INDIAN COUNCIL OF AGRICULTURAL RESEARCH (I.C.A.R)

New Delhi

Vertebrate Pest Management

University of Agricultural Sciences,
Bangalore - 560065

Regional Research Station, Mudigere - 577 132

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Final Report of Research Scheme

1. Project Title : Vertebrate Pest Management on Cardamom (Elettaria cardamomum Maton) and other crops in Malnad region.

2. Sanction No. and date : F. No. 1-25/87 PP. dated 9.3.1989

3. Date of Start : **30.5.1989**

4. Date of termination : 29.11.1993

5. a. Name of Institute : University of Agricultural Sciences, GKVK, Bangalore - 560 065

b. Division / Department : Regional Research Station, Mudigere - 577132

c. Location of work : Regional Research Station, Mudigere - 577132.

6. Technical Personnel employed :

Name with Designation	Date of joining	Date of leaving	Total no. of man months spent
1. J.B.Narendra Kumar, Research Associate	25.08.1989	27.11.1990	15.0
2. K.Krishnappa, Field Investigator	12.02.1990	30.07.1991	17.5
3. JavareGouda, Research Associate	30.06.1991	08.11.1991	3.5
4. A.M.Ramananda Field Investigator	29.08.1991	01.10.1991	1.0
5. P.L.Chandrappa, Field Investigator + Research Associate	18.11.1991	29.11.1993	24
6. Y.M.Somasekhara, Field Investigator	10.03.1993	11.9.1993	6.0

7. Total outlay : Rs.2,38,200

(a) Share of ICAR : 100%

(b) Share of participating agency : Nil

8. Total amount spent : Rs.1,72,454 (upto 30.5.1993)

(a) Share of ICAR : 100%

(b) Share of participating agency : Nil

9. Objectives and how far these have been achieved :

1. To survey and identify the vertebrates damaging crops, specifically cardamom in Malnad. In many situations of crop damages by vertebrates the" identity of the species has remained a question.

2. To assess crop losses due to each species on cardamom, coffee, cocoa, arecanut and fruit crops like sapota as a vertebrate is often implicated in damage on more than one crop.

3. To compare the methods for protecting crops from vertebrate pests. Traps, repellents, mechanical and cultural methods will be compared for their efficacy and efficiency in protecting cardamom from vertebrate pests.

4. As far as possible, the qualified benefits of the animals to the ecosystem will be maintained. For example, squirrels feed on soil insects like ants, termites, bugs and grubs, wildboar up-turns sub-surface soil to surface etc. in Malnad.

The technical programme was carried out under three heads :

1. Vertebrate pests of cardamom and other spices in Malnad region and their management.

2. Vertebrate pests of cocoa (*Theobroma cocoa L.*) and other plantation crops in Malnad region and their management.

3. Vertebrate pests of paddy and other cereal crops in Malnad region.

During 1989-90, surveys for identification of vertebrate pests depredating cardamom in Malnad region were undertaken. This also included assessment of crop losses due to vertebrate pests. Cultural practices and anticoagulants were evaluated for the management of vertebrate pests.

The Species composition of vertebrate pests, depredating plantation, fruit and cereal crops was determined with their relative economic importance.

During 1990-91, observations on elephants raids on paddy and plantation crops in Kodagu district were recorded. So the problem was dealt with separately. Jungle cat damage on cocoa, monkey damage on cashew and coconut, birds damage on sunflower and vegetable crops and porcupine damage on Pineapple was observed extensively. Studies on yield-loss, turn-over rates of animals and field behaviour were undertaken in addition to the on-going projects, Research on plantation crops was intensified.

During 1991-92, birds as crop depredators and predators of insect pests received much attention in addition to the above listed projects.

During 1992-93, studies concerning monkey damage to cardamom and arecanut, rodents damage to coconut, arecanut and paddy; birds damage to guava, orange, areca and sorghum; wildboar damage to potato and sunflower; squirrel damage to cardamom and wildboar, jackal, jungle cat and rodents damage to sugarcane were carried out in addition to the on-going projects.

Effective management tools for protecting cardamom from rodents, wildboar and monkey damage; cocoa from Jungle cat damage; paddy from birds and rodents damage and certain cereals from birds and other vertebrates have been evolved. An assessment of the elephants and bisons raids on crops in hill region has been made. This should help in conducting further studies in these two aspects. The efficacy of electric fencing as a management tool has been evaluated. Over-all, an appraisal of the vertebrate Pest Management vis-a-vis the role of vertebrates in sustaining crop production and Environmental quality has been made for the first time in hill region of Karnataka.

10. Approved technical programme :

A survey of the portions of the Malnad Region that include parts of Shimoga, Chickmagalur, Kodagu and Hassan districts will be made and the vertebrate pests will be identified by trapping, shooting or netting. Apart from cardamom growing areas, other cultivated patches where the animal frequents will be surveyed.

Crop-loss assessments will be made following a Randomized Design. Site selection, replication, randomization and local control or arrangement of any treatments will be made so as to eliminate known causes of variation. A number of small plots in a field might be put under protective netting to give a measure of expected yield with which damaged areas can be compared. Methods for protecting the crop. Efficiency will be in terms of the time , required to execute the method in field and this would also include the cost factor. The methods will be compared in replicated plots in multiple locations in diverse habitats following statistical designs/tests.

a. The main items of observations to be recorded.

i) The identification of the animal and nature of damage

ii) The relative abundance of the animal in a unit area

iii) The yield loss assessment

b. Arrangements for suitable analysing data : statistical techiques will be followed to give a valid evaluation of the treatments.

c. Collaboration arrangements

Rodent Biology section,
Department of Zoology, GKVK, Bangalore - 560 065;
Dr.Keshav Bhat, CPCRI, Kasargod, Kerala

Remarks of scientific Panel on earlier Annual Report

The four Annual Reports of this project was discussed by the scientific Panel for entomology in detail. The Reports were adjudged as "Good"and suggestions were made to generate information on turn-over rates and extent of crop-losses due to a definite number of individuals of a vertebrate species in a given area. The reports were adopted by the Panel.

11. Detailed Report

Please see Annexure - 1

12. Summary :

Studies on vertebrate Pest Management on cardamom (Elettaria cardamomum Maton) and other crops in Malnad region were conducted between 1989 to 1993 in four districts of hill region of Karnataka.

The annual yield-losses in cardamom (in terms of % capsule loss) due to rodent pests varied from 8.70 to 12.60. This amounts to about 75 to 100 kg of green capsules/acre. Of the several protection methods tried, cultural practices like timely harvests, dispersing panicles in an overlapped fashion, trapping rodents during August-September and clean cultivation protected cardamom capsules to about 10 to 15%. These practices were easy to execute, cheap and were not labour intensive. The practices were also eco-friendly.

Commercial formulations of anticoagulants like Storm, Quintox, Rodacake and Bromodiolone were tested in replicated trials at different locations. The formulations did not prove effective. Similarly four different non-toxic compounds as fish oil, neem oil, cluster bean and algal extracts did not prove effective.

Monkey damage to cardamom can be reduced by selective debranching a selected number of shade trees and by trapping. Wildboar damage in cardamom nurseries can be minimized by proper drainage and by suspending, at borders, punched polybags containing 5g dry sand + 5g 10% G Thimet.

Birds damage in rice can be minimized by synchronous planting. Jungle crow nuisance and destruction of rice seedlings can be stopped by regulating water levels in the main field. Through this project it was possible to develop a package of practices for supressing rodent damage in rice.

Vertebrate pests species composition of sugarcane, cocoa, areca, coconut, guava, oilpalm, ragi and cereal crops in hill region was identified. In many instances of cropping situations, the extent of crop losses due to a vertebrate was quantified.

The information on local plant protection practices adopted by planters against the onslaught of Vertebrate pests was systematically collected. Many of these practices were evaluated and compared with other crop protection measures.

Basic information on elephants and bisons raids on crops, bison raids on crops, electric fencing and vertebrate pest Management in Forest nurseries was collected. This information should help us in further studies and projects. Certain ecological and behavioural aspects of key vertebrate species in hill region were studied.

13. Results which can be exploited in pilot or field scale.

Crop-Protection practices against vertebrate pests in cardamom, cocoa, rice, areca, coconut, guava, sugarcane, other cereals and forest nurseries can be followed. The practices recommended are cheap, easily practicable and are ecofriendly.

14. Papers/Articles prepared/ published

please see Annexure-II

15. Suggestions for future lines of research

There is an urgent need to develop a holistic approach for managing vertebrate pests on several crops such as rubber, oilpalm, forest tree species, sugarcane and many other fruit crops remains to be done. In view of the occurrence of a vertebrate in several cropping situations, their roles in all the crops needs to be evaluated and a decision on their status need to be arrived at. Turn over rates and density of a species/km^2 need to be known for a number of vertebrate species. The information so gathered may be useful not only for vertebrate pest Management, vertebrate conservation, integrated control of insect and non-insect arthropods, forest and land use planning and in the over all management of forests and agroecosystems in the hill region.

16. Acknowledgment

Please see Preface.

PREFACE

This publication presents results of studies conducted from 1984 to 1993 on vertebrate pests of plantation, horticultural and agricultural crops in four hill districts of Karnataka, Viz., Chikmagalur, Hassan, Shimoga and Kodagu. From 1989 to 1993, the Indian Council of Agricultural Research, New Delhi sanctioned an ad-hoc project entitled, "Vertebrate Pest Management on Cardamom *(Elettaria Cardamomum* Maton) and other crops in Malnad Region".

Preliminary data on the ecology of vertebrate pests in different agroecosystems and forests of hill region is presented. More importantly it places results of studies conducted on protection of crops from Vertebrate pests in different situations. Results discussed here should enhance understanding on vertebrates. It should also help planters to protect their crops more realistically and conserve beneficial activities of vertebrates and natural resources of the region. This book should prove useful in developing integrated vertebrate pest management practices for forest and agricultural ecosystems of hill region.

Encouragement and guidance received from the Vice-Chancellor, Director of Research, Associate Director of Research (RRS, Mudigere) and Prof. and Head, Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore - 560 065, is gratefully acknowledged. This project on vertebrate pests is sponsored by the Indian Council of Agricultural Research (ICAR), New Delhi.

CONTENTS

INTRODUCTION

Forests cover considerable area (upto 30% in some areas) in Malnad (hill region). Among the speices limited to Western Ghats region are Nilgiri langur *(Presbytis johni)*, Liontailed macaque (*Macaca silenus*), Nilgiri brown mangoose (*Herpestes vitticollis*), Malabar Giant Squirrel *(Ratufa macroura)*, Civet (*Moschothera civettina*), Flying Squirrel, *(Petinomys fuscocapillus),* Spiny mouse (*Mus platythrix*), The Great Indian Hornbill (*Buceros bicornis)* etc., Wild animals abode forests and frequent cultivated areas in search of food and shelter. In the process, animals cause enormous losses to crops. To protect crops, planters often aim at eradication of wild animals. This leads to 'imbalance in nature' and environmental degradation. Such practices also are expensive and often ineffective.

There is an urgent need to device protection measures that are practicable, economically feasible and ecologically and environmentally sound.

The crop protection measures should also help simultaneously in conserving the beneficial activities of the concerned animals. The Indian Council of Agricultural Research (ICAR) New Delhi sanctioned a project in 1989 to generate data on Vertebrate Pest Management.

In Malnad, Coffee, Cardamom, Tea, Cocoa, Arecanut, etc. need specialized agro-climatic conditions and such cultivable tracts are not extensive and met frequently in India. So, crop protection measures should be innovative and novel. Some of the important vertebrate pests of the region are Rodents (rat, mice, squirrel), Wildboar, Monkey, Junglecat and Birds.

During 1989-90 observations on species composition, relative abundance and crop depredation were recorded. During 1990-91, elephants raids on paddy and plantation crops in Kodagu (Coorg) district was observed extensively. Jungle cat damage on cocoa, monkey damage on cashew and coconut, birds damage on sunflower and vegetable crops and porcupine damage on Pineapple was also observed. Studies on yield-loss, turn-over rates of animals and field behaviour were undertaken in addition to the on-going studies. Research on plantation crops was intensified. Role of birds as crop depredators and predators of pests received much attention.

During 1991-92 studies concerning monkey damage to cardamom and arecanut; rodents damage to coconut, arecanut and paddy; birds damage to guava, orange, arecanut and sorghum; Wildboar damage to potato and sunflower; squirrel damage to cardamom and wildboar, jackal, jungle cat and rodents damage to sugarcane were carried out.

During 1992-93, Kodagu district was surveyed more extensively and observations on elephants and wildbison damage to fruit and plantation crops were recorded. Studies on Integrated Vertebrate Pest Management were also begun.

In this publication, results of few studies conducted prior to 1989 are also presented and few observations recorded on vertebrate pests outside hill region have also been incorporated. Literature on Vertebrate pests in the region is reviewed.

Most of the studies on Vertebrate pests was carried out in Chikmagalur district. Chikmagalur phytogeographically is an inseparable part of the hill region of Karnataka and the Western Ghats. The Western Ghats range from Dangs district in Gujarat to Kanya Kumari in Tamil Nadu. In its expanse of rolling mountains and deep valleys, it supports an ever rich diversity of biotic features, whose combinations present a wide range of habitats for wildlife. It is only second to Himalayas in the biological wealth and diversity of species and communities. It contributes 12.5 % to the State Agricultural productivity (Status Report, 1989). Therefore, the productivity of the land and life of the people of Chikmagalur depend much on the way the natural resources are utilised and managed. The sustenance and perpetuation of wildlife, therefore, is of pivotal importance.

Although legislation provides for protection to wildlife, there is little protection actually provided. Several man-influenced impacts are affecting the wildlife. Of these, encroachment into the habitats of wild animals by man, conversion of forests to agricultural lands,

erosion, siltation, monoculture free plantations and pollution are some.

The district is located between latitudes 13 °7'29" North and longitudes 75 °37'35" East. The terrain has an elevation of 800 to 900 m in major areas. The altitudes of hill ranges vary from 667 m to 2103 m.

The climate of the district is hot and humid. Rainfall varies from 15" in Kadur to 250" in Mudigere. The average annual precipitation varies from 52" to 152". South West monsoon is active June to September . Heavy rains (70 to 75%) are received during July-August. The North-East monsoon is received in spells from October to December as a result of depression in the Bay of Bengal.

The year can be indistinctly classified into summer (February to May), Monsoon (June to September) and winter (October to January) seasons. Summer shower received during March-April are important for coffee for blossoming. The minimum temperature is in January (14.5°C) and the hottest in March with mean maximum temperature of 29.9°. At this time, a few species of trees blossom. Maximum temperature does not exceed 33° in March. Soils in the hill zone are neutral to weakly acidic. Principal soil type is red clay loam. Soil erosion in Malnad has been mainly due to high intensity of rainfall, improper water management, overgrazing of pastures, deforestation and non-scientific methods of cultivation.

Since the Western Ghats bear Bauxite, Iron and Manganese in substantial quantities, there has been a great deal of open cast mining for these ores in the area. Each mining centre like Kudremukh is responsible for the loss of natural regeneration extending a distance of 8 to 10 km. Vegetation in mining areas is represented by broken grass and scrub patches. Such habitats hold depauparated faunas. Kemungundi and Kudremukh are good examples for such sites. There is considerable scope for biologists to restore vegetation and animal life in these areas. So that the vertebrates are confined to area under vegetation cover.

Most rivers rise in the elevated areas of Western Ghats and flow west to east. River waters have not been appropriately tapped for sustaining clean waters for drinking and domestic purposes, irrigation, fisheries, crops and stored for times of water deficit. Krishna, Bhima, Cauvery, Hemavathi, Bhadra, Tunga, Veda and Yagachi rivers originate in and around Chikmagalur.

Vertebrate pests :

The vegetation in Chikmagalur is diverse and its complexities vary with topography. Forests cover 350 square miles (16%). Owing to variations in rainfall, altitude and topography, mainly three types of forests are met within Chikmagalur. They are - Evergreen or moist and Dry deciduous forests and Scrub Jungle. (Status Report, 1989).

Evergreen forests form a part of the Western Ghats in Mudigere. The canopy of the forest is formed of tall, hard and soft-wood trees. Canopy is a closed type that provides a secured niche for a variety of species of rodents (rat, squirrel, shrew), monkey and cats. Due to tree felling for plywood and timber, the canopy is now becoming open. This is imposing changes in the composition of vegetation and in turn, Vertebrates. For instance, in areas of open canopy - species of *Bandicota* and *Mus* are becoming more common and abundant.

The evergreen forests envelope some of the most interesting valleys, streams and extensive rocky beds and ledges. Soil appear black due to accumulation of humus. These forests form part of the Bhadra Wildlife Sanctuary and harbour bison, elephant, sambar, barking deer, porcupine, malabar squirrel and langur monkey. Rarely Panther and Tiger can also be spotted for instance in Muthodi and Hebbe forests area.

Evergreen forests form good sources of matchwood and plywood in species of *Bombax* (Buruga), *Evodia* (Mongappa), *Machilus* (Gulamova), *Alstonia* (Maddale) and *Dicopsis* (Halasu). People are debarking the *Machilus* trees entirely in the area, killing all of them. This is a pernicious menace going on in the area unchecked. Much prized sandalwood trees are also present here. This is facing extinction in the hands of the ever increasing smugglers. Evergreen forest patches consist of species of *Acrocarpus* (Billungi), *Artocarpus* (Halasu)," *Calaophyclum* (Surrahonnae), *Dalbergia* (Beete), *Dipterocarpus* (Kalpine), *Diospyros* (Tupra), *Dipterocarpus* (Karidhupa), *Kin-*

in brackets are local names

giodendron (Bhogi), *Lophopetalum* (Sattaga), *Lagerstroema* (Kadu chakke), *Mesua poecilonuron* (Balgi), *Polaquium* (Hadasale) and *Knema* (Patta Mara) are common in Gangamoola, Kudremukh, Kalasa and Agumbe but not so in Sakleshpur and adjoining areas.

One of the widely distributed tree is *Mimusops elengi L* (Ranja) which attracts rodents and birds by their fruits, is commonly found in Sringeri, Agumbe and Kalasa areas. *Myristica dactylodes gertu* (Ramanadike) is encountered at higher altitudes of Agumbe, Gangamoola, Kudremukh, Kalasa, Magundi and South Kodagu areas and is well known for attracting birds, bats, wildboar and rodents.

The trees in Evergreen patches are traversed by woody lianas like *Bauhinia phoemicea* wt. & *arn* (Kembittu Balli) common in Agumbe, Gangamoola, Sakleshpur and Coorg and *Chonemorpha fragrans* (Moon) *Alston* (Maramallige) along the ghat roads in mid and upper ghats. Lianas, lichens and moss are a principal nesting material source for squirrels which nest in tree holes or earth cutting covered by vegetation. *Thunbergia mysorensis* (wt) Andrerson (Kamanabilla Balli) - a striking, showy, flowering plant and *Geetum ula* Brogn (Goddu Adike) is common in Semi evergreen to evergreen forests. The tree trunks are covered by *Pothas scandens L* (Marayettu Balli), *Rapiclophora pertusa* (Roxb) Schoot and species of *Peperomea* and *Piper* (Kadu menusu).

The evergreen forest undergrowth mainly comprises seedlings of plants like *Alpinia melaccensis* (N. Burman), Roscae (Gandhamula) *Amomum canicarpum* (Wt.) (Kadu Yelakki) and several species of *Psychotria* (Daddle). These plants do not support much arthropods as well as birds and other vertebrates. Similarly, the undergrowth in parts of Belur and Sakleshpur in Hassan and in South Coorg, *Schemannianthus virgatus* (Roxb) Rolfe (Kadu Arisna) forms prominent undergrowth.

Moist and Dry deciduous forests:

In this type of forests, the tree vegetation gets mixed. For instance, teak (*Tectona sp.)* (Taega) forms major portions in Magundi, Koppa, Jaipura, Sangameshwarpet and Gulanpete forests area. Bamboo forms major portions in Muthodi and Hebbe forests area. It is observed, that in Malnad, the bamboo mixed forests hold more number of small animals than teak-mixed forests. These forests have suffered much owing to over-grazing, annual fires and over-exploitation by Man. These forests cater to the needs of public for forest-based industries, timber, firewood and charcoal. *Acacias* (Gobli), *Albizias* (Baage) and *Cassias* (Kakke) are first to appear. Further improved conditions pave way for species like *Bachunania lanzan* sprengal, *Butea monosperma* (Lam) Tanb, *Cassia fistula L.* (Kakke) *C. siamea* Lami (Sime Tangadi) and *Diospyros montana* Roxb. (Jagalagunti) are seen. Around Arasikere, Channagiri, Kadur and Kushalnagar area, *Santalum album L* (Srigandha) is frequently seen.

Scrub jungle :

In the drier tracts of Arasikere, Belur, Kadur and Chikmagalur, Scrub jungle is seen. *Phoenix sylvestris* Roxb. forms the dominant community. These forests are found in mounds, hillocks/uplands or elevated plainland where soil is poor, stony without much cover of top-soil and humus. Species of bamboo, *Albizzia,* (Baage), *Acacia* (Gobli), *Sapindus* (Antwala), *Pongaemia* (Honge), *Odoratissima, Tamarindus* (Hunise) etc. are important.

Cultivated areas :

Coffee occupies more than 55% of the cultivated area in Chikmagalur. *Arabica* and *Robusta are* two commercially cultivated species. Agribusiness is centered round coffee in the district. *Erythrinas* (Halavana) occupy major portion of coffee estates as shade trees. It is attractive to birds of atleast 15 families. Coffee estates with elements of original vegetation hold atleast hares, squirrel, rat, mongoose, wildboar and monkey.

Paddy is the most important cereal. Rainfed paddy is found in valleys and lower reaches of the slopes. Native forest and wetlands are being destroyed to accommodate expanded agricultural production. Changes in land use of the magnitude attributed to crop lands are having a serious impact on vertebrates. In plains, sorghum, pulses, oilseeds, sugarcane and vegetables are grown.

Apart from forests and agricultural fields, the terrain throughout malnad provide a diversity of habitats for vertebrates. The higher altitude vegetation consists of particular species of plants and in many ptaces the hill tops are devoid of tree vegetation due to heavy winds and are clothed by grasses and few herbaceous ephemerals. There is a need to manage hill tops. They should conserve water, locally recharge ground water, serve as a depot of humus and organic matter and attract higher altitude wildlife.

The sholas near hill top mainly have species of *Elaeocarpus* (Sattuga), *Cinnamomum* (Kadu chakke) and Gordon/a. Often *Symplocos cochinchinensis* (Lour) Moore and *Emblica officinalis* (Betta nelli) Geartner stand as stray, stunted trees along small crevices of hill-tops. Sholas are shrinking. Because of the uniqueness, sholas are of high conservation value and hold both small animals like deer, hare, etc., and large animals like elephant, tiger and bison. Shankar Shola near Kemungundi is being threatened as large areas are being brought under coffee plantations.

One of the most striking aspects of the landscape in Malnad is the presence of streams. Vertebrates extensively use streams through out the year.

In the drier parts of Arasikere, Kadur and Belur there are stretches of area covered by *Phoenix sylvestris* Roxb (Eechalu) community. The commonly encountered climbers and herbs are species of *Argyrea* (Kallanagida), *Cadaba* (Managade), *Gymenma* (Madhnashini), *Ionnocarpus* and *Jasminum* (Mallige). After the showers, species of *Crinum* and *Scilla* appear amidst boulders and *Urginea* appear amidst grasses. In the transition areas, a richer flora is seen with representatives of *Jerminalia* (Taare), *Tectona, Santalum, Pterocarpus* and *Shorea* (Jalari). The roadside vegetation also supplements food and shelter requirements of Vertebrates, especially goat, deer and hare. The vegetation include *Ficus benghalensis L., F. racemosa L., Mangifera indica L* (Mavu), *Tamarindus indica L.*, (Hunise), *Madhuca indica Gmel* (Hippe) and *Syzygium cumini L* Skeels (Naerale).

Role of Vertebrate pests :

To develop vertebrate pest management practices, it is essential that an understanding of the role of vertebrates in ecosystems is known. Understanding the relationship between vertebrates and nature conservation is the key to the ecology of Western Ghats.

The decline of a carnivore generally alters the ecological balance of it's biological community. Cats are linked through predation to herbivores which are, in turn, linked to each other through competition and to plant communities by theirforaging pattern. Reduction in Tiger population in hill region of Karnataka has led to increase in Wildboar population and in turn, consumption of plant biomass. Wildboar, *sus scrofa*, incurs, on an average, ten per cent yield losses in paddy. Cent per cent loss has been observed in paddy fields adjacent to forests without any carnivores. Forests with carnivores have generally climax vegetation types with overlapping and closed canopy trees.

Succession :

Spatial and temporal variations in the intensity of herbivore result from grazing/browsing in different regions by vertebrates. Bonnet monkey *Macaqua radiata* feeds on new flush of leaves, buds and fruits of *Terminalia, Cedrela, Albizzia, Ficlus, Salmalia* and *Bombax* during post monsoon (October- February). On oranges, *Artocarpus, Dipterocarpus* etc., during pre-monsoon (March-June) and on paddy, banana etc., during monsoon (July-September) period in coffee plantations in Chikmagalur. But animals are major regulators of their habitats in their own way. Individual vertebrate species consistently consume a characteristic proportion of grass or browse in the diet, (b) eat only a subset of the plant species available, (c) occupy only a subset of the habitat types available at any given time and (d) partition renewable resources temporarily by using the same habitat at different times. Wildboar in Mudigere subsists on *Diascoria allata, Cyperus rotundas,* paddy, potato, sweet potato, *Colacasia, Allocasia* tubers during monsoon (July-September) and post-monsoon (Oct-Feb) and on refuse heaps, ragi, root grubs, etc., during pre-monsoon (March-June) period. Being a highly sensitive animal, it locates food by the odorants emanating from the plants.

Seed Dispersers :

Studies in tropical forests have now shown that the highest chances of survival are possessed by seeds

that have been dispersed away from the parent tree. Seedlings of cardamom, a plant of high economic value growing on tree holes, tree surfaces, amidst stones and boulders, stream edges, forest floors is a common sight in Mudigere. This is because squirrels, rats, spurfowl - a ground bird and shrew split cardamom capsules to feed on the mucilage and defecate seeds away from the feeding site. Similarly seeds of *Ficus, Scizhigium, Artocarpus, Michaelia are* dispersed as wildboar, monkey, large birds like hornbills feed on their fruits. In Western Ghats, large vertebrate/birds are more effective in dispersing seeds because

(a) they tend to be more selective of large, hardwood species (=mature phase species)

(b) they consume more fruits/feeding bout and

(c) they tend to carry the seeds farther before regurgitating or defaecating them. More information on these aspects is available in Bawa and Hadley(1990).

Of more than 300 species of mammals and birds recorded in Muthodi, Magundi, Someshwara and Hebbe forests area, 50% are fruit and seed eaters, exerting profound influence on vegetation. Future management plans for tropical forest should include two components :

(a) strategies for sustaining large vertebrate dispersers in the ecosystem and

(b) strategies for increasing the representation of tree species of particular economic and ecological significance. Management and conservation policies should be based on many species so that animals depending on them can survive.

These observations firmly establish the indispensable role of vertebrates in forest stands and the relationships between seed dispersal and seedling demography have profound implications for vertebrate pest management.

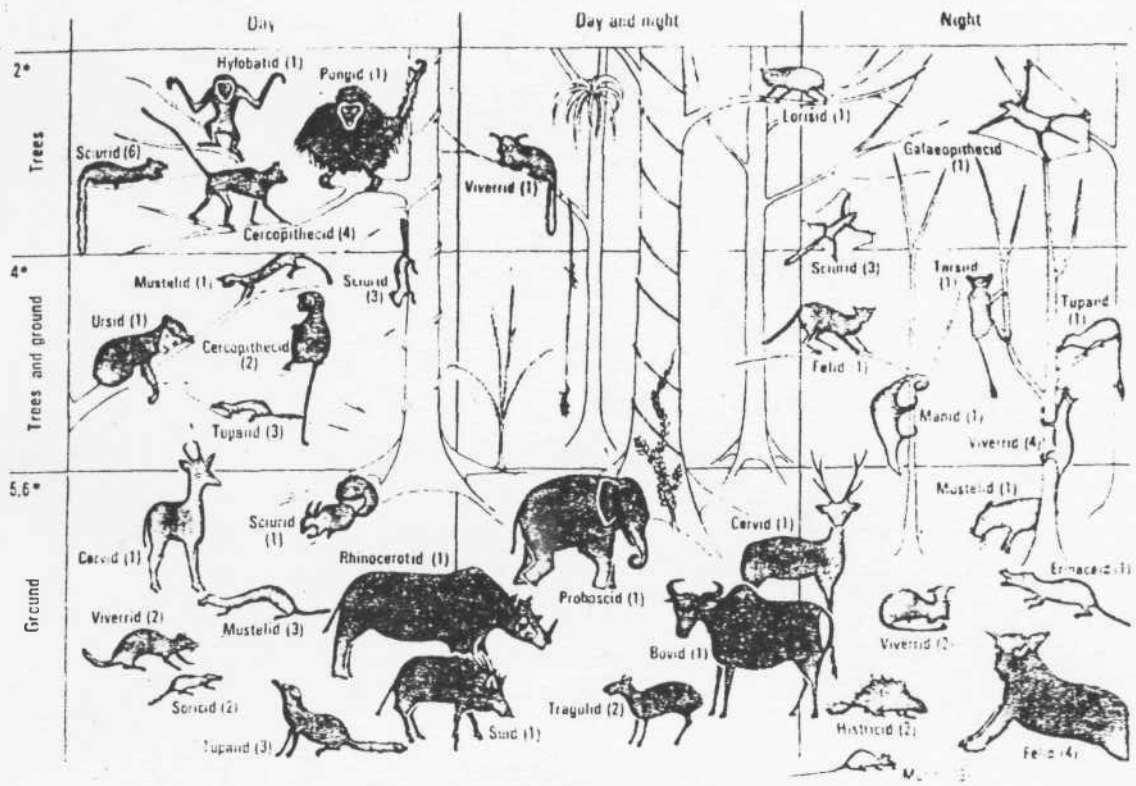
Energy flow and nutrient cycling :

The high levels of herbivory in forest ecosystems have major implications for both energy and nutrient budgets. Mixed feeders (grazers, browsers, borrowing animals, etc) consume varying proportions of grass, green flush, seeds and fruits in different seasons. For instance, squirrels of *Funambulus* species in Mudigere feed on cardamom capsules, ants, termites, seeds of *Solanum,* ground beetles and bugs during fruiting period of cardamom (August to February) and on *Salmalia, Bombax. Carya, Melia, Scizigium,* etc. buds and flowers during non-fruiting period of cardamom in Mudigere.

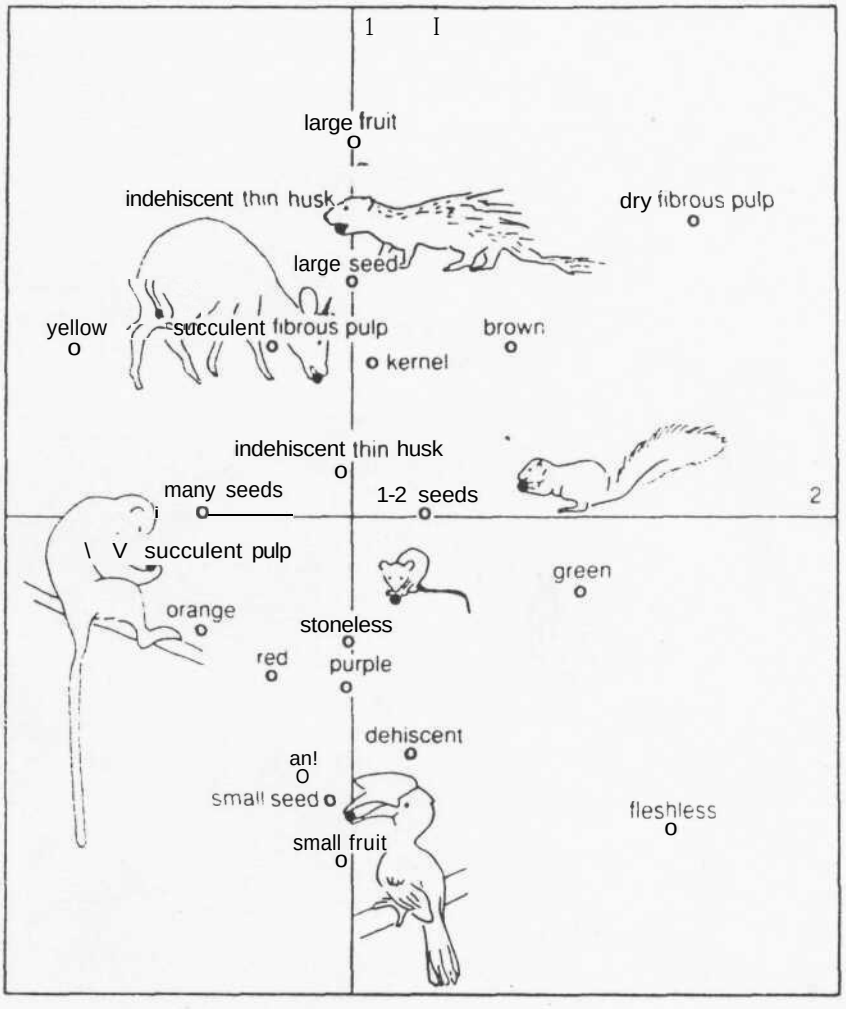
Herbivore body size not only determines energy demands, it also governs the rate and the extent of energy extraction from the diet. Small herbivores (monkeys, logomorpus, sheep, goat) are forced to satisfy relatively higher energetic demands by selecting high quality items such as new shoots, fresh green grass, fruits and flowers. Large herbivores (elephants, wildboar, bison) are forced to expand their diets by incorporating lower quality, more abundant and easily available plant material. So energy flow may depend on body size, distribution within the animal community. Body size also influences the biomass consumption in agroecosystems.

Animals have another mechanism of plant resource partioning. Niche differentiation allow co-occurrence of animals to reduce the impact of competition. For example feeding in different heights from the ground contributed to resource partitioning among species as did the use of different habitats in dry and wet seasons. Cocoa fruits in natural patches are fed upon by jackal, jungle cat, squirrels, rats and monkeys. Jackal selectively harvest fruits upto 1 m height; rats and squirrels from any portion of the canopy and monkeys, from the top canopy. Of rodents, squirrels injure only fresh pods during day but rats reinfests the infested fruits during night. Understanding niche of vertebrate pests is essential for finding the target site for placing the bait, etc.

These observations indicate that the structure and state of natural ecosystems in Western Ghats are influenced by animal density and community species composition. Since vertebrates strongly influence species composition and structure of vegetation and also its productivity, it seems unwise to ascribe a passive role to them as recipients in a donor-control-



Stratification of the non-flying mammals in the lowland rain forest



The interrelationships among the six groups of consumers and the fruit characters of their food

led rainfall-determined ecosystem.

Natural ecosystems are mostly in the form of tropical forests in Western Ghats consisting of teak (*Tectona grandis*), Beete (*Dalbergia latifolia*), Mathi *(Terminalia sp.),* Nandi *(Lagerstroemia lanceolata),* Gandhagarigae *(Cedrella toona), Bombax* species, *Dipterocarpus* species, *Elacocarpus, Evodia* species, *Machilus* species, *Santalum album, Sapindus,* Rosewood, etc. which are put to manifold uses. Tropical forests also have tourist, recreation and scientific value. So these forests continue to be rapidly denuded and disturbed and so are vertebrates. As a result, the productivity of the remaining forests in Western Ghats is extremely low and the quality, still lower. Therefore, an Integrated approach is urgently required for conservation of forests and vertebrates as also for their management. This will also help to reduce vertebrate depredations on crops in the region.

Under certain conditions vertebrates can partly replace the pressure in grazing by domestic stock, of occasional selective cutting, of prescribed burning and of other means often suggested now for preserving some vegetational types. The difficulty is that the precise influence of free-living vertebrates on a limited area is not predictable. The size of a conservation area for simultaneous protection of vertebrates and rare or desirable plant communities must, therefore, be rather large. The influence of vertebrates is very variable and on occasion can even be deleterious in small protection areas. So the influence of vertebrates on vegetation can be positive, neutral or negative in terms of regeneration/succession and the possibility for occurrence of these shifts be recognized and considered by the protection specialists.

Statistics :

Use of statistical methods in vertebrates pest management studies will help researchers to make appropriate interpretations of the data. Collecting data on vertebrate pests, their numbers and damage to crops was often difficult in the forested and cultivated tracts. We need to spend more time in collecting relevant and precise data. Samples of data on vertebrate pests were often small and variable. In many situations the identity of the vertebrate pest itself was in question. Researchers on vertebrate pests need statistical techniques so that data can be analysed without information on the distribution of the vertebrate population, scores which are not exact in numerical sense and computation is simple and not time-consuming. In view of these conditions the choice of suitable statistical methods become important for studies in vertebrate pest management.

In certain situations of vertebrate pests problems, estimation of populations, crop damage, etc. and in others, tests of hypotheses become the primary concern. Both the parametric and non- parametric tests need to be deployed.

The basic conditions which must be satisfied for conducting parametric tests are that the observations must be independent drawn from normally distributed populations. In analyses concerning two groups, the populations must have the same variance and the variables are measured in atleast an interval scale. These conditions are ordinarily not tested in the course of the performance of a statistical analysis. Rather, they are presumptions which are accepted. Whenever these conditions were met in the data, the parametric tests, viz., 'F' or 't' tests were performed. If these conditions were not met, non-parametric tests viz., Binomial 'Z' or X2 or 'u' tests were performed. Non parametric tests make fewer assumptions, are suitable when sample made up of observations are from different populations and are easier to learn and apply. "Non-parametric statistics for the behavioral sciences," (II edition) by Sidney Siegel and N.J. Castellan and "Statistical methods" by Snedecor G. W and Cochran, W.G. may be consulted for more details.

Literature :

Published literature on vertebrates and crop protection in hill region of Karnataka is meagre. So, selected, published information even from outside the hill region is reviewed here. Work on vertebrate pests outside India is also briefly mentioned.

Barnett and Ishwar Prakash (1980) described features of the biology of rodents, relevant to their control. They also covered principles of population dynamics and other aspects of ecology of rodents found in India. Fitzwater and Ishwar Prakash (1988) covered several basic aspects of vertebrate pests like marking techni-

ques, baiting, use of repellents, capturing and handling wild animals, bioassay techniques and important species of vertebrate pests found in India.

Plantation crops :

Cardamom, *Elettaria cardamomum* is the principle spice of the hill region. Siddappaji and Reddy (1973) reported that squirrel and rat caused extensive damage in cardamom plantations during 1969-71 at Mudigere. Shooting, trapping and clean culture were recommended as remedial measures. Srihari and Chakravarthy (1992) conducted comprehensive studies on rodent pests of cardamom highlighting species composition, relative abundance, extent of yield loses, field behaviour and management practices for crop protection. Chakravarthy *et. al.* (1991) suggested protection measures for cardamom from rodents.

Keshava Bhat and co-workers have extensively studied the problems of vertebrate pests, especially rodents on cocoa, coconut and arecanut in Kerala, a state adjoining Karnataka in the Western Ghats region. Bhat and Sujatha (1989) evaluated Brodifacoum against the Indian Black rat in cocoa. Abraham et al. (1979) reported the nature and extent of damage to cocoa pods by squirrel, *Funambulus tristriatus* and efficacy of different crop protection methods in Kerala. Bhat et al. (1981) listed vertebrate pests of cocoa in South India and extent of losses caused by each species. Bhat (1992) reviewed the literature on rodent damage to coconut, cocoa, oilpalm, arecanut, cashew and rubber.

Bhat (1990) recorded *Rattus rattus* as a pest of oilpalm, *Elacis guineensis* seedlings, a crop recently introduced for commercial cultivation in India. Rats, squirrels, Bandicoots and Porcupines have been observed to damage cashew in India (Bhat, 1992). The house rat, *R. r. rufescens* has been reported to gnaw open nuts in godowns and eat away the cotyledons of the germinating cashew in the field (Abraham, 1958). The squirrel, *F. palmarum* destroys cashew seedlings (Basheer and Jayaraj, 1964).

Urs (1978) estimated losses of coconut seedlings (9 months old) by *Bandicota bengalensis* in nursery. Advani (1984) reported on ecology, status and postnatal development of the black rat, *R. rattus* on coconut and cocoa. He also evaluated efficacy of Rodafarin cakes against mixed population of rodents infesting coconut in Western Ghats region. Bhat and Sujatha (1988) evaluated baits using multiple dose anticoagulants on the population of Black rat, *Rattus rattus* in coconut fields. Rat, *B. bengalensis* caused, on an average 9.29% losses in coconut in Gujarat from 1983 to 1986 (Patel and Mittal, 1988). He also evaluated efficacy of Rodafarin cakes against mixed population or rodents infesting coconut in Western Ghats region. Bhat and Sujatha (1988) evaluated baits using multiple dose anticoagulants on the population of Black rat, *Rattus rattus* in coconut fields. Rat, *B. bengalensis* caused, on an average, 9.29% losses in coconut in Gujarat from 1983 to 1986 (Patel and Mittal, 1988). Bromodiolone baits were found effective in protecting tender coconuts from rat damage (Bhat and Sujatha, 1989).

Several species of rodents including rats, squirrels, bandicoots, gerbils and porcupines *(Hyxtrix indica)* damage coconut at every stage of cultivation. Among these rodents, the black rat, *Rattus rattus* which is primarily responsible for tender nut damage is considered to be the major pest (Bhat, 1992).

Nambiar (1949) reported about 20% squirrel damage to tender arecanuts. In Karnataka, Naidu (1962) and Bhat (1982) reported squirrel and rat damages to arecanut, but the damages were not of a serious nature.

In India the rodent problem in oilpalm was first reported by Subiah (1983). He noticed rat damages to seedlings, female flowers and immature and mature fruits of oilpalm in Andamans. Bhat et al.(1990) reported *R. r. wronghtoni* as a pest of oilpalm seedlings. In a nursery about 45% of the seedlings were totally destroyed by this pest.

Ali and Ripley (1969) and Fizwater and Prakash (1989) have dealt with the various aspects of birds and vertebrates, respectively, in India.

Literature - Abroad

A great variety of Vertebrate pest situations occur in urban, agricultural and other environments throughout the world. The resulting problems include severe economic losses, threats to human or domestic animal health, impacts on fragile ecosystems or endangered species or simply the nuisance of undesirable animals (National Academy of Sciences, 1970). The ecology and behaviour of many of the vertebrate pests is not well known. Murton and Wright (1968) touched on the problems of birds as pests mainly in Britain. National Academy of Sciences (1970) documented information on Vertebrate pests, their problems and control methods mostly in the U.S.A.

Vertebrates have not received the degree of attention given to other agricultural pests. Damage by vertebrate pests is, however, calculated in hundred of millions, perhaps billions of dollars, annually. Nearly all the food crops grown on small farms are susceptible to bird and rodent damage from planting until consumption (Fieldler et al., 1987). Jackson (1977), Hopf et al (1976) and De Grazio (1978) provided some details on a great variety of damage problems caused by rodents and birds. Different pest species or groups may be implicated, depending on the kind of crop or geographic region. Because species have different reactions to management methods, local research and evaluation are necessary before recommendations can be made on a specific problem. Vertebrate management techniques and programs must be compatible with the social, economic, philosophical and religious situations of the villages where they would be used.

Rodent pests :

Numerous rodent species damage emerging and maturing grain crops through out tropical regions (Sanchez, 1975). Rodent problems with coconuts and sugarcane have received considerable attention (Taylor, 1972). Rats feed on and damage developing nuts in many tropical countries of the world. In the Tokelan Islands, Wodzicki (1973a) estimated losses of upto 84% by Polynesian rats (*Rattus exulans*) in his study plots. Williams (1974) found losses in Fiji islands between 1970 and 1972 to range from 5.6 to 13.3 per cent. In the Phillipines, which supplies majority of the world's copra exports, rats are implicated as a limiting factor (Anonymous, 1975).

Sugarcane is damaged by rats wherever it is grown. Rodents gnaw the internodes, particularly of the less fibrous varieties and feed on the sweet tissues within. The sugar content of canes decrease after rodent damage as a result of secondary bacterial and fungal growth (Taylor, 1992).

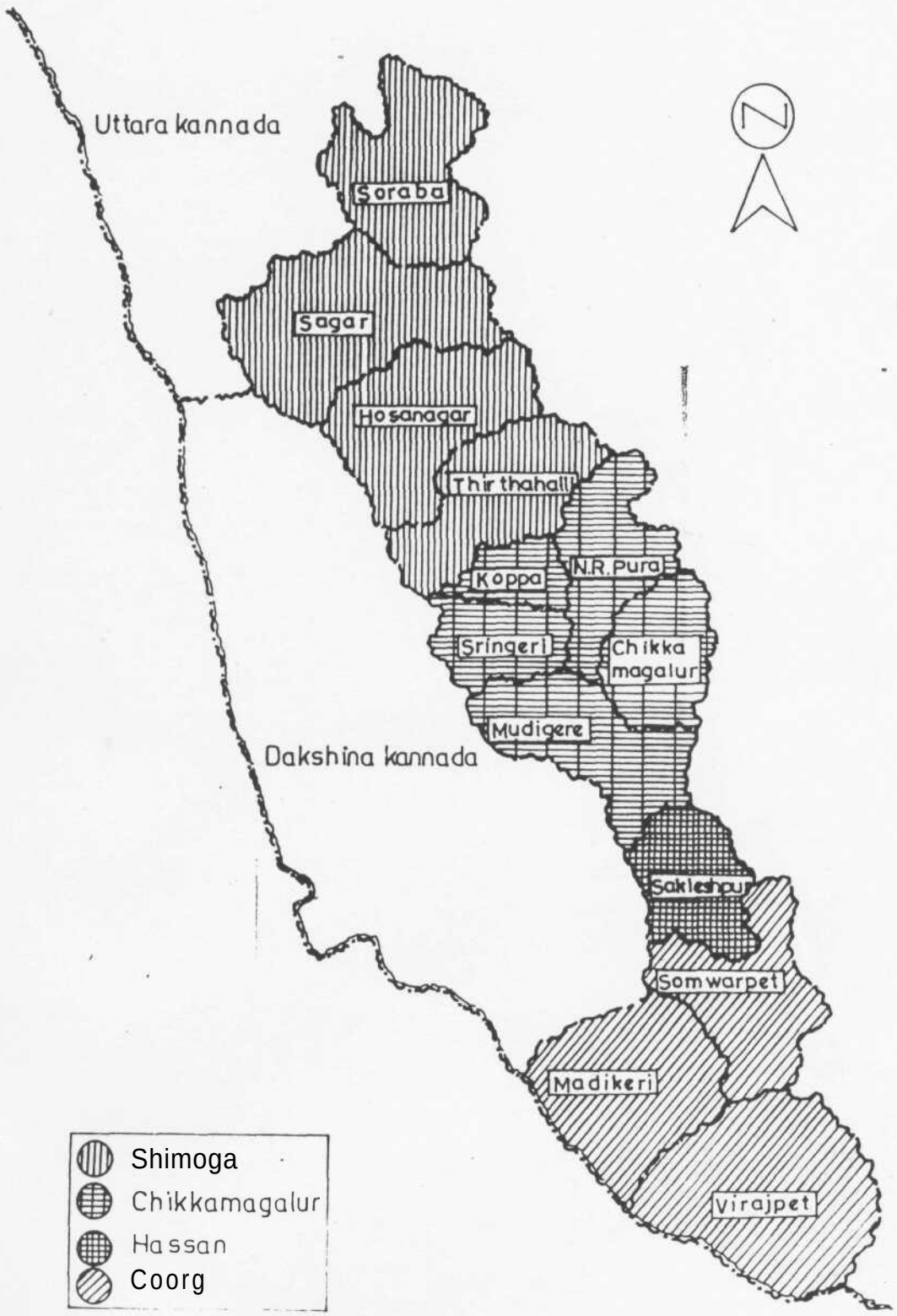
Rodents are known to damage both groundnuts and several kinds of vegetables. Fiedler et.at.(1983) quoted D'jrra who reported an assessment in which four villages in Louga, Senegal showed an abundance of about 2000 rodent burrows and 35 kg of catched groundnuts/ha, amounting to about 6% of the groundnut production of these villages in 1976. In another village, it was reported to one of us that of a 600 kg/ha groundnut harvest , rodents had stored 100 kg/ha underground.

Damage in small plots of tomatoes, potatoes, beans, cabbage and carrots is widespread. Depending on the crop stage, either vegetative growth or the edible fruit is damaged. Sweet potato and cassava (Manioc) are frequently damaged by rats in Asia, Africa and Latin America.

Rodent damage to agroforest systems occurs worldwide but is not well-defined in the tropics. Fiedler (1987) summarized reported forestry and plantation crop rodent damage to seeds, seedlings, roots, bark and fruit. Ten per cent of young paw paw trees in Zimbabwe were chewed by Porcupines *(Hystrix sp.)* and upto 50% of young cypress and pine trees in Uganda were girled by *Otomys sp.* and *Lophuromys sp.* (Hopf et al., 1976).

Bird Pests :

In the Latin American countries of Guyana, Guatemala, Colombia, Uruguay and Mexico, emerging rice, corn, soyabeans, wheat and sunflowers are damaged by blue-winged teal *(Anas discors),* great-tailed grackles *(Cassidix mexicanus)* eared doves *(Zenaida auriculata)* and brown-headed cowbirds (*Molothrus sp.)* (Grist and Lever, 1969). Doves caused loses to emerging wheat equivalent to US $



A MAP OF FOUR DISTRICTS OF MALNAD REGION

VERTEBRATE PEST MANAGEMENT IN SPICE CROPS IN MALNAD REGION

Important spice crops of the region are cardamom (*Elettaria cardamomum*), Pepper *(Piper nigrum*), Cinnamon (*Cinnamomum zeylanicum*), Ginger (*Zingiber officinale*), Turmeric *(Curcuma longa*) and Chillies *(Capsicum annum).* Of the spice crops, cardamom is threatened by vertebrate pests. Cardamom occupies more than 29,000 ha in Malnad which contributes 89% of area under cardamom in the State and is the 'Queen of spices'. It finds its use in food preparations, confectionaries, beverages, liquors and ayurvedic medicines.

Survey and identification of vertebrate pests (VPs) depredating cardamom and other crops in Malnad :

A survey of cardamom plantations in Mudigere, Kalasa, Sringeri, Tarikere, Chikmagalur and Kadur taluks of Chikmagalur district; Thirthahalli, Hosanagar, Sagar and Soraba taluks of Shimoga district and Virajpet, Madikeri and Somwarpet taluks of Coorg district was conducted during 1988-90. During the survey, all types of habitats were covered. Observations were recorded by a 8 x 30 binoculars on animals. Characters of the species of vertebrate involved in depredation on crops in Malnad is given in Appendix I. Wooden snap traps (75 x 35 cm) were employed for trapping and identifying some of the species.

Bandicota bengalensis, Bandicota indica, Rattus rattus and *Mus booduga* among the species of rats; *Funambulus palmarum, Sus scrofa, Felis chaus, Macaqua radiata, Galloperdixspadicea, Gallus sonneratti* and *Zoothera citrina* were implicated in crop damage. Rodents formed the core group. Wildboar and monkey were the next important group of animals causing economic losses to farmers. The species composition of Vertebrate pests in Hill and Coastal regions is given in Table 1.

In Mudigere, a survey revealed that rodents caused, on an average, about 9% losses in cardamom yields. Cultivation practices of cardamom and other crops vary regionally due to geographical variations in soil, climate and relief. These factors may themselves limit the distribution of some species. Vertebrate pests are also affected by regional cultivation practices. Highest vertebrate pest depredations were found where cardamom was cultivated intensively. Crop yield - losses in Hill and the adjacent, coastal regions due to vertebrate pests and theirturn-over rates is given in Table 2. The qadrupets constituted 10 species and birds, seven species. These pests become important limiting factor in one or the other cropping situation or farming systems in Hill and coastal regions. Crop yield losses due to major species of vertebrate pests in coastal region are given in Table 3. Wildboar, monkey, stag and birds are the major vertebrate pests (VP) in coastal region. Jungle cat, elephant, wildboar, rodents, jackal and parakeets are important vertebrate pests in Hill region (Table 4).

Troupe behaviour of monkey in cardamom ecosystem

The Bonnet Monkey *Macaqua radiata* troupes comprise of multimales, multifemales, sub-adults and babies. While the males were found outside the troupe, it is the females that cling all through to the natal troupe. This relationship is thus exploited while trapping these animals. Trapping operation has been successfully carried out at Mudigere. It was observed that some males disappeared from the natal troupe. Reasons for this are not known. Monkeys have no natural enemies at the study site except for the interference of Man. During breeding and reproductive periods, i.e., during September - October, many males disappeared. Mating behaviour in monkey troupe could be found from August-September to March-April. It was also observed that a troupe or part of the troupe foraged outside the accustomed range to fetch food. During November-December, 2 or 3 troupes were found sharing a common feeding ground. Most of the mating, delivery and infant rearing were carried out in the foraging zone of the troupe." Mating and breeding activities were observed throughout the year, but peak was observed during March-April. Pregnant females were sighted in June-July and mothers with babies were seen during September. These preliminary observations showed that the number of monkeys in a troupe fluctuated widely as also the size of their foraging and feeding zones. The monkey forage in the canopy of trees. When food

TABLE 1

Species composition of vertebrate pests in Hill and Coastal regions

Common Name	Species	Shimoga	C.maglur	Coorg	Hassan	S.Kanara
Rat	Mus booduga	+	+	+	+	—
	Bandicota bengalensis	+	+	+	+	+
	Bandicota indica	+	+	+	+	+
	Rattus rattus	+	+	+	+	+
Squirrel	FunambuluspalmarumS	+	+	+	+	—
Wildboar	Sus scorfa	+	+	—	—	+
Monkey	Macaqua radiata	+	+	—	+	+
Jungle cat	Felis chaus	+	+	—	—	+
GreyFowl	Gallus sonneratii	+	+	+	+	—
Spurfowl	Galloperdix spadicea	—	+	+	+	—
Thrush	Zoothera citrina	—	+	+	+	—
Sambar	Cervus unicolor	—	—	+	+	+
Rabbit	Lepus nigricellis	—	+	+	+	+
Elephants	Elephas maximus	+	+	+	—	—

\+ = Economically important
— = Not economically important

TABLE 2 Crop yield-losses in Hill and Coastal regions due to vertebrate pests and their turn-over rates(N = negligible (0–5%); M = Moderate (5–20%); C = Considerable (20%)

Common name	Scientific name	Crop	yield	Remarks	Turnover rate/yr
Wild goat	*Capra* sp.	Sugar cane	N	Regular Pest	2 to 4
Jungle cat	Felis chaus	Cocoa	C	Wide Spread	2 to 3
		Cotton	M	Boll nipping	
		Sugar Cane	N	Stem chewing	
Porcupine	Hystrix sps	Pineaple	M	Patchy	2 to 4
		Peas	N	pod peeling	
		Potatao	N	Tuber feeding	
		Banboo	N	Fresh planting	
Squirrel	Funambulus sp	Cardamom	M	wide spread	3 to 4
		Cocoa	N	Patchy	
Rat	Bandicota Sps	Paddy	N	Wide spread	6 to 8
		Coconut	N	Tender fruits	
		Aracanut	N	Tender fruits	
		Oil Palm	M	Sev in Shimoga	
		Rubber	M	Sev in S.Kanra	
Wild Boar	S.Scrofa	Paddy	M	Sev in valleys	6 to 8
		Aracanut	M	Seedlings	
		Rubber	M	Seedlings	
		CardamNursery	N	in Summer	
		Mulbery	M	Browsing	
		Sunflower	C	Lodging	
		Fingermillet	C	Browsing	
		Sugarcane	M	Lodging	
		Sorgum	M	Ear Feeding	
		Potato	M	Earthing up	
		Groundnut	C	Up rooting	
Elephant	E.maximus	Banana	M	Sept & Nov	1
		coconut	M	Nut & Seedling	
		Coffee	N	Trampling	
		Paddy	N	Trampling	
Monkey	M.radiata	Cardamum	M	Tender culmns	1 to 2
		Fruit Crop	M	Seasonal	
		Coffee	N	Berries	
		Areca	N	Tender & Ripe	
		Coconut	C	Tender	
		Paddy	M	Milky	
Jackal	C.aureus	S.cane	M	Wide spread	2
		Coffee	M	Ripe Berries	
		Ground Nut	M	field borders	
Sambar	C.unicolor	Rubber	M	Bark pealing	2
		Paddy	N	Seedling	
Jungle Crow	C.macrhynchus	Fruit Crop	M	Patchy	2
		Sorghum	M	Wide spread	
		Paddy	M	Seedling	
Small Green Barbet	M.viridis	Fruit, Vegetable	M	Small farms	2
		PlantationCrop	M		
Finch Bird	Lonchura sps	Sorghum, Rice	N	Patchy	2 to 3
	Ploceus Sps	Rice	M	Patchy	2 to 3
	Emberiza sps	Sunflower	N	Patchy '	2 to 3
	P.domesticus	Rice, Sorghum	N	Patchy	2 to 3
R. Parakeet	P.krameri	Vegetables	N	Coastal region	2 to 3
		Paddy	M	Wide spread	

TABLE 3

Yield-loss due to vertebrate pests in coastal region

Vertebrates	Crops	Yield Loss (%)	Taluk/ Hobli
Monkey	Areca, Coconut, Banana, Cocoa	30 to 40	Dharmastala
Monkey, Wild Boar Stag, Rodent, Bat	Areca, Coconut, Banana, Mulberry, Paddy	10 to 15	Navuru
Monkey, Wild Boar Jungle Crow	Areca, Coconut, Pineapple, Banana, Cocoa	10 to 12	Kikamba
Monkey, Wild Boar Stag, Jungle Crow	Areca, Coconut, Banana, Orange, Cocoa, Pepper	15 to 20	Mundaje
Wild boar, Monkey Birds	Areca, Coconut Cocoa, Pineapple,	10 to 15	Katinadaka
Wildboar, Monkey, J Crow, Bat	Areca, Coconut, Pepper, Banana	20 to 25	Manjatti
Wildboar, Monkey, Stag, Elephant	Coconut, Areca, Pepper, Banana, Rubber, Jackfruit	10 to 15	Neria
Rat, Monkey, J Crow, Wild Boar	Coconut, Areca, Rubber, Paddy, Areca	10 to 15	Gandi Bagilu
Stag, Monkey, Wildboar, Rodent	Coconut, Paddy, Banana	1 to 5	Chibidre
Stag, Monkey, Wildboar	Mulberry, Paddy, Banana	3 to 5	Pudure
Stag, Birds Rodents	Mulberry, Rubber, Pineapple	5 to 10	Mongotti

4 surveys were conducted in each taluk during 1992–93

becomes scarce they descend down to feed on food available on ground.

Monkey descend on to the peripheral area of paddy fields, one by one and try to obscure as much as possible. The animals break- down the plants at almost mid-point, hold the panicles by two hands and feed on the grains. The animals in the process of feeding spill 70 to 80% of the grains. Thus, a troupe of about 8 to 10 monkeys in one hour spilled 10 to 12 kgs and fed only about a kg or two. Monkeys were observed consuming, uprooting seedlings, splitting pseudostem and feeding on the tender culms.

Number of Monkeys

A population count on monkey, *Macaqua radiata* was made at RRS, Mudigere during July and August, 1991. The counts were made in three habitats, viz., valley, plain and slope. The count revealed that on an average, 27.40 animals in 105 acres were present. All the animals were found in one troupe. It was observed that when the food is abundant at RRS, another troupe of 25 to 30 animals forage. Therefore, the population splits or coalesce depending on the availability of food.

. *Monkey damage to cardamom in different habitats and at different age groups :*

Monkey damage did not differ significantly from one habitat to another based on per cent shoots damaged, year wise. For instance, during 1989-90 and '90-91, maximum damage was recorded in plains, while during '91-92 and '92-93 maximum damage was recorded in slope habitat.

Field observations revealed that monkey preferred to feed on tender (less than 3 years old) pseudostems of cardamom in the absence of wild fruits like guava, jackfruit, chakota, oranges, banana and paddy. At times of no or negligible human activity, monkeys were found entering the cropped area one by one. The animals held the base of the pseudostems with one hand and with teeth, peeled out the outersheaths; cut open the yellowish white pith and fed on it. The animals usually fed on 10% of the shoot biomass they destroyed. Monkey was the only pest feeding on cardamom shoot.

There were non significant differences in the percent clumps loss in three habitats, viz plains, slopes and valleys. When the loss in clumps was compared during 1990 and 1991, the loss was higher in 1990. The possible reasons are : (a) During 1991, area under cardamom increased by 6 ha; (b) there was reduction in monkey population due to trapping and watch-and-ward was intensified and was even extended from 6.00 a.m. to 6.30 p.m. In 1992, the damage by monkeys again increased in RRS, Mudigere.

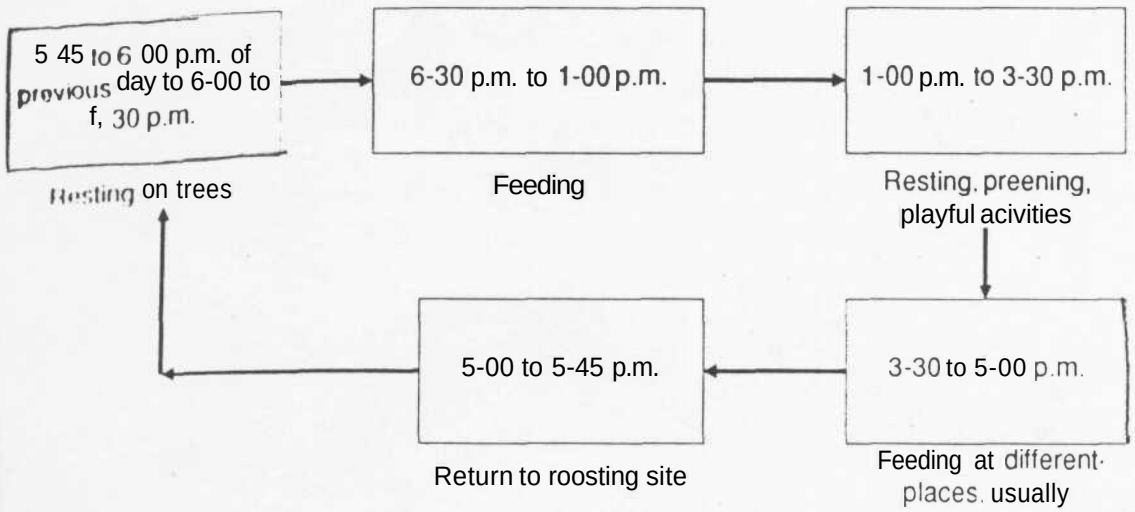
Observations on monkeys damage to cardamom clumps at two different age-groups viz. below and above 3 years' revealed significant differences. 'T' test showed significant differences in the per cent clumps damaged. Clumps of less than 3 years were preferred than those over 3 years old. Concurrent results to this effect were obtained even during 1990. Of clumps less than 3 years old, one year old clumps were the most preferred with 53.38% damage. Less than one year old clumps are tender and so are more palatable for the animals to consume. This experiment clearly revealed that young plantations are prone to heavy monkey depredations and deserve protection.

Seasonal movement of monkey troupe at RRS, Mudigere and population growth.

The seasonal movements of monkey troupe is shown in Figure 1. For convenience, the year was divided into pre-monsoon (January to April), monsoon (May-August) and post-monsoon (September- December) periods.

During pre-monsoon period, monkeys fed on cardamom, sapota, guava, orange and paddy. For feeding, the troupe covered considerable distance as the crops were located in different habitats. During monsoon, the animals fed on cardamom, jackfruit, *Ficus* Jambolana and Lantana all found in and around the same habitat. So the distance foraged would be less. During post- monsoon period also the monkeys were found mostly in the plantations only. The normal movements of the troupe was altered by the watch and ward. The group size was reduced. The animals had to expend considerable time and energy for movements from one habitat to another, inter group aggression, screams and hiding. The animals had to forage

Seasonal movements of monkey troupe in Mudigere



more to obtain sufficient quantity of food. This basic information on troupe foraging patterns would be useful in the management of monkey menace. The population structure of monkey observed at different periods at RRS, Mudigere is as follows :

	Aug. 90	Dec 90	March 91	March 92
Young one	21	16	15	22
Sub-adult	21	15	21	19
Adult	18	11	18	40
Total	60	42	54	81
March. 1991	–	–	16	Trapping

Under Malnad conditions, in monkeys breeding occurs throughout the year. However, peak occurs during April-May. Observations throughout the year revealed that numbers increased during April- May and December-January. Monkeys could be conveniently trapped during summer (March-May) when the variety of food resources shrink or it gets limited to few patches only.

The extent of monkey damage in different blocks of Regional Research Station (RRS), Mudigere has been depicted in a Map (See Annual Report, VPM - 1989-90). The average per cent loss of cardamom clumps was 31.81 per cent during different years. This level of loss is economically important. The diel activities of the monkey troupe in RRS, Mudigere in general, is shown in Figure 2. More than 50% of the time the monkeys were found engaged in feeding and foraging activities.

Observations on monkeys damage to cardamom clumps at two different age-groups revealed that monkey preferred clumps of less than three years old (Table 5). The shoots of 3 years old clumps were more palatable and tender. Monkey damage to cardamom clumps of two distinct groups is given in Table 6. The Binomial test revealed significant differences between the two age-groups.

It has been observed that shade regulation deters monkeys as the shelter sites become less secured. To confirm this observation, monkey damage to clumps in shade-regulated and unregulated sites was recorded and the data is given in Table 7. The shade regulated site recorded significantly less damage than the normal site. In shade regulated plots the branches are cut and the habitat becomes open, making movement and feeding difficult for monkey.

Protection to cardamom from monkey damage :

Before trapping, habitat use patterns and foraging behaviour of the animals were ascertained. The rectangular trap (6.5' x 2.5' x 2.5') made of angled iron had two chambers, an outer called 'receiving chamber' and an inner 'collecting chamber' both provided with sliding doors for closing. At base, the trap was provided with four wheels for easy movement. The trap was placed at spots (in cardamom cultivated tract) frequented by the group of monkeys regularly. The animals were pre-baited with fruits of banana, jackfruits, oranges and sapota, naturally available in the plantations. Pre-baiting was done for a week in order to make the animals get 'use' to the trap.

After a week, the sliding door at the front was operated by a rope, 15-20 m away. Sufficient number of fruits were placed in the first chamber and as soon as the animals entered 'receiving chambers', the doors were closed by the rope and animals, with the help of a stick were moved to 'collecting chamber'. Water and food (natural) was provided to the animals in the chamber. The front gate of the 'receiving' chamber was again held open for trapping more animals. This procedure was repeated until sufficient number (20 to 25) of animals were trapped.

After trapping the animals were marked and the trap was driven to a forest area about 20 km away and animals were released there. Observations from the past 6 months revealed that monkeys stayed in the forests. The forest tract should be sufficiently large and should have natural foods so as to hold the animals and newly born for long periods. The released animals should not become 'pests' in orchards or plantations. Observations on monkeys are in progress (e.g. movements of the animals in the study area are traced) and trapping will also be continued. This preliminary studies revealed the following points :

TABLE 4

Major venebrate pests on crops In Hill and Coastal regions

Vertebrate Pest	Crops	Hill Region	Coastal Region
Jungle Cat	Cocoa	+	—
Elephant	Banana	+	—
	Paddy		
	Coconut		
Monkey	Rubber	—	+
Stag	Coconut	—	+
Wildboar	Rubber	+	—
Rat & Squrriel	Paddy	+	—
Jackel	Cardamom	+	—
Parakeets (6 sps)	Sugarcane	+	—
Small Green Barbet	Paddy	—	+
	Vegetables		

+ = Major pest;
— = Not a major pest

TABLE 5

Monkey damage to cardamom climps at different stages

	Age of Cardamom (years) Percent clump damage			
Dates	1	1 to 2	2 to 3	3 to 5
05.02.90	32.10	35.00	30.10	0.60
20.02.90	38.00	37.10	32.00	0.24
04.01.91	49.50	42.00	38.20	0.59
19.01.91	60.20	57.10	59.20	3.93
03.03.91	69.00	59.20	63.00	6.05
18.03.91	71.50	60.10	68.50	6.93
Mean	53.38	48.42	48.50	3.06

CD @;Age of cardamom = 9.10;Dates = 6.1 5AæD = 1.37

Bonne! Macaque
(*Macaca radiata*)

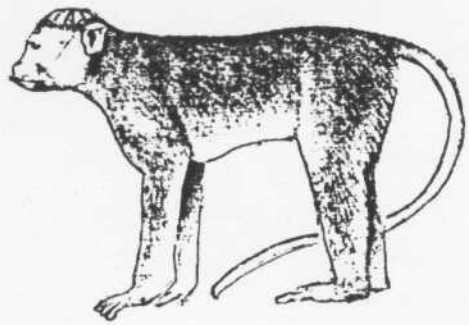


TABLE 6

Monkey damage to cardamom clumps of different age groups

Clumps Percent Damaged			
< 3 years age		> 3 years age	
1990-91	1991-92	1990–91	1991-92
41.57	32.37	0.00	0.00
62.57	35.70	3.20	0.24
70.04	43.23	6.10	0.59
75.41	58.83	7.30	3.93
79.98	63.73	7.80	6.05
88.70	66.70	9.06	6.93
Mean 69.71	← 50.00	←——5.58	← — 2.96

Binomial expansion Z 1.70 0.554

Age (1990-91 = 7.28Age (1991-92) = 6.31

TABLE 7

Monkey damage to cardamom in shade unregulated and regulated plantations

	Clump Damage (Percent)	
Plot Nos.	Shade unregulated	Shade regulated
1	42.02	10.00
2	34.29	1.61
3	27.92	6.60
4	33.33	8.75
Mean	34.39	6.74

Binomial expansion (Z) test at 1% 4.15

TABLE 7a

Yield-loss due to rodents in cardamom, RRS, Mudigere

Capsules (%) split*								
1984	1985	1986	1987	1988	1989	1990	1991	1992
8.70	9.91	11.45	12.60	10.00	9.50	10.80	12.15	20.9

* = n = 75 to 125 clumps/year

Monkey trap made of bamboo or cheap wood can be placed wherever animals regularly descend down on ground for food, shelter, etc. Trapping can be continued with natural foods till a sufficient number of animals are trapped (i.e., 20 to 25 or 40 to 45 depending on the size of the trap).

Protection to cardamom from other vertebrate pests :

Wildboar, elephants and birds do damage cardamom. Problems related to these VPs are referred to in other chapters.

Rodent damage and yield loss :

The year-wise data on yield-loss due to rodents is given in Table 7a. Minimum (9%) capsule damage was recorded during 1984 compared to the maximum damage of 20% during 1992. The month-wise data on yield loss was collected during 1992. Yield-loss per clump varied from 172 to 228 capsules. The maximum yield loss incurred/clump in terms of fresh weight was about 40 g/clump. This corresponds to, at the current rate, Rs. 25/clump which is economically important. Therefore, the protection measures need to be executed during August as the rodent damage start during this month and maximum effort should be made during September, so as to protect cardamom during the period of peak damage.

Rodent damage in different habitats :

Damage of capsules by rodents was identified by the presence of a large number of split locules scattered at the base of the clump. A close examination revealed the presence of paired teeth impressions on the convex aspect of pericarp. Observations with binoculars revealed squirrels plucking the mature capsules by teeth, holding them with forelimbs, shelling the capsules with their teeth by perching on the ground or on the trees and devouring the seeds with the mucilage. Rats caused irregular holes or removed bits of capsule coat to feed on seeds. Four *M. booduga* rats were individually caged in metal traps (20 x 10 cm) and fed with capsules. The capsules were irregularly bored with tooth marks on the coat. All seeds in a capsule were not eaten. Each rat fed, on an average, 50 capsules/day.

Bird damage on capsules could be distinguished by large holes on capsules with no internal contents. Presence of faecal pellets, plume feathers of birds and pug marks served as additional clues to the bird damage.

At each harvest, the proportion of capsules damaged to the total number of capsules harvested was counted and expressed as per cent. The per cent capsules damaged in harvests over the entire season was averaged to get an estimate of the loss incurred. The damage assessment due to rodents was made in 35 to 50 randomly selected cardamom clumps of same age at different habitats.

Of the three habitats, the maximum yield loss was observed in plains and in valley (Table 8). In slopes, the damage was negligible. However, this data does not reflect the generalised situation as damage varies from one habitat to another and from place to place. The yield loss varied significantly from one habitat to another. More than 5% capsule loss, in general, should be considered as economic loss at which protection measures are desired.

Rodent damage in relation to the age of capsules :

To determine capsule age most vulnerable for rodent damage and for timing the protection measures, ten clumps/site were randomly selected. Each flower-bud was labelled and capsules were categorized into 3 groups based on the colour development as follows :

a) Green (70 days old)

b) Greenish yellow (90 days old) and

c) Yellow (110 days old).

Rodents preferred 110 days old capsules (Table 9). Statistical analysis showed significant differences in the preference for matured capsules i.e., green over yellow. However, rodents damaged to an extent of 20% Greenish yellow capsules (90 days old). This is the stage when protection measures are to be adopted. The matured capsules emanate typical cardamom odour and contain sweet mucilaginous matter and such matured capsules are easy to split. So rodents preferred matured capsules.

TABLE 8

Rodents damage to cardamom capsules in three different habitats, Mudigere 1989-90

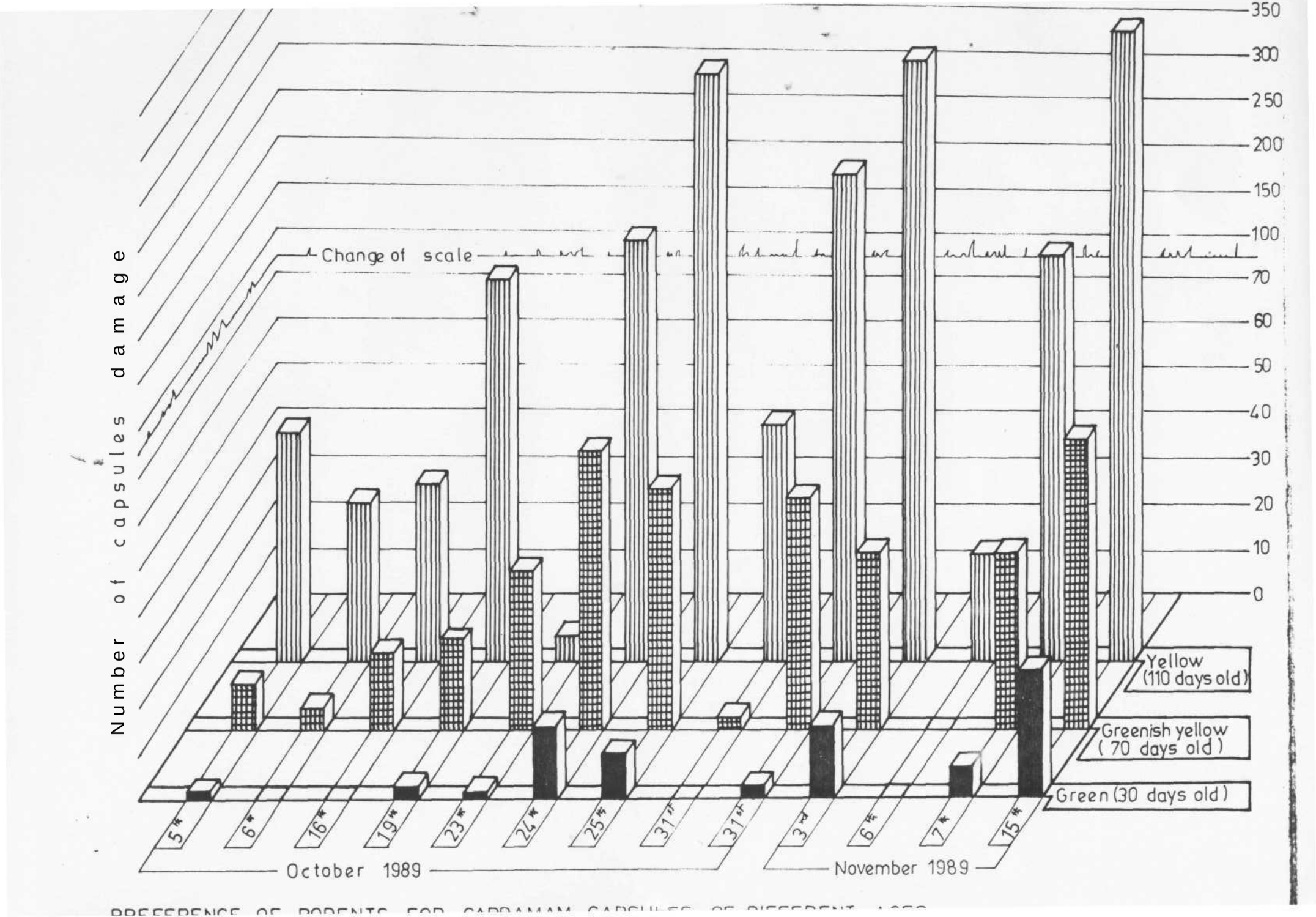
	Capsules (%) damage		
Dates	Plain	Slope	Valley
23.09.89	0.16	0.25	0.44
06.10.89	0.66	0.11	1.27
14.10.89	1.16	1.38	3.65
26.10.89	3.26	1.07	3.25
08.11.89	2.49	0.88	2.48
17.11.89	12.47	0.24	7.26
27.11.89	5.61	0.56	8.21
04.12.89	8.54	0.00	7.25
Mean	4.29	0.56	4.22

CD @ 5%Plains v/s slope = 2.16; Plains v/s valley = 2.16; slope v/s valley = 2.14

TABLE 9

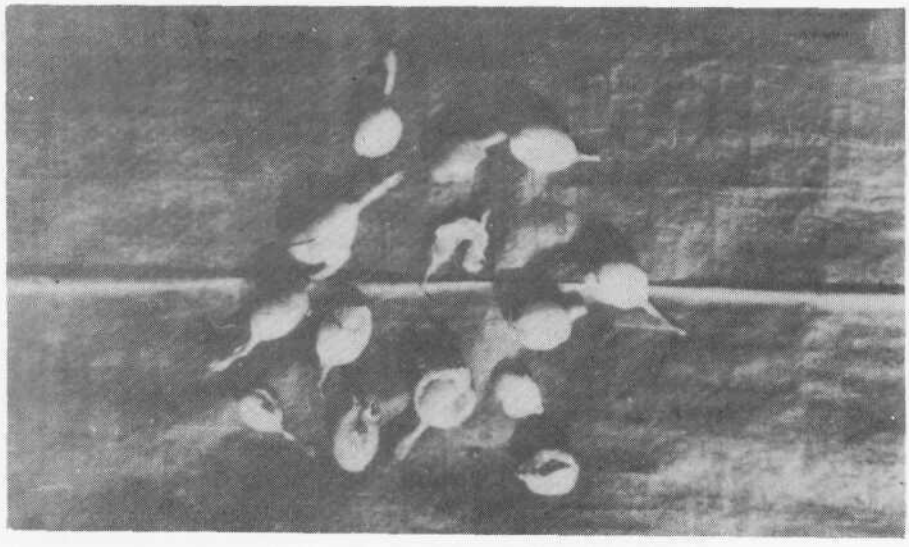
Rodent damage in relation to the age (days) capsules

	Capsules (%) damaged (days)		
Date	Green(70)	Greenish yellow (90)	Yellow (100)
05.10.89	3.23	16.13	80.64
06.10.89	0.00	12.50	87.50
16.10.89	0.00	30.36	69.64
19.10.89	2.09	13.99	83.92
23.10.89	4.65	81.40	13.95
24.10.89	6.56	25.00	68.44
25.10.89	2.44	12.93	84.63
31.10.89	1.02	17.41	94.55
03.11.89	3.79	9.24	86.57
06.11.89	0.00	0.00	100.00
07.11.89	3.55	19.80	76.55
10.11.89	5.66	12.93	85.41
Mean	2.74	20.94	77.65



PREFERENCE OF PARENTS FOR CARDAMAM CAPSULES OF DIFFERENT AGES

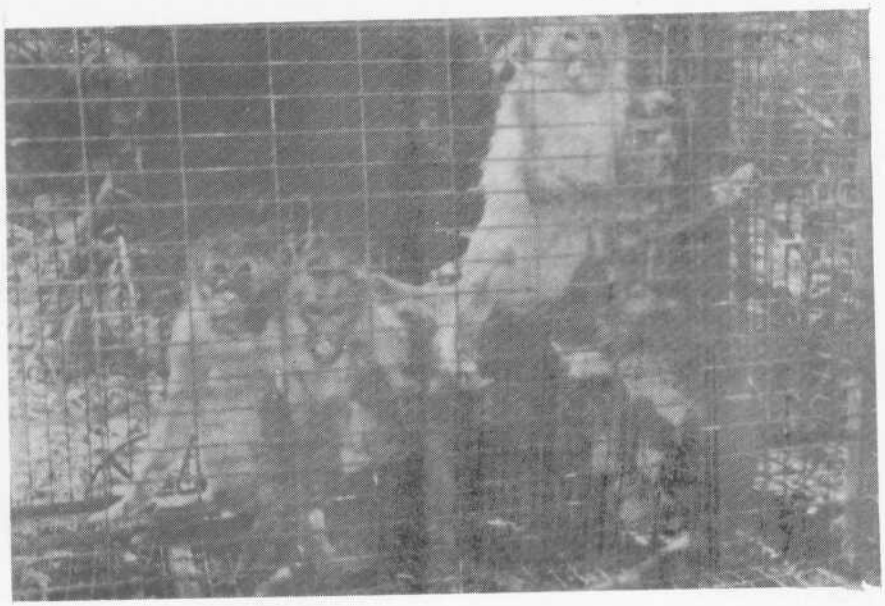
Panicles of Cardamom 'Overlapped'



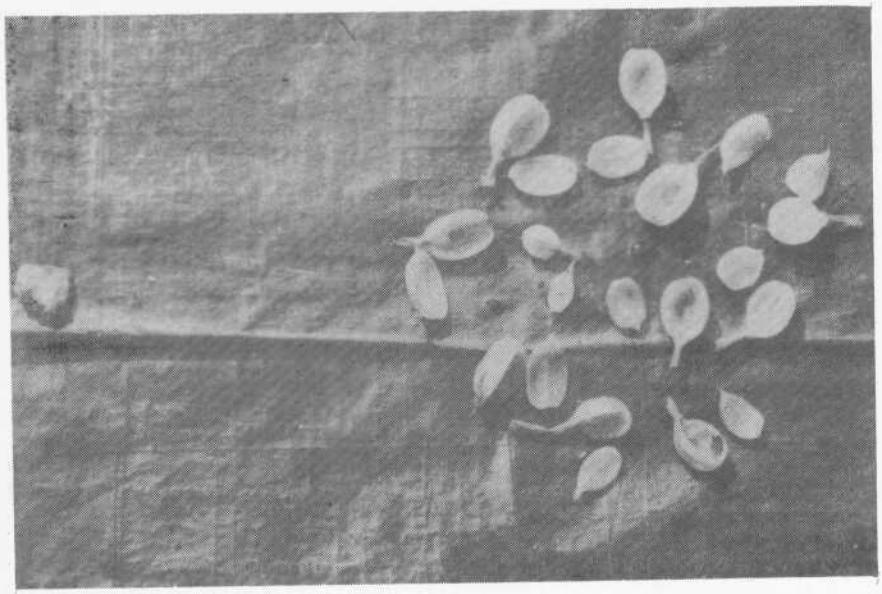
Cardamom Capsules damaged by rats

Forest in Mudigere

'Local Snap Trap' to trap rodents



Monkeys trapped !



Cardamom Capsules split by Squirrel

Monkey damage to Cardamom Clump

The data on the damage in different age of capsules is also shown in Figure 3. In all the three months, the Malabar type cardamom received the maximum damage. This is obvious because in Malabar type the capsules are borne just above soil. The Vazhukka type was preferred next for capsule damage as they have semi-erect panicles with some capsules just above soil (Table 10).

Trapping rodents :

In the cardamom valley where rodent damage was substantial, ten wooden snap traps (100 cm x 30 cm) were placed at RRS, Mudigere during May-June when rodent damage had just begun. In trap operated site, capsule damage was around 5% and in non-trap operated site, the capsule damage was 8%. The Binomial expansion test showed significant differences between the two (Table 11). Observations have shown that systematic trapping only temporarily reduces the rodent population. Also, when an individual rodent was removed there was always immigration by another. When most of the rodents here removed by shooting, another community (birds) immigrated and depredated. This was found particularly in cardamom plantations adjoining vacant sites, scrub, waste or woodland.

Traps :

Two types of traps, viz., Metallic (17 cm x 9 cm) and Wooden Snap Traps (100 cm x 30 cm) were evaluated for their efficacy and efficiency in trapping rodents. The metallic traps, 200 in number were stationed during June-July and September-October 1988-89 and 1989-90 in an area of 8 acres. 'Vada' pieces (a preparation of Bengal gram) were used as bait.

Ten Wooden snap traps were placed in cardamom growing tracts at RRS, Mudigere during March-May, 1990, i.e., before capsule formation/flowering stage. These traps were placed for one month and subsequently shifted to another place. Paddy grains served as the bait. Observations were recorded daily and trapped animals were dissected. The bait was replenished every day in the same trap.

The animals caught in metallic traps were identified and the trial was repeated twice at an interval of 2 to 3 days. Vada pieces attracted *B. bengalensis,* two species of birds and squirrels. These animals were recovered during capsule bearing stage. After the harvest of cardamom, *Rattus meltada, Mus musculus* and *Funambulus palmarum* were trapped.

Response of rodents to baits in wooden snap traps :

Planters in Malnad frequently deploy wooden traps to trap rodents. However, details concerning the effectiveness of traps in cardamom plantations are lacking. In order to standardize the trapping procedure following trials were run from August to November 1987 to 1989. Each trial was laid out in valley region. RRS, Mudigere, repeated three times.

(0.1) Number of traps/acre : 10, 15, 20, 25

(0.2) Duration of trap (in days): 10, 15, 20, 25, 30

(0.3) Spatial distribution (in metres): 8, 12, 16, 20, 25, 30

(0.4) Baiting material: Grains, fruits, flour-pellets, dry-fish, jackfruit peal and water extract of ripened jackfruits.

In areas of heavy rodents activity and where rodent depredations exceeded 10%, 20 traps/acre of cardamom was adequate. Where rodent activity was moderate, 10 to 15 traps effectively exterminated the local population of squirrels and rats. The traps exposed for more than 25 days were ineffective in trapping the animals. Traps placed for a period of 20 days continuously had the chances of trapping a rodent. It was observed that in 90% of the traps, the animals were trapped within five days of placement. So a trap could be maintained at a spot for a maximum period of 20 days only.

The spatial plan of the trapping grid depended upon the depredative activity of rodents, the terrain and the niches preferred by the rodents. In valley region at RRS, Mudigere, the traps were placed 10 to 20 m apart and a number of rodents could be conveniently trapped at this spacing.

A number of natural and artificial baits/bait preparations were tried to render traps more effective. Paddy grains in wooden snap traps and 'vada' in metallic

TABLE 10

Rodent damage to capsules in relation to the (days) in three cardamom types

		Capsules (%) damage		
Month	Cardamom types	Green (90 days)	Greenish yellow (120 days)	Yellow (150 days)
July	Malabar	—_	9	13
	Vazhukka	—	—	—
	Mysore	—	—	—
August				
	Malabar	—	41	53
	Vazhukka	—	3	8
September	Mysore	—	—	—
	Malabar	3	63	79
	Vazhukka	1	9	16
	Mysore	—	—	

TABLE 11

Comparison of rodent damage in trap and non-trap operated in portious cardamom plantation

Clumps No.	Clumps (%) damaged	
	Trap operated area	Non-trap operated area
1	3.10	9.12
2	5.47	8.08
3	12.29	5.21
4	6.31	11.57
5	8.85	2.97
6	6.59	0.32
7	2.04	6.95
8	2.56	3.73
9	0.81	3.69
10	2.03	10.58
11	4.50	11.10
12	1.99	4.95
13	2.28	10.48
14	8.40	22.39
15	7.38	11.42
Mean	4.97	8.17

Binomial expansion Z value0.6077

traps proved the most effective baits in Mudigere. These details would help the planter to improve the effectiveness of wooden traps in cardamom plantations.

The number of rodents trapped with different baits in wooden and metallic traps is given in Table 12. Paddy grains and banana pieces attracted rodents to the maximum. In 3 months, 42 individuals were trapped, of which, 12 were squirrels, 1 shrew, 2 species of birds and the rest, rats (Table 13). Of the rats, *M. booduga* was the most abundant which accounted 60% of the total trapped animals. The number and species of rodents trapped during March-June 1991, is given in Table 14. As stated earlier, *M. booduga* was the dominant species followed by F. *palmarum.* Problems encountered in trapping during rainy season are -

1. Due to rains, soil spills and settles below the trap, thereby reducing the gap meant for entry of animals.
2. Jute threads absorb water and cuts easily with little weight.
3. The wooden portion gets readily infested with termites.
4. Trap closes often as rain droplets impinge on the strip (trigger) of the trap on which bait is kept.
5. The trapping operations is interfered with species of birds, monkey (young ones), jackals and other wild animals.

The trapped animals were dissected in laboratory. The gut contents analysis of the squirrels, F. *palmarum* (n = 28), for instance, showed that its diet contained ants, termites, bugs, *Solanum, Melia, Carya, Bombax,* coffee, *Seigizium*cardamom, paddy etc.

Field behaviour of squirrel, *Funambulus palmarum* in cardamom plantations at Mudigere

Field activities of the squirrel, F. *palmarum* were recorded at the RRS, Mudigere and in a neighbouring Coffee estate (20 acres) with cardamom in 2 acres. At RRS, Cardamom covered about 20 acres. A closer examination of shade trees at RRS in later half of September, 1991 revealed 5 nests of squirrels, details of which are given jn Table 15. Cardamom formed the principal item of food for squirrels during the nesting period. Observations on various activities of squirrels were also recorded through 8 x 30 binoculars at RRS between 17.12.91 to 6.2.92. Study area consisted of three habitats, viz., slope, valley and plains.

The frequency of occurance of various activities are given in Table 16.

Frequency of occurrence of various activities during morning (10.30 to 11.30 a.m.) in different habitats revealed that squirrels actively searched for suitable plant surfaces to perform their activities. During January-February, the animals depended much on sprouting flower-buds. The squirrels also actively foraged on ground especially for termites and ants, as evidenced from gut contents analyses in laboratory. During the period of capsule formation, squirrels restricted almost all their activities within the confines of Cardamom plantation including nesting. During non-flowering period (January to May) squirrels were observed foraging outside cardamom ecosystem especially on fresh flush of wild trees and shrubs. In valley, a maximum of 6 squirrels/200 m^2 area was observed.

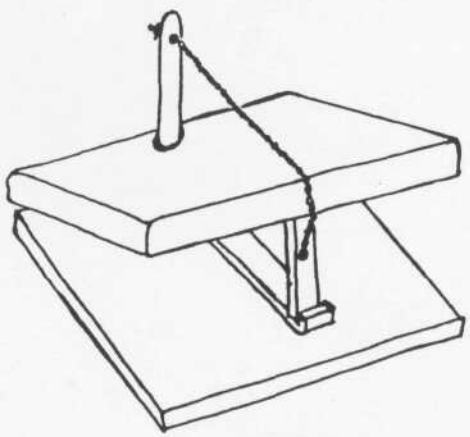
The field activities of the squirrel did not differ significantly from one habitat to another except for foraging. As the different habitats differed in their relative amount of food resources, the length of foraging bout also differed significantly. The rodent most frequently was observed foraging. This can be expected from the energy budget point of view for the squirrel. The squirrels were observed to spend more than 50% of their time foraging. This is to meet their metabolic demands. However, the frequency pattern of activities change from habitat to habitat and from season to season. These animals with small home ranges (Km^2) may have to depend on few, key food sources.

A closer look at the reproductive and nesting activities is warranted for exploitation of the same in the rodent Pest Management Programmes.

TABLE 12

Response of rodents to baits in wooden snap traps at RRS, Mudigere

Baits	No. of rodents (rat + squirrel) trapped/10 days in 20 traps
Paddy grains	5
Jack fruit	0
Jack fruit jelly (300 Jack fruit + 3 lit water)	0
Dehydrated Jackfruit	0
Wheat flour pellets	0
Cotton wad laced with jaggery solution	0
Wild jack fruit	0
Dry fish	0
Spagnum Mass solution (Mass 15 g + water 250 ml + Sandovit 5 ml)	0
Algal solutions (Algae 250 ml + Sandovit 10 ml + Water 100 ml)	0
Banana fruits	7
Vada (in Metallic snap traps)	24
Mean	3
CD @ 5%	NS

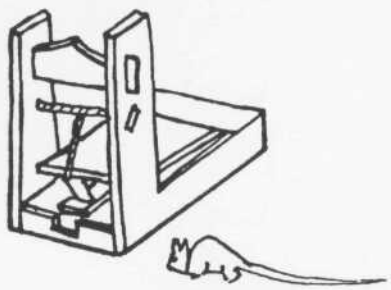


Square mouce trap

TABLE 13

Vertebrates trapped in wooden snap traps between Mar-May 1990, Mudigere

	Number of rodents and VPs (week)									
Species	1	2	3	4	5	6	7	8	9	10
Bandicota bengalensis	1			4	—	—	—	—	—	—
Mur booduga	—	2	5	5	4	5	2	2	—	—
Funambulus palmarum	—	—	3	—	—	3	2	2	—	1
Pattur meltada	—	—	—	—	—	—	—	—	—	1
Shrew	—	—	—	1	—	—	—	—	—	—
Monkey	—	—	—	—	—	1	—	—	—	—
Red spurfowl	—	—	—		—	1	—	—	—	—
White breasted ground thrush	1	—	—		—	—	—	—	—	—
Total	3	0	8	10	4	9	4	4	0	2



The mousetrap

TABLE 14

Rodent species trapped in wooden snap traps March-June 1991, Mudigere

Month	*B.bengalensis*	*M. booduga*	*F. palmarum*	*R. meltada*
March	2	1	1	—
April	—	5	2	—
May	—	2	2	—
June	3	3	2	1
Total	5	11	7	1

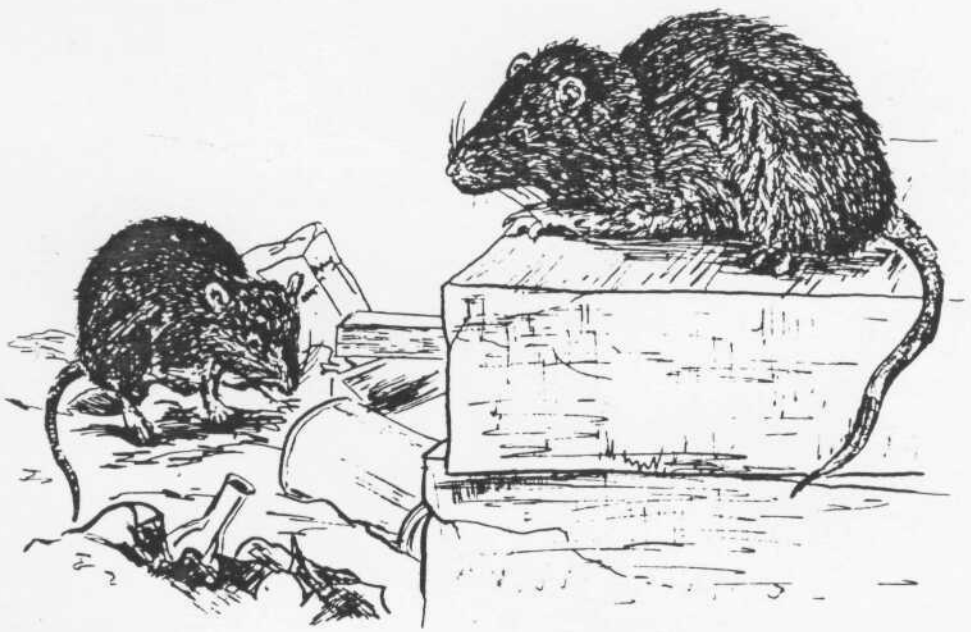


TABLE 15

Nests of squirrels in cardamom plantation, Mudigere, 19891-92

Location	Tree.sps	No of nests	No of adults	No of young ones	Height of Nests M	Materials used
RRS	*Larger stromea indica*	1	2	2	3	Woodchips, ferms, moss, etc.
	Samanea saman	1	–	4	3-5	Dried leaf and shoot bits
	Ficusspecies	1	3	2	6.0	Coir, leaf bits
	Ficusspecies	1	2	2	5.8	Lichens, leafbits, fibres, dried vegetable an root malter
	Toddy palm	1	–	–	7.0	– d0 –
Amravathi estate	*Lagerstromea* sp	1	–	–	5.0	Wild silk cotton, shoot and leaf bits

TABLE 16

Frequency of occurrence of activities by squirrel in three habitats of cardamom plantation, Mudigere, 1991-92

	Behavioural Traits						Substarte Used			Food Used		
Habitats	Freq .call /30m ts	1	2	3	4	5	T	G	P	F	B	GR
Slope	12	5	12	7	14	7	4	11	17	8	3	5
Valley	13	6	6	7	8	8	7	6	15	5	5	6
Plains	13	7	10	6	11	9	8	9	15	6	6	5
Mann Whitney 'U' test (P 0.05)	NS			NS			NS			NS		

1 = Call;2 = Chase;3 = Feed;4 = Forage;5 = Aggressive

T = Tree bark;Gr = Ground;P = plant surface;F = Flower;B = Bud;Gr = Ground dwelling or thro pods

Foraging behaviour

Observations on foraging behaviour in cardamom and coffee plantations showed that squirrels aggregated in 2 or 3 numbers to exhibit playful or agonistic behaviourduring mating. The animals foraged singly, an individual following a definite route. But the route varied from one individual to another, although patches visited by one in a foraging zone frequently overlapped with another. Squirrels are animals dependent on cover for safety. So squirrels preferred valley region with well spread canopy cover of shade trees, for feeding and foraging. Clumps just below the canopy of nesting or roosting tree (especially the *Hanathare)* recieved the maximum damage. In a preliminary finding during November 1993 it was found that clump below Hanalthare tree received, on an average 8% capsule damage compared to 1 to 3% in clumps away from the tree(n = 6). Eight per cent corresponded to 60 to 70 capsules, while 1-2% corresponded 10 to 12 capsules/clump. Further, under the canopy of cardamom, the probability of escaping from a detected predator increases for these rodents. Potential predators at the study site for squirrels and their young include over a dozen species of hawks, eagles, owls, 2 to 3 species of jungle cats, snakes and dogs. Although individual variation in squirrel may occur with respect to feeding rate. foraging efficiency, antipredator tactics depending on age, sex, rank, status, etc. Our observations indicated little or no variation in these parameters among individual rodents. With this background, it is presumed that the squirrel, *F, palmarum in cardamom ecosystem follow an ideal free distribution or habitat matching rule, so that all individuals obtain the same amount of resource and so achieve the same fitness. This implies that habitat matching foraging bacomes (a) effective even before all individuals feeding rates become densely dependent and (b) is sensitive to foraging economics and hazard of predation.*

Bahavioural responses of rodents (squirrel and rat) to toxic baits and plant products

In order to avoid lethal control of rodents, certain materials were offered under natural conditions to elicit responses of rodents and work out the feasibility of using them for the management of rodents.

Fish Oil and Neem Oil

One and four per cent water solution of these two oils were prepared and sprayed on capsules on rainless days. Each concentration of each oil was replicated thrice with ten clumps/treatment. A control was maintained for each oil. Since oil and water are immiscible, 4.5 ml of vettoplant (1 ml/litre) was mixed with the solution. Observations on capsule damage were mixed with the solution. Observations on capsule damage were recorded a day before and three days after each application. Each treatment was repeated once in 15 days. The response, in terms of capsule damage is given in Table 17. Neem Oil significantly reduced number of capsule damage by rodents.

The effect of the application of Fish oil on capsule damage by rodents is given in Table 17. The application of fish oil at four different concentrations when compared to control did not decrease capsule damage by squirrel. However, the damage recorded on capsules treated with fish oil is much less compared to the recorded on Neem oil treated clumps. Although neem oil reduced the number of damaged capsules, yet the above two oils cannot be used for affording reasonable protection to the crop from rodents. Further odour-laden fruits may even interfere with the normal flavour of capsules. It is for the flavour that capsules are valued. Use of such oils for crop-protection against vertebrates pests damage is not suggestive.

Clusterbeans

The active principal of cluster beans. *Phaseolus ultiflorus* is known to repel rats. To test this, a laboratory experimentwas conducted with *Rattus rattus.* Tender, fresh pods of cluster beans were dried in an oven at 50°C for 18 hr, powdered in a mixy and the powder was mixed with wheat flour in 1:1, 1:2 and 1:3 proprotions. Paddy grains served as control.

Cluster beans powder in three different proportions was offered to four animals at 1/wooden cage (1 m^2). Each animal served as a replicate.

None of the rats fed on cluster-beans baits. While in control, the rats fed on the paddy grains, and in the treated cages, rats did not elicit any feeding respon-

TABLE 17

Rodent damage on capsules treated with Neem oil and Fish oil

	Capsule (Nos.) damaged	
Concentration (%)	Neem Oil	Fish Oil
0	170.33	155.67
1	137.00	102.00
2	128.00	102.67
3	59.33	82.00
4	65.00	56.00
Mean	111.99	99.67

CD (3) 5%Amendments = 53.7; Conçentrations = 24.8A æ C = 17.2

ses. The same baits were also tried in stores (600 X 300 cm) and the baits remained untouched. Since cluster beans is non-toxic edible legume, it may be interesting to further test this material against rodent damage, both in the field and in the stores.

Bingo

Bingo is a non-poisonous sticky substance manufactured by Rambo Chemical Industries Pvt. Ltd., Bombay.

Bingo, was applied over a card board (12" X 12"). Eight inch card boards were used. Bingo paste was heated so as to make it adhere on to the board. The paste was smeared all over the board, leaving 3" space at centre to place the baiting materials (paddy grains) at the centre.

The Bingo-pasted card boards were placed at 1 m distance in cardamom growing tract during September in rain-less days. Observations revealed that while the rodents fed on the paddy grains, the sticky material was unable to hold the animals. Cover of leaf-mulch on panicles.

Cover of leaf mulch on Panicles

Panicles of twenty-five cardamom clumps were covered by leaf- mulch so that capsules were invisible to the rodents. Panicles of neighbouring clumps were left uncovered to serve as control. Weekely observations on capsule damage were recorded.

On an average, the leaf mulch reduced rodent damage on capsules to 2.49% compared to 41.72% in the control. There was statistically significant reduction in capsule damage. Since the experiment was conducted on a small scale, it needs to be repeated on a large scale. Adverse effects, if any, on capsule development needs also to be ascertained. In the long run, on a large scale this method cannot be recommended as removal of leaf- mulch would cause soil erosion. Rodents have excellent explorative behaviour and the animals may learn to heavily depredate upon the covered capsules in course of time. Further studies on this aspect are in progress. It has to be further explored to see if this method is applicable at small scale. It is observed that capsules that are hidden naturally by leaf-fall ramains protected from rodents/birds damage.

Effect of overlapping panicles on rodent damage

A field study was conducted during September 1991 st RRS, Mudigere when panicles in twenty-five clumps were overlapped to find out if capsule damage by rodents differed in the treated clumps compared to normal ones. In the clumps witth overlapped panicles, 6% less rodent damage was recorded. T-test revealed significant differences in capsule damage between the two. Similar results have also been found during 1990 and 1991.

Methods to trap live rodents

To trap live rodents, a cotton net (15 m X 1 m) was spread in a vacant site (200 m^2) along cardamom valley at RRS, Mudigere.

Ripened guava fruits were placed inside the net at the centre as bait. The same net placed in 12 different sites for 5 days at each site. Rodents could not be trapped by this method.

Six metal traps (20 cms X 10 cms) were placed daily from 25.9.90 to 10.10.90 in valley at RRS, udigere. Paddy grains served as bait. One dead jungle fowl, *B, bengalensis* and four, *M, booduga* rats were trapped by this trap. One *F. palmarum* (dead) was also trapped, which wighed 85 g. Gut-content analyses of the animal showed 221 un-digested cardamom seeds, seeds of wild fruits and the jack-friut and 114 termites. On an average (n=20), each capsule contained 17 seeds and so 13 capsules were consumed in all. But in reality, more number of capsules would have been damaged by the squirrel.

Local Trap

Tribals in hil region of Karnataka deploy traps, locally called as 'Pot trap' to catch live rodents, especially squirrels. The trap consisted of two long (2") sticks with a small stick, thread and a pot-like depression (4") in soil. The soil-pot was supported with a main stick and two supporting sticks at base stuck to ground. The bait (fish) is placed at the centre of the pot. The animals, for feeding necessarily have to disturb the small stick, kept between main and base stick and in

the process, the animal would be trapped in the pot alive.

Experiments on live animals are important to develop understanding of their biology, behaviour and feeding habits. So far, we have been unable to trap live squirrels for experimental purposes. Efforts in this aspect are in progress.

The local wooden snap traps are effective but the rodent is killed in these traps. For instance, during August 1991, the traps were placed in cardamom plantation at RRS, Mudigere. Dry fish was placed as bait. In 30 days, 8 rats, were trapped. Maximum number of rodents were trapped during June obviously because the rodents begin foraging for cardamom capsules. The predominant species trapped was *Mus booduga*.

Assessment of crop losses due to squirrel

Cardamom capsules damage due to squirrel was recorded from August 1992 to January 1993 at RRS, Mudigere. Damaged capsules were collected at monthly intervals and expressed as per cent capsule damage.

The month-wise data on yield-loss incurred due to squirrel, . palmarum is presented in Table 18. Yield loss/clump from August 1992 to January 1993 varied from 172 to 229 capsules. The maximum yield loss incurred per clump in terms of fresh weight was about 40 g/clump. This corresponds to, at the current rate, Rs.25/clump which is economically important. Therefore, the protection measures need to be executed during August as the rodent damage start during this month and maximum effort should be made during September, so as to protect cardamom during the period of peak damage. Squirrel damage (cumulative) is shown in Table 18a.

Weather and Rodent damage

Cardamom production is related to weather conditions. As rodents respond to the pattern and level of production, weather is also related to the rodents depredation. Information on selected parameters in this regard collected at RRS, is given at the end of this chapter.

During 1991, rains were normally recieved and the capsules matured during August when first harvest bagan. The rodent damage also began during August and 18% damage was recorded at RRS.

During 1992, climatic conditions were normal and the cardamom clumps in most of the plots at RRS were in good yielding stage with area under cardamom being doubted. With availability of capsules, rats and squirrels caused a much higher loss of 39%. During 1993, Mudigere received rains from June to October with cloudy overcast. As a result, maturity of capsules was delayed and harvest began only from October first week. Most of the clumps at RRS recorded lower yields. Upto November 7 harvests were made at weekly intervals. In view of the uncertainties of availability at the initial stages, timely harvests and lower yields, capsule damage by rodents was only 2%.

Cultural practices for reducing losses due to rodents

Two cultural practices i.e., dispersion of panicles and clean overlapped fashion vs natural dispersion of panicles and clean cultivation were evaluated at Hugluvalli, Thirthahalli (Shimoga dist.). Ten cardamom clumps per treatment were chosen in Areca based croping system where cardamom was grown as intercrop with cocoa and pepper. The site chosen for treatment was atleast 5 m away from the control site. Damage assessments following the procedure indicated above was made during September-October, 1989. Similar observations were recorded during 1988 and 1990 seasons.

Data on the impact of two cultural practices on rodents damage is given in Table 19. It was found that by proper weeding 3.57% loss can be avoided and by overlapping panicles at regular intervals 2.95% damage can be prevented. Although the loss prevented is small, yet it is desirable to implement these practices as these are practicable, cheap and cause no side-efects. Harvesting capsules in time protected matured capsules. The above results were obtained consistently for three seasons. The Binomial expansion test revealed significant differences between the untreated and treated sites.

TABLE 18

Yield loss assessment due to squirrel damage in cardamom, 1992–93

Clumps No.Month capsules (No.) damagedFresh weight* Dry weight**

	Aúg	Sep	Oct	Nov	Dec	Jan	(g)	(g)
1	10	29	95	49	11	4	188.1	37.6
2	5	30	89	36	9	3	163.4	32.7
3	8	30	101	67	16	4	214.7	42.9
4	7	35	89	76	11	7	213.8	42.7
5	11	20	96	46	19	4	186.2	37.2
6	9	23	98	57	21	9	206.2	41.2
7	6	21	99	61	31	6	212.8	42.6
8	4	26	101	53	19	8	200.4	40.1
9	7	20	106	33	18	4	178.6	35.7
10	10	31	149	29	9	5	216.6	43.3
Mean	7.7	26.5	102.3	50.7	16.4	5.4	198.0	39.2

CD @ 5%3.62

* = Total No. of capsule multiplied by mean capsule weight

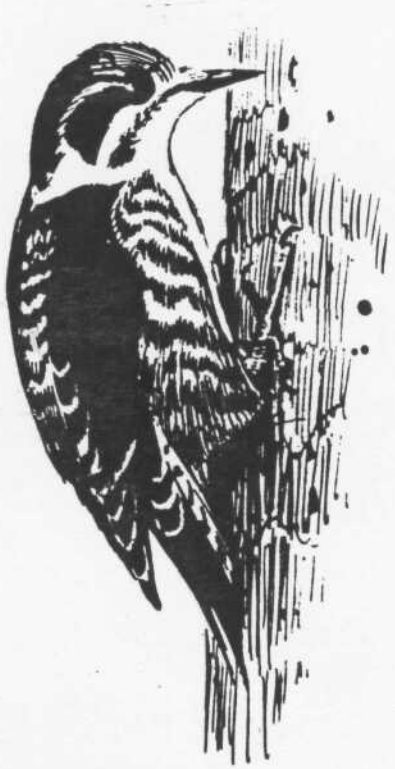
** = Dry weight calculated on then basis of 1:5 (% recovery)

TABLE 18A

Cumulative capsule damage in cardamom due to squirrel

	Capsules (Nos.) damaged*					
	Aug'92	Sept	Oct	Nov	Dec'92	Jan'93
Mean	7.7	26.5	102.3	50.7	16.4	5.4

*n = 50 clumps

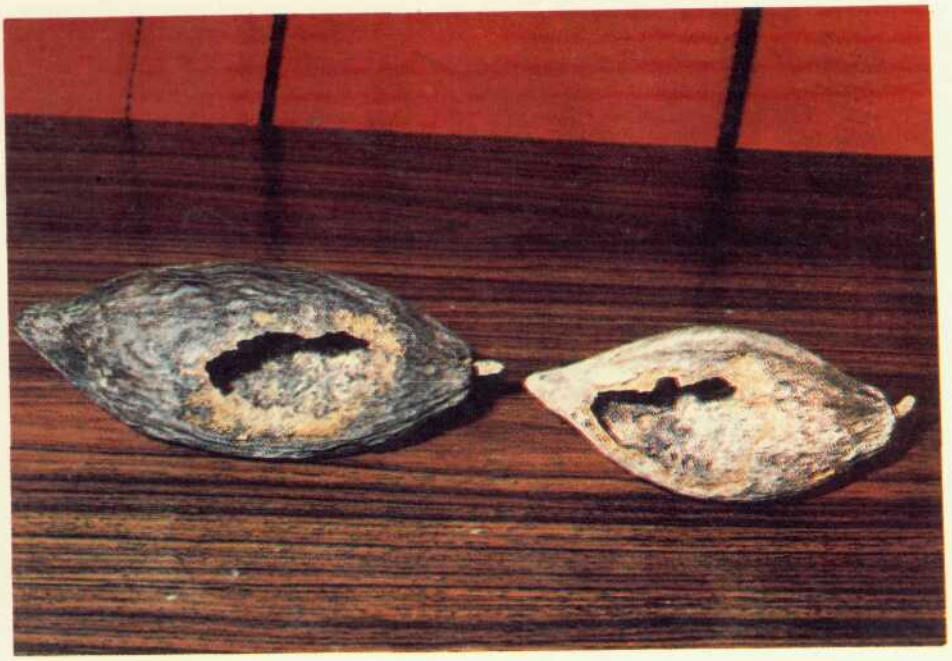


THREE-TOED WOODPECKER

TABLE 19

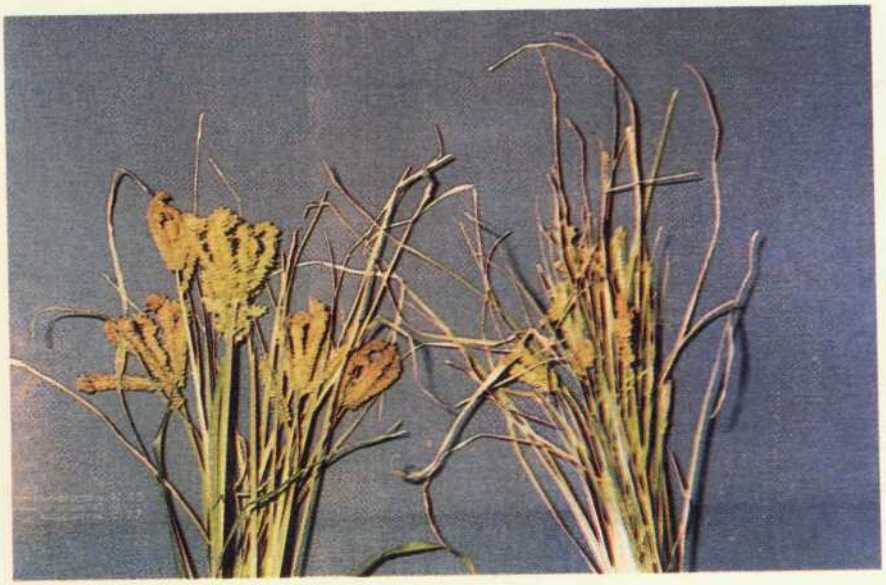
Effect of two cultural practices on rodent damage to cardamom capsules 1989-90

Clumps No.	Capsule (%) damaged With weeds	Without weeds	Dispersed panicles	Overlapped panicles
1	5.66	2.62	4.55	2.75
2	7.39	0.00	6.98	0.00
3	5.55	1.68	2.77	4.00
4	7.41	0.00	4.08	1.69
5	1.64	1.87	3.59	4.55
6	1.96	2.83	5.02	3.76
7	8.73	2.34	11.29	2.42
8	7.89	0.00	7.77	2.45
9	2.40	4.29	3.48	3.81
10	2.70	0.00	8.26	1.44
Mean	5.13	1.56	5.77	2.68
%Capsules saved		69.53		53.55
Binomial expansion Z value		0.9938		0.7192



Cocoa damaged by Jungle Cat

Ragi ears browsed by Wildboar



Three cultural practices i.e., dispersion of panicles in an overlapped fashion, clean cultivation and timely harvests were the efficacy of each cultural practice. The 'test sites' were separated from each other by atleast 50 m. Damage assessments were made and details of methodology have already been mentioned in Annuals Report of the project.

Data on the impact of three cultural practices on rodents damage is given in Table 20. Itwas found that by Weeding 3.57% loss can be avoided and by overlapping panicles at regular intervals 2.95% damage can be prevented.

By timely pick, 6.63% damage could be avoided. The above results were obtained consistently for 2 seasons.

Although the loss prevented is small, yet the practices are desirable as these are practicable, cheap and cause no side effects. These practices together with natural rodent predation and habitat modification would ameliorate rodent problem. More importantly, one has to ascertain before hand as to why at a place rodent depredative activity is heavy or intense.

Two cultural practices viz., dispersion of panicles and clean cultivation vs. no clean cultivation were evaluated at RRS, Mudigere from 05.11.1992 to 20.12.1992. Two hundred cardamom clumps per treatment were chosen. The site chosen for treatments was atleast 30 m away from the control site. Capsules damaged by rodents were collected and expressed as number of capsules damage/clump.

The efficacy of two cultural practices viz., mulching and overlapping panicles in protecting cardamom capsules due to rodents damage were studied. Per cent capsule damage was reduced by 63.68 in mulched plot than when compared to unmulched plot and in plots with overlapped panicles, damage was reduced by 79.89 per cent comparable to that in non-overlapped plots (Table 21). These two cultural practices are practicable and to some extent reduced the rodent damage. Data is also indicated in Table 21a. Damage to capsules by rodents in insecticide treated plots:

While evaluating insecticides against pests on cardamom, capsule damage by rodents was also observed. The insecticidal trial was laid out in RBD with three replications. A single row of 15 clumps represented a replicate. A 'control' was maintained for intervals from August when rodent damage on capsules begin under Mudigere conditions. Known quantity of capsule (samples) were drawn and number of capsules damaged by rodents was worked out on 'per cent basis'. During 1991, the capsule varied from 4.46 to 13.58 per cent. Control plot recorded 12.5 per cent capsule damage. On 30.09.91; the capsule damage was negligible. There were non-significant differences between the 'treated' and 'control' sites.

Rodent damage on capsules in different years in insecticide treated plots is given in Tables 22 and 23. Insecticide treated rows had no impact on the rodent damage. It was observed that rows/clumps neighbouring borders or edge suffered more damage than those in the interiors. These observations pin point that rodent pest management need a separate and specialised effort and cannot be combined with insect pest management practices.

Practices for reducing monkey/wildboar and bird menace in cardamom plantations

During May 1988-89, shade trees were debranched in a cardamom plantation and percent clumps injured by monkey were recorded before and after debranching.

During 1988-89, in valley region at RRS, Mudigere cardamom planted in 0.5 ac was severely affected by wildboar. The drainage system was altered and thimet 10% G. 5 gm + 5 gm dry sand in punched polythene bags was suspended along the south border of the plot. Observations were recorded subsequently on clump damage.

After debranching trees, the clump damage was reduced by 11% in the plot. However, monkey troupe reused the plot after a month when the branches began sprouting and growing. The damage to sapota fruits was reduced by over 50%. Trapping can be executed in areas with sufficient forest cover so that the animals can be released there. Else one has to think the way animals could be disposed before trapping. Other methods alternative to trapping needs to be worked out.

TABLE 20

Effect of cultural practices on rodent damage to cardamom capsules, 1990-91

Clumps No.	Capsules (%) damaged					
	With weeds	Without weeds	Dispersedt panicles	Overlapped panicles	Delayed harvest	Timely harvest
1	0.81	9.12	1.61	2.75	3.10	2.20
2	3.51	8.08	0.00	4.00	5.47	1.53
3	2.71	5.21	3.66	1.55	12.29	1.89
4	1.61	11.57	0.53	1.69	6.31	3.83
5	0.48	2.97	0.95	4.55	8.85	3.57
6	3.42	0.32	4.64	3.76	6.59	4.48
7	1.02	6.95	0.50	2.42	2.04	2.43
8	1.16	6.95	0.43	2.45	2.04	2.84
9	1.92	3.69	1.02	3.81	0.81	5.69
10	1.76	0.58	1.06	1.94	2.03	4.82
11	4.73	1.10	4.98	3.51	4.50	3.51
12	2.48	4.95	2.52	2.71	1.99	1.61
13	4.09	10.48	5.34	1.61	2.28	2.69
14	6.47	22.39	7.25	3.42	8.40	3.57
15	3.26	11.42	1.69	3.26	7.38	1.89
Mean	2.62	7.05	2.41	2.89	4.93	3.10
% Capsules saved		62.83	16.6		37.11	
Binomial expansion Z value		1.103	0.6343		NS	

TABLE 21

Effect of cultural practices on rodent damage to cardamom capsules, 1991-92

1991-92	1992-93					
	Capsule damaged/clump				Nos	
Days after treatments	% Mulched	% Unmulched	Nos Mulched	Nos Unmulched	Overlapped panicles	Dispersed panicles
0	0.96	29.40	119.6	741.3	313.3	528.6
4	1.69	73.80	155.6	817.6	259.3	662.6
6	1.68	47.16	166.0	876.3	247.6	586.0
9	2.24	49.00	129.3	553.0	134.3	551.6
18	6.52	41.00	165.6	651.0	180.6	496.6
27	1.43	60.00	195.3	679.0	197.6	413.6
29	1.85	11.70	111.23	820.0	200.0	537.3
40	3.84	32.25	151.0	843.0	186.6	684.0
45	1.42	57.00	120.3	539.6	142.6	595.3
Mean	2.40	44.59	145.9	724.5	206.8	569.5
% Capsules saved		94.61		79.86	63.68	
Binomial expansion (Z)		6.01		19.91	12.98	

TABLE 21A

Effect of cultural practices of squirrel damage

Year	Capsules (%) saved			
	Mulched	Weeds	Overlapped	Timely harvest
1989-90	—	69.53	53.55	—
1990-91	—	62.83	16.60	37.11
1991–92	94.61	—	—	—
1992-93	79.86	—	63.68	—
Mean	87.23	66.18	44.61	37.11

- not tested = n = 250 clumps/year

GREAT HORNED OWL

TABLE 22

Squirrel damage on capsules applied with insecticides

Insecticide	Capsules (%) damaged 1985	1986	1987
Thimet 10 G	8.70	—	—
Demecron 100 EC	8.03	15.96	13.77
Ekalux 25 EC	23.81	26.58	16.61
Anthio 50 EC	24.81	13.72	15.64
Metacid 25 EC	19.16	29.68	2.20
Metasystox 25 EC	17.19	27.57	14.64
Zolone 35 EC	22.90	19.58	13.18
Melathion 50 EC		25.54	14.70
Rogar 30 EC	11.57	—	—
Monocrotophos 35 EC		20.44	15.88
Nuvacron 40 EC	28.75	—	—
Asataph 75 WP		11.75	15.14
Furadon 3 G	28.92	13.08	7.89
Control	48.71	35.52	34.26
Mean	22.05	21.76	14.90

* — not tested

TABLE 23

Rodent damage to capsules treated with insecticides

Treatments	Capsule (%) damage 7.9.1991	30.9.1991
Monocrotophos + Phosalone + Phosalone	4.46	2.37
Phorate + Endosulfan + Malathion	7.29	3.41
Chlorpyriphos + Eridosulfan + Endosulfan	8.55	5.04
Cypermathrin + Phosalone + Phosalone	7.91	2.15
Rogor + Endosulfan + Endosulfan	7.23	1.67
Monocrotophos + Endosulfan + Endosulfan	13.58	5.35
Monocrotophos + Endosulfan + Malathion	10.87	2.27
Control	12.15	2.46
Mean	9.05	3.09

CD @ 1 % Treatments = 1.03; Dates = 4.47
T x D = 0.7288

The trial on wildboar menace proved effective as wildboar damage in the plot was reduced cent per cent. So, by proper drainage and use of repellents, wildboar menace to some extent can be checked. However, the same protection methods may not be effective equally at all sites. Further experiments in this direction are needed.

Birds, in general, cannot be branded as pests. In fact, many of the species are insectivore and are beneficial. In some situations only birds depredate on cardamom and cause losses that are economically important.

Thus, these preliminary trials and experiments indicate that by trapping, selective debranching of shade trees and by consolidating young plantations in one block/unit, monkey menace can be reduced.

Protection of cardamom from rodents by rodenticides:

During 1986-87, Roadcake (0.005%) was tested for protection of cardamom capsules from rodents. The control operation was carried out at three different sites in valley region at RRS, Mudigere. Each experiment plot was 200 m^2 being separated by atleast 0.25 Km approximately. A 'control' plot was maintained.

After observations on capsule damage, Roadcake pieces (3 cm^2 were exposed in three randomly selected cardamom clumps each per row of 20 clumps. There were ten rows. The efficacy of Roadcake application was estimated by the per cent damage to intact cardamom capsules between the 'experimental' and 'control' plot. During 1988 and 1989, Bromodiolone, another formulation of Rodafarin was similarly tested.

Experimental Site 3 recorded less damage, i.e. only 14% when compared to control (46%) (Table 24). The effect of Roadcake baiting although offered protection nevertheless it failed to check the rodent menace completely. Even after baiting, rodents damage was observed in the treated plots. Results of experiment with Roadcake during 1987 also showed a similar trend. Hence, Roadcake baiting offered only a partial protection.

The damage on capsules was not consistsent in response to the Bromdiolone baits. The percent damage to capsules was significantly high in 'control' on 13.10.1988 and 15.12.88, while the percent damage was non-significant on 14.11.88 and 5.1.89 (Table 25).

During 1989, rodents bit the bait pieces only at two spots. There was a poor response from rodent community to the baits. The capsules damage was consistently and continuously observed even after the placement of baits. Hence anticoagulated baits cannot consistently protect capsules from rodents damage.

Effect of 'Storm' and 'Quintox' on Rodents infesting Cardamom

During 1992, Quintox (0.75%) and Storm (0.005%) chemicals were tested for protection of cardamom capsules by rodents. Two grams of quintox/storm was placed/clump. Each experimental plot was 50 to 70 m being separated by atleast 0.25 Km. A control plot was also maintained. The rodent damaged capsules were collected and expressed in number of capsules damaged clump.

Effect of two rodenticides viz. Quintox and Storm on rodent damage could not yield conclusive results (Table 26). The data presented in the Table 26 did not reflect on the effect of treatments and the resulting damage is not related to the rodenticides effect. This experiment will have to be repeated with more number of replications in more than one locality.

Year	Weather	Area under cardamom (ac)	Capsule yield (quin)	Date of first harvest	Date of last harvest	Capsule (%) damage by rodents
1991	Open, clear, rains In June-July	7	4	August 15	December 15	18
1992	do	15	9	August 20	December 15	39
1993	Rainy and cloudy, open and clear in November	15	5	October 5	January 15	2

TABLE 24

Effect of Rodacake baits on per cent capsule damage

Site	Area (m^2)	Capsule (%) damage in valley	$\bar{X}^2$ Test-
A	200	21.0	
			(P > 0.05)
B	300	17.0	
C	200	14.0	
			(P < 0.05)
Control	200	46.0	

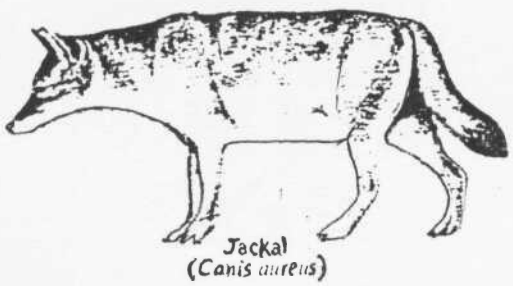


TABLE 25

Effect of Bromodiolone baits on rodent damage in cardamom

	% Capsule damage*		
Date	Treated	Control	X^2 Test
3.10.88	1.7	12.4	(P.>0.05)
14.11.88	10.7	6.7	
15.12.88	5.5	7.7	(P < 0.05)
05.01.89	4.6	1.2	

* Mean of 20 clumps; 3 cm^2 bromodiolone pieces were hung from 0.3 m height over the panicles

TABLE 26

Effect of rodenticides on rodent damage in cardamom

Dates	Capsules (Nos.) damaged/clump			
	Control	Stream	Quintox Pellets	Cakes
05.11.92	1768.0	126.0	139.0	153.0
10.11.92	1768.0	148.6	92.3	75.0
15.11.92	1085.0	123.0	284.7	106.7
20.11.92	1078.6	132.3	288.0	105.3
25.11.92	610.3	120.3	255.4	103.3
30.11.92	567.7	123.3	289.7	97.3
05.12.92	774.3	150.3	344.7	103.0
10.12.92	697.0	141.0	341.7	110.7
10.12.92	708.0	135.6	267.6	136.7
Mean	1006.3	133.4	255.9	110.1

CD @ 1% Chemicals = 908.22; dates - 39.85

Chemicals x dates = 14.30

Vertebrate Pest Management in Plantation and Fruit Crops in Malnad Region

Introduction

Important plantation and fruit crops of Malnad are Arecanut (Areca catechu), coffee (Coffee arabica), Cocoa (Theobroma cacao), Cashewnut (Anacardium occidentale), Orange (Citrus reticulata), Coconut (Cocos nucifera), Banana (Musa paradisiaca), Mango *(Mangifera indica),* Pineapple *(Ananas comosus),* Sapota *(Achrassapota),* Guava *(Psidiumgujava)* and others. Vertebrates depredate on all of the above crops.

Survey and identification of vertebrate-pest problems on plantation and fruit crops in Malnad region.

An extensive survey of Malnad covering four districts namely, Shimoga, Hassan, Chickmagalur and Coorg was conducted during 1989-90, so that all types of habitats were covered. Observations were recorded with a 8 x 30 binoculars on species, their incidence and yield-losses (%) incurred. For instance, in cocoa the losses due to jungle cat and rodents was measured. In three coffee plantations in Mudigere, losses to orange crop due to monkeys was measured. In Hosur (Koppa taluk, Chickmagalur) losses of arecanut seedling due to wildboar was measured.

At Thirthahalli (Shimoga district) in cocoa plantation of 2 acres, the pods lost due to jungle cat and rodents was estimated.

During October, 30.6% pods were lost due to VPs. At Hugluvalli, in 1.5 acres of cocoa plantation, there was a cent per cent loss. The farmer could not harvest a single pod. In cocoa, Jungle cat problem begins after seed formation i.e. 100 days after flowering. At Kurvalli the damage due to jungle cat was 21% and due to rodents, 7.06%.

At Niranki (Mudigere Taluk) damage due to VPs in 4 acres of Areca (10 years old) based cocoa plantation was assessed. The damage to cocoa pods by various vertebrates was as follows:

Jungle cat	15.20
Squirrel	10.15%
Rat	0%
Bird	2.5%

At Nemmar (Sringeri taluk), Chickmagalur the loss due to monkey, squirrels and rats amounted to 60%. At Thangalesara (Thirthahalli taluk) Shimoga, the planter abandoned cocoa cultivation in view of the total loss of the crop by VPs.

In Mudigere, in a 20-years old coffee plantation the loss due to oranges by monkey was assessed. From 15th December 1989 to 5th January 1990, 60 monkeys caused a loss of 150 kgs fruits. During a feeding bout, each animal was found feeding on 70 to 75 fruits. In two other coffee estates, the loss of fruits to monkey was 28 to 35%.

In a ten acres Robusta Coffee estate, monkeys were found climbing on coffee bushes and plucking 14 to 15 berries. The animals were seen removing the outer coat and feeding on the internal contents and seeds of coffee berry. In 1989, 60 to 70 monkeys caused a loss of 20 to 25 kgs coffee. It was estimated that in a season a monkey caused a loss of 0.25 kg coffee berry. Monkey at Hugluvalli (Thirthahalli) caused a 100% loss to pineapple.

In Hosur (Koppa taluk), wildboar caused a cent-per-cent loss to areca seedlings.

Current Protection Practices

At Kuuvalli (Thirthahalli), 3 to 4 banana fruits/bunch is hanged as a bait with 3% G Carbotunan. The planter was able to kill 9 jungle cats. In Sagar, Shimoga cocoa planters place 2-3 gm of Furadan 3% G granules in crabs. By this method, the planters were able to protect cocoa. In Sirsi, Furadan in wet jagary served as an alternative bait against jungle cat.

Few planters only are able to shoot down monkeys. However, shooting was found not satisfactory. Trained dogs are employed to chase away monkeys as the shelter sites become less secured. Now planters are electrifying the fence. However, this alone may not protect their crops completely.

Electric fencing, baits in dry-fish, rotten animal wastes, diamond mesh or other forms of fencing, exploding crackers, watch and ward, opening fire, hunting and maintaining cleaner environments in villages are

some of the methods being followed by planters against wildboar in Malnad. Some planters protect less than two years old areca seedlings with porcelain pipes that are cheap and easily available locally.

Cocoa

Cocoa is popular in Malnad and is being grown as an intercrop in Areca, Coffee, Cardamom plantations or as a pure crop in small farming systems or planted after thinning a part of the natural forests. So cocoa forms a component crop of natural forests or forests-like habitats. Thus a number of wild animals are attracted to the crop. Cocoa fruits are depredated upon by

1. Jungle cat – *Felis chaus*
2. Squirrel – Species of *Funambulus*
3. Monkey – *Macaqua radiata*
4. Rat – *Bandicota bengalensis*

The first animal observed damaging cocoa pods was squirrel which fed on unripen or about to-ripen pods.

It made irregular, small holes to feed on internal contents. Rat and Jungle cat were observed feeding during night while rat was observed damaging already damaged or fresh pods. The Jungle cat selectively attacked only fresh pods as also the squirrels. The cat made a circular hole, sufficiently big enough to insert head and feed upon. The cat was observed feeding on seeds. The feeding activity leaves molar teeth marks on the surface of the pods.

Rat damage was found mostly confined at the proximal end by gnawing. The rats were not selective of the matured or young pods. Temporal differences in the feeding of rat, squirrel and Jungle cat was observed in Thirthahalli. While squirrel damage commenced at the beginning of the fruiting season, the Jungle cat damage occurs during ripening stage. Rat damage persists throughout the fruiting period. A survey of cocoa plantations revealed that Jungle cat was the principal species of vertebrate feeding on cocoa in Sringeri, Koppa, Kalasa, Thirthahalli, Sagar and Soraba taluks.

A systematic baiting trial was undertaken at Kurvalli, Thirthahalli in 5 acres cocoa plot. Fruits of Banana of local variety 'Putta Bale' were incised and 2-3 g of 3% G Carbofuron was placed in the split portion. Two-Three such banana fruits were hung from the plant at 1-1.7 mt ht. After 24 hours, 3 bunches were eaten and 30 bunches after 48 hours. After 72 hours, 6 Jungle cats in an unconscious state and dead cats were located in the plot. Of the 7 cats, 3 were males and the rest were females. Before control measures annual income from the plot was Rs.800-900. After control measures, the income increased to Rs.8000-9000 annually. The baiting operation against Jungle cat need to be taken up when the first few pods turn yellow.

Observation on the feeding potential of Jungle cat during 1989-90 in the cocoa plantation in Thirthahalli was recorded. The farmer cultivated 220 cocoa plants. Fruits were harvested during April- May and the IInd crop during October-November. The first crop yielded, on an average, 40 pods/plant, and the second, 6 pods/plant (n=220).

In five acres plot, 22(n=18) squirrels were observed. Each squirrel was observed feeding on 4.4 pods (n=30)/day and each rat injuring 6.7 pods (n=24)/day. Bromodiolone baits did not prove effective in cocoa plantations. However rat and squirrel were easily trapped in live wooden snap traps with paddy grains as bait. The cocoa pods damaged by four VPs is given in Table 46.

In Addegadde, Sringeri and in Hugluvalli, Thirthahalli 300 and 120 cocoa trees were cent-per-cent damaged by VPs. Rodents and Jungle cat were the principal species attacking the fruits. During September 1990, carbofuran 3% G baits in banana (Putta bale) were hung at 10 and 6 spots, respectively. After a week 2 and 1 jungle cats., respectively were found dead and further damage to pods ceased.

Cocoa is depredated upon by rodents, jackal, monkey and jungle cat. Squirrels usually damaged the pods at the centre, while rats damaged the pods at the corner. Jackals damaged the pods from the lower half and the pods nearest to the ground were depredated upon by the jackals. Monkeys damaged the pods irregularly. Timely harvests; 3% carbofuran baiting in jaggary, banana, etc. and snap-trap would help in crop protection.

TABLE 46

Vertebrate pests damage on Cocoa

Plot Nos.	Cocoa pods (%) damaged				
	Jungle cat	Monkey	Jackal	Squirrel	Rat
1	29	1	0	0	0
2	24	0	0	0	0
3	7	0	0	13	7
4	7	0	0	12	11
5	18	0	0	12	0
6	12	0	32	3	17
7	42	0	0	27	30
Mean	19.85	0.14	4.57	9.57	9.28
CD at 5%	5.88				

Oil palm

Preliminary observations on B.indica damage to oil palms is reported here. Of 35 palms, 4 were killed due to rodent damage. Twenty gm of 10% G. Thimet was applied at the base of each palm on 21.5.1991. On 15.9.91, Bromodiolone baits were placed at the base of 15 palms. Six palms suffered mortality due to rodent damage. Of 15, 7 bait-pieces were fed by animals. Observations during May, 1992 revealed mortality of 7 palms. Rat, *B. indica* damage was first noticed on oilpalm as scratches at base of the oilpalm, where the shoot peels are cut and removed from palm. The rats work further to remove lumps of soil from base of the palm and damage the base in a manner that the palm is eventually killed. From 30.10.1990 to 21.5.1991, of > 35 palms 11.43% palms i.e. four palms were killed. To protect oilpalms, 20 g, 10% G Thimet was applied at the base of damaged palms. The effectiveness of Thimet lasted for a month, after which rodents began damaging the palms.

Bamboo

In Banakal, about 8.km from Mudigere, Rabbit severely impaired growth of bamboo in about 10 ha. Just • planted bamboo clumps, were completely defoliated and faecal pellets of animals were strewn all over the place. Damage estimations revealed 50% damaged clumps. For completely destroyed clumps, with no capacity to regenerate, the bamboo clumps were replanted with 'yellow stem' variety, that offer resistance to rodent and rabbit damage. The clump covered all-round with a thick pad of thorny sticks. For 'partially damage' clumps, a mixture of 5 g, 10% G Thimet + 5g dry sand in perforated polythene bags was suspended at base to serve as repellent. For 'slight damage' clumps, a thick padding of thorny sticks to act as mechanical barrier, was provided. At the approach route of the animals to the site noose-traps of nylon threads were erected.

Six months after treatments, the rabbit damage was reduced by over 80%.

Coconut and Arecanut

Monkey and rodents are the principal VPs on coconut. The group size of monkey troupe varied from 60 to 70. Monkeys damaged the tender nuts to drink water or damage the matured nuts for copra. While feeding, the animals may drop the nuts. In a day, the animals dropped 2 to 3 nuts/tree. To protect coconut palms, the growers adopted drum beating, stone or stake throwing, burning crackers, scaring by trained dogs and trapping. Trapping is usually done using live traps. Inside the traps, Banana, coconut, copra, jackfruit, groundnut, etc. are used as bait. Trapping is done usually when monkey population is at peak and damage is severe.

Rats and squirrels together damaged 12 to 15% of tender nuts in coconut palms. The rodents preferred border palms or palms near the fence or shade trees. The per cent nuts damage due to rodents in 5 acre plot at Kadur varied from 4.5 to 5.5%. Rodents usually attacked tender nuts but also scrape, make holes and scoop out the internal contents. Mechanical killing and poison baiting, cleaning of crown region, etc. are some of the methods in practice. Use of thorny bushes/sticks around the stem or banding is also practiced, but by a small section of growers. Some growers also deployed snap traps or plastic sheets on stems for rodent control.

Monkey troops while moving from one place to another cause nutfall. The animals also bite, split and chew the shoot peels from the tender stems and cause damage. When the loss due to nutfall was estimated it amounted to, on an average, 3.2%(n=9). Wildboars uproot the seedlings. In Sagar, Soraba and Hosadurga taluks of Shimoga, the seedlings are enclosed in earthern pipes of dia, 2" - 3". Two years old seedlings are the most vulnerable for wildboar damage. Rodents (rat + squirrel) also caused nut fall. Losses due to VPs were estimated at 6% in 1.2 acre in Sakrayapatna.

At Kuruvalli, 15-year old coconut plantation in 5 acres was attracted by rat, *B.bengalensis* and squirrel, *Funamubulus species.* More damage (@ 10 nuts/day) was observed during rainy season (June-September). Majority of the nuts damaged were tender ones. A count during August revealed 26 squirrels and 47 rat burrows in 5 acres. Of 300 trees, rodent damage was noticed in 20 trees. Rodent damage on coconut was found through out the region. In plain areas, the damage was more than in hill areas. Rat

Preference of Rodents for Coconut Palms in Sakreyapatna

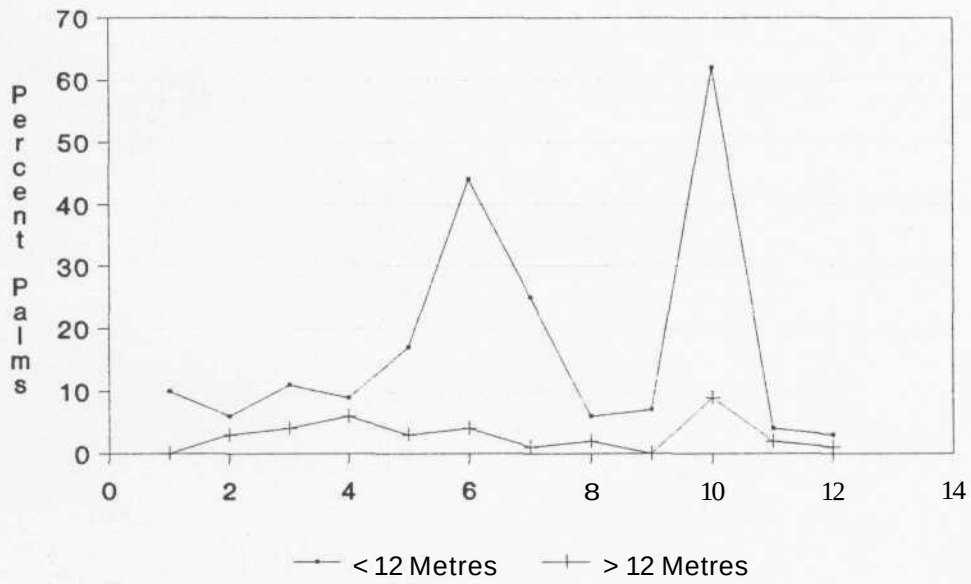


TABLE 49

Damage to Areca by vertebrate pests at Sakrepatna, 1991–92

Dates	Nut loss (g/tree)		
	Rodents	Monkey	Birds
13.07.92	250	300	100
23.07.92	300	100	150
03.08.92	400	200	130
13.08.92	600	130	450
23.08.92	750	150	350
04.09.92	350	160	150
14.09.92	550	180	200
24.09.92	350	190	150
05.10.92	450	100	180
15.10.92	300	150	150
25.10.92	450	160	150
Mean	432	165	195
CD @ 5%	29.43	12.35	38.17

Paddy nursery damaged by rats

preferred less than 12 m tall coconut palms compared to more than 12 m tall palms for damage (t at *5%* = 2.62, Table t = 2.07).

In Kadur and Chickmagalur taluks, monkey, *M.radiata* caused a loss of *2.5* to *3.5%* of arecanuts/acre. Monkeys while foraging or moving from one to another garden-bite, split and chew the shoot peels from the tender stems and also drop the tender and mature nuts from palms. Such loses usually amount to 10-15 nuts/tree (n=28).

Wildboar, *S.scrofa* was also found trampling and uprooting areca seedlings. This damage was found widespread, practically in every areca garden. Planters used porcelain 0.8 m long pipes to enclose the seedlings and such seedlings remain protected for two years from wildboar damage. By electric fencing (Ibex battery) too the problem could be solved.

Jungle cats and species of *Felis* have been observed during night feeding on nuts of areca palms. One cat was observed feeding on nuts of 3 consecutive palms/day. The animals plucked, peal off and chew and sip the juice after biting and cutting. Of 100 trees of arecanut, nuts on 5 trees were completely fed by the cats in 2 days. Frugivorous bats were observed feeding on nuts during night. The nut-fall due to Jungle cat, bat and rodents was observed to be more during June, July and August. The efficacy of chemical and cultural methods in protecting coconut plant is given in Table 47.

Cashew

Deer, squirrel, monkey, wildboar and porcupines have been observed to damage cashew in Malnad. Cashew seedlings are damaged by rodents, wildboar and porcupine. Monkey and porcupine to some extent, damaged nuts also. The total loss due to VPs in cashew at Mudigere was estimated during 1991 and 1992. Seedling loss was estimated at 17% and nut loss at 21%. So the VPs caused economic loss to the farmer. Watch-and-ward, timely harvests and scaring would help in crop protection.

During April-May, monkeys were observed feeding on cashew fruits. Observations on damage were recorded on five days, from 8.4.1991 to 12.41991. The animals, in troupe of eight at Mudigere caused on an average, 24% loss, i.e. consumed the fruits and 47%, extra-depredative loss (fruit-fall) (n=104). Thus, in this patch the animals caused economic loss.

Pineapple

Mongoose, Jungle crow, Wildboar and Jackal were found feeding on pineapple. Mongoose posed the major threat. The animals fed on ripened fruits, completely destroying the fruit. Jungle crow was observed excavating the fruit by beak and feeding on immature/ripened fruit bit-by-bit. Wildboar fed on the entire fruit while Jackal was found chewing and sipping the fruit juice. On an average, in Ujjre (south Kanara) the VPs caused a loss of 10-12% losses in fruit production.

Yield loss of arecanut due to rodents, monkey and birds were recorded during July-September 1992 at Sakrayapatna, Chickmagalur. Effected nuts were collected and nut loss was expressed in g/tree. Rodents caused maximum nut loss per arecanut palm compared to birds and monkey at Sakrayapatna (Table 49). Rodents caused a nutfall weighing 432 g/tree compared to 196 and 166 g/tree by birds and monkey, respectively. However, the preponderance of one vertebrate pest species compared to others may vary from one plot to another. As monkey potentially caused more damage than rodents, care should be taken to protect areca from monkey damage.

An experiment was carried out for the management of rodents on coconut by using cultural and chemical methods. Twenty trees were covered with a mat of thorny sticks at 2 to 3m, and zinc sheets (0.6 m) were fixed by nails. Quintox pellets and cake pieces were placed at the crown portion of the palm after cleaning the same. For each treatment, control plots were maintained. Infected nuts were collected and the loss was expressed in number of nuts/tree. Mounting zinc sheets (2 ft.) on tree trunk at about 2-3 m height caused the least damage to coconut by rodents. Next in effectiveness was the mat of thorny sticks, with 9.3 nuts/tree. Quintox, cakes and pellets recorded 17.6 and 18.2 nuts/tree, respectively compared to 32 nuts/tree in control. Thus, in treated palms significantly less number were recorded when compared to control. Banding tree trunk either with zinc sheets or with a mat of thorny sticks were effective in protecting coconut from rodents. Zinc sheets can be substituted by any other used-up metallic sheets, thus lowering the initial costs required for protecting the coconut palms.

TABLE 47

Efficacy of cultural and chemical methods in protecting Coconut from rodents damage at Sakrepatna, 1991-92

Dates	Nuts (*Nos.) dropped/tree with				
	Control	Thorny mat	Zinc sheet	Quintox (0.75%) Cakes	Pellets
13.07.92	25.0	13.0	2.0	12.0	15.0
29.07.92	19.0	4.0	3.0	14.0	18.0
29.07.92	19.0	4.0	3.0	14.0	12.0
12.08.92	15.5	5.0	2.3	18.0	18.0
23.08.92	25.5	16.0	1.5	25.0	19.4
10.09.92	35.4	7.3	2.3	20.0	23.6
24.09.92	45.4	18.5	3.3	25.0	15.5
08.10.92	50.5	13.5	1.5	20.0	16.8
28.10.92	25.5	4.8	1.3	25.0	18.3
23.11.92	30.5	5.4	2.2	13.0	25.4
30.11.92	45.5	6.8	3.5	13.5	13.8
15.12.92	30.5	13.5	2.0	13.5	20.4
29.12.92	35.8	4.0	3.5	13.5	19.7
Mean	32.0	9.3	2.4	17.7	18.2

CD @ 1-1, Treatments = 4.42; Dates = 1.08
T x D = **0.483**

Coffee

Coffee is an important and principal plantation crop of the region. Vertebrates interact actively with the coffee plantation. Perhaps, this is the one crop housing the maximum number of vertebrates in Malnad. Species-richness-wise also coffee ranks first of all the crops in the region. The main reason is that it is this plantation crop that imitates natural forest and contain elements of the forests. Vertebrates feeding on coffee berries are listed below:

Vertebrates	Berries Consumed (%/Coffee bush)
Birds	11.28
Squirrel	2.80
Rat	1.9
Jungle Cat	1.5
Jackal	1.7
Monkey	0.5

Vertebrates normally do not cause alarming loses to coffee berries. However, birds at times may incur slight losses. But this should not be, in fact considered as 'loss' as birds have invaluable role to play in coffee ecosystems via insect predation, deposition of organic matter and in transfer of nutrient and energy matter. Among birds, Jungle crows, coucal, parakeets, munias, sparrows, bulbuls and barbets are the important groups of birds that supplement their diet with coffee berries. It was estimated that in Mudigere, due to birds feeding about 2.25 kg of coffee seeds are lost in 5 acres. For 78 acres about 175 kg of berries are lost. This amounts to about Rs.4500/- . This is an economic loss.

Guava

Guava is depredated upon by Jungle crow, *Corvus macrorhynchos*. Small green barbet, *Megalaima viridis* Roseringed parakeet, *Psittacula krameri* and flying fox in Mudigere. Five trees/row x 10 rows were randomly chosen and percent fruits damaged by vertebrate pests was worked out for a orchard in Mudigere. Of 50 frees, 3.21 per cent fruits were damaged by all VPs. There were no significant differences in fruit damage by VPs, mainly birds. The fruit damage was negligible and warrant no protection measures. Details of fruit damage are given in Table 48.

The guava fruit depredation due to various species of birds chiefly, jungle crow, small green barbet and parakeets were observed at RRS, Mudigere from August 1992 to October 1992 with an interval of 4 days with a pair of 8 x 30 binoculars. Observations on number of unripened, partially ripened and fully ripened fruits damaged by birds were also recorded.

The depredative loss and rate of depredation to guava fruits by birds varied depending upon the maturity of the fruits. It must be noted here that birds with relatively strong beaks preferred to depredate guava than other fruits like oranges. Jungle crow, *Corvus macrorhynchos,* Small green barbet, and parakeets were the principal species damaging the fruits. Birds destroyed, on an average of about 14 per cent unripened, 24 per cent partially ripened and 33 per cent ripened fruils; the depredalion increased as the fruit malured

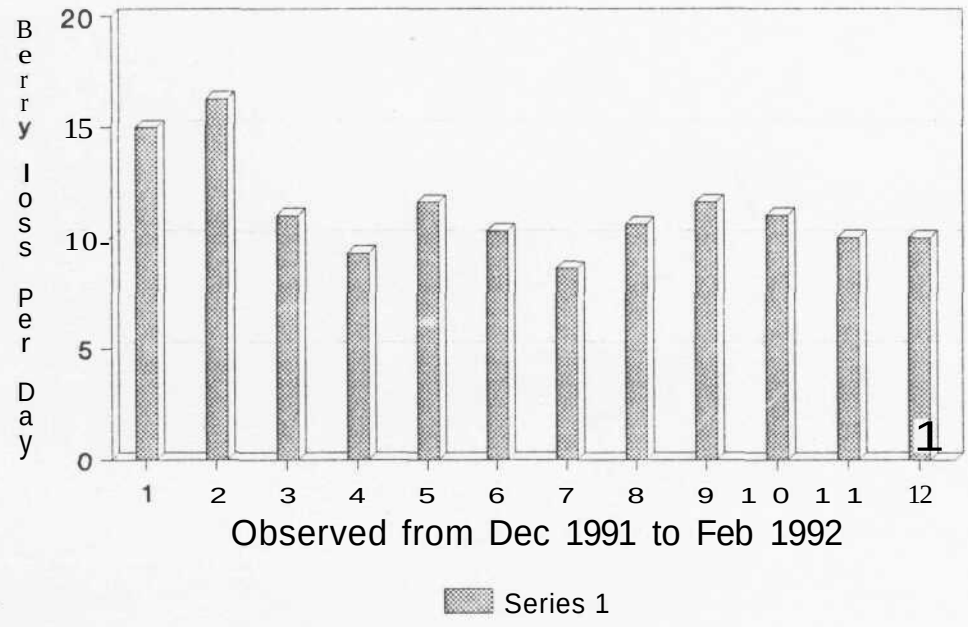
, The rale of depredalion on unripened, partially ripened and ripened fruils was 1.4, 2.37 and 3.2 fruits per day, respectively. The rale increased as the fruit matured, i.e. the loss incurred was positively correlated partially (r = 0.2169) with the age of the fruit. By covering the exposed fruit with dried grass, thatched materials, mat of dried leaves, etc. it may be possible to reduce fruit losses.

Oranges

Observations on bird damage in Mudigere in a Coffee estate (82 acres) was recorded during 14.12.91 to 21.2.92. There were 1500 orange trees, 10 years old. Number of fruits/tree varied from 132 to 150(n=50).

Following bird species were found feeding on fruits:

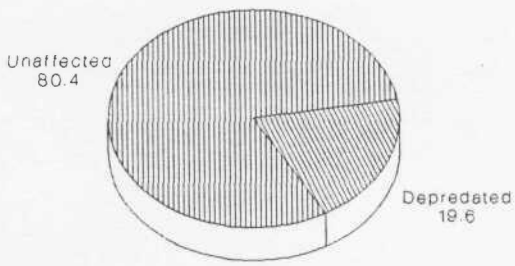
Loss	(%fruits/tree)
Jungle crow	30.0
Small Green Barbet	10.0
Blue Winged Parakeet	5.0
Chloropsis	3.0
Others (Coppersmith, Bulbul, Thrush, etc.)	4.0



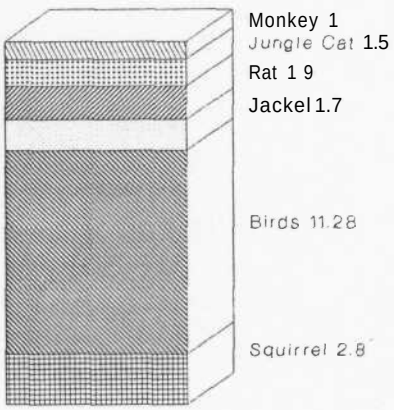
Daily Berry Loss-almost constant

&100

Vertebrates on Coffee In Mudigere
Species Compositon & Relative Damage



Relative Damage



Percent Damage

TABLE 48

Depredation by birds on Guava, RRS, Mudigere, 1992-93

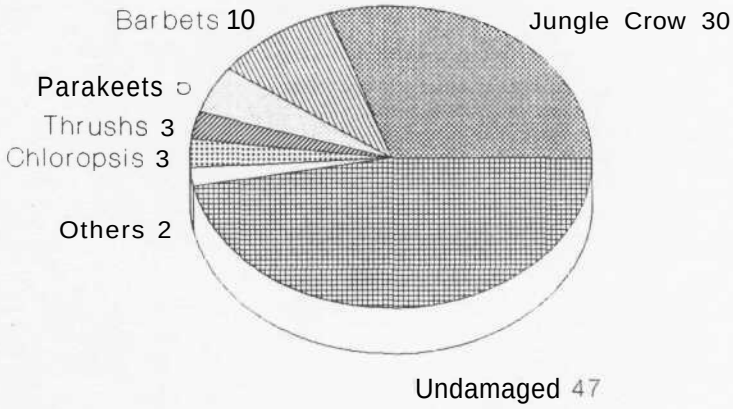
Dates	Fruits (Nos.) damage/tree Fruits		
	Unripened	Partially ripened	Fully ripened
11.08.92	10.55	25.55	30.25
15.08.92	20.50	32.50	45.95
19.08.92	10.55	35.45	50.25
23.08.92	20.25	15.25	35.45
30.08.92	18.75	25.35	32.45
08.09.92	16.35	20.35	17.58
16.09.92	18.25	19.75	30.45
24.09.92	10.35	35.25	43.75
02.10.92	8.35	12.35	20.35
10.10.92	6.25	15.45	22.15
Mean	14.02	23.75	32.86
CD @ 1%,	Maturity = 10.20;	Dates = 2.56;	M x D = 0.88

Jungle crow was the dominant species depredating oranges. An individual crow gives out call for others to come and join and 7 to 8 crows/tree were found together feeding on oranges. The crow extracted sap of fruit, gulped it down and again inserted beak to feed on juicy fruit-matter. An individual consumed 12 + 1.4 (n=18) min. to empty the internal contents of a fruit. The crows actively fed on fruits between 7.30 - 8.30 a.m. and 4.30 p.m. onwards. On an average, in an hour, an individual crow destroyed 7 to 8 fruits. In 15 days period, crows damaged about 2000 fruits, with extra-depredative loss being 7 to 8% (n=18). Chloropsis siphoned out juice from the fruit by poking the fruit with its beak.

Orange fruit depredation due to vertebrate pests was recorded in 'with watch/ward' and 'without watch and ward' areas at RRS, Mudigere from 22nd January to 10th March 1993. Orange fruits depredation due to various vertebrate pests was expressed in number of fruit loss/tree.

Orange fruits are fed upon by a number of species of birds in hilly region of Karnataka. The principal species are jungle crow, barbets, bulbul, chloropsis, parakeets, etc. By watch/ward the fruit loss could be reduced due to jungle crow by 66.29 per cent, due to other birds, 51.57 per cent and 44.45 per cent due to monkeys (Table 50). Thus, by watch and ward alone 41.31 per cent of fruit could be prevented and there is scope for further saving orange fruit-loss by effectively watching and scaring away the birds.

Feeding lossess in Oranges by Birds in Mudigere



Percent fruit Loss

TABLE 50

Effect of Watch and ward on Orange fruit loss due to vertebrate pests, Mudigere, 1992-93

Dates	Fruit (Nos.) loss/tree					
	Jungle crow		Other birds		Monkey	
	a	b	a	b	a	b
22.01.93	10	7	4	3	10	2
24.01.93	12	3	5	2	8	3
28.01.93	15	5	6	2	5	2
02.02.93	18	4	7	2	4	4
06.02.93	20	3	8	2	3	3
10.02.93	15	2	9	3	4	3
14.02.93	12	2	6	1	4	1
18.02.93	14	3	5	3	3	3
22.02.93	15	4	4	2	3	2
26.02.93	16	10	3	4	8	3
30.02.93	17	9	3	2	4	3
10.03.93	14	8	5	4	8	4
Total	178	60	65	30	64	34
Mean	14.8	5	0.54	2.5	5.33	2.83
% Reduction by watch/ward	66.29		53.84		46.88	
Binomial expansion (Z)	2.00		NS		NS	

a = Without watch and ward b = With watch and ward

Vertebrate Pest Management in Field Crops in Malnad Region

Paddy is the most prominent cereal grown in over 45% of the cultivated area in Malnad. The crop is often cultivated in small, fragmented plots adjacent to plantations is low-lying areas. Such low-lying tracts is frequented by vertebrates. Rodents, birds, wildboar and elephant not only trample but cause enormous losses by way of feeding in certain localized patches.

(a) Survey, identification and feeding behaviour of birds in paddy fields and a cultural tool to protect paddy from birds damage in Malnad

Chickmagalur, Coorg and Shimoga districts were surveyed during 1989 and 1990 to identify and record bird species damaging paddy. Observations on birds were made using a pair of 8 X 30 binoculars. Farmers were also interviewed on bird pests problems of paddy.

Four species of Parakeets and six species of Finch birds were recorded feeding on paddy.

Parakeets:

(a) Large Indian Parakeet *Psittacula eupatria*

(b) Roseringed Parakeet *Psittacula krameri*

(c) Blossomheaded Parakeet *Psittacula cyanocephala*

(d) Bluewinged Parakeet *Psittacula columboides*

Finch Birds:

(a) House sparrow, *Passer domesticus*

(b) Indian Baya, *Ploceus philippinus*

(c) Whitethroated Munia, *Lonchura malabarica*

(d) Whitebacked Munia, *Lonchura striata*

(e) Spotted Munia, *Lonchura malacca*

The identifying features and status, abundance and frequency of occurrence of each species is given below:

Large Indian Parakeet

A large green parakeet with short, deeply hooked red bill and a conspicuos deep red patch on wing shoulders.

This parakeet supplemented its natural food with guava, sapota, sunflower, sorghum and rice. Depredating activity of this species has been observed in Chickanahalli on guava and sapota; on grapes in Kadur and Bellimoda and on rice in Balehonur, Mudigere and Kenchige.

Roseringed Parakeet

A green parakeet with red bill. Male with a rose-pink and black collar. Female without the collar.

This species was sighted near-about human habitations and towns. Nests were found near about human habitations during August- September. In flocks of 10-12 birds, this species was found depredating on rice crop.

Blossomheaded Parakeet

A yellowish-green parakeet with bluish red head and a maroon red patch on wing shoulders. Female has head duller and greyer.

Observed in coffee estates, fruit orchards, gardens and scrub thickets in four to five or eight to twelve birds. First to congregate on Erythrina blooms to feed noisily in mornings. An individual cut 13 earheads of paddy in eight minutes on 17th March at about 6.00 p.m in Mudigere.

Bluewinged Parakeet

A bluish green parakeet with pink grey head and a brilliant blue- green and a ring of black color on occiput. Lower back rump and upper tail coverts greenish blue. Tail feathers tipped yellow.

This species in groups of four to five or ten to fifteen was observed feeding on Lantana, Fig, Erythrina and such otherflowerbuds in scrub. Two chicks recovered from a log during mid- December. Seldom found feeding on rice.

HouseSparrow

Very common bird. Sexes differ in coloration. Male and female over-all grey brown. Male-below and sides of throat white. Centre of throat and breast black. Female-below, plain brownish white.

Small parties found near about human habitations and cultivation in plains. Found with weaver birds and munias feeding on paddy, sorghum, fingermillet and pearlmillet grains in plains of Coorg, Hassan and Chickmagalur districts.

Yellow Throated Sparrow

Above, grey-brown, wings and tail darker, with a chestnut shoulder-patch and two whitish wing-bars. Below, pale grey-brown with a yellow throat-patch; chin and belly whitish. Tail forked.

Together with Spotted Munia, Yellow Throated Sparrow caused 5% loss in rice grains in Ponnampet. Usually gleans on grass, sometimes gather in three to four numbers on wires over-hanging cultivated tracts for preening.

Indian Baya

Male. Above, crown yellow. Rest of upperparts dark brown streaked with yellow on back. Below, throat brown; breast, yellow. Female similar to Male, but duller, less boldly streaked breast, bright yellow.

Surprisingly distribution of this species is highly localized and patchy, inspite of paddy (one of its food item) being grown in over 45% of cultivated area in Malnad. At a locality, not more than ten individuals have been sighted. On 12th January saw a pair courting in Melia species tree in cardamom valley in Mudigere. On 16th November at 2.5 m height in Somwarpet located eight weavernests. Female tomale, 4:1 ratio in a population at Kanachuru, as counted on 6th July in a paddy field. Sighted feeding on paddy with other finch birds.

White-backed Munia

A small brown-and-white finch with a heavy bluish conical and pointed bill. Rump and belly white. Sexes alike.

Spotted Munia

Adult. Above chocolate-brown with pale shaft streaks. Rump barred with white. Below, sides of head, neck and lower throat chestnut. Breast speckled black and white.

Found in mixed-species flock of White-Throated Munia, White- backed Munia, House Sparrow, Immature White-backed Munia and Red Munia in rice, sorghum, pearlmillet, fingermillet fields; grass laden open patches and lawns. Nesting sighted in *Polyalthea* and *Casuarina.*

Blackheaded Munia

Above, head black. Rest of upperparts rufous chestnut, rump darker. Below, throat, breast and centre of belly and under tail coverts black. Rest of underparts white.

A member of mixed species flocks comprising White-backed Munia, Spotted Munia, Red Munia and Weaver birds. Invariably come a crossed in or around paddy growing tract. Immatures sighted during August. A nest was located in *Casuarina* in Mudigere during August. On 9th February sighted two birds copulating near paddy fields on a tree 2 m tall.

Large Indian Parakeet	R	LA	IF
Roseringed Parakeet	R	A	F
Blossomheaded Parakeet	R	LA	F
Bluewinged Parakeet	R	LA	IF
House Sparrow	R	A	VF
Indian Baya	R	LA	F
Whitethroated Munia	R	LA	F
Whitebacked Munia	R	A	F
Spotted Munia	R	A	IF
Blackheaded Munia	R	LA	IF

R = Resident; A = Abundant; LA = Less abundant

IF = Infrequent; F = Frequent; VF = Very frequent

Observations revealed that only parakeets feeding caused paddy earhead loss above a critical threshold level. The earhead loss was localized and varied from 2 to 18% in a patch.

The birds followed three types of foraging patterns. The foraging patterns are: (a) Direct cutting of earheads by lowering (b) Perching on poles, fence, etc.

and cutting the adjacent earheads and (c) Nearly settling on paddy plants and cutting the earheads around. The most common was that the birds in flocks of 6 to 8 cut the base of earheads (with milky grains) hovering over the plants and returned to the thicket with the earhead. At perch, the parakeets handled the earhead with legs and beak to feed on grains. Often, the birds spilled the grains more than what they consumed.

Since parakeets fed at edge, ways of reducing the effects of grain feeding on paddy may depend on how bird's feeding effort might be spread more evenly from the edge. Three methods were tried. They are (a) Scaring intermittently (b) Growing at edges early/late maturing rice/alternative crops less attractive and (c) Reducing asynchrony in grain maturation in a patch/zone.

Scaring intermittently the flocks of birds did not help much as the flock would resettle on another edge and growing of alternate crops was found impracticable in most situations and birds failed to feed on the alternate crop. Reducing the asynchrony in grain maturation in a patch was found to be practicable and effective in reducing the damage to paddy by birds in Malnad.

Feeding and Foraging behaviour of parakeets on paddy

Visual observations through a pair of 8 x 30 binoculars permitted recording of feeding rate, number of birds and foraging behaviour. Observations were recorded during November-December, 1990 repeatedly in 10 to 20 min sessions throughout the day at Amaravathi Estate, Mudigere where Intan paddy was grown in over 2 ha. *Pandanus* border was at one edge and patches of marsh intermixed with paddy fields were found on other three sides.

Roseringed parakeet and Blossomheaded parakeet were the two principal species found feeding on paddy grains. The birds were sighted alighting on trees bordering the fields at 6.40 a.m. Most of the individuals used tree-branches or fence as foraging substrates. In a forage-group, individuals of the two species were intermixed. The foraging method used most frequently by parakeets was to commute from roosting sites to foraging locations. As the day advanced at 7.20 a.m, 3 to 4 birds alighted on paddy plants by hovering first to pick the earheads. At 7.32 a.m. flocks up to 20 birds would leave perch site, fly to paddy fields and feed there. Individual birds continuously pick 6 to 8 earheads for 5-30 min, return to site, feed on grains and again fly to field. The birds were found feeding on grains, preening, cleaning beak and resting. The foraging activity of birds were separated by bouts consisting of preening, cleaning beak and resting pauses. This entire range of activities consumed 35 to 50 minutes. In paddy field, individuals or groups were loosely spread out over a wide area but within sight of eachother.

The feeding rate varied from 1 to 3 min/earhead(n=55). On disturbance, birds were observed picking 8 to 12 earheads at a stretch(n=18). While carrying the earheads, the birds frequently dropped 3 to 4 earheads.

The feeding activity of birds reduced after 8.20 a.m. touching a further low at 9.15 a.m. The feeding activity in birds ceased after 10.00 a.m. and only a few individuals (3 to 4) were seen, in and around paddy fields i.e. at foraging site.

From 10.00 a.m. to 2.58 p.m. parakeets were found under the vegetation cover (shade-trees in coffee estate). After 3.00 p.m., 5 to 6 birds resumed feeding in paddy fields. From 4.00 p.m. to 5.15 p.m., the birds voraciously fed on paddy grains and after 5.47 p.m. the feeding activity completely ceased. The birds returned to roosting site.

The birds also fed on harvested earheads of paddy. The birds preferred the harvested earheads over earheads on the standing crop as the birds conveniently fed on more number of grains without hovering and birds could feed on the spot where the earheads were stacked.

At the study site, the foraging range of birds varied from 3 to 4 Km and feeding range, 1.5 to 2.0 km. Flock or group size varied from 20 to 45 birds (n=50). The feeding period on paddy by parakeets extended upto 24 days. In 95% situations, the flocks congregated at borders of the fields only. The importance of social foraging in parakeets lies in their relative foraging success and the multiple advantages, the group ac-

crue by feeding in patches.

Feeding and Foraging behaviour of Finch birds on Paddy

All observations on finch birds foraging behaviour were made from borders of the fields that provided clear views of the surrounding terrain. Flocks of finch birds were located in paddy fields, facilitating continuous observations of birds and enabling us to follow , with binoculars individual foraging finches. Most observations were made in 10 to 12 min. feeding sessions. The feeding rates of birds were quantified. Birds moving to and from perch sites or nest sites or engaged in nest collection material or any other non-foraging activities, were not considered for these analysis. Feeding rates were compared for separate 'foraging bouts' and averaged.

White backed Munia was the principal species depredating on paddy grains of the six species of finch birds recorded on paddy.

The Munias were sighted arriving at the feeding site at 6.42 a.m. in flocks. The birds were found feeding from 6.45 a.m. to 5.48 p.m. The foraging method most frequently used by Munias was to commute from the roosting sites to perching sites, i.e. trees (upto 0.5 km away) and then to feeding sites. While at perch, the birds preen, fly branch-to-branch, call, scratch and move from tree to tree towards paddy fields. The bird perched on paddy plant to feed on adjacent plant.

The birds' feeding range included 3 to 4 ha of paddy and foraging range 0.5 to 1.5km with flock size varying from 30 to 72 individuals with average 42(n=50). Feeding period extended upto 27 days.

The feeding rate was computed at 8 grains/min(n=55) and feeding bout lasted upto a maximum 12 min (n=100). Three to 15 min. elapsed between two feeding bouts. The birds preferred to feed on milky to maturing grains.

Yield-losses in paddy due to parakeets and finch birds

The yield-loss studies were carried out at Amaravathy Estate, Mudigere and the losses were categorised as Depredative and Extra-Depredative losses. Depredative losses included grains consumed by birds and extra depredative losses included those that were spilled by birds and not consumed. The losses were computed on earhead basis. The two kinds of losses were compared, before and after the harvests. Data concerning depredative, extra-depredative losses before and after harvests due to birds are given in Tables 27 and 28.

The depredative losses were significantly higher than extra depredative losses due to parakeets. There were non significant differences in these two parameters before and after harvest, although extra depredative losses were more than depredative losses. Even in White-backed munia, depredative losses exceed over extra-depredative losses. The White-backed munia significantly preferred more the green milky paddy grains than matured ones, when both the types of grains were available to the birds. However, at the absence of milky grains, birds fed on matured grains.

Differences in feeding and foraging behaviour between Yellow- throated sparrow and White-backed munia on paddy are given below:

	Yellow-throated sparrow	White-backed Munia
Feeding rate:	06 grains/min	06 grains/min
Feeding-group size:	Solitary/pair/3 to 4 birds	30-70 birds
Distribution while feeding:	Throughout the field; flock loosely knit	Fringe areas near hedge/bush/shrub
Feeding period:	Throughout the day	At specified periods
Roost:	Reeds/Grasses/broken hedge/marsh	Small,medium-sized trees/bushes
Preference of grains:	Equally prefers milky as well as mature grains	Prefers milky grains

The depredative and extra-depredative losses in paddy due to White-backed munia is given in Table 28. Both milky and matured grains are preferred for feeding and the extra-depredative loss varied from 4% to 6% at milky grain stage and from 9% to 15% at matured grain stage.

TABLE 27

Depredative and extra depredative losses in paddy duetoparakeets, 1990–91

Dates	Depredative loss (%)	Extra depredative loss (%)	Chatty grains (%)
03.12.90	69.69	8.86	21.50
08.12.90	72.87	10.82	7.94
12.12.90	59.43	15.15	24.45
15.12.90	77.09	6.60	14.19
18.12.90	64.89	18.48	16.64
21.12.90	77.60	8.06	4.50
22.12.90	72.22	13.08	5.52
29.12.90	77.09	32.83	14.97
Mean	71.36	14.23	13.71

CD @ 5% Treatment = 9.139; Dates = 3.112
T x D = 2.174

TABLE 28

Depredative and extradepredative losses in paddy due to whitebacked Munia, Mudigere

Plot No.	Number of paddy grains picked					
	Depredative loss				Extradepredative loss	
	1990-91		1991-92		1991-92	
	Milky	Matured	Milky	Matured	Milky	Matured
1	121	14	118	11	3	3
2	109	30	107	29	2	1
3	59	16	54	14	5	2
4	46	29	42	27	4	2
5	62	20	58	19	4	1
6	126	32	120	29	6	3
7	57	15	54	12	3	3
8	84	24	79	21	5	3
9	100	21	96	18	9	3
10	139	25	134	22	5	3
11	108	27	105	25	3	2
12	57	11	55	10	2	1
13	82	19	78	18	4	1
14	99	27	87	25	3	2
15	131	13	125	10	6	3
Mean	92.0	21.5	87.5	19.3	4.3	2.2
Binomial expansion Z		6.52		6.40		0.433

Jungle crow damage to paddy seedlings

Jungle Crow in transplanted paddy plots removed just-planted seedlings. The seedlings damage was recorded in different experimental plots (one seedling/hill, two seedlings/hill) at three locations viz., Anwar, Desouza and New plots in RRS, Mudigere. Number of seedlings damaged by Jungle crow was recorded in 5 m^2 area and expressed in per cent seedlings loss/m^2.

The maximum (9.37%) seedling loss due to Jungle crow was recorded in single seedling/hill transplanted plots than two and three seedlings/hill transplanted plots. The percent seedlings loss in two seedlings/hill transplanted plots was 3.59, where as in three seedlings/hill transplanted plots, it was 2.29 (Table 29).

Jungle crow *Corvus macrorhynchus* in transplanted plots remove just planted seedlings. As a playful behaviour of these birds, observations were recorded to see if it caused any economic impact. Seedlings were categorized into two groups: (a) less than 15 days old and (b) greater than 15 days old. There were significant differences in crow damage between less than 15 days old and greater than 15 days old seedlings. Less than 15 days old seedlings suffered significantly more losses than greater than 15 days old seedlings. This playful activity of crows may cause economic impact especially in small plots. From Table 30, it is clear that crows damage seedlings with no water. if there is 1-3 cm standing water, crows do not damage the seedlings as the birds are unable to alight and settle on sheet of water. It was found that in drill sown paddy (Table 31) the rat damage was significantly less compared to transplanted paddy. By mechanically catching and killing rats the percent damage to rice seedlings reduced from 10.49% to 1.09% (Table 32). Consolidated data on crow damage to paddy seedlings for two years is given in Table 32a.

Peacock damage on paddy

Peacocks and peahen were observed feeding on grains as well as trampling the paddy fields. The feeding rate was 5 earheads/min. Group size varied from 9 to 14 individuals (n=15). The birds also fed on harvested paddy grains. Birds also have been recorded feeding on seedlings of other crops like pulses in Malnad.

Rodent damage to paddy

Assessment of damage to paddy was carried out in 6 acres Anwar lands, Mudigere at the time of harvest during December last week 1991 to 1st week of January, 1992. The average number of burrows/200 m^2 was 2.58 and in 6 acres, there were 129 burrows. On an average, rats stored 22 g paddy grains/burrow, with minimum being 36.2 g and the maximum 79.4 g. In all, 2676 g of paddy grains were stored in 6 acres containing 129 burrows. More number (68%) of the burrows were concentrated at the borders of the entire field. At the beginning of the paddy growing (kharif) season, the nursery site received considerable damage from rodents. Distribution of burrows in paddy fields at RRS, Mudigere showed that more than 50% of the burrows were found at the nursery site. Poisoning such burrows would offer much protection to the seedlings (Table 33). At another site in Mutkeputa (Mudigere), 8% of the rat, *B.bengalensis* burrows were found at the centre and the rest at the borders of the field. Another assessment during December 1992 in Mudigere showed 3.62 to 5.60 g of paddy stored per burrow (Table 34).

Seedling loss due to rodent damage

To estimate loss of seedlings to rat, *B. bengalensis,* the number of rows per bed and per cent rows damaged in a bed were recorded. For analysis, partially damaged rows were averaged (two 50% damage row = one 100% damage row). Rice seedlings in ten, randomly selected rows with no rat damage were counted to set the average number of seedlings per row for a rice nursery. For each sowing date, a control, rat-free nursery was maintained by repeated application of Aluminium phosphide, a rodent burrow fumigant. Currently this compound is banned in India. Soil was sandy loam, seeds were hand-sown in rows, 0.1 m apart. Rats scooped out lumps of mud to feed on germinating rice seeds, damaging seedlings in the process. Rats caused significant losses to rice seedlings sown on 23rd January and 31 July (Table 35).

TABLE 29

Jungle crows damage in transplanted paddy seedlings plot, Mudigere, 1992-93

Dates	Seedlings (%) pulled/m^2 a	b	c
12.7.92	9.00	4.50	3.00
16.7.92	9.50	5.65	1.75
18.7.92	11.0	3.50	2.00
20.7.92	13.50	4.60	3.50
23.7.92	4.50	3.00	4.00
24.7.92	4.00	2.75	1.00
25.7.92	5.50	3.00	1.25
27.7.92	6.00	4.25	1.75
31.7.92	12.50	1.50	1.00
06.8.92	13.50	1.75	1.78
11.8.92	10.55	3.25	2.25
Mean	9.37	3.59	3.29

Binomial expansion Z

One vs two seedlings	=	1.327
One vs three seedlings	=	1.780
Two vs three seedlings	=	NS

a = @ One seedlings/hill;
b = Two seedlings/hill;
c = Three seedlings/hill

TABLE 30

Paddy seedlings picked by Jungle crows in relation to water level, 1991-92

Paddy field	Seedlings (%) uprooted		
	With no water	3 cm standing water	Greater than 3 cm water
1	100.0	30.5	0.0
2	98.0	24.6	0.0
3	99.5	22.4	0.0
4	98.9	20.9	0.0
5	96.8	25.0	0.0
6	100.0	28.0	0.0
Mean	98.8	25.2	0.0
CD @ 5%	2.624		

TABLE 31

Jungle crow damage to paddy seedlings under transplanted and drill-sown conditions

Quadrates (10 m^2)	Seedlings (%) damage	
	Transplanted paddy	Drill sown paddy
1	10.2	5.9
2	15.0	1.1
3	5.2	5.1
4	10.0	20.7
5	20.0	25.6
6	20.5	12.5
7	5.0	2.9
8	10.1	0.6
9	5.2	0.0
10	30.0	0.0
11	50.0	0.0
12	20.0	0.0
13	5.1	0.0
14	10.1	0.0
15	5.1	0.0
Mean	14.8	4.96
Binomial expansion Z value	1.9909	

TABLE 32

Rodent damage to paddy before and after mechanically killing the animals, 1991-92

Plot No.	Seedlings (%) damaged	
	Before killing	After killing
1	15.00	2.00
2	3.00	0.25
3	14.66	1.13
4	9.30	1.00
Mean	10.49	1.09
Binomial expansion Z value		2.469

TABLE 32a

Damage to transplanted paddy seedlings by Jungle crows, Mudigere

Spot No.	Paddy seedlings (%) pulled			
	Before 15 days of transplantation		After 15 days of transplantation	
	1990–91	1991–92	1990–91	1991–92
1	10	12	1	2
2	51	15	1	5
3	16	51	0	3
4	13	49	0	2
5	20	54	0	1
6	38	12	0	4
7	22	16	0	5
8	0	27	0	4
9	13	12	0	2
10	0	14	0	1
Mean	18.3	26.2	0.2	2.8
Binomial expansion Z		1.03		0.92

Before vs after 15 days transplantation (1990–91)	3.97
Before vs after 15 days transplantation (1991–92)	4.22

TABLE 33

Distribution of *B.bengalensis* burrows fn paddy fields, 1991–92

Location	Dates	Number of burrows/ac	
		Standing crop	Fallow (border area)
RRS	2.7.91	10.00	8.33
	11.7.91	7.70	6.94
	2.8.91	7.01	6.67
Hale Mudigere	2.7.91	2.34	5.31
	12.7.91	4.68	4.81
	2.8.91	4.72	4.2
Mutkepura	3.7.91	29.00	31.00
	14.7.91	32.00	16.00
Mean		12.18	10.41
Binomial expansion test Z			NS

TABLE 34

Hoarding of paddy grains by *B.bengalensis,* Mudigere, 1992-93

Dates	Paddy grains hoarded (g/burrow)		
	Anwar plot	Desouza plot	New plot
10.12.92	220	220	230
15.12.92	190	200	210
20.12.92	170	180	200
25.12.92	140	160	180
30.12.92	180	210	220
05.01.93	170	120	270
10.01.93	250	320	290
15.01.93	300	250	230
20.01.93	150	230	250
25.01.93	190	230	290
30.01.93	180	220	200
Mean	195.4	212.7	233.6
Binomial expansion test (Z)			

Z value	Anwar vs Desouza	=	0.8060
	Anwar vs New plot	=	1.7900
	Desouza vs New plot	=	0.9422

TABLE 35

Paddy seedlings loss due to *B. bengalensis*, Mudigere, 1992–93

Dates	Seedlings damaged (m2/bed)		
	Anwar plot	Desouza plot	New plot
12.7.92	5.0	8.0	2.0
16.7.92	5.0	7.0	3.0
18.7.92	5.0	8.5	1.5
20.7.92	4.2	9.3	3.3
22.7.92	1.4	3.3	1.0
23.7.92	1.3	2.5	1.5
24.7.92	1.8	4.3	1.0
25.7.92	3.7	8.3	1.3
27.7.92	5.2	12.0	3.4
31.7.92	1.5	3.0	1.5
Total	34.1	66.2	19.3
Mean ($850\ m^2$)	3.4 (4%)*	6.62 (8%)*	1.95 (2.3%)*

* Paddy seedling (%) loss

Binomial; expansion test (Z)

1	Anwar plot vs Desouza plot	=	0.699
2	Anwar plot vs New plot	=	NS
3	Desouza plot vs New plot	=	1.25

Under Malnad (hill region) conditions, rats and rabbits are the first to attack the rice seedlings. Birds such as crows in the transplanted paddy plot and finch birds like Baya weavers, Buntings, Munias and Sparrows feed on paddy at the earhead stage. Peacock and Peahen were observed feeding on matured grains from 7.20 to 8.40 a.m. A flock of birds (3 female and 6 male) trampled the clumps by their legs while foraging. The birds lodged the plant slightly by one leg, the plant by another and then fed on grains. The birds also frequented the fields during 4.45 p.m. when paddy is stacked. The birds pulled the entire clumps by beak, drag the earheads or pull out and feed on grains. Rose- ringed parakeet too cause considerable extra-depredative losses in paddy. Observations in Mudigere have shown that extra- depredative loss may extend upto 68-70% of the losses caused by feeding. Additional data on earhead loss due to *B. bengalensis* is given in Table 36.

Four hundred and sixteen rice varieties were sown in nursery beds (5 M x 1 M) on 16.6.89 at 20 cm x 10 cm on 25.7.89 in the main field. There were two replications. Number of clumps damaged by rats was counted on 20.1.89 in 1.5 M x 0.6 M plots(=45 clumps) per replication. *B.bengalensis* and *M.booduga* were the species found damaging rice. Rat damaged 36 of the 416 varieties and rat damage was noticed two weeks after transplanting in the main field. There were significant differences in percent hills damaged by rats in 416 varieties. IET 11207 and IET 11223 (40%) were significantly more damaged than the rest (Table 37).

Paddy seedlings loss due to *B.bengalensis*

Amount of paddy seedlings loss due to rat, *B.bengalensis was* worked out in nursery beds (850 m^2) at RRS, Mudigere. The observation on paddy seedlings loss due to rats was recorded from 12.07.1992 to 31.07.1992 and data was expressed in m^2 loss/bed.

Rats scooped out lumps of mud to feed on germinating rice seeds damaging seedlings in the process. Rats caused significant losses to rice seedlings sown during July 1992. The area damaged due to rats was 34.1 m^2/bed, 66.2 m^2/bed in Anwar, Desouza and New Plot, respectively.

Paddy earheads loss due to *B.bengalensis*

The amount of paddy straw and earhead damaged due to B.bengalensis was recorded in paddy fields of Anwar (6 ac) and new plots 910 ac) during crop period from 25.11.1992 to 10.01.1992 at RRS, Mudigere. The amount of area damaged due to rats expressed in m^2/ac.

Loss of paddy earheads by *B.bengalensis* was expressed in terms of square metres area lost. The 'area lost' varied from 1.7 to 18.3 m^2. Area in terms of percentage was 1.3 in Anwar, 1.5 in Desouza and 0.95 in New area plot in one acre of paddy fields.

Amount of paddy grains hoarded by *B.bengalensis*

The amount of paddy grains hoarded in burrows by *B.bengalensis was* recorded in three different paddy fields of Anwar (6ac), Desouza (6 ac) and New plots (10 ac) during crop maturity (25.11.1992 to 10.01.1993). The rat burrows in the above area was identified during crop maturity stage and the burrows were deeply dug and the amount of paddy grains hoarded by rats was collected and expressed in g/burrow.

Rodents, in addition to damaging paddy seedlings in field, hoarded paddy grains in burrows. Observations were recorded on hoarding of paddy grains in burrows in three locations in Mudigere. The amount of paddy grains hoarded/burrow varied from 120 to 320 g/burrow. On an average, in 11 burrows the amount of paddy grains hoarded was 195.4 g/burrow in Anwar, 212.7 g/burrow in Desouza and 233.6 g/burrow in New area plots. The distance of the burrow from the point from where grains were picked-up influenced the amount of paddy grains hoarded.

Therefore, the total loss due to *B.bengalensis* in three different stages amounted to 46 kg/ac, which is economically important. Therefore, the protection measures against *B.bengalensis* are warranted.

TABLE 36

Loss of paddy earheads by *B. bengalensis*, Mudigere, 1992-93

Dates	Earheads damaged (m^2/ac)		
	Anwar plot	Desouza plot	New plot
25.11.92	3.0	3.2	1.7
30.11.92	12.0	12.3	7.0
05.12.92	3.3	3.2	2.1
10.12.92	2.7	2.0	2.1
15.12.92	6.7	5.8	4.5
20.12.92	8.0	4.7	6.8
25.12.92	2.5	2.8	1.3
30.12.92	2.0	3.0	0.6
05.01.93	5.0	4.2	3.5
10.01.93	16.0	18.3	8.2
Total	61.2	59.5	37.8
Mean ($4000\ m^2$)	6.12 (1.53%)*	5.95 (1.5%)*	3.78 (0.94%)*

Paddy earhead (%) loss

Anwar plot vs Desouza plot = NS
Anwar plot vs New plot = NS
Desouza plot vs New plot = NS

TABLE 37

Rat damage in fifteen paddy varieties, Mudigere, 1991-92

Variety	Tillers (%) damage*
IET 10854	44.50
IET 11223	40.00
IET 11207	40.00
IET 10615	30.00
IET 9614	24.40
IET 10131	21.20
IET 10618	11.10
IET 10133	10.00
ES 18	5.50
MD 5	2.20
IET 10629	1.10
IET 7261	1.10
IET 11202	1.10
IR 46	1.10
IET 10121	1.10
Mean	15.63
CD % 5%	11.57

* $\bar{X}$ of 50 clumps/variety

Wildboar damage on paddy

During 1989-90 damage assessments to paddy by wildboar were made. The damage was categorised into three types: trampling, lodging and browsing. The farmer incurred heavy losses due to lodging effect. During December,1991 in Anwar lands, Mudigere observations on damage assessments were carried out. Intan was grown in 6 acres. The crop was planted during September and harvested during last week of December. The per cent area containing lodged clumps was measured and expressed as per cent of the total plot area. The losses due to lodging was measured in four plots at milky stage.

Herds of wildboar foraged in paddy fields from 8.00 p.m. to about 2.00 p.m., generally in Mudigere. The wildboars caused lodging in about 4465 m^2 paddy area i.e. 13.5% of earheads lost was estimated to about 10,800. The average number of grains/earhead ranged from 300 to 400. The total loss of the paddy in terms of kg worked out to be 330 kg. In terms of rupees it worked out to be Rs.1450/-. A herd consisting of a female and 3 young ones could cause a loss of Rs.1450/- in 16 days from 14.1'0.91 to 30.12.91. The damage due to lodging, trampling and feeding by wildboar is presented in Table 38.

Wildboar while foraging in paddy fields trampled the plants and caused loss of earheads. The clumps affected have been expressed as number of clumps trampled/m^2. A group of 4 wildboar in 18 days caused a loss of 20 clumps/m^2. The total number of clumps lost was 12,942, weighing about 52 kg of paddy grains. This much loss amounted to about Rs.240/-, which is negligible. However, among dates, there was a significant difference in number of clumps damage.

The loss caused by wildboar by feeding on grains was expressed in terms of number of earheads fed by wildboar. The feeding activity could be identified by the left over half-grains on the earheads. This number was expressed as per cent of the total number of earheads present in that plot. During the period of observation of two weeks, wildboars (3 to 4 No.) caused 12.31 to 36.98 per cent losses. When this percentage was worked on weight basis, damage by feeding accounted for nearly 21 % loss of the total field, i.e. about 36 kgs and about Rs.180/-.

Thus, wildboar in 6 acres Anwar lands caused a loss of about 418 kgs costing Rs.1860. The amount of damage varies considerably from one place to another and so requires crop protection measures. Habitat management practices like proper drainage conditions, watch-and-ward and use of Thimet 10%G as repellent may reduce wildboar damage in paddy.

Wildboar encroachment into the fields can be identified by hoof- marks found on bunds. The extra-depredative loss due to trampling and lodging exceeds losses due to direct feeding. Observations through three years have revealed that the animals prefer matured panicles over milky grains. Usually the corner and border plots received the maximum damage. For instance, on 6.12.90 at Anwar lands, 5 animals trampled 1200 paddy clumps; 2000 clumps on 7.12.90 and 400 earheads on 8.12.90.

Wildboar, *Sus scrofa L.* is the most abundant and common wild Quadrpet found in Malnad. Wildboar damage on paddy, sorghum, maize, potato, sugarcane, cardamom, pineapple and groundnut has been observed in Malnad. Wildboar damage at times results in entire crop failures.

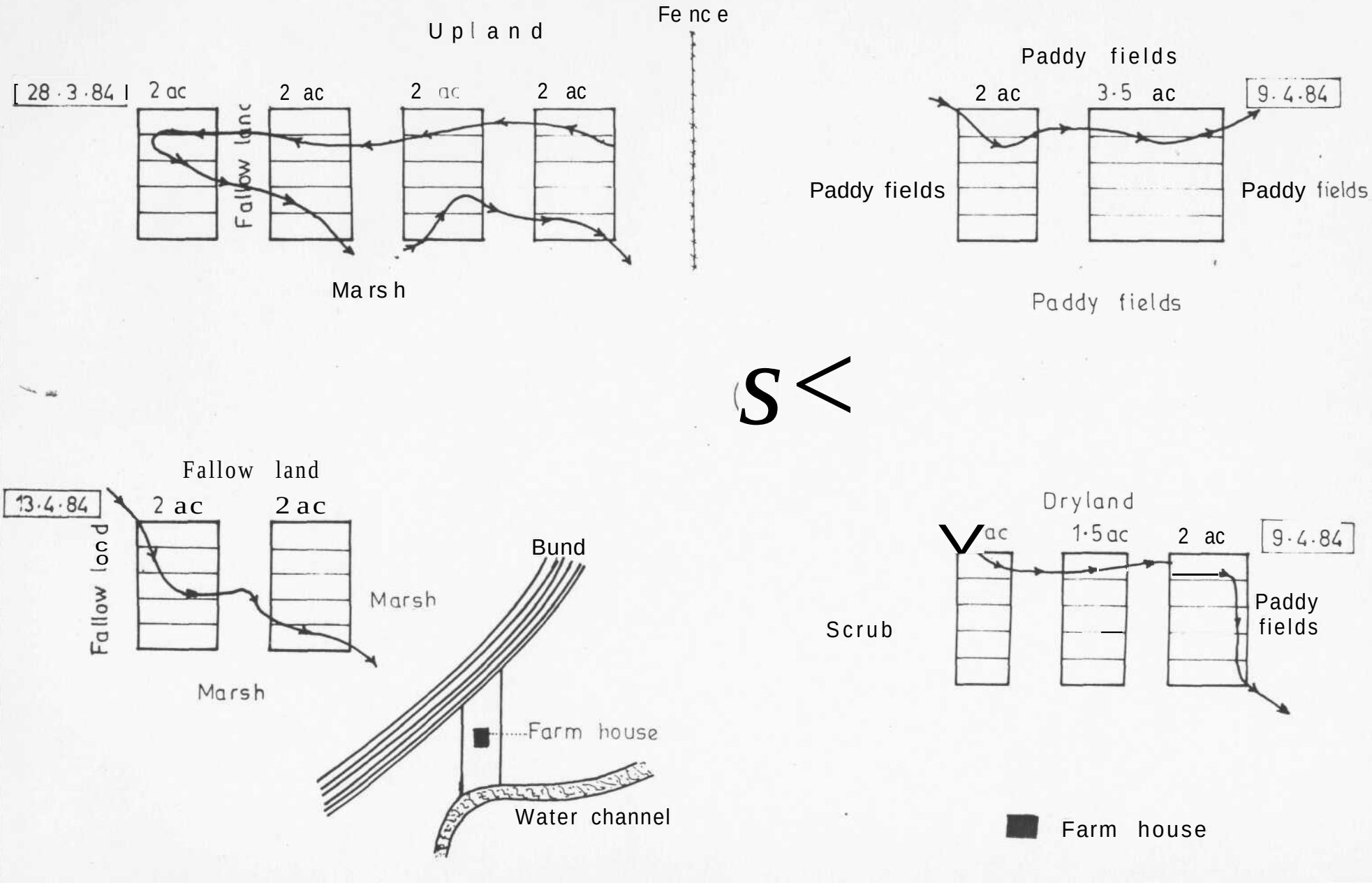
Wildboar wreak havoc in potato and groundnut crops as the tubers or seed pods are developing. Normally the animals lie up during the daylight hours in thick cover, such as is afforded by natural swamps or paddy fields. Ar night animals were found foraging in small parties in search of food. Litters can be born throughout the year, but in Malnad boars have been found producing young ones during monsoon (June-September) period.

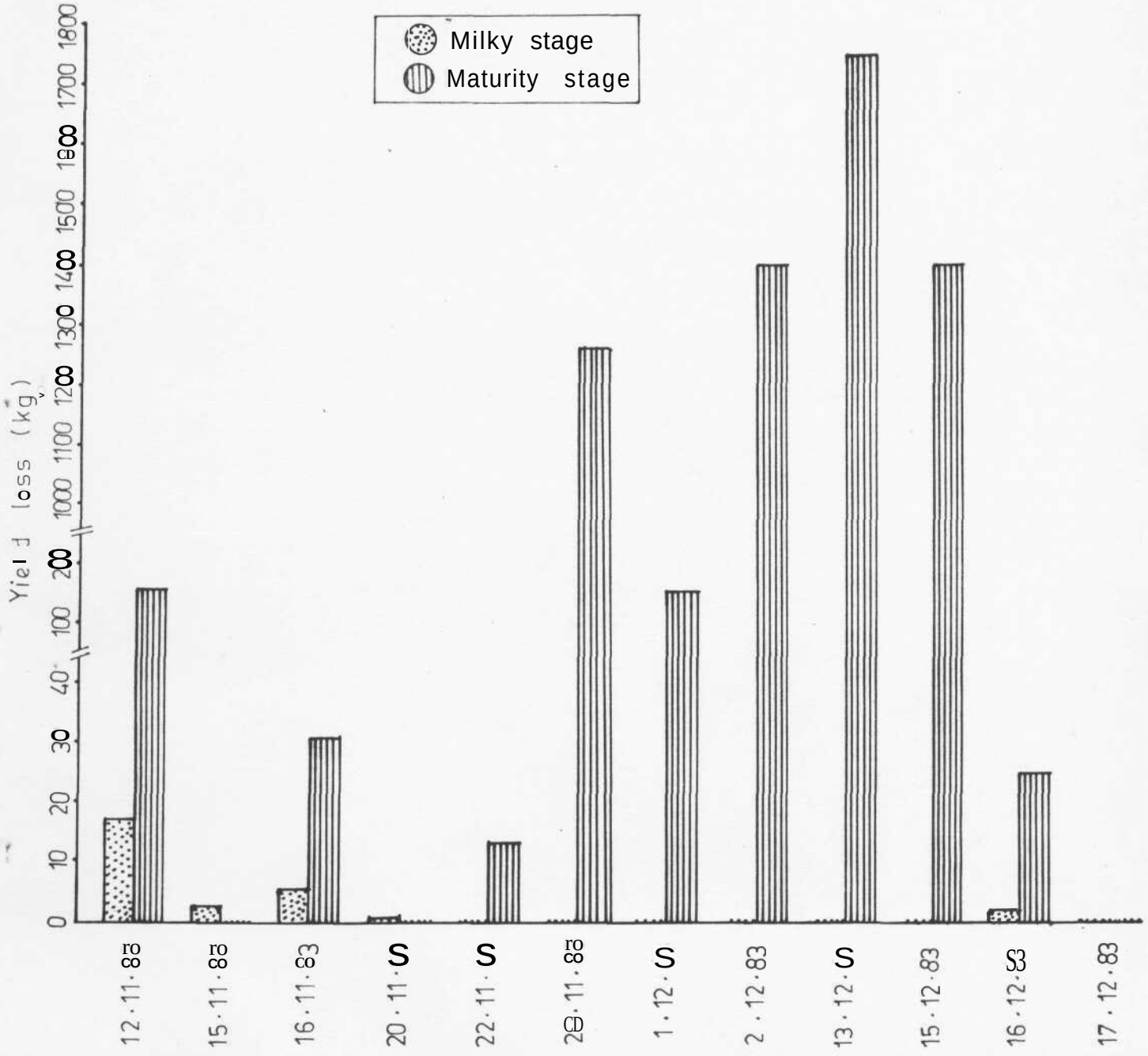
During 1989-90, paddy growing tracts visited by wildboars were surveyed in Mudigere. Yield-loss due to wildboar damage at harvest was estimated by measuring the area trampled. The yield- loss was expressed as per cent area over the total area damaged by the wildboar.

In another study the yield-loss was estimated at milky and grain- maturation stages of the crop for timing protection measures.

Yield-loss estimation studies revealed that of the total 27 ha in Mudigere considered, the loss amounted to 24% i.e. 6.25 ha.

MAPPING OF DAMAGE PORTIONS IN PADDY FIELDS BY WILDBOAR ON A DAY IN MUDIGERE DURING MARCH AND APRIL 1984



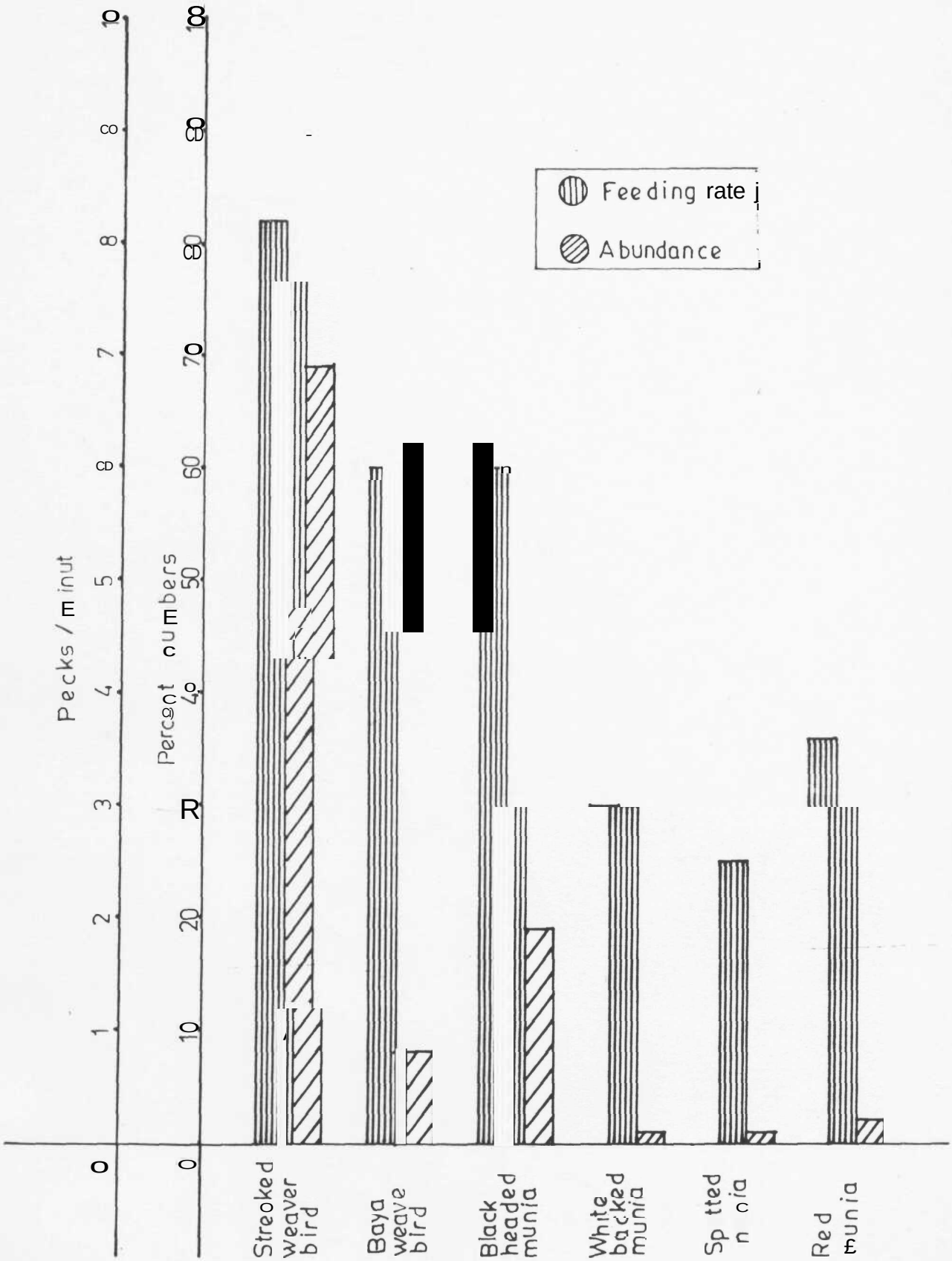


YIELD LOSS AT MILKY AND MATURITY STAGES OF PADDY DUE TO WILDBOAR DAMAG
ON DIFFERENT DATES IN MUDIGERE

TABLE 38

Wild boar and Monkey damages on paddy, Mudigere, 1991-92

Dates	Tillers damaged/m^2			
	Wild boar			Monkey
	Lodging	Trampling	Feeding	
14.12.91	7.25	5.95	11.11	24.83
16.12.91	13.98	8.00	12.29	22.70
17.12.91	7.31	8.15	24.70	25.69
19.12.91	19.73	26.66	23.38	18.51
21.12.91	28.47	25.00	22.61	16.26
23.12.91	25.55	23.00	17.80	21.00
26.12.91	10.88	40.00	29.21	19.04
28.12.91	21.08	22.00	23.73	19.32
30.12.91	33.14	21.00	24.04	21.08
Total	167.39	179.76	188.87	188.43
Mean	18.59	19.97	20.98	20.93
CD @ 1% Types of damage	=	8.73%;	Dates = NS	3.18
Types of damage x Dates	=	1.09		



FEEDING RATE AND ABUNDANCE OF BIRDS FEEDING ON RICE IN MANDYA IN1986

Wildboar was found damaging paddy when the plants were stacked one over another in bundles. On an average, for consecutive five days, wildboar caused a loss at 160 kgs/day.

In 15 acres area of paddy under Intan, the damage due to wildboar at milky and grain maturation stages was monitored. During milky stage, wildboars damaged 7,729 kgs and during maturation stage 1,601 kgs. 't test' revealed significant differences in damage (cal 't' value = 14.54' Table 't' value = 3.182) yield-loss at milky and grain maturation stages. Since the wildboar damage commences during milky stage, it is advisable to protect paddy from wildboar during milky stage.

The wildboar was observed feeding on *Diascorea allata tubers.* This plant is widely distributed in Malnad. To exploit this preference, a field trial was conducted. Clumps and tubers of *D.allata* were placed at 40 spots found in the wild, in and around paddy growing tracts. Such a trial was also conducted during 1988. However, the animal was not attracted to the *D.allata* tubers, both the years.

Monkey damage on paddy

Observations on monkey damage to paddy was carried out from 14.12.91 to 2.1.92 in 6 acres Anwar lands, near RRS, Mudigere. Intan was planted during September and harvested in the last week of December, 1991. The mode of feeding and loss assessment were recorded. Three troupes of monkey each containing, on an average, 38 animals were found feeding on paddy during different hours of the day (n-12). Monkeys were observed approaching paddy fields from thick vegetation cover and settling on bunds first. Then, they begin damaging paddy, one-by-one. A group of monkeys were seen perched on bunds to hold, pull and feed on grains. The animals gobble-up the grains, store in the cavity and then feed on the grains. Monkeys caused two types of losses; depredative loss and non-depredative loss. The depredative loss (direct consumption) far exceeded the non-depredative loss. The depredative loss ranged between 20 to 22% (X = 21.83%). The non- depredative loss varied between 10 to 12% (X = 11.5%). The peak feeding activity occurred during 6.30 to 7.30 a.m. and 3.30 to 4.30 p.m.

During the day, the animals fed for 2 to 3 hr. Two troupes of monkey (n = 175) destroyed 20 x 12 m^2 paddy area/day. In 6 acres of paddy, the total loss amounted to about 200 kgs of paddy, amounting to Rs.900 to 1000/-.

Extent of losses caused by monkeys to paddy

Observations with 8 X 30 binoculars were made from about 100 m. So that animals could be continuously sighted without disturbance.

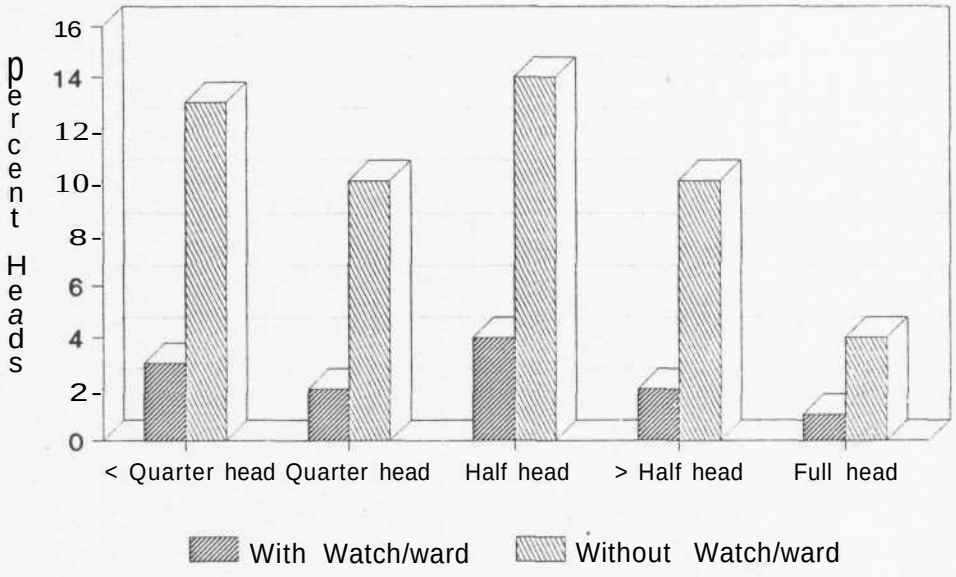
Monkeys were found feeding on paddy from milky stage, but at crop maturity, the feeding activity became intense. On standing crop, the animals held paddy earheads on one hand, the plant on another and devoured grains. The grains are stored in the mouth cavity first and then swallowed/gulped down. The animals were also sighted carrying stacked earheads to trees for feeding on grains. On several occasions grains were devoured at the spot where earheads were stacked. Paddy fields having a stretch of vegetation around them contained significantly more damage (58.54%) than those without any patch **(5.92%; t-test at 5%).**

Birds damage on sunflower

Roseringed Parakeet was found depredating on sunflower in plains of Malnad. The feeding activity on sunflower began at 8.00 a.m. and extended upto 6 p.m. An acre plot at Sakrayapatna was divided into edge and middle portions. Hundred heads were randomly selected in each region and extent of damage was worked out. 14% heads were damaged at edges compared to 9% at middle portion. The damage period extended upto 7 weeks.

Other bird species involved was Western Turtle Dove, Streptopelia sp. locally called as "Belavnahakki:. This species is not originally adapted for feeding on sunflower. According to farmers this bird was first sighted depredating sunflower in 1989 at Sakrayapatna. Its beak is not too strong to directly feed on seeds from head as in Parakeets. So the bird was observed perching on head and removing rind first, pecking at the seed and picking it in beak, splitting the seed coat and feeding on internal contents. The bird was observed feeding on the crop from 6.15 a.m. to 10 30

Sunflower Head damage by Birds in Sakreyapatna



a.m., 11 a.m. to 12 noon and from 12.20 p.m. to 3.00 p.m. The feeding rate was timed at 8-10 seeds/2 min(n=60) compared to 6-7 seeds/min (n=40) in the parakeet. Doves feed singly. 12-18 birds/acre were found at Sakrayapatna.

Protection methods against bird damage

, Two plots, of 1/4 acre each were chosen to evaluate the impact of watch-and-ward on bird damage in Beekanahalli, Chickamagalur. Two labourers were deployed per hectare of Sunflower to scare away birds for 7 weeks. The birds were scared away either by shooting, producing sound with metal box or by pelting stone using the same in leather strap, commonly called as 'Kavane'. Observation on head damage was recorded weekly for consecutive 7 weeks on 50 randomly selected heads in each plot. There was significantly less damage (10.60%) compared to control (18.86%), (Calculated t at 5% = 2.29; table t=2.09).

Birds and wildboar damage to sunflower

Wildboar/birds damage to sunflower at Bukkasagara of Kadur taluk were recorded from 13.07.1992 to 01.09.1992. 25, 50 and 100 per cent damaged Sunflower heads were counted in watch/ward sunflower grown fields. The seed depredation is expressed in terms of percentage damage to sunflower heads.

The depredation to sunflower by wildboar and birds is presented in Tables 39 and 40. The data revealed that, on an average, birds depredated 100% heads/ac compared to 1019 heads/ac (17%) by wildboar in without watch/ward area. In watch/ward field, the loss could be reduced to 732 heads/ac from birds and to 450 heads/ac from wildboar i.e. watch/ward could save more heads from wildboar than from birds.

The pattern of depredation by birds differed from that of wildboar. As birds caused more damage to 25, 50 percent heads than fully damaged heads and in case of wildboar, the vice versa. This is obviously because of different mode (extraction of seeds from head and mode of feeding) of feeding behaviour. Wildboar also trampled and lodged the heads while foraging and feeding. Thus, accounting for more number of fully damaged heads. Different species of birds glean seeds from heads in different ways. Parakeets perched on thalamus or stalk and fed on seeds. Finch birds like sparrows and buntings perched on the head and pecked on seeds one-by-one. Doves like spotted dove and Western turtle dove perched on the outer rind or stalk to remove portion of head bit-by-bit and then feed on seeds one-by-one. The parakeets and the doves essentially began feeding from the rim of the head. The finches selected more matured seeds from any portion of the head. The finches selected more matured seeds from any portion of the head. These differences among the species, over space and time may allow species to more efficiently exploit food resources.

Birds damage to sorghum

Management of sorghum earheads loss due to various birds was carried out at Sakrayapatna area of Chickmagalur from 13.07.1992 to 30.07.1992. Sorghum earheads were covered with dried sorghum leaves. Each treatment was maintained in three replications. The sorghum earheads damage due to birds were recorded and expressed in terms of number of earheads damage per acre.

Parakeets, jungle crow, house sparrow, spotted munia, blackheaded munia, baya weaver were some of the important bird species observed feeding on sorghum grains at Sakrayapatna. To reduce the damage to sorghum earheads by birds, the practice of covering the earheads with flag leaf and other leaflets was evaluated. The number of earheads damaged could be reduced to 212 from 589 in uncovered plots (Table 41). 35.97 per cent earheads could be saved just by covering sorghum earheads with leaves. These observations need to be repeated to get reliable estimate of the earheads that could be saved. It was observed that birds preferred tall and early maturing plants over dwarf and late maturing plants. So such preferred plants, to begin with, may be covered with flag leaf.

TABLE 39

Wildboar damage to Sunflower at Bukkasagar, Kadur, 1992-93

Dates	Sunflower heads (Nos.) damage/ac % heads damage					
	25		50		100	
	a	b	a	b	a	b
13.7.92	22.2	18.5	35.3	15.3	40.4	17.5
18.7.92	23.3	15.2	25.5	13.2	38.8	13.0
28.7.92	30.3	19.6	35.5	15.9	45.3	15.3
12.8.92	26.4	19.5	36.8	19.9	37.3	16.4
13.8.92	30.5	15.1	50.3	25.5	58.8	17.6
14.8.92	40.3	25.3	45.3	15.5	65.3	15.3
24.8.92	15.8	18.8	32.3	13.5	39.3	15.0
25.8.92	22.5	19.3	32.8	10.5	45.8	12.5
26.8.92	15.3	10.8	30.3	3.5	38.3	5.3
01.9.92	19.5	15.3	13.8	5.5	25.8	6.3
Total	246.1	177.4	337.9	138.3	435.1	134.2
% Reduction by watch and ward	27.92		59.07		69.16	
Mean	24.61	17.74	33.79	13.83	43.51	13.42
Binomial expansion (Z)		0.9030		2.74	3.85	

a = Without watch and ward (Total heads loss = 1019/ac)
b = With watch and ward (Total heads loss = 449.9/ac)

TABLE 40

Birds damage to Sunflower at Bukkasagar, Kadur, 1992–93

Dates	Sunflower heads (Nos.) damaged/ac % heads damaged					
	25		50		100	
	a	b	a	b	a	b
13.7.92	35.8	32.4	25.4	15.3	15.2	10.2
18.7.92	36.3	35.0	23.3	18.4	18.2	11.2
28.7.92	37.5	15.8	22.8	22.5	22.5	15.9
12.8.92	38.8	22.5	18.8	19.3	18.5	10.5
13.8.92	39.8	25.2	35.3	19.8	25.5	8.5
14.8.92	42.3	42.8	42.8	35.3	32.6	19.5
24.8.92	45.8	33.3	45.3	23.8	33.5	25.0
25.8.92	45.3	32.8	48.8	24.4	32.8	15.8
26.8.92	49.8	40.3	40.3	36.3	25.5	20.5
03.9.92	45.3	45.8	38.8	38.0	20.8	15.8
Total	416.7	325.9	341.6	253.1	245.1	152.9
% loss reduction by watch & ward	21.79		25.91		37.62	
Mean	41.67	32.59	34.16	25.31	24.51	15.29
Binomial expansion (Z)	0.938		1.018		1.30	

a = Without watch and ward (Total heads loss = 1 003.8/ac)
b = With watch and ward (Total heads loss = 731 .9/ac)

Wildboar damage to potato

Wildboar damage to potalo at three different locations of Beekanahalli, Chickmagalur district was determined during July- Augusl 1992. Three locations chosen were - Borders (hilly region), centre (1/2 km away from hilly region) and interior (1 km away from hilly region). Potato damage in field due to wildboar was recorded in an acre during 90-120 days of crop , stage and yield loss was expressed in terms of kg/ac.

Wildboar is an animal that prefers to feed on underground plant parts. So potato is preferred as food of the animal. The animal upturned soil to feed on the potato tubers. Wildboar is a nocturnal animal and in Beekanahalli, Chickmagalur, it was observed that the loss due to wildboar depended on the location of the potato field from their roosting and resting sites. For convenience the potato field in Beekanahalli was categorized as that present in Border, Centre and Interiors from the roosting place. The border fields suffered the maximum of 466 kg/ac compared to 264 and 125kg/ac at the Centre and Interiorfields, respectively (Table 42). This is obviously because the feeding efficiency will be the highest in the fields at the borders.

Vegetable Cowpeas

During February-March 1989, observations with a pair of 8 x 30 binoculars were made on birds depredating cowpeas *(Vigna unquiculata)* and crop-yield losses were measured in Ujjre (12°52'N, 74°53' E). Acowpea pod was considered unfit for harvest if it lose market value due to feeding activities of birds. In 1989, the farmer grew local cowpea without any support in 0.1 ac. This has been referred to as Bush cowpeas(B.C). During 1990, he trailed cowpeas on a frame (Pendal) (2m high with 1.5m at the base) made of local wooden straps and coconut fibres. This system of cultivating cowpeas has been referred to as pendal cowpeas (P.C). Three species of birds, viz. Redvented bulbul, Roseringed parakeet and small green barbet depredated on cowpeas, of both the types. The depredators caused more damage and loss on B.C. compared to P.C.;23.70 and 25.80, respectively on B.C. and 17 and 16, respectively on P.C. There were significant differences in pod damage and loss between the two systems. The preference of pods for bush-cowpeas may be related to the relative abundance and distribution of pods on the plant. Pods were more clumped on bush, than on pendal cowpeas. The three avian depredators preferred B.C. because the plants offered a better vantage point from which to detect predators than the P.C. In sum, the B.C. allowed a more efficient foraging and harvest of pods than P.C. Pendal system of growing cowpeas conferred ecological and additional economic benefits to the grower in Ujjre.

Cucumber

In 1989, a cucumber plot (0.4 ac) grown in Belthangady (12°59';183m AMSL) was frequented to record bird depredators. 'Local' cucumber was grown in 1.8 m x 1.0 m on wooden support at 2 m height. Observations were recorded during September to November, 1989 on birds with 8 x 30 binoculars. Crop losses were measured. In August 1990, the same grower cultivated a mixture of cucumber, bottle gourd and pumpkin on raised basins(2 m dia) at 5 m x 2 m with red, sandy loam soils. Local cultivars were used.

Small Green Barbet (SGB) damaged 29.2% fruits of cucumber in sole crop compared to 9.7% in mixed crop. T-test revealed significanl differences in the damage between the two systems. In Basin system, SGB damage on cucumber was significantly less because the bird was observed expending considerable time in searching and locating cucumber from among cucumber, bottle gourd and pumpkin fruits, partly or fully covered by foliage. The birds being arboreal, are less used for perching on ground and feeding .

TABLE 41

Bird damage to Sorghum (CSH 6), Sakrepatna, 1992

Dates	Earheads (Nos.) damaged/ac		Percent loss reduced by c overing
	Earheads uncovered	Earheads enclosed with flag leaf	
13.7.92	43.92	30.44	30.69
18.7.92	41.64	18.44	55.91
25.7.92	68.12	19.32	71.63
08.8.92	66.24	16.64	74.87
14.8.92	59.64	20.32	79.60
24.8.92	59.12	20.64	65.08
30.8.92	46.32	20.00	56.82
08.9.92	48.32	15.64	68.03
16.9.92	35.24	19.32	45.18
23.9.92	42.72	14.00	67.22
30.9.92	36.72	17.00	53.70
Total	588.60	211.76	
Mean	53.51	19.25	35.97
Binomial expansion (Z)	3.90		

TABLE 42

Wildboar damage to potato in thee different locations at Beekanahalli, Chickmagalur, 1992

Dates	Yield loss (kg/ac) Borders*	Center**	Interior***
28.7.92	45.50	32.25	10.25
22.7.92	50.25	30.50	12.50
30.7.92	60.25	40.25	15.50
12.8.92	62.50	45.50	20.50
13.8.92	75.50	29.85	25.25
21.8.92	90.25	30.25	15.25
25.8.92	45.50	25.00	10.00
26.8.92	35.75	30.00	15.75
Total	465.50	263.60	125.00
Mean	33.18	32.95	15.63

CD @ 1% Locations = 13.57; Dates = 5.00; Lx D = 2.60

* Adjacent to roosting site

** 1/2 km away from roosting site

*** 1 km away from roosting site

Sugarcane

Sugarcane is damaged by a number of different kinds of vertebrate pests. Rodents cause damage at all the stages of the crop. Observations in Sakrayapatna revealed rodents consuming the growing tissues like buds on seed cane, young shoots and growing point. Rodents also damage roots and underground portion by burrowing and thirdly by direct consumption of internode tissues. Rodent damage can be identified by drying of crown and leaves, lodging of clumps and heaps of soil around clumps. Losses during seedling stage are minimum. Against rodents, inadequate uptake of bait is the major problem in sugarcane as also in cardamom. Cereal and vegetable baits have proved best in sugarcane. A regular rotation of baits may prove more effective in Sugarcane.

Apart from rodents, Wildboar, jackal, wildgoat, rabbits and mongoose also cause considerable damage to sugarcane in Malnad. Maintaining strong bunds, covering the base of clumps with dried shoot peels, dried thorny sticks, coconut mat, electric fencing, watch-n-ward, etc. are the methods currently being used against VPs.

Control measures followed by sugarcane growers in Sakrayapatna include watch and ward. This practice starts when canes are 7 to 8 months old. Intensity of watch-and-ward increases with the crop maturity. Duration of watch and ward varied between 4 to 6 months. The wildboars and Jackals are also hunted and shot at. Against rodents, crop-protection practices include coconutpowder + Zincphosphide or Bengalgram powder + poison of Banana fruit + poison. Rabbit damage on sugarcane was observed at sprouting and tillering stages, when the crop is 13 months old. Sugarcane is taken up after cotton or paddy or sugarcane ratoon is followed.

Observations on VPs of sugarcane were continued during 1992 at Sakrayapatna between February and May, 1992. The trampling loss to sugarcane by wildboar exceeded the loss from direct feeding. Seven to nine months old canes were preferred for damage. The animals crushed the canes at 1.0 to 1.2 m height. While feeding, the animals uproot the canes also. Minimum loss by wildboar group in a day was estimated at 0.30 tons/acre and average loss was 0.22 tons/acre. Of the 9 observations, the loss was 1.98 tons/acre amounting to about Rs.800/-. The Jackals in groups 3 to 5 crushed and split the stem portion upto 5 m height. Normally, the Jackals preferred 11 months old canes. Out of nine observations, the jackals caused a minimum of 0.1 tons/acre and maximum of 0.15 tons/acre. Total loss in 9 days amounted to 1.35 tons/acre amounting to Rs.600/-. By creating live-barrier, or buffer zone or by providing alternative foods, losses due to these VPs can be minimized. Growers adopted watch and ward and fencing around the field as protection measures. In conclusion, it can be said that VPs in sugarcane do cause economic losses to the growers.

A survey of sugarcane fields in Malnad revealed the characteristics of Sugarcane ecosystem that favor Vertebrate pests. The crop provides excellent cover for vertebrate pest; due to the long harvesting intervals the sugar-bearing canes are an attractive food source and staggered planting in an area recieves considerable damage as vertebrate pests can move from harvested areas to areas of maturing cane nearby.

The cost of vertebrate pest control are relatively easy to account but the same cannot be said for benefits, which are difficult to assess. Nevertheless, assessments should always be made in financial terms since information of this type is essential for policy makers.

In the study area at Sakrepatna, sugarcane is damaged by Jackals, Wildboars, Rats, Rabbit and Wildgoat. Local variety, Honnavar local was grown and crop duration was 11 to 12 months. Surrounding, the sugarcane plots, sunflower, groundnut pulses etc. are grown.

Wildboar enter sugarcane patches in 1 to 30 numbers usually between 7.00 to 12.00 p.m. The animals crush the canes from base at 1 mt height and desap the canes. While feeding, the animals sufficiently trample the crop. The crop-losses were found higher via trampling than by direct feeding. When the canes are about 6- 7 months old, the animals damage or uproot canes by up-turning the soil.

Jackals visit fields between 7.00 to 7.30 p.m. in groups of 2 to 8. The animals crush and tear away the stem portion of the canes at upto .5 to .8 m height. Chewed-

up portions of canes and peg- marks of animals could be readily seen in the field. Animals cause no trampling impact on the crop and 8-12 months old canes are preferred by the animals.

Rat, *B.bengalensis* damage was noticed in 8-12 months old canes. The rats scoop out soil and damage the canes at base and such canes could be lodged easily before attaining maturity.

Yield-losses:

The average yield of sugarcane in Sakrayapatna varied from 40-50 tons/acre. Due to vertebrate pests 5 to 7% loss(n=18) was incurred by farmers generally. The losses due to four vertebrate pests have been presented in Table 44.

Sugarcane is damaged by a number of different kinds of vertebrate pests. Rodents caused damage at all the stages of the crop. Observations in Sakrayapatna revealed that rodents consumed the growing tissues like buds on seedcane, youngshoots and growing point. Rodents also damaged roots and underground portions by burrowing and thirdly by direct consumption of internode tissues. Rodent damage can be identified by drying of crown and leaves, lodging of clump and presence of heaps of soil around clumps. Sugarcane yield loss due to wildboar, jackal and jungle cat was recorded in Kg/ac.

In most situations of vertebrate pests depredation, watch/ward is the only method extensively followed. In sugarcane the yield loss due to Wildboar was reduced to 42.09, 41.05, 31.73 and 12.5 percent due to wildboar, jackal, jungle cat and rodents, respectively. Thus, on an average 50 per cent yield loss could be saved by watch/ward alone at Sakrepatna area. However, to draw conclusive results, this needs to be recorded for more than two years. Sugarcane yield loss due to VPs was about 400 to 700 kg/ac during 1992-93 compared to 150 to 200 kg/ac during 1991-92.

Wildgoat damage on Mulberry

Mulberry cultivation is gaining importance in Malnad. Farmers plant Mulberry in small patches (0.5-1 acre) or as an intercrop (in coconut plantations). During December in Anegunda, Sringeri succulent stems and twigs of 3 1/2 months old plants were defoliated by wildgoats. The goats while feeding on tender twigs and leaves break down the stems also. The animals take refuge in forest and forage during dusk and on disturbance leap to 2-3 m distance and disappear in the jungle/thickets. Of 500 plants sampled, about 100 plants were defoliated completely with no scope for regrowth/regeneration.

Bird damage on vegetables and cultural practices to reduce damage.

Vegetable cowpeas, brinjal, chillies and cucurbits grown by small scale farmers (2 acres) in Ujjre, South kanara district adjacent to hill region were chosen for study. The vegetables were grown in plain land. Cultivated patches of these vegetables were frequented to record activities of birds, their depredations and elements of the patches utilized by birds for feeding on insects. A pair of 8 x 30 binoculars was used. A good rapport with growers was established and information on various aspects of vegetable cultivation and birds was elicited and confirmed.

During 1989-90, observations with a pair of 8 x 30 binoculars were made on birds depredating on crops and resulting losses in crop yields were measured.

Small scale farming systems (SSFS) in hill region are traditional farming systems, primarily of a subsistence nature where farm size varies between 0.1 to 1.0 ha. Family labor is utilized. Surplus produce is mostly marketed to suit local needs.

Details concerning bird depredators on vegetables is given in Table 45.

By trailing cowpeas on wires and wooden frame, by not spraying insecticides and maintaining vegetation around, nesting and insectivorous activities of birds were promoted and by raising a mixture of cucurbitaceous crops like ridgegourd, cucumber and snakegourd, feeding of birds on these crops could be reduced. The farmers also intermittently scared away the birds damaging crops from the site.

Growing crop mixtures of three cucurbit vegetables on raised basins (2 m dia) reduced small green Barbet, *Megalaima viridis* damage to vegetables by 20%. Trailing vegetable cowpeas on 3 m tall stands

TABLE 43

Effect of watch and ward on Sugarcane losses due to vertebrate pests, Sakrepatna, 1992-93

Dates	Yield loss (kg/ac)							
	Wild boar		Jackal		Jungle cat		Rodents	
	a	b	a	b	a	b	a	b
10.10.92	87	43	33	21	30	20	15	10
25.10.92	90	35	25	15	22	12	13	11
10.11.92	85	45	21	10	19	18	12	10
25.11.92	85	75	32	13	29	19	13	10
10.12.92	92	39	35	23	33	32	14	11
25.12.92	30	25	41	20	39	21	13	10
10.01.93	25	23	52	32	49	31	12	11
25.01.93	77	29	53	23	48	29	15	12
10.02.93	83	35	53	28	50	39	17	13
25.02.93	43	20	29	18	53	33	19	14
Total	700	369	374	203	372	254	143	112
Mean	70.0	36.9	37.4	20.3	37.2	25.4	14.3	11.2
% Reduction by watch/ward	47.28		45.72		31.72		21.67	
Binomial expansion (Z)	3.107		2.12		1.36		NS	

a = Without watch and ward b = With watch and ward

TABLE 44

Yield-loss due to Vertebrate pests in Sugarcane

Year	Yield loss (tonnes/ac			
	Wild boar	Jackal	Jungle cat	Rodents
1990–91	10.29	3.21	0.80	1.30
1991-92	2.00	1.36	1.44	0.52
1992-93	1.07	0.58	0.63	0.26

TABLE 45

Small green barbet damage on cucumber in relation to the planting system

Plot Nos.	Cucumber fruits damaged (%) (n = 15)	
	Pendal system	Basin system
1	30	10
2	35	12
3	28	8
4	24	9
Mean	29.25	9.75
Binomial expansion test (m = 0.01)	2.964	

protected cowpeas by 8 to 10% from Red vented bulbul, *Pycnonotus cafer* and Roseringed parakeet, *Psittacula krameri* damage. Bird communities in vegetable ecosystems were better structured with large populations of predators.

Foraging and Feeding behaviour of crows on groundnuts:

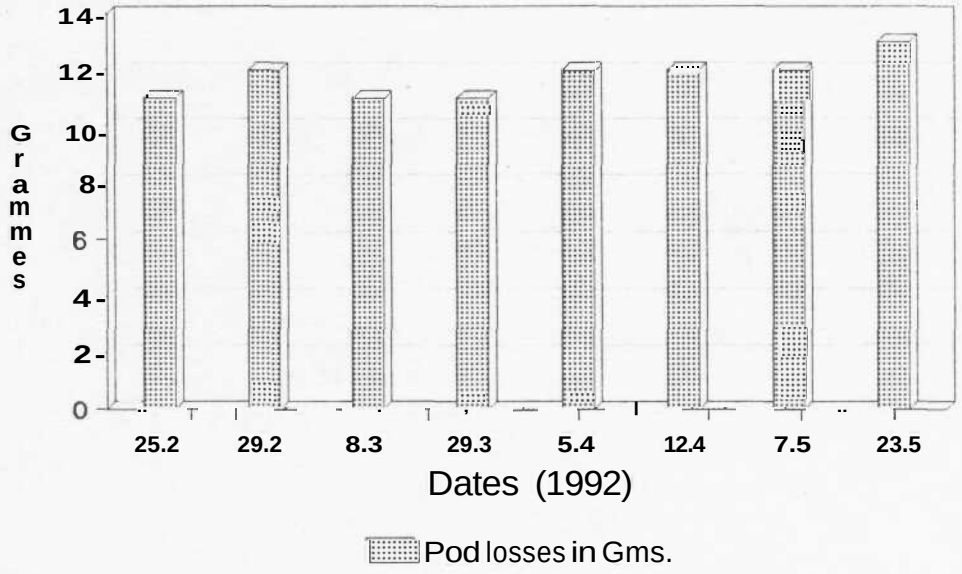
Two species of crows viz. Jungle crow, *Corvus macrorhynchos* and House crow, *Corvus splendens* were the species depredating on groundnut in Sakrayapatna, Chickmagalur.

The feeding of crows on crop began at Peg forming stage. Birds perched on ground to scoop out the soil and devoured the exposed pods by deshelling them, right from 6.00 a.m. onwards. The birds did not feed on groundnut pods from 10.00 a.m. to 3.30 p.m. The birds took refuge under canopy of trees. The numbers of crows varied considerably among the plots. 20-30 birds/acre of groundnut was common.

Without watch-and-ward, 75-80% damage and with watch-and-ward, 4- 5% damage of ground nut plants was recorded in plots (3m x 3m) sampled randomly. There were highly significant differences between the two plots by t-test.

Scaring, watch-and-ward, hanging killed birds and use of artifacts are some of the methods followed by farmers to protect groundnut from crows. However at vacant spots in the field ragi could be planted as an inter crop so that landing and feeding of crows is not facilitated. This is particularly because seventy percent damage was restricted to the edge rows.

Pod losses in Groundnut due to Vertebrates in Sakreyapatna



HOUSE SPARROW

Vertebrate Pest Management In Forest Nurseries

Rodents, Rabbits, Hares, Deers and-birds were found troublesome in forest nurseries in the hill region. Grazing by cattle, sheep, Goat and other animals were destructive to seedlings. Grazing damage to regenerating forest stands depended on the type and population of grazing animals and the , type of terrain-slope, valley or plains. Browsing (eating of vegetation other than grass and herbs) proved more harmful than proper grazing. In hill region, wildboar, sheep and goats are the common browesers and bison and deers are the common grazers.

Damage to nurseries is pronounced in the dry and hot seasons when grass and herbage is not available to the animals.

In Banakal, near Mudigere, bamboo (Yellow stem) sedlings planted in 25 ha. in upland was depredated by Rabbits and Rodents during monsoon (July-August) when new shoots and flush appeared. Bamboo saplings damaged to more than 50% were substituted by fresh plantings with green stem bamboo saplings that are known to be not attacked by Rabbits and Hares. Saplings receiving less than 50% foliage damage and seem to have the capacity to regenerate, were covered by a thick mat of thorny sticks. Saplings receiving relatively less damage were also machanically protected with perforated polybags (Thimet 10%g, 3G+5g dry sand) suspended for repelling away the animals. In this way, the establishing bamboo plantation could well be protected.

During December in Nemmar, Sringeri, saplings of *Artocarpus*(Halasu), *Calophyllum*(Honnae), *Dalbergia*(Beete), Subabul, etc. were defoliated and tender shoots were cut due to the feeding of wildgoat on fresh flush of leaves. The animals foraged in the nursery during dusk and night. Watch-n-ward, animal proof fencing or maintenance of thick live hedge of either *Euphorbia,* Agave, *Prosopis*or *Acacia* can help. Rats-*Bandicota indica*, *Bandicota bengalensis* and species of *Funambulus*(Squirrel) were observed by inflicting injury by burrowing into the soil or feeding on tender vegetative and reproductive or regenerating plant parts. Rodents damage occured on seedlings by debarking or by slicing the stem. Effective methods of controlling rodents in nurseries, as elsewhere are by poison baiting and by burrow treatment.

Soft-wood tree saplings at several nurseries in Chikmagalur and Kodagu were found with barks peeled-off. This may be the result of feeding by stag or Toddy cat or Deer. At times, the buds, flowers and tender fruits are nipped-off by different species of parakeets, barbets and bulbuls. Forest nurseries can be protected from large animals either by trenches, stone-walling or by electric fencing. However, protection of teak stands in Chettahalli by electric fencing was not successful mainly because of intrusion by elephants. Often recently sown seeds and germinating plant become vulnerable for granivorous birds and window screening may be of some help.

Vertebrate Management is largely by exclusion or eradication in forest nurseries. Though, keeping small animals and birds out of the nursery is impracticable, some physical methods and encouraging predatory birds against rodents may be useful. In extreme situations, traps, shooting or poisoning might be selectively used to eliminate vertebrate pests. The chemicals used must be environmentally friendly and nontarget effects of pesticides must also be of concern.

ELEPHANTS RAIDS ON CROPS

During 1990-91 local newspapers reported several incidents of elephants raids on crops in Malnad. Maximum number of reports were received from Kodagu district. To protect their crops, farmers scared and even shot at the elephants. Human deaths were also reported.

Reports of Elephants raids on crops is increasing year-by-year in Malnad. Local planters and farmers believe that elephants are their greatest enemies. Herds that wander in and around the cultivated tracts have a great potential to destroy or damage plantations. The government is also helpless without proper techniques and laws to compensate for elephants raids on crops. A survey was conducted in Kodagu and Chikmagalur districts during 1991 to 1993 and observations on nature of damage on crops were recorded.

Causes:

Conversion of forest to agriculture is a serious cause for elephants raids on crops. Since three decades croplands have increased and several thousand ha. are deforested each year. Changes in land-use patterns have resulted in a steady contraction of habitat available to the elephant. In the forest reserves of Muthodi and Nagarhole, the elephant population has increased and so the movements of animals have been restricted. The Reserve area is not large enough to protect the entire seasonal home ranges of the elephants herds. As a result, elephants roam over cultivated areas and raid on crops.

Season:

Maximum raids occurred during fruiting (May-June) of Jackfruit(*Artocarpus*). During summer (February-April) the animals mostly confined movements near water sources. The elephants herds moved from Chikmagalur-Mysore to Kodagu. Elephants raids also depended on coconut and banana planted areas. Banana and coconut received maximum damage from elephants raids. Paddy fields were affected due to trampling of elephants herds. Fruit orchards and coffee estate in Virajpet and Chettahalli taluks incurred heavy losses.

Extent of losses:

It is difficult to precisely quantify the extent of losses due to elephant raids. In certain situations, growers have discontinued cultivation of certain crops altogether. Some estimates of losses are indicated under Elephant raids on crops in Malnad.

The compensation forthe loss of crop due to elephant havoc, death/ injury of men due to elephant attack and killing of domestic cattle by wild elephants are paid by the Forest Department,Kodagu district, Government of Karnataka. The details of the compensation paid for the last three years are furnished below: 3 2

But seen in a larger context, elephants, however, are a long-term resource in Malnad. The wild habitat actually available for the animal has shrunk by 30 to 40% in Malnad region. About 50 years before, elephants were the animals that found sufficient space and food to carry out all life activities. Local people began, on a large scale, conversion of forest into agricultural holdings. Elephants soon began loosing their range and habitat. Logging and forest clearance has further degraded habitats of elephants. As a result, their raids on crops are becoming more frequent in recent years.

Elephants could be most useful today, when rapid but wasteful mechanical logging methods result in so much environmental damage. The elephant, used selectively for logging operations could be the basis for a comparatively less destructrive mode of resource extraction.

A trained elephant is better than machinery which is both economical and has environmental advantages.

Elephants does not require expensive logging roads needed for heavy machinery.

Unlike machinery, elephants do not pollute the environment and do not require replace of parts or repairs.

Elephants depend on undergrowth in forests and their feeding thins the undergrowth. This enhances the germination and growth of many tree seeds.

Elephants cause less damage to the land than heavy machines.

Trained elephants (excepting pregnant females and bull elephants that have a period of "must") can work through out the year.

In swampy areas or on steep hills, elephants are the most cost efficient means of timber extraction.

So the use of elephants must be made in the production processes. The animals can also be used for promoting tourism, they can be distributed among parks and sanctuaries, can help in transportation and can be put to farming operations. There are certain ways of minimizing human-elephant conflicts. The measures include translocation of herds from problematic to safety of parks and protected areas, to the establishment of barriers (e.g.electric fences) capture of chronic crop raiders and formulation of insurance policies and compensation-cover for affected farmers/people.

Elephant raids on crops in Malnad

March, 1990	Mudigere to Byrapura, Kumbardoddi, Kunduru, Saragody and surrounding villages-from 3 to 4 years. Coffee, paddy, lakhs of rupees losses every year.
July, 1991	Kudlipet and Surrounding villages, Coffee, banana paddy.
July, 1991	South Kodagu-Coffee,paddy
Sept, 1991	Rangasamudra, Kushalnagar, Virupakshapura, Vaspatna, Coconut seedlings and other crops 20-once in 2 days.
Sept, 1991	Rangasamudra-Coffee estates
July, 1991	Virajpet to Bhadragula, Titimathi, Hebbale, a troup of elephants: 18 coconut palms raided, Coffee bushes.
July, 1991	Madikeri-Coffee
July, 1991	Virajpet-Polybetta, Parvathi Coffee Estate, Coffee
Sept, 1990	Banakal, Kunduru, Biraguru, Guttihalli, Mooladahalli, Baluru, Koove, Gubagal, Nandanil, Kalmane, Hordini, Gowribeedu, Bhairapura, Kumbaradi, Saragodu, villages in Mudigere taluk. Rs.5 to 6 lakhs loss/per year and death of 5 to 6 persons/year. Crops damaged-Coffee, paddy, Areca, Banana and other fruit crops.

During June-July 1992, a detailed survey of parts of Kodagu district was conducted to ascertain the extent and nature of damage to crops.

March 1992	Somvarpet, Apangala-Sugarcane, paddy, coffee cardamom
July 1992	Bellur-Sugarcane
August 1992	Siddapura, Kattepura-Coffee, paddy Ragi, Coconut, Banana, Areca (600 acres affected)
June, 1993	Kamblihane-Coffee, Banana. Coconut, Mango, Ginger(worth Rs.1 lakh/year)
July, 1993	Chettahalli-Orange, Jack, Vegetables papaya, Mango, Pomegranate, Pineapple.

Feeding behaviour and nature of damage:

Elephants entered orchards in 3 to 4 or 8 to 9 numbers, feeding on leaves of bamboo, bhendi tree, teak bark, citrus fruits, silk cotton, citrus bark, tender parts of palm trees, sapota tree bark, grasses, etc. To reach the edible parts, the animals also fed by trampling and on bark of teak, branches of guava, sapota, citrus by cutting and lodging the parts. The elephants uprooted banana, citrus and guava trees. In Kodagu, maximum damage to crops was recorded in May to October. During summer, elephants spent most of the time, in forests near ponds and fed on bamboo and other forest trees.

Management:

The Forest Department, Kodagu adopted following Management practices:

a. IBX fencing (not effective for a long period), cost is 1 lakh/2 km. (12 volts)

b. Sulphur tears which act as a Elephants repellant.

c. By putting lights, the animals to some extent, can be scattered away from orchards.

d. Firewood burning also helps to scatter the elephants in the orchards.

e. Trenching is very effective method for avoiding entry of elephants into the field (width of trench, (15'; height, 10')

f. Elephants in orchards, cropped areas will be trapped and will be maintained in Reserve Forest area.

	1990-91		1991-92		1992-93		1993-94
	No.of cases (1)	Amt paid(Rs.) (2)	(1)	(2)	(1)	(2)	
1. Compensation paid for the loss of crops by wild elephant	181	1,18710	385	5,11,615	415	8,87,889/-	1
2. Compensation paid for the loss of cattle by wild animals	96	58,250/-	139	1,16,350/-	193	1,62,850/-	20
3. Compensation paid for the loss of human life and injury bywild animals	10	1,85,520	5	86.000	5	?	2

BISON AS PEST

Bison, like Elephant is increasingly becoming a pest in several areas of hill region in Karnataka. In Kodagu and Chikmagalur districts, Areca, Sugarcane, Coffee and Banana plantations are affected by bison. Bisons break the branches of sapota, citrus and guava trees. While feeding on fruits, the branches are broken. These animals like cattle, graze on vegetables like Radish, chilli, brinjal, etc. The animal also cause trampling.

Bison were found depredating crops in groups. Both the young and the adult together enter the field. Bison jump over the Ibex fencing to raid crops. so, erection of E.F. at a height (1m.) is suggestive. These are nocturnal animals found foraging in cropped areas usually during 9.00 p.m. to 4.00 a.m. Management practices followed against Elephant raids can also be followed against bisons. More observations on bison as pests need to be recorded.

FINCH

ELECTRIC FENCING

From the last six years, planters in hill region are increasingly using electric fencing (E.F.) for protecting crops from vertebrate pests. The fence would ensure time-proven performance, can be used aginst various species of vertebrates, it is cost effective, non-toxic to non-target species and cause no side- effects. Across the hill region, planters who have installed electric fencing in Thirthahalli, Sringeri, Koppal, N.R.Pura, Jaipura, Somwarpet, Virajpet, Shimoga, Sagara, Soraba, etc reported that Electric Fencing effectively checked the encroachment of various vertebrate species and that it is a potentially good tool for crop protection against vertebrate pests.

Electric Fencing contains Ibex battery of 12 volts and it gives out a shock to the wild animal so that it does not intrude into the plantation. The animals have been found not to touch the fence again. On both sides of the electric fencing, in 1 to 2 m. space nothing should be grown. Electric fencing in combination with watch-n-ward and good husbandary practices can be very effective. Electric fencing is considered by some, to be the best long term solution against the depredation of VPS.

Response of Vertebrate Pests:

Wildboar, Jungle cat, Rabbit, Mongoose and other animals of medium to small size have been found to escape from the electric fence. Wherever these animals are highly destructive, other crop protection measures need to be supplemented with electric fencing. Monkey, Dog, Stray cattle and Jackal are known to learn to avoid electric fencing. Under high feeding pressure these animals even encroach into the plantation. Elephants, Bison, Stag and Wildboar are repelled away.

Cost effective:

For an area of 40 acres, Rs.25,000/- is needed. In addition to this, the maintenance cost is also involved.

Maintenance:

1. Regularly, everyday check the Electric Fencing.
2. Electric Fencing should not be in touch with any green part of the plant.
3. The life of electric fencing under Malnad conditions usually last for 3 years.
4. Electric fencing serve as a tool in the Integrated Vertebrate Pest Management.

Integrated Vertebrate Pest Management

In hill region, a Vertebrate frequents more than one crop. For instance, the squirrel, *Funambulus palmarum* frequents cardamom plantation, of the incurring economic losses in capsule yields. Simultaneously, feeding on ants, rootgrubs, etc that are inimical to the crop growth and production. The animals also feeds on a number of kinds of seeds, fruits, buds and nuts. But for this the vegetation structure and composition would have remained changed.

In the same patch, squirrel forages in coffee plantation, feeding on fallen nuts, seeds, arthropods and also coffee berries. However, the losses are not substantial and often are within tolerable limits. On cocoa the squirrel causes economic losses. Therefore the status and the ecological role of squirrel varies depending on the farming situation. Similarly, Wildboar(*Sus scrofa*) activities may cause economic losses in paddy area and in cardamom nurseries. But often not so in coffee and cardamom plantation.

There is a need to assess the overall role of an animal in the area and the impact management practices would hold on the ecosystem. The crop-protetion practices should be compatible, practically feasible and environmentally friendly. Integrated vertebrate Pest Management (IVPM) involves protecting crops by a compatible combination of two or more different methods without causing any side effects. Preliminary results of IVPM studies for a selected number of crops is given below.

Cardamom:

During 1992-93, a combination of cultural(timely harvests, overlapping panicles, clean cultivation) and mechanical (trapping) methods were tried on hundred clumps at a site at RRS, Mudigere. In another site(n=100 clumps) (1km.away) no protection methods were executed. The capsule damage was compared on ten observation dates during October-November. The cumulative rodent and bird damage in protected and unprotected clumps is given below. It is clear that by adopting a combination of methods capsules, as many as six folds could be saved.

Combined effect of three cultural practices on rodent damage

Date	Protected Cardamom (n = 100 clumps)	Unprotected Cardamom (n = 100 clumps)
1.11.93	190.22	1448.00
4.11.93	346.22	2560.00
7.11.93	512.00	2744.00
10.11.93	858.00	4382.25
13.11.93	1047.75	6135.81
16.11.93	1386.00	8121.47
20.11.93	1681.00	9861.00
24.11.93	2020.00	11753.00
27.11.93	2345.00	13481.00
30.11.93	2480.00	15306.00
Total	2480.00 1286.22	15306.00 66029.0
Mean (for 10 dates)	248.00 1286.6	1530.60 6602.9

Guava:

Guava fruits are depredated by Jungle Crow, *Corvus macrorhynchus* small Green Barbet, *Mgalaima viridis*, Roseringed parakeet, *Psittacula krameri* and flying fox in Mudigere. During 1993, on an average, 5.00 per cent fruits were damaged by birds in 2 ac (mean of 50 trees). To protect the fruits from birds damage, trees in 0.5 ac. in one corner(North- west) of orchard was partially covered with a mat made of paddystraw and dried grass. Birds were constantly scared away from this cover. In the diagonally opposite corner, no protection measures were adopted. It was ascertained that protection measures at one corner did not affect feeding by birds in another corner. The observations were recorded on fruit damage during August-September, 1993, on ten randomly selected trees/site. The protected patch recorded 4.15 per cent fruit damage (mean of 10 trees) compared to 7.50 damage in the unprotected plot.

Rice:

Rodents are regular pests on rice in Mudigere. Three rice fields, viz.Anwarulla lands(40c) New area fields (8 ac) and Desouza fields (5ac) all within 4 km were selected for the study. Rice was transplanted during June-July in all the fields. In New Area, before transplanting, the rat burrows were fumigated with Aluminium phosphide tablets. The bunds were trimmed and the grasses and herbs on bunds were pruned. Observations on rodent damage(area under rice affected in m^2) were recorded before 15th July and 15 September at weekly intervals. In New Area, where protection measures were implemented 6.77 m area was affected compared to 13.63 m in Anwarulla lands and 17.16 m in Desouza fields.

APPENDIX-I

CHARACTERS FOR IDENTIFICA TION OF FEW VERTEBRATE PESTS

A. Rodents:(Rats, Mice & Squirrels)

Chirel-shaped incisors (two in the upper jaw and two in theb lower). Inner surfaces of cheek are brought together inside the mouth and the face gives cone-like appearance.

Have three ture molars on each side of each jaw.

a) Rats:

(i) Larger Bandicoot Rat-*Bandicota indica Bechstein*
Long, black, rough hairs on coat, Robust bodies. Head & body 30- 40 cm.

(ii; Lesser Bandicoot rat-*Bandicota bengalensis)* or Indian mole rat.
Bandicoot is robust form, round head, round ears, short, broad mule. Coat colour-dark greyish brown speckled with buff, Undersides-paler. Tail is shorter than or equal to head and body put together.

(iii) House rat-*Rattus rattus*
Dorsal fur-black, belly, Ventral fur-smoky grey, Tail-longer than head and body put together.

(iv) Soft furred field rat-*Rattus meltada*
Head and body-13-15 cm. Soft fur, large and rounded ears, dorsal fur-pale brown, Ventral fur-greyish white. Tail-as long as or longer than head and body together.

(b) Mice

(i) Field mouse-*Mus booduga*(Grey)
body 5-8 cm. tail over 5 cm. Dorsal fur-dark greyish brown, Ventral-white

(ii) Spin field mouse-*Mus platy thrix*
Size and fur colour-same as above. Dorsal fur-dark-to light brown. Ventral fur-paler.

c) Squirrels

(i) The three stripped palm Squirrel-*Funambulus palmarum (Linnaeus)* 3 dorsal strips.

(ii) The five striped palm squirrel-*Funambulus pennanti wroughton. 5 pale strips on the dorsal side.*

d) The Indian Porcupine

-Hystrix indica. Head and body 70-90 cm, tail 8-10 cm, body hairs, modified into spines.

B.Vertebrates other than Rodents

a) Wild boar-sus scrofa Linnaeus

Color-black mixed with grey, rustly brown and white hairs. The young are browner and old boars greyer. both the upper and lower tushes curve outwards and project from the mouth. Size-90 cm. high at the shoulder.

b) The Bonnet Monkey-Macaqcua radiata(Geoffroy)

long tailed, long dark hairs radiates in all directions from a whorl on its crown. The bonnet does not cover the forehead, where the hairs are short and neatly parted in the centre.

c) Rabbit-Lepus nigricollis F.Cuvier

Dark brown/black patch on the back of its neck from the ears to the shoulder, upper surface of tail black,(*Lepus nigricollis nigricollis).*

Rufous brown coat much mixed with black and back and face, breast and limbs rufous, chin, upper throat and lower parts white, upper surface of tail rufous-brown (*L.n.ruficaudatus*).

APPENDIX II

Vertebrate Pests Damage on some Cereal Crops in Malnad

Location	Cereal	feeding by vertebrate	behaviour	Loss or damage (%)	No.of Observa-tions(n)	Sampling method
Beekanahalli valley(CKM)	Finger millet	Wildboar	Browsing	35	9	/m^2 earheads
" (CKM)	Sorghum	Wildboar	Feeding	19	12	/m^2 earheads browsed
" (CKM)	Potato	Wildboar	Earthing up & feeding	100	10	Plants uprooted/ row.Damage is less on full- moon days
" (CKM)	Potato	Wildboar	Earthing up & feeding	25	10	With watch and ward, damage is 25%. Tin-beating did not deter the animals. Based on number of palms/m^2
RRS, (M)	Oil palm	Rodents	Scooping out soil, burrowing & feeding	20 palms killed		6 No.of plants/m^2
RRS, (M)	Rice	Rodents	Cutting & lodging	50 damaged		20 No.of clumps damaged/m^2
Sakraypatna	Groundnut	Wildboar, jackal, crow	Uprooting & feeding, Pecking		40 Plants/m^2 Seeds depredated	Flocksize=50 (65-70 birds)
-do-	Sunflower	Buntings		6-10	/head Pecking	
-do-	Cotton	MC5 is more susceptible compared to DCH/to square /boll nipped by Jungle cat		8	rate=2 seeds/min	

CKM = Chickmagalur, M = Mudigere

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