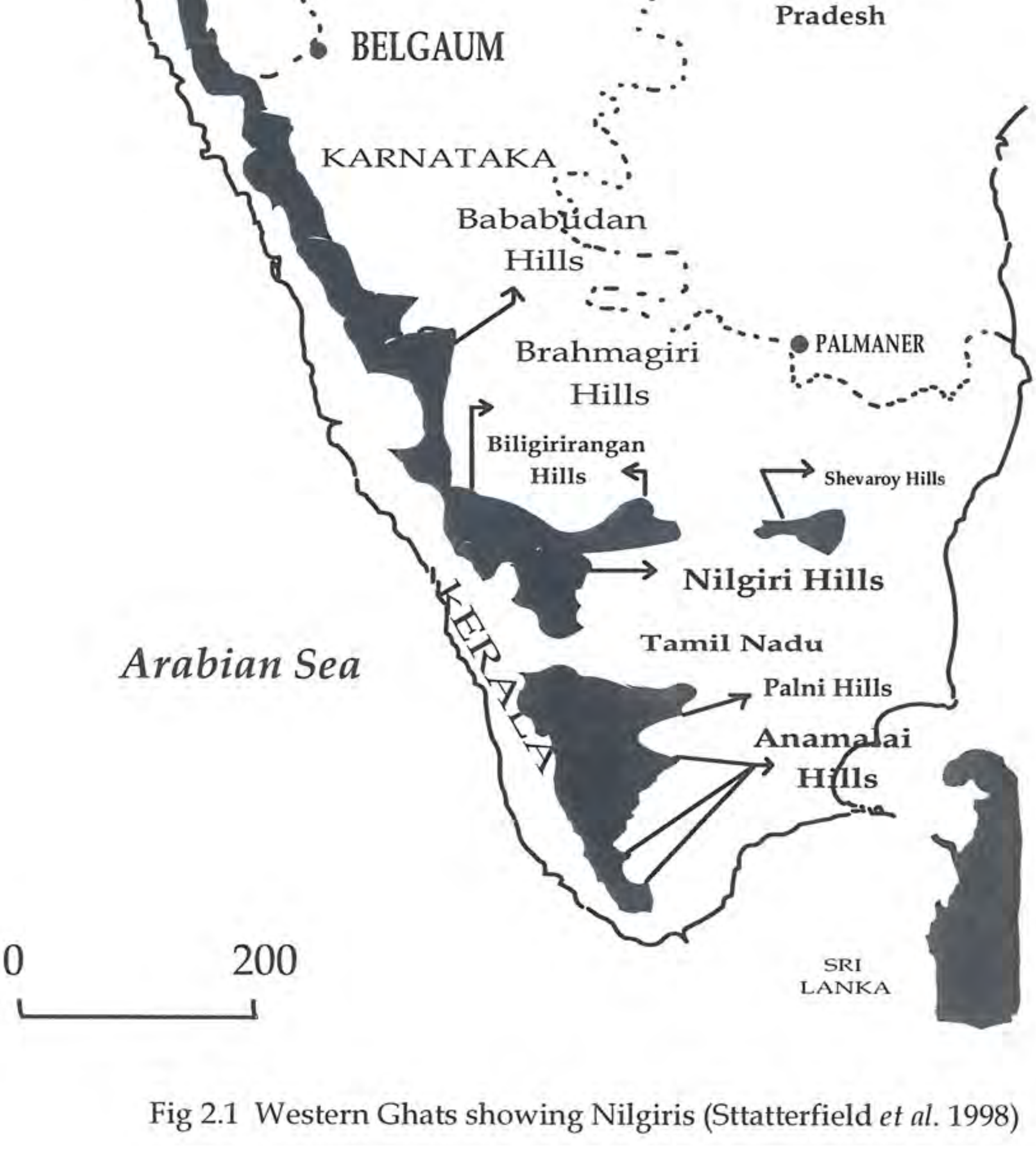


Fig 2.1 Western Ghats showing Nilgiris (Sttatterfield *et al.* 1998)

The climate of the Western Ghats shows rainfall and temperature gradients. The western slopes of the Ghats are subject to direct influence of rain-bearing winds of the south-west monsoon. They receive 2000 to 7500 mm of rainfall (Daniels 2002). It declines rapidly to <800 mm, towards the east within a distance of seven to 60 km. The eastern slopes receive heavy rains during the north-east monsoon. The temperature gradient is related mostly to increase in altitude. However, it is not uniform throughout the Ghats because of variability in the relief from south to north. In general, the mean temperature of the coldest month varies from 23^{0}C at sea level to 12^{0}C at 2300 m.

Noted by its rich biodiversity, the Western Ghats is considered as one of the two 'biodiversity hotspots' in the country; the other being the Eastern Himalayas (Myers 1988). Later, in a revision when 34 biodiversity hotspots were recognized around the world, the Western Ghats along with Sri Lanka and, the Indo-Burma region covering the Eastern Himalayas were considered as two hotspots (Mittermeir *et al.* 2005). The region has also gained international attention, as a globally important eco-region (Olson and Dinerstein 1998). The high levels of diversity and endemism are expressed at both higher and lower taxonomic levels (Daniels 2002). The montane grasslands, described as an interesting biome in India (Nair 1994) towards the upper reaches (>1600 m asl), followed below by the evergreen/semi-evergreen, moist deciduous and deciduous forests are the major natural vegetation of the Western Ghats. Among them the montane grasslands are unique in terms of species composition, physiognomy, and ecology. Characterized by the juxtaposition of grasslands with shola forests (hence known as shola-grasslands or montane grasslands or montane scrub-savannah), these formations give a unique appearance to the hilltops of the Western Ghats, especially in the Nilgiris and Anamalais. These grasslands were considered as a sub-climax (Raghavan 1957, Gupta 1960) and as edaphic or climatic climax by Champion and Seth (1968).

The shola-grassland ecosystem not only harbours a rich biodiversity but also exhibits the ecological conditions that have led to evolution and coexistence of grassland - forest mosaic which poses interesting ecological questions (Gupta *et al.* 1967, Singh and Yadava 1977). These formations form the upper catchments of majority of perennial streams below. Besides, the area is home to many rare, endemic and threatened species.

The influence of humans in the Western Ghats has been felt since stone-age of Palaeolithic era over 12,000 years. Although early history about humans in the Western Ghats is inadequate, it has been noted that the most significant ecological changes occurred since the early 19th Century, following British colonization and consequent exploitation of forests. Increasing populations and changing lifestyles, technologies and needs also undoubtedly played a significant role in intensifying human impacts on the Western Ghats ecosystem (Gadgil and Guha 1992). British colonial impacts on the Western Ghats was largely through natural resource exploitation and conversion of natural habitats to monoculture plantation of teak *Tectona grandis*, tea *Camellia sinensis*, coffee *Coffea arabica*, black wattle *Acacia mearnsii*, eucalyptus *Eucalyptus* spp., rubber *Hevea brasiliensis*, arecanut *Areca catechu* and pine *Pinus* spp. and, opening up of remote areas through construction of roads and railways. The recent estimate put the loss and conversion of the original natural vegetation of the Western Ghats during 1920 to 1990, to be around 40%, with an annual rate of deforestation to be around 0.57% (Menon and Bawa 1997, Jha *et al.* 2000).

The Western Ghats is a biodiversity hotspot having high human population densities (Cincotta *et al.* 2000). Moreover, here the ecosystems have limited size of reserves surrounded by an intervening matrix of land that is under intense human pressures than in any other hotspots in the world (Myres *et al.* 2000, Mittermeir *et al.* 2005).

2. 1. 2. Intensive study area – the Upper Nilgiris

Although the study area included most of the high range hills of the Western Ghats, intensive ecological study was undertaken in the Upper Nilgiris, an area from 1,700 m to the highest hill Doddabetta (2,636 m). The Upper Nilgiri plateau in the Nilgiris is one of the important areas for the conservation of the endemic birds of the Western Ghats (Vijayan *et al.* 1999). A large part of the plateau has been converted into plantations of black wattle, eucalyptus and pine (Prabhakar and Gadgil 1994, Prasad 1998, Jha *et al.* 2000) which has adversely affected the population of the endemic birds (Vijayan and Gokula 1999, 2006).

The Mukurthi National Park on the south eastern corner of the Nilgiri plateau with the adjacent Upper Bhavani area formed the major study area. The Park encompasses the relatively untouched shola-grassland ecosystems. The park is like a misshapen dumb-bell with larger areas on the south and north. It is bordered on the south-west by the Upper Bhavani reservoir, the east by the south division of the forest department, the north-east by Nilgiri Peak, and reserve forests and, the west by the Western Catchments (Figure 2.2).

Fig 2.2 Upper Nilgiris showing study area - Upper Bhavani

2. 1. 3. Upper Bhavani

Upper Bhavani, about 60 km from Ooty, is one of the entry points to the Mukurthi National Park. The habitat in this area comprises rolling hills with grass carpets, shola forests and plantations of pine, eucalyptus and wattle.

2. 1. 3. 1. Climate

Rainfall

The plateau receives both the south-west and north-east monsoons. The Upper Nilgiris around the crest of Mukurti National Park receives annually around 5600 mm rainfall. However, there is considerable local variation in the average monthly rainfall and number of rainy days (Figure 2.3) from 99 days in 2003 to 95 days in 2004. The large share of rainfall was during the north-east monsoon in all the years; except in 2002. The month of highest rainfall was August in 2002, October in both 2003 and 2004. Unusually high rainfall occurred during August 2002 and May 2004.

The annual rainfall also varied from 1803 mm in 2002 to 1680 mm in 2003 and 2642 mm in 2004. Lengerke (1977) recorded around 10,867 mm of rainfall in Western Catchment 111 during 1961. It may be noted that the annual rainfall in the area has declined drastically; from 3832 mm in 1994 to 1222 mm in 2003 (Figure 2.4).

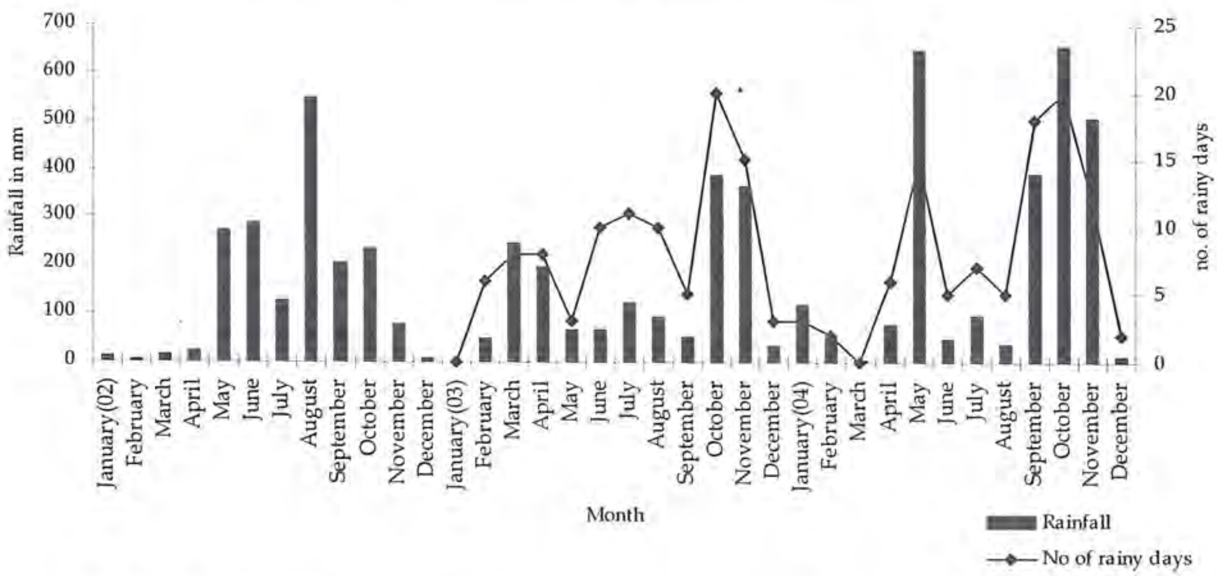


Fig 2.3 Rainfall and number of rainy days in Upper Bhavani (2003-2004)

Note: No data for the number of rainy days in 2002

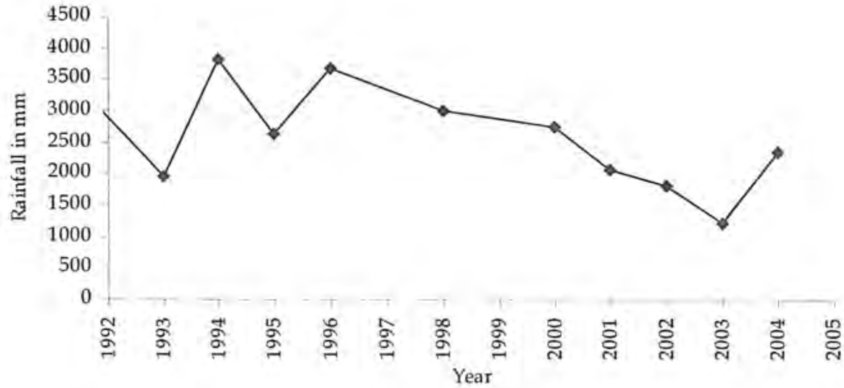


Fig 2.4 Annual rainfall in the Upper Bhavani (1992-2005)

Relative humidity

The average monthly humidity was about 90% at 0700 h during the south-west monsoon while it was slightly less during summer. The average of morning and evening showed a maximum of 90% in November in 2003 and a minimum of 50% in March 2004 (Figure 2.5).

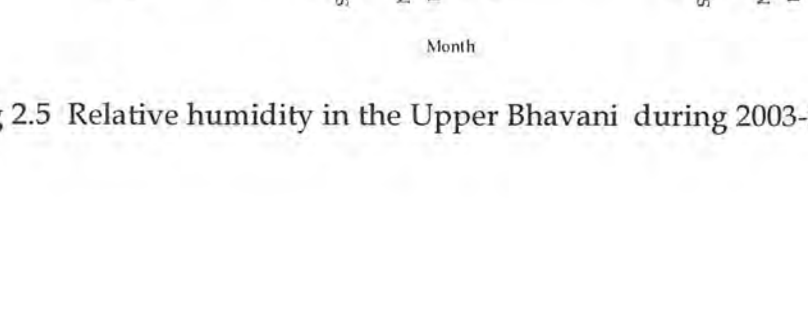


Fig 2.5 Relative humidity in the Upper Bhavani during 2003-2004

Temperature

The average monthly maximum temperature varied from 19.3⁰C (November 2004) to 26.3⁰C (May 2003) and the average minimum temperature from 19.3⁰C (September 2004) to 10⁰C (Decemebr 2004) (Figure 2.6). Minimum temperature recorded was -8⁰C on 30th Decemeber 2003. In the Upper Bhavani region, the dry season lasts from January to April when the ground temperatures vary from -8 to 45°C in the grasslands. The temperature falls subzero level in most of the days during monsoon and winter.

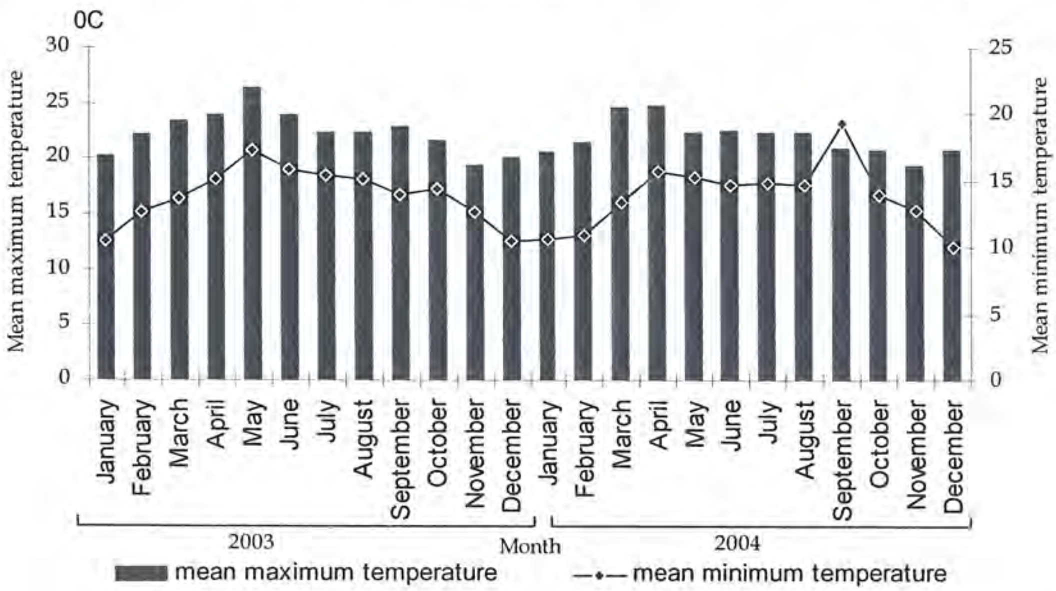


Fig 2.6 Mean maximum and minimum temperature in Upper Bhavani during (2003-2004)

Wind speed

Velocity of wind was quite high in the upper Nilgiris, especially at Upper Bhavani during January to April 2003, and February to March and December 2004. Velocity was low during August, October and November 2003, and during July and September 2004 (Figure 2.7). Wind has definite impact on upper plateau vegetation as emphasized by Champion and Seth (1968). This is found to be true for birds depending on grasslands.

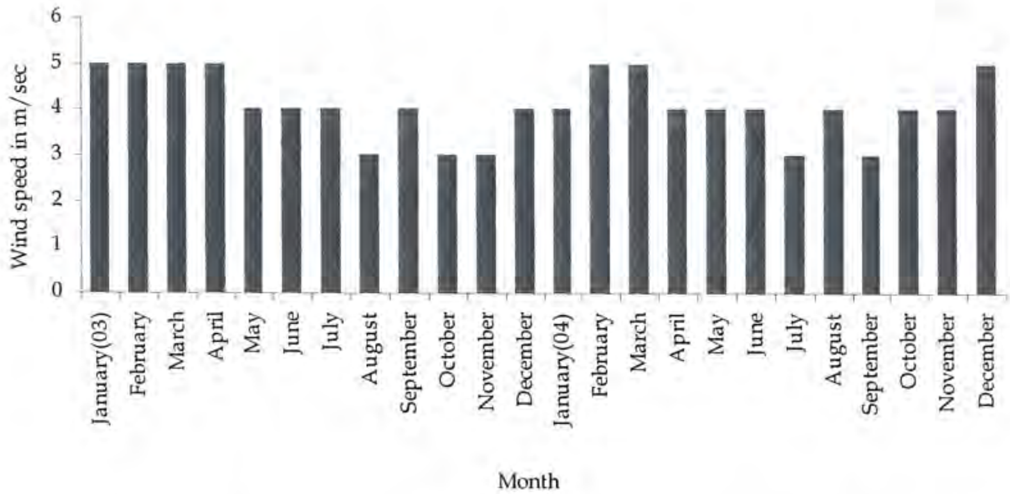


Fig 2.7 Mean wind speed in Upper Bhavani during 2003-2004

Frost

Frost occurs generally in the grass valleys with marsh patches between November and April in the Upper Bhavani area. Frost is also believed to be one of the factors controlling the shola-grassland formation.

2. 1. 3. 2. Vegetation

There are 2760 vascular plants recorded in the Nilgiris (Sharma *et al.* 1977). Blasco (1970) recorded 82 endemics, exclusively confined to the Nilgiris at high elevations. Around 120 orchids, including 9 endemics, and 11 endemic *Impatiens* spp. were recorded from the Upper Nilgiris. The major vegetation types found in the area are; 1. southern montane wet temperate forests, 2. montane grasslands, and 3. plantations.

1. *Southern montane wet temperate forests* (Champion and Seth 1968):

Commonly known as sholas, these are isolated, compact, patch of forests in the valleys among extensive grasslands covering rolling hills. Evergreen species with abundance of mosses, lichens, ferns and orchids are characteristics of the shola vegetation. These include elements of both tropical and temperate origin. The major species forming the top storey belong to the genera: *Michelia, Gordonia, Meliosma, Elaeocarpus, Cinnamomum, Syzygium, Litsea, Neolitsea, Evodia, Ilex, Glochidion,* and *Ternatroemia. Turpinia, Viburnum, Saccinium, Garcinia, Vernonia, Euonymus, Symplocos, Memecylon, Hydnocarpus, Rhododentron, Eurya,* and *Microtopis* form the second storey. Common shrubs are *Maesa, Lasianthus, Psychotria, Sarcococca, Strobilanthus, Polygala, Bambusa,* and *Alsophila.* Other scandant shrubs and Lianas in the sholas are mainly *Toddalia, Rosa, Maboia, Rubus, Berberis, Caesalpinia, Smilax, Pentapanax, Jasminum, Ipomoea, Passiflora, Polygomum, Piper,* and *Gleichenia.* Most common epiphytes are innumerable types of mosses, lichens, ferns and orchids. Herbaceous plants present in the shola grasslands are, mainly *Oxalis, Impatiens, Erigeron, Hydrocotyle, Anotis, Laportea, Chlorophytum, Fragaria, Desmodium* and *Rannunculus.*

2. ***Montane grasslands*** (Figure 2.8)

The abundant species in the grasslands are *Tripogon narayani, Andropogon polypticus, Eulalia phoethrix, Arundinella setosa, Themeda triandra, Chrysopogon zelanicus, Isachaemum indicum, Tripogon bromoides, Eragrostis nigra, Poa annua* and *Agrostis pilosula.* Other common species belong to the genera *Anaphalis, Helichrysum, Senecio, Conysa, Osbeckia, Rubus,* and *Viola.*

3. ***Plantations***

Plantations consist mainly of Black Wattle, Eucalyptus, Mexican Pine, Cinchona, Coffee, Cardomom and Tea. There was a drastic increase in the extent of plantations at the cost of natural vegetation between 1849 and 1992 (Table 2.1). Grasslands have been reduced to 15.7% while shola forests to 49%. Within 143 years grasslands which was 60.54% in 1849 reduced to just 9.85% and the shola forest was reduced to 8.85% from that of 17.43% (Table 2.1). The reduction of grassland was more than 50%.

Total area	Outcherlony's map (1849)	Recent map (1992)
Sholas	8,600 ha (17.43%)	4,225 ha (8.85%)
Grasslands	29,875 ha (60.54%)	4,700 ha (9.85%)
Cultivation	10,875 ha (22.04%)	12,400 ha (25.98%)
Tea	0 ha	11,475 ha (24.04%)
Wattle	0 ha	9,775 ha (20.48%)
Eucalyptus	0 ha	5, 150 ha (10.79%)

Table 2.1 Comparison of the different types of vegetation in the Nilgiris between 1849 and 1992.

Source: www.nilgiriibiosphere.com

Photo by Uma J Vinod

Photo by Uma J Vinod

Marshy valley

Photo by Uma J Vinod

Grass-slopes with shola

Fig 2.8 Typical habitat of the Nilgiri Pipit

Seed abundance

The seed abundance in the study area where the birds foraged was quantified as percentage of seeds available in the area. The exact spot where the individual bird was feeding is considered as the central point and, a radius of one metre around it was graded visually for the abundance of seeds. Observations were made from each feeding block and monthly averages are calculated.

Main grass seeds recorded in the area was of *Isachnae kunthiana.* There was marked seasonal variation in seed abundance which had a peak in winter (39%) and then gradually declined to a minimum during south-west monsoon (11%) (Figure 2.9).

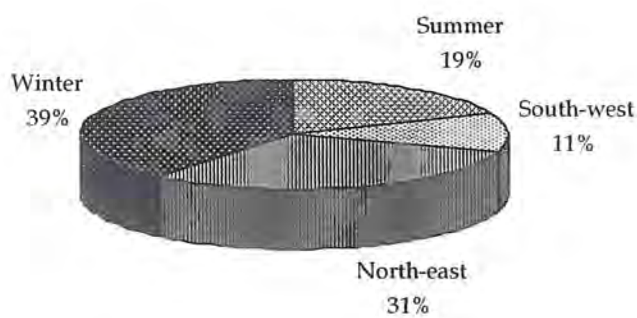


Fig 2.9 Total seed abundance in different seasons

The F4 block had the maximum seed abundance among the five feeding blocks. In almost all the feeding blocks, seed abundance was the maximum in winter (Figure 2.10).

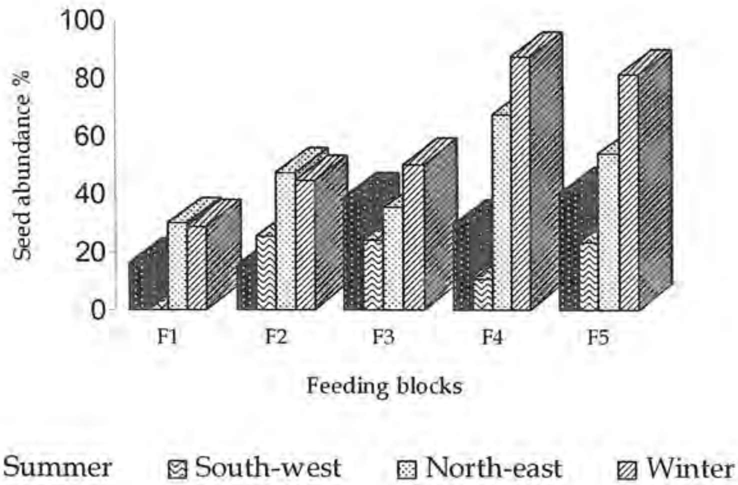


Fig 2.10 Seed abundance in different seasons in different feeding blocks

2. 1. 3. 3. Fauna

Invertebrate abundance

Invertebrates were sampled by following standard methodologies such as sweep, line transect and ground quadrats (Southwood 1971) to quantify their abundance in the study area. The methods were modified to match the foraging maneuvers of the Nilgiri Pipit. Samplings were done from the south-west monsoon of 2002 to the summer of 2004 between 1000 – 1200 h. Sampling was done in a 200 X 200 m plot; the size was rather proportionate to the comparatively smaller size of the foraging area of the pipits. The main plot was then divided into eight 50 X 50 m sub-plots to carry out the detailed sampling twice a month. The data were pooled for each season. Such data were collected for 23 months and pooled for each season.

Sweep method is intended to sample the insects from ground layer vegetation (grass, herb and shrub). It was done with a sweep net made of cotton having a mouth diameter of 40 cm, fixed with a handle. Each sampling contains ten sweeps at a stretch, and 30 samples were taken in a month.

Transect sampling was to sample the lepidopterans and odonates in the air. Five 50 m line transects were walked and the insects flying over 25 m on each side were counted.

Quadrats of 25 X 25 cm were searched for the invertebrates on the ground. 80 such samples were done in a month.

Insects were categorized into different size classes from 0.0 mm to 5.0 mm, 5.1 mm to 1.0 cm, 1.1 cm to 2.0 cm , 2.1 cm to 3.0 cm, 3.1 cm to 4.0 cm, 4.1 cm to 5.0 cm and >5 cm to find out the difference in size class distribution.

The invertebrates in the samples in the order of abundance were Diptera (51%), Lepidoptera (11%), Coleoptera (8%), Hymenoptera (8%), Arachnida (7%), Odonata (6%), Phasmida (3%), Hemiptera (2%), Isoptera (1%) and Annelida (1%) (Figure 2.11). Bigger insects such as butterflies, moths, caterpillars and grasshoppers could be identified while capturing.

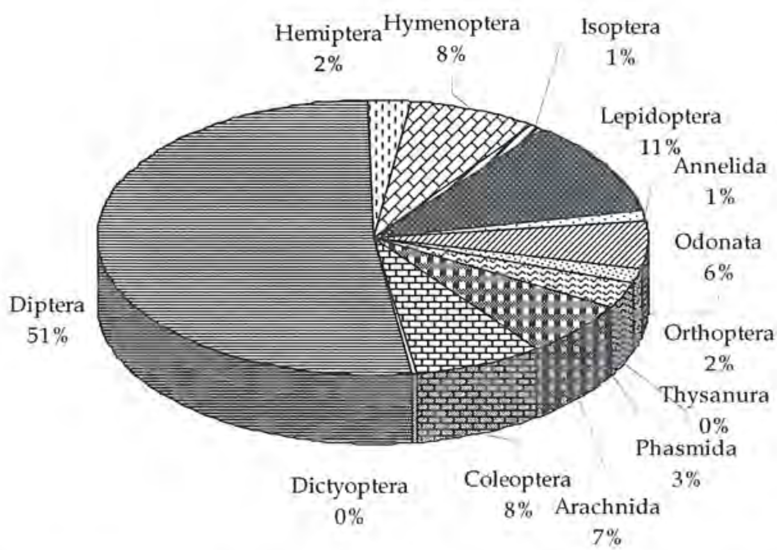


Fig 2.11 Invertebrate abundance in the study area during 2002-2004

The abundance of invertebrates varied in each month showing a bimodal pattern. (Figure 2.12).

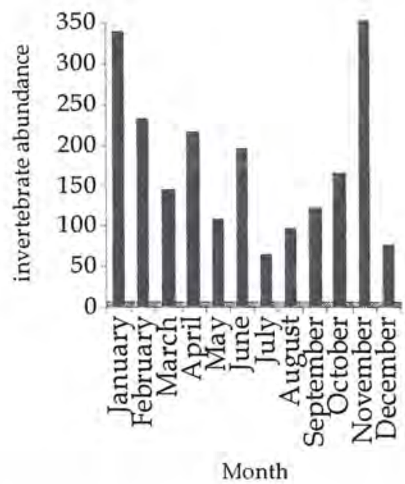


Fig 2.12 Variation of total invertebrate abundance in each month

Invertebrate abundance varied between seasons within the year and also between the years but it followed almost the same pattern with Diptera as the dominant group (Figure 2.13). However, total invertebrate abundance showed significant variation between years (ANOVA; F=29.07, p<0.00) and between seasons (ANOVA; F=27.39, p<0.00).

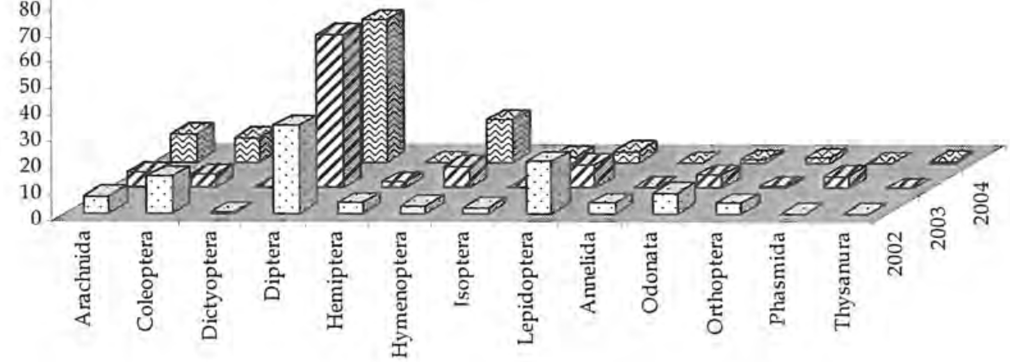


Fig 2.13 Year- wise variation in the abundance of invertebrates at Upper Bhavani

Invertebrate abundance was maximum during winter and north-east monsoon; 31% and 30% respectively and, minimum during south-west monsoon (17%); during summer it was 22% (Figure 2.14).

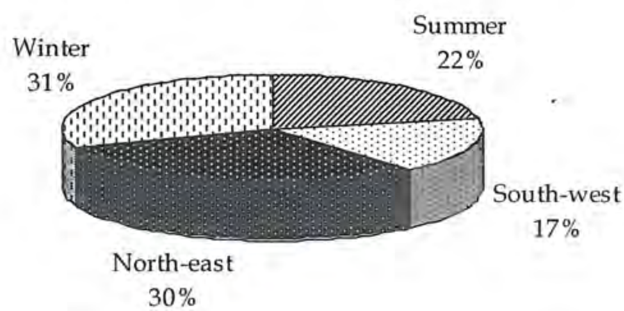


Fig 2.14 Seasonal variation in the abundance of invertebrates in Upper Bhavani

Spiders were significantly higher in south-west monsoon (Figure 2.15). Hemipterans and hymenopterans were more during summer. During the winter of 2003 the dipterans were more. Coleoptera, Lepidoptera and Phasmida were in the highest number during north-east monsoon. Orthopterans were more during south-west monsoon.

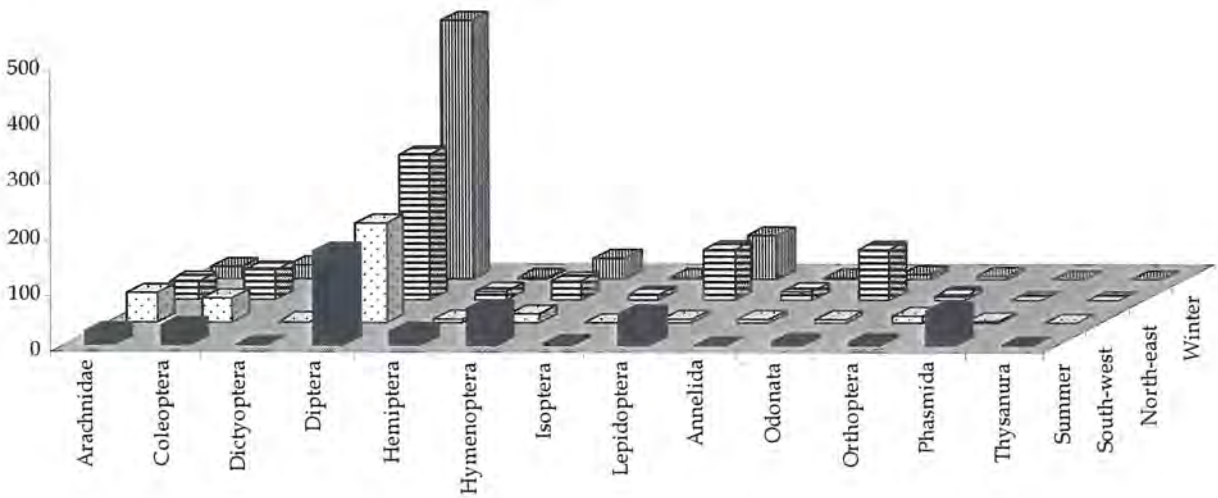


Fig 2.15 Seasonal abundance of different groups of invertebrates at Upper Bhavani

Abundance of Coleoptera, Lepidoptera and Orthoptera

Since the main food items of Nilgiri Pipit were Coleoptera, Lepidoptera and Orthoptera both in nestling and fledgling period, the abundance of these three major groups were analyzed separately to know the variation in each month (Figure 2.16a, 2.16b and 2.16c).

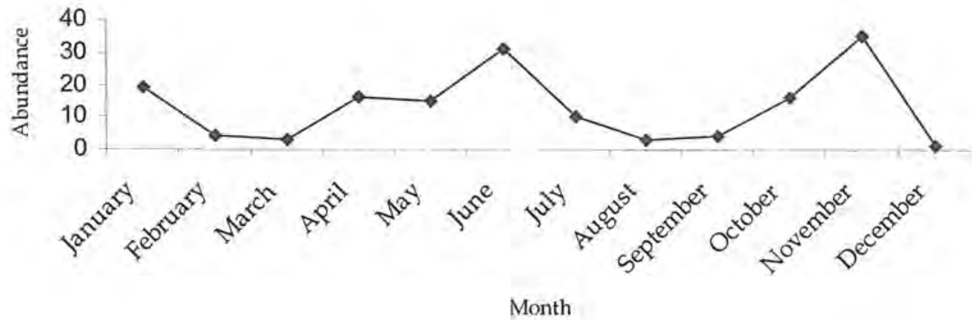


Fig 2.16a Variation of abundance of Coleoptera in each month

Fig 2.16b Abundance of Lepidoptera in each month

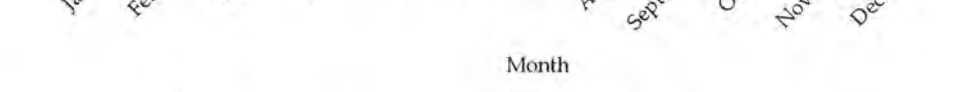


Fig 2.16c Abundance of Orthoptera in each month

Abundance of major groups in the summer of each year was also calculated; the highest was in 2003 (Figure 2.17).

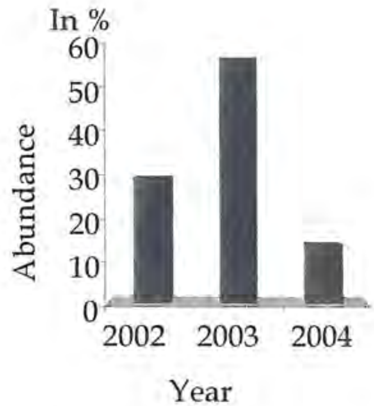


Fig 2.17 Abundance of major groups of insects in the summer of each year

The abundance of coleopterans and lepidopterans were in the north-east monsoon, whereas orthopterans were more in south-west monsoon (Figure 2.18).

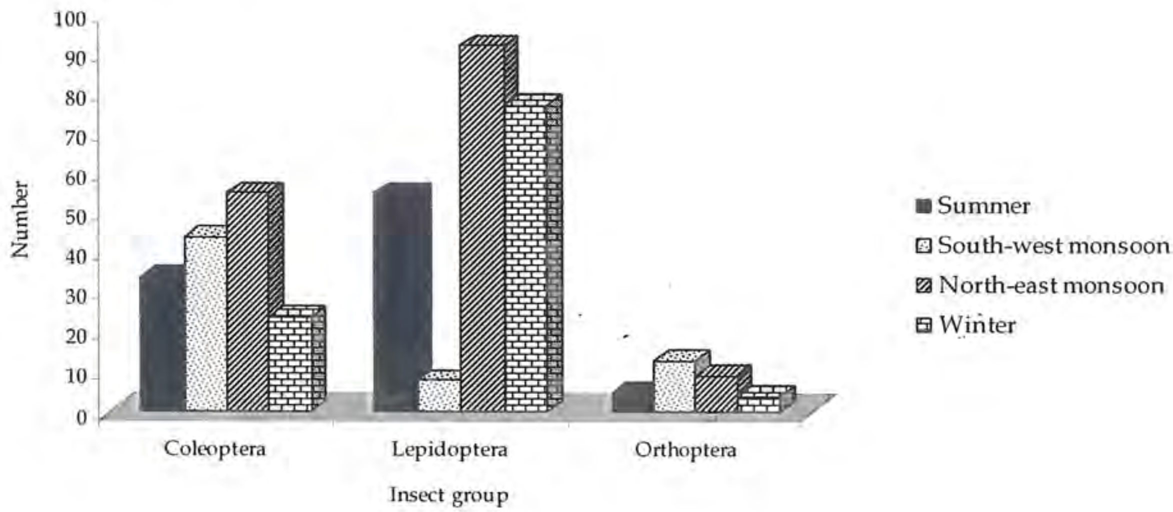


Fig 2.18 Abundance of Coleoptera, Lepidoptera and Orthoptera in different seasons

Abundance of invertebrates in different size classes

Insects of 0.0 to 0.5 mm size (49.31%) were more in the study area followed by 0.5 mm to 1.0 cm (23.96%) and >5 cm (7.43%) (Table 2.2). Dipterans were the most abundant order in the study area.

Size class	No of individuals	%
0.0-0.5mm	969	49.31
0.6-1.0cm	471	23.96
1.1-2.0cm	107	5.41
2.1-3.0cm	95	4.83
3.1-4.0cm	69	3.51
4.1-5.0	108	5.49
>5	146	7.43

Table 2.2 Abundance of total invertebrates in different size classes in the study area

Spatial difference in the invertebrate abundance

Abundance of invertebrates varied significantly between the feeding grass area and nesting (marshy) area; 71% of the individuals were collected from the former. Arachnids were more in the nesting area than in the feeding area. 74% of the dipterans were collected from feeding area. Coleopterans and hymenopterans were also more in the feeding area than in the nesting area.

Mammals

No regular sampling was done for the mammals but species sighted were recorded. Upper Bhavani has most of the large mammals found in the Western Ghats. However, some of them are occasional visitors while others are found in low densities. The tiger, leopard, wild dog, jackal, elephant and bison are resident in the park. Smaller carnivores include the jungle cat, leopard cat, small Indian civet, and palm civet. Among the primates, the Nilgiri langurs in the sholas and bonnet macaques in the plantations and at the edges of sholas were recorded. The most common herbivore is the sambar; barking deer and mouse deer are also found. The Nilgiri tahr is found on steep slopes and near cliffs.

Bird community in the Upper Bhavani

Altogether 68 species were observed in and around the Upper Bhavani during the study period (Appendix 1), but only 24 species with 332 individuals could be counted during the survey in a 10 ha area. Six of them were grassland species and 18 associated with trees or habitat generalists in the Upper Bhavani grasslands. The diversity index was 1.03. 44 species of birds were recorded from the edges where the grassland is bordered by shola, plantations of wattle, pine or tea.

Habitat	Species richness	Species diversity index
Grasslands	24	1.03
Grassland/wattle edge	21	1.0
Grassland/ pine edge	17	1.07
Grassland /tea edge	32	1.13
Grassland /shola edge	18	0.81

Table 2.3 Species richness and diversity of birds in the Upper Bhavani area

The diversity index of birds at the wattle edge is 1.0, pine edge has 1.07 and tea edge 1.13 while shola edge has 0.81 (Table 2.3). Although, bird diversity and abundance are often positively correlated with vegetation complexity (Roth 1977, Cody 1985), the present data do not conform to this. Since the vegetational structure in grasslands is fairly homogeneous, grassland bird communities are correspondingly simple compared to most other habitats. Again the low bird species diversity in the Upper Bhavani supports the hypothesis that high altitude grassland harbours still lower diversity than the lowland grasslands (Vickery *et al.* 2003). However, shola edge is more diverse in terms of plants (habitat) and therefore expected to have higher diversity of birds. In the present case, the lowest diversity index at shola edge might be because of the more number of specialists which have a tendency to avoid the open edges. But at the tea edge having closed edge, the diversity was high including both the shola specialists and other generalists. Other reason might be the availability of moderate temperature at the tea edge than other plantations such as wattle. Simple declines in the taxonomic diversity with altitude have been documented also for other groups of organisms (Brown 1988, Haffer 1990). However, the higher species diversity in the habitat edges shows that it is not the altitude alone which determines the diversity, but also the habitat diversity. It may also be noted that there is generally an inverse relationship between altitude and bird species richness (Hawkins 1999, Lan and Dunbar 2000, Vickery *et al.* 2003), due to the reduced variety of habitats at high altitude.

2. 2. Species under study

Pipits are the common name for more than 45 species of small songbirds belonging to the family *Motacillidae* found over most of the world.

2. 2. 1. Major characteristics of *Motacillidae* (Ali and Ripley 1987, Alström *et al.* 2003, Hoyo *et al.* 2004)

The family Motacillidae, Small Oscine Passerines (Suborder Passeres), is mainly terrestrial and insectivorous. 54-58 species are in five Genera and in two closely related groups- Pipits (genera-1-3) and Wagtails (4-5). "Body is slender and shape often exaggerated by longtail. Neck is short. Sexes are similar in size. Bill is thin, pointed and notched. Nasal operculum and rictal bristles are present. Wing is medium to long with 10 primaries but the 10^{th} considerably reduced. Tertials long in most species. Flight is strong. Song flights, launched from ground or perch, are characteristic of both Pipits and Wagtails. Legs are medium to long, slender; hind claw often elongated - least so in forms which regularly perch in trees or on hard, bare ground. Legs and feet rather similar to those of Larks (*Alaudidae*) but tarsus acutiplanter with sides covered by unbroken sheath and front by fused scutes. Plumage is soft, streaked and cryptic in *Anthus*, brightly and contrastingly coloured (with black, yellow, white, or orange) in other Pipits and Wagtails. Annually they moult twice. Non-breeding plumage is slightly different from breeding, except in most *Anthus* and some tropical species. Upper parts of nestlings covered with rather dense, often long down feathers; mouth bright but usually without contrasting spots. Young often leave nest (on ground in most species) before capable of flight".

Family is well defined and homogenous. Relationships to other Passeres, as indicated by traditionally accepted characters. Evidence from egg-white protein data seems to point ties with Old World Babblers (Sylvidae) or flycatchers (Muscicapidae) (Sibley 1970), but reduced outer primary indicates affinities with 9-primaried Oscines and this is supported by DNA data which place Pipits and Wagtails as a Subfamily (Motacillinae) with in Ploceidae together with Old World Sparrows (Passerine), Waxbills (Estrilidinae), Weavers (Ploceinae) and Aaccentors (Prunellinae) (Sibley and Ahlquist 1990).

2. 2. 2. Pipits

Pipits are dull brownish, more or less streaked with black, often with white outer tail feathers and long hind claws. They resemble many Larks in color and in habits, being chiefly birds of open grasslands or rocky areas and often singing while in flight. Size ranges between c.14 and 17 cm and body slender with long tails that are often wagged up and down. The legs and toes are long and these birds either walk with a rather deliberate gait or run at great speed over the ground. The hind-toe is elongated in most species. The bill is slender and pointed. All Pipits (*Anthus*) are duller and cryptic in colouration, often with heavily streaked brown plumage. Many species look alike and are often difficult to identify.

Pipits inhabit open country from rocky shores (Rock Pipit *Anthus spinoletta*) to wet meadows and grassland (e.g. Meadow Pipit *Anthus pratensis*), arid and sandy regions (e.g. Tawny Pipit *Anthus campestris*) and mountain tops (e. g. Hodgson's Pipit *Anthus roseus* which occurs up to 4,000 m in the Himalayas). The Pipits are among the most widely distributed songbirds in the world. They breed in all continents from the Arctic Tundra, through the South American Pampas and African Desert to the Antarctic, where one species (*Anthus antarcticus*) breeds on the island of South Georgia. The Rock Pipit *Anthus spinoletta* has a wide distribution, inhabiting rocky shores in Northern Europe, high mountain valleys through out the Palearctic (where it is known as Water Pipit) and Alpine Meadows and Tundra in North America. The Tree Pipit *Anthus trivialis* inhabits open woodland and regularly perches on tall trees. Richard's Pipit *Anthus novaeseelandae* extends throughout the Palearctic to Australia where it is the only Pipit. The Palearctic Pipits are migratory, many moving to tropical Africa and Asia during winter.

Pipit's food is mainly insects, both adult and larvae picked off the ground. Adult diptera (especially scatophagidae, tipulidae and chironomidae) are common in the diet, also grasshoppers, spiders, worms, molluscs and crustaceans. Seeds are occasionally eaten.

In summer, Pipits space their nests out and defend breeding territories. In favourable habitats, there may be up to 5 pairs of Rock pipits per km of Coastline. In winter some species usually feed in flocks (Meadow pipits), and exploit large patches of abundant food.

The Pipits are well known for their spectacular song flights (e.g. Meadow Pipit, Tree Pipit) in which the song is delivered from high in the air as the bird parachutes slowly back down to the ground or a tree perch. Pipits often give flight calls which are one of the best ways of identifying species in the field.

Pipits build their nests in hollows on the ground, using mostly grass and mosses, sometimes lining the nest with hair. The clutch varies from three to seven. The eggs are white or buff, speckled brown or grey. Incubation, usually only by female, is from 12-16 days. Both parents usually care for the young, which fledge in c.14 days.

2. 2. 3. Nilgiri Pipit *Anthus nilghiriensis*

Nilgiri Pipit is a monomorphic, territorial and strongly social monogamous passerine, endemic to the Western Ghats. They are distributed in the hills of the Nilgiris and Anaimalai in Tamil Nadu and Kerala from 1000 m to over 2300 m (Ali and Ripley 1987). They are closely associated with short grasslands with marshy grounds. It is Near Threatened (Birdlife International 2001); common in the shola grasslands in Upper Bhavani; >2000 m elevation (Vijayan *et al.* 1999).

The main characteristics of the Nilgiri Pipit is its size (17 cm), buff under-parts, broadly streaked with dark brown on breast, abdomen and flanks; dark brown tail with buff outer edge; black beak curved at the tip; buff eye ring; and darker pink leg. It is often confused with Paddyfield Pipit *Anthus novaeseelandiae (Anthus rufulus)* in the field. The size and measurements and colours of bare parts are conclusive for the distinction between the two (Table 2.4). In the field Padyyfield Pipit is distinguishable with its pink beak, not curved at the tip and the white outer edge of the tail. Variation in the light intensity adds on the confusion in differentiating the two in the field. Moreover, the mode of flight and many of the behaviours are common for both the Pipits making the job more difficult unless the observer is very familiar with the species (Figure 2.19).

Parameters	Nilgiri Pipit	Paddyfield Pipit
Size	17 cm	15 cm
Wing	Male: 76-81mm Female: 73-82	Male: 77-87mm Female: 74-84 mm
Bill	Black curved at the tip	Pink not curved at the tip
Tarsus	24-29 mm	24-28 mm
Hind claw	Not exceeding hind toe; 9-13 mm	Exceeding hind toe; 12-18 mm
Tail	Male : 53-66 mm Female: 52-67 mm	Male : 51-62 mm Female: 50-60 mm
Eye ring	Buff in colour	White in colour
Colour of :		
Eyes	Iris brown.	Iris brown
Bill	Bill blackish brown, paler at base of lower mandible	Upper mandible and tip of lower mandible horny brown, rest of lower mandible pale flesh colour, gape yellow; mouth orange yellow varying with age;
Leg	Pale reddish fleshy	Brownish yellow
Feet	Pale reddish fleshy	Brownish yellow
Claw	Darker brown	Dusky

Table 2.4 Characteristics of the Nilgiri Pipit and Paddyfield Pipit

Photo by Uma J Vinod

Nilgiri Pipit - showing buff eye ring

Photo by Uma J Vinod

Photo by Uma J Vinod

Fig 2.19 Nilgiri Pipit and Paddyfield Pipit

2. 3. Summary

- Distribution and status of the Nilgiri Pipit were assessed by surveying select areas of the Western Ghats. The intensive study on the ecology of the Nilgiri Pipit was conducted in the Upper Bhavani area of the Nilgiris.
- The main habitats in the area comprise rolling hills with grass carpets, shola forests and plantations of pine, eucalypts and wattle.
- The Nilgiri Plateau receives both the south-west and north-east monsoons which varied during study period; 1803 mm in 2002 to 1680 mm in 2003 and 2642 mm in 2004.
- There was a drastic decline in the rainfall from 3832 mm to 1222 mm in 10 years (1992 to 2002).
- The average monthly humidity was about 90% at 0700 h during the south-west monsoon while it was slightly less during summer.
- Monthly average temperature varied from 19.3 ^{0} C (November 2004) to 26.3 ^{0} C (May 2003).
- Minimum temperature recorded was -8 ^{0}C on 30th Decemeber 2003.
- Velocity of wind was quite high at Upper Bhavani during January to April 2003, and February to March and December 2004.
- Frost occurs generally in the grass valleys with marsh patches between November and April in the Upper Bhavani area.
- The major vegetation types found in the area are; 1. southern montane wet temperate forests, 2. montane grasslands, and 3. plantations.
- 24 species of birds were recorded in a 10 ha area of grassland in Upper Bhavani and the diversity index was 1.03.
- 44 species of birds were recorded from the edges where the grassland is bordered by shola, plantations of wattle, pine or tea.
- Major characteristics of the family Motacillidae and the study species, the Nilgiri Pipit, were described.
- The characteristic differences between Nilgiri Pipit and Paddyfield Pipit were tabulated to distinguish the two species in the field.

Chapter III

Status, distribution and habitat of the Nilgiri Pipit

3. 1. Introduction

Information on the status and distribution of particular species is of utmost importance in planning conservation strategies and management programmes for the species and its habitat (Wiens 1977, Vijayan 1996) and hence it has become one of the focal areas of avian research (Mc Arthur 1972, Cody 1985).

Spatial and temporal distribution patterns of species are related to various ecological factors and processes (Burel 1992). They are influenced by biotic and abiotic factors mainly food, rainfall and temperature. In other words, distribution and status of any species depend mainly on the habitat quality which varies from place to place. Variations in habitat structure, to which individual birds may respond, exist in a hierarchy of both spatial and temporal scales (Wiens 1973, Kotliar and Wiens 1990, Orians and Wittenberger 1991). The most suitable habitat is the one which confers maximum success for reproduction and survival for the occupants (Newton 1998). Hence, study of habitat utilization is of importance for management programmes for individual species (Martin and Finch 1995, Sherry and Holmes 1996, Kligo *et al.* 2002, Kwit *et al.* 2004). Moreover, information on bird-habitat relationships can help to predict the effects of management and habitat change on bird populations (Bibby *et al.* 1992).

Grasslands contain relatively homogeneous vegetation patterns that lack structural diversity, or patchiness, thus limiting the number of bird species that can exploit them (Roth 1976). Many species of grassland birds are area sensitive and are particularly vulnerable to loss of grassland habitat (Smith and Smith 1990, Vickery *et al.* 1994). Since the early 1900s, agricultural activities, plantations and rehabilitations have profoundly altered the grassland ecosystems of the Western Ghats. Compounding to these are development activities such as hydro-electric projects with construction of dams, reservoirs, canals and tunnels (Prabhakar and Gadgil 1994) which have also changed the ecological landscape of the area. The Nilgiris, particularly, have been undergoing drastic changes in the landscape with the replacement of forests and grasslands by monoculture plantations and agriculture (Gokula and Vijayan 1996, Vijayan and Gokula 2006).

For effective conservation of a species, better understanding is needed on the factors that limit numbers within areas of the remaining habitat. Since the Nilgiri Pipit is highly specialized to its habitat, the grasslands, any perturbation of the habitat would affect the survival of the species. Hence, the present study was conducted to assess: a) status of the Nilgiri Pipit in selected areas of Southern Western Ghats, b) their response to disturbed habitats, and c) the species-habitat associations at macro and micro habitat levels.

3. 2. Methodology

3. 2. 1. Status and distribution

3. 2. 1. 1. Earlier records

Information on the locations of sightings and collection of the Nilgiri Pipit till 2002 were compiled from literature and other sources and plotted on a map.

3. 2. 1. 2. Present records

The locations where the Nilgiri Pipit were recorded earlier and other probable areas were selected for the field survey. Unlimited - distance point counts were performed (Reynolds *et al.* 1980, Dawson 1981) in select areas. The observer stood at fixed locations for 10 minutes recording all birds seen or heard. Distance from the observer was also noted. Both Protected Areas (National Parks, Sanctuaries) and unprotected areas were surveyed covering altitudes up to 2500 m. Besides these, bird census, employing the point count method was conducted regularly in and around the intensive study area twice a month covering various habitats such as shola, grassland, tea, wattle and pine plantations; each of 10 ha for general bird abundance and the target species.

3. 2. 2. Habitat

Habitat use was analyzed at the macro and micro levels.

3. 2. 2. 1. Macro-habitat

At the macro level the vegetation type was determined from the vegetation map of the valley (Zumbuhl and Burnad 1986) and the general habitat of the occupied and unoccupied points in the area was analyzed.

3. 2. 2. 2. Micro-habitat

Data were collected and analyzed following Rotenberry and Wiens (1980) for studying the microhabitat of the Nilgiri Pipit. Vertical structure, density and heterogeneity of vegetation with species richness and diversity of plants were assessed in the intensive study area. Habitat and bird data were collected in a 10 ha study plot divided into 50 x 50 m grids marked with stakes. Grids were selected randomly for sampling. All grids sampled were surrounded by a "buffer zone" of similar vegetation at least 100 m wide in order to minimize edge effects (Rotenberry and Wiens 1998).

Vertical structure, cover, and diversity of vegetation

In all, 40 plots of 2 x 2 m were sampled from eight 50 X 50 m plots in the intensive study area. Vertical vegetation was recorded by noting the number of plant contacts along a 1 m long wooden dowel of about 5 mm thickness sub-divided into bands positioned vertically on the vegetation. The species of plants making contact with the dowel was recorded. The height of the vegetation at the four corners and centre of the

2 m square quadrat was measured to calculate vegetation heterogeneity (Rotenberry and Wiens 1998).

The standing vegetation cover was measured by placing a 10 x 10 cm board, marked into 1 x 1 cm squares vertically on the vegetation at five points in a 2 x 2 m plot. From a distance of 5 m, the number of squares obscured by vegetation was noted and calculated as percentage of cover.

Density and diversity of plant species were estimated in eight 50 x 50 m grids. In all, 40 plots of 1 x 1 m were sampled. The grasses and herbs present within the plots were identified to species level. The percentage of occurrence was noted and species richness and diversity were calculated.

Utilization of microhabitats for feeding, breeding, and roosting

The microhabitat of the Nilgiri Pipit was determined by its frequency of occurrence at particular sites within the grasslands. Observations were made generally from 0600 to 1900 h recording: a) the time, b) the activity, c) exact location, d) plant species, and e) grass height, and f) other species of birds around.

3. 2. 3. Data analyses

- Encounter rate (ER) was calculated as the number of individuals seen per hectare.
- Abundance was correlated with different factors using Spearman's correlation test.
- One-way ANOVA, two sample 't'-tests, Pearson correlation and χ^2 tests were also performed in appropriate places.
- Vegetation heterogeneity was calculated, as below:

$$\text{Heterogeneity index} = \frac{\Sigma(\text{max-min})}{\Sigma x}$$

Where max = maximum height of the vegetation in the quadrat, min = minimum height of the vegetation in the quadrat, and x = mean height of the vegetation in the quadrat.

Low values of this index indicate homogeneity of the vegetation and high values heterogeneity. Values are summed for the whole plot to give an overall heterogeneity measure which is compared with other plots and against the abundance of birds.

- All analyses were done using SPSS 10.0 version.

3. 3. Results

3. 3. 1. Status and distribution

3. 3. 1. 1. Distribution of the Nilgiri Pipit

Based on the literature available on the sightings and localities of collection of specimens of the Nilgiri Pipit, a tentative map of its distribution is prepared (Figure 3.1). Data from Trivandrum Museum, Bombay Natural History Society Museum (BNHS), British Museum of Natural History (BMNH), American Museum of Natural History (AMNH), Museum for Comparative Zoology and United States National Museum of Natural History (USNMNH) were consulted for locality of collection. The exact location and source are given in the table 3.1.

Location	Source	
	Sight record	Specimen collected
Karnataka Coorg	Betts 1951	-
Kerala		
Malabar	-	BNHS 1888
Sirendhri and Poochipara, Silent Valley National Park	Vijayan *et al. 1992*	-
Periyar Tiger Reserve	Srivastava *et al.* 1993	-
Eravikulam	Robertson 1984	BNHS 1947
Devikulam	Salim Ali 1935-37	Trivandrum museum
Ponmudi	Ali 1968), Ferguson (1898), Ferguson & Bourdillon (1903-4)	-
Anamudi	Ali 1947, 48	BNHS
Tamil Nadu		
Avalanche, Nilgiris Mukurti, Western Catchment , Nilgiris	A E Jones 1943, RBGrubh & RJP 1977 RBGrubh & RJP 1977 S. D. Ripley 1947	BNHS BNHS USNMNH
Coonoor	Davison & Meinertzagen in 1876, 1881, 1901	BNHS
Kothagiri	Cockburn 1870, 1874	-
Kallatty	Phytrian-Adams May1935, Whistler June 1935	-
Naduvattom	Davison 1883 Jerdon 1839-40, Sharpe 1885, Betham 1903	-
Ooty	W. Davison January-March 1881, C. J. Davidson July 1894, H. R. Baker June 1901, P. Gosse June 1918 Koelz 1947	AMNH 1883
Montford, Kotagiri	Bednall 1936	-
Coonoor and around	Khan 1977, 78	-
Guddalore	Gokula 1995	
Upper Bhavani, Bison Swamp, and Doddakatti- Coonoor	Vijayan and Gokula 1994-98	-
Palni Hills	Terry 1887	BMNH
Kodaikanal	Fairbank 1877, Ticehurst 1883 and P. Gosse 1918 W. Koelz March 1937 Nicols 1937, Koelz 1947 Hussain 1992	BMNH AMNH BNHS 1982
Perumalmalai	Fr N A Fuller 1947	BNHS
Palani		MCZ 1881
Highwavy Mountains (Upper Manalar) and Upper Cumbum valley	B. M. Beehler 1986	USNMNH

Table 3.1 Locations of Nilgiri Pipit

[Source: Draft for "Threatened birds of Asia" India section (Vijayan, L. pers. Comm.)]

Fig 3.1 Distribution of the Nilgiri Pipit

Totally around 3273.5 ha area was surveyed and 134 individuals of the Nilgiri Pipit were sighted in the 2103 ha (0.06 / ha) of grass-slopes and marshes, mainly in the high altitude regions. It shows that Nilgiri pipits are present along the high elevated hills of the Southern Western Ghats. Results of the survey in each state are given below separately.

Kerala

Eight localities were surveyed in Kerala, namely Silent Valley National Park, Eravikulam National Park, Mathikettan Shola National Park, and Chinnar Wildlife Sanctuary, Munnar (out side National Park), Mannavan Shola (Marayur), and Meesapulian mala (Near Munnar) and Siruvani (Muthikulam Reserve Forest) (Table 3.2). Nilgiri Pipit was more in the Eravikulam National Park, which has extensive short grasslands in the high altitude. In the 260 ha grassland surveyed, 26 individuals (0.1 individual / ha) were encountered. Density was higher in the marshy grasslands than in the upper grass slopes. In Munnar, outside the Eravikulam National Park, Nilgiri Pipit was recorded in the available grass patches among the plantations. In Silent Valley no Nilgiri Pipit was found during the survey of 15 days. However, later, three breeding pairs were recorded; one in Neelikkal and other two in Sispara but a few days later, the nest at Neelikkal was destroyed by forest fire (Anoop Das 2005, Pers.Comm).

			Areas covered in ha						**Total area covered**	**No. of the Nilgiri Pipit/ha**
			Natural Vegetation			**Plantation**				
Place	**Elevation**	**No. of NP**	**Shola**	**Grass**	**Ever-green**	**Co**	**Tea**	**Cd**		
Munnar out side NP	2000	12	45	82	*	*	121.5	18	266.5	0.04
Mannavan shoal	1750	0	28	*	*	*	2	*	30	0.00
Eravikulam NP	2000	26	*	260	*	*	*	*	260	0.1
Meesapulian mala	2000	5	*	260	*	*	*	*	260	0.01
Mathikettan shola NP	1000	0	10	*	*	*	*	5	15	0.00
Chinnar WS	700	0	*	*	20	*	*	*	20	0.00
Silent Valley NP	1000	3	*	*	35	*	*	*	35	0.08
Siruvani	1000	1	*	25	25	*	*	*	50	0.02
Total		47	83	628	80		123.5	23	936.5	0.03

Table 3. 2 Sightings of the Nilgiri Pipit in Kerala

Note: NP= Nilgiri Pipit; Cd = Cardamom; Co =Coffee.

Tamil Nadu

Twelve areas were surveyed in Tamil Nadu. The Nilgiri Pipit was noted in all the areas from 2000 m and above (Table 3.3) except for one where the elevation was 1200 m. In the Upper Nilgiris, pipits were recorded inside the Mukurthi National Park where the short grasslands with marsh and streams were present. In the 1444 ha area in and around the Upper Bhavani including Bangithapal, 26 adults (0.018 / ha) were recorded. 350 ha area surveyed in the Western Catchment III, 35 individuals were recorded (26 adults and 9 chicks; 0.069 / ha). Three pipits from 10 ha (0.3 / ha) in the Western Catchment II and four pipits from 25 ha in the Western Catchment I were also recorded. However, in 2004, the same area in the Western Catchment III had only 10 birds (0.028 / ha).

Place	Elevation	No. of NP	Areas covered in ha							Total area covered	No. of the NP/ha
			Natural Vegetation			Plantation					
			Shola	Grass	Ever-green	Co	Tea	Wt	Pine		
Upper Bhavani	2290	6		14	*	*	*	*	*	14	0.42
Bangithapal	2200	27	10	1414	*	*	*	10	10	1444	0.01
Korakundha	2200	2		2	*	*	20	*	*	22	0.1
Pai Banglaw	2200	2		10	*	*	*	*	*	10	0.2
UpperPalnis	2000	2	15	5	*	*	*	13	5	38	0.05
Lower Palnis	1200	0		31	51	12	*	*	*	94	0.00
Madippumala	2200	2		10	*	*	*	110	*	120	0.01
Western catchment 111	2200	35		350	*	*	*	*	*	350	0.1
Western catchment 11	2000	3		10	*	*	*	*	*	10	0.3
Western catchment 1	2000	4		25	*	*	*	*	*	25	0.16
Pallipara	2000	2		20	*	*	*	*	*	20	0.1
32 Aada	2000	2		20	*	*	*	*	*	20	0.1
Total		87	15	1911	51	12	20	133	15	2167	0.129

Table 3.3 Sightings of the Nilgiri Pipit in Tamil Nadu

Note: NP= Nilgiri Pipit; Co= Coffee; Wt=Wattle

Karnataka and Goa

The Nilgiri pipits were not recorded in Belgaum and Castle Rock in Karnataka and in Catigao and Bondla Wildlife Sanctuary, Bhagwan Mahavir National Park and Canacona in Goa where the survey was conducted in December-January, 2004 (Vijayan *et al.* 2005) (Table 3.4.).

KARNATAKA

Place	Elevation	No. of NP	Areas covered in ha			Total area covered	No. of the Nilgiri pipits/ha
			Shola	Grass	Evergreen		
Belgaum	300	0	*	*	15	15	0.00
Castle Rock	700	0	*	10	*	10	0.00
GOA							
Catigao WS	200	0	*	20	30	50	0.00
Bondla WS	350	0	*		15	15	0.00
Bhagwan Mahavir NP	350	0	*	22.5	22.5	45	0.00
Canacona	400	0	*		25	25	0.00
Total		0		52.5	107.5	170	

Table 3.4 Sightings of the Nilgiri Pipit in Karnataka and Goa

3. 3. 1. 2. Comparative abundance of the Nilgiri Pipit

Among the states surveyed, namely Kerala, Tamil Nadu, Karnataka and Goa, the encounter rate of the Nilgiri Pipit was high in Tamil Nadu (0.13 / ha).

Abundance of the Nilgiri Pipit in protected and unprotected areas

In general, the Nilgiri Pipit was more in the Protected Areas than in the unprotected areas; 114 (96.5%) in the former and 20 (4%) in the latter. Outside the Eravikulam National Park in Munnar, the number of pipits (0.04 / ha) was fewer than inside the Park (0.1 / ha).

Abundance of the Nilgiri Pipit in different altitudes

The Nilgiri Pipit does not occur in the low altitudes (< 1000 m), but found in low densities in the medium altitude of 1000-2000 m and, in higher numbers in high altitude areas (>2000 m), especially in montane grasslands (Table 3.5). Higher number was observed above 2300 m in the Nilgiris and Anaimudis.

Altitudinal range in m	No of Nilgiri Pipit recorded	Total area covered in ha	Encounter rate of NPs / ha
<500	0	152	Nil
500-1000	0	30	Nil
1000-1500	1	194	0.005
1500-2000	0	30	Nil
2000-2500	133	2867.5	0.046
Total	134	3273.5	0.040

Table 3.5 Altitudinal variation in the occurrence of the Nilgiri Pipit

Habitat-wise variation in the distribution of Nilgiri Pipit

The Nilgiri Pipit was present in the grasslands throughout the year (Figure 3.2) comparatively in higher numbers; the mean encounter rate was 0.6 / ha varying from 0.4 to 0.7 / ha. They were found in small numbers on the edges of shola forests in all the seasons, except in north-east. On the edges of plantations of wattle and pine also they frequented in small numbers but not throughout the year. The edges of the tea plantations were used very rarely that too only during south-west monsoon (Figure 3.2).

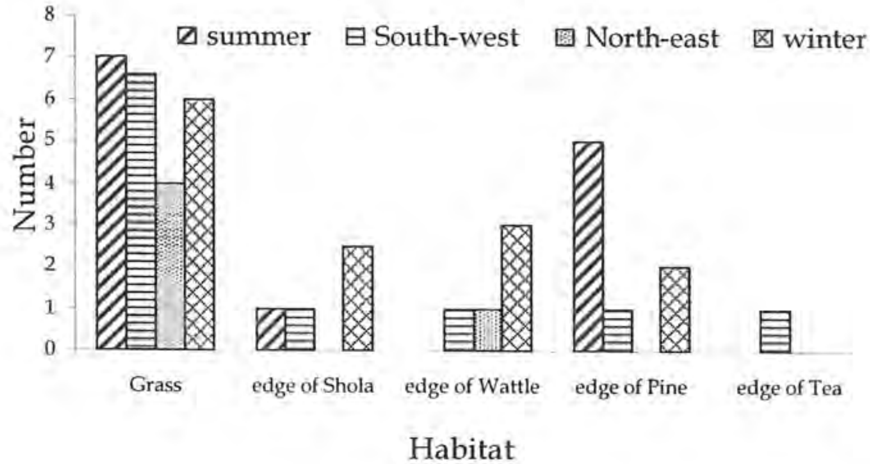


Fig 3.2 Seasonal variation of the Nilgiri Pipit in different habitats

3. 3. 1. 3. Population of the Nilgiri Pipit in the study area

Population of the Nilgiri Pipit in the intensive study area in Upper Bhavani was estimated twice a month using point count method. Average of the two readings is considered as the population of the month. The maximum encounter rate was 1.0 / ha in April 2003 and minimum 0.1 / ha in October 2002 and, the number fluctuated frequently (Figure 3.3) without any definite pattern. The mean encounter rate was 4.8 / ha in 2002-2003 and 6.7 / ha in 2003 - 2004. The 14 ha grassland included 6 ha of marsh in the study area which had six breeding pairs of the Nilgiri Pipit in 2002, eight in 2003 and four in 2004 throughout the nesting period. The density was maximum with about one pair / ha. On the whole the number of birds and breeding pairs were more in 2003. Totally 12 chicks of the Nilgiri Pipit were ringed and none of them came back to the area later. However, one chick of the Paddyfield Pipit ringed in 2003 returned in 2004 for nesting.

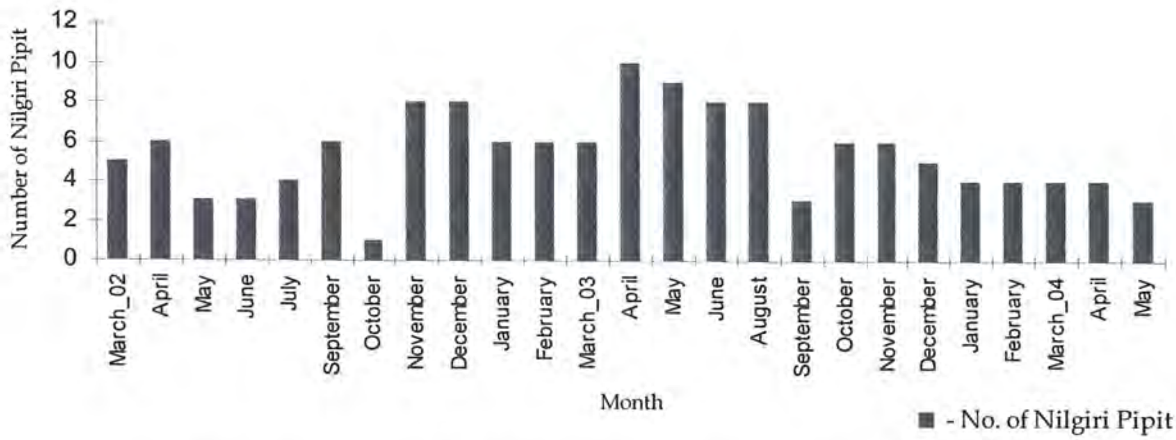


Fig 3.3 Number of Nilgiri Pipit in Upper Bhavani (2002-2004)

Number of the Nilgiri Pipit showed significant negative correlation with monthly rainfall ($R^2 = 0.10$) (Figure 3.4a). Their abundance was not correlated significantly with the mean maximum temperature (r_s = 0.182; $p<0.5$). The variation in number was significantly correlated with the length of bright sunshine ($Z = -3.408$; $P <0.001$). Pipits were more during summer with minimum rainy days.

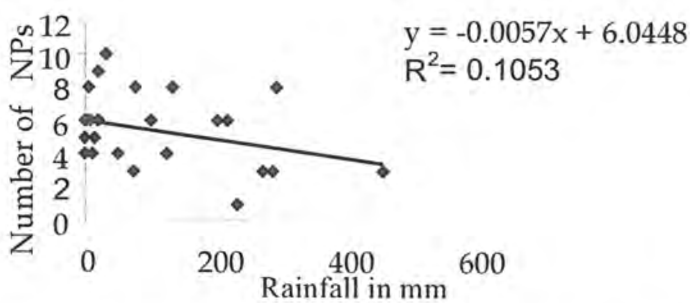


Fig 3.4a Correlation between the number of the Nilgiri Pipit with monthly rainfall

Also the number of pipits negatively correlated significantly with the abundance of seeds (R^2=0.28; Figure 3.4b) and positively with the abundance of invertebrates (R^2 = 0.34; Figure 3.4c).

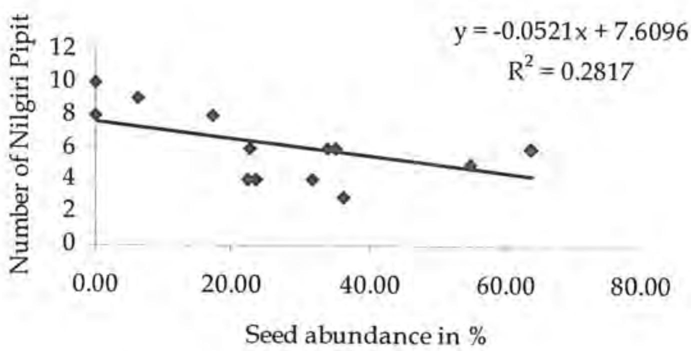


Fig 3.4b Number of Nilgiri Pipit with seed abundance

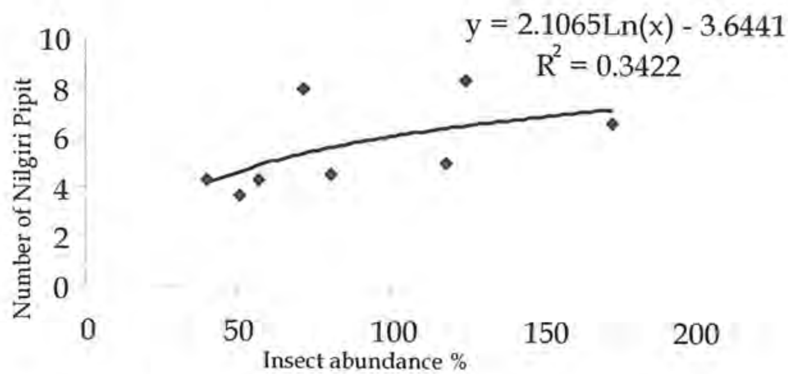


Fig 3.4c Number of Nilgiri Pipit with insect abundance

3. 3. 2. Habitat

3. 3. 2. 1. Macro-habitat

The Nilgiri Pipit was recorded mainly in shola- grasslands of the high altitude areas of Tamil Nadu and Kerala part of the Western Ghats above 1700 m. Pipits selected short grasslands on hill slopes with marshy valley throughout the year (Table 3.6).

Landscape	Number of pipits	Area Surveyed in ha	No/ha
Grass-slopes	45	1859.50	0.02
Marshy Valleys	86	726	0.11
Others	0	688	0
Total	**131**	**3273.50**	**0.04**

Table 3.6 Frequency of sightings of the Nilgiri Pipit at different landscapes

Area with continuous stretch of montane grasslands and shola forests with the presence of streams tended to be occupied, whereas area without the water source was unoccupied.

3. 3. 2. 2. Micro-habitat

The Nilgiri Pipit has specific microhabitat requirements for feeding and breeding activities.

Vertical vegetation structure

Average density of the standing forbes were 92.7% inside the marsh, whereas it was less than 50% in the slopes. The Pipit preferred two dominant species, namely *Mariscus cyperinus* (50%) followed by *Andropogon polypticus* (35%) for feeding and breeding respectively. Average height of them in the area was 8.74 cm and 22.90 cm respectively.

Vegetation heterogeneity

The edge of the marsh had high heterogeneity where both marshy plants and grass species were present. The high value shows the heterogeneity (0.86) whereas the low value shows the homogeneity in plants (0.396). The heterogeneity was the highest in plot 8 (1.206) followed by plot 2 (0.86) which covered part of the feeding block F2 and, the lowest (0.396) in plot 4 covering block F3 and above marsh (Table 3.7). For details of the feeding blocks, refer chapter IV.

Plots with feeding blocks and marsh	Heterogeneity
1(F1 and marsh)	0.77
2(F2 and marsh)	0.862
3(F2 and marsh)	0.798
4(F3 above marsh)	0.396
5(F4 and marsh)	0.478
6(F4 and marsh)	0.502
7 Marsh(sites of Nests 5a and 6a)	1.206
8(F5 and marsh)	0.516

Table 3.7 Heterogeneity of plants in the 8 plots including feeding blocks

Species richness and diversity of plants

In the 4 ha area sampled, 45 species of grasses and 83 herbs were recorded (Appendix 2). In each plot mean density of grasses and herbs were recorded; density was more in plot 1 and 2 (Table 3.8) which correspond with the feeding blocks 1 and 2.

Plot No.	Mean grass	Mean herb
1	3.8	4.2
2	4.2	4.4
3	2.6	2.2
4	2.8	4
5	1.8	2.8
6	2.6	3.6
7	3.4	3.8
8	3.8	2.6

Table 3.8 Mean density of grasses and herbs in the plots

Species such as *Centella asiatica* (12.38%), *Myriactis whightii* (11.91%), *Mariscus cyperinus* (8.46%), *Andropogon polypticus* (7.83%), *Ischaemum ciliare* (5.95%), and *Anaphalis sp.*(5.48%) were abundant in the area. The diversity index in each block including the feeding blocks was calculated; highest diversity of plants was in F4 block (1.4) and lowest in F3 block (1.21). The species richness was high in F2 (39) and F4 (41) and low in F3 (26) (Table 3.9). The vegetation cover was calculated in percentage of cover; it was the highest in Plot 2 (84%) and lowest in Plot 6 (12.2%) (Table 3.10).

Plot No.	**Feeding Blocks**	**No. of species**	**Diversity index**
1	F1	37	1.41
2	F2	34	1.32
3	F2	39	1.37
4	F3 above Marsh	26	1.21
5	F4 and Marsh	37	1.37
6	F4 and Marsh	41	1.43
7		31	1.35
8	F5	27	1.29
Total		117	1.56

Table 3.9 Species richness and diversity of plants in different plots including feeding blocks

Plot No.	Feeding blocks	Vegetation cover in %
1	F1	44
2	F2	84
3	F2	52.8
4	F3	38.8
5	F4	9.6
6	F4	12.2
7		31.8
8	F5	31.25

Table 3.10 Vegetation-cover in 8 plots

3. 3. 2. 3. Habitats for specific activities

Feeding habitat

Of all the feeding attempts of the Nilgiri Pipit, 92% was from short grassland where creeping grasses were present and 8% was from ecotone between the grassy slopes and the marsh area (Figure 3.5). During the northeast-monsoon and winter they fed under the trees (more details in Chapter IV, pp:68).

Breeding habitat

The Nilgiri Pipit bred in grasslands with slightly taller grasses in areas restricted to the valleys (Figure 3.5). There is a significant preference for wet grasslands (marsh) and nearness to stream for nesting ($\chi^2 = 27.867$; $p < 0.001$); 93% of the nests in the area were in marshy grasslands. Number of grass species and herb species were high at the nest sites of the species. *Andropogon polypticus* was the most used species of nesting plant for Nilgiri Pipit. (More details in Chapter V, pp: 105).

Roosting site or habitat

The roosting area of the bird was inside the marshy grasslands with high density of grasses and herbs in the stream banks (Figure 3.5). No Nilgiri Pipit was seen roosting inside the shola and wattle plantations. *Andropogon polypticus* and *Juncus* spp. were the dominant species in the roosting area. During nesting time birds roosted inside the territory itself and the female sat inside the nest.

Photo by Uma J Vinod

Feeding habitat

Photo by Uma J Vinod

Breeding habitat

Photo by Uma J Vinod

Roosting habitat

Fig 3.5 Habitats of the Nilgiri Pipit for specific activities

3. 4. Discussion

The Nilgiri Pipit is restricted to the high altitude grasslands (>2000 m) with marshy valleys in the Southern Western Ghats. The number of pipits recorded in the marshy valleys was more than that in the grass slopes which is the breeding ground for Nilgiri Pipit.

Analyses show that distribution and abundance of the Nilgiri Pipit are affected by various factors such as habitat disturbance, presence of montane grasslands and marshy valleys. Firstly, their sensitivity to habitat disturbance is shown by their occurrence in the Protected Area more than in the unprotected area. The extensive grass-slopes with marshes were very scanty in the unprotected areas due to the conversion of natural habitats to monoculture plantations, agriculture and human habitation (Vijayan and Gokula 2006). Therefore, a network of Protected Areas is essential for the conservation of this species as suggested by Lawton (1996) as an effective conservation strategy for birds.

Secondly, the presence of montane grasslands: The Nilgiri Pipit is restricted mainly to the montane grasslands at higher altitudes; more above 2200 m like the Hellmayr's Pipit in Bailarin Chico Argentine (Casanas 1997). But some species of pipits such as Short-billed Pipit (occasionally in montane), Chaco Pipit and Yellowish Pipit are restricted to lowland grasslands while some occur both in high land and low land grasslands (Vickery *et al.* 2003).

Thirdly, the presence of extensive grass-slopes with marshy valleys: The Nilgiri Pipit is present in more numbers in the Upper Bhavani area than in any other surveyed areas during breeding season. The species richness of plants, moisture and water source near by short grasslands appear to be the key factors deciding the particular habitat quality of the Nilgiri Pipit, as they are more abundant here than elsewhere. Most birds are more abundant in habitat of higher quality (Swengel and Swengel

2001, Hill *et al.* 2001) and, availability of the same is probably the most important ecological variable that influences population size and are likely to reflect their foraging and nesting requirements (Vanhinsbergh and Chamberlain 2001). The distribution often is tied to particular habitat types and their seasonal changes. The Meadow Pipit was positively associated with grassland. Henslow's Sparrow chooses specific vegetation and grassland size (Herkert 1994).

In the Nilgiris, the grasslands are highly fragmented due to the agricultural activities and monoculture plantations thereby restricting the distribution of the Nilgiri Pipit to the fragmented grassland patches. The long-term survival of the species may be in jeopardy as small fragments of grasslands cannot support species that need interior habitats (Samson 1980, Johnson and Temple 1990). It may be noted that grassland birds are particularly sensitive to habitat fragmentation (O'Connor *et al.* 1999). Winter and Faaborg (1999) analyzed the grassland birds' area sensitivity and through site-specific studies found that Henslow's Sparrow increased significantly with increasing patch size. Vickery *et al.* (1994) and Herkert (1994) showed that grassland birds are more likely to occur in large patches of grassland habitat than in small ones. Vickery *et al.* (1994) demonstrated the area sensitivity for Eastern Meadowlarks, Upland Sandpipers, Vesper, Savannah and Grasshopper Sparrows.

The Nilgiri Pipit is also area sensitive, although it is occasionally on the edges of plantations. Seldom was it seen inside the plantations. Similarly the Sprague's Pipit is area sensitive (Maher 1973, Owens and Myres 1973, Dale 1983, Faanes 1983, Pylypec 1991, Madden 1996) and it requires a minimum area of 190 ha (SWCC 1997). The present study could not work out the minimum area requirement of the Nilgiri Pipit, but as has been seen in other pipits, small patches of grasslands will not be adequate. Large extent of grasslands would be required for a viable population of the Nilgiri Pipit. It may be noted that human-induced changes to the landscape can benefit some species but, equally, they can be detrimental to species like the Nilgiri Pipit.

Population of the Nilgiri Pipit in the Upper Bhavani area fluctuates frequently but increases in the breeding area (marshy valley) during breeding season. Some of them move off from the breeding ground after breeding while a few pairs remain throughout the year. Similar phenomenon was reported by Vega *et al.* (2004) in the Red-Breasted Chat which aggregates in the habitat during breeding season and disappears after breeding.

The patterns of influence of climate variables were significant in the population abundance of the Nilgiri Pipit in the study area. Although there is no correlation between the abundance of the Nilgiri Pipit with mean temperature, it does have correlation with day length and number of rainy days in summer when they breed. The negative correlation with rainfall also shows their avoidance of heavy rains. O'Connor *et al.* (1999) also observed that breeding abundance of most of the grassland bird species are significantly associated with climate and weather variables. O'Connor *et al.* (1999) found a complex pattern of responses to temperature for Eastern Meadow Larks with more birds in summer.

In broad terms, the taxonomic diversity of an area will usually be found to alter predictably with changes in several environmental variables (Gaston and David 1994, O'Brien 1993). However, environmental factors which are energy-related (food or limiting nutrient availability, productivity) have more explanatory power than other factors (Lack 1954, Wright *et al.* 1993, Newton 1998). The food abundance for the Nilgiri Pipit varied in different feeding blocks in the area. Positive correlation between bird numbers and food abundance in different blocks recorded are similar to those in various other species (Brooke and Birkhead 1991, Graham *et al.* 1995, Jenkins and Ormerod 2002).

The microhabitat use of the Nilgiri Pipit also influenced the abundance. Variables such as vegetation height, density and heterogeneity appear to affect the abundance. In most grassland birds these along with grazing density, soil-moisture and ease of obtaining food appear to influence the distribution and abundance (Bibby *et al.* 1992). Microhabitats which provide protection from biotic or abiotic disturbances can have a disproportionately large influence on community structure (Witman 1985). The edge of the marsh in the Upper Bhavani had high heterogeneity and density of plants. The number of the Nilgiri Pipit was higher in these areas in summer. Similarly, the Song Sparrow (Chase 2002) and Chestnut-collared Longspur (Young and Hutto 1999) also aggregate in relatively dense vegetation. But Sprague's Pipit chooses sparse to intermediate density of vegetation with taller grass (Madden 1996, Sutter 1996, Sutter and Brigham 1998) while Grasshopper Sparrow prefers intermediate grassland type (Vickery 1996). In contrast, Horned Lark (Wiens *et al.* 1987) had strongest negative association with grass height. But the Western Meadowlark (Young and Hutto 1999) and the Brown-headed Cowbird (Young and Hutto 1999) did not show any significant relationship with grass height. In general, birds that are shy in nature and require thick grass cover like the Nilgiri Pipit leave the area in search of better grassland (Janson 1997). It shows that the microhabitat requirements of the grassland birds are so specific that their diversity depends on the diversity of micro-habitats in the grasslands.

Cattle grazing and grassland fire change the nature of the grassland ecosystem, changing the vegetation height, cover and plant species composition (Janson 1997) and, they affect the abundance of the Nilgiri Pipit as in the Yellow Breasted Pipit which also frequent montane grasslands (Janson 1997). However, it is interesting to note that the response to grazing varies in different species. Kantrud and Higgins (1992) found that nesting success of Upland Sandpiper was higher in un-grazed than in grazed habitats. In contrast, the response to grazing was positive in the Horned Lark, mixed in Sprague's Pipit, weak or inconsistent in Vesper Sparrow and negative in Baird's Sparrow. Grasshopper Sparrow was negatively affected by grazing in short and mixed-grass prairies but positively affected in tall-grass prairies (Saab *et al.* 1995, Johnson *et al.* 1998c).

Although the Nilgiri Pipit selects short grasslands throughout the year, the feeding activities are confined mainly to short creeping grasses and the breeding to wet grassland in the valleys with streams. The latter is with slightly taller grasses and interspersed with bunches of sedges. Again, the feeding habitat is related to their diet and foraging ecology. In winter, pipits have a broad diet consisting of a variety of seeds and insects. Thus, availability of the habitat for a particular activity is the key to habitat selection as reported earlier (Rotenberry and Wiens 1980, Clark and Shuttler 1999) and it is in turn dependent on the distribution and abundance of food (Morris *et al.* 1958, Koplin 1972). For example, if food is patchily distributed, a species may be restricted only to a portion of its potential habitat.

Food abundance plays a vital role in the selection of habitats. Much of optimal foraging theory attempts to explain how the distribution, abundance, and quality of food influence distribution, habitat use, and movements of birds. In the case of Nilgiri Pipit, food abundance in relation to the breeding site is also important, as they invariably feed around the breeding sites.

Marshy grasses in the valleys are the crucial breeding habitat of the Nilgiri Pipit. The comparatively tall grasses and bunches of sedges in the area provide necessary nesting site and reduce risk of predation. The food was also abundant around the area. The same area was used for roosting also. Hence, habitat selection meets all the major criteria reported elsewhere (Buckley and Buckley 1980, Birdhead and Furness 1985, Croxall and Rothery 1991, Justafon 2005). It is obvious that habitat quality would also affect individual fitness (Debora 2003). Grazing and fire during the breeding season is a major threat to Nilgiri Pipit and other grassland birds (detail in chapter V).

Habitat loss due to various anthropogenic activities compounds the threats to its population. As a result of all these, the Nilgiri Pipit has been designated as Near Threatened (Birdlife International 2001) and is now recommended to be included in the list of globally Threatened Species as Vulnerable.

3. 5. Summary

- All the localities where the Nilgiri Pipit was sighted and, collected for museum studies were gathered and compiled.
- Field survey was conducted covering Goa, Karnataka, Tamil Nadu and Kerala focusing on likely areas of occurrence of the Nilgiri Pipit.
- Habitat preference of the species for various activities was studied.
- The Nilgiri Pipit is confined to higher altitudes above 2000 m, mainly in the Nilgiri hills and Southern Western Ghats.
- There were no sightings at the localities surveyed in Goa and Karnataka.
- The mean encounter rate was 0.04 / ha in the 3273.5 ha surveyed. It was comparatively higher in the Nilgiris (Tamil Nadu) followed by Anamalai (Kerala).
- The Nilgiri Pipit is more abundant in Protected Areas (National Parks/ Sanctuaries) than in unprotected areas.
- It was not found inside the plantations, but occasionally at the edges of the plantations bordering grasslands.
- The typical habitat of the species is montane grasslands interspersed with shola forests.
- Day length and rainfall appear to affect the abundance of the species.
- The nesting site is close to the feeding area where the food is abundant.
- Microhabitat for nesting and roosting is comparatively taller grasses interspersed with bunch of sedges in the marshy valleys near streams.

- Nesting area almost invariably has a grass, namely *Andropogon polypticus*.
- Loss of the essential habitats, namely the grasslands, especially the marshy valleys due to plantations and other anthropogenic activities affect the population of the species.
- Grazing and frequent fire in the grassland compound the threat to its population.
- The Nilgiri Pipit is rare in all its ranges and hence, it is recommended to be included in the list of Globally Threatened species (as Vulnerable).

Chapter IV

Food and feeding habits of the Nilgiri Pipit

4. 1. Introduction

Studies on foraging behaviour and food resources constitute part of an overall effort to comprehend diverse aspects of avian biology such as population dynamics, community structure, eco-morphology, physiology, and predator-prey relationships (Morrison *et al.* 1990, Krebs and Davies 1993). The amount and quality of food are often a critical resource limiting the fitness of animals (Brodmann *et al.* 1997). Birds exhibit a variety of food habits; some are herbivores, while some are carnivores, or omnivores. Such habits have evolved over a long period of time with changes in the morphology, physiology and environment (Wiens and Rotenberry 1979) resulting in varying foraging strategies. Studies on foraging pattern consider mainly the method of exploiting resources.

Foraging behaviour often reflects food availability in a variety of ways. In habitats where food availability is high, predators shift the area less frequently, move more slowly and attack prey more often than in habitats where food availability is low (Brown 1988). When animal forages in a depletable patch, the rate of energy the animal gains from that patch declines with the amount of time spent in the patch. Charnov (1976) argues that to maximize fitness, foragers leave patches when the quantity of food being harvested per unit time declines to a value – the quitting harvest rate – that matches the sum of the costs they incur while foraging. These costs include the risk of predation, the energy or metabolic costs of foraging, and the missed opportunity costs; the costs of not engaging in other activities such as foraging elsewhere, defending a territory, looking for a mate, and grooming (Brown 1988). He again showed that these three costs could be translated into a common unit of currency by expressing all three costs in terms of their fitness value to the animal.

The food hits have been found affected by various factors such as habitat structure (Fitzpatrick 1985, Holmes and Schultz 1988), plant species (Holmes and Robinson 1981), substrate (Fitzpatrick 1980), structural complexity of vegetation (Robinson and Holmes 1982, 1984) and degree of human modification (Vanderwerf 1994). Foraging success is one of the basic components of individual fitness and adaptation to the environment. However, for small passerines it would be very difficult to assess the same in the field. Data on foraging behaviour are often used for examining the use of habitat and describing community structure among co-occurring species of birds using the same resource base (Cody 1974, Rusterholz 1981, Gokula and Vijayan 2000). Feeding ecology and feeding behaviour of one particular species is known in terms of use of its feeding habitat, diet and energy constraints. In the present study, attempts are made to find out: a) the feeding habitat, b) diet, c) feeding techniques, d) feeding pattern and, e) various adaptive tactics of the Nilgiri Pipit to meet its food requirements.

4. 2. Methodology

Observations on the foraging of the Nilgiri Pipit were conducted from February 2002 to May 2004. For each foraging attempt, microhabitat details such as the height above ground level, foraging substrate, feeding maneuvers, and foraging methods were recorded.

In general, Focal Animal Sampling method (Altmann 1974) was followed. Each individual encountered was followed as long as possible; till it goes out of sight. This was desirable for two reasons. First, small ground-foraging pipits are very difficult to observe in the grassland; so that once a foraging bird was located it is only opportune to observe it as long as possible. Second, long sequences of observation might reveal more about the foraging behaviour of the species than the initial observation which would indicate only the more conspicuous act while sighting and lead to biases in the results. It was difficult to observe the foraging success of this small bird with its minute prey and hence, each of its feeding attempts was considered as a foraging observation.

Observations were made using a pair of field binoculars (8 x 40) at different times of the day. A telescope (20X) was also used periodically.

4. 2. 1. Foraging habitat

The habitat was classified as short creeping grass-slope, marsh and, ecotone between marsh and grass-slope. Total feeding area was again divided into five blocks as F1, F2, F3, F4, and F5 based on the habitat quality.

4. 2. 2. Foraging height

Vertical foraging habitat was divided into 10 categories: 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-25 cm, 25-30 cm, 30-35 cm, 35-40 cm, 40-45 cm, 45-50 cm and above 50 cm. In each scale the records are from the lower figure to less than the higher figure. For example, 5-10 cm category means 5 cm and above but less than 10 cm.

4. 2. 3. Foraging substrate

A substratum is the base from which food is taken by the bird. Substrates are classified as ground, grass, herb, log and air.

4. 2. 4. Foraging maneuver

Remsen and Robinson (1990) classification was followed for categorizing the foraging maneuvers of the pipits. The Nilgiri Pipit followed four types of feeding maneuvers:

1. *Glean (pick):* To pick food items off a nearby substrate, including the ground that can be reached without full extension of legs or neck; no aerobic movements are involved.

2. *Reach (Reach-up and reach-out):* To extend completely the legs or neck upwards, outwards, or downwards to reach food. Equivalent to stretching from glean.

3. *Leap:* It is a leg-powered maneuver into the air to reach a food item too far for a "reach" but too close for a "sally". This differs from "sally" in that the upward thrust seems to come mostly from leg movements rather than wing movements (Davies and Green 1976) and,

4. *Lunge (rush):* When the food item is beyond the "reach ", rapid leg movements rather than flight are used to approach and capture the prey.

4. 2. 5. Food

Food of the Nilgiri Pipit was studied by direct observations in the field and by faecal analysis. Gut content analysis was impossible because of the risk involved in sacrificing this Near Threatened species. The option left to complement the field observation was faecal analysis which also was limited because of the size of the bird and droppings. However, some samples of droppings could be collected and analyzed.

4. 2. 5. 1. Direct observation

Food taken by individual bird was observed in the field through binoculars and telescope. Prey items taken were grouped into two categories, namely seeds and invertebrates and the percentage frequency of each was calculated from the total number of food items consumed. Items were identified with the help of identification keys wherever possible. Species identified while sampling food abundance helped in identification during observation.

4. 2. 5. 2. Faecal analysis

Fresh faecal samples were collected when the opportunity offered by itself, by noting the locations and collecting the material after the birds quit the site. Samples were air dried and stored in vials. Prior to analysis they were re-hydrated in water and shaken to loosen them. They were then examined with a microscope and the material identified using suitable keys (Sanchez *et al.* 2000). Individual arthropods within a sample were counted on the basis of parts available (e.g. six beetle legs = one Coleoptera; two spider fangs or Chelicera = one Arachnida; two grasshopper mandibles = one Orthoptera). Odd numbers of parts were counted as an additional individual (Miller and McEwen 1995). The volume of each diet component was estimated as a proportion of the total sample volume in percentage.

4. 2. 6. Feeding rate and rhythm

Observation on the feeding was made on two sessions; from 0600 h to 1300 h and, 1300 to 1900 h alternatively for four days to get data for two full days in a month. Average feeding rate per hour, month, season and year was calculated. Feeding rhythm of the species is obtained by finding the feeding rate per hour in different hours of the day. Continuous observations on an individual for more than 10 minutes were difficult as the birds disappeared from the sight frequently. Environmental factors that may influence the feeding rate, namely temperature, light intensity and wind velocity were recorded using a maximum and minimum thermometer, Lux meter and anemometer respectively every ten minutes during the period of observation.

4. 2. 7. Association of the Nilgiri Pipit with other birds while foraging

Number of individuals of other species within a radius of 5 m from the focal bird was considered as associated species. Interaction of the Nilgiri Pipit with other birds was also noted.

4. 2. 8. Data analyses

Niche breadth or Specialist-Index *J'*: The foraging specialization of each bird category for each foraging dimension (dimension includes method, substrate, vertical layer and canopy) was analyzed using the Shannon-Weiner index $H' = -\Sigma pi \ ln \ pi$ (Where H'= diversity and pi = the proportion of observation in subset i). These values were then converted to a standardized range using the formula $J' = H'/H \max$ (Where J' = specialization and $H \max$ = the maximum H' value obtained when the observations are distributed equally across all subsets of the foraging dimension) following Crome (1978) and Recher *et al.* (1985). J' value ranges between one and zero, with foraging specialization increasing as J' falls.

The feeding rate was calculated with

$$\text{Feeding rate} = \frac{\text{Number of feeding attempts}}{\text{Duration of observation per hour}}$$

The rate was correlated with different external factors such as temperature, relative humidity, rainfall, wind speed and light intensity. The Kolmogrov-Smirnov test was done to find out the significant level of variation in the feeding rate. Statistical tests were considered significant at $p \leq 0.05$. All analyses were done using SPSS version 10.0.

4. 3. Results

Fieldwork was conducted in the intensive study area in the Upper Bhavani grasslands during February 2002 to May 2004 spending 4219 field hours in which the species could be observed for about 600 hours. During this period the actual contact hours with the foraging Nilgiri Pipit was 380.80 hours. In total 12,988 feeding observations were made. Nilgiri pipits walked on the ground and picked seeds, insects and other invertebrates off the soil or grasses and herbs. They searched dwarf shrubs also from the ground.

4. 3. 1. Foraging habitats

Of the five foraging blocks, namely F1, F2, F3, F4, and F5, F1 had creeping grass-slope and herbs edged with shola strip, marsh and wattle. F2 had marsh and shola strip, F3 marsh and wattle borders, F4 shola plants and wattle plantations and the creeping grass and, F5 had wattle edge, grass-slope and marsh edge covering a small portion (Figure 4.1). In total 932 observations were made, of which 92% were from creeping grass and the rest (8%) was from ecotone between the marsh area and the grassland. In F1, 94% was from creeping grass and 6% from ecotone area; in F2, 85% from creeping grass and 15% from ecotone; in F3, 24% from ecotone and 76% from creeping grass area; in F4, 100% from creeping grass; and in F5, 96% from creeping grass area and 4% from ecotone area.

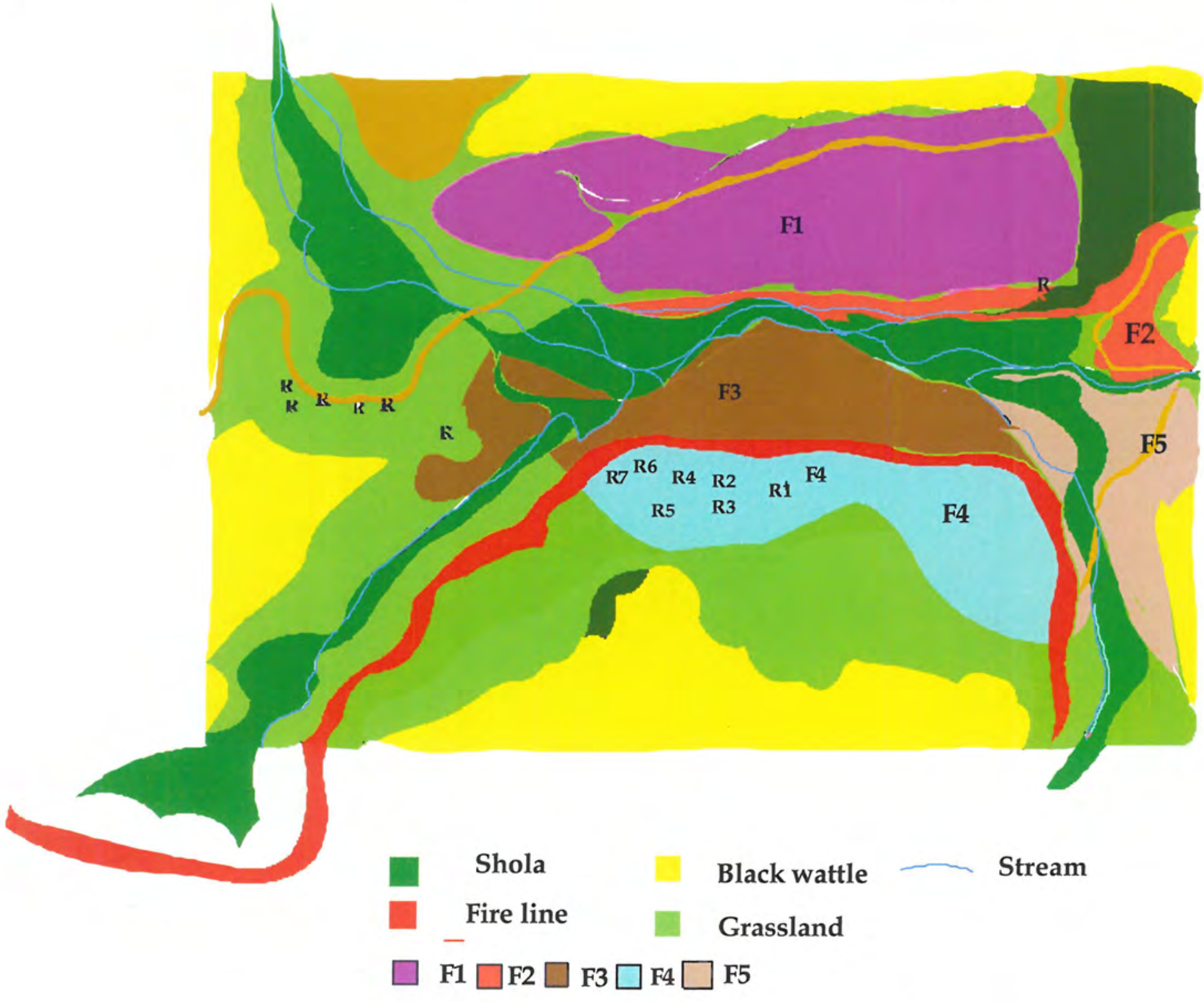


Fig 4.1 Feeding blocks of the Nilgiri Pipit

4. 3. 2. Foraging height

Feeding height was recorded in 1744 observations. Out of these, 82% (n=1445) was from <15cm, 15% (n= 255) from 15-30 cm, and 3% (n=44) from >30 cm (Figure 4.2).

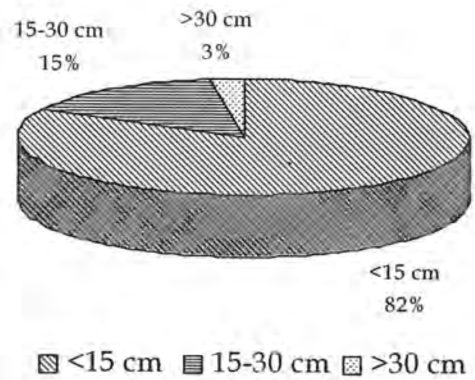


Fig 4.2 Foraging frequency of the Nilgiri Pipit in different height classes

Seasonal variation in the height preferences (Figure 4.3) was significant (ANOVA; F=351.04, p<0.00). Although feeding from <15 cm was high in all seasons, the proportion was very high and maximum during north-east monsoon.

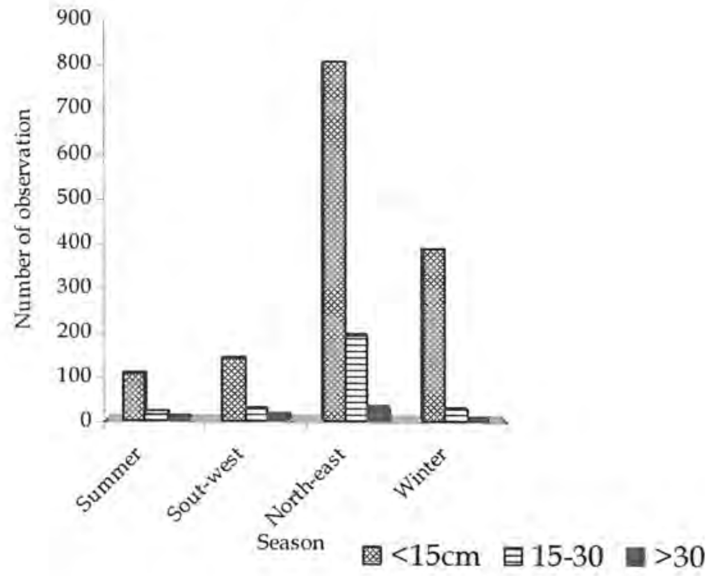


Fig 4.3 Foraging frequency of the Nilgiri Pipit in different height classes in different seasons.

4. 3. 3. Foraging substrate

Foraging substrates could be recorded only in 932 feeding observations. Five categories of feeding substrates were recognized: air, fern foliage, grass and herb foliage, ground, and logs. The main substrate from which the Nilgiri pipits picked their food was grass and herb foliage (96%); (Table 4.1).

No	Substrate	No of observations	% of use
1	Air	7	0.75
2	Fern foliage	12	1.28
3	Grass and herb foliage	894	95.92
4	Ground	11	1.18
5	Logs	8	0.85
	Total	**932**	99.98

Table 4.1 Frequency of various substrates used for foraging by the Nilgiri Pipit

4. 3. 4. Foraging maneuvers

Foraging maneuvers were recorded, on the whole, 7176 times. Of these, 6562 (92%) attempts were gleaning, 350 (5%) reach up, 168(2%) leaping, and 94 (1%) lunge (Figure 4.4). The Nilgiri Pipit resorted to 'lunge' when the prey was a flying insect.

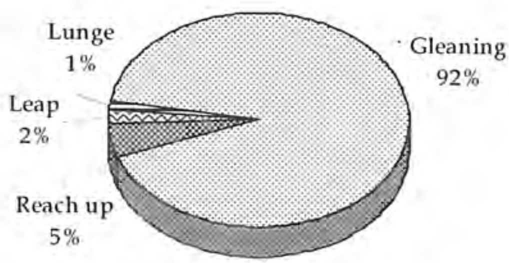


Fig 4.4 Frequency of various foraging maneuvers of the Nilgiri Pipit

Seasonal variation was observed in the foraging maneuvers (Figure 4.5). Gleaning was the major method in all the seasons with maximum in winter. All the maneuvers were used during the north-east monsoon. Leap was comparatively more during south-west monsoon when only two maneuvers were used.

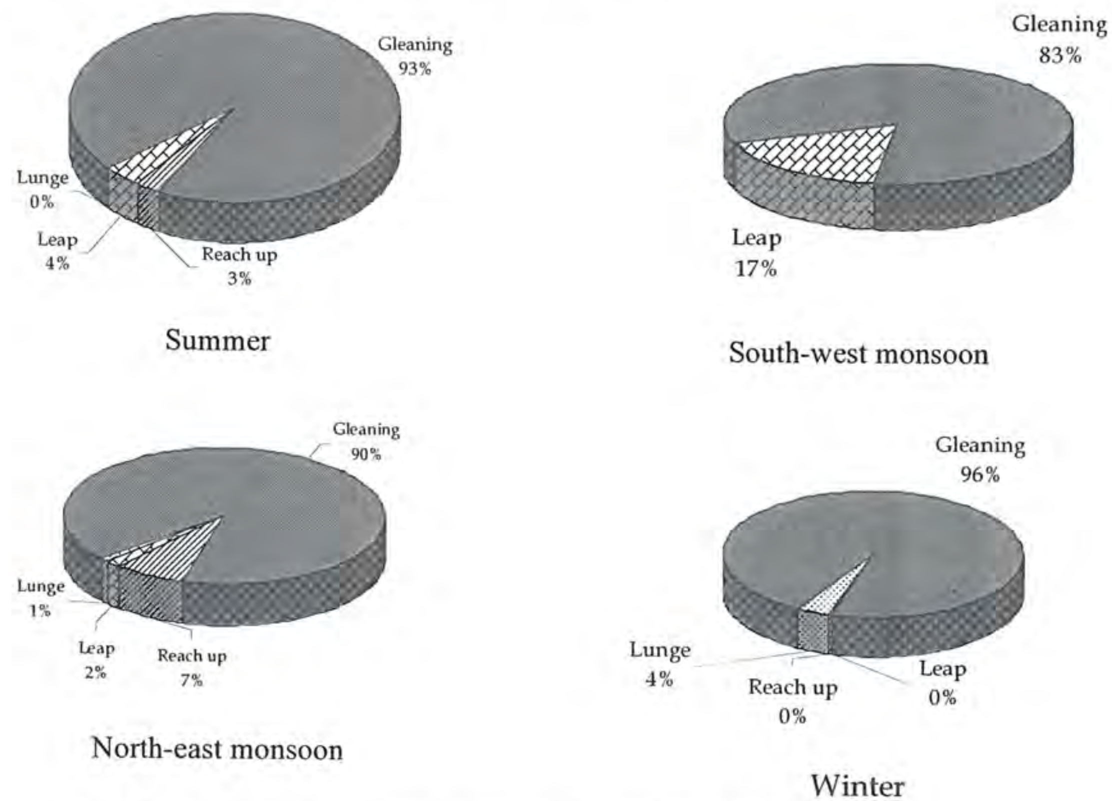


Fig 4.5 Foraging maneuvers of the Nilgiri Pipit in different seasons

4. 3. 5. Food

Out of the 12,988 feeding observations on the adult pipits, feeding items could be detected only on 6626 attempts. Out of these, 4227 attempts were for seeds (63%) and 2439 (37%) for invertebrates. The pipits took 86% invertebrates and 14% seeds during breeding season, whereas it was 32% and 68% respectively in the non-breeding season (Figure 4.6). The seed intake was highly correlated with the seed abundance (r_s=0.957; p=0.043) which in turn was highly correlated with the humidity (r_s=0.648; p=0.043). Seasonal variation in the abundance of food was also significant (ANOVA; F=19.27, P<0.009).

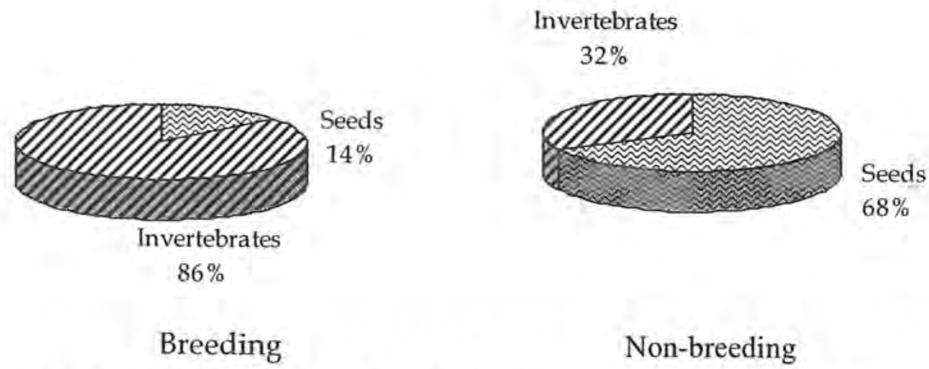


Fig 4.6 Food of the Nilgiri Pipit in breeding and non-breeding seasons

The Nilgiri Pipit took seeds mainly of three species of grasses (*Eragrostris nigra, Isachnae kunthiana, Isachaemum ciliare)* and herb (*Cyanotis wightii*). The invertebrates in the diet belong to the orders Coleoptera (42%), Diptera (16%), Orthoptera (18%), Arachnida (13%) and, the Lepidoptera (8%) including their larvae (Figure 4.7).

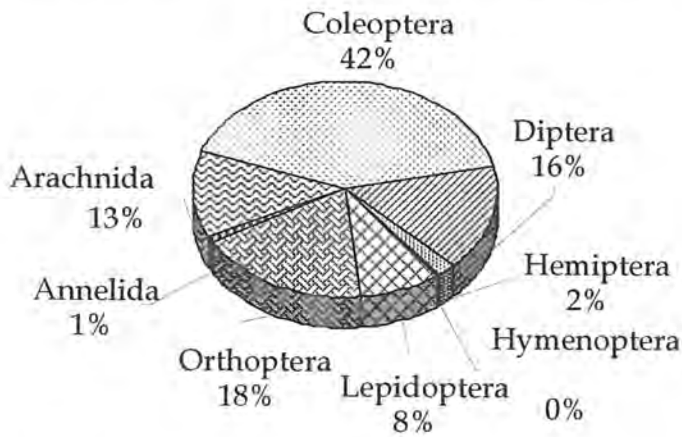


Fig 4.7 Invertebrate diet of the Nilgiri Pipit as assessed from direct observation

Four faecal samples analyzed also showed that Coleoptera (61%) was the maximum followed by Diptera (25%) and Hymenoptera (7%); (Figure 4.8). Others were negligible.

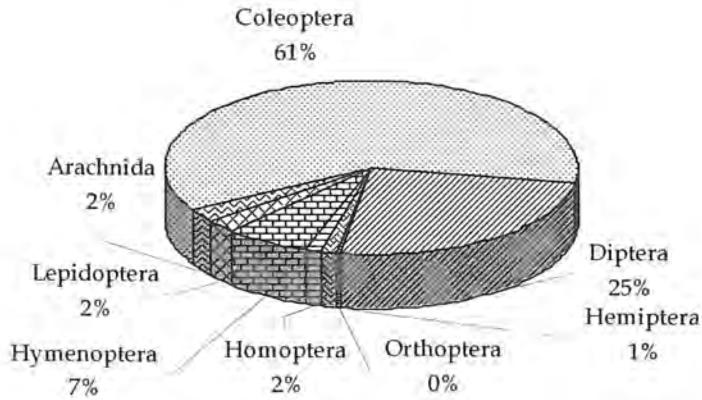


Fig 4.8 Invertebrates in the faecal contents of the Nilgiri Pipit

Faecal samples contained more seeds during winter but the total volume was less compared to that of the invertebrates. In summer no seeds were found in the faecal samples.

4. 3. 6. Niche breadth

The Nilgiri Pipit is a specialist in different foraging dimensions, niche breadth being very narrow on foraging substrate ($J' = 0.009$), foraging maneuver ($J' = 0.008$), food (0.07), and foraging height ($J = 0.02$).

4. 3. 7. Rate of feeding

In all 12,988 feeding attempts of the Nilgiri Pipit were recorded during 1111 observations made in 600 hours. The feeding attempts were made in a total of 28 hours. Hence feeding rate was calculated from this. The average feeding rate during the study period 2002 - 2004 was 465.94 / h which varied according to the season. Maximum was in the north-east monsoon of 2003 (616.18 / h) followed by the winter of 2002 (492 / h) and, the minimum in the south-west monsoon of 2002 (174.06 / h) (Table 4.2).

Season	Feeding rate / h
Summer 2002	300.75
South-west 2002	174.06
North-east 2002	404.96
Winter 2002	492
Summer 2003	340.89
South-west 2003	267.6
North-east 2003	615.18
Winter 2003	347.1
Summer 2004	202.73

Table 4.2 Seasonal variation in the feeding rate of the Nilgiri Pipit

The pooled data on feeding rhythm for three years do not show a definite pattern (Figure 4.9), but it shows a pattern in different seasons. Altogether more feeding was in the morning from 0700 to 1300 h. The morning peak during summer was between 0700 - 0800 h while it was between 0900-1000 h during south-east and north-east monsoons. In winter, the peak was during 1000 to 1100 h. The afternoon peak was between 1700-1800 h during summer, while it was 1400-1600 h in all other seasons (Figure 4.10). The seasonal variation in feeding rhythm is significant (ANOVA; $F=181.703$, $p<0.057$).

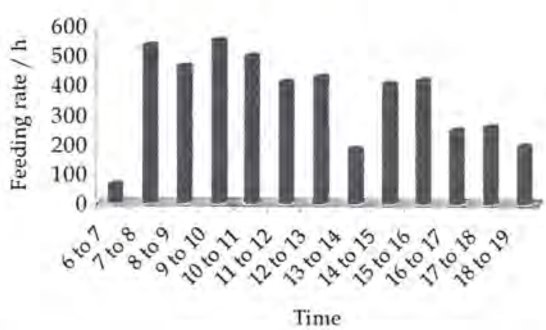


Fig 4.9 Summary of observations on the daily pattern of feeding rate of the Nilgiri Pipit

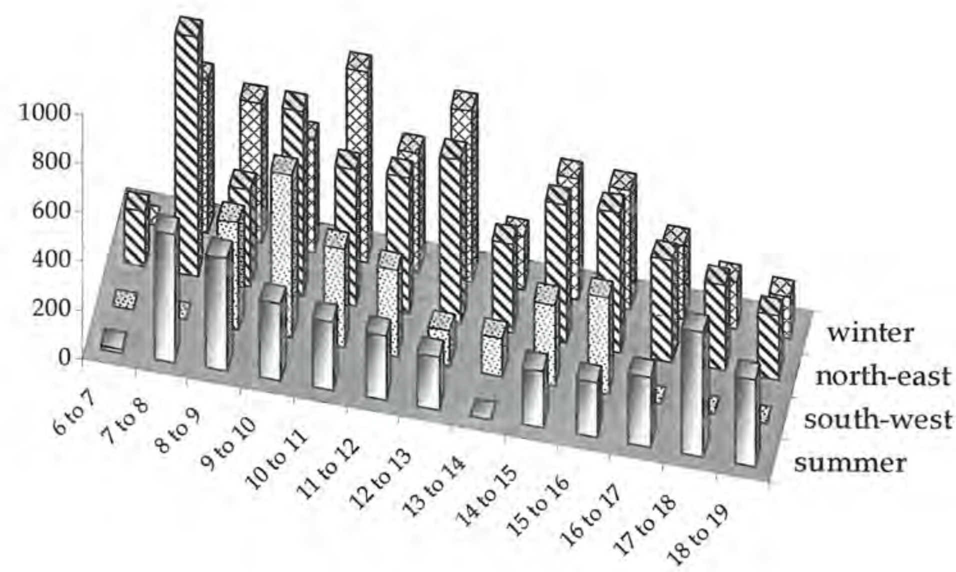


Fig 4.10 Seasonal feeding rhythm of the Nilgiri Pipit

The feeding rate had significant negative correlation with mean maximum temperature (r_s= -0.853; p=0.002), wind speed (R2 = 0.19) and day length (R2 = 0.12; Figure 4.11a, b and c) during 2003-2004, while it showed a positive correlation with mean relative humidity (R2 = 0.2; Figure 4.11d).

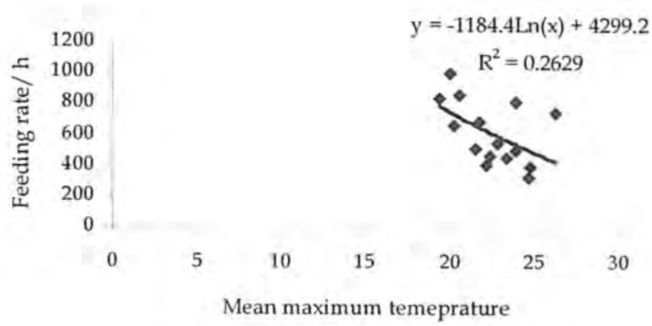


Fig 4.11a Correlation of feeding rate of the Nilgiri Pipit with mean maximum temperature

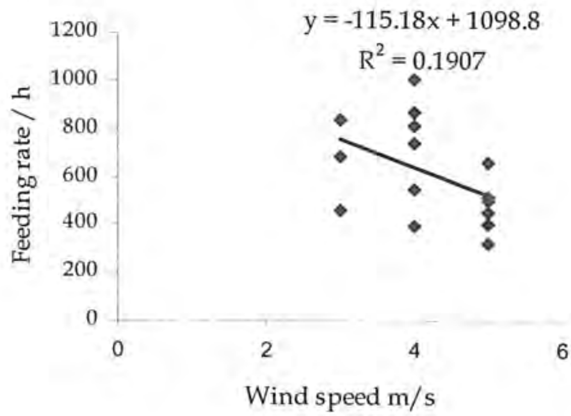


Fig 4.11b Correlation of feeding rate of the Nilgiri Pipit with wind speed

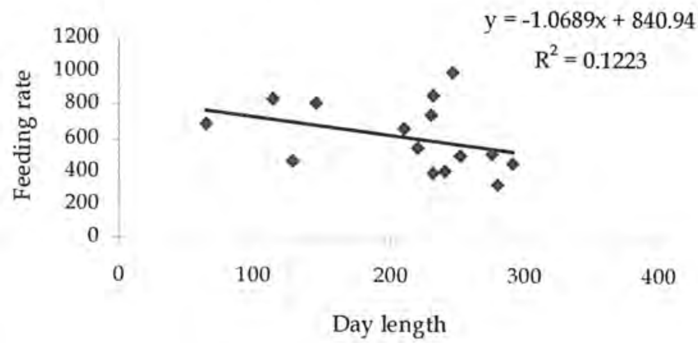


Fig 4.11c Correlation of feeding rate of the Nilgiri Pipit with day length

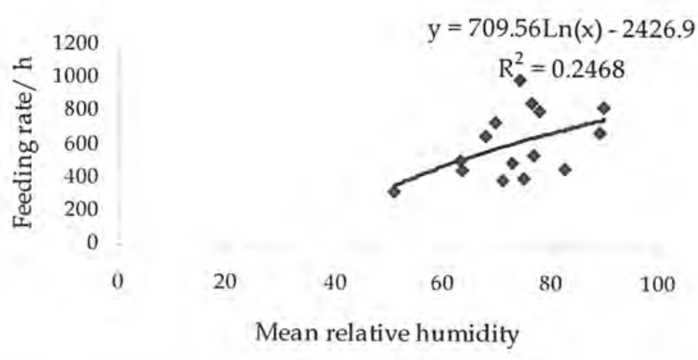


Fig 4.11d Correlation of feeding rate of the Nilgiri Pipit with mean relative humidity

Feeding rhythm had a significant positive correlation with ground temperature (R^2=0.18) and light intensity (R^2=0.42); (Figure 4.11e and f).

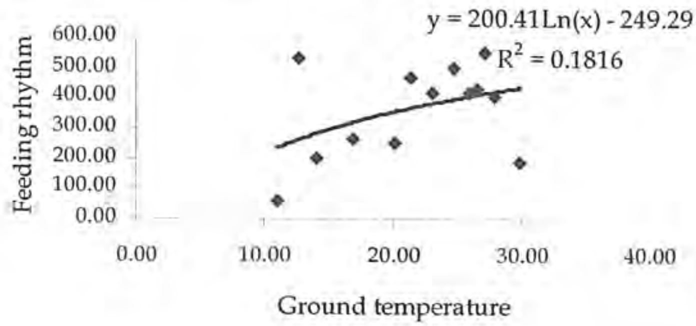


Fig 4.11e Correlation of feeding rhythm of the Nilgiri Pipit with ground temperature

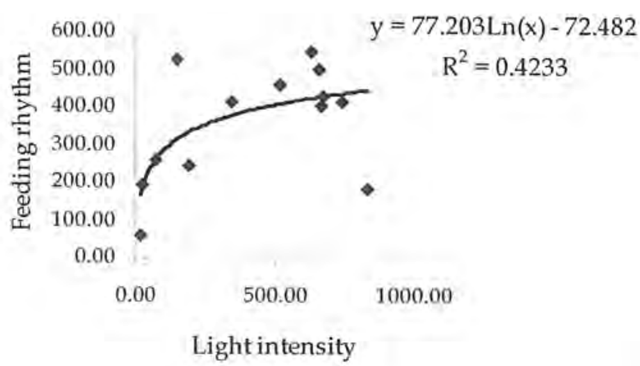


Fig 4.11f Correlation of the feeding rhythm of the Nilgiri Pipit with light intensity

4. 3. 7. 1. Spatial variation in the feeding rate

The Nilgiri Pipit fed in specific areas for invertebrates and seeds. In the five feeding blocks recorded, namely F1, F2, F3, F4 and F5, the highest rate was in F1 block, followed by F4 (Figure 4.12).

Fig 4.12 Spatial variation in the feeding rate of the Nilgiri Pipit

The feeding rates varied within each block among the seasons and within each seasons among the blocks. High rate was recorded in F1 and F3 during summer, whereas it was in F1 and F5 during south-west, F1 and F2 during north-east and, F4 and F5 during winter (Table 4.3).

Season	F1	F2	F3	F4	F5	't' value	*p*
Summer	396.79	269.88	354.53	256.13	0	-3.267	0.002
South-west	508.99	318.36	272.45	239.54	413.78	-7.015	0.002
North-east	761.01	721.15	335.71	524.13	607.00	-7.68	0.002
Winter	524.03	182.51	529.10	742.34	668.74	-5.496	0.005
't' value	-7.153	-3.104	-6.798	-3.672	-7.347		
P	0.006	0.053	0.007	0.035	0.018		

Table 4.3 Seasonal variation in the feeding rate in different feeding blocks

4. 3. 7. 2. Seasonal variation in the spatial utilization for feeding

The time spent for feeding in each block also varied in different seasons. The most used block during summer (63.15%) and winter (51.27%) was F1 block, whereas it was F5 (44.85%) during south-west monsoon and F2 (35.23%) during north-east monsoon. F1 block was the most preferred block for feeding (Figure 4.13).

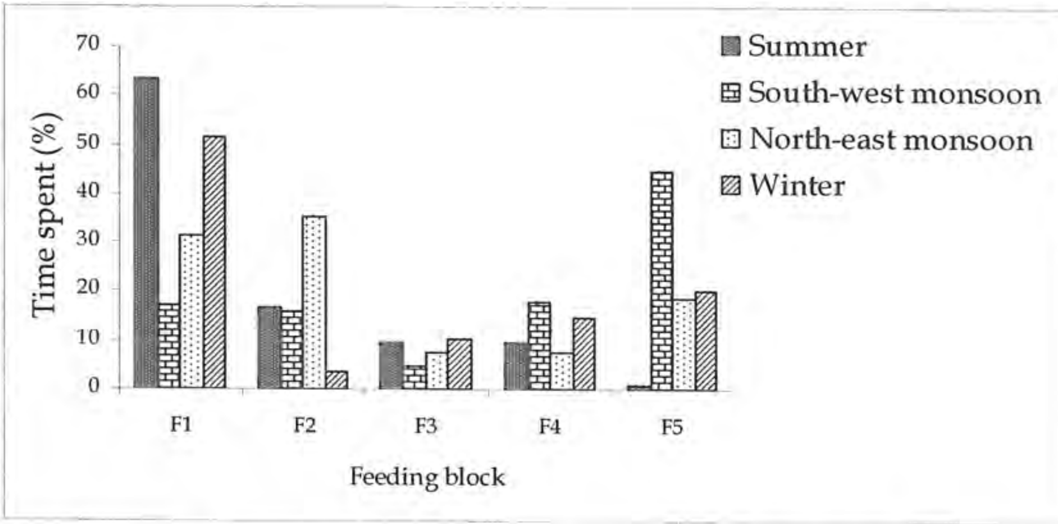


Fig 4.13 Seasonal variation in the utilization of the feeding blocks

4. 3. 7. 3. Feeding rhythm in different blocks

The Nilgiri Pipit preferred F1 block during 0800-1000 h; F2 during 1000-1100 h; F3 during 0900-1000 h and 1600-1700 h; F4 during 1300-1500 h and F5 during 12.00-13.00 h (Figure 4.14).

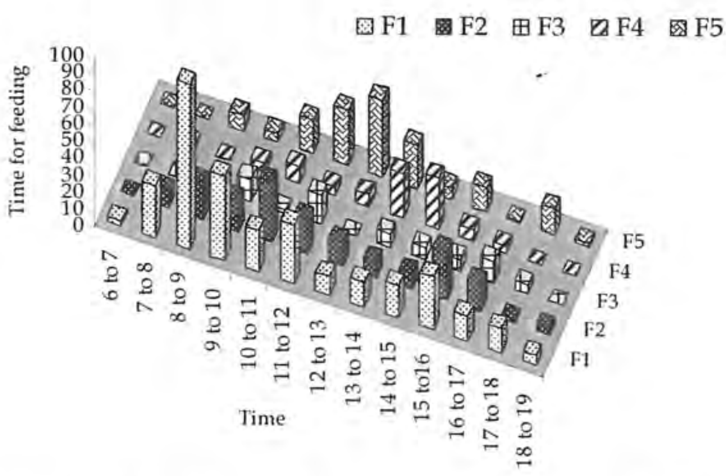


Fig 4.14 Feeding rhythm in different feeding blocks

4. 3. 8. Detailed feeding behaviour

Pipits walked along the grass covered ground and searched for the prey. The duration of each pick was measured and the search time recorded. The actual act of swallowing a prey was always very quick (<1 second).

When the dung beetles were common during the summer, the Nilgiri Pipit could feed on them without much energy expenditure and risk. At times, the flying beetles were trapped into the beak so quickly as if the beetle flew into the mouth! The Nilgiri Pipit often chased the flying beetle, but it was successful in catching only when the beetle flew at a lower height.

The Nilgiri Pipit fed the chicks with earthworms and the fledglings with grasshoppers. Rarely did the adult eat earthworms. However, the male fed the female with grasshopper. It may be noted that abundance of grasshoppers was high during breeding season than in the non-breeding season.

Dipterans were more abundant in the area through out the study period. While picking dipterans, the Nilgiri Pipit used 'glean', a technique involving less energy. Foraging on larger prey such as caterpillar from grass foliage, it carried the prey and perched on a tree, bare ground or on a stone; hit the prey back and forth against the substrate, probably to kill the prey, kneaded and, rotated in the bill before slowly swallowing part by part. Once completely devoured, it wiped the beak on the substrate. On average, it took 1. 54 minutes for swallowing a caterpillar. Very rarely did it lift the head while swallowing larger prey. Pipits caught the praying mantis mainly for feeding chicks; sometimes the wings and legs are removed before feeding the chicks. Rarely, it chased the butterflies. Millipedes also were frequently taken; after killing them by hitting on the substrate.

4. 3. 9. Association of the Nilgiri Pipit with other birds while foraging

Most of the time, the Nilgiri Pipit fed in pair (Figure 4.15). On the whole, 340 observations were made while the Nilgiri Pipit fed along with other species. The association was more with the Pied Bushchat (25.59%) followed by Paddyfield Pipit (19.7%), Tickell's Leaf Warbler (15.29%) and Prinia (12.35%) (Table 4.4). Most such associations were seen in the morning and that too in the F1 block.

Photo by Uma J Vinod

Photo by Uma J Vinod

Fig 4.15 Nilgiri Pipit in the feeding ground

Species	Frequency (%)	Species	Frequency (%)
Grey Wagtail	**4.71**	Black Bird	0.8
Nilgiri Flycatcher	2.64	Black Bulbul	0.58
Pied Bushchat	**25.59**	Common Crow	0.29
Paddyfield Pipit	**19.7**	Greyheaded Flycatcher	1.17
Ashy Prinia	**12.35**	**Great Tit**	**8.82**
Rose Finch	2.1	House Sparrow	0.29
Redwhiskered Bulbul	0.8	Jungle Crow	0.29
Tickell's Leafwarbler	**15.29**	Nilgiri Laughingthrush	0.58
Black and Orange Flycatcher	0.8	Tytler's Leaf Warbler	1.17
		White Eye	1.76

Table 4.4 Percentage frequency occurrence of the Nilgiri Pipit with other birds

The number of species associated was maximum in winter (13) followed by summer (11) and north-east monsoon (10) and the minimum in south-west monsoon (8). The Pied Bushchat from the perch pounces at the insect on the ground and some times tries to snatch the food from pipit. The presence of tree dwelling species was seen in the ecotone of the feeding area. Most of these sightings were in the mid-day when the pipits fed under the shade of trees.

Great Tit, a tree dwelling species reaches the feeding area and exploits the food resource on the top level of fern and lower branches of trees, one meter high in the ecotone area. During the time, the Nilgiri Pipit and other smaller ground feeding birds reach the area and start feeding on the ground. Once the Great Tit is through with the branches, it joins other ground feeding birds and hunts the insects disturbed from the ground. After a while, as soon as the Great Tit moves on to the next feeding site the other birds follow it. The Great Tit makes different calls while arriving and leaving. Likewise the Nilgiri Pipit also makes different calls, as if to give signal to other associated species. There was no sign of any competition between the Great Tit and Nilgiri Pipit.

Tickell's Leaf Warbler was seen with Nilgiri Pipit in summer in the ecotone area between wattle and shola. The number of warblers was high (2-10). They perch frequently on the lower branches of the tree and catch insects from the grass by sally-pouncing. The Nilgiri Pipit was seen with Ashy Prinia on the stream side. Pied Bushchat and the Paddyfield Pipit appear to be the main competitors of the Nilgiri Pipit for food.

4. 4. Discussion

Nilgiri Pipit is an omnivorous bird, feeding on invertebrates as well as grass seeds.

4. 4. 1. Foraging habitats

The patterns of habitat use can be explained by study of bird's diet and foraging ecology (Gillings and Fuller 2001). The Nilgiri Pipit was selective in the feeding area in different times and seasons. Pipit's choice of feeding areas was based mainly on food abundance and to some extent on the presence or absence of predators and its decision to avoid predators.

Land birds are known to vary their foraging in response to a number of factors, including structural differences in the habitat (Collins 1983, Holmes and Schultz 1988), inter and intra specific competition (Rappole and Warner 1976, Laursen 1978, Morse 1980), including gender (Morse 1968, Holmes 1986, Ornat and Greenberg 1990, Petit *et al.* 1990b) and age (Woodrey 1995) interactions, weather (Pinkowski 1977), ambient temperature (Ford *et al.* 1990), thermoregulatory requirements (Martin and Karr 1990), distribution, diversity and the abundance of prey species (Holmes and Schultz 1988, Ford *et al.* 1990, Szaro *et al.* 1990, Smith *et al.* 1998).

4. 4. 2. Foraging height

Nilgiri Pipit foraged largely on the short grassland with a height below 15 cm. At times, they went up to 30 cm depending on the availability of food. Variation in foraging height based on food availability was already reported elsewhere (Martin and Karr 1990, Moermond 1990, Gokula 1998, Nirmala 2002, Ranjini 2004, Nirmala 2004). Height used for the feeding varied with the height of grass which varied with the season. Since the height of the grass was more during the monsoon, the pipits had to reach up for picking the insects or seeds from the top of the grass foliage. Therefore, choice of foraging location of the Nilgiri Pipit within the feeding area was associated with fine-scale habitat heterogeneity as found in other birds (Recher *et al.* 1985, Goss-Custard 1996, Oddeskaer *et al.* 1997, Nirmala 2004, Whitehead *et al.* 2005).

4. 4. 3. Foraging substrate

Of the five substrates, namely air, fern foliage, grass and herb foliage, the Nilgiri Pipit preferred the grass foliage the most (96%) where the food was comparatively more abundant for the species which more or less agrees with Rosenberg (1993) that the substrate selection is non-random based on the differential food availability. Also the Nilgiri Pipit is more adapted to forage on the ground on insects and grass seeds. The substrate use may also be constrained by morphology and physiology of the species as seen in most species (Rosenberg 1993).

4. 4. 4. Foraging maneuvers

Gleaning was the main foraging technique of the Nilgiri Pipit. The result supports the findings of Rosenberg (1993) that the smaller prey-eaters select gleaning as the main foraging maneuver. Differences in foraging methods depend on the bird's prey-type selection. By glean the birds can obtain smaller prey than by sally and, feeding on seeds could only be by gleaning. Apart from this, gleaning is presumably the least costly maneuver in terms of energy expenditure. The major feeding technique of most foliage and ground-searching birds is "glean"; 51% of the forest species in the Andes (Remsen 1985) and 53% of species in the similar habitat in Australia (Ford *et. al.* 1986) used glean as their principal foraging maneuver.

The other maneuvers used by the Nilgiri Pipit are reach, leap and lunge in that order. Lunge was used by other ground feeding birds such as thrushes (Heppner 1965, Smith 1973, Tye 1981, Willis 1985a. and 1986) and Ground Cuckoos (Willis 1982a), and also some Bulbuls (Willis 1983a), Tyranids (Smith and Vuilleumier 1971, Willis 1983b), and Antbirds (Willis 1968, Parker *et al.* 1985).

Foraging behaviour of the Nilgiri Pipit reflects partly on the foraging habitat and partly on food abundance. Feeding rate was high in F1 block where the habitat was more suitable with creeping grass on slopes. Food was also comparatively more abundant. It has been reported that the arthropod abundance and diversity affect the foraging behaviour of insectivorous birds (Cole 1995). The changes in foraging behaviour were not only because of the spatial and temporal patterns of resource abundance, but also the kinds of prey and foraging substrates they used (Recher *et al.* 1985) which are also constrained by morphology (Ricklefs and Travis 1980, Robinson and Holmes 1982, Gokula and Vijayan 2000).

4. 4. 5. Food

Investigations on food variables that influence dietary choices should be valuable in understanding foraging behaviour (Perrins and Birkhead 1983). Nilgiri Pipit is selective in their food, both in non-breeding and breeding season like other grassland species. As much as 86% of the food in the breeding season was invertebrates and a considerable amount of the same was fed on to nestlings. Seeds constituted 68% of food during non-breeding season. However, the ratio of 60-85% insects and seeds were found in many other species (Baldwin 1973, Maher 1979, Wiens and Rotenberry 1979). Diet of the pipits in Tokomaru Bay, showed that they fed mostly on invertebrates and rarely on seeds (Garrick 1981). Begg *et al.* (2003) reported that Honey Badger maintained its intake level by varying dietary breadth.

Most grassland bird species appear to be generalized omnivores, in terms of their diets, and feed both on insects and seeds (Cody 1985). In temperate region, American Pipit also showed the same trend (Verbeek 1993). Johns and Ward (1976), Robbins (1981), West (1973) and Williams (1987) reported that, in general, granivorous/omnivorous breeding birds commonly switch to an animal (primarily insect) diet in response to increased demands for protein, energy, and other nutrients for reproductive activities. In Upper Bhavani, seed was comparatively less in the early monsoon, as it was the season for germination of most surface seeds. The Nilgiri Pipit evidently responded to the reduced seed availability by choosing the insects. Moreover, it took seeds as major food during non-breeding season, whereas it fed mostly on animal diet, invertebrates, during breeding season. Wiens and Rotenberry (1979) have noted that major intake of insects were for the nestlings in the breeding season. Wiens and Rotenberry (1980) found only weak correlation between bill morphology and diet and emphasized the opportunistic nature of foraging grassland birds.

Most of the insect food consumed by adult Nilgiri Pipit belonged to Coleoptera, Diptera, Orthoptera and, Lepidoptera adults and larvae. The seeds consumed were mainly of *Eragrostis nigra, Isachnae kunthiana, Isachaemum ciliare* and *Cyanotis wightii*. Diet of the pipits based on gut analysis alone may be misleading because most of the seeds in the pipits' gizzard were much smaller than invertebrates and hence, the volume of seeds in the diet was less unlike that found by Moeed (1975). As diets are likely to vary with time, season, location and availability of prey, and because sample sizes and methods usually differ between food studies, comparison of the results with those of others is limited. However, Garrick (1981) found the same diet trend as of the Nilgiri Pipit in other Pipits and Larks.

Nilgiri pipits were selective in catching insects of different sizes, not withstanding the abundance. Although insects of the size 5 mm and below (mainly Diptera) were more abundant in the study area, the Nilgiri Pipit fed more on comparatively larger insects

(Coleoptera) which were less abundant. This apparently must be more profitable to the species as explained by the optimal food selection (Charnov 1976, Krebs 1986). Davies (1977) found that when wagtails fed on yellow dung-flies, they selectively captured flies of a specific size rather than taking flies at random. The birds took a disproportionate number of 7 mm dung-flies, indicating prey selection by the birds. Goss-Custard (1977) reported in Redshank that in the areas where the density of large (profitable) worms was high, a greater number was taken, but the rate at which small (unprofitable) worms taken was inversely proportional to the density of large worms.

4. 4. 6. Niche breadth

Pianka (1981) defines ecological niche as "the sum total of the adaptations of an organismic unit or as all of the various ways in which a given organismic unit conforms to its particular environment". The resource gradient along with species showing partially non-overlapping distributions is a niche dimension (Cody 1974).

The Nilgiri Pipit is a specialist in different foraging dimensions, as the niche breadth or the utilization of the resource on that particular dimension is very narrow (Cody 1974, Remsen and Robinson 1990). It was the lowest on foraging substrate ($J' = 0.009$), as feeding is mainly restricted to foliage of grasses and herbs (96%) followed by foraging maneuver ($J' = 0.008$) using mostly gleaning (92%). It was a specialist on food (0.07) taking seeds and invertebrates; similarly foraging height ($J = 0.02$) using <15cm (82%). The niche breadth is also a measure of competition among co-existing species; it goes down with increase in competition and also with the size of the species (Grinnel 1917, Cody 1974, Vijayan 1984, Seagle and Mc Cracken 1986).

4. 4. 7. Rate of feeding

The feeding rate of the Nilgiri Pipit varied between 174.06 / h (3 / m) and 615.18 / h (10 / m). Average rate was lower than in the Rock Pipit in Great Britain where it was 15-20 / m during winter (Gibb 1956). A higher feeding rate is expected during winter because of the shorter day-length and high energy demand (Gibb 1956). In Great Britain the winter is quite pronounced and hence the feeding rate, whereas in the Upper Bhavani it is not very striking, except in the winter of 2002 where a marginal increase (8.2 / m) was noticed. In other season (north-east monsoon) it was 3.5 / m.

However, the feeding rate of the Nilgiri Pipit is higher than that of the Black-and - Orange Flycatcher (73 / h) (Khan 1978) and, the Bronzed Drongo (53.3 / h), Grey Drongo (33.33 / h) and the Racket-tailed Drongo (21.1 / h) (Vijayan 1984). Foraging rate of the Nilgiri Pipit has a negative relation with maximum temperature as in Pied Bushchat (Nirmala 2004), Junco flocks (Coraco 1980), and Drongos (Vijayan 1984). Optimum level of temperature influences high rate of foraging but after the limit the rate slows down. The rise in temperature influences the rate of foraging and stimulates the bird to shift to an area with suitable environment (Vijayan 1984, Nirmala 2004, Bhupathy and Vijayan 1999).

4. 4. 7. 1. Variation in feeding rate and use of different area

The Nilgiri Pipit was selective in their feeding habitats according to the season. Of the five blocks (F1, F2, F3, F4, and F5) where the feeding rate and use of the area were studied, F1 block had the highest feeding rate and use mainly because of the diversity of habitats and vegetation. F1 and F2 blocks showed a bimodal rhythm, whereas the F4 showed a peak only in the afternoon and F5 in the midday and a minor peak in the evening. In F3, the number was negligible as this block had the minimum feeding habitat; the grass-slopes.

The first feeding peak between 0800 - 0900 h and 0900 - 1000 h in F1, is because it is fairly an open habitat with marsh and, where the shade is limited to a corner. The pipits fed in open area during the morning hours when the temperature was low and shifted to edge with shade when sun became hot. High feeding rate was observed in F1 and F2 blocks in the evenings, where they roosted. These variations in the utilization of various microhabitats during different times of the day appear to be related to the habitat availability, sunshine, shade and abundance of food. Utilization of space depending on environmental conditions (Coraco 1980, Vijayan 1984, Tidemann 2004, Nirmala 2004) and food abundance (Morris *et al.* 1958, Koplin 1972, Meyer *et al.* 1994, Meyer 2001) was reported earlier.

4. 4. 8. Association of the Nilgiri Pipit with other birds while foraging

The Nilgiri Pipit fed mostly in pairs and occasionally with other species. The species which were found along with the Nilgiri Pipit for a relatively considerable amount of time were Pied Bushchat, Paddyfield Pipit, Tickell's Leafwarbler and Prinia. Among them, the Pied Bushchat was seen more frequently (25%) which was also a permanent resident of the study area and shared similar microhabitat. Both would have, probably, had mutual benefits as found in other species (Morse 1970, Byrkjedal *et al.* 1997, Robin and Davidar 2002).

The number of species associated with the Nilgiri Pipit varied with the season, because of the arrival of migratory species such as the Tickell's Leaf Warbler, Rose Finch and Grey Wagtail. The Paddyfield Pipit is also a local migrant to the area, arriving in summer for breeding. Such variation in the feeding flock through migratory species was reported earlier in several cases (Lee *et al.* 2005).

4. 5. Summary

- Feeding behaviour of the Nilgiri Pipit was studied for 600 hours during 2002-2004.
- Observations amounting to 12,988 for feeding, 1744 for feeding height, 932 for foraging substrate and 7176 for foraging maneuver were made.
- Invertebrates formed the major diet (86%) during breeding and seeds (68%) during non-breeding.

- Small beetles followed by grasshoppers and flies formed the major invertebrate diet.
- Seeds in the food comprised those of grasses *Isachnae kunthiana, Eragrostris nigra, Isachaemum ciliare)* and a species of herb (*Cyanotis wightii*).
- The Nilgiri Pipit has specific feeding habitat; grassland with short creeping grasses around marshy area.
- Feeding substrate was mainly grass and herb foliage with definite feeding technique, "glean".
- They fed mainly less than 15 cm height.
- Nilgiri Pipit was selective in feeding locations.
- The Nilgiri Pipit is a specialist in different foraging dimensions, namely substrate, maneuver, height and food.
- It had a bimodal pattern of feeding in certain seasons with a major peak in the morning and a minor one in the afternoon /evening. The peak hours of feeding varied in different seasons and locations.
- The feeding rate varied from 174 / h to 615 / h .
- Seasonal variation occurred in feeding rate; comparatively less during south-west monsoon and more during north-east.
- The rate of feeding varied with different factors such as insect and seed abundance, temperature, humidity, wind speed and day length.
- Ambient temperature has a negative correlation with the feeding activity.
- Feeding activity is positively correlated with ground temperature and light intensity.

Chapter V

Breeding biology of the Nilgiri Pipit

5.1. Introduction

Survival of a species essentially depends on its ability to reproduce and bring up the offspring. This is based on both the number of young in a brood and the number of broods raised per season (Hötker and Sudfeldt 1982, Askenmo and Unger 1986, Westmoreland *et al.* 1986). Food is considered to be one of the major factors influencing the ultimate success (Lack 1968, Stiles 1985, Martin 1987, 1992; Ralph *et al.* 1995, Dias and Blondel 1996). Moreover, food provided to nestlings by the parents both in quality and quantity can have a substantial influence on nestling survival and condition at fledging (Martin 1987, 1995, Mock *et al.* 1991, Sullivan and Weathers 1992, Dykstra and Karasov 1993).

One of the major factors determining the reproductive success is the habitat quality (Rosenweig 1991, Werner 1992, Petit and Petit 1996, Vanhinsbergh and Chamberlain 2001). Habitat likely affects nest placement and success at two spatial scales: nest patch-characteristics of the habitat surrounding the nest-site and, nest site characteristics in the immediate vicinity of the nest (Martin and Rooper 1988, Norment 1993, Badyaev 1995, Clark and Shutler 1999).

Establishment and defense of breeding territories help reproductive success, the size of which again depends on habitat. Territoriality is a common feature among land birds; 84% of the passerines and 81% of the non-passerines breed in territories (Lack 1968). Territorial defense by males is a conspicuous component of many vertebrate mating systems (Clutton-Brock 1989, Davies 1991, Ligon 1999). For male, resource defense through territorial exclusion of competitors is usually a pre-condition for obtaining mates, and reproductive success of both sexes may increase with territory size and /or quality (Davies 1991, Goodburn 1991). Ens *et al.* (1992) listed the existence of differences in the quality of territories.

Long-term studies show three main factors to be good quality measures related to reproductive success. First, the amount and quality of food as critical resource determining the fitness of animals (reviewed by Martin 1987, Boutin 1990). Second, protection from nest predation influences breeding success (Holm 1973, Weatherhead and Robertson 1977, Askenmo and Neergaard 1990). Third, micro-climatically advantageous nest sites may be a limiting resource and contribute to variation in reproductive success (Ligon and Ligon 1988, 1989).

Parental care is yet another factor affecting the reproductive success. The Nilgiri Pipit is a monogamous, passerine inhabiting the grasslands. Such biparental passerines expend considerable parental effort in provisioning altricial nestlings and fledglings (Skutch 1976, Zaias and Breitwisch 1980, Breitwisch 1989, Clutton-Brock 1991). Over 90% of bird species are predominantly socially monogamous and have some type of biparental brood care (Lack 1968, Verner and Willson 1969). Also it has been assumed that the need for the two parents to raise the young successfully may even be a cause of monogamy in birds (Wittenberger and Tilson 1980). In species with biparental care, females may benefit by choosing mates who provide suitable paternal care.

Information on reproductive success, factors determining the same, such as habitat quality, food abundance, microclimatically advantageous nesting site, predation, parental care are not available for the Nilgiri Pipit. Knowledge on these are vital for effective conservation measures (Lack 1968, Perrins 1996) which have to be taken on priority as the Nilgiri Pipit is considered to be a Near-Threatened species (Birdlife International 2001). The present chapter presents: a) basic breeding biology, b) selection of breeding ground and site and, c) factors affecting the breeding seasonality and breeding success of the Nilgiri Pipit in the Upper Nilgiris.

5. 2. Methodology

Data on the breeding biology of the Nilgiri Pipit were collected by direct observation (Rotenberry and Wiens 1980, Bibby *et al.* 1993) during February 2002 to June 2004. Nests and nest-sites were routinely checked, with minimal disturbance to the birds, to record information on the date of egg laying, length of incubation, date of hatching, and development and survival of the young. Nests of the pipits were measured to record the length, width and height.

5. 2. 1. Breeding season

Date of egg-laying is considered for analyzing the breeding season. Intensive nest searching was performed in select areas of grass-slopes and marsh valleys of the Upper Nilgiris in all seasons.

5. 2. 2. Breeding habitat

The habitat details at the macro and micro levels were examined as explained in Chapter III for analyzing the breeding habitat.

5. 2. 3. Nest searching and territory mapping

The sites were systematically searched for the nests of the Nilgiri Pipit. Birds were observed with a pair of binoculars (8 x 40) and telescope (20X) and noted the distance, location and behaviour (e.g. song posts, presence of females, and territorial disputes). Nests were located when the birds flew off from nests, and, by following the birds with nesting material, males delivering food to incubating females or feeding trip by either parent to the nest. Each nest was numbered separately for 2002, 2003 and 2004.

Breeding density of birds in the intensive study area was assessed following mapping method, using a grid map. Territorial behaviour of the Nilgiri Pipit was recorded following breeding pairs and observing behaviour such as the extent of movements, display calls and locations of agonistic behaviour. The maps constructed from daily tracking were used to derive territory boundaries for pairs based on the methods of Rotenberry and Wiens (1980) and Silkey *et al.* (1999).

5. 2. 4. Nesting

5. 2. 4. 1. Nest substrate and material

Nest substrate was defined as the substrate on which the nest was built. The material forming the substrate and nest was analyzed and the grass species identified after fledging or nest failure. Some of the nest materials were identified during nest building itself, when the bird came with material in its beak at the nest site.

5. 2. 4. 2. Nest- patch and nest-site characteristics

The following details were recorded on each nest as done in earlier studies (Bechard *et al.* 1990, Hullseig and Becker 1990): a) nest: height, length, width in cm, orientation and concealment; b) nest plant (substrate): species and height of the plant; and, c) nest patch: canopy cover (%), microhabitat, distance to trek path, distance to settlement, and distance to water.

A one-meter radius circular plot centered at nest-substrate was laid for every nest to study the above variables to asses the nest-site selection as suggested by Titus and Mosher (1981). Distance to path and disturbance on nest-substrate were included to identify whether site selection was affected by human activity. The same set of data was collected from exactly the same micro habitat not used for nesting (potential nest site) to identify the factors responsible for selection of the nest site. The entire study was done in the intensive study area of 14 ha.

'Nest orientation', the angle bisecting the entrance to the nest, was measured. The nest entrance is the area around the nest without the typical protective structure of vegetation and is the direction by which incubating birds leave from and return to the nest.

"Nest concealment" was estimated by using a 10 X 10 cm checkered board. The board was placed at the nest site and was viewed from one metre away, at the nest level, from the four cardinal directions (Holway 1991). Concealment was calculated as the average number of white squares that were more than 50% obscured by vegetation.

5. 2. 5. Nesting cycle

5. 2. 5. 1. Egg-laying and Clutch

Actual date of egg-laying was recorded wherever possible. It was also computed by subtracting duration of incubation and completion of clutch from the known date of hatching.

5. 2. 5. 2. Incubation

Regular observations were made at the nests till the eggs were hatched. The duration of attentiveness by parent was recorded for each hour of the day to get the incubation rhythm.

5. 2. 5. 3. Provisioning of nestlings

Foraging observation began once the chicks were three days old and continued on different sessions until they dispersed from the nest. The number of feeding trips by each parent to the nest was recorded. All the observations were from an optimum distance so as to avoid disturbance to the nest. Each observation, lasting an hour from the first foraging bout, was made from a concealed location. The following details were recorded at each observation: a) distance from the nest to the foraging location; b) sex of the parent, identified either by natural marks or the coloured rings; c) number, size, and type (adult or larval insect) of prey whenever possible; and d) other activities of the parents around the nest.

Droppings of the chicks of 12 to 13 days, made at the time of banding and also the faecal sac dropped on the ground by the parents were collected, stored and analyzed as explained in Chapter IV on food and feeding habits.

Feeding data were recorded with sampling periods scattered through out the day 0600 to 1900 h on several days up to fledging. The number and age of nestlings of each nest were recorded. Mean feeding frequency per brood per hour and mean feeding distance were calculated. The rate of feeding the young in a day was taken and compared with the age of the young. The vegetation type and food abundance at each pair's main foraging site within the territory and food availability are explained in Chapter IV.

5. 2. 5. 4. Parental care of fledgling

Movements and behaviours of the fledglings and parents were monitored. Details recorded include the type of substrate (ground, bush, and tree), height of perch, spatial separation of young and parents, and interactions between parents and young.

5. 2. 6. Reproductive success

All the nests in the intensive study area were marked with pegs and checked two to three times per week, recording the laying date, clutch size, hatching and fledging dates and, number of young. Success was calculated at different stages. Annual reproductive success was calculated from the total number of eggs laid and the number of fledgling (Murray 2000). The nest that fledged at least one young was considered successful and that lost all eggs or nestlings at one shot is considered as preyed upon. Nests failed, because of predation, exposure, or abandonment, were listed as unsuccessful.

5. 2. 7. Data analyses

Discriminant function analysis was performed to identify factors separating the nest-sites from the random sites. Uni-variate analyses of variances (ANOVA), Mann-Witney U, Chi-square, and correlation and other simple statistics were used wherever appropriate (Sokal and Rohlf 1981). Uni-variate analyses of variances (ANOVA) were used on continuous variables while Mann-Whitney U was performed on ranked variables to compare nest-sites and random sites (Titus and Mosher 1981) as well as successful and unsuccessful nests. Results are reported significant if probability value is ≤ 0.05. The SPSS (SPSS for MS windows, Release 10.0) was used for data analyses. Reproductive success was calculated in different stages by following:

$$\text{Hatching success} = \frac{\text{Number of eggs hatched}}{\text{Total number of eggs laid}} \times 100$$

$$\text{Fledging success} = \frac{\text{Number of young fledged}}{\text{Total number of eggs hatched}} \times 100$$

$$\text{Nesting success} = \frac{\text{Number of young}}{\text{Total number of eggs laid}} \times 100$$

5. 3. Results

The breeding biology of the Nilgiri Pipit was studied from February 2002 to June 2004 on the grasslands of the Upper Nilgiris. The intensive study area of 14 ha at Upper Bhavani has marshy grassland surrounded by creeping grasses and bordered by shola patches, pine and wattle plantations. Five adult pipits were colour marked for individual identification in the field.

5. 3. 1. Breeding season

The Nilgiri Pipit commenced breeding activities during late February in the Upper Nilgiris and nesting extended from March to May with a single peak of breeding in April in all the three years (Figure 5.1). Only in 2003, one nest was observed in June.

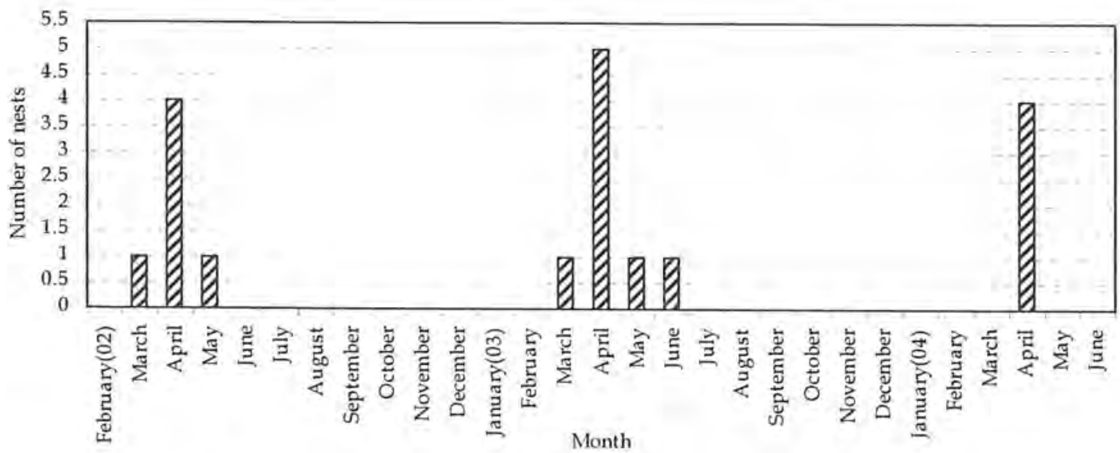


Fig 5.1 Breeding season of Nilgiri Pipit in three years (2002-2004)

Principal Component Analysis of all probable abiotic and biotic factors influencing breeding season showed three components accounting for a total variance of 76%. The first component was positively associated with number of rainy days, relative humidity and abundance of Orthoptera, Coleoptera and Arachnida, and negatively with wind speed, bright sun, total invertebrate and seed abundance. The second component was associated positively with maximum and minimum temperatures and abundance of Hemiptera and Hymenoptera and negatively with total rainfall. The third component was associated with Lepidoptera, but negatively with the abundance of Diptera (Table 5.1).

Parameters	PC1	PC2	PC3
Total rainfall	0.174	-0.539*	0.521
No. of rainy days	0.585*	-0.575	0.269
Relative humidity	0.786*	-0.547	-0.007
Maximum temperature	0.009	0.846*	0.425
Minimum temperature	0.575	0.623*	0.415
Wind speed	-0.661*	0.338	-0.386
Bright sun	-0.930*	0.338	-0.003
Seed abundance	-0.723*	-0.571	-0.000
Total invertebrate abundance	-0.745*	0.202	-0.006
Coleoptera	0.811*	0.189	-0.409
Diptera	-0.366	0.128	-0.658*
Lepidoptera	-0.430	-0.547	0.429*
Orthoptera	0.801*	-0.124	-0.413
Arachnida	0.610*	0.529	-0.446
Hemiptera	0.270	0.614*	0.354
Hymenoptera	-4.62	0.737*	0.395
Percentage of total variance	36.11	26.15	14.32
Cumulative percentage of total varience	36.11	62.27	76.59

*High correlations with their respective principal components

Table 5.1 Factor loading of various parameters influencing breeding season of the Nilgiri Pipit

The breeding season of the Nilgiri Pipit had positive correlation with minimum and maximum temperatures (Figure 5.2a, b). The correlation was negative with rainfall (Figure 5.2c), relative humidity (Figure 5.2d) and seed abundance (Figure 5.2e). A slight correlation was observed with invertebrate abundance (Figure 5.f). There was no relation with number of rainy days (Figure 5.2g).

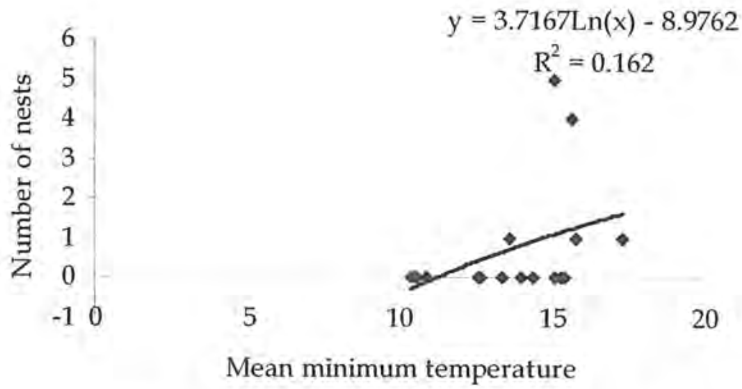


Fig 5.2a Correlation of the number of nests of the Nilgiri Pipit with minimum temperature

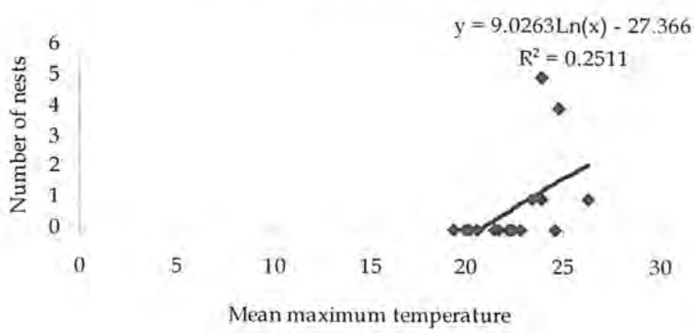


Fig 5.2b Correlation of the number of nests of the Nilgiri Pipit with maximum temperature

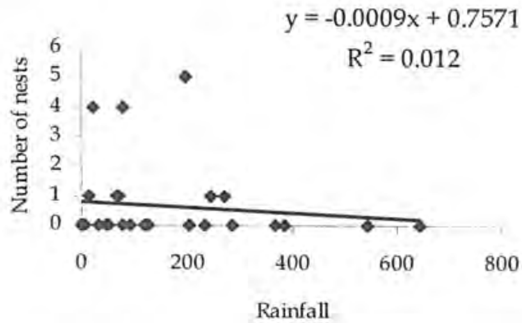


Fig 5.2c Correlation of the number of nests of the Nilgiri Pipit with rainfall.

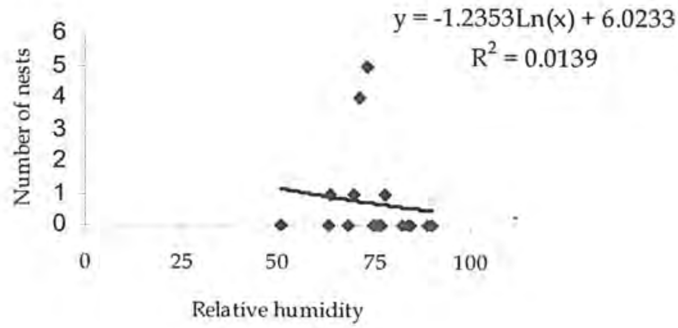


Fig 5.2d Correlation of the number of nests of the Nilgiri Pipit with relative humidity

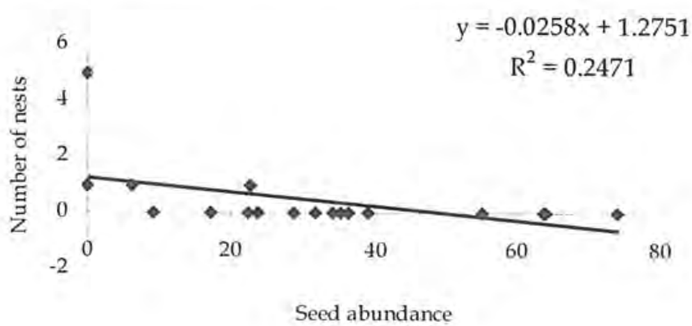


Fig 5.2e Correlation of the number of nests of the Nilgiri Pipit with seed abundance

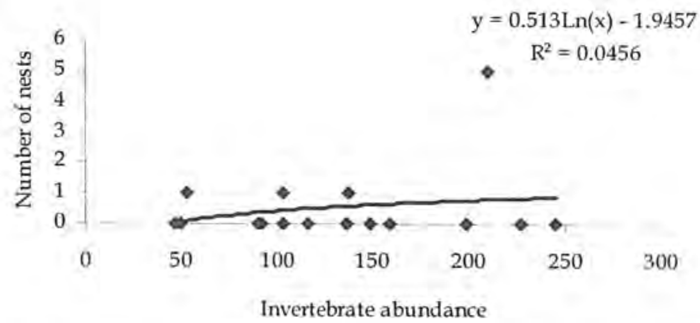


Fig 5.2f Correlation of the number of nests of the Nilgiri Pipit with invertebrate abundance

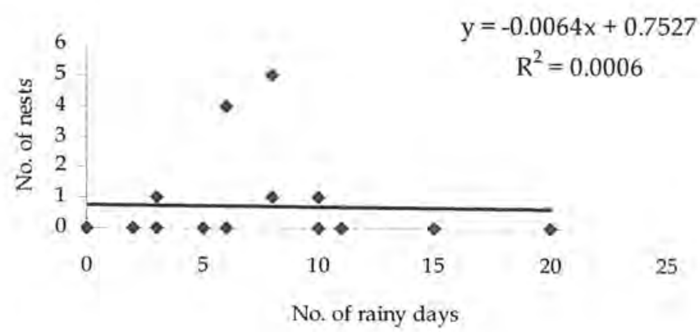


Fig 5.2g Correlation of the number of nests of the Nilgiri Pipit with number of rainy days

5. 3. 2. Habitat use of breeding birds

The Nilgiri Pipit preferred short grassland habitat with marshy grasses (90%) restricted to valleys with streams for nesting (Table 5.2). The preference to wet grasslands (marsh) and nearness to stream was significant (χ^2=27.867; p<0.001). Species diversity of grasses and herbs was high at the nest sites (data in Chapter III). *Andropogon polypticus* is the most used species of the nesting plant of the Nilgiri Pipit.

Nest site	No of nests	%
Marsh	27	90
Grassland near by marsh	3	10
Total	**30**	100

Table 5.2 Number of nests of the Nilgiri Pipit in different habitats

5. 3. 3. Territory and site fidelity

In the intensive study area of 14 ha, six territorial pairs were present in 2002, eight in 2003, and four in 2004. However, exact territory could be marked only for two in 2002, four in 2003, and three in 2004. The territory size varied from 0.06 to 0.25 ha with a mean of 0.154 ha (Figure 5.3a, b, and c; Table 5.3). However, some times they intruded into other's territory. The first arrived males as well as the resident pair defended more area than the latecomers. The territory size decreased because of the occupation of more breeding pairs during the peak breeding time. The resident ringed pair confirmed the male occupancy in the area.

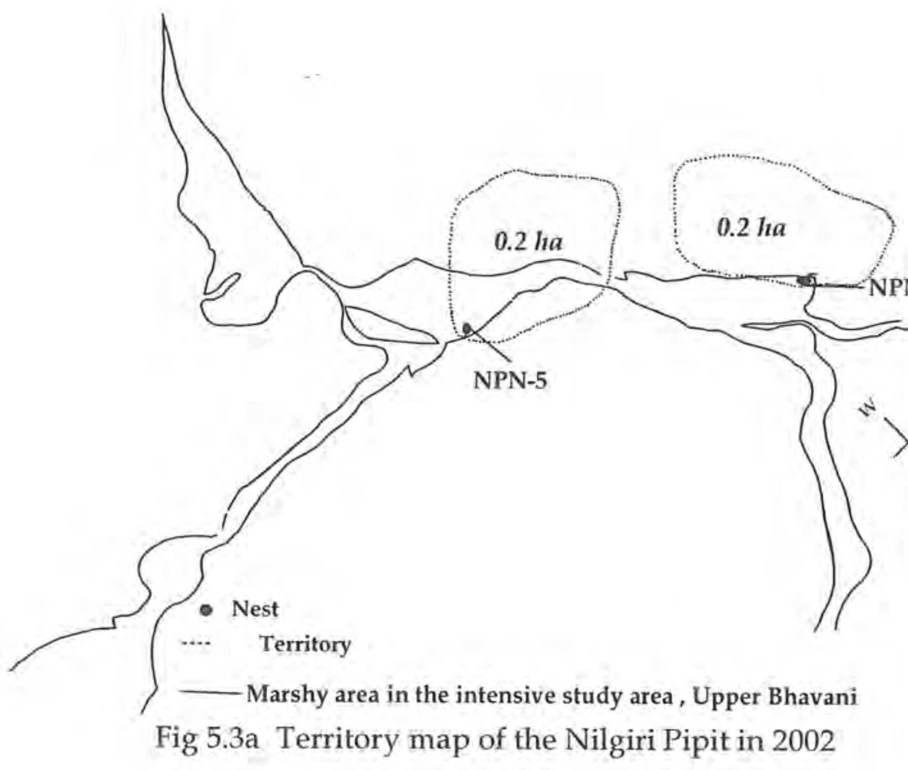


Fig 5.3a Territory map of the Nilgiri Pipit in 2002

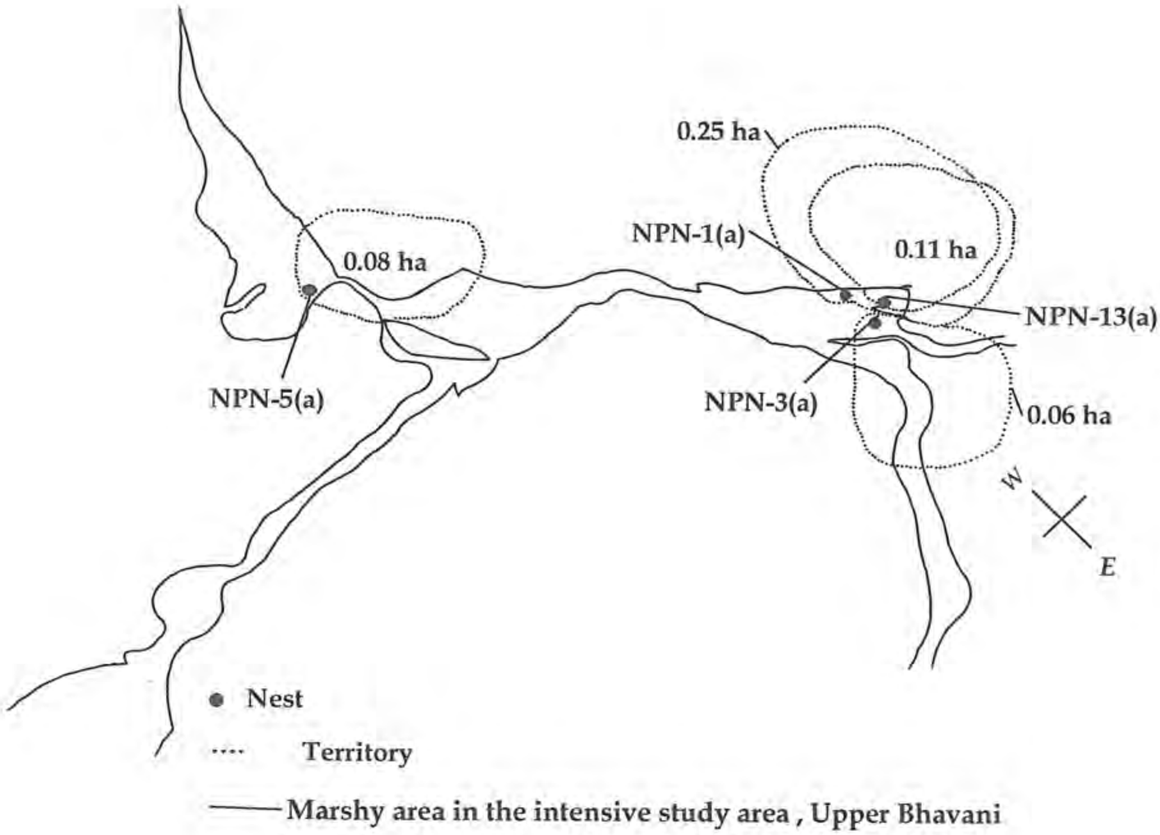


Fig 5.3b Territory map of the Nilgiri Pipit in 2003

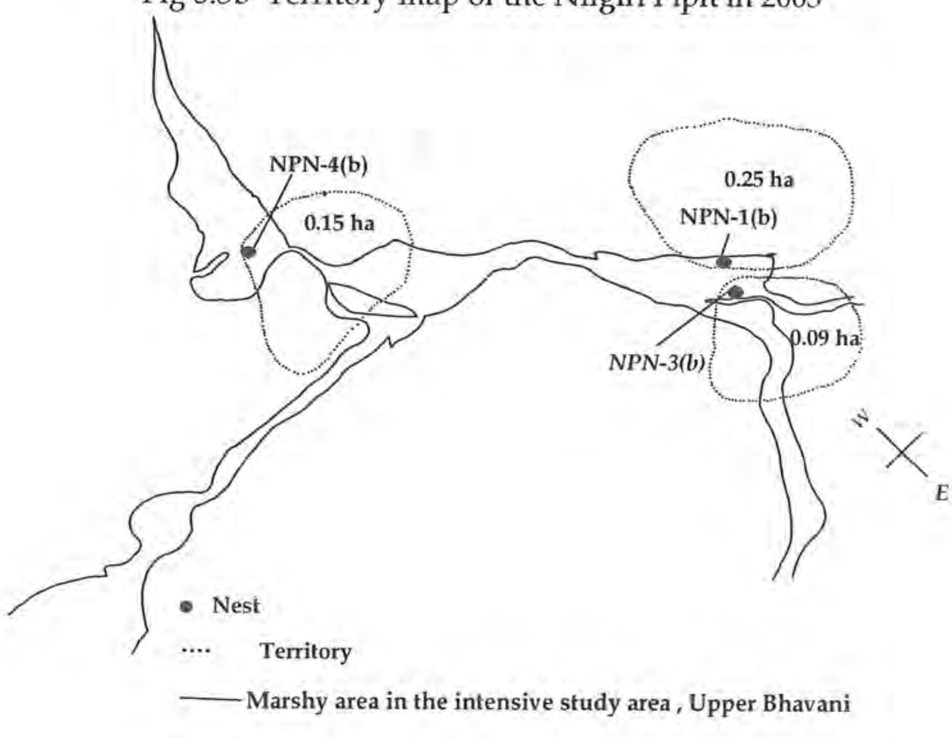


Fig 5.3c Territory map of the Nilgiri Pipit in 2004

Nests	Size of the territory in ha
NPN-1	0.2
NPN-5	0.2
NPN-1(a)	0.25
NPN-3(a)	0.06
NPN-5(a)	0.08
NPN-13(a)	0.11
NPN-1(b)	0.25
NPN-3(b)	0.09
NPN-4(b)	0.15
Average	0.154

Table 5.3 Territory size of the Nilgiri Pipit

Site fidelity was observed in the Nilgiri Pipit. In 2003 and 2004 the same pair, NPN-1(a) and NPN-1(b) used the same site for nesting. NPN-5(a), NPN-6(a) and NPN-4(b) also nested in the same area. Re-nesting was found in the NPN-4(b) by the same female pipit. In 2003 NPN-1(a) pair raised a second brood successfully.

Upper Bhavani area had the highest density of nesting; 0.6 pair / ha in 2003 in the intensive study area of 14 ha. But the density in the 6 ha marshy area where they nested was 1.3 pair / ha.

Displays and mating were observed inside the territory. Mating was found during the nesting time at a particular spot nearer the nest. While the male approached the female, she showed display behaviour, spreading the wings, quivering the tail and wings and, lowering the head (Figure 5.4). In between, the male made typical breeding call as *trrrr.....sisisii...sisisii......sisisii*. Copulation was observed five times lasting a few seconds. It was at the nest site, occasionally interrupting the nest-building bouts of females. When the male Nilgiri Pipit tried to mount, it approached the female aggressively and mounted. Mounting was observed for 4.99 minutes and the average time was 2.7 minutes.

Fig 5.4 Display of the female Nilgiri Pipit

5. 3. 4. Nest and nest-site selection

Thirty one nests were found in the Upper Nilgiris, 18 were in the intensive study area and the rest from outside. Details of the nests and nest-site are given below.

5. 3. 4. 1. Nest

The nest is a cup, in most cases fully concealed, and located in a depression, usually at the base of tussocks of grass (*Andropogon polypticus, Mariscus cyperinus roots, Eriocholon. Spp.)*, and, it is composed mainly of the blades of grass, namely *Scirpus fluitans, Bulbostylis densa, and Fimbristylis subtrabiculata,* roots of the grass *Mariscus cyperinus* and lichens. Long grasses growing around the nest are typically interwoven to form a dome. The mean length, width and the height of the nests were 11.15, 6.5 and 5.16 cm respectively. The mean concealment was 92%. The nest NPN-13(a) at the late stage of breeding season in June 2003 was inside a deep depression under the grass tussock unlike all other nests.

5. 3. 4. 2. Orientation of nest entrance

All the nests were oriented towards the water source. No significant directionality was found in nest-entrance orientation, although more nests were towards east (Figure 5.5).

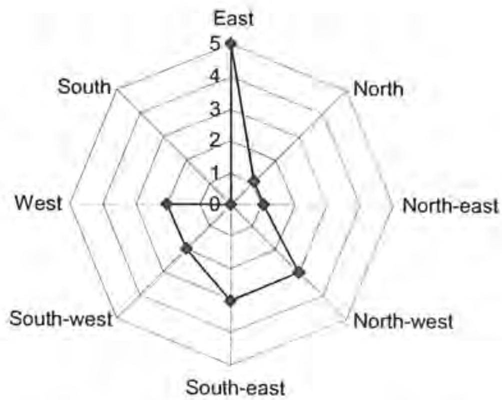


Fig 5.5 Nest orientation of the Nilgiri Pipit

5. 3. 4. 3. Nesting substrate

The nesting substrate varied slightly according to the site and the grassland fire. Most of the nests were at the tussocks of the grass *Andropogon polypticus* (82%), followed by *Mariscus cyperinus* (7%), *Eriocholon* spp. (7%), and *Isachnae gardneri* (4%).

5. 3. 4. 4. Nest-site selection

Nest variables were measured for 28 nests; 11 outside the intensive study area and 17 inside. The nests were placed at a mean height of 4.78 cm, inside the intensive study area and 5.86 cm outside (Table 5.4).

Nest Variables	Outside intensive study area	Intensive study area
Nest Height	5.86±1.98	4.78±0.78
Nest Length	13.81±3.87	9.4±3.35
Nest Width	7.35±0.7	5.96±0.82

Table 5.4 Nest variables of the Nilgiri Pipit inside and outside Upper Bhavani

The nest-site characteristics showed variation between inside and outside the study area. The mean and SD values with the significance of difference between the variables are given in the table 5.5. Grass height above the nest and distance to human settlement showed significant difference; the former was higher at the nesting site inside the intensive study area.

Nest parameters	Nest-site			
	outside ISA	inside ISA	Mann-witney - U	p value
Distance to path(m)	169.54±167.29	26.88±23.13	64	ns
Distance to human settlement(m)	877±11763	521.47±907.79	6	0.00*
Distance to Stream	18.54±17.48	15.21±17.6	78	ns
Nest placement above ground(cm)	5.25±6.49	7.66±8.69	83.5	ns
Shrub cover (%)	4.54±15.07	0.41±1.27	92	ns
Grass cover (%)	83.45±26.44	90.94±11.09	86	ns
Herb Cover (%)	11.09±14.32	8.35±10.94	90	ns
Grass height (cm)	32.58±12.18	48.67±8.33	26	0.001*
Fern Cover(cm)	2±6	0.11±0.48	81.5	ns
Ground Cover(cm)	0±0	0±0	93.5	ns

Note: ISA= Intensive study area, ns = not significant

Table 5.5 Comparison of nest-site variables inside and outside the intensive study area

Comparison of variables between used and unused nesting sites both within and outside the intensive study area was made to find out the important factors determining the nest-site selection (Table 5.6, 5.7).

Nest site parameters	Used site	Unused site	U	p
Distance to path(m)	26.88±23.13	21.44±20.55	120	ns
Distance to human settlement(m)	521.47±907.79	522.94±907.26	143.5	ns
Distance to Stream	15.21±17.6	24.58±15.05	80	0.026*
Nest placement above ground(cm)	7.66±8.69			
Shrub cover (%)	0.41±1.27	1.88±5.26	134.5	ns
Grass cover (%)	90.94±11.09	68.7±19.29	48	0.001*
Herb Cover (%)	8.35±10.94	23.64±17.82	67.5	0.007*
Grass height (cm)	48.67±8.33	38.23±8.08	50	0.001*
Fern Cover(cm)	0.11±0.48	1.17±4.85	144	ns
Ground Cover(cm)	0±0	4±11.48	127.5	ns

Note: ns = not significant

Table 5.6 Comparison of variables between used and unused sites inside the intensive study area

Nest parameters	Nest-site	Unused site	U	p
Distance to path(m)	169.54±167.29	145.9±167.97	52.5	ns
Distance to human settlement(m)	877±11763	5413.63±5631.37	52	ns
Distance to Stream	18.54±17.48	24.36±17.3	41.5	ns
Nest placement above ground(cm)	5.25±6.49			
Shrub cover (%)	4.54±15.07	2.27±6.06	56	ns
Grass cover (%)	83.45±26.44	84.09±16.09	54.5	ns
Herb Cover (%)	11.09±14.32	11.36±13.61	60	ns
Grass height (cm)	32.58±12.18	25±12.04	40.5	ns
Fern Cover(cm)	2±6	3.63±12.06	56	ns
Ground Cover(cm)	0±0	2.27±7.53	55	ns

Note: ns = not significant

Table 5.7 Comparison of variables between used and unused sites outside the intensive study area

Distance to stream (U = 80; p<0.026), grass cover (U=48; p<0.001), herb cover (U= 67.5; P<0.007) and grass height (U= 50, p<0.001) are significantly different between the nest-sites and the unused sites both inside and outside the intensive study area. Hence distance to stream, grass and herb cover and, grass height are the major factors for nest-site selection.

Nest-site and nesting success

Nest success was recorded in 18 nests from the intensive study area. Among them, seven were 100% successful, while one was 50% successful and 10 were unsuccessful. All the seven nests were inside marsh and the one with 50% successful was on the border of the marsh with the grass-slopes. Among the unsuccessful nests, three were inside marsh and the other seven on the border of marsh. All the successful and eight unsuccessful nests were under *Andropogon polypticus* tussock, whereas other unsuccessful nests were under the depression of *Isachnae spp.* and *Mariscus cyperinus*.

Comparison of nest-site variables between successful and unsuccessful nests showed only the position of nest above ground (nest height) as the significant factor ($U = 9.5$; $p<0.01$) (Table 5.8).

The Discriminant Function Analysis (stepwise) gave two variables, namely nest height (0.81) and nest concealment (0.72), as the key factors influencing the nesting success.

Nest parameters	Successful nests mean ±SD	Unsuccessful nests mean ±SD	U	P
Nest height(cm)	4.93 ± 0.82	4.63±0.77	24.5	0.44
Nest length(cm)	9.81±2.25	8.98±4.31	31.5	0.95
Nest width(cm)	6±0.70	5.93±0.97	25.5	0.5
Nest concealment (%)	100±1.60	92.8±1.38	26	0.57
Dist to trek path(m)	24.37±13.99	20.25±14.35	27	0.64
Dist to human settlement(m)	331.25±128.69	276.87±169.51	25	0.5
Dist to River/Stream(m)	10.00±10.21	7.42±7.13	29.5	0.79
Nest-placement above ground/cm	21.62±23.77	3.21±4.55	9.5	0.01**
Shrub cover (%)	0.62±1.76	0.25±0.7071	31.5	0.95
Grass cover (%)	93.12±9.61	92.62±8.50	31	0.95
Herb Cover (%)	8.12±10.99	7.25±8.56	31.5	0.95
Grass height over nest /cm	49.43±21.05	45.37±20.24	24.5	0.44

Table 5.8 Nest-site characteristics of successful and unsuccessful nests.

5. 3. 5. Nesting cycle (Figure 5.10)

5. 3. 5. 1. Nest building

Most nests were built inside the depressions in the ground under the tussock of grass *Andropogon polypticus*. Two nests were observed during construction while one was found at the very beginning stage itself. The period required for nest building was 5-6 days. The mid point of nest construction is the completion of the cup and the beginning of lining inside. Nest building activity was highly restricted to morning (Figure 5.6) with a peak during 0800 to 1000 h.

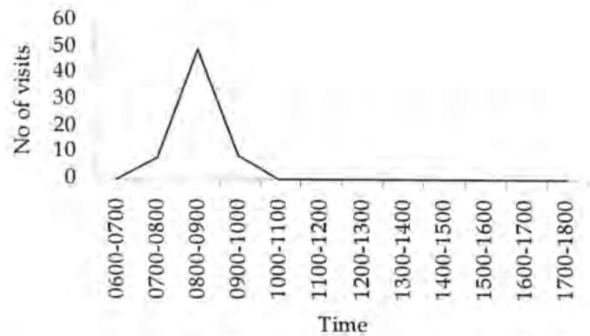


Fig 5.6 Hourly variation in the nest building activities of the Nilgiri Pipit

Effort of the male and female in nest building was 15% and 85% respectively (Table 5.9). The male's contribution was comparatively more in the first phase and least in the second phase. The second phase of nest construction was done entirely by the female. Of the 165.54 minutes observed on one nest, 73.95 minutes (45%) were for the first phase and 91.59 minutes (55%) for the second phase. The number of visits made by the male for nest building was only 8%, whereas it was 92% by the female (N = 87).

Nesting Stage	Sex	Time spent in minutes	%
I	Male	22.09	29.87
	Female	51.86	70.12
II	Male	2.83	3.08
	Female	88.76	96.91
Total	Male	24.92	15.05
	Female	140.62	84.94

Table 5.9 Nest building effort of each sex of the Nilgiri Pipit

The female usually did not fly directly into the nest while transporting nest material; it waited on nearby perches and finally entered the nest or walked into more stealthily with body closer to the ground towards nest. While the female carried the nest material towards nest, the male perched on a tree and looked around making calls.

5. 3. 5. 2. Eggs and clutch size

The eggs were greyish cream with coffee brown speckles on the broader side and spots on the narrow end. The darkness and the size of speckles increased as incubation advanced and the day prior to the hatching, the eggs became fully dark with coffee brown at the broader end and dull cream on the narrow end.

The clutch size varied from one to three, but mostly it was two in a sample of 31 nests (Table 5.10). The mean clutch size was 2.13. The females laid replacement clutches when a clutch is lost and, only one had second brood. One pair re-nested because of failure of the first brood, whereas the other one successfully completed the brood early and raised a second brood successfully.

Clutch size	No of clutches
1	1
2	25
3	5
Mean clutch size	2.13

Table 5.10 Clutch size and number of nests of the Nilgiri Pipit

5. 3. 5. 3. Incubation

Incubation period was calculated from the completion of clutch to the commencement of hatching. Eggs were laid in the morning; one each in a day. Only completed clutches (those to which no eggs were added over 72 h period) were taken for the analysis of incubation behaviour. The mean incubation period was 14 to 15 days (n=

12 clutches). Overall incubation constancy (percentage of total observation time during which eggs were covered) was very high in the early days than in the later stage. Most of the incubation was done by the female, whereas the male attended the nest all the time, guarding and occasionally feeding the female and also chasing other intruder pipits. Incubation pattern had almost, a bimodal peak in the morning and evening (Figure 5.7) with peaks in the morning and evening, the latter being higher. When the female left for feeding, male accompanied her and fed together in the nearby area. Attentiveness was low during midday.

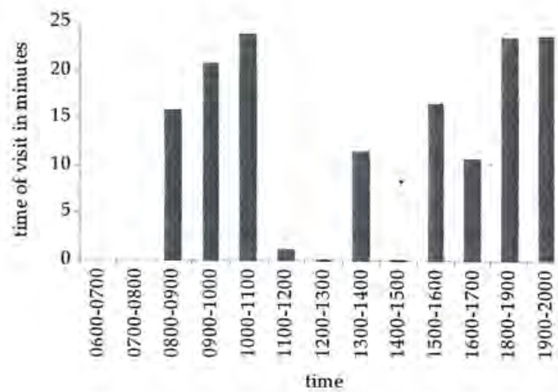


Fig 5.7 Incubation pattern of the Nilgiri Pipit

5. 3. 5. 4. Nestling care

All the eggs in a clutch hatched in the same day in most of the nests. The newly hatched young were pinkish and had no feathers; eyes were closed and the gape was dark yellow. The young opened the eyes on 5th day of hatching. The nestlings were quite active on the 12th day with feathers developed almost fully. The nestling period was 15-16 days (n=6).

Detailed observations were made on six nests (nest number 1, 1a, 1b, 5, 5a, and 6a). Most of the brooding was by the female. As they grew, brooding spells became shorter and infrequent the whole day, except when it fed the chicks with the prey delivered by the male. Later she spent progressively more time away from the nest collecting food for the chicks. However, older nestlings were also brooded by the female occasionally.

The Nilgiri Pipit carried several prey items in their beak (multi-prey loader) to the nest for feeding the nestlings. Feeding intensity was estimated by number of visits with food per hour which increased with the age of the nestling and became almost steady after 10^{th} day (Figure 5.8). The male's share of feeding the chick was the greatest up to the third day, during the period when the female spent all the time for brooding. Male contributed 55% and female 45% of their total effort for feeding the nestlings. The effort between male and female was almost equal at most stages in the breeding cycle, but overall it was slightly higher by the male.

When parents brought food simultaneously, only one of them entered the nest and the other waited outside. The parent that spotted the predator first gave a warning call and soon was joined by its mate. The parents removed faecal droppings from the nests. Un-hatched eggs were retained in the nests. Even the dead young were not removed.

Time taken for delivering food varied with average of 2.26 minutes. Female took more time to collect the food and deliver at the nest in the absence of male.

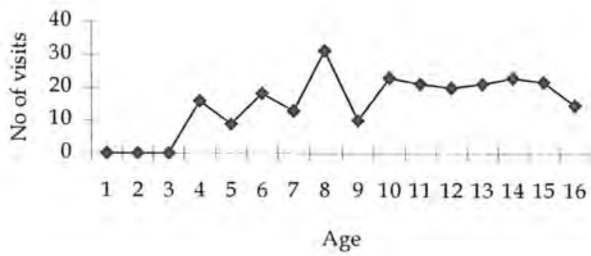


Fig 5.8 Frequency of feeding the nestlings of the Nilgiri Pipit

The number of visits with food for nestlings per hour in a day showed a bimodal pattern with peaks in the morning and evening (Figure 5.9).

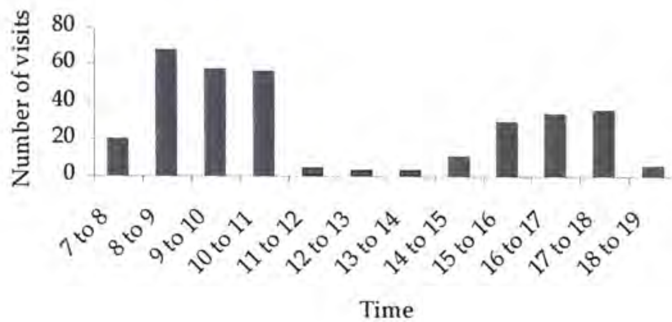


Fig 5.9 Number of visits for feeding the nestlings

Nest with eggs

Incubating bird

Nest with chicks

Nest with 12 days old chick

Fig 5.10 Nest and chicks of the Nilgiri Pipit

5. 3. 5. 5. Food of nestlings

Ninety nine prey items consisting mainly of lepidopterans (33%), orthopterans (25%), dipterans (20%), and coleopterans (17%) were identified by direct observation (Figure 5.11). Most of them were caterpillars and grasshoppers. These insects were moderately abundant in the breeding season. The dipterans were high in the area throughout the period (more details in Chapter II; seasonal variation of insect abundance).

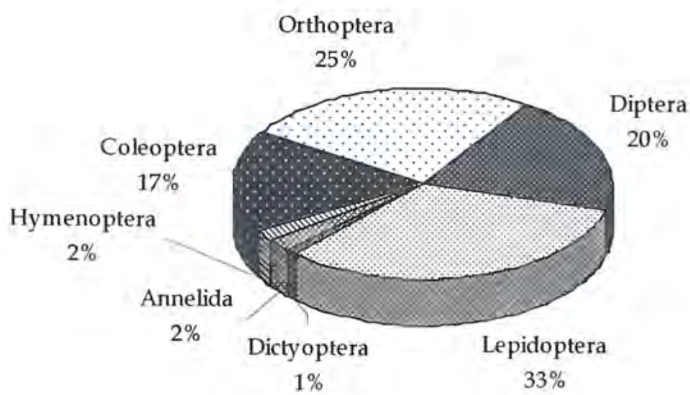


Fig 5.11 Food of the nestlings of the Nilgiri Pipit - direct observation

Faecal samples of the nestlings showed Coleoptera (33%), Orthoptera (16%) and lepidopteran larvae (23%) as dominant items (Figure 5.12).

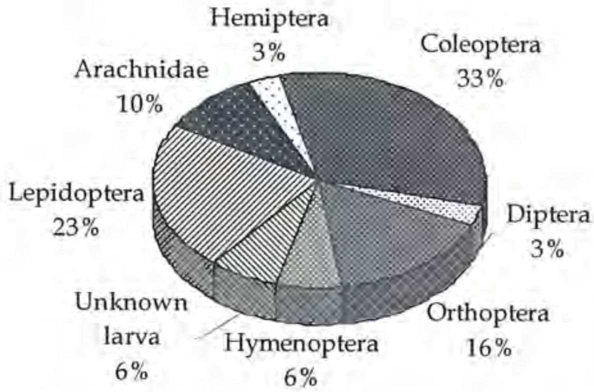


Fig 5.12 Faecal contents of the nestlings of the Nilgiri Pipit.

5. 3. 5. 6. Parental care of fledgling

Both parents continued to feed the young for approximately two weeks after fledging. Fledglings were seen with one or two adults. Most of the post-fledging observations were of single juveniles.

The main food of the fledglings was coleopterans (34%) and orthopterans (34%), in addition to some lepidopteran larvae (18%), dipterans and odonates (Figure 5.13). The fledglings remained themselves in the thick marshy areas near the nests during the first few days. Parents carried food from 5-50 m distance. The interval between the trips was long and the quantum of food brought in and the prey size were larger. Most of the food was collected within the territory. They communicated with each other by calls; a weak "*see…seee….*" call made by parents could help the fledglings to approach their parents and vice versa. One of the parents remained in the area while the other left for fetching food. One parent made calls when the other carried the food towards fledglings.

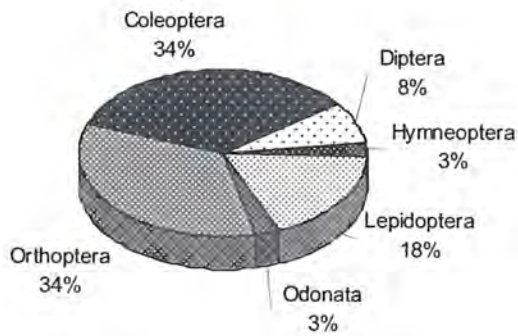


Fig 5.13 Food composition of the fledglings of the Nilgiri Pipit.

5. 3. 6. Reproductive success

On the whole 44 eggs were laid in 18 nests in the intensive study area; out of which 36 hatched, and 17 fledged making the nesting success to 38.6% (Table 5.11). Nesting success was 16.66%, 66.66% and 25% in 2002, 2003 and 2004 respectively.

Year	No of eggs laid	No of eggs hatched	Hatching success (%)	No of chicks fledged	Fledging success (%)	Nesting success(%)
2002	18	13	72.22	3	23.07	16.66
2003	18	17	94.44	12	70.58	66.66
2004	8	6	75	2	33.33	25
Total	**44**	**36**	**81.82**	**17**	**47.22**	**38.63**

Table 5.11 Summary of nesting of the Nilgiri Pipit

5. 4. Discussion

Nilgiri Pipit is strictly monogamous with both the parents investing in all stages of raising young; nest building, incubation and, feeding nestlings and fledglings.

5. 4. 1. Breeding Season

The Nilgiri Pipit breeds from late February to May with a single peak of breeding in April. However, in 2003 one nest was observed in June. Das and Vijayan (2005) recorded nesting of this pipit in Silent Valley National Park in April. This short breeding season per year is similar to that of the Water Pipit in the alpine environment (Bollman and Reyer 2001). Unlike these, in North Dakota, Sprague's Pipit has two breeding seasons, the first from late April to early June, and the second from mid-July to early September (Stewart 1975).

Breeding season of the Nilgiri Pipit was influenced positively by minimum and maximum temperatures, negatively by rainfall and relative humidity (5.2a-g) However, the Principal Component Analysis shows that the first component was closely associated with number of rainy days, relative humidity, wind speed, bright sun, invertebrate abundance, and abundance of Coleoptera and Arachnida. In most passerines in the tropics, temperature and rainfall are the major factors which regulate the breeding season (Yahya 1980, Naik and Mistry 1980, Vijayan *et al.* 1998, Das and Vijayan 2005). While the number of nests was negatively correlated with the seed abundance, invertebrate abundance had a slight correlation. The abundance of Lepidoptera, and Coleoptera was moderately high during the breeding season. All the three years, the Nilgiri Pipit started breeding activities after the pre-monsoon shower. It appears, pre-monsoon in the summer gives cues to commence breeding activities in the Nilgiri Pipit in the Upper Bhavani as found in Chamela, Mexico (Lister and Aguayo 1992) where the insect abundance increases after the first rain. In the Red-breasted Chat (Vega *et al.* 2004) also breeding season is associated with the appearance of insects. Also, in African Savannah, the peak in nesting activity of insectivores occur when insect abundance is high (Sinclair 1978). Breeding peaks varied with various factors (Sutter 1996). Abundance of invertebrates along with the pre-monsoon appears to be the major factor for the pipits. During fledgling period of the Nilgiri Pipit the orthopteran abundance was moderate and the fledglings fed more on the same. More or less similar trend was shown in the case of House Wrens (Young 1994); they started nesting two months prior to the peak in food abundance (Komdeur 1996), so that at the time of the dispersal of fledglings more insect food was available.

Breeding of the Nilgiri Pipit was at its peak during summer and it was completed before the arrival of south-west monsoon. Mostly it is having only one brood; rarely two (n=1). In 2003, during March the first brood started and in April the chick fledged and then, the pair had a second brood which fledged in June. Hence, it shows that the early breeders can try for the second brood. In tropical and temperate regions, passerine birds generally have two or more broods per breeding season (Oring 1982). This phenomenon was documented in Dotteral (Smith and Whitefield 1995) and Water Pipit (Bollmann and Reyer 2001). Lack (1968) stated that females attempting more than one brood per season should nest as early as possible, and the advantage of such early breeding was later documented by several empirical studies also. The rarity of second brood in Nilgiri Pipit shows, perhaps, the breeding season constraints as reported in the Water Pipit by Bollmann and Reyer (2001).

Fledglings of the Nilgiri Pipit disperse from the area after two weeks of the fledging. Since they never returned to the area, survival could not be assessed. It is reported that early fledglings experienced higher survival (Siikamaki 1998, Veboven and Visser 1998). It is also recorded that offspring survival seems to be reduced in early breeders under some circumstances (Perrins and McCleery 1989, Nilsson 1994). Hence, the seasonal pattern might vary between populations or between years (Van Noordwijk *et al.* 1981).

5. 4. 2. Habitat use of Nilgiri Pipit for breeding

The Nilgiri Pipit selected its major breeding ground in marsh as found in Meadow Pipit (Vanhinsbergh and Chamberlain 2001). This is because, the marsh valley could provide: a) suitable nesting habitat, b) low predation risk and, c) abundant food supply for nestlings as well as the breeding birds. The Nilgiri Pipit is very selective in their nesting area in the marshy valleys depending on factors such as cover, height of grass and nearness to stream. Zeider (1993) demonstrated how the height and thickness of saltmarsh vegetation were important for Clapper Rail nest construction and protection. Heterogeneity in habitat quality is an important factor as the Nilgiri Pipit shows habitat specific reproductive success as found by Vanhinsbergh and Chamberlain (2001) in the Meadow Pipit.

Nilgiri pipits were selective in their territories with heterogenic and dense vegetation in the marsh surrounded by creeping grass. Consistent with this, Redpath and Thirgood (1997), Vanhinsbergh and Chamberlain (2001) found Meadow pipits nest in areas containing a mosaic of heather and grass. The choice of breeding area had the largest effect on reproductive success because of differences in predation and microclimate. The Nilgiri Pipits's close relationship with marsh and the orientation towards the stream are consistent with the studies of habitat preference of Water Rail (Jenkins and Ormerod 2002). The Water Pipit females breeding on the south-west slope suffered a high rate of nest predation by adders (Bollmann and Reyer 2001), but in the north-east slope the key predator was absent. In contrast, losses through mammalian and avian nest predators did not differ in space and time (Rauter *et al.* 2002)

5. 4. 3. Territoriality and breeding density

The Nilgiri Pipit in the study area was aggressive and defended territory by the pair during the nesting season as found by Clapp (1982) in Willie Wagtail. The Nilgiri Pipit had a small territory compared to that of others (Vijayan 1984), probably because of the availability of more suitable sites offering good nest concealment and foraging area within the territory as found in the Meadow Pipit (Vanhinsbergh and Chamberlain 2001). Such a phenomenon was noted by Martin (1993) and, Petit and Petit (1996) explain that it brings about high nest density. However, Arvidsson *et al.*

(1997) records that the time saved when food is easy to find may be used to defend more space, unless increased defense costs offset the savings in foraging time.

One pair of the Nilgiri Pipit which appeared to have nested in the same area in the previous year, remained throughout the year and bred in the subsequent year. This pair occupied the marshy area. Territories occupied in the beginning of the breeding season (1, 5, 1a and 1b), defended larger areas, but with the arrival of more pairs, the size of the territories got gradually decreased, in spite of the defense between the pairs. However, the last arrived pair established larger territory (13a) when almost all other breeding pairs had completed their breeding activities.

The early nesting pairs (1a, 1b, 3b, 5a, and 5b) were successful in the case of Nilgiri Pipit. Earlier arrival may give some advantages, for example obtaining a good territory (Mitrus 2004). Many studies on passerines have shown a positive correlation between early breeding and reproductive success (e.g. Stutchbury and Robertson 1988, Bensch and Hasselquist 1991, Potti and Montalvo 1991, Tye 1992, Lundberg and Alatalo 1992, Johnson 1997). This is because early birds have advantages in resource acquisition and are phenotypically superior (Arvidsson *et al.* 1997).

Density of breeding Nilgiri pipits was high in the Upper Bhavani than in other surveyed areas. The distance between the nearest two nests was 5 m, 10 m , 12 m and 20 m. In four cases, the nest of Paddyfield Pipit was noticed, one each closer to the nest of Nilgiri Pipit. The entire eight nests in 2002, six in 2003, four in 2004 were in an area of 4 ha, 6 ha and 4 ha respectively. Therefore, the nesting density was comparatively higher (average: 1.5/ha) . Though such phenomenon was observed in the Water Pipit (Bollman *et al.* 1997), there was no density-dependent variation in its reproductive success (Bollmann 1996). Higher density of nests could reduce predation rate through better predator detection and more efficient defense and distraction (Witenberger and Hunt 1985, Anderson and Hodum 1993). In contrast, disadvantage of density also was noted such as intra-specific competition for food and nest site influencing breeding success (Wiens 1989) and, increased predator attraction with increasing density (Hoi and Winkler 1994, Kleidorfer *et al.* 1996).

5. 4. 4. Nest-site selection

Habitat quality traditionally has been viewed as the primary factor in nest-site selection for birds (Danchin and Wagner 1997). High diversity of grass and herb in the marsh, the dome like vegetation cover over the nest and, nearness of stream are the basic characteristics of the nest-site of the Nilgiri Pipit. Vegetation cover directly over the nest helps in concealment (Schieck and Hannon 1993, Delong *et al.* 1995, Howlett and Stutchbury 1996), which could reduce the risk of nest predation as it reduces detection by or access to predators (Martin 1995, Rangen *et al.* 1999). It could impair the movements or foraging efficiency of predators (Sugden and Beyersbergen 1986). Chances of successfully raising at least one chick were higher for nests with vegetation cover (Yorio *et al.* 1995). Further advantages to the Nilgiri Pipit for having the nest with vegetation cover could be of protection from the weather, either as a windbreak or sun-shield, as in ground nesting larks and other grassland birds (Maclean 1970, With and Webb 1993) or suitable microclimate for the chicks (Calder 1973) as reported in other grassland bird community and in Black-throated Blue Warbler (Holway 1991). Vegetation cover over nests can also be beneficial at night, because the vegetation limits heat loss and emits 20-30% more long-wave radiation than the night sky (Walsberg 1985). Nesting inside the grass tussock also might have importance for protecting the nests from thermal environment (Hoekman *et al.* 2002). Most ground-nesting species in the arid regions of southern Africa, house their nests at the base of small herbs, stones and grass tufts to get at least some shade during the hottest time of the day (Maclean 1970), when ground temperature regularly exceeds 45^0C (Dixon and Low 1978). In the Nilgiri Pipit also temperature plays a vital role in the selection of nesting site, as the vegetation characteristics are strikingly different between used and unused nest sites; the former with more cover. In contrast, Ricketts and Ritchison

(2000) found no differences in vegetation characters between used and unused nest sites, that correlated with nesting success.

Prey abundance appears to be one of the important factors influencing site selection of the Nilgiri Pipit. It may influence choice of nest sites through the benefits of more efficient nestling provisioning (Schroeder 1990, Smith 1991). The difficulty in searching food may be the reason for avoiding the inner area of marsh, and using the ecotone between the marsh and the feeding area for feeding the chicks as well as nest guarding. Moreover, lepidopteran larvae and Arachnidae were more in the ecotone and the orthopterans in the feeding area. It is correlating with the faecal content of the nestlings; Arachnidae (10%) and Lepidoptera (24%). It is reported that food abundance reveals insight into habitat quality (James 2001) and the female selects habitat which has adequate resources to successfully rear offspring and maintain lifetime fitness (Post and Greenlaw 1982).

Nest patch variables were recorded in each nest-site and compared with the unused sites to find out the important parameters which regulate the selection of nesting site in the Nilgiri Pipit. The nest patch has been defined as the habitat patch immediately surrounding the nest (Martin 1988). Among the parameters selected, distance to water (river/stream), grass and herb cover over the nest and, grass height over the nest was different from the unused sites. All the nests were towards stream. Two possible reasons for this obvious preference are that invertebrates concentrated at the bank of the stream provide abundant prey close to the nest and, the avoidance of mammalian predators those hesitate to enter into the water. Grass and herb cover were important for concealment, especially from aerial predators. Although the grassy slopes with creeping grass is more abundant where the pipit feed often, the nesting patch differed - the marshy areas, as in the songbird (Martin and Rooper 1988, Kelly 1993, Steele 1993, Kligo *et al.* 1996a, b). There may be differences between successful and unsuccessful nests according to nest patch characteristics (Martin and Rooper 1988, Kelly 1993, Norment 1993, Tarvin and Smith 1995, James *et al*. 2002).

Nest height from the ground is one of the parameters influencing the selection of nest patch in the Nilgiri Pipit. Presence of ground predators and the drastic changes in ground temperature by frost and rain might be the reasons for selecting the site from 12 to 19 cm above ground.

Site fidelity is noted in the Nilgiri Pipit. A ringed male (nest 1, 1a and 1b) returned to the same site thrice during study period. The tendency to return each season to the same nest site or breeding colony, known as "site tenacity," "site fidelity", or "philopatry" is wide spread in passerine birds (Greenwood and Harvey 1982). The major advantage of returning to an established breeding site is that the bird's familiarity with the area results in reduced susceptibility to predation and other adverse conditions (Switzer 1993). In the case of Nilgiri Pipit, nesting-site fidelity may be due to discontinuous distribution of marshy grasslands with suitable resources. Nest-site choice would depend on the behavioural plasticity as a function of previous success (Switzer 1995, 1997, Martin 1998, Yosef 2001). Successful double brood of the Nilgiri Pipit shows that previous success is a definite factor determining nest-site selection. Apart from these, sex and age of the nesting bird, and physical stability of the nest site are all important factors affecting site tenacity (Switzer 1997). Survival and reproductive benefits afforded through familiarity and prior experience of quality habitats have been demonstrated to promote site fidelity in many birds (Jamieson and Zwickel 1983, Bollinger and Gavin 1989, Bensch and Hasselquist 1991, Ligon *et al*. 1991, Montalvo and Potti 1992). Dispersal of female may be influenced by familiarity and previous experience with available habitat (Reynolds and Cooke 1988, Part and Gustaffson 1989, Bensch and Hasselquist 1991). Male dispersal may be influenced by their prior experience with female abundance and availability (Reynolds and Cooke 1988, Wheelwright and Mauck 1998).

One male Nilgiri Pipit ringed in the beginning of the study period helped to identify the male's tenacity towards the used nest-site in the forthcoming years. In general, males tend to return to the same site and are able use to its advantage, whereas females are free to search for males of the highest quality. This situation is illustrated in most birds (Greenwood and Harvey 1982, Clarke *et al.* 1997). Individuals may be using reproductive experience to assess habitat quality of the site (Switzer 1993, Aebischer *et al.* 1995, Switzer 1997) such as nearness of stream, vegetation density, and nest placement above ground. While other cues, such as habitat structure (Smith and Shugart 1987) and the presence of con-specifics (Stamps 1991) like the Paddyfield Pipit in the study area may also provide information on the suitability of a habitat.

5. 4. 5. Nesting

The breeding pair of the Nilgiri Pipit collects the nesting material and builds the nest in between the feeding bouts. They select the nest materials from the nearest available site inside the territory. In nest 1a and 1b, the nest materials were collected from the same patch. Material of the nest for basement was collected from below the shola trees just 15 meters away and, for lining just two meters from the nest site. This apparently could be to save time for feeding in between the nesting bouts, as nest building activity itself is energy expensive and, many trips are required to complete the nest (Putnam 1949, Collias and Collias 1984). It could also be to avoid the possible exposure of birds to an increased risk of predation (Lima and Dill 1990).

5. 4. 5. 1. Orientation of nest: All nests of the Nilgiri Pipit were oriented towards stream and mostly towards east and, towards the runway to the feeding places. Similar nest orientation pattern was noted in the Sprague's Pipit (Sutter 1996). By placing the nest or its entrance towards the most favourable direction, birds reduce their exposure to prevailing winds, avoid direct exposure to severe storms, or get the best insulation conditions (Collias and Collias 1984), thus achieving a favourable thermal environment. A few studies have documented the influence of microclimate on nest orientation (Inouye *et al.* 1981, With and Webb 1993). The factors that affect the nest orientation in the Nilgiri Pipit appear to be easy approach to the streams for escape and feeding sites and, the vegetative cover at the nesting site. While the first two relate to predation risk and feeding efficiency, the third factor, i.e the direction to the east apparently helps in thermal regulation. The pattern of nest orientation related to vegetation was reported in several other species in a variety of ecosystems (Canning 1981, Cannings and Threlfall 1981, Verbeek 1981, Walsberg 1981, Zerba and Morton 1983a, Petersen and Best 1991, With and Webb 1993).

5. 4. 5. 2. Incubation: Incubation in the Nilgiri Pipit usually started when the last egg was laid, which decreased the duration of hatching within a brood. The incubation period varied from 12 to 16 days which is comparable with the incubation period reported for other Pipits; 12-13 days in African Pipit (Van Someren 1956, Tait 1991), 14 days in Sprague' Pipit (Maher 1973), and 14.5 days in Water Pipit (Verbeek 1970). Throughout the incubation period, the male feeds the female which is expected to increase attentiveness by the female as reported in Water Pipit (Verbeek 1970) and in Meadow Pipit (Halupka 1994). This may help the female to avoid predators and to provide ambient temperature to the brood through out, as suggested by Halupka (1994).

5. 4. 5. 3. Food of nestling: Both direct observation and faecal analyses were done to identify the important food of nestlings. The analysis of faecal droppings has certain advantages over direct observation, considering the difficulties in identifying the prey captured by adult birds (Greig-Smith and Quicke 1983, Moreby 1988, Gallbraith 1989, Jenni *et al.* 1990, Gallbraith *et al.* 1993, Brickle and Harper 1999, Moreby and Stoate 2000). One of the main advantages of faecal analysis is the ease with which samples can be collected with very little distress to young chicks (Jenni *et al.* 1990).

Food of nestlings is exclusively of animal material as reported elsewhere that nearly all small land birds switch to protein-rich animal diets during the breeding season especially for feeding their young (Martin *et al.* 1951, Bird and Smith 1964, West 1973, James 2001, Mizutani and Hijii 2002).

The main food items identified through direct observation were lepidopteran larvae (33%), orthopterans (25%), dipterans (20%) and coleopterans (17%), whereas faecal contents had coleopterans (33%), lepidopteran larvae (23%), orthopterans (16%), and arachnids (10%) in that order of abundance. Although these insects were moderately abundant during summer, the most abundant group was dipterans. It is reported that composition of prey items fed to nestlings is influenced by prey availability in the area (Bauer 1992, Bollmann and Reyer 1999). This doest not hold true for the Nilgiri Pipit. Here, it appears to be the size of the food material which influences the food selection for nestling, purely based on profitability (Charnov 1976, Krebs 1986).

The Nilgiri Pipit carried several prey items simultaneously in their beak (multi-prey loader) to the nest. In the initial stage, the size of the prey was large like caterpillars and grasshoppers, but the frequency of feeding was less. And the number delivered also was small. Earlier studies demonstrate that avian single prey loaders preferably transport larger prey to their nests (Carlson 1985, Krebs and Avery 1985, Yosef 1993). Nilgiri Pipit increases load size as well as frequency of feeding with the increasing age of the nestlings. But the frequency declined after the 8th day. Again increased on the 10th day and maintained almost the same frequency till they fledged. The volume of food increased with the age of the nestlings in the Nilgiri Pipit as reported in other species (Pinkowski 1978, Walsh 1978, Beirmann and Sealy 1982, Breitwisch *et al.* 1986) and, the volume of food delivered per visit also increased with increasing nestling age (Johnson and Best 1982, Breitwisch *et al.* 1986, Haggerty 1992).

There is evidence that with increasing distance of the foraging site to the nest, Water pipits select heavier prey and increase load size (Frey Roos *et al.* 1995). In the case of the Nilgiri Pipit also the load appears to have increased towards the advanced age of the nestlings; but the foraging distance was almost the same, confining to its own territory. Differences in brood size and nestling age may contribute to changes in feeding rates or the size and type of prey delivered to nestlings as in the Bachman's Sparrow *Aimophila aestivalis* which made more feeding visits to large broods than to small broods (Haggerty 1992). But such a phenomenon was not seen in the Field Sparrow *Spizella pusilla* (Best 1977).

The feeding frequency of the nestlings showed a bimodal pattern, most of the feeding trips were between 0800 -1100 h, and 1300 - 1800 h. The record of feeding frequency during nestling period leads to a greater understanding of the foraging strategies and of the effort made by the parents to raise their young, as well as to a better identification of the factors which might affect bird's activity (Freitag *et al.* 2001).

Both the sexes shared feeding the nestlings; the male fed more frequently in the first three days till the female took over the responsibility on the 4th day. Since then she continued feeding the chicks progressively. The female brooded the newly hatched chicks most of the time during the first three days while receiving the food for her from the male. The total contribution of the male feeding the nestlings was slightly more (55%) than that of the female (45%). In the Willie Wagtail (Andrzej 1994) the male's contribution exceeded in some nests, although the average was high in the case of female. The males and females of monogamous bird species should contribute equally to most breeding activities (Clutton-Brock 1971, Trivers 1972). In the case of the Nilgiri Pipit, the female appears to be more cautious and hesitant to approach the nest with food, before getting a 'signal call' from the male. This reduces their participation in feeding the chicks. In true monogamy, both parents gain the same future benefit from survival of their offspring, and it has been found on many occasions that biparental care can appreciably improve reproductive success (Alatalo *et al.* 1988, Whitingham 1989, Wright and Cuthill 1989, Wolf *et al.* 1990).

Male Nilgiri Pipit fed with larger food items to its female during courtship, egg-laying, incubation and brooding which is a familiar behaviour in passerines and can be considered as a form of indirect parental care (Lyon and Montgomerie 1985).

5. 4. 5. 4. Food of fledgling: The main food of fledglings as identified through direct observation was coleopterans, orthopterans and, lepidopteran larvae. Although the abundance of orthopterans and coleopterans were high in the fledgling period, dipterans were dominant throughout. Still the preference was for coleopterans and orthopterans. However, Orthoptera as a group was more abundant during fledgling period of the Nilgiri Pipit and it correlated with the high intake of grasshoppers. It is reported that abundance of grasshoppers and the diet of nestlings brought by the parents were directly correlated as availability is a major factor influencing usage and appearance of food items in the diet (Krementz and Ankey 1988, Twedt *et al.* 1991). Grasshoppers formed an important component of the breeding-season diet of the Nilgiri Pipit as in many other avian species (Martin *et al.* 1951) probably due to their high crude protein content (>50%), energy value, and other nutrients (DeFoliart 1975, Ueckert *et al.* 1972). Declines in large invertebrates have been implicated in the extinction of the breeding population of the Red-backed Shrike *Lanius collurio* in UK (Van Nieuwenhuyse *et al.* 1999).

The duration of parental care of fledglings in the Nilgiri Pipit is almost the same as the nestling period, lasting for about two weeks as in Water Pipit (Bent 1950) and in most passerines (Skutch 1976). The care offered by the parents for the fledglings is important for the survival of fledglings because of the little experience they had in foraging and predator avoidance (Anders *et al.* 1998).

The Nilgiri Pipit showed mate guarding throughout the breeding period as in Red-Breasted Chat (Vega *et al.* 2004). The male did the job mostly which according to Bjorkland and Westman (1983), and Moller (1987) can significantly reduce the frequency of extra-pair copulations by females, while according to Patricia *et al.* (1989) it can provide sufficient food to the young and help avoidance of predators.

5. 4. 6. Reproductive success

Nilgiri Pipit is socially monogamous in that typically a single pair builds a nest and only the female incubates. Nesting success was low in 2002 and 2004, where as it was high in 2003. The reproductive success of the Nilgiri Pipit was 16.66% in 2002, 66.66% in 2003 and 25% in 2004.

The hatching success of the Nilgiri Pipit was 92.85% in 2002, 94.44% in 2003 and 75% in 2004. The fledgling success was 23.07% in 2002, 70.58% in 2003 and 33.33% in 2004. A high risk of predation was seen in the early nestling period of the Nilgiri Pipit, as in most altricial birds when they are confined to the nest. During this time mortality rates are high and many nests fail (Leibezeit and George 2002). Predation risk can vary between stages of the nesting cycle also. Skutch (1949), Redondo and Castro (1992) have reported higher predation rates during the nestling period. In the Nilgiri Pipit there was no direct observation on predation, but most of the nests appeared to be preyed upon by unknown predators. Although several sources of egg and nestling mortality have been described, predation seems to be the main cause of nest loss in most studies (Ricklefs 1969, Martin 1993a).

The reproductive success of the Nilgiri Pipit varied among the years indicating that several factors affect the success. Variations in nesting success within the breeding season (Lack 1966, Perrins 1970) were also noticed. The early breeding pairs of the Nilgiri Pipit (nest 1a, 1b, 5, 5a and 6a) were more successful. Most of the early-nesting birds had a higher reproductive success. Of the various factors influencing reproductive success in birds, the most important is the amount of food available to raise the young (Lack 1968, Drent and Daan 1980, Martin 1987, Boutin 1990). In the case of the Nilgiri Pipit this appears to be partly true. However, it is not the abundance of any particular group, but the availability of comparatively more profitable food. The pipits feed on invertebrates during the breeding season and also feed the chicks with the same. The insects they feed are mainly colepterans, lepidopteran larvae, and orthopterans. Although these were present in the intensive study area throughout the year, the dominant insects present were dipterans. Coleopterans and lepitdopteran larvae were moderately high in the summer, but their peak of abundance was in other season. It is therefore the profitability and not mere abundance that determines the food as mentioned earlier.

Pattern of rainfall could be one of the factors affecting the reproductive success. In March-April, when nesting was at the peak, the rainfall was quite low (16 mm) in 2002, moderate (246 mm) in 2003 and again less (4 mm) in 2004. The number of rainy days was eight in 2003 and one in 2004. The reproductive success was the highest in 2003 when rainfall was modest while the number of rainy days was high. This might have been one of the reasons for the increase in number of breeding pairs (eight) in 2003. However, the quantum of rainfall in the subsequent month, may also appear to affect the success; heavy rain in May reduces the success; in May 2002, the rainfall was 272 mm and the success was 16.66%; in May 2003 it was 65.2 mm and the success was 66.66%, while in May 2004 it was 646.2 mm and the success was 25%. Hence, moderate rainfall is more suitable for nesting success in the case of Nilgiri Pipit. However, it has been reported that in general, less rainfall in breeding season gives more suitable environment for nesting successfully (Cooke *et al.* 1995).

Food availability could be one of the factors for fluctuation in annual breeding success. Among the three years, food abundance was the maximum in 2003, so also the nesting success. Year-to-year differences in fledgling productivity and nest predation levels have been shown in several cases (Rotenberry and Wiens 1980, Petrinovich and Patterson 1983). Nesting success can differ temporally (Perrins 1965, Lack 1966).

One of the major reasons for the high success during 2003 could be the removal of cattle grazing from the nesting area. However, during 2004, although the cattle were absent, the success was comparatively low.

Annual reproductive success of birds may be influenced by a variety of factors such as temperature (Perrins 1965, Goodburn 1991, Rodenhouse and Holmes 1992, Simmons 1993), precipitation (Grant 1986), abundance of food (Lack 1954, Hogstedt 1980, Zanette *et al.* 2003), demograpghic variables such as age and experience of breeders (Perrins 1979, Buitron 1988, Birkhead 1991) and interspecific interactions such as competition (Hogstedt 1980) and predation (Perrins 1979, Zanette *et al.* 2003).

Predation pressure on the Nilgiri Pipit is poorly known but they seemed to occasionally fall prey to eagles, kestrel and buzzards. Birds of prey, namely common Kestrel, Black-winged Kite, White-eyed Buzzard, Common Buzzard, Crested Serpent Eagle, and Shikra were frequent visitors in the area. Only one observation of predation on adult pipit could be obtained during the study period. Feathers of the Nilgiri Pipit along with those of a raptor were observed. However, it is more likely that predation pressure is high on the young chicks, as 42% of the chicks were lost presumably because of predation. It is reported that nest predation is the most important proximate cause of reproductive failure in birds (Martin 1995).

Response to the predators by the parents was not observed frequently, but there was threshold distance from where parents responded against the predators approach. It was 5-6 m for an approaching jackal and the Jungle Crow. The response varied; it made alarm calls and ran here and there when the Jackal approached, whereas the pipit flew off when the Jungle Crow reached the threshold distance. The bird froze itself when the Buzzard and Black Winged Kite came 100 m above the nest. It has been reported earlier that nesting birds start to respond to an approaching predator when it reaches a threshold distance (Kruuk 1964, Curio and Regelmann 1985). Birds behave differently (more or less conspicuous) in the presence of ground-living and flying (olfactory and visually oriented) nest predators (Buitron 1983, Byrkjedal 1989, Brunton 1990). The Nilgiri Pipit removes the brood sac from the nest regularly. This finding is consistent with the hypothesis that fecal sac removal reduces cues predators use to locate nests with the smell of sacs.

Fire during the breeding season could be one of the threats to the survival of the Nilgiri Pipit. Although there was no fire in the intensive study area, adjacent areas including the hut area inside the National Park were burned by forest fire. The area is prone to fire from the end of winter to the end of summer till the rain commences. There was no observation of destruction of nests during the study period. However, nests with eggs or chicks of the Nilgiri Pipit destroyed by fire were recorded at several localities (pers. comm. Kunhikrishnan 2004, Das and Vijayan 2005). Although there was no record of nest loss in the study area, fire alters the microhabitats and reduces insect abundance (Forde *et al.* 1984), the two major factors vital for breeding success.

5. 5. Summary

- Breeding biology of the Nilgiri Pipit was studied from February 2002 to June 2004 in a 14 ha grassland in the Upper Bhavani area in the Upper Nilgiris.
- The Nilgiri Pipit has a very short breeding period; from February to June with a peak in April.
- Average nesting density is one nest / ha in the nesting area. While it varies from 0.3 to 0.6 nests / ha in the study area of 14 ha during different years.

- The breeding season has positive correlation with maximum and minimum temperatures and negative correlation with rainfall, relative humidity and seed abundance.
- Abundances of Coleoptera, Orthoptera are important factors influencing the breeding season.
- The Nilgiri Pipit prefers marshes on grassy slopes for nesting.
- Major nest-site characteristics are nearness to water (river/stream), higher density of grass and herb cover and grass height.
- The Nilgiri Pipit shows site fidelity.
- It is highly territorial; the average territory size is 0.154 ha.
- Male defends the nest most.
- Nest is a cup, fully concealed in a depression, mostly at the base of tussocks of grasses.
- Nest is placed at a mean height of around 5 cm.
- Nest construction takes 5-6 days.
- Nest construction is mostly by the female, as much as 90%.
- Clutch size is mostly two, rarely three or one.
- Incubation period is 14 - 15 days; incubation is exclusively by the female.
- The male and female are involved in feeding the nestlings; first three days only by the male as the female broods and latter mainly by the female.
- Major diet of the nestlings and fledglings comprised, Lepidoptera, Orthoptera, Diptera and Coleoptera in varying proportions.
- Abundance of the above groups of insects and the pattern of rainfall influenced the breeding seasons.
- Average reproductive success for three years is 38.64%; nesting success being the highest (66.66%) in 2003.
- Early nesting pairs are more successful.
- Predation pressure is higher at the nestling period.
- Grassland fire and cattle grazing affect the breeding habitat of the Nilgiri Pipit.

Chapter VI

Activity budget and pattern of the Nilgiri Pipit

6. 1. Introduction

The behavioural patterns of animals are the product of their interaction with external biotic and abiotic stimuli (Ramachandran 1998, Robinet *et al.* 2003). Time or activity budget is a quantitative description of how animals apportion their time for feeding and other activities (Baldassarre and Bolen 1994). It is species specific and adapted to local environmental conditions (Verner 1965).

It also reflects a combination of factors including individual physical condition, social structure and environmental conditions (Paulus 1988). The amount of time allocated to various behaviours is therefore critical in understanding a species' ecological needs and the pressures acting upon the individuals (Muzaffar 2004). Examining the influences of temporal and environmental factors on a species' time budget will enable us to understand the ecological significance of behavioural pattern (Boettcher and Heig 1994). Although some types of behaviours require more time and energy than others, the optimizing paradigm predicts that the individuals perform at the most opportune time (Smith 1976).

The basic activities of the species for its own survival are mainly foraging; maintenance such as roosting, resting and preening; and breeding. Seasonal variation in the reproductive activities (Verner 1965, Vijayan 1984), day length (Gibb 1956), ambient temperature (Verbeek 1964, 1972) and food abundance (Boxall and Lein 1989) affect the activity budget of the species. The ability of the species to fruitfully allocate time for each activity according to the changes in the environment manifests its mechanism of adaptation to environment (Engel and Young 1992).

Since the animals select particular habitat for particular activities (Palomares and Delibes 1992), information on the activity pattern and budget would help evolve conservation programme for the species (Robinet *et al.* 2003). As there is no information on these aspects of the Nilgiri Pipit, a study was undertaken to document the activity pattern and budget and, the spatial and temporal variations in the same.

6. 2. Methodology

Activity pattern of the Nilgiri Pipit was observed for 598 hours over two years (2002-2004) and data were pooled into four seasons. The seasons were defined with respect to the weather, regardless of the year. Observation was made in two sessions from 0600 h to 1300 h in a day and 1300 h to 1900 h in another day making two full day observations of 26 h in four days. Direct observation following Focal Animal Sampling method (Altmann 1974) was made, using a pair of 8 x 42 binoculars and 20X telescope. Each bird was observed as long as possible. The duration of each activity was measured by a stopwatch. At each observation, the following details were recorded: a) time of the day, b) locality, c) specific activity such as feeding (searching and catching), d) breeding (territorial, courtship, nest-building, egg-laying, incubating the egg, brooding the chick and, feeding the nestling and fledgling), e) maintenance (preening, oiling, stretching, bathing, resting, scratching, fluttering the body and tail), f) spatial activity (walking, running and hopping), g) agonistic (threatening, fighting, fleeing, submitting, hiding, buffing, icing) and, h) vocalization (calls/songs).

Awakening and roosting behaviour were also recorded. Time of the first call or sighting was considered as the awakening time; in most cases it is the first flight from marsh (roosting site) to feeding area or to the perch on adjacent trees. The time of last flight to the marsh is considered as roosting time. As there was no information on the roosting site of the species when the study was commenced, the first few records were omitted in order to avoid bias.

6. 2. 1. Data analyses

Time spent for each activity in each hour and the total for a day was calculated. The percentage of time spent for each activity during the hour was estimated. The data were pooled for each season, for breeding and non-breeding periods and also for the total study period to obtain the activity budget for the respective periods. The activity of the Nilgiri Pipit was classified into six major categories for analysis, namely feeding, breeding, maintenance, spatial, agonistic, and vocalization or communication (Pettingill 1985).

Different samples of the same season were pooled, and the activity pattern for that season was plotted, using a locally weighted smooth procedure (Wilkinson 1988a). The paired't' test were employed for seasonal comparison of activities using SYST (Wilknson 1988b). The activities were correlated with the environmental parameters using Spearman's correlation in SPSS (10.0).

6. 3. Results

6. 3. 1. Description of the activities of the Nilgiri Pipit

6. 3. 1. 1. Feeding and breeding

Feeding and breeding activities which form bulk of the activities are explained in Chapters IV and V respectively. While feeding, Nilgiri Pipit walks along the creeping grass ground and picks up the prey off the grass or herb foliage. It wags its tail up and down at each bout of feeding. Activity such as territory defense, courtship, nest-building, egg-laying, incubation, brooding and feeding the nestlings and fledglings are considered as breeding activity while dealing with activity budget.

6. 3. 1. 2. Maintenance

Maintenance activities included preening, oiling, spreading the wings and tail, fluttering wing, shaking the body and tail, scratching eyes and shoulders, sunbathing, bathing and resting.

Preening commences from the body feathers and on completion moves on to wings and tail and finally head (Figure 6.1). Preening is done during sunning and also between the feeding bouts, the latter in the feeding ground itself.

Fig 6.1 Preening of the Nilgiri Pipit

Oiling was done in between preening, but the sequence followed was from wings to tail, body and head (Figure 6.2). The Nilgiri Pipit spreads and also flutters the wing in between preening. It scratches the eyes and shoulders with legs (Figure 6.3), mostly during feeding among the grasses and also when perching on the grass blades inside the marsh during morning and late evening.

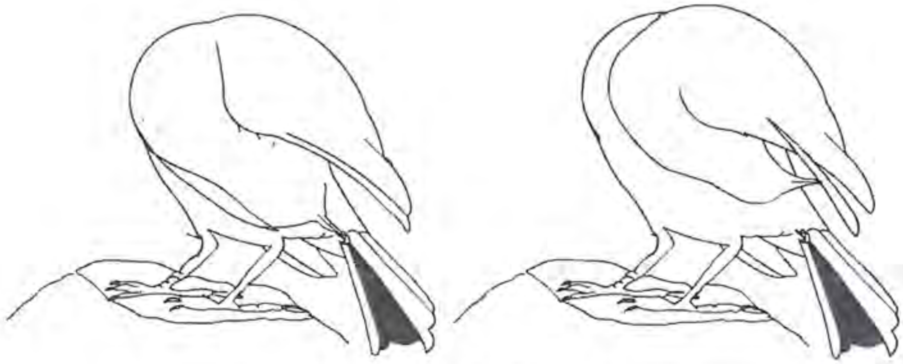


Fig 6.2 Oiling of the Nilgiri Pipit

Fig 6.3 Scratching of the Nilgiri Pipit

Sunning: The Nilgiri Pipit exposes itself to the bright sun, stretching the body and wings with fluffed feathers while perching on trees, logs or stones. Occasionally, it turns to face the sun.

Bathing of the Nilgiri Pipit was observed in shallow pools. While bathing, it dips its body, mainly the breast and wings followed by head with frequent fluttering (stand - in method). On completion, it moves on to the feeding ground or to a perch and begins fluttering and preening as if to dry the feathers. Bathing was observed only in the evening before roosting (Figure 6.4).

1. Entering in the pool

2. Dipping the breast and body

3. Dipping the wings and tail

4. Fluttering in the water

5. Dipping the head

6. Looking up after bath

Fig 6.4 Bathing of the Nilgiri Pipit

Resting: The bird is considered as resting when it perches on a branch and remains there with fluffed feathers without any activity. Resting was more in the afternoon.

6. 3. 1. 3. *Spatial activity* includes any movement of the bird by walk whose purpose could not be assigned. It could be a movement from one micro-habitat to the other.

6. 3. 1. 4. Agonistic behaviours considered here are those in response to threat including withdrawal. The pipit bends its whole body, remains silent without any activity when threatened, often among grasses and herbs that help camouflaging the bird. While chased by species such as Paddyfield Pipit, Pied Bushchat and Prinia, the Nilgiri Pipit mostly withdraw by flying into the marsh or perching on a tree. Rarely was it seen showing aggressive behaviour towards other species. Breeding males of the Nilgiri Pipit constantly engage in trespassing into the neighbour's territory. Intruding males are aerially pursued and chased; also fought in the air. Chasing occurred often but it lasted only for a few seconds. Body contact and fight between males were common (Figure 6.5); at times quite severe with much thrashing of wings, jabbing of bills, and clawing. Once a fight lasted for eight minutes, during which two males grappled intently for a while, let off and again grappled repeating the same four times lasting from 1730 to 1738 h.

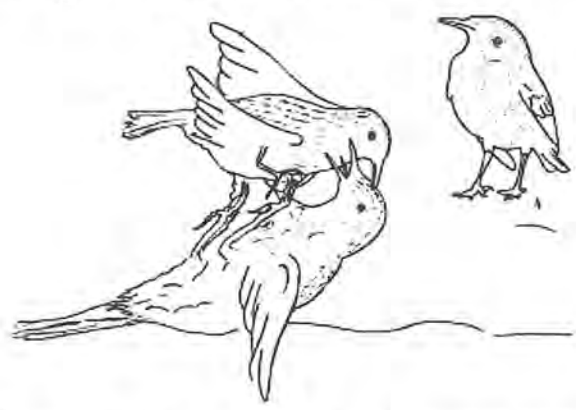


Fig 6.5 Fighting between male Nilgiri pipits

6. 3. 1. 5. Vocalization The calls and songs of the Nilgiri Pipit were difficult to distinguish, although the latter is long with varying pitches. However, 40 types of vocalizations could be distinguished (Appendix 3). The most common ones are given below with the 'guessed' purpose.

***Breeding*:** Communication between the parents in the territory sounds like a *seee….see….* by one which is responded by *sisisisi….sisisisi* or, *chwee..chwee..* responded by *chr..she..shwee…sheweee.* Male's signal to female when the food is brought to her is by a weak si…si…. The typical call of a male in the territory is *trrrr……sheee….shee…..* & *shwee…shishishishi…….* Male's signal to female while carrying nest material to the nest and the female's response are *shi…shi…shi…* and *kre..ke..shee…*respectively. A weak *see…. see….* is the signal to the nestlings when the parents bring food.

Feeding: After a few feeding bouts when the male perches on a tree it calls like shwee..shi..shi..shi… and the female answers yiyo.. yiyo.. yiyo ..yiyo.. from feeding ground. When shifting from one feeding site to the other, they give *si..si..si..i…*and move or fly to other site. The feeding-pair communicates with each other with different calls; *ki.ki..ki..shiyo..shiyo…. ; tree…trrr…; treee…se….* When take off from the perch or feeding ground it calls *sisisisi….,* when perches on a tree or on grass *shishishishee….*and, when the pair sits close to each other *chr..she..shwee…sheweee.*

***Alarm call*:** Typical alarm call is *kwe…trwe…sisi…* Intra-species intruders into the territory are warned by the owner with *kwe..kwe..shwee….* Other related calls are: if the intruder dares to fight *see…shishishihsishiyo..shiyo….;* while chasing species like Paddyfield Pipit *krew…krew… ;* when predator approaches the vicinity *kr….shwee… and , shwe.. shwe….shwee….sisisisi…. ;* when chase other individual *chewe..chewe shrew…..* and, when fighting with each other *loud sisisisisisii….Shwey….shwee… qli…qli…qli…qli…*and *see….see….see…see…* louder in between. After the combat the winner calls from the feeding ground itself *Erkrwey…tritri….* but the loser calls from perch *shishishishi…. Shishi…shishi…*

Preening: When the bird preens, it makes a variety of calls; *Shwee……… , shwee…..shoe..shoe…. , see..se..se..se… , trrr……..shee.shee……shee…… , shi.shi…..shi….. , chew…..shee….. , shiyo…….shiyo……shiyo…….. , chwe….chwe…..chwe…… .*

Roosting: When the Nilgiri Pipit goes to roost, it makes *chick..chick…chick…* together for some time .

6. 3. 2. Activity budget

Out of the 598 hours of observation for assessing the activity budget of the Nilgiri Pipit during 2002-2004, the total contact hours with the bird was 380.80 h. The Nilgiri Pipit spent 185.76 h (49%) for feeding followed by 68.73 h (18%) for breeding, 59.93 h (16%) for maintenance, 37.32 h (10%) for vocalization, 19.69 h (5%) for spatial activity and, 9.37 h (2%) for agonistic behaviour (Figure 6.6).

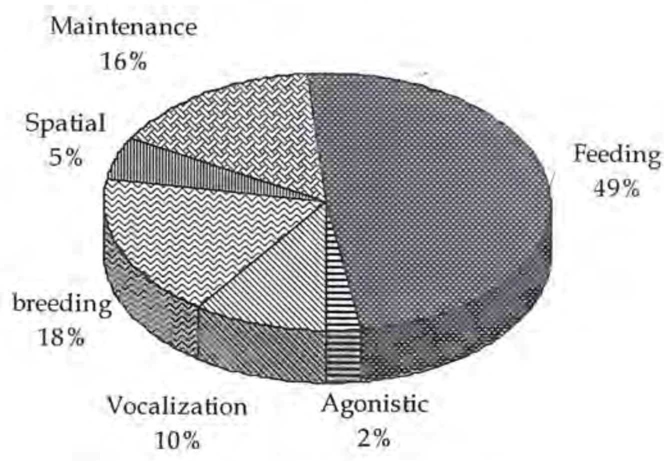


Fig 6.6 Activity budget of the Nilgiri Pipit (2002-2004)

6. 3. 2. 1. Yearly variation in activity budget

There was no apparent difference in the activity budget between the years. Feeding was the major activity followed by breeding and maintenance with some slight variations. In 2002, the time spent by the Nilgiri Pipit for feeding was 47% followed by breeding (21%), maintenance (20%), and vocalization (7%) (Figure 6.7a). In 2003, it was slightly more for feeding (51%) than for breeding (14%) and maintenance (12%) (Figure 6.7b).

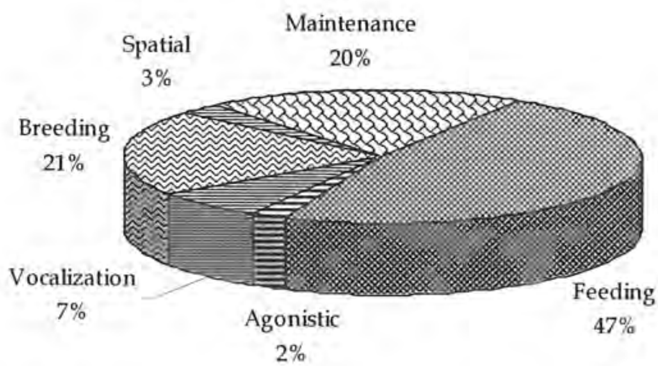


Fig 6.7a Activity budget of the Nilgiri Pipit in 2002

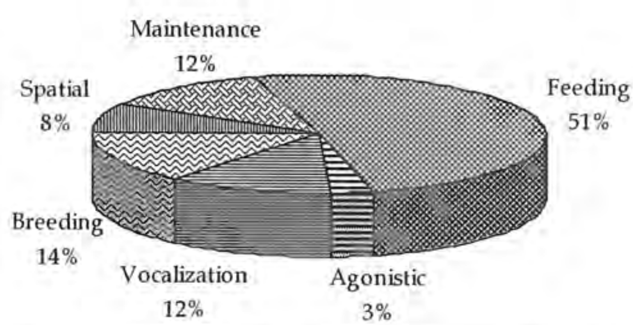
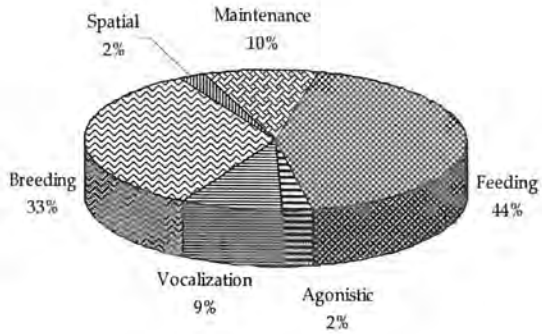
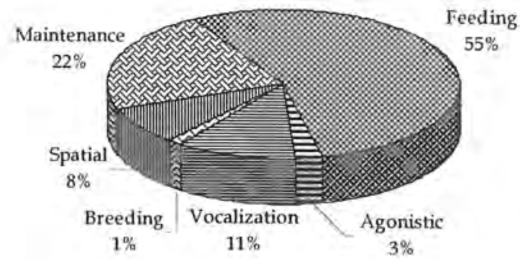


Fig 6.7b Activity budget of the Nilgiri Pipit in 2003

6. 3. 2. 2. Activity budget during breeding and non-breeding seasons

Seventy seven percent of time was spent for feeding and breeding activities during the breeding season, 44% and 33% respectively (Figure 6.8a), whereas during non-breeding season 55% of time was spent for feeding and 22% for maintenance (Figure 6.8b).





a During breeding b During non-breeding season

Fig 6.8 Activity budget of the Nilgiri Pipit

6. 3. 2. 3. Seasonal variation in the activity budget

The time spent for feeding was the maximum in all the four seasons- 44% to 62% , while for breeding it was confined mainly to summer (33%). Time spent for maintenance was 10%, 13%, 28% and 19% respectively for summer, south-west, north-east and winter respectively (Figure 6.9).

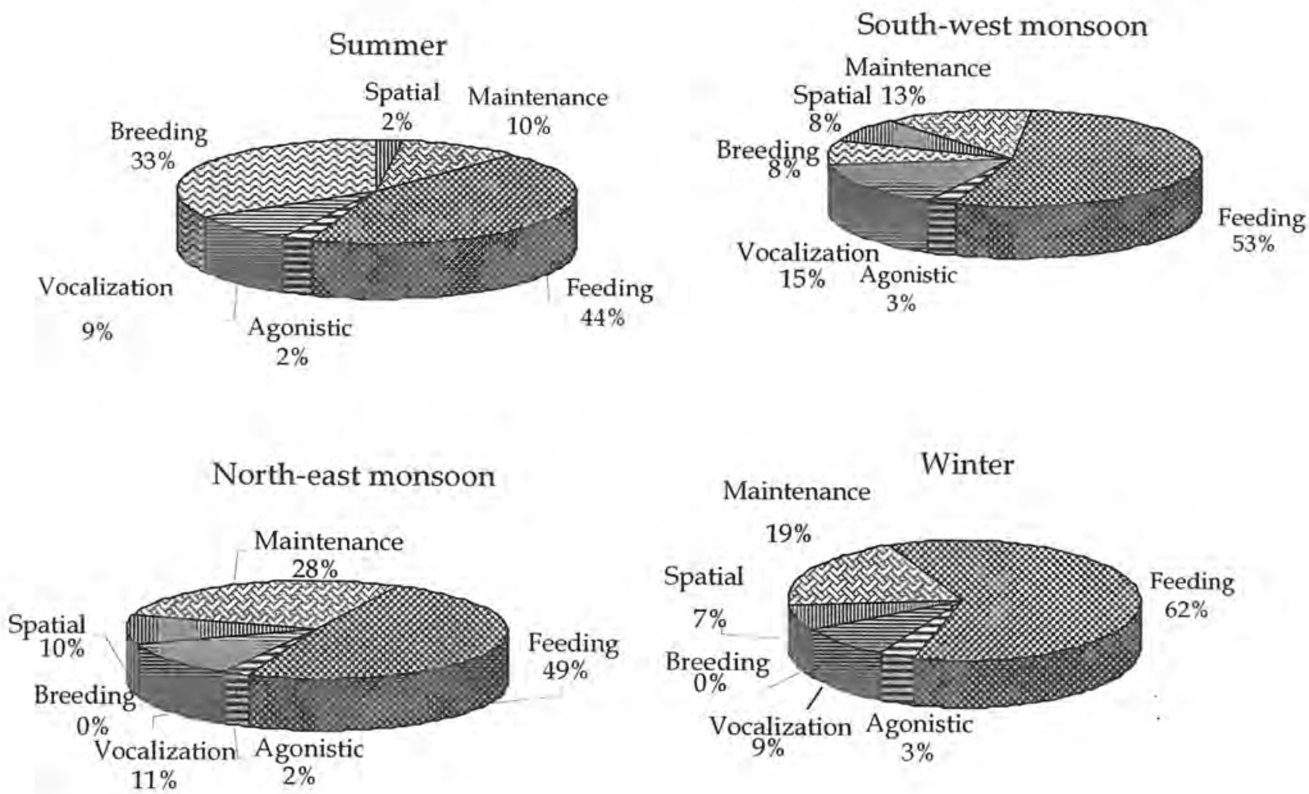


Fig 6.9 Activity budget of the Nilgiri Pipit in different seasons

6. 3. 3. Activity pattern

Daily activity pattern of the Nilgiri Pipit showed feeding as the major activity throughout the day with a few peaks as explained in chapter IV. Breeding activities are more in the afternoon while maintenance activity in the early afternoon. Vocalization (calls) was more in the forenoon and midday (Figure 6.10). The activity showed no significant correlation with the environmental factors such as temperature (r_s= 0.286; p=0.34), wind speed (r_s=0.116; p=0.707) and light intensity (r_s=0.297; p= 0.32) recorded during the observation. However, maintenance activity was significantly correlated with the wind speed (r_s=0.577; p<0.039).

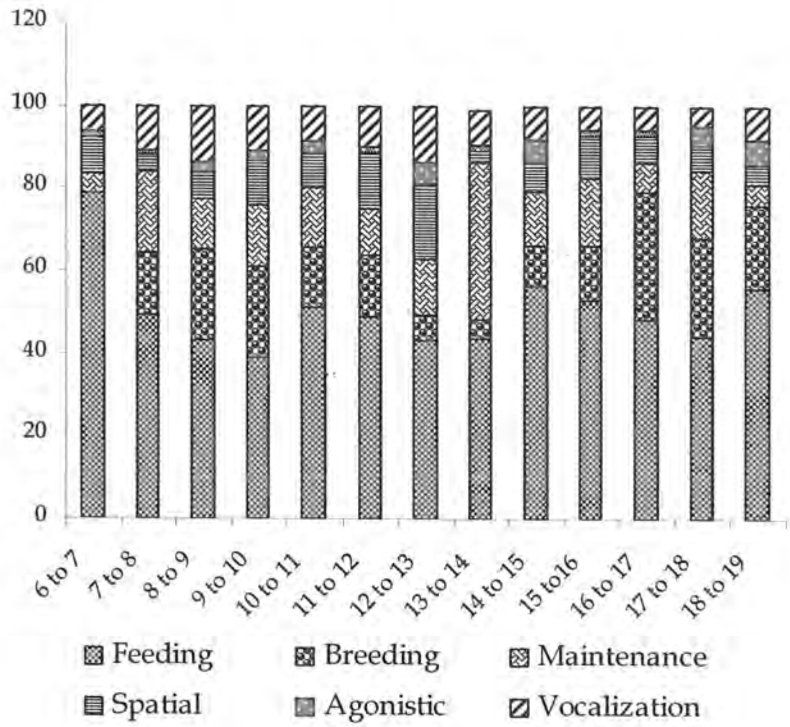


Fig 6.10 Daily activity pattern of the Nilgiri Pipit

6. 3. 3. 1. Seasonal variation in the activity pattern

Summer

Feeding was the highest during 0600-0700 h, while the breeding activities were comparatively more during 1100 to 1200 h. Maintenance was more between 1300 and 1400 h while spatial activity between 1200 and 1300 h, agonistic between 1400 and 1500 h and vocalization between1200 and 1300 h (Figure 6.11).

South-west monsoon

Feeding rate had an almost bimodal rhythm with one peak during 0700 to 0800 h and the other in the afternoon 1300 to 1400 h. Breeding activity was mainly during 1600 to 1700 h while maintenance was more during 0600-0700 h and 1000 to 1100 h, spatial activity during 0600 to 0700 h and 0900 to 1000 h, agonistic during 1300 to 1400 h and vocalization during 1000 to 1100 h (Figure 6.11).

North-east monsoon

Feeding was more during 1100 to 1200 h and in the afternoon from 1500 to 1600 h. The bird was engaged only for feeding during 1800 to 1900 h. Maintenance was more during 1800 to 1900 h, 1300 to 1400 h and 1700 to 1800 h; the highest in the last. Spatial behaviour was observed more during 0700 to 0800 h, and 1200 to 1300 h and, vocalization during 1200 to 1300 h (Figure 6.11).

Winter

Maximum feeding in winter was between 1000 to 1100 h, but more time was spent in the afternoon for feeding. Maintenance behaviour was observed more during 1300 to 1400 h followed by 1200 to 1300 h. Spatial activity, comparatively, was more during 1200 to 1300 h and vocalization during early morning 0600 to 0700 h (Figure 6.11).

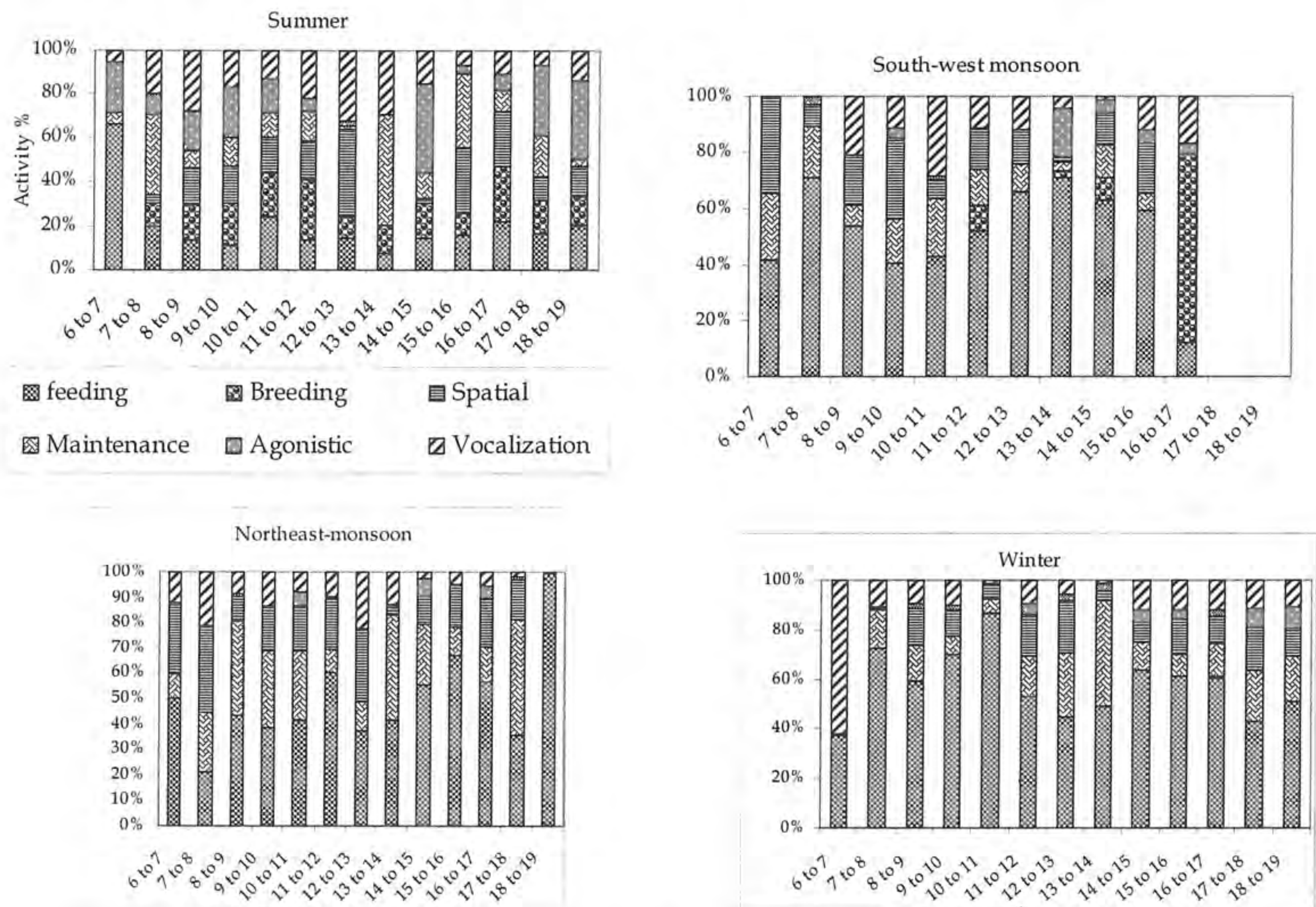


Fig 6.11 Seasonal variation in the activity pattern of the Nilgiri Pipit

6. 3. 4. Awakening and roosting time

6. 3. 4. 1. Awakening time

The awakening time of the Nilgiri Pipit was 0615 to 0740 h; mostly before sunrise. It had a significant correlation with sunrise (r_s= 0.769; $p<0.00$) and with various environmental factors such as wind speed (r_s =0.590; $P < 0.04$) and sunshine (r_s =0.690; $P < 0.01$). Relative humidity had negative correlation with the awakening time (r_s = -619; $P <0.03$). Pipits commenced their daily activities as the sunshine reached the area, till then they remained inside the marsh itself and called or kept silent with fluffed feathers apparently due to cold weather. The awakening time was late during rain, cold or frosty mornings in winter.

6. 3. 4. 2. Roosting time

At dawn, the Nilgiri Pipit fed near the marsh, the roosting area, and went to roost as it got dark or disturbed by other species. It often flew to a perch and then to the marsh for roosting. On arrival at the roost it called continuosly for a few minutes before becoming silent. The Nilgiri Pipit roosted before sunset throughout the year. When it rained, or in cold and foggy evenings in winter and monsoon the roosting time was earlier than the sunset. The birds continued their activity until dark during summer. Hence, there was no direct relation between roosting time and sunset for roosting. Also, the roosting time was not significantly correlated with the environmental factors such as mean maximum temperature (r_s = -0.319; $p<0.33$), mean minimum temperature (r_s= -0.364; $p<0.27$), relative humidity in the evening (r_s= -0.183;$p<0.58$), monthly rainfall (rs= -0.145;$p<0.67$), wind speed (r_s= 0.306; $p<0.36$) and sunshine (rs=-0.064; $p<0.85$).

6. 4. Discussion

Time budget and activity pattern

The Nilgiri Pipit exhibited a variety of activities and apportioned time for each with variations in different seasons to suit its ecological requirements. It has been reported that through behaviour, the animal moves in an organized and directed way and manipulates the objects to suit its basic requirements (Huntingford 1984). Evidently foraging was the major activity as reported in many other passerines (Perrins and Birkhead 1983); particularly in the Black and Orange Flycatcher (Khan 1977), Nilgiri Flycatcher (Ranjini 2004), and Pied Bushchat (Nirmala 2004). It spent as much as 51% of the time for feeding in 2003 and 47% in 2002. It was slightly less during breeding season (44%), but much higher during non-breeding seasons (55%). This variation could be explained by the difference in food and feeding habitat. In the breeding season it fed more on insects while in the non-breeding season on seeds to meet its differential energy requirements, as found in the American Pipit (Verbeek 1993). Most birds feed on insects during breeding season as it is more profitable than the seeds (Williams 1987, Hutto 1990). The effort to be taken and the energy to be spent for obtaining a given amount of energy will be much less if the food chosen is insects rather than seeds or fruits (Rotenberry and Wiens 1980). Again, analysis of the time spent for feeding shows that the pipits spent maximum time for feeding in winter (62%) and minimum in summer, apparently for the same reason as mentioned above and also that they were engaged in breeding activities. Moreover, the energy requirements during winter is more than that in other seasons and, since the insects are comparatively less, they have to feed on seeds mostly, which require proportionately more time (More details in chapter IV).

Breeding activities were confined mainly to summer, spending 33% of the time. It may be noted that summer is the main breeding season of the pipit when the insect food availability was higher (refer chapter V). The other major activity during breeding season was feeding.

Maintenance activities were high during non-breeding season, as much as 22% of the time was spent for maintenance. It was only 10% during the breeding season. Such variations were noticed in most birds (Ford *et al.* 1990, Hutto 1990). Percent of time spent for maintenance also varied seasonally; maximum was during north-east monsoon (28%) when the bird had to spent more time for activities such as preening, oiling, resting, keeping the feathers tightly closed; probably as measures to reduce the impact of rain and wind. In summer the maintenance was less as the bird had to spend more time for activities related to breeding and feeding. The increased rate of maintenance activities in winter may be an adaptation to reduce the impact of cold weather. Often the birds were seen with fluffed up feathers. Moreover, the birds spend more time for maintenance during the non-breeding season, which is north-east monsoon and winter. In some species such as Helmeted Honeyeater (Runceman 1996) and Sulphur Crested Cuckatoo (Lindenmeyer *et al.* 1996) no significant variation was found.

Activity pattern

The activity pattern from the pooled data of two years shows that the Nilgiri Pipit prefers to feed maximum in the early hours of the day 0600 - 0700 h (Table 6.5). Time spent for feeding 1000 - 1200 h, 1400 – 1600 h and 1800 – 1900 h was comparatively high. The peak feeding hours varies according to the season; it was between 0600 – 0700 h during summer, 0700 - 0800 h and 1300 – 1400 h during south-west monsoon; 1800 – 1900 h during north-east and, 1000 – 1100 h during winter (Table 6.6). The high feeding in the morning during summer may be because they feed more on insects and spend more time on the day attending to breeding activities as reported in Drongos (Vijayan 1984). They become rather opportunistic during south-west monsoon spending more time throughout the day for feeding (more details in chapter IV).

Maintenance activity was more during 1300 - 1400 h in summer as in most passerines, but it is scattered throughout the day in south-west monsoon, probably as a consequence of the opportunistic feeding during the season. It was high from 0800 - 1100 h, 1300 - 1500 h, and 1700 - 1800 h during north-east monsoon. In winter, the maintenance was high during 1300 - 1400 h followed by 1200 - 1300, making use of the bright sunshine. Maintenance behaviour of the Nilgiri Pipit resembles the maintenance activity of Eastern Meadowlarks (Lanyon 1995).

The Nilgiri Pipit spent 10% of the time for calling/singing which varied seasonally; 9% in summer, 15% in south-west monsoon, 11% in north-east monsoon and 9% in winter. The higher percentage in south-west monsoon is probably because of calls of the parent made to maintain contact with the fledglings recruited during summer, the breeding season. The songs in the late winter and summer helps to establish and maintain the territory (Krebs 1977, Nolan and Geoffrey 2004) and increase the chance of attracting males (Catchpole 1982, Bensch and Hasslquist 1992). The Nilgiri Pipit made calls throughout the day, spending varying time periods in various seasons. Among the different hours in four seasons, the hour the pipit spent maximum time for singing was in the early hours (0600 - 0700 h) in the winter and, the hour without any call was in the late hours (1800 - 1900 h) in the north-east monsoon. In some grassland birds including Henslow's Sparrow (Walk *et al.* 2000), the singing rate was high during night.

The time spent for agonistic behaviour is comparatively less 2% in 2002 and 3% in 2003, probably an indication of fewer predatory species and low competition in the area. Seasonal variation is also not pronounced. However, the hourly variation in the agonistic behaviour in the four seasons shows that the pattern is distinctly different in summer from rest of the seasons (Figure 6.6). It is more both in the forenoon and afternoon during summer, whereas it is so only in the afternoons in south-west and north-east monsoons, and in winter. It may be because during summer when the birds breed, defense of the territory may call for agonistic behaviour throughout the day. Quite often the male pipits engage themselves in combats during this season as reported in Great Plains Meadow Lark (Rohwer 1973) and Eastern Meadow Lark (Lanyon 1995). The increased agonistic activities in the afternoons in non-breeding seasons may be because of the increased feeding and presence of likely competitors.

6. 5. Summary

- The activities of the Nilgiri Pipit was classified into six major categories, namely breeding, feeding, maintenance, spatial, agonistic, and vocalization.
- Major activity was feeding followed by breeding, maintenance, vocalization, spatial movement and agonistic behaviour.
- Time spent for activities varied seasonally; feeding being the major activity in all the seasons. Feeding and maintenance were more during non-breeding season.
- Breeding was confined mainly to summer.
- Feeding was the highest in winter (62%) followed by south-west monsoon (53%), north-east monsoon (49%) and summer (44%).
- Activity pattern varied significantly in various seasons.
- Nilgiri Pipit roost inside the marsh, mostly before sunset and wake up before sunrise.
- Forty calls/songs of the Nilgiri Pipit could be recognized, out of which purpose could be 'guessed' for more frequently heard calls/songs associated with major activities.

Chapter VII

Summary and conclusion

The Nilgiri Pipit *Anthus nilghiriensis,* an endemic Near Threatened species of the Western Ghats, facing various anthropogenic threats has been studied to: a) determine the status and distribution, b) unravel the ecology and, c) identify the key factors affecting their survival.

Distribution and status of the Nilgiri Pipit were studied in select areas covering around 3273.5 ha in the Western Ghats in Kerala, Tamil Nadu, Karnataka and Goa. All the sightings were from grass-slopes and marshes in high altitude, which constitute 2103 ha of the total area covered. Based on the literature available on the sightings and localities of collection of specimens of the Nilgiri Pipit, a tentative map of its distribution has been prepared. Among the states surveyed, the encounter rate of the Nilgiri Pipit was high in Tamil Nadu (0.13 / ha). It was more in the Protected Areas than in the unprotected areas. The Nilgiri Pipit does not occur in the low altitudes (<1000 m), but found in low densities in the medium altitude of 1000-2000 m and more (0.045 / ha) and, slightly higher densities in high altitude areas (>2000 m). They are more abundant above 2300 m in the Nilgiris and Anamalais.

Intensive studies were conducted in the Upper Bhavani area of the Upper Nilgiris, mostly within the Mukurthi National Park. Weather in the Upper Bhavani area remains wet much of the year. Dry season lasts from January to April. The ground temperatures vary from -8 to 45°C in the grasslands during the dry season. High velocity of wind has been experienced in the Upper Nilgiris and especially in Upper Bhavani. Frost occurs generally in the grass valleys in Upper Bhavani from November to April.

The major vegetation types found in the area are: a) southern montane wet temperate forests, b) montane grasslands, and c) plantations. Seed and invertebrate abundance were quantified in the area. There was marked seasonal variation in seed abundance which had a peak in winter (39%) and then gradually declined to a minimum during south-west monsoon (11%). The F4 block had the maximum seed abundance among the five feeding blocks.

Invertebrates were sampled by following standard methodologies such as sweep, line transect and ground quadrates. The invertebrates in the order of abundance were Diptera (51%), Lepidoptera (11%), Coleoptera (8%), Hymenoptera (8%), Arachnida (7%), Odonata (6%), Phasmida (3%), Hemiptera (2%), Isoptera (1%) and Annelida (1%). Insects up to 0.5 mm size (49.31%) were more in the study area. In the case of birds, 332 individuals belonging to 24 species were counted during the survey in a 10 ha area and the diversity index was 1.03.

The maximum encounter rate of the Nilgiri Pipit at Upper Bhavani was 1.0 / ha in April 2003 and minimum 0.1/ ha in October 2002 and the number fluctuated frequently without any definite pattern, but it had a significant negative correlation with monthly rainfall. Pipits were more during summer with minimum rainy days. Also the number of pipits was correlated significantly with the abundance of seeds in the non-breeding season and with the abundance of invertebrates in different size classes. The Nilgiri Pipit has specific microhabitat requirements for feeding and breeding activities. The edge of the marsh had high heterogeneity where both marsh and grass species of the plants were present. The Nilgiri pipits fed mostly from creeping grass in the valleys, nested in marshy grasslands with slightly taller grasses and sedges and roosted in the stream banks inside the marshy grasslands with thick grasses and herbs.

Nilgiri pipits walked on the ground and picked seeds, insects and other invertebrates off the soil or grasses and herbs. They fed mainly (92%) from creeping grass. The most preferred feeding height (82%) recorded in 1744 observations was <15cm. However, there was significant seasonal variation in the height preferences. Five categories of feeding substrates were recognized: air, fern foliage, grass and herb foliage, ground, and logs. The main substrate from which the Nilgiri pipits picked their food was grass and herb foliage (96%). Foraging maneuvers were recorded, on the whole, 7176 times. Of these, 92% attempts were gleaning, 5% reach up, 2% leaping, and 1% lunge. Seasonal variation was observed in the foraging maneuvers.

From 12,988 feeding observations, food items could be detected only in 6626 attempts. In total, 63% attempts were for seeds and 37% for invertebrates. The pipits took 86% invertebrates and 14% seeds during breeding season, whereas it was 32% and 68% respectively in the non-breeding season. The Nilgiri Pipit took seeds mainly of three species of grasses (*Eragrostris nigra, Isachnae kunthiana, Isachaemum ciliare)* and a species of herb (*Cyanotis wightii*). The invertebrates in the diet belong to the orders Coleoptera (42%), Diptera (16%), Orthoptera (18%), Arachnida (13%), and Lepidoptera (8%) including their larvae. The faecal samples analyzed also showed that Coleoptera (61%) was the maximum followed by Diptera (25%) and Hymenoptera (7%). The Nilgiri Pipit is a specialist in different foraging dimensions, niche breadth being very narrow on foraging substrate ($J' = 0.009$), foraging maneuver ($J' = 0.008$), food (0.07), and foraging height ($J = 0.02$).

The average feeding rate during the study period, 2002 - 2004 was 465.94 / h which varied according to the season. The feeding rate had significant negative correlation with mean maximum temperature, light intensity and wind speed, but showed a positive correlation with mean relative humidity.

Most of the time, the Nilgiri Pipit fed in pair. It was seen feeding with other species on 340 occasions. The association was more with the Pied Bushchat (25.59%) followed by Paddyfield Pipit (19.7%), Tickell's Leaf Warbler (15.29%) and Prinia (12.35%).

Breeding biology of the Nilgiri Pipit was studied from February 2002 to June 2004 on the grasslands of the Upper Nilgiris. Breeding season of the Nilgiri Pipit was late

February to May. The breeding season had positive correlation with minimum and maximum temperatures. The Nilgiri Pipit preferred short grassland habitat with marshy grasses restricted to valleys with streams for nesting. The most used species of nesting plant of the Nilgiri Pipit was *Andropogon polypticus*. The territory size varied from 0.06 to 0.25 ha with a mean of 0.154 ha. Site fidelity was observed in the Nilgiri Pipit. The intensive study area at Upper Bhavani had the highest density of nesting, 0.6 pair / ha in 2003. Thirty one nests were found in the Upper Nilgiris, 18 in the intensive study area and the rest from outside. The nest is a cup, in most cases fully concealed, and located at the base of tussocks of grass (*Andropogon polypticus, Mariscus cyperinus roots, Eriocholon. Spp.)*. The mean length, width and the height of the nests were 11.15, 6.5 and 5.16 cm respectively. The mean concealment was 92%. All the nests were oriented towards the water source. The nests were placed at a mean height of 4.78 cm, inside the intensive study area and 5.86 cm outside. The nest-site characteristics showed three parameters as important in deciding the site, namely nearness to water or stream, higher densities of grasses and herbs and height of grass. The period required for nest building was 5-6 days.

The eggs were greyish cream with coffee brown speckles on the broader side and spots on the narrow end. The mean clutch size was 2.13 and incubation period 14 to 15 days. Incubation had almost a bimodal pattern with peaks in the morning and evening. The number of visits with food for nestlings per hour in a day also showed a bimodal pattern. The food of nestlings identified by direct observation was mainly of lepidopterans (33%), orthopterans (25%), dipterans (20%) and, coleopterans (17%). Faecal samples of the nestlings showed coleopteran (33%), orthopteran (16%) and, lepidopteran larvae (23%) as dominant items. The main food of the fledglings was coleopterans (34%) and, orthopteran (34%). Abundance of these major groups of insects and pattern of rainfall influenced breeding success. Nesting success was 16.66%, 66.66% and 25% in 2002, 2003 and 2004 respectively. Among the 18 nests in the intensive study area, 7 were 100% successful while one was 50% successful and 10 were unsuccessful.

The activity of the Nilgiri Pipit was classified into six major categories for analysis, namely breeding, feeding, maintenance, spatial, agonistic, and communication. Major activity was feeding followed by breeding, maintenance, vocalization, spatial movement and agonistic behaviour. Time spent for activities varied seasonally; feeding being the major activity in all the seasons. Breeding was confined mainly to summer. Feeding was the highest in winter (62%) followed by south-west monsoon (53%), north-east monsoon (49%) and summer (44%). Activity pattern varied significantly in various seasons. Nilgiri Pipit roosted inside the marsh, mostly before sunset and woke up before sunrise. Forty calls/songs of the Nilgiri Pipit could be recognized, out of which purpose could be 'guessed' for more frequent calls.

The present study recommends the status of the Nilgiri Pipit as Threatened (Vulnerable) because of their a) restricted distribution in specific habitat, montane grasslands interspersed with montane wet temperate (shola) forests mainly above 2000m, b) low abundance and, c) reduction in the range of distribution with almost extinction in some localities. Their basic biology shows that the crucial habitat for their survival is creeping grass slopes with marshy valleys with minimum disturbance, especially during summer, as they nest only in this habitat. This habitat forms an essential part of the larger shola-grassland ecosystem which needs to be conserved for the long-term survival of the Nilgiri Pipit and many other endemics. Hence, it is recommended that more of the montane grasslands should be given full protection and, restored with community participation.

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Appendices

Appendix I Birds of Upper Bhavani

Sl.No.	Common Name	*Scientific Name*
1	Ashy Prinia	*Prinia socialis*
2	Black Bulbul	*Hypsipetes leucocephalus*
3	Black Drongo	*Dicrurus macrocercus*
4	Black Eagle	*Ictinaetus malayensis*
5	Black-and-Orange Flycatcher	*Ficedula nigrorufa*
6	Blackheaded Cuckoo Shrike	*Coracina melanoptera*
7	Black-rumped Flame	*Dinopium benghalense*
8	Black-shouldered Kite	*Elanus caeruleus*
9	Blyth's Reed Warbler	*Acrocephalus dumetorum*
10	Brahminy Kite	*Haliastur indus*
11	Brown Wood Owl	*Strix leptogrammica*
12	Common Buzzard	*Buteo buteo*
13	Common Chiff Chaff	*Phylloscopus collybita*
14	Common Hoopae	*Upupa epops*
15	Common Kestrel	*Falco tinnunculus*
16	Common Myna	*Acridotheres tristis*
17	Common Rosefinch	*Carpodacus erythrinus*
18	Common Snipe	*Gallinago gallinago*
19	Crested Serpent Eagle	*Spilornis cheela*
20	Eastern Black Redstart	*Phoenicurus schisticeps*
21	Eurasian Blackbird	*Turdus merula*
22	Grass Owl	*Tyto capensis*
23	Great Barbet	*Megalaima virens*
24	Great Tit	*Parus major*
25	Grey Junglefowl	*Gallus sonneratii*
26	Grey Wagtail	*Motacilla cinerea*
27	Grey-breasted Laughingthrush	*Garrulax jerdoni*
28	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*
29	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*
30	Honey Buzzard	*Pernis ptilorhynchus*
31	House Crow	*Corvus splendens*
32	House Sparrow	*Paser domesticus*
33	Indian Scimitar Babbler	*Pomatorhinus horsfieldii*
34	Indian Spotted Dove	*Streptopelia chinensis*

Birds of Upper Bhavani

35	Large-billed Crow	*Corvus macrorhynchos*
36	Large-billed Leaf Warbler	*Phylloscopus magnirostris*
37	Little Egret	*Egretta garzetta*
38	Long-billed Pipit	*Anthus similis*
39	Montagu's Harrier	*Circus pygargus*
40	Mountain Imperial Pigeon	*Ducula badia*
41	Nilgiri Laughing Thrush	*Garrulax cachinnans*
42	Nilgiri Pipit	*Anthus nilghiriensis*
43	Nilgiri Wood Pigeon	*Columba elphinstonii*
44	Oriental Honey-buzzard	*Pernis ptilorhyncus*
45	Pacific Swallow	*Hirundo tahitica*
46	Paddyfield Pipit	*Anthus rufulus*
47	Pied Bushchat	*Saxicola caprata*
48	Red-rumped Swallow	*Hirundo daurica*
49	Red-vented Bulbul	*Pycnonotus cafer*
50	Red-wattled Lapwing	*Vanellus indicus*
51	Red-whiskered Bulbul	*Pycnonotus jocosus*
52	Richard's Pipit	*Anthus novaeseelandiae richardi*
53	Rock Pigeon	*Columba livia*
54	Shikra	*Accipiter badius*
55	Small Sunbird	*Nectarina minima*
56	Tickell's Leaf Warbler	*Phylloscopus affinis*
57	Tree Pipit	*Anthus trivialis*
58	Tytler's Leaf Warbler	*Phylloscopus tytleri*
59	Velvet fronted Nuthatch	*Sitta frontalis*
60	Verditer Flycatcher	*Eumyias thalassina*
61	White eye	*Zosterops palpebrosa*
62	White eyed Buzzard	*Butastur teesa*
63	White-bellied Blue Flycatcher	*Cyornis pallipes*
64	White-bellied Shortwing	*Brachypteryx major*
65	White-cheeked Barbet	*Megalaima viridis*
66	White-rumped Shama	*Copsychus malabaricus*
67	White-throated Kingfisher	*Halcyon smyrnensis*
68	Wood Snipe	*Gallinago nemoricola*

Appendix 2 Plants of Upper Bhavani

Sl.No	*Scientific name*	Family	Sl.No	*Scientific name*	Family
1	*Strobilanthus wightianus*	Acanthaceae	26	*small lavender*	Compositae
2	*Curculigo orchioides*	Amaryllidaceae	27	*Hypochaeris glabsa*	Compositae
3	*Arisaema leschnaultii*	Araceae	28	*Capsella bursa-pasoris*	Cruciferea e
4	*Impatiens clavicornca*	Balsamineae	29	*Kyllingia melanosperma*	Cyperaceae
5	*Impatiens modesta*	Balsamineae	30	*Elaeocharis congesta*	Cyperaceae
6	*Impatiens rufescens*	Balsamineae	31	*Fimbristylis subtrabiculata*	Cyperaceae
7	*Lobella excelsa*	Campanulaceae	32	*Bulbostylis densa*	Cyperaceae
8	*Commulina hirsuta*	Commulinaceae	33	*Rhyncospora rugosa*	Cyperaceae
9	*Commulina clavata*	Commulinaceae	34	*Scirpus subcapitatus*	Cyperaceae
10	*Cyanotis wightii*	Commulinaceae	35	*Fimbristylis uliginosa*	Cyperaceae
11	*Dicrocephala chrysanthemifolia*	Compositae	36	*Scirpus aticulatus*	Cyperaceae
12	*Myriactis wightii*	Compositae	37	*Carex nubicena*	Cyperaceae
13	*Erigeron mueronatum*	Compositae	38	*Kyllinga brevifolia*	Cyperaceae
14	*Anaphalis travencoria*	Compositae	39	*Cypeus angulatus*	Cyperaceae
15	*Anaphalis obloнca*	Compositae	40	*Cyperus digitatus*	Cyperaceae
16	*Anaphalis aristata*	Compositae	41	*Cyperus globosus*	Cyperaceae
17	*Anaphalis wightiana*	Compositae	42	*Mariscus cyperinus*	Cyperaceae
18	*Anaphalis neelgerriana*	Compositae	43	*Carex speciosa*	Cyperaceae
19	*Picris hieracioides*	Compositae	44	*Carex flicina*	Cyperaceae
20	*Erigeron linifolius*	Compositae	45	*Carex myosurus*	Cyperaceae
21	*Conuza positae*	Compositae	46	*Scirpus fluitans*	Cyperaceae
22	*Blumea hieracifolia*	Compositae	47	*Drosera burmanni*	Droseraceae
23	*Emilia sonchifolia*	Compositae	48	*Drosera peltata*	Droseraceae
24	*Notonia walkeri*	Compositae	49	*Rhododendron arborium*	Ericaeae
25	*Cnicus wallichii*	Compositae	50	*Eriocaulon robustum*	Eriocaulaceae

Plants of Upper Bhavani

Sl. No	*Scientific name*	Family	Sl.No	*Scientific name*	Family
51	*Ericaulon collinum*	Eriocaulaceae	76	*Tripogon bromoides*	Graminae
52	*Eriocaulon geoffrey*	Eriocaulaceae	77	*Eragrostris amarilis*	Graminae
53	*Eriocaulon hoesely-kundae*	Eriocaulaceae	78	*Eragrostris willdenoriana*	Graminae
54	*Phyllanthus simplex*	Euphorbiaceae	79	*Eragrostris tenuefolia*	Graminae
55	*Gentiana quadrifaria*	Gentianaceae	80	*Agrostis pilosula*	Graminae
56	*Impatiens scapiflora*	Geramiaceae	81	*Eragrostris nigra*	Graminae
57	*Geranium nepalense*	Geraneaceae	82	*Briza major*	Graminae
58	*Biophytum intermedium*	Geraneaceae	83	*Poa annua*	Graminae
59	*Andropogon foulkerii*	Graminae	84	*Festuca bromoides*	Graminae
60	*Isachnae kunthiana*	Graminae	85	*Ophiopogon inermedium*	Haemodoraceae
61	*Isachnae australis*	Graminae	86	*Serpicula brevipes*	Helorrhagidaceae
62	*Isachaemum commutatum*	Graminae	87	*Hypericum laponicum*	Hypericineae
63	*Isachnae gardneri*	Graminae	88	*Ilex wightiana*	Ilinieae
64	*Panicum villosum*	Graminae	89	*Juncus prismatocarpus*	Juncaceae
65	*Oplismenus undulatifolius*	Graminae	90	*Juncus glaucus*	Juncaceae
66	*Polinia quadrinerves*	Graminae	91	*Luzula campestris*	Juncaceae
67	*Seteia gloauca*	Graminae	92	*Micromeria riflosa*	Labiatae
68	*Isachaemum ciliare*	Graminae	93	*Leucas suffruticosa*	Labiatae
69	*Chrysopogon nodulibarbis*	Graminae	94	*Leucas hirta*	Labiatae
70	*Heteropogon centortus*	Graminae	95	*Utricularia carulea*	Lentibulariaceae
71	*Andropogon polypticus*	Graminae	96	*Chlorophytum malabaricum*	Liliaceae
72	*Anthisteria ciliata*	Graminae	97	*Linum mysorense*	Linaceae
73	*Calamogrostris pilosula*	Graminae	98	*Modiola caroliana*	Malvaceae
74	*Zenkeria elgans*	Graminae	99	*Osbeckia cupularis*	Melastomaceae
75	*Coelachne pulchella*	Graminae	100	*Osbeckia spp.*	Melastomaceae

Plants of Upper Bhavani

Sl.No	*Scientific name*	Family	Sl.No	*Scientific name*	Family
101	*Acacia dealbata*	Mimoseae	121	*Plantaco major*	Plantaginaceae
102	*Rhodomyrtus tomentosa*	Myrtaceae	122	*Polygonum alatum*	Polygonaceae
103	*Cyzygium jsmbolana*	Myrtaceae	123	*Rannunculus subpinnatus*	Rannunculaceae
104	*Microstylis versicolor*	Orchidaceae	124	*Rannunculus nullichianus*	Rannunculaceae
105	*Aerides crispum*	Orchidaceae	125	*Rubus recemosus*	Rosaceae
106	*Saccolabium filiform*	Orchidaceae	126	*Fragaria nilgerrensis*	Rosaceae
107	*Spiranthus australis*	Orchidaceae	127	*Fragaria indica*	Rosaceae
108	*Habenaria cephalotes*	Orchidaceae	128	*Fragaria nilgerrensis*	Rosaceae
109	*Wabenaria subpubens*	Orchidaceae	129	*Anotis leschnaultiana*	Rubiaceae
110	*Eulophia nuda*	Orchidaceae	130	*Hedyotis severtiodes*	Rubiaceae
111	*Cheirostylis flabellata*	Orchidaceae	131	*Parnessia mysorensis*	Saxifragaceae
112	*Disperis neilgherrensis*	Orchidaceae	132	*Calceolaria mexicana*	Scrophulariaceae
113	*Oxalis corniculata*	Oxalideae	133	*Pimopinella caudolleana*	Umbellifeae
114	*Oxalis tetraphylla*	Oxalideae	134	*Hydrocotyle sibthorpioides*	Umbelliferae
115	*Ulex europaeus*	Papilonaceae	135	*Centella asiatica*	Umbelliferae
116	*Cystisus scoparius*	Papilonaceae	136	*Companula fulgens*	Vacciniaceae
117	*Crotalaria albida*	Papilonaceae	137	*Oldenlandia heynii*	
118	*Parochetus communis*	Papilonaceae	138	*Pouzolzia wightii*	
119	*Desmodiium parifolium*	Papilonaceae			
120	*Piper schmitii*	Pipieraceae			

Source: (Fyson 1974)

Appendix 3. Calls and purpose – Nilgiri Pipit

Sl.No	type of call	Time of call	Call	Purpose
1	Breeding	Communication	seee….see….answering by sisisisi….sisisisi….	While communicate each other
2		Communication	si…si….	while carrying food for female male communicate
3		Territorial	trrrr……sheee….shee….. & shwee…shishishishi……	Male. From perch
4		Communication	See…. See…. a weak call	while carrying food for chicks
5		Communication	See….see….	fledgling's call
			Shi…shi…shi…	Male Np calls for giving the signal to female to take nest material inside the nest.
			kre..ke..shee…she….	Female answers when the male gives signal shi…shi…shi…
6		communication	chwee..chwee.. one chr..she..shwee…sheweee. other	in pair(male and female)
7			she..she..she…..	Male communicate with female when in pair
8			chwee..chwee..	Female communicate when in par
9	Feeding		shwee..shi..shi..shi… male call from perch and female answers yiyo.. yiyo.. yiyo ..yiyo..	in pair
10			si..si..si..i…	Signal call for shifting the feeding activity to preening
11			ki.ki..ki..shiyo..shiyo…	While feeding
12			tree…trrr…	While feeding
13			treee…se…	While feeding
14			sisisisi…	While feeding
15			ohhrrr….sisisi	While perching after feeding
16			shik..shee….	After hearing this other approached the first made sisisisi… and fed together
17				
18			sisisisi…..	Take off call
19			shishishishee….	In perch
20			sisisisi…	After hearing shishishishee…. Other partner made this and came to the first partner
21			shwee…shwe…shi..shi..shi..	Fledgling

Calls and purpose – Nilgiri Pipit

Sl.No	type of call	Time of call	Call	Purpose
23	Alarm		kwe…trwe…sisi…	
24			kwe..kwe..shwee…	Alarm call when the intruder of the same species enter in to the terrtory
25			see…shishishihsishiyo..shiyo…	Intruder's call
26			krew…krew…	When chased one Paddyfield pipit
27			Krew…	
28			kr….shwee…	When Kestrel approached
29			shwe.. shwe….shwee….sisisisi….	When predator approaches
30			chr..she..shwee…sheweee.	When the partners come closer
31	Fighting		loud sisisisisisii…. Shwey….shwee… qli…qli…qli…qli…	Both
32	Winner of the fight		Erkrwey…tritri….	
33	Loser of the fight		shishishishi…. Shishi…shishi…	
34	Threatened call		chewe..chewe shrew…..	threatened call while being chased by same species
35	Flight call		see….see….see…see…	
36			si.si.shi.shi.loud vocal	While chasing each other
37			sisisis…shiyo..shiyo…	While chasing eachother
38			sisisi…	While chasing eachother
39	Preening		1.Shwee……… 2.shwee…..shoe..shoe…. 3.see..se..se..se… 4.trrr……..shee.shee……shee…… 5.shi.shi…..shi….. 6.chew…..shee….. 7.shiyo…….shiyo……shiyo…….. 8.chwe….chwe…..chwe……	Preening
40	Roosting		chick..chick…chick…	While roosting